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Priorities for Ecological Protection: An Initial List and Discussion Document for EPA

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EXECUTIVE SUMMARY

EPA's mission, and the environmental laws that underlie policy and regulations, require the Agency to "protect human health and the environment." Although we may debate the degree of acceptable risk, there is general agreement on the human health endpoints of concern; there is far less agreement on the corresponding endpoints for protecting the environment. Decision makers in EPA have sought guidance on specifically what resources to protect and how they and the public can become more involved in the ecological risk assessment and decision-making process.

One purpose of this document is to stimulate Agencywide discussion on which ecological entities should be considered priorities for protection by all Agency programs. (*Ecological entities* are the valued resources to be protected and can be species, ecosystem functions or characteristics, or specific places and habitats.) Another purpose is to propose a process by which decision makers can set specific ecological objectives to guide both assessment and action.

As a first step in framing this discussion, our work group reviewed past and current trends in ecological protection as revealed in Federal statutes, EPA actions, policies of natural resource management agencies, community-based projects, and other management actions involving the public to see what has been valued and whether there is evidence of consistent directions.

The results of this review show that there is a trend in environmental legislation. The early statutes tended to be concerned with short-term narrow utilitarian objectives (e.g., use of commercially valuable natural resources). In later statutes, there is much more evidence of longer term broader utilitarian objectives (e.g., protecting natural areas such as National Parks and Scenic Rivers for the enjoyment of present and future generations). This trend has culminated in legislation that protects individual species and whole ecosystems for posterity.

There is also a trend in the complexity and the time and space scales of ecological protection objectives. Environmental legislation has a long history of protecting certain groups of animals such as fish, shellfish, migratory songbirds and waterfowl, and large mammalian game species. More recently, legislation has sought to protect entire ecosystems and to ensure their "integrity" for the foreseeable future. Integrity can be defined as "the interaction of the physical, chemical, and biological elements of an ecosystem in a manner that ensures the long-term health and sustainability of the ecosystems" (U.S. EPA, 1994b). It incorporates the concepts of *sustainability*, or the ability of an ecosystem to support itself over a long time; *resiliency*, or the ability of an ecosystem to recover from a stress; and *biodiversity*, or the variety of life at the genetic, individual, and ecosystem levels.

This trend has resulted in a shift in focus from simply protecting single species on a chemical-by-chemical basis to more complex approaches involving basinwide watershed management and consideration of both direct and indirect effects of multiple stressors. There is

evidence that a broad segment of the public holds beliefs that tend to support these trends. These trends suggest that decision makers should increasingly focus on long-term goals in addition to short-term objectives; to articulate these goals to encompass sustainability, resiliency, and appropriate biodiversity; and to consider how foreseeable changes in the environment resulting from natural and human-induced changes may modify current risks and risk-reduction strategies.

Because it is usually not possible to protect everything at once, it is important to be able to prioritize for the ecological entities that may be most worthy of concern and protection. Such entities include individual species and their immediate habitats, whole ecosystems containing many species and the processes that link them, and "special" places that are of unique or particular ecological or societal value. Some criteria for ranking risks to these entities include statutory mandates, valued or unvalued utility to society, the threat of irreversible harm (e.g., extinction), and the importance of the entity to the survival of other entities (e.g., species or ecosystems).

Our review of current practice suggests eight ecological entities that are of widespread concern: (1) aquatic communities in lakes, streams, and estuaries; (2) regional populations of native species and their habitats; (3) severe episodic threats (such as massive bird or fish kills); (4) important ecosystems functions and services; (5) wetlands; (6) endangered ecosystems; (7) endangered species and their habitats; and (8) other special places. These categories are not listed in order of priority, nor are they mutually exclusive. They are presented as a reasonable and useful set of entities for setting ecological objectives.

Ecological objectives are needed in a variety of regulatory and nonregulatory applications at EPA. Two of these applications are when national program managers make risk-based decisions and in Community-Based Environmental Protection (CBEP) projects.

Risk-based decisions use ecological risk assessment, which has taken a large step forward with EPA's publication of a new *Framework for Ecological Risk Assessment* (U.S. EPA, 1992a) and the *Proposed Guidelines for Ecological Risk Assessment* (U.S. EPA, 1996c). The critical role of the risk manager in this process is to (1) identify the problem and the appropriate legal mandates and restrictions; (2) review the applicable entities potentially at risk; (3) meet early with the technical risk assessors and the attentive public; (4) define the societal *objectives* associated with risk to a particular entity; and in working with the risk assessors, (5) identify the *assessment endpoints*; (6) review and understand the conceptual model underlying the risk assessment; and (7) establish quantitative *measures of effect*.

The CBEP projects use a similar set of steps: (1) identify the problem and sources of information; (2) form partnerships and bring in the public; (3) establish boundaries; (4) inventory the resources of the area; (5) list the local values; (6) establish specific objectives; and (7) plan the analysis, either by the risk assessment paradigm or some other process.

The order of the steps is somewhat flexible for both processes and may require iteration. The Waquoit Bay Problem Formulation provides a good example to illustrate both processes and is discussed in chapter 5.

Our work group believes that EPA risk managers will be increasingly called upon to consider ecological risks, in addition to those that directly affect human health. As people become more educated about the complexity of ecosystems and their importance to the quality of life, risk managers will be required to increase the scope and complexity of ecological risk assessments. We hope that the review of past practice, of the ecological entities that have been of most concern in past and current statutes and regulations, and of the ecological basis for concepts such as sustainability, resilience, and biodiversity prove helpful for risk managers who lack extensive training or experience in these areas.

We hope that the recommendations in this report will lead to agreement on the entities that should be considered in all Agency activities and on other principles of ecological protection. We believe that a common list of entities and ecological principles for the entire Agency can provide many advantages: It can promote consistency among our programs, make our actions more understandable to the public, provide structure for those programs than do not yet have much experience with ecological risk, aid in research planning, and focus risk-communication efforts. Even before the Agency agrees on the common ecological entities, we believe the information and suggestions in this document can be of immediate use to Agency decision makers. The list given in chapter 4 can serve as a convenient checklist to help turn the general goals provided by EPA laws into concrete, specific objectives that can guide assessments and actions.

Above all, we hope that Agency decision makers will use these suggestions and recommendations and share their experiences with other offices, including the Office of Research and Development and the Office of Policy, Planning, and Evaluation. Only by learning from actual experience can we develop the processes and principles that will provide a sound and useful EPA approach to protection of valued ecological entities.

1. INTRODUCTION

1.1. BACKGROUND

EPA's mission is to protect human health and the environment. Initially EPA emphasized protection of human health (U.S. EPA, 1990c; Russell, 1995), and although ecological impacts are now considered to a greater extent, the focus on human health remains. As a result, many risk managers have had more experience in incorporating human-health concerns than ecological concerns into the decision-making process. Also, the degree to which different statutes consider ecological risk varies.

Some risk managers in EPA have indicated that they would like to consider ecological risk to a greater extent, but they need something more specific than the "protect human health and the environment" found in many laws. They want further guidance, including advice on what resources should be protected.

The 1994 report *Managing Ecological Risks at EPA* (U.S. EPA, 1994a) reviewed the ecological concerns already considered in many EPA program areas. The report concluded with a set of recommendations, one of which was that EPA develop common ecological concerns to be considered in all Agency activities. The report states: "these concerns can take the form of Agencywide principles or objectives and can also support other ecosystem management and nonregulatory efforts being undertaken by the Agency."

Although *Managing Ecological Risks* did not precisely define "concerns," some examples of potential Agencywide concerns cited were risks to migratory birds, wetlands, commercial fisheries, congressionally designated wilderness areas and Wild and Scenic Rivers, public lands, and important privately owned lands such as Nature Conservancy preserves and National Audubon Society sanctuaries (U.S. EPA, 1994a, p. 18).

In this document, we modify this notion slightly and define an entity (or ecological entity, or valued ecological entity) as the valued resource to be protected. With this, we hope to launch a discussion, within and outside of the Agency, to achieve consensus on what valued ecological entities should be considered routinely in all Agency programs for which they might be relevant.

1.2. AUDIENCE

Our primary audience is EPA decision makers who determine what aspects of the environment are to be protected or restored, their priority, and the extent to which they are protected or restored. They could be developing regulations, criteria (e.g., water quality criteria), policy, or guidance, or they could be making decisions about pesticides, toxic chemicals, or cleanup of Superfund sites. We also include those who work with partners to reduce ecological risk.

This document may also be of interest to those who support these activities with technical information, risk assessments, monitoring programs, research, grant or budget activities, and community outreach; it may also be of interest to those who implement decisions (by permit reviews or enforcement activities).

This audience includes people with a wide range of experience in managing ecological risk. It has been challenging to write for the entire audience; consequently, the reader may find some parts of the document more relevant than others. Furthermore, the extent to which particular entities are already considered varies greatly among programs; any list of potential Agencywide concerns will probably seem new to some readers and routine to others.

Advantages of a Common List of Entities

A list of valued ecological entities to be considered in all EPA activities has several advantages.

Consistency: A general list of entities can promote consistency within the Agency.

Understandability: A list of specific entities can make it easier for the public to understand what we do.

Structure: A list of valued entities can help decision makers set specific, measurable objectives.

Research Planning: The experience of attempting to use common entities in varied areas can identify where we lack knowledge and help focus research.

Communication: The entities discussed in this document can help focus risk-communication efforts around valued resources.

1.3. APPROACH

The approach taken here is based on a view of government as both responding to public values and providing information and leadership. Thus, it is important for the Agency to understand the societal value attached to various ecological entities. On the other hand, EPA must also help the public understand the relationship between (1) those resources and services that are widely valued and (2) those whose value may not be widely recognized but are necessary to support other attributes that are valued.

Ecological principles and processes must be considered when determining priorities for ecological concerns. To accomplish this, we combine an initial list of valued ecological entities (i.e., ecosystems and their components) with the goal of maintaining long-term ecosystem integrity. It does this by:

- Making some inferences about the value placed on particular ecosystems and ecosystem components and how these values change over time as shown in Federal

laws, Federal agency actions, and local (community-based) environmental protection (chapter 2)

- Introducing the idea of ecosystem integrity as an environmental protection goal (chapter 3)

- Proposing a set of criteria for setting priorities as to what should be protected (chapter 4)

- Proposing a set of ecological concerns for consideration as a common Agencywide list to be used in all EPA activities for which they might be appropriate (chapter 4)

- Showing how concerns can be used in two major risk-management approaches (chapter 5).

1.4. LIMITATIONS

We do not intend our recommendations to prescribe how much any particular entity should be protected. This depends on many factors, including discussions between the risk manager, the attentive public, and the risk assessor, and will differ from case to case. This document is intended to facilitate those discussions and help ensure that all appropriate ecological entities are given due consideration. In addition, the document deals only with entities that contain some important nonhuman biological component. Human health and abiotic issues such as groundwater contamination are related to these issues but are not addressed directly.

We also want to recognize that some entities are not readily amenable to sound scientific assessment and that some ecological risks may not be amenable to reduction or prevention under existing statutory authority. Nevertheless, decision makers should not be deterred from considering them or from including them when documenting Agency decisions.

2. VALUES AND TRENDS

This chapter examines Federal laws and current environmental practices that reflect widely held values. It describes the ecosystems and ecosystem components favored by the public, including the way this has changed over time, and delineates a baseline from which to consider the need for change. The appendices contain additional information on environmental laws and practices.

Ecological concerns—as evidenced by current laws, government and private action, and expressed values and philosophies—extend across a broad spectrum from immediate human utility to values independent of humans. At one end of the spectrum are highly utilitarian concerns such as the protection and availability of natural or manmade resources for economic use and direct human consumption. As one moves across the spectrum, concerns of this type grade into recreational and aesthetic uses and human-derived preservation values. At the other end are those associated with moral, religious, and spiritual values.

We do not intend to make any choice for the Agency or the public along this continuum. Rather, we present values as inferred from legislation and environmental action and describe the ways in which these values have changed over time. This approach examines historical actions at a national level. In setting priorities and goals, risk managers should keep in mind that values change over time and may vary in different geographical areas.

2.1. LAWS

In a democratic society, the values represented in Federal law are often good indicators of widely held values. Frequently, they have gone through an extended process of public debate and examination. As an executive agency, EPA must implement laws. But beyond this mandate, laws can provide insights into the ecosystem components, services, and whole ecosystems that are particularly widely valued. These inferences, although not limiting what the Agency can do, can help the Agency interpret those laws that state the ecological goals in general terms.

2.1.1. EPA Laws

Existing laws direct EPA to consider a variety of general and specific ecological concerns (see table F-1 in appendix F). At the most general level, most of the laws administered by EPA focus the Agency on ecological concerns through mandates to protect "the environment." Although Congress' use of the term *environment* does not help identify specific ecological entities, its plain meaning indicates that EPA may reasonably consider a broad range of ecological entities in its programs. Statutory definitions of *environment* in the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) and the Toxic Substances Control Act (TSCA), for

example, explicitly include water, air, land, living things (including humans), and the interrelationships among them.

A number of statutory provisions in existing law also direct EPA's attention to more specific ecological concerns:

- **Ecosystem Components**: The Clean Water Act repeatedly mentions fish, shellfish, and wildlife in many places and contexts. The Clean Air Act refers to wildlife protection.

- **Ecosystems**: The Clean Water Act has many references to specific types of aquatic ecosystems, including rivers, lakes, and estuaries. The Clean Air Act mentions "regionally representative" and "critical" ecosystems.

- **Special Places**: Both the Clean Water and Clean Air Acts mention the Chesapeake Bay, the Great Lakes, and Lake Champlain. In addition, the Clean Air Act makes special provisions for national parks and wilderness areas, and the Clean Water Act lists specific types of waters as "Outstanding Natural Resource Waters" for enhanced protection.

2.1.2. Historic Review of Federal Laws

In the late 1970s, the then-Office of Toxic Substances (OTS) prepared *Federal Laws, Treaties and Conventions Pertaining to the Environment* as a basis for determining the environmental effects of regulatory concern under TSCA (U.S. EPA, 1983). The appendix to the OTS report listed environmental legislation chronologically from 1785 to 1978 (U.S. EPA, 1983). This section reviews this chronology to consider both the trends in the way laws consider ecological entities and the entities that have been targeted for protection.

- **1785 to 1899**: The earliest legislation dealt with the use and disposal of public land for homesteading and mining (e.g., the Mining Act of 1866) and similar uses. Such laws seem to have been motivated primarily by a narrow view of the utility of natural resources. However, Yellowstone Park was also set aside "for the pleasure of the people" during this era (1872), thus including a broader utilitarian view.

- **1900 to 1925**: Laws specifically protecting fish, birds, and wildlife appeared early in this period, with the Lacey Act established to protect endangered game and wild birds in 1900. This was in response to an alarming rate of extinction of wild animals and the commerce in game birds for plumage during the last decades of the 19th century. The first national wildlife refuges for the protection of game animals, birds, and fish were also established during this period. The Fish and Game Sanctuary Act, which authorized the executive branch to establish such refuges, was passed in 1916. The Migratory Bird Treaty Act, a major step toward protecting birds, was passed in 1918 to implement a 1916 treaty with Canada. Among other provisions, the Act specifically

prohibited the hunting of insectivorous birds, thus clearly going beyond the protection of game species. The National Park Service Act of 1916 created the National Park Service, with authority to make such rules and regulations necessary for the proper use and management of National Parks for various purposes. The law specified that grazing can be allowed when not detrimental to the primary purpose for which a particular park was established. This demonstrated support for the "broadly utilitarian" use of natural areas. Concerns for more narrowly utilitarian uses also continued through this period. Examples are the Kinkaid Homestead Act of 1904 and the Amended Mineral Leasing Act of 1920.

- **1926 to 1947**: In general, this era showed a growing awareness of the need to conserve natural resources, both abiotic and biotic. Examples are the Wildlife Restoration Act of 1937, which authorized the use of firearms tax revenues for wildlife conservation, and the Migratory Bird Conservation Act of 1929, which authorized the acquisition of migratory bird reservations. Notable during this period are the laws combining conservation projects with depression relief such as the Tennessee Valley Authority Act. There was also continuing activity on land use issues, especially grazing, during the period.

- **1948 to 1978**: The late 1940s and the 1950s saw the early versions of the major EPA antipollution acts (the Air Pollution Act and the Federal Water Pollution Control Act). These were amended at various times, notably in the 1970s. In addition, other antipollution laws (e.g., the Toxic Substances Control Act of 1976) and laws encouraging recycling of wastes (the Resource Conservation and Recovery Acts of 1970 and 1976) were passed during the period.

Numerous laws and treaties (one or more per year) were enacted for the protection of fish, birds, and other wildlife. One example is the Fish and Wildlife Act of 1956, which established a comprehensive national fish and wildlife program. Among other things, this program was to develop measures for maximum sustainable production of fish. Another example is the National Wildlife Refuge System Administration Act of 1966. This provided guidelines and directives for managing wildlife refuges, areas for protection of endangered fish and wildlife, waterfowl production areas, and similar refuges.

Ecosystem types specifically protected by laws during this period include wetlands (e.g., the Convention on Wetlands of International Importance as Waterfowl Habitats of 1972). These acts were primarily concerned with wetlands as waterfowl habitat. Coastal areas were the focus of acts in 1968, 1972, and 1976, which were designed to protect, preserve, develop, and restore the resources of the coastal zone.

Concern for recreational and historically important areas continued throughout the period, with the Wild and Scenic River Act of 1968 to preserve sections of selected river to protect their scenic value, the National Parks and Recreation Act of 1978 to provide for the acquisition and

management of areas with scenic and recreation value, and the Endangered American Wilderness Act of 1978 to preserve wild areas with outstanding natural characteristics, and various other acts concerning national parks and forests. The Federal Land Policy and Management Act of 1976 provided authority to manage Federal lands according to multiple use and sustained yield principles.

A new concept was introduced by the 1974 law establishing Big Cypress National Preserve in Florida. This law created a new category for preservation and protection of areas that are unique mainly for their flora and fauna, for the benefit of future generations. This represents a departure from the previous emphasis on scenic or recreational importance. Several other laws show a broader view of the value of natural resources:

- **The National Advisory Committee on Oceans and Atmosphere** (along with some endangered species treaties) showed a concern for global environmental issues.

- **The Endangered Species Act** (1973 and 1978) went beyond the concern for fish, birds, and other wildlife to encompass all plants and animals that are listed as threatened or endangered. It articulated a concern for species diversity rather than particular categories of species.

- **The National Environmental Policy Act** (1969) explicitly stated a policy of preserving the quality-of-life benefits of natural areas and resources for future generations. The regulations implementing this Act require that Federal agencies analyze the effects of their significant actions on components, structures, and functioning of affected ecosystems.

2.2. CURRENT POLICIES AND PRACTICES AT EPA

2.2.1. Past Review of EPA Programs

The 1994 report *Managing Ecological Risks at EPA* (U.S. EPA, 1994a) reviewed past Agency actions and summarized the ecological concerns historically considered in EPA decision making. Among the major findings:

- Animals (e.g., birds and fish) are more frequently assessed than plants. An exception to this rule is the Air Program.

- Except for endangered species, no case was found in which an individual nonhuman organism, or even a small number of individuals, was protected by a regulatory decision. However, effects somewhere between the individual and population levels, such as widespread mortality in fish or birds, were used as the basis for decisions.

- EPA pays considerable attention to protecting wetlands, estuaries, and large natural resources such as the Chesapeake Bay. However, only a few programs consider interactions occurring among animal and plant communities and their physical environment.

A summary table and more detail is provided in appendix B. Additional details may be found in the 1994 report.

2.2.2. Trends

Managing Ecological Risks at EPA was a snapshot of the whole Agency. Individual programs, however, are in very different stages of development in managing ecological risk. The two sections below look at the history of a program and a region to show how the management of ecological risks may change over time.

2.2.2.1. *Water Quality Criteria*

The Clean Water Act provides for the protection of aquatic life through the establishment of physical, chemical, and biological criteria.

For about 10 years after EPA was created, the Agency based its criteria on the same methodology that was used by the Department of the Interior. This approach focused on the direct, immediate effects of single chemicals, which meant, among other things, that the criteria were based on acute risk (mainly lethality) to various aquatic species (U.S. EPA, 1976).

In 1980, the Office of Water published new methods for setting criteria, including a provision for considering chronic effects (U.S. EPA, 1980). This approach takes a longer term view.

More recently, the Office of Water has expanded beyond these chemical-specific criteria to include whole-effluent testing (U.S. EPA, 1995c) and biological testing. Whole-effluent testing, for point sources, considers the combined effects of many chemicals that may be present. Biological Criteria directly measure attributes of the aquatic community and compare these measures to those of unimpaired waters (U.S. EPA, 1990b). Biological Criteria integrate the effects of multiple stressors of various types and their interaction. Both of these changes take a more holistic view of impacts on the aquatic community and allow consideration of complex interactions. Together they represent a large step toward an ecosystem approach.

The watershed protection approach (U.S. EPA, 1991b) goes even further: It uses an integrated and holistic strategy that focuses on a watershed rather than on specific sources or pollutants. As such, it encourages the consideration of cumulative chemical, physical, and biological effects throughout the watershed.

2.2.2.2. *Region I*

Some regions have also moved toward more holistic approaches for protecting the natural resources in their areas. The Resource Protection Project (Ueland et al., 1995) is a good example. Region I, in cooperation with State environmental agencies and the New England Interstate Water Pollution Control Commission, initiated this project in 1993 to help target the most important natural resources in each State and to promote an ecosystem approach to environmental protection. This is not a new regulatory program but an approach that uses existing regulatory programs to effectively protect valuable natural resources.

2.2.3. Other Policies and Practices

2.2.3.1. *Scientific Advisory Board Recommendations*

The 1990 report from EPA's Scientific Advisory Board, *Reducing Risk: Setting Priorities and Strategies for Environmental Protection* (U.S. EPA, 1990c), listed habitat alteration and loss of biological diversity among the high-risk problems. Although this report ranked risk rather than valued entities, this ranking does reflect a high value placed on habitat and biodiversity by the Scientific Advisory Board.

2.2.3.2. *EPA Goals and Milestones for the Year 2005*

The *Proposed Environmental Goals for America With Milestones for 2005* ("*Goals Report*," U.S. EPA, 1996b) has been developed to encourage innovation in improving the effectiveness and reducing the costs of environmental protection and to help EPA and other Federal agencies be more accountable for protecting the environment.

The quantitative benchmarks of the *Goals Report* go beyond the scope of this document. However, there is a connection to this document in the ecological resources that are targeted by these benchmarks. The *Goals Report* specifically mentions aquatic communities, regional populations of native species and their habitats, wetlands, ecosystem functions, endangered species, and endangered ecosystems such as old-growth forests and natural prairies. The proposed list of common entities in chapter 4 is consistent with the list of ecological resources targeted in the *Goals Report*.

2.2.3.3. *Community-Based Environmental Protection*

Recent EPA policies have called for holistic ecosystem protection in partnership with local communities and other agencies. The CBEP policy promotes an inclusive process to advance environmental results, with a clear emphasis on the protection of whole ecosystems (U.S. EPA, 1994b). EPA has adopted this new approach as a more effective way of protecting ecosystems than more fragmented media- or stressor-oriented approaches.

2.3. CURRENT PRACTICES AT OTHER AGENCIES

Appendix C reviews the current policies of Federal land and natural resource management agencies. The focus of concern for each of these agencies is obvious from their names. For example, the mission of the U.S. Fish and Wildlife Service (FWS) is "to conserve, protect and enhance the Nation's fish and wildlife and their habitat for the continuing benefit of the American people."

The agencies described in appendix C have modified their processes over the last 10 years to include greater stakeholder involvement and to consider a wider range of risks to resources along with sound watershed and habitat management practices. This process is generally known as ecosystem management.

An example of ecosystem management at the U.S. Forest Service is the Service's Northern Goshawk Guidelines. These guidelines will be used to develop national forest plans in the Service's southwestern region that will sustain goshawk populations and also benefit forest health, soil productivity, and the habitats of other old-growth-dependent plants and animals (CEQ, 1993, p. 19).

Another example of ecosystem management can be found in several agencies' implementation of the Endangered Species Act. The FWS and National Marine Fisheries Service (NMFS) have adopted a formal policy that incorporates ecosystem considerations into a variety of activities under the Endangered Species Act. For example, where appropriate, group listings are made on an ecosystem basis, recovery plans are developed for entire ecosystems inhabited by multiple-listed species, and consultation is carried out on an ecosystem basis (Interagency Ecosystem Management Task Force, 1995, Vol. II).

All of the agencies reviewed combine the concept of ecosystem integrity or sustainability with the mission of maintaining valued resources for human use. They recognize that real protection of the resources over the long run can be accomplished effectively and efficiently only by protecting the ecosystems on which these resources depend.

2.4. COMMUNITY- AND PLACE-BASED PROJECTS

Locally based projects are important sources of information both on the current status of ecological protection and, by inference, on what is valued.

The value of fish and wildlife is as obvious in these projects as elsewhere. For example, the EPA Ecosystem Protection Inventory (U.S. EPA, 1995b) shows that fish and fisheries figure in at least one project in each of EPA's 10 regions and figure in five or more projects in most regions. Comparative-risk projects tend to mention fish and wildlife and their habitats under both ecological and quality-of-life categories (U.S. EPA, 1993).

Aquatic ecosystems, and especially wetlands, tend to be frequent concerns. Endangered species or other biodiversity issues (such as the range of native species) are also frequent. Both the Wisconsin Tribes project (U.S. EPA, 1992b) and the Kahalu'u O'ahu, Hawai'i, project (University of Hawai'i at Manoa, 1992) include "respect for the land" or "respect for the earth" among their human welfare values.

Community-based projects are more likely than national projects to include specific religious or spiritual values. For example, the Wisconsin Tribes project values eagles for religious reasons.

2.5. OTHER INDICATIONS

2.5.1. The Interagency Ecosystem Approach

The Interagency Ecosystem Management Task Force was established in August 1993 to implement the mandate to adopt an ecosystem management approach throughout the Federal Government. The findings of this task force are presented in the three-volume report *The Ecosystem Approach: Healthy Ecosystems and Sustainable Economies* (Interagency Ecosystem Management Task Force, 1995). Although much of this report deals with the process of acting through partnerships, it also stresses the need to work on an ecosystem scale and sustain natural resources for future populations.

2.5.2. Public Opinion Research

There is some recent research (Kempton et al., 1996) to indicate that the American public understands that there are complex interrelationships between natural entities within ecosystems and that, consequently, stress to the environment can have unexpected and disastrous results. This same study shows wide support for preservation of species for reasons other than human utility.

2.6. CONCLUSIONS: SOME COMMON AREAS OF CONSIDERATION

2.6.1. Ecological Entities

Some inferences can be made about ecological entities that are clearly considered to be valuable from the discussion of laws and ecological protection efforts.

- **Fish, Birds, Other Wildlife, and Associated Ecosystems**: These entities are the subject of many Federal laws. They are routinely considered by both EPA and local projects. The associated ecosystems are given prominent attention in the new approaches recently adopted by the natural resource agencies.

- **Ecosystem Types and Services**: Many types of ecosystems are considered. The value of wetlands, for example, has become widely recognized in the last 20 years, and wetlands are considered by a number of Agency programs. In local projects, wetlands, stream corridors, forests, and other ecosystem types are frequently mentioned as important resources.

- **Special Places and Species**: Many of these are designated by Federal law. The Federal and State natural resource agencies have missions that usually involve the care of specific places, such as national parks. Local areas tend to focus on locally important places that may be important for ecological, recreational, aesthetic, or cultural reasons. EPA, other Federal agencies, and communities all focus on endangered species, which is a congressionally mandated concern.

2.6.2. Trends

The laws and examples of ecological protection also show some trends over time.

- **Toward a Larger Geographic Scale**: There is a clear trend toward looking at the larger geographic picture, including recent use of watershed and regional-scale assessments and the global effects of climate change.

- **Toward Taking a Longer Term View**: The chronology of Federal laws show a clear trend toward a longer term view. Early U.S. policies appeared to start out with little or no concern beyond immediate exploitation of natural resources. Many laws show that we have moved away from this view. No longer do we view our resources as unlimited. The desire to be able to pass on our natural heritage to future generations has increasingly formed the basis for environmental legislation. It is especially evident in the Endangered Species Act and the National Environmental Policy Act.

  In a slightly different sense, EPA programs have taken a longer term view by moving from immediate, urgent, and highly visible problems to those that are less visible right now but may have as large or even larger impact in the future. Water quality criteria illustrate this trend.

- **Toward an Ecosystem Approach**: Perhaps the clearest trend, especially in the last few years, is toward consideration of entire ecosystems, including cumulative effects of multiple stressors and complex interactions between individual components. This is mandated by the National Environmental Policy Act, shown in the latest actions of the Office of Water, and embodied in the policies of EPA and other Federal agencies and in the Interagency Task Force on Ecosystem Management. At least one recent study of public opinion shows that much of the public supports this trend (Kempton et al., 1996).

3. ECOLOGICAL INTEGRITY

As scientific and public understanding of ecological principles evolves, so, too, must the focus of ecological assessment and management. EPA is moving toward consideration of risk on larger scales of both geography and time than in the past. These trends show a consideration for ecological integrity and related ideas such as sustainability and resiliency. This approach puts specific organisms and resources in the context of what they need to survive in the long run. It also links valued components, services, special places, and what is needed to support them in the context of ecological protection. So maintaining ecosystem integrity is not an endpoint but a way to achieve environmental protection. It is the focus of many of our laws and how they are implemented. In this document, we approach the concept as a way to identify the interconnections between a particular component, service, or special place and its associated ecosystem.

We also encourage managers to adopt a long-term strategy and provide information that enables them to develop decisions that work not just until the next review or sampling round but for generations. Certain widely valued components, services, or other defined characteristics help focus ecological risk-management decisions. Yet if ecosystem integrity is not considered as a part of the goal, any protection offered may be only momentary or may require a drain on future resources in order to maintain it. Thus, decisions designed for long-term success are likely to be more cost-effective than those that provide immediate results but must be reevaluated and possibly reengineered every few years. Better long-term decisions are made when the concepts of ecological integrity, sustainability, resiliency, and biodiversity (described below) are considered.

3.1. ECOLOGICAL INTEGRITY[1]

Why consider ecological integrity? There is not much point in protecting, say, a particular animal without also protecting its food supply, shelter, and the area in which it searches for a mate: An animal deprived of food will starve, and one deprived of shelter will succumb to the elements or predation. Some animals can move to other areas, but they may face increased competition or have to survive with inferior resources. Plants, too, have individual requirements. Some have circumvented the issue of finding a mate by way of asexual reproduction, but they all live within specific nutrient, moisture, and sunlight constraints.

The goal of maintaining ecological integrity requires definition and measurement. Here we draw upon the Edgewater Consensus (U.S. EPA, 1994b), which defines *ecological integrity* as

[1]This chapter assumes some familiarity of ecological concepts and terms such as *ecosystem structure*. Several ecosystem concepts are defined in Appendix A.

"the interaction of the physical, chemical, and biological elements of an ecosystem in a manner that ensures the long-term health and sustainability of the ecosystem." It goes on to say that integrity can be evaluated by measuring organism health, species and community diversity, and ecosystem functions. The term *health* may not apply very well to ecosystems, but we have chosen this definition as one that was developed and adopted by consensus within the Agency for purposes of our discussion document.

Ecological integrity includes the system's ability to recover from stress and retain its distinctive characteristics. Forest regeneration after a fire is an example of recovery from a stress, but a clearcut replanted with a monoculture is not; even though the vegetation is replaced and soil erosion is checked, a single tree species cannot fulfill all of the functions of the variety of plants in the original forest. There are times when such a management decision is appropriate: The system may be more conveniently managed and yield more valuable timber. However, the ecosystem cannot function as it once did: its processes are simplified; "fail-safe" redundancies are eliminated; and many associated species are missing, with their roles in the ecosystem left unfilled. The monoculture probably will be more vulnerable to storm damage, fire, disease, and pest infestation than the original forest.

3.2. SUSTAINABILITY

Sustainability, a related ecological concept, is the ability of an ecosystem to support itself despite a continued harvest, removal, or loss of some sort. In managed forests, the harvest is balanced with tree growth in an effort to maintain continued wood or pulp production over time. NMFS uses fish reproduction, growth, and recruitment to determine allowable fish harvests. At a Superfund site, some inhibition of fish reproduction might be balanced against reductions in the fish populations that would otherwise occur due to competition for food. Pesticides are evaluated in terms of the benefits they provide as well as the risks they pose to the environments. Such an approach (risk-benefit balancing) could take into account the long-term effects of pesticide use on the sustainability of agricultural systems. So in general, the preferred goal would be something like "a self-sustaining fish population for the next 100 years" rather than "the fishery yield we want right now." It is not always possible to take such a long-term approach, but the most successful decisions will use it at least to some extent.

3.3. RESILIENCY

Another related ecological concept is *resiliency*, or the ability of an ecosystem to adapt to change (or stress). The change or stressed may be natural (e.g., flood, forest fire, pest infestation) or anthropogenic (e.g., commercial fishing, timber harvest, chemical releases). Note, however, that an altered system will not return exactly to its original prestress state. Resiliency also reflects

the system's adaptability in the face of changing conditions such as drought, temperature, and various organisms' population cycles. All organisms have adapted to stress from other species (such as feeding) and abiotic factors (such as storms or fire). But human activities tend to go beyond the range of natural stress and overcome ecosystem resilience. For example, although a forest may easily recover from patchy storm damage, it may take much longer to recover from a clear-cut timber harvest because the disturbed area has a very different microclimate and is too large to be effectively buffered by the remaining trees. Similarly, small fires leave mature trees blackened but not actually burned (and even encourage cones of certain species to open and release their seeds), while fire suppression efforts can result in a large accumulation of debris on the forest floor. This accumulation can fuel a large crown fire that consumes all trees as well as the soil's organic matter, leaving sterile soil without seeds or seed sources.

3.4. BIODIVERSITY

Norse (1990) describes *biodiversity* as "the variety of life on all levels of organization, represented by the number and relative frequencies of items (genes, organisms, and ecosystems)." He points out that biodiversity is not just a question of numbers but also of maintaining the integrity of the genetic mixture within populations, the richness of species within ecosystems, and a mix of ecosystems.

Biodiversity is also related to sustainability and resiliency in that an ecosystem with varied genetic makeup (e.g., one that contains more species and varied individuals within a species) may be better able to recover from disturbance than one with less genetic variation. Internal structural and functional redundancies mean that, although some individuals or species may be wiped out, others with somewhat different characteristics may be able to survive the shock and carry on the functions of the ecosystem.

Management decisions are most likely to succeed when they look beyond the entity and stressor of concern and consider potential impacts in a larger context. By considering ecosystem integrity, the manager can factor sustainability, resiliency, and biodiversity into the decision and ensure that it is not only practical but provides effective, comprehensive environmental protection over the long term.

3.5. ECOLOGICAL PROCESSES AND INTERACTIONS

There are a number of interactions and ecological processes that influence ecosystem integrity. Recognizing these ecological links by consulting with ecologists, or, better yet, performing ecological risk assessments according to a plan developed by the process described in chapter 5 will enable the manager to make a decision that better protects against unanticipated indirect effects. The following are a few examples.

- Effects on the population of one species may have drastic or detrimental effects on its predator or prey species. In addition, the impact on the first species or its associated predator or prey species could have a cascading effect on a number of other species in an ecosystem.

- Effects on environmental conditions (e.g., temperature, moisture, light) may exceed the tolerance range of species in the ecosystem.

- Disturbance of preserves or corridors between preserves could eliminate the areal extent and intermingling of reproductive individuals necessary for species to survive.

- The carrying capacity (number of individuals of one species that an area can support) of a habitat may be decreased by some indirect pathway—for example, by disruptions of soil quality caused by increased runoff due to an increase in impervious surfaces in a neighboring area.

3.6. HOW TO INCORPORATE ECOLOGICAL INTEGRITY INTO GOALS AND OBJECTIVES

How does all this apply to the role of decision makers in setting goals and objectives? The following three principles summarize much of what is stated above and provide a good start in making ecological integrity a part of the goal.

1. Take a longer viewpoint in setting goals—several generations rather than several years.

2. If possible, put the goal in terms of sustainability rather than immediate use. That is, make the goal "self-sustaining fish population for the next 100 years" rather than "the fishery yield we want right now."

3. Consult scientists about indirect effects and how the particular ecosystem or resource of concern relates to other ecosystems. Consider whether the goals ought to be modified in this light.

The next chapter discusses choosing the ecological entities to which these principles might apply.

4. ECOLOGICAL ENTITIES TO BE PROTECTED

In this chapter, we propose some general criteria for prioritizing valued entities and we apply these criteria to a proposed set of initial common entities to be considered in all Agency activities. These recommendations are intended to improve the Agency's consideration of ecological issues by helping EPA decision makers focus on valued ecological entities that are appropriate for their particular program or project.

4.1. SOME CRITERIA FOR PRIORITIZING ECOLOGICAL PROTECTION

Based on what we found in chapters 2 and 3, we propose four criteria. These criteria are then used to justify the eight entities proposed later in this chapter.

- **Mandated Protection**: We are required by law to protect entities such as endangered species. The section on EPA laws in chapter 2 describes some of these.

- **Other Societal Value**: Society values organisms, places, ecosystems, and their functions for commercial, recreational, spiritual, and other reasons. Previous sections on laws, current practice in EPA and Federal natural resource agencies, and community projects all provide examples of concerns that are highly valued.

- **Rare or Under Threat**: Some species of animals and plants, as well as some entire ecosystems, appear to be declining or are already so rare that it would not take much to eliminate them entirely. Alternatively, they may be threatened by some trend or development (not necessarily anything EPA controls). They need not appear on any official list to meet this criterion. An example is neotropical migrant birds: Although few of them are on the endangered species list, their populations appear to be diminishing and their habitats in both hemispheres are declining.

- **Ecological Significance**: This criterion includes organisms that help sustain the ecosystem. Plants and animals are considered ecologically important when they provide a significant food base, provide shelter for other species, promote regeneration of critical resources, or serve another important function of an ecosystem. Certain major categories of organisms and ecosystem processes are generally considered important to the ecosystem. They are often referred to as "keystone" species or functions.

4.2. SOME COMMONLY VALUED ECOLOGICAL ENTITIES

One of the recommendations of *Managing Ecological Risk* is that the Agency identify an initial common list of ecological concerns, or entities, to be considered in every EPA decision where relevant. Reaching consensus on such a list will require discussion within the Agency and some dialogue with partners and interested groups outside the Agency. As a start, however, we

propose eight ecological entities for this list. They are organized in broad categories to help decision makers go beyond the particular entities listed. Table 4-1 presents the categories, entities, and criteria by which the entities are valued.

Neither the individual entities nor the categories are mutually exclusive. For example, wetlands as habitat for waterfowl might be included in (2) regional populations of native species, (4) ecosystem functions and services, or (5) wetlands and stream corridors. Any specific local ecosystem could be considered as a habitat for some group of plants or animals, as a whole ecosystem or provider of services, or as a special place. The program or project goals determine which category is most appropriate.

We describe these entities broadly enough to cover a great deal. They do not, however, include everything worthy of protection. For example, local populations might be of concern for some programs or projects. Some EPA programs routinely include entities not on this list in their decisions; we expect this practice to continue whatever the final list. The common list should not inhibit any program or project from going beyond it.

The remainder of this chapter discusses each of the entities.

4.2.1. Animals, Plants, and Their Habitats

Chapter 2 demonstrated that many plants and animal are widely valued. In particular, native fish and wildlife and some plants are valued for reasons that range from the narrowly utilitarian to a belief that they have rights of their own.

However, much of EPA does not give the same consideration to habitats. To protect species at the population or community level, one must consider the integrity of the ecosystems that support them as well as direct threats to the plants or animals themselves. Otherwise, any gains made in protecting them from direct threat may be very short-lived.

Entity 1: Aquatic Communities in Lakes, Streams, and Estuaries

This entity focuses on aquatic plants and animals and the surface water habitats that support them. Depending on the nature of the program or project, the goal for protection could include the entire range of species (e.g., “protect 95 percent of the species”), one or more species that have particular social and ecological value (e.g., “maintain lake trout as the top predator”), or the community as a whole (e.g., “maintain a balance of species typical of an oligotrophic lake”). Attributes depend on the goals; table 4-1 provides two examples.

Table 4-1. Proposed List of Ecological Entities

Category	Ecological entity	Examples of attributes	Examples of objectives[a]	Criteria			
				Mandated	Societal value	Rare, under threat	Ecological significance
Animals, plants, and their habitats	1. Aquatic communities in lakes, streams, and estuaries	Survival, development, reproduction of aquatic species; habitat extent for key species	Protect 95 percent of aquatic species, or maintain population of a key species	Some (CWA)	High for fish and shellfish	Some	Relatively high
	2. Regional populations of native species and their habitats—terrestrial and aquatic	Survival and recruitment; habitat extent	Maintain viable regional population of native species; maintain or restore habitat for native species	Some in CAA, CWA	High for some	Some	High for some
	3. Groups of native or migratory species exposed to severe or acute threat	Survival without visible damage	Avoid widespread and recurring or massive die-offs	Some (e.g., Migratory Bird Treaty Act)	Usually high	Not usually	Varies, often unknown
Whole ecosystems	4. Ecosystem functions and services	Nutrient recycling, ability to filter pollutants, habitat extent for diversity of species	Maintain or restore function or service to some standard	Some general authority	Not always recognized	A few	Very high
	5. Wetlands and stream corridors	Extent	Maintain extent of wetland	Yes	High for many	Some	High

Table 4-1. Proposed List of Ecological Entities (Continued)

Category	Ecological entity	Examples of attributes	Examples of objectives[a]	Criteria			
				Mandated	Societal value	Rare, under threat	Ecological significance
Special places and species	6. Endangered ecosystems (e.g., old-growth forests, tall-grass prairies)	Extent	Maintain extent of endangered ecosystem types	Some	High for some	All	Important for biodiversity
	7. Endangered species and their habitats	Survival, development, reproduction, and recruitment	Maintain and restore populations	Yes	Potential for some	High	Usually low
	8. Other places[b] with high ecological or societal value, as appropriate	Species diversity; nutrient levels, etc., appropriate to the type of ecosystem; landscape measures	Restore biodiversity, maintain as oligotrophic[c] lake, maintain extent of certain habitat	Some (e.g., Great Waters by CAA)	High for many	Some	High for many

[a]In this document, the term *objective* is used to refer to a specific objective for an ecological entity. See glossary.

[b]Special places do not necessarily fit the definition of entity used in the *Proposed Guidelines for Ecological Risk Assessment* (U.S. EPA, 1996c). See glossary.

[c]An oligotrophic lake is one with low nutrient and high oxygen levels.

Note: CAA = Clean Air Act; CWA = Clean Water Act.

This entity ranks high on most of the criteria. The Clean Water Act mandates water quality that supports a "balanced indigenous population of fish, shellfish, and wildlife." Because other parts of the aquatic community are needed to support fish and shellfish, this in effect mandates the protection of aquatic communities.

Chapter 2 points out that many aquatic species are highly valued. Many fish and shellfish have commercial as well as recreational value. Fish are considered by virtually every EPA program and by many community environmental protection projects. Although it is not clear that the entire aquatic community is always considered, protecting the community must be a part of the action if it is to be effective in protecting fish populations.

Some aquatic habitats are rare or under threat. Although pollution from point sources has been greatly reduced since EPA was established, nonpoint sources still pose a problem. States have reported that only about half the assessed miles of river were found to have healthy communities (U.S. EPA, 1996b).

This entity also ranks very high in ecological importance. Because it includes all members of the aquatic community, it necessarily includes those that are most important to the ecosystem.

Entity 2: Regional Populations of Native Species and Their Habitats—Terrestrial and Aquatic

This entity targets native plants and animals at the regional population level, together with the habitats necessary to support them. At least some of the species or their habitats rank high on each of the four criteria.

Many Federal laws were promulgated to protect populations of native species, especially wildlife, and their habitats. Among the laws governing EPA actions, the Clean Air Act and Clean Water Act have provisions that focus on wildlife or aquatic species and their habitats.

This targeting of native species indicates their high societal value. In addition, many laws focus on natural areas as habitat. EPA and other Federal agencies already protect populations of native species, as do local community projects. In the case of EPA actions, it is not always clear that the efforts extended to habitats; however, as with the aquatic species in entity 1, protection of the habitat is essential to protection of the population.

Many of these species and their habitats are declining or under threat, in addition to those designated as endangered (see entity 7). Two examples are many bird species, especially among the warblers and waterfowl, and most amphibians. Habitat examples are large forests, grasslands, and wetlands.

Some of the species considered here are, by themselves, important to the ecosystem by virtue of their role as prey or predator, for example. Because this entity includes not only the

particular species but also its habitat with all its biotic and abiotic components, this entity is critical to the ecosystem.

Entity 3: Native or Migratory Species Exposed to Severe or Acute Threat

The purpose of targeting this entity is to avoid large acute incidents to fish, wildlife, or plants, such as massive fish or bird kills. It may be focused below the population or community level. However, except in the case of endangered species (see entity 7), it does not protect single individuals but rather large numbers of individuals.

There are mandates for some members of this group. For example, the Migratory Bird Treaty Act, the Bald Eagle Act, and others prohibit the killing of many bird species except under permit for specified reasons.

Most of the animals and plants likely to be covered here are highly valued. These species are also protected by other Federal agencies and community projects. These species and the avoidance of large-scale incidents have been the focus of past EPA actions.

The pesticide diazinon provides legal precedent for this entity. The U.S. Court of Appeals Fifth Circuit upheld EPA's finding that recurring bird kills are an unreasonable environmental risk, regardless of any population effect. Following this finding, the Administrator's final decision to cancel diazinon determined that "as a matter of policy an unnecessary risk of regularly repeated bird kills will not be tolerated" (U.S. EPA, 1990d).

Some of the species in this category are rare and under threat, although for obvious reasons one would not expect a rare species to appear in large numbers in a major incident. The examples of rare or declining species given for entity 2 also fit this category.

Because these incidents are usually evaluated on an individual basis, the actual degree of ecosystem impact may not be known. However, in at least some cases, it seems likely that a stressor causing such devastating effects on large plants or animals will also have some wider ecosystem effects.

This entity targets regional populations for Agencywide consideration, similar to the National Goals Project (U.S. EPA, 1996b), which also mentions regional populations of native species. However, specific programs and projects may go beyond this.

4.2.2. Whole Ecosystems

This category includes ecosystems as a whole. Associated goals are to maintain their geographic extent or special character or to preserve their value for providing certain services to humans or other ecosystems. The goals focus on the movement of energy and matter through the ecosystem, in processes such as nutrient cycling, rather than on specific components.

Entity 4: Ecosystem Functions and Services

Ecosystem functions result from ecosystem processes (see appendix A). Ecosystem services are those ecosystem functions perceived as beneficial to society. Both are included in this category because some functions that are not immediately perceived as beneficial may turn out to be of great ecological value and, ultimately, of indirect societal value, as well.

Services and functions of wetlands are discussed in the next section. Services and functions of other ecosystems to consider are nutrient cycling (all ecosystems), maintenance of air quality by absorbing and breaking down pollutants (many ecosystems), climate control (forests and others), flood control (stream corridors), generation and maintenance of soils (many heavily vegetated terrestrial ecosystems), pest and disease control (prairies), pollination (prairies), and provision of biodiversity (many ecosystems, and also diversity in ecosystem types).

Although few specific functions are mentioned in the laws reviewed in chapter 2, many laws mention types of ecosystems and/or the interactions of ecosystem components.

The value of entities in this category may not always be appreciated. However, the value of services is increasingly being recognized by the public, as illustrated by the new understanding of wetlands. In addition to wetlands, ecosystems such as forests, stream corridors, and many aquatic ecosystems are targeted for protection by law or by Federal and local protection projects. The service most often mentioned in these projects is biodiversity, but others such as flood control are also mentioned.

Some ecosystems are rare or disappearing. Those considered endangered are included in entity 6.

Many functions of ecosystems have great ecological value. By, for example, helping to provide clean air and water, they benefit other ecosystems, as well as benefiting humans directly. Ultimately, the continued existence of all valued components depends on the continuation of critical functions. Their benefit to human welfare is greater than is yet commonly recognized. As Westman (1977) described these benefits, ecosystem services "maintain clean air, pure water, a green earth, and a balance of creatures: the functions that enable humans to obtain the food, fiber, energy, and other material needs for survival."

Entity 5: Wetlands and Stream Corridors

This entity includes the protection of wetland and stream corridor extent and functions. Some functions to consider (U.S. EPA, 1990b) are:

- Water-supply services
- Floodwater regulation
- Shoreline anchoring and erosion control
- Water purification

- Habitat provision for biodiversity.

Most of the discussion below is about wetlands. Stream corridors are included with wetlands because many of their functions are similar (e.g., flood and erosion control) and because they are similarly located in many cases.

Protection of wetlands is mandated by the Clean Water Act and other laws, as discussed in chapter 2.

The societal value of wetlands has been increasingly recognized over the past couple of decades. No longer are they thought of as mosquito-ridden swamps; instead, they are valued for the various functions and services they provide. As pointed out in chapter 2, wetlands are considered by many Agency programs and local environmental protection projects.

Wetlands are under threat in that they have been declining for many years. An estimated 53 percent of wetlands in the continental United States have been lost since colonial times (U.S. EPA, 1996b).

Wetlands have high ecological value, for many of the same reasons cited in the previous section on ecosystem functions and services. In particular, wetlands help maintain biodiversity. Almost 35 percent of all rare and endangered animal species are either located in wetland areas or depend on them, even though wetlands constitute only about 5 percent of the Nation's lands (Conservation Foundation, 1988).

4.2.3. Special Places and Species

One category specifically mentioned in *Managing Ecological Risks at EPA* (U.S. EPA, 1994a) is specific geographic places of special interest because of their unique character or contribution to America's natural resources. Their importance is reflected both in the laws, which set aside many of these places to be maintained as important natural areas, and in many local or community-based projects, which target rare or unique natural areas for special consideration in environmental protection efforts.

There are at least two ways in which risk managers can afford special treatment to certain places. First, they can be given high priority for ecosystem protection. Second, they can be considered for a higher degree of protection than other places or species.

The special character of the place needs to be carefully and explicitly defined so that it is clear just what is being protected. Many places are considered special because they provide habitat for rare species or for biological diversity (e.g., National Wildlife Refuges). Others are noted for characteristics of the ecosystem as a whole (endangered ecosystems). Still others are valued for their aesthetic qualities or because they are among the few relatively pristine ecosystems of a particular type (e.g., National Wilderness Areas).

Similarly, certain species may be considered special for different reasons. Endangered species are the best-known example, but others may be singled out for religious or cultural reasons or because of their ecological importance.

Entity 6: Endangered Ecosystems

Endangered ecosystems are among those places most urgently in need of special protection. They include ecosystems listed by the National Biological Survey (NBS) as critically endangered, endangered, or threatened (Noss et al., 1995). Some of these listings are fairly generic (old-growth and other virgin forests in the United States, except Alaska); others are geographically very specific (Hempstead Plains grasslands on Long Island, New York). The list includes 30 critically endangered, 58 endangered, and more than 38 threatened ecosystems.

Many portions of these ecosystems are protected under the Endangered Species Act as habitat for listed species. For example, the NBS report listed more than 100 candidate, proposed, or listed species associated with just one of the listed ecosystems (long-leaf pine or wiregrass communities in the southern coastal plain).

There is little question about the rarity of these ecosystems. The NBS report estimates that from 70 percent to 99.9 percent of the listed ecosystems have been lost since European settlement. Many are now represented only in very small areas. These areas are ecologically important for the contribution to biodiversity. They support not only endangered species, but also those that are rare, declining, and unlikely to survive without the specific types of ecosystems upon which they depend.

Federal laws and past actions at both the Federal and community levels show that a high value is placed on protecting rare natural areas for future generations. Protecting ecosystems is also an efficient way of preserving highly valued species.

Entity 7: Endangered Species and Their Habitats

Included in this entity are all species that are federally listed as endangered or threatened and their habitats. Protection of these species is mandated under the Endangered Species Act.

Endangered species have been the focus of many Federal and local environmental protection efforts. This is one of the entities that nearly every EPA program already includes in its activities. From this and its inclusion in Federal law, it can be inferred to be of high societal value. Every species listed here is both rare and under threat; this is the qualification for inclusion.

By the time a species has made the Federal endangered or threatened list, the population is so small that its role in the ecosystem may have been largely lost. However, biodiversity, which is the goal of endangered species protection, has great ecological importance.

Entity 8: Other Places of High Ecological or Societal Value, as Appropriate

Many places that are not considered endangered or threatened are of special importance nonetheless. These should be considered by decision makers as appropriate to the program or project being considered. They may be particularly important for CBEP initiatives. Although we do not here propose a definitive list of places for Agencywide use, there are examples to consider.

A nationwide list of special places has already been compiled in *Targeting Priority Natural Resource Areas: A Review of National Lists* (U.S. EPA, 1991a). A summary of this list is provided in the appendix E.

Some programs provide special consideration for special places. For example, Superfund has regulations assigning point values, used for prioritization, to certain sensitive environments, such as marine sanctuaries and national parks. Both of these are included in the *Review of National Lists* (U.S. EPA, 1991a). Another example comes from EPA's Office of Air: The Great Waters Program conducts special monitoring and evaluation for the Great Lakes, Chesapeake Bay, and other bodies of water designated by Congress.

Some of these nonendangered special places are mandated for special consideration in EPA legislation, such as the Great Waters mentioned above. Many others have been set aside by Congress, such as national parks and national wildlife refuges. Some EPA programs, such as the Air Office and Superfund mentioned above, already give special consideration to specific places, and they are considered by many local projects. This attention indicates the high societal value of these places.

Although most of these places are not considered endangered or threatened ecosystems, many are considered rare and under some threat from development or pollution. The Nature Conservancy's "Last Great Places" provides examples of these. They are listed in the *Review of National Lists* (U.S. EPA, 1991a).

Many places are considered to have great ecological importance. Ecological importance was the basis for the *Review of National Lists* (U.S. EPA, 1991a).

To direct assessment and action for a program or project, these entities should lead to specific objectives. The next chapter provides some advice on how to go about setting these objectives.

5. PRACTICAL ADVICE

This chapter describes how the ecological entities and criteria recommended in the last chapter can be used in conjunction with ecological risk assessment, risk-based national program decisions, and CBEP. In either case, decisions makers have the important task of setting specific measurable objectives. The processes outlined in this chapter are focused on that task. A detailed example is provided to illustrate the processes.

5.1. ECOLOGICAL RISK ASSESSMENT

This section explores the relationship between risk assessment and the entities to be protected. We use definitions from EPA's *Framework for Ecological Risk Assessment* (*Framework*, U.S. EPA, 1992a) and the *Proposed Guidelines for Ecological Risk Assessment* (*Guidelines*, U.S. EPA, 1996c). Terms in the *Guidelines* and *Framework* are defined, and examples are given to illustrate the terms.

Ecological risk assessment is a process that evaluates the likelihood that adverse ecological effects may occur or are occurring as a result of exposure to one or more stressors. The risk may be expressed in a variety of ways, both quantitative and qualitative. The *Framework* sets out the basic structure and principles of ecological risk assessment at EPA.

Ecological risk assessment can evaluate risk to a single species, as well as to natural communities and whole ecosystems. Stressors can be single or multiple chemicals, biological agents, or physical disturbance. A risk assessment may be initiated because of a particular stressor (e.g., a chemical or biological pesticide) or source of stressors (e.g., a toxic waste site), by some observed ecological effects (e.g., large bird or fish die-offs), or by a valued resource that seems to be in danger of deteriorating.

Although ecological risk assessment is not always required for decision making, it can help identify environmental problems, establish priorities, and provide a scientific basis for decisions. The process can identify existing risks or forecast the risk of stressors not yet present in the environment.

Risk management evaluates the advantages and disadvantages of a particular action in the context of such factors as risk assessment information, regulatory setting, practicality, political climate, resource constraints, and the manager's own experience. Both the *Framework* and *Guidelines* stress the involvement of managers to ensure that the manager understands the intent of the analysis and that the final assessment provides information that truly supports the decision to be made. Risk managers can get the most out of risk assessment and forge a good working relationship with risk assessors by actively participating in the planning stages.

At EPA, ecological risk assessments may support management decisions by, for example, predicting the risks of a new chemical intended for use in manufacturing, evaluating the risks associated with pesticides that are intentionally released into the environment, weighing the risks of multiple stressors in watersheds, evaluating the need for air quality standards, or determining risks of chemicals at hazardous waste sites. Because some people define "risk assessment" more narrowly than we do here, it is possible that some Agency decision makers use risk assessment in some form as a part of their decision making without recognizing it as such. For example, a qualitative evaluation of the likely effects of an exotic species or continued residential development on a lake ecosystem can be a risk assessment even though it is neither quantitative nor dealing with a specific chemical.

The potential complexities of an ecological risk assessment demand careful planning for its design. Many of the complexities differ from those of human-health assessments and include deciding what species, populations, ecosystems, or functions are most relevant; species interactions and indirect effects; and the significance of nonchemical stressors.

The risk assessment process outlined in the *Framework* provides a way to develop a logical, sequential approach to solving this complex problem.

The parts of the process most relevant to this discussion document are planning and problem formulation, which are the first phases of ecological risk assessment and establish the goals, objectives, breadth, and focus of the assessment. They are systematic planning steps that identify the major factors to be considered in a particular assessment, and they are linked to the regulatory and policy context of the assessment.

The most important part of the risk manager's job at these stages is to set specific objectives for the program. The next section provides some concrete steps to accomplish this by using the entities listed in the previous chapter.

5.2. APPLICATION TO NATIONAL PROGRAMS' RISK-BASED DECISIONS

Most EPA programs make at least some risk management decisions at a national level. These decisions focus on criteria, licensing, cleanup, or other regulatory decisions made by EPA, although they may include partnerships or community involvement. Regardless of the focus, the process for these programs is generally laid out in the *Framework*.

Planning and problem formulation can be done on a case-by-case basis, but it is usually more practical for national programs to plan generically and develop standardized procedures and methods for dealing with individual cases. The national program needs to consider both what is appropriate to the program's functions (e.g., clean up Superfund sites, set water quality criteria) and their ecological goals and objectives. There is usually no question about the program's

function, but objectives more specific than "protect the environment" usually require considerable thought. Valued ecological entities are considered during this problem formulation phase.

The following steps detail one way to plan and formulate the problem of a risk assessment of national scope.

1. Identify the Problem: Basically, this means stating why you are doing this assessment. Is it based on a stressor (e.g., for a pesticide registration), a source (e.g., a Superfund site), or a resource (e.g., the Great Waters Program of the Air Office)? Under what mandates or restrictions do you operate?

2. Review the Categories and Particular Ecological Entities: These are listed in chapter 4. What entities on this proposed list of common entities, or other entities suggested by the categories, are susceptible to your stressor or otherwise relevant to your problem? This step needs to be done with the help of the risk assessors, who can provide information on susceptibility to the stressor. At the conclusion of this step, you will have a list of ecological entities that are relevant to your problem.

3. Meet With the Risk Assessors and the Public: The purpose of this step is to determine the societal value and ecological relevance of each of the entities you identified in step 2. The risk assessors are responsible for determining the ecological relevance and you (and the public or your partners, as appropriate) are responsible for determining the societal value. Although you can meet separately with the public and the risk assessors, it is beneficial to meet with them together so that the connection between societal value and ecological relevance can be discussed. For example, in the Waquoit Bay watershed assessment (discussed later in this chapter), it was clear that scallops and fish had high societal value. Eel grass was not initially perceived to be of such great value, but its importance to the development of the scallops and fish led to its being included in the risk assessment. A meeting with risk managers, assessors, and the interested public facilitates discussion of such connections.

4. Set Environmental Protection Goals and Objectives: Using the information from the first three steps, set your environmental goals and objectives for the assessment. As illustrated in tables 4-1 and 5-1, these objectives should include what you are doing (e.g., protecting, maintaining, restoring), the resource or entity under consideration (general or specific animals, plants, or ecosystems), and the desired state for that entity (e.g., maintain a population at its current level, restore a function to a specific past state, no unreasonable risk). Although the

"desired state" implies a level of protection, the examples show that this need not be quantitative or even based on risk to ecological entities alone. The pesticide example of avoiding unreasonable risk (discussed below) is one that is based on balancing the risk against the benefits that pesticide use provides to agriculture. While you are setting objectives, consider how to incorporate ecosystem integrity. Can you take a longer view? Be more geographically expansive? Specifically include sustainability? It is important to write the objective as explicitly as possible, even if you believe your program has been working toward this objective for many years. Sometimes things are not as clear as they seem; for example, is the program really concerned with the entire aquatic community? Or are fish really the concerns and the other measures important because they affect fish? If the objectives are specific enough, the remaining steps can be completed by the risk assessors without the close involvement of risk managers. However, it is useful for all concerned, including risk managers, to review and understand each of the steps listed below.

5. Set Assessment Endpoints: As defined in the glossary, an assessment endpoint is some particular attribute of the ecological entity that will be the focus of the protection effort. Assessment endpoints should be susceptible to the stressor, have societal value, and have ecological relevance (U.S. EPA, 1992a). These three criteria were explicitly considered in steps 1-3. If the objectives are specific, they will contain enough guidance on societal value so that the risk assessors can complete this step without further guidance from risk managers.

6. Review and Understand the Conceptual Model: Work through the conceptual model (see glossary for definition) for the assessment with the risk assessors. Make sure that there is general understanding about the relationship between the objectives, the assessment endpoints, and the measures of effect. Do some changes need to be made to ensure that the objectives are addressed? This is also a good time to explicitly identify all of the regulatory questions, the degree of certainty required, and other issues important to the assessment (see U.S. EPA, 1996c, for more on this step).

7. Document the Analysis Plan: The analysis plan delineates the assessment design. This includes identifying gaps and limitations. Are there aspects (entities, sources, or stressors) important to the goal that are impossible to address properly for scientific or other reasons? If so, these barriers should be explicitly discussed in all documentation of the process and a plan for overcoming them should be implemented. The documentation should include explicit relationships between the overall goal, the objectives, the assessment endpoints, the conceptual model, and the analysis plan.

5.2.1. Some Examples

Table 5-1 provides some brief examples. One of these (Waquoit Bay) is described in more detail in section 5.4.

In table 5-1, the first column simply identifies the source of the example, a national or international program in some cases, a special local or regional project in others. The second column identifies the *ecological entity* to be protected in this example. Each of these entities is included in one or more of the eight entities listed in chapter 4, but most of the entities in the table are more specific than the listings in chapter 4. The entity listed may be only one of many entities for a given program or project. These examples are for illustration only; no attempt is made to describe any program in its entirety. The next column is a short summary of the *objective* for that particular entity, as implied or stated by the program or project. The *assessment endpoints* describe the particular attributes of the entity that is to be protected (see glossary), and are based on the objective. Finally, the *measures of effect* are the measures used to evaluate the condition or response of the assessment endpoint. All of the just-mentioned terms are defined in the glossary.

Iteration of Steps

The steps listed for both national programs and CBEP are suggestions. Although some steps clearly need to come before others, there is much flexibility in their order.

In addition, some iteration is usually necessary. For example, in the national program case, risk assessors must have at least a general conceptual model in mind before they can say which entities may be susceptible to a stressor in step 2.

Later, in step 6, they work out the model more explicitly. At this point, they may discover something that was not considered in step 2 and need to revisit that step. In CBEP, the interested public may change during the course of the planning stage, requiring an early step to be revisited.

5.3. CBEP PROJECTS

The CBEP approach is introduced in chapter 2. CBEP projects are usually driven not by a particular stressor or medium, but by the valued resources in a particular area. These projects involve working in partnership with local and State organizations and working closely with the public.

The following steps detail one way to plan a CBEP risk assessment.

1. Identify the Problem: This includes clearly identifying the sources of information (e.g., citizen complaints, ambient monitoring results) that make the Agency aware of the potential problem.

Table 5-1. Some Examples of Ecological Entities and Assessment Endpoints

Source of example	Ecological entity	Objective for entity	Assessment endpoints	Measures of effect
Water Quality Criteria (U.S. EPA, 1996c)	Aquatic communities	Protect 95 percent of aquatic species	Survival, development, and reproduction of fish, aquatic invertebrates, and plants	Lab data on mortality and reproduction
U.S. pesticide registration[a]	North American native and migratory birds	No unreasonable effects on bird survival or maintenance of bird populations	Survival, development, and reproduction of birds	Lab data on mortality and reproduction; field observations of bird kills
EPA wetlands program	Wetlands and their services	No net loss of wetlands	Extent of wetland	Extent of wetland plants and soil
Superfund (one of several entities)	Fish populations	Minimize ecologically significant impacts on fish	Survival and reproduction of fish	Lab data on mortality growth and reproduction
Great Lakes initiative (Ryder and Edwards, 1985)	Lake Superior, oligotrophic[b] lake, lake trout	Maintain as oligotrophic lake with lake trout as top predator	Lake trout abundance	(partial list) Average age and size; percentage of fishing harvest
Lake Washington (Edmundson, 1991)	Clarity and appearance of Lake Washington	Restore, maintain water clarity	Depth of visibility	Depth a white disc can be seen
Waquoit Bay watershed[a] (U.S. EPA, 1996d)	Scallops and their estuarine ecosystems	Reestablish a self-sustaining scallop population that can support a viable fishery	Abundance and distribution of eel grass habitat; diversity, abundance, and distribution of benthic invertebrates	Eel grass (percent cover and distribution); benthic index

Table 5-1. Some Examples of Ecological Entities and Assessment Endpoints (Continued)

Source of example	Ecological entity	Objective for entity	Assessment endpoints	Measures of effect
U.S. Forest Service northern goshawk guidelines (CEQ, 1993)	Northern goshawk and its old-growth habitat	Sustain goshawk population and benefit old-growth habitat	Goshawk abundance and several habitat attributes	Measures of abundance and habitat for goshawks and prey
European Pesticide Registration (one of several entities)	Soil communities	Protect soil community to maintain soil fertility	Survival and reproduction of soil invertebrates and plants	Lab data on mortality and reproduction
Hubbard Brook National Experimental Forest (N.Y. Times, 1996)	Forest plants	Maintain plant abundance	Plant abundance, soil nutrients	Total plant biomass, soil calcium level

[a]The entity described is only one of several entities targeted by the program.

[b]An oligotrophic lake is one with low nutrient and high oxygen levels.

2. Form Partnerships; Bring in the Public: First, contact State and local agencies and involve them in the next decision-making step. Then, identify and contact all stakeholders who may become a part of the CBEP effort. Finally, convene a meeting for all to explain and discuss the problem and the CBEP process.

3. Establish the Boundaries: What are the geographic limits for the project? These may be political or natural boundaries. They need to be broad enough to encompass all influential factors but narrow enough to retain the focus of the effort.

4. Inventory the Resources: What are the ecosystems within the area? What makes them unique? What is the connection between organisms? Where is the energy flow? This results in a list of potential entities. The proposed list in chapter 4 can be useful in making sure that everything is considered, but the list for the individual project must include the resources in the area concerned and may go well beyond what is listed in chapter 4.

5. List the Local Values: The values and criteria that are most important to a community-based project are those of the people in the area. However, the organizers should help the public consider the variety of resources that might be important to them, as well as understand the connections between the resources they value and others that may not be publicly recognized (e.g., the eel grass in the Waquoit Bay project).

6. Establish Goals and Objectives: Goals and objectives should be based on the information gathered in steps 4 and 5 and should reflect the societal values of the partners and public. Objectives should be explicit enough so that it will be possible to devise measures of them that retain the societal values.

7. Plan Analysis: This can follow the risk paradigm as listed in steps 5-7 for national programs or some other process. In either case, the relationship between the goals and objectives and the results of the analyses must be clear, unambiguous, and explicitly documented. More detailed guidance for conducting these projects is available from the comparative-risk projects (U.S. EPA, 1993). Soon there will also be guidance available from watershed case studies, regional initiatives, and the CBEP Handbook being prepared by the Office of Sustainable Ecosystems and Communities in the Office of Policy, Planning, and Evaluation.

5.4. WAQUOIT BAY

The Waquoit Bay Watershed Ecological Risk Assessment Case Study is one of five watershed case studies sponsored jointly by the Office of Water and the Office of Research and Development. These case studies are designed to demonstrate the ecological risk assessment process in a community setting; therefore, the Waquoit Bay experience combines many features of both the risk-based national-program approach and CBEP. A brief summary of Waquoit Bay planning and problem formulation is given here. More detail is available in the case-study report (U.S. EPA, 1996d).

1. The Problem (corresponds to step 1 for both the national programs and CBEP): Waquoit Bay, on Cape Cod, has long been prized for its natural beauty and recreational value and as a habitat for a diversity of plant and animal life. Lately it has been under heavy pressure from residential development and recreational industries. Fish kills are occurring; scallops no longer inhabit the bay; the groundwater aquifer underlying the watershed is contaminated. There is a high level of public concern. Several Federal and State government agencies are studying or working in the area.

2. Relevant Ecological Entities (corresponds to step 2 for national programs and steps 2-4 for CBEP): A State-Federal group, including EPA's Region I, called the Waquoit Bay National Estuarine Research Reserve initiated the study and established risk management and risk assessment teams of individuals from many interested organizations. The boundaries of the watershed and the inventory of potentially threatened ecological resources were summarized from existing information. The summary emphasizes the diversity of species that are or have been supported by the watershed's varied surface water systems.

3. Goals and Objectives Based on Societal Values (covers steps 3 and 4 for national programs and steps 5 and 6 for CBEP): The first step in establishing a goal was a public meeting at which people were asked for their input on what was valuable to the public about the Waquoit Bay watershed. A wide range of amenities were suggested, including scenic views, recreation, and open space. Among those that would be considered ecological (i.e., they include some nonhuman biological component), aquatic and wildlife habitats were the most frequently mentioned. Examples were indigenous wildlife, flyway integrity, and fish and shellfish.

The following overall goal was based on the results of this meeting:

"Reestablish and maintain water quality and habitat conditions in Waquoit Bay and associated wetlands, freshwater rivers, and ponds to (1) support diverse, self-sustaining

commercial, recreational, and native fish and shellfish populations and (2) reverse ongoing degradation of ecological resources in the watershed." (U.S. EPA, 1996d)

Note that this goal explicitly includes sustainability.

Because this goal by itself was considered too general to serve as a basis for setting assessment endpoints, 10 more specific objectives were also established. These were based on the goals of 14 organizations working in the area. Four of these objectives dealt with estuarine areas, three with freshwater areas, and three with both. Most of the objectives targeted entities that would be included in common ecological entity 1 from chapter 4, "Aquatic Communities in Lakes, Streams, and Estuaries." An example is one of those concerning estuarine areas: "Reestablish a self-sustaining scallop population that can support a viable fishery."

The entities that form the focus of these objectives are evidently based on concern for particular groups of plants and animals, but the objectives do not focus on these alone. Most types of aquatic ecosystems are included in the objectives, as are wetlands (for the water-dependent wildlife). Special places are represented by the endangered species habitat and, indeed, by the bay itself.

The risk assessment team developed these more specific objectives, which were then reviewed and approved by the risk managers.

4. Assessment Endpoints (corresponds to step 5 for national programs and step 7 for CBEP): Eight assessment endpoints were selected based on three criteria: how well they represent the management goal and objectives (societal value), how well they represent ecological integrity in the ecosystem (ecological relevance), and how likely they are to be exposed to and adversely affected by known stressors (susceptibility).

The risk assessment team for Waquoit Bay selected assessment endpoints using the 10 specific objectives discussed above to guide them on what was of societal value; therefore, the risk management team did not need to be so closely involved with this step as with previous steps. Ecological relevance and susceptibility were evaluated based on available information on the ecosystems and known and predicted stressors. The Waquoit Bay problem formulation report provides a complete justification of each of the eight assessment endpoints in terms of these three criteria.

The assessment endpoints can be illustrated by the two that relate most directly to the "reestablish scallops" objective stated above. They are the abundance and distribution of eel grass habitat and the diversity, abundance, and distribution of clams and other benthic invertebrates. Although scallops are the focus, they were not explicitly made an assessment endpoint. Their

numbers fluctuate so widely in nature that their absence cannot be interpreted to mean that their environmental requirements are not being met.

5. Conceptual Model (corresponds to step 6 for national programs and step 8 for CBEP): The conceptual model for Waquoit Bay describes the relationship of various sources and stressors to each of the eight assessment endpoints. It also indicates what measures of effect will be used for each assessment endpoint.

For example, the abundance and distribution of eel grass can be affected by toxic chemicals, disease, nutrients, suspended sediments, and physical alteration of its habitat. These stressors in turn can come from various sources. For example, toxic chemicals are released from industrial, agricultural, and residential sources.

The Waquoit Bay problem formulation diagrams and discusses the overall relationship of sources, stressors, assessment endpoints, and measures. It also provides detailed diagrams and discussions for some of the assessment endpoints; others are under development (U.S. EPA, 1996d).

6. Analysis Plan, Including Limitations (corresponds to step 7 for national programs and step 9 for CBEP): The Waquoit Bay risk assessment will not be able to assess most of the risk paths laid out in the conceptual model because the resources for the analysis are extremely limited. The analysis will concentrate on nutrient loading, which is thought to be the most important stressor for most of the assessment endpoints.

The Waquoit Bay problem formulation provides a thorough justification of this choice. It also gives considerable detail about the stressors and risk hypotheses. These will not be included in the analysis plan but should be completed at some time.

6. NEXT STEPS

Since it was formed after the first Earth Day in 1970, EPA has made a great deal of progress in addressing environmental concerns. As we have discussed, EPA initially focused most of its efforts on protecting human health, but we are expanding our efforts to protect ecological concerns. Many EPA decision makers have made an effort to consider ecological concerns in the decision-making process and would like to expand their efforts. Others have not considered ecological concerns in the past, but are interested in expanding their decision making. We support the efforts of all of these risk managers and hope that this document will not only initiate discussion on the topic, but encourage more managers to consider ecological issues.

In this discussion document, we have reviewed Federal laws and environmental protection actions to determine common values and trends, encouraged consideration of ecosystem integrity, made recommendations for decisions makers who are setting ecological objectives for their programs or projects, and proposed processes for setting those objectives. We hope that the recommendations will lead to agreement on the entities that should be considered in all Agency activities and on other principles of ecological protection.

A common list of entities and ecological principles for the entire Agency can provide many advantages: It can promote consistency among our programs, make our actions more understandable to the public, provide structure for those programs that do not yet have much experience with ecological risk, aid in research planning, and focus risk-communication efforts.

A workshop held in July 1996 concluded that one of the most important barriers to including ecological endpoints in decisions is the lack of a common set of Agency ecological goals and objectives. The Agency decision makers who participated in this workshop proposed that the Agency develop a set of specific ecological objectives including not only the entities to be protected, but also the aspects of those entities and the degree of protection desired (U.S. EPA, 1996e).

Even before the Agency agrees on the common ecological objectives, we believe the information and suggestions in this document can be of immediate use to Agency decision makers. In particular, we urge that Agency decision makers set specific objectives for each program or project by:

- Following processes similar to those suggested in chapter 5
- Using the common entities in chapter 4 as a checklist
- Incorporating ecological integrity as suggested at the end of chapter 3

Above all, we hope that Agency decision makers will use these suggestions and recommendations and share their experiences with other offices, including the Office of Research and Development and the Office of Policy, Planning, and Evaluation. Only by learning from

actual experience can we develop the processes and principles that will provide a sound and useful EPA approach for the protection of valued ecological entities.

GLOSSARY

Assessment Endpoint: The *Framework* (U.S. EPA, 1992a) defines an assessment endpoint as "an explicit expression of the environmental value to be protected." Thus, assessment endpoints are those attributes of entities that are the focus of protection. They are the parameters by which success is measured. They should be theoretically measurable, although it may not be practical to measure them directly. Examples of assessment endpoints are shown in table 5-1.

Community: This term has two meanings at EPA, and it is used both ways in this document. First, it is used to mean the *human* community, as in *community*-based environmental protection. In this context, it means all the people who live in, work in, or visit an area. Second, it is used to mean an *ecological* community, that is, "an assemblage of populations of different species within a specified location." The second definition is from U.S. EPA (1996a).

Conceptual Model: In problem formulation, a conceptual model is a written description and visual representation of predicted responses by ecological components to stressors to which they are exposed. It includes ecosystem processes that influence these responses. Conceptual models developed for ecological risk assessments require three basic elements: stressor, exposure, and predicted effect on an ecological entity. Depending on why a risk assessment is initiated, one or more of these three elements is known at the outset; the unknown elements must be identified and characterized (based on discussion in U.S. EPA, 1996c).

Entity (also ecological entity or valued ecological entity): This is the valued resource to be protected. It can be a species, a group of species, an ecosystem function or characteristic, or a specific place or habitat.[2] Entity is a more general concept than the assessment endpoint (see above) in that it only specifies the valued resource, not particular attributes of the valued resource. Thus, native fish are an ecological entity, and their survival and reproduction may be assessment endpoints. Examples of entities are shown in tables 4-1 and 5-1.

Measures: There are three categories of measures. *Measures of effect* evaluate the response of the assessment endpoint when exposed to a stressor (formerly measurement endpoints). *Measures of exposure* describe how exposure may be occurring, including how a stressor moves

[2]This definition is based on the definition provided in the *Guidelines* (U.S. EPA, 1996c) but differs from it slightly. The definition given here includes places as entities, whereas that given in the *Guidelines* would not describe a place such as a national park as an entity in itself, but as containing entities. This difference is mentioned here to avoid confusion among risk assessors who use both documents; it is not likely to make any difference to other readers.

through the environment and how it may co-occur with the assessment endpoint. *Measures of ecosystem and receptor characteristics* portray the behavior and location of assessment endpoints, the distribution of a stressor, or the response of an assessment endpoint to the stressor. Two examples are water temperature and the age distribution of a population of fish (U.S. EPA, 1996c). Some measures are shown in table 5-1.

Objective: In this document, the term *objective* means an explicit statement of the desired state for the valued ecological entity (e.g., a viable fishery population). Thus, an objective is a specific statement about what we would like to see happen with respect to the entity. The related term *goal* is reserved here for more general aims, such as those expressed by most environmental legislation (definition is based on and consistent with the discussion in U.S. EPA, 1996c). Objectives need to be defined well enough so that it is possible to measure progress toward them. However, they do not have to be quantitative or based only on the risk to the valued resource. For example, the Office of Pesticide Programs must weigh the risks of pesticides to human health or entities against their benefits to agriculture and other use sectors. The term *no unreasonable risk* refers to any pesticidal risk that is not balanced or outweighed by the benefits of the pesticide use. Examples of objectives are shown in tables 4-1 and 5-1.

BIBLIOGRAPHY

Ad Hoc Committee on Ecosystem Management. (1995) The scientific basis for ecosystem management. Washington, DC: Ecological Society of America.

Cairns, J. (1995) The case for ecosystem services as toxicological endpoints. Hum Ecol Risk Assess I(3):171-174.

Conservation Foundation. (1988) Protecting America's wetlands--an action agenda: The final report of the national wetlands policy forum. Washington, DC: The Conservation Foundation.

Council on Environmental Quality (CEQ). (1993) Incorporating biodiversity considerations into environmental impact analysis under the National Environmental Policy Act. Washington, DC: Council on Environmental Quality.

Edmundson, WT. (1991) The uses of ecology: Lake Washington and beyond. Seattle, WA: University of Washington Press.

Florida Department of Environmental Protection. (1995) Toward ecosystem management. Tallahassee, FL.

Interagency Ecosystem Management Task Force. (1995) The ecosystem approach: Healthy ecosystems *and* sustainable economies: Vol I. Overview; Vol II. Implementation issues. NTIS PB95-265583 and PB95-265591.

Kempton, W; Boster, JS; Hartley, JA. (1996) Environmental values in American culture. Cambridge, MA: MIT Press.

Levin, SA; Kimball, KD. (1984) New perspectives in ecotoxicology. Environ Manag 8(5):375-442.

New York Times News Service. (1996) Effects of acid rain on a New Hampshire forest. New York Times News Service, April 15, 1996.

Norse, E. (1990) Threats to biological diversity in U.S. Report prepared for EPA by Industrial Economics. Contract No. 68-W8-0038, Work Assignment 115.

Noss, RP; LaRoe, ET; Scott, JM. (1995) Endangered ecosystems of the United States: A preliminary assessment of loss and degradation. Washington, DC: U.S. Department of the Interior, National Biological Service.

Russell, EP. (1995) Lost among the parts per billion: Ecological protection at the United States Environmental Protection Agency 1971-1993. Prepared for Office of Policy, Planning, and Evaluation, U.S. Environmental Protection Agency. Charlottesville, VA: University of Virginia.

Ryder, RA; Edwards, CJ. (1985) A conceptual approach for the application of biological indicators of ecosystem quality in the Great Lakes Basin. Great Lakes Fishery Commission.

Sarasota Bay National Estuary Program. (1992) Framework for action. Sarasota, FL.

Ueland, KM; Monahan, R; Zimmerman, J; Hsu, A. (1995) The New Hampshire Resource Protection Project. U.S. Environmental Protection Agency, Region I.

U.S. Department of the Interior. (1994) Ecosystem management in the National Park Service: Discussion draft. U.S. Department of the Interior, Washington, DC.

U.S. Environmental Protection Agency. (1976) Quality criteria for water. Washington, DC: U.S. Environmental Protection Agency. NTIS PB-263943.

U.S. Environmental Protection Agency. (1980) Water quality criteria. Federal Register 45:79318.

U.S. Environmental Protection Agency. (1983) Compilation of Federal laws, treaties, and conventions pertaining to the environment: 1785-1978. Prepared by RG Clements for Office of Toxic Substances, Health and Environmental Review Division, Ecological Effects Branch, U.S. Environmental Protection Agency, Washington, DC.

U.S. Environmental Protection Agency. (1990a) Ecosystem services and their valuation. Prepared by RCG/Hagler, Bailly, Inc., for Office of Policy, Planning, and Evaluation, U.S. Environmental Protection Agency, Washington, DC.

U.S. Environmental Protection Agency. (1990b) Biological criteria: National program guidance for surface waters. U.S. Environmental Protection Agency, Washington, DC. EPA/440/5-90/004.

U.S. Environmental Protection Agency. (1990c) Reducing risk: Setting priorities and strategies for environmental protection. Report of Science Advisory Board's Relative Risk Reduction Strategies Committee to William K. Reilly, Administrator.

U.S. Environmental Protection Agency. (1990d) Remand decision relating to diazinon in the matter of Ciba-Geigy Corporation et al. FIFRA Docket Nos. 562 et esq. (July 16).

U.S. Environmental Protection Agency. (1991a) Targeting priority natural resource areas: A review of national lists. Prepared by Dynamac Corporation for Office of Policy, Planning, and Evaluation, U.S. Environmental Protection Agency, Washington, DC.

U.S. Environmental Protection Agency. (1991b) The watershed protection approach framework document. Office of Wetlands, Oceans, and Watersheds, U.S. Environmental Protection Agency, Washington, DC.

U.S. Environmental Protection Agency. (1992a) Framework for ecological risk assessment. Risk Assessment Forum, U.S. Environmental Protection Agency, Washington, DC. EPA/630/R-92/001.

U.S. Environmental Protection Agency. (1992b) Tribes at risk: The Wisconsin Tribes Comparative Risk Project. EPA/230/R-92/017.

U.S. Environmental Protection Agency. (1993) A guidebook to comparing risks and setting environmental priorities. U.S. Environmental Protection Agency. EPA/230/b-93/003.

U.S. Environmental Protection Agency. (1994a) Managing ecological risks at EPA: Issues and recommendations for progress. Prepared by ME Troyer and MS Brody, U.S. Environmental Protection Agency. EPA/600/R-94/183.

U.S. Environmental Protection Agency. (1994b) Toward a place-driven approach: The Edgewater consensus on an EPA strategy for ecosystem protection. Ecosystem Protection Workgroup, U.S. Environmental Protection Agency, Washington, DC, March 15, 1994 (draft).

U.S. Environmental Protection Agency. (1995a) Ecological risk: A primer for risk managers. Prepared by Agency Ecological Risk Communication Group, U.S. Environmental Protection Agency. EPA/734/R-95/001.

U.S. Environmental Protection Agency. (1995b) A phase I inventory of current EPA efforts to protect ecosystems. Prepared by D Norton, U.S. Environmental Protection Agency. EPA/841/S-95/001.

U.S. Environmental Protection Agency. (1995c) Whole effluent toxicity: Guidelines establishing test procedures for the analysis of pollution. Federal Register 60:53529.

U.S. Environmental Protection Agency. (1996a) Community-based environmental protection: A citizen's handbook for protecting ecosystems and communities. Office of Sustainable Ecosystems and Communities, U.S. Environmental Protection Agency (in preparation).

U.S. Environmental Protection Agency. (1996b) Proposed environmental goals for America with milestones for 2005: Review draft. U.S. Environmental Protection Agency, Washington, DC.

U.S. Environmental Protection Agency. (1996c) Proposed guidelines for ecological risk assessment (September 1996 public review draft). Risk Assessment Forum, U.S. Environmental Protection Agency, Washington, DC.

U.S. Environmental Protection Agency. (1996d) Waquoit Bay watershed ecological risk assessment problem formulation. U.S. Environmental Protection Agency (review draft).

U.S. Environmental Protection Agency. (1996e) Workshop on ecological priorities for EPA decision makers. Workshop report prepared by Friday System Services for National Center for Environmental Assessment, U.S. Environmental Protection Agency.

University of Hawai'i at Manoa. (1992) A community-based environmental risk ranking: rural and Hawai'ian quality of life: Kahalu'u O'ahu. University of Hawai'i at Manoa, Department of Urban and Regional Planning.

Westman, WE. (1977) How much are nature's services worth? Science 1977:960-964.

APPENDICES

APPENDIX A
ECOSYSTEM CONCEPTS

This appendix attempts to introduce a few basic ecosystem concepts in straightforward nontechnical language. It does not repeat definitions provided in the main document.

Definitions are from appendix A of *Ecosystem Management in the National Park Service: Discussion Draft* (U.S. Department of the Interior, 1994).

Ecosystems refer to a system formed by the interaction of a group of organisms and their environment. An ecosystem may be a pond or the entire globe. It can be natural or artificial. All ecosystems are composed of components, structure, and processes. *Components* are plants, animals, soil, air, and water. *Structure* refers to spatial and temporal distribution of those components. For example, the location and extent of typical wetland plant species is an aspect of the structure of a wetland. *Processes* are the flow or cycling of energy, materials, and nutrients through space and time. For example, plants use water, elementary nutrients, and sunlight to produce material that, in turn, provides food for other species.

All components, structures, and processes have various functions that can change over time and space, from one ecosystem to another, as well as within ecosystems.

Ecosystems occur in geographic arrangements. Smaller ecosystems exist within larger ones. The scale selected and the boundaries used to define an ecosystem depend on the problem or question to be addressed. Spatial scales range from microbial activity to the entire biosphere.

APPENDIX B
EPA PAST CONSIDERATION OF CONCERNS BY CONCERN CATEGORY AND MAJOR EPA OFFICE

This section provides background information for section 2.2.1 (Past Review of EPA Programs) in the main document. It is adapted from table D-7 of *Managing Ecological Risk at EPA* (U.S. EPA, 1994a).

Table B-1. Category I: Animals, Plants, and Their Habitats

Concern	Comments/Specifics	A	N	P	R	S	T	W
Fish	"Individual" (avoid kills), populations, or species; sport, anadromous, salmon, juvenile	A	N	P	R	S	T	W
Birds	"Individual" (avoid kills), population, or species; migratory or resident; waterfowl, wading; suburban, special interest		N	P	R	S	T	W
Mammals	"Individual" (avoid kills), population, or species; small or large; predatory, plant-eating, fish-eating; terrestrial, aquatic; deer, bear				R	S	T	W
Amphibians and reptiles	"Of special interest"							W
Wildlife (unspecified)	"Individual" (avoid kills), population, species; aquatic or terrestrial; plant-eating, predatory		N	P	R	S	T	W
Aquatic invertebrates	Populations, species, water column, benthic organisms or community or community structure, commercial species	A					T	W
Terrestrial invertebrates	Bumblebees, honeybees, soil organisms			P				W
Plants	Aquatic, terrestrial; distribution and abundance; vegetative succession, algae, crops	A		P	R	S	T	W
Unspecified biota	Aquatic, terrestrial species, or organisms or life, community structure, community health, important organisms, commercially important species, estuarine biota	A		P	R	S		W
Habitat	Aquatic, terrestrial, remote, high quality, habitat corridors, breeding areas, critical spawning area, habitat for unique communities, bird habitat, fisheries, fish habitat		N		R	S		
Wetlands	Maintain size, hydrology, habitat value, filtering and binding of pollutants, wetland functions, special types, interconnected wetlands		N		R	S		W

Table B-1. Category I: Animals, Plants, and Their Habitats (Continued)

Concern	Comments/Specifics	A	N	P	R	S	T	W
Other ecosystem types	Riparian habitat, streams, coastal barriers, subtidal habitats, upland habitats, aquatic ecosystems, deltas, estuaries		N		R	S		W
Rare or threatened ecosystems	Terrestrial, aquatic, sensitive, rare, exposed and valued, sage scrub		N			S		W
Ecosystem functions	Function of aquatic or terrestrial community, function of plant community, nutrient recycling			P	R			

Key to major office areas and legislation: A: Air; N: NEPA; P: Pesticides; R: RCRA; S: Superfund; T: Toxics; W: Water.

Table B-2. Category II: Ecosystems, Their Functions and Services

Concern	Comments/Specifics	A	N	P	R	S	T	W
Wetlands	Maintain size, hydrology, habitat value, filtering and binding of pollutants, wetland functions, special types, interconnected wetlands		N		r	s		W
Other ecosystem types	Riparian habitats, streams, coastal barriers, subtidal habitats, upland habitats, aquatic ecosystems, deltas, estuaries		N		r	S		W
Rare or threatened ecosystems	Terrestrial, aquatic, sensitive, rare, exposed and valued, sage scrub		N			S		W
Ecosystem functions	Function of aquatic or terrestrial community, function of plant community, nutrient recycling			P	r			

Key to major office areas and legislation: A: Air; N: NEPA; P: Pesticides; R: RCRA; S: Superfund; T: Toxics; W: Water.

Note: Uppercase letters refer to concerns that have been used (or in a few cases were about to be used) at the time of the interview in a documented decision. Lowercase letters indicate concerns that were reported as of interest in an interview or were inferred from measures used in the assessment but not contained in a documented decision.

Table B-3. Category III: Special Places and Species

Concern	Comments/Specifics	A	N	P	R	S	T	W
Special places	Wilderness Areas, National Forests, State or Federal Refuges, National Estuaries, National Parks, Wild and Scenic Rivers, Wildlife Refuges, Great Lakes Vital Habitats, Marine Sanctuaries	A	N			S		
Special species	Endangered or threatened species, their habitat or food		N	P	R	S	T	W

Key to major office areas and legislation: A: Air; N: NEPA; P: Pesticides; R: RCRA; S: Superfund; T: Toxics; W: Water.

APPENDIX C
RECENT POLICIES OF FEDERAL RESOURCE MANAGEMENT AGENCIES

This section provides more detail for the summary provided in section 2.3 of the main document.

As the individual descriptions show, many agencies have modified their processes to include greater stakeholder involvement and consider multimedia and multipathway pollution exposures simultaneously with sound watershed and habitat management practices. This, of course, is very similar to the community-based environmental protection approach of EPA. Although the process and multistressor aspects are beyond the scope of this document, there are also implications for environmental goals and assessment endpoints. In addition to greater concern with global issues (climate change, biodiversity, health of oceans), there is an overall trend toward ecosystem sustainability to provide for longer term protection of valued resources.

C.1. FOREST SERVICE

The Forest Service has moved toward managing for sustainable ecosystems. According to a 1995 Federal Register Notice: "[the] agency would retain the discretion to determine for each plan area which conditions are indicative of sustainable ecosystems and how the plan area could be managed to promote those conditions." This indicates that the actual management goals are established on a case-by-case basis for each area. However, the definition of "sustainable ecosystem" gives some indication of the kinds of goals they will consider: "the ability to sustain diversity, productivity, resilience to stress, health, renewability and or yields or desired values, resource uses, products or services, from an ecosystem while maintaining the integrity of the ecosystem over time." This combines concepts related to sustainability (diversity, resilience to stress) with those related to human utility (yields, desired values, resource uses, products or services).

The Forest Service also adopts a two-stage (course filter/fine filter) process that first considers the ecosystem as a whole and then an additional consideration of species that may not be protected by the general ecosystem protection.

C.2. BUREAU OF LAND MANAGEMENT (BLM)

BLM has also moved toward an ecosystem approach. Like the Forest Service, BLM sets specific management goals on an area basis. Some of the BLM principles and definitions show that, also like the Forest Service, ecosystem integrity and utility to humans are to be combined in their goals:

- Sustain the productivity and diversity of ecosystems and provide for human values, products, and services

- Determine desired future landscape functions based on historic, ecological, economic, and social considerations

- Sustainable development: the use of land and water to sustain production indefinitely without environmental deterioration, ideally without loss of native biodiversity

- Sustainable ecosystem: management of ecosystems so that the desired mix of values and resources are tempered to ensure that their capabilities and suitabilities are not compromised for future generations.

C.3. SOIL CONSERVATION SERVICE (NOW THE NATURAL RESOURCE CONSERVATION SERVICE)

This Agency has also moved toward ecosystem management that provides for human utility. It considers integrated resource, or ecosystem, management, a concept based on the self-healing ability of viable ecosystems. Ecosystem management is also a means to establish or maintain living systems that improve rather than degrade over time.

C.4. FISH AND WILDLIFE SERVICE (FWS)

The FWS mission is "to conserve, protect and enhance the nation's fish and wildlife and their habitats for the continuing benefit of the American people."

This clearly includes human use and also points to ecosystem protection.

More explicitly: "An ecosystem approach to fish and wildlife conservation means protecting or restoring the function, structure and species composition of an ecosystem while providing for its sustainable socioeconomic use."

The FWS defines 52 geographically defined ecosystem units, closely corresponding to watersheds in most cases. Specific goals are established for particular watershed units. However, the FWS also prioritizes units based in part on the "significance of the resources present in the ecosystem." Highest priority is given to those ecosystem units most important to FWS's trust resources (listed species, migratory birds, etc.). Other considerations beyond the scope of this document (such as the ability of the service to address the resource need) are also considered.

C.5. NATIONAL PARK SERVICE (NPS) ECOSYSTEM MANAGEMENT

The NPS is charged with managing specific places that are highly valued as natural resources. In NPS' words, these are "the Nation's most precious natural and cultural resources, which are important symbols of our rich and diverse heritage" (U.S. Department of the Interior, 1994).

The overall vision emphasizes ecosystem integrity: "NPS to lead by example through continuous improvement and excellence in direct stewardship efforts while actively assisting and educating other stakeholders to help them better manage resources for the goal of greater ecosystem integrity" (U.S. Department of the Interior, 1994).

Specific goals are established separately for each park. However, the principles indicate a focus on biodiversity and resources valued for heritage reasons: ". . . It is imperative that the NPS work to restore and/or maintain biological diversity (species, genetic, and ecosystem) and the ecological patterns and processes that maintain that diversity. Viable populations of native species and natural-disturbance regimes should be maintained. The overall objective is to maintain ecosystems that are resilient to short-term stresses and receptive to long-term evolutionary and ecological influences of change" (U.S. Department of the Interior, 1994).

"Preserving and maintaining significant resources and advocating or assisting others to protect important archeological, historical, and ethnographic resources in their historic context" (U.S. Department of the Interior, 1994).

APPENDIX D
SOME COMMUNITY PROJECTS

Section 2.4 of the main text discusses some community-based projects. This section provides information on the projects and sources referred to in that section and adds brief summaries of a few more projects.

D.1. EPA SUMMARY OF ECOSYSTEM PROJECTS

In January 1995, EPA's Office of Water published *A Phase I Inventory of Current EPA Efforts to Protect Ecosystems* (U.S. EPA, 1995b). This included summaries of projects involving EPA and its partners in place-based management and ecosystem protection. Although the inventory did not specifically list the entities protected for each project, many summaries provided information on this point. The following table summarizes the entities protected by projects in this inventory, to the extent this information was provided.

Table D-1. Ecosystem Protection Inventory: Entities Protected by Region (Number of Projects)

Region	1	2	3	4	5	6	7	8	9	10	L[a]	M[b]
Fish, fisheries	5	10	2	7	5	1	8	4	1	8	3	6
Shellfish	2	2	1	3		3			1			2
Birds	1	4			3				1		2	1
Wildlife		5			3		1					
Aquatic life		1	1	1	3		1					
Endangered or native species	2		2	2	1	1	2	1	3	2	3	2
Biodiversity			1		1	1	2				5	2
Habitat or ecosystem	1	3	5	3	3	3	7	2	5	1	4	2
Aquatic habitat (unspecified)	4	5	1	1	3	1	4	1	1	5	3	
Estuaries	2	3		3							3	1
Lakes	1	7	1		2		2					1

Table D-1. Ecosystem Protection Inventory: Entities Protected by Region (Number of Projects) (Continued)

Region	1	2	3	4	5	6	7	8	9	10	L[a]	M[b]
Streams	1			1			1	2	5	7	5	1
Wetlands	2		5	12	1	6	5		2	4	10	6
Terrestrial habitat					1	1	4	2	2	7	4	
Unique habitat				4		2	1		1		5	
Soil			1			1		3	1	1	3	

[a]Large-scale projects.
[b]Multiregion projects.

D.2. OTHER COMMUNITY-BASED PROJECTS

This section summarizes projects from various sources, many from the Office of Policy, Planning, and Evaluation (OPPE) Comparative Risk Project (U.S. EPA, 1993).

1. The Wisconsin Tribes Comparative Risk Project (U.S. EPA, 1992) ranked several natural resource issues as "high" under the ecological or quality-of-life categories. These included:

   - The effects on fish from nonpoint source discharges to lakes and rivers
   - Loss of wild rice habitat, fish spawning, cover habitat, and aesthetic value from physical degradation of water and wetland habitats
   - Acid rain impacts on fish, birds, and mammals
   - Abandoned hazardous waste sites (regarded as an insult to the Tribes' respect for the earth).

2. *The Community-Based Environmental Risk, Ranking: Rural and Hawai'ian Quality of Life: Kahalu'u O'ahu* (University of Hawai'i at Manoa, l992) listed access to natural resources as one of the most important values of this community; respect for the land and for nature was also ranked high.

3. Issues rated high under Vermont's quality-of-life comparative risk assessment include alteration of Vermont's ecosystems, the effects of acid rain on native species, and pollution of lakes, ponds, and streams (U.S. EPA, 1993, section 2.4).

4. Louisiana listed various stressors of aquatic ecosystems and especially marine ecosystems as high in their comparative risk project; wetlands were also listed as high (U.S. EPA, 1993, section 2.4).

5. Sarasota Bay National Estuary Program (Sarasota Bay National Estuary Program, 1992) adopted a vision for a brighter future for the Sarasota Bay; this vision specifically mentions fish for recreational and commercial fishing and wetlands.

6. Six ecosystem projects are used by the State of Florida as examples of its ecosystem management approach (Florida Department of Environmental Protection, 1995). All six are valued as habitat for a wide variety of species. Native species of amphibians, reptiles, fish, aquatic invertebrates, migratory and resident birds, and other wildlife are mentioned for one or more of the areas; endangered, rare, or threatened species are mentioned for nearly all of the six; and commercially important fish and shellfish are mentioned for most. The project areas contain important rivers, estuaries, and wetlands. One has been designated a Wild and Scenic River. Ecosystem functions and services such as aquifer recharge, flood water storage, and prevention of saltwater intrusion are also mentioned as deserving protection.

APPENDIX E
LISTS OF SPECIAL PLACES

Many activities within Federal and State natural resource agencies and private environmental organizations focus on identifying and ranking the most important natural resources deserving special protection and management. These institutions have produced lists of specific areas characterized by their uniqueness, ecological significance or rarity, recreational importance, or other special designation. A 1991 report (U.S. EPA, 1991) described many of these lists, and the results are summarized below.

Table E-1. Proposed Master Lists for EPA Use in Targeting Natural Resource Priorities

List	Number of sites	Area (×1000 acres)	U.S. coverage (percentage)
Sites with multiple designations from different lists	43	18,682	0.82
Biosphere reserves	46	42,565	1.86
TNC last great places	8	16,339	0.71
Wetlands of international importance	10	1,129	0.05
World heritage sites	10	15,757	0.69
Areas of critical environmental concern	448	6,699	0.29
Experimental ecological reserves	96	2,709	0.12
National natural landmarks	587	8,692	0.38
Research natural areas	375	3,733	0.16
National conservation areas	7	13,833	0.60
National park system	152	75,181	3.28
National wilderness areas	488	90,960	3.97
National wildlife refuges	492	88273	3.85
Total	2,762	384,552	16.79

Source: U.S. EPA, 1991.

APPENDIX F
STATUTORY PROVISIONS THAT AUTHORIZE EPA TO CONSIDER SPECIFIC CONCERNS

Existing laws direct EPA to consider a variety of general and specific ecological concerns. The following table summarizes some of the more specific provisions of the major laws governing EPA. Provisions of the Endangered Species Act (ESA) and National Environmental Policy Act (NEPA) are also included because ESA and NEPA address all Federal agencies and because their requirements may be triggered by certain EPA activities. The table is not comprehensive, and provisions of the laws are paraphrased or excerpted.

Table F-1. Specific Provisions of Major Laws Governing EPA

Law	Provision
Clean Air Act (CAA) §103	Authorizes collection and dissemination of data on "**chemical, physical, and biological effects of varying air quality**." Mandates interagency research on "**ecosystems damage**" from air pollutants, including identification of "**regionally representative and critical ecosystems**" for research; evaluation of "**risks to ecosystems**"; assessments of the "**short-term and long-term ecological effects**" of atmospheric deposition on surface water and groundwater, and air pollution effects on "**forests, . . . biological diversity, soils, and other terrestrial and aquatic ecosystems**"; and "associated economic costs of ecological damage." Establishes biennial reporting requirements on "the **status of ecosystems (including forests and surface waters**)" affected by acid deposition and "the occurrence and effects of episodic acidification, particularly with respect to high elevation watersheds. . . ."
CAA §108	Authorizes EPA to "assess the risks to ecosystems from exposure to criteria air pollutants. . . ."
CAA §109	Requires EPA to establish national ambient air quality standards for the protection of public health and welfare. (*Welfare* is defined in CAA §302 to include effects on "**soils, water, crops, vegetation, . . . animals, wildlife, weather, visibility, and climate**.")
CAA §111	Incorporates consideration of, among other things, "non-air quality . . . **environmental impact**" into performance standard definition.
CAA §112(a)(1)	Authorizes EPA to designate sources emitting lesser quantity of hazardous air pollutants as "major" based on the potential for **bioaccumulation**, among other factors.
CAA §112(b)(1)	Provides an initial list of hazardous air pollutants that may be revised by EPA; the criteria to add or delete from the list include adverse environmental effects, defined as "**any significant and widespread adverse effect, which may reasonably be anticipated, to wildlife, aquatic life, or other natural resources, including adverse impacts on populations of endangered or threatened species or significant degradation of environmental quality over broad areas**."

Table F-1. Specific Provisions of Major Laws Governing EPA (Continued)

Law	Provision
CAA §112(m)	Requires EPA, in cooperation with NOAA, to conduct a hazardous air pollutant assessment program for the **Great Lakes, Chesapeake Bay, Lake Champlain, and coastal waters, including** "sampl[ing] for such pollutants **in biota, fish and wildlife,**" and investigating "the sources of air pollutants deposited in the [**Chesapeake Bay and Lake Champlain] watersheds**. . . ."
CAA §160	Establishes as one of the purposes behind preventing deterioration of air quality "to . . . enhance the air quality in **national parks, wildernesses, national monuments, national seashores, and other areas of special national or regional natural, recreational, scenic, or historic value**. . . ."
CAA §162	Designates **international parks, national wilderness areas exceeding 5,000 acres in size, national memorial parks exceeding 5,000 acres in size, and national parks exceeding 6,000 acres as of 1977** for permanent special air quality protection.
CAA §164	Authorizes special protection through State action for **national monuments, primitive areas, preserves, recreational areas, wild and scenic rivers, wildlife refuges, lakeshores, and seashores.** Authorizes special protection for **national parks and wilderness areas exceeding 10,000 acres established after 1977.** Authorizes similar action by federally recognized Indian tribes. Directs Federal land managers to review all **national monuments, primitive areas, and national preserves** and recommend appropriate areas for special protection.
CAA §165(d)	Places responsibility on Federal land managers to "protect the **air quality related values (including visibility)" in certain protected areas**. Requires an analysis of "ambient air quality, **climate and meteorology, terrain, soils and vegetation**," among other things, as part of the consideration of possible adverse impacts of proposed major emitting facilities on protected areas.
CAA §173(a)(5)	Under the nonattainment New Source Review program, a State permitting authority may only issue a permit if it determines that an analysis of alternatives "demonstrates that benefits of the proposed source significantly outweigh the **environmental** [and other] costs imposed as a result of its location, construction, or modification."
CAA §302	Defines *welfare* to include effects on "**soils, water, crops, vegetation, . . . animals, wildlife, weather, visibility, and climate**," among other things.

Table F-1. Specific Provisions of Major Laws Governing EPA (Continued)

Law	Provision
CAA §309	Directs EPA to review and comment on other Federal agency actions and, "[i]n the event the Administrator determines that any such legislation, action, or regulation is unsatisfactory from the standpoint of public health **or welfare or environmental quality**, . . . the matter shall be referred to the Council on Environmental Quality."
CAA §401	Congressional finding that acid deposition "represents a threat to **natural resources [and] ecosystems**," among other things.
CAA §401 note	Directed EPA to submit a report to Congress on the feasibility and effectiveness of acid deposition standards "to protect **sensitive and critically sensitive aquatic and terrestrial resources**." The report was to include identification of sensitive and critically sensitive aquatic and terrestrial resources in Canada that may be affected by acid deposition.
Clean Water Act (CWA) §101	"The objective of the [CWA] is to restore and maintain the chemical, physical, and biological integrity of the **Nation's waters**." Established national (interim) goal of "water quality which provides for [among other things] the protection and propagation of **fish, shellfish, and wildlife**. . . ."
CWA §102	Authorizes, upon State request, grants to planning agencies for comprehensive water quality control plans for "a basin or portion thereof," defined to include "**rivers and their tributaries, streams, coastal waters, sounds, estuaries, bays, lakes, and portions thereof as well as the lands drained thereby**."
CWA §104	Authorizes, among other things, grants for "basic research into the **structure and function of freshwater aquatic ecosystems**, and to improve understanding of the characteristics necessary to the maintenance of the chemical, physical, and biological integrity of freshwater aquatic ecosystems" and "interdisciplinary studies on the nature of **river systems, including hydrology, biology, ecology**, economics, . . . and the effects of development within river basins on river systems and on the value of **water resources and water related activities**."
CWA §117	Continues the **Chesapeake Bay** Program to, among other things, address water quality impairment and "determine the impact of natural and man-induced environmental changes on the **living resources of the Bay** and the relationships among such changes, . . . with special attention given to the impact of such changes on **striped bass**."

Table F-1. Specific Provisions of Major Laws Governing EPA (Continued)

Law	Provision
CWA §118	Establishes programs for the **Great Lakes**; directs or authorizes development of Lakewide Management Plans and Remedial Action Plans, defined as "systematic and comprehensive ecosystem approach[es] to restoring and protecting the beneficial uses" of the Great Lakes' open waters and "areas of concern," respectively, in accordance with the Great Lakes Water Quality Agreement; required EPA to develop water quality guidance, including specific protection for **aquatic life and wildlife**, to promote consistency in controlling water pollution in Great Lakes States.
CWA §119	Continues **Long Island Sound** environmental restoration efforts and promotes implementation of its Comprehensive Conservation and Management Plan.
CWA §120	Establishes **Lake Champlain** management efforts to address sources of pollution necessary "to restore and maintain the chemical, physical and biological integrity of water quality, [and] a **balanced, indigenous population of shellfish, fish and wildlife**," among other things.
CWA §302	Authorizes EPA to establish effluent limitations on discharges from point sources as necessary for the protection and propagation of **shellfish, fish, and wildlife**, among other things.
CWA §303©	Authorizes States and EPA to establish and review, on a triennial basis, water quality standards to, among other things, "enhance the quality of water and serve the purposes of the Act."
CWA §304(a)	Gives EPA broad authority to develop and publish scientific information related to, among other things, restoring and maintaining the **chemical, physical, and biological integrity of navigable waters**, **ground waters, and waters of the contiguous zones**.
CWA §307(a)	Authorizes EPA to establish a national effluent standard for toxic pollutants applicable to certain point sources that takes into account the effects of the pollutants on "**affected organisms in any waters [and] the importance of the affected organisms**," among other things.
CWA §311	Establishes mechanisms to prevent or minimize effects of oil and hazardous substance discharges on, among other things, "**fish, shellfish, and wildlife, . . . shorelines, beaches, habitat, and other living and non-living resources**." Establishes contingency planning that includes procedures for protecting "**sensitive environmental areas, and . . . fisheries and wildlife," and describes "areas of special . . . environmental importance**."

Table F-1. Specific Provisions of Major Laws Governing EPA (Continued)

Law	Provision
CWA §314	Establishes programs to address lake water quality issues, including a demonstration program. Specifies **priority lakes** for demonstration projects.
CWA §320	Authorizes establishment of management conferences to develop comprehensive conservation and management plans "to restore and maintain the **chemical, physical, and biological integrity of the estuary,** including restoration and maintenance of water quality, [and] a **balanced indigenous population of shellfish, fish and wildlife**," among other things. States are to develop implementation programs on a watershed-by-watershed basis, to the maximum extent practicable. Creates research programs, including a long-term program of monitoring to measure variations in, among other things, "**marine ecology**"; "**ecosystem assessment**"; and the impact of nutrients, sediments, and pollutants on "water quality [and] the **ecosystem" of estuarine zones**, among other things. Defines estuarine zone to include "**associated aquatic ecosystems and those portions of tributaries draining into the estuary up to the historic height of migration of anadromous fish or the historic head of tidal influence, whichever is higher**."
CWA §402	Establishes permitting process for States and EPA to control discharges of pollutants from point sources in an effort to achieve water quality standards.
CWA §404	Authorizes EPA to "veto" Corps or State authorization of a discharge of dredged or fill material into waters of the United States where EPA finds that it will have an unacceptable adverse effect on "municipal water supplies, **shellfish beds and fishery areas (including spawning and breeding areas), wildlife, or recreation areas**."
Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) §101	Defines "environment" as the **navigable waters, the waters of the contiguous zone, certain ocean waters, and any other surface water, ground water, drinking water supply, land surface or subsurface strata, or ambient air** under U.S. jurisdiction. Defines "natural resources" as "**land, fish, wildlife, biota, air, ground water, drinking water supplies, and other such resources**. . . ."
CERCLA §102	Directs EPA to promulgate regulations designating as hazardous substances "substances which, when released into the environment may present substantial danger to the public health or welfare or the environment."

Table F-1. Specific Provisions of Major Laws Governing EPA (Continued)

Law	Provision
CERCLA §107	Establishes liability for damages for injury to, destruction of, or loss of natural resources from releases of hazardous substances from facilities at which such substances were disposed of or treated. Establishes trustees to assess natural resource damages for purposes of CERCLA and §311 of the CWA.
CERCLA §121	Specifies that remedial action for the treatment of hazardous substance shall be "protective of human health and the environment."
CERCLA §301	Directs the President to promulgate natural resource damages assessment regulations that take into consideration "factors including . . . **replacement value, use value, and ability of the ecosystem or resource to recover**."
Endangered Species Act (ESA) §2	Congressional finding that at-risk **species of fish, wildlife, and plants "are of aesthetic, ecological, educational, historical, recreational, and scientific value to the Nation and its people**." Establishes among the purposes of the Act "to provide a means whereby the **ecosystems upon which endangered species and threatened species depend may be conserved**. . . ." Establishes as congressional policy that Federal agencies "shall seek to conserve **endangered species** and threatened species and shall utilize their authorities in furtherance of the purposes of [the Act]."
ESA §3(16)	Defines "species" as including "any **subspecies of fish or wildlife or plant, and any distinct population segment of any species of vertebrate fish or wildlife which interbreeds when mature**."
ESA §7(a)(1)	Directs all Federal agencies, with the assistance of FWS and NMFS, to utilize their authorities in furtherance of the purposes of the ESA "by carrying out programs for the conservation of **endangered and threatened species**. . . ."
ESA §7(a)(2)	Directs all Federal agencies, in consultation with FWS/NMFS, to insure that "any action authorized, funded, or carried out" by them is not likely to jeopardize the continued existence of any **endangered or threatened species or result in the adverse modification of the designated critical habitat of such species** unless the agency has been granted an exemption from the Endangered Species Committee.
ESA §9	Prohibits any person (including EPA) from **"taking" listed endangered species of fish or wildlife without a permit." "Take" is defined to include "harm" or "kill"** in ESA §3(19). Protects endangered species of plants on areas under Federal jurisdiction or covered by State law.

Table F-1. Specific Provisions of Major Laws Governing EPA (Continued)

Law	Provision
Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) §2(j)	"The term 'environment' includes **water, air, land, and all plants and man and other animals living therein, and the interrelationships which exist among these**."
FIFRA §2(bb)	"The term 'unreasonable adverse effect on the environment' means any unreasonable risk to man or the environment, taking into account the economic, social, and environmental costs and benefits of the use of any pesticide."
FIFRA §3(c)(5)	Authorizes registration of a pesticide product only if it performs its intended pesticidal function without causing "unreasonable adverse effects on the environment."
FIFRA §4	For purposes of the reregistration process, directs EPA to give priority to active ingredients that, among other things, "may result in residues of potential toxicological concern in potable groundwater, edible fish, or shellfish. . . ."
FIFRA §10	Requires public availability of certain information concerning a pesticide's effects on "any organism or the behavior of such pesticide in the environment, including, but not limited to, data on **safety to fish and wildlife, humans and other mammals, plants, animals, and soil**, and studies on persistence, translocation, and fate in the environment, and metabolism. . . ."
FIFRA §20	Directs EPA to "undertake such monitoring activities, including, but not limited to monitoring in **air, soil, water, man, plants, and animals**. . . ."
Marine Protection, Research, and Sanctuaries Act (MPRSA) §2	Establishes as national policy the regulation of ocean dumping and to prevent or strictly limit ocean dumping of any material "which would adversely affect human health, **welfare, or amenities, or the marine environment, ecological systems, or economic potentialities**."

Table F-1. Specific Provisions of Major Laws Governing EPA (Continued)

Law	Provision
MPRSA §102(a)	Authorizes EPA to issue permits for the transportation of material for ocean dumping if such dumping will not unreasonably degrade or endanger, among other things, "**the marine environment [and] ecological systems**." Directs EPA to establish permit application criteria that consider, among other things, "the effect of such dumping on **fisheries resources, plankton, fish, shellfish, wildlife, shore lines and beaches . . . [and] marine ecosystems, particularly with respect to . . . potential changes in marine ecosystem diversity, productivity, and stability, and . . . species and community population dynamics**."
MPRSA §102©	Authorizes EPA to designate sites and times within which certain materials may not be dumped if "[the Administrator] finds it necessary to protect **critical areas**."
MPRSA §103	Authorizes waivers "unless the Administrator finds that the dumping of the material will result in an unacceptably adverse impact on . . . **shell-fish beds, wildlife, fisheries (including spawning and breeding areas), or recreational areas**."
National Environmental Policy Act (NEPA) §2	States that the Act's purpose includes declaring a national policy to, among other things, "promote efforts which will prevent or eliminate damage to the **environment and biosphere . . . [and] enrich the understanding of the ecological systems and natural resources important to the Nation**. . . ."
NEPA §101	Sets forth congressional recognition of, among other things, "the profound impact of man's activity on the **interrelations of all components of the natural environment** . . . ." Provides that it is the continuing responsibility of the Federal government to improve Federal programs "to the end that the Nation may fulfill the responsibilities of each generation as trustee of the **environment for succeeding generations**. . . ."

Table F-1. Specific Provisions of Major Laws Governing EPA (Continued)

Law	Provision
NEPA §102	Congress "authorizes and directs that, to the fullest extent possible: (1) the policies, regulations, and public laws of the United States shall be interpreted and administered in accordance with the policies set forth in [NEPA], and (2) all agencies of the Federal Government shall . . . develop methods and procedures . . . which will [e]nsure that presently **unquantified environmental amenities and values** may be given appropriate consideration in decision making . . . [and] include in every recommendation or report on proposals for legislation and other major Federal actions . . . [an environmental impact statement] . . . [and] recognize the worldwide and long-range character of environmental problems . . . [and] initiate and utilize **ecological information** in the planning and development of resource-oriented projects . . . ."
NEPA §201	Directs the President to transmit to Congress an annual report on "the status and condition of the major **natural, manmade, or altered environmental classes of the Nation, including, but not limited to, the air, the aquatic, including marine, estuarine, and fresh water, and the terrestrial environment, including, but not limited to, the forest, dryland, wetland, range, urban, suburban, and rural environment; . . . [and] the adequacy of available natural resources for fulfilling human and economic requirements of the Nation in light of expected population pressures**. . . ."
NEPA §204	Establishes among the duties of the President's Council on Environmental Quality "to conduct investigations, studies, surveys, research, and analyses relating to **ecological systems and environmental quality**. . . ." This duty was delegated to EPA in Reorganization Plan No. 3 of 1970.
Solid Waste Disposal Act (SWDA) §1003	Establishes as one of the Act's objectives "promoting . . . solid waste management, resource recovery, and resource conservation systems which preserve and enhance the quality of **air, water, and land resources**." Declares a national policy that any waste generated "should be treated, stored, or disposed of so as to minimize the present and future threat to human health and the environment."
SWDA §3002	Directs EPA to promulgate standards applicable to generators of listed hazardous wastes "as may be necessary to protect human health and the environment."
SWDA §3003	Directs EPA to promulgate standards applicable to transporters of listed hazardous wastes "as may be necessary to protect human health and the environment."

Table F-1. Specific Provisions of Major Laws Governing EPA (Continued)

Law	Provision
SWDA §3004	Directs EPA to promulgate performance standards applicable to owners and operators of facilities for the treatment, storage, or disposal of listed hazardous wastes "as may be necessary to protect human health and the environment."
SWDA §9003	Directs EPA to promulgate release detection, prevention, and correction regulations applicable to all owners and operators of underground storage tanks, "as may be necessary to protect human health and the environment."
Toxic Substances Control Act (TSCA) §3	"The term 'environment' includes **water, air, and land and the interrelationship which exists among and between water, air, and land and all living things**."
TSCA §4	Authorizes the Agency to require testing of chemical substances or mixtures that may present an unreasonable risk of injury to "health or the environment."
TSCA §6	Authorizes action by EPA to protect against chemical substances or mixtures that present or will present an unreasonable risk of injury to "health or the environment." Requirements imposed may be limited to "specified geographic areas."
TSCA §8	Authorizes the Agency to require, among other things, submission of "health and safety data," defined as "any study of any effect of a chemical substance or mixture on health or the environment or both, including . . . **ecological studies**."

REFERENCES FOR APPENDICES

Florida Department of Environmental Protection (1995). Toward ecosystem management. Tallahassee, FL.

Sarasota Bay National Estuary Program (1992). Framework for action. Sarasota, FL.

U.S. Department of the Interior (1994). Ecosystem management in the National Park Service: Discussion draft. U.S. Department of the Interior, Washington, DC.

U.S. Environmental Protection Agency (1983). Compilation of Federal laws, treaties, and conventions pertaining to the environment: 1785-1978. Prepared by RG Clements for Office of Toxic Substances, Health and Environmental Review Division, Ecological Effects Branch, U.S. Environmental Protection Agency, Washington, DC.

U.S. Environmental Protection Agency (1991). Targeting priority natural resource areas: A review of national lists. Prepared by Dynamac Corporation for Office of Policy, Planning, and Evaluation. U.S. Environmental Protection Agency, Washington, DC.

U.S. Environmental Protection Agency (1992). Tribes at risk: The Wisconsin Tribes Comparative Risk Project. U.S. Environmental Protection Agency. EPA/230/R-92/017.

U.S. Environmental Protection Agency (1993). A guidebook to comparing risks and setting environmental priorities. U.S. Environmental Protection Agency. EPA/230/B-93/003.

U.S. Environmental Protection Agency (1994) Managing ecological risks at EPA: Issues and recommendations for progress. Prepared by ME Troyer and MS Brody, U.S. Environmental Protection Agency. EPA/600/R-94/183.

U.S. Environmental Protection Agency (1995). A phase I inventory of current EPA efforts to protect ecosystems. Prepared by D Norton, U.S. Environmental Protection Agency. EPA/841/S-95/001.

U.S. Environmental Protection Agency (1996). Waquoit Bay watershed ecological risk assessment problem formulation. U.S. Environmental Protection Agency (review draft).

University of Hawai'i at Manoa (1992). A community-based environmental risk ranking: Rural and Hawai'ian quality of life: Kahalu'u O'ahu. University of Hawai'i at Manoa, Department of Urban and Regional Planning.