Council on Environmental Quality

Incorporating Biodiversity Considerations
Into Environmental Impact Analysis
Under the National Environmental Policy Act

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Council on Environmental Quality
Executive Office of the President
722 Jackson Place, NW
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This report presents the results of consultations by the Council on Environmental Quality (CEQ) concerning the consideration of biological diversity in analyses prepared under the National Environmental Policy Act (NEPA).

This report is intended to provide background on the emerging, complex subject of biodiversity, outline some general concepts that underlie biological diversity analysis and management, describe how the issue is currently addressed in NEPA analyses, and provide options for agencies undertaking NEPA analyses that consider biodiversity.

The report does not establish new requirements for such analyses. It is not, and should not be viewed as, formal CEQ guidance on this matter, nor are the recommendations in the report intended to be legally binding. The report does not mean to suggest that biodiversity analyses should be included in every NEPA document, without regard to the degree of potential impact on biodiversity of the action under review.

Contents

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We especially acknowledge the contributions of Allan Hirsch, whose loss was deeply felt by those of us who worked with him on this report, and by his colleagues everywhere.

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Preface

Between December 1991 and June 1992, the Council on Environmental Quality (CEQ), in conjunction with the Environmental Protection Agency (EPA) and with support from the Departments of Defense, Interior, and Transportation, conducted a series of conferences designed to explore the need for improved incorporation of concerns for ecosystem integrity and the protection of biological diversity into the decision-making process under the National Environmental Policy Act (NEPA). Five conferences were held in different regions of the country:

December 9-11, 1991 - Denver, Colorado

February 18-20, 1992 - Atlanta, Georgia

March 23-25, 1992 - Boston, Massachusetts

April 28-30, 1992 - Chicago, Illinois

May 19-21, 1992 - Anchorage, Alaska

The conferences served to (1) familiarize agency staff with emerging thinking on biodiversity and other ecological issues; (2) encourage and provide some guidance for analysis of these issues in NEPA documents; and (3) gather information on existing and developing methodologies for improving consideration of biodiversity in the NEPA process. Each conference also explored NEPA issues not directly related to biodiversity such as the use of environmental assessments, third party contracting, public participation, and cumulative impacts analysis.

Presenters at the conferences included experts on biological diversity and ecological theory from academic and other non-governmental institutions; NEPA legal experts and natural resource policy analysts from CEQ; members of EPA's Office of Federal Activities; federal agency NEPA coordinators and scientists from both regional and headquarters offices; state officials; and others. Conference attendees were predominantly regional federal agency staff directly involved in the preparation or review of environmental analysis documents under NEPA; they represented more than 20 federal agencies. State governments (e.g., departments of fish and game, transportation, environmental conservation, and natural resources) also were well represented.

This report is based in part on these conferences.

Introduction

Biological diversity, or the variety of life and its processes, is a basic property of nature that provides enormous ecological, economic, and aesthetic benefits. Its loss is recognized as a major national as well as global concern with potentially profound ecological and economic consequences.

Conservation of biological diversity is a national goal that requires the combined efforts of federal, state, and local governments, and the private sector. Opportunities for biodiversity conservation exist on actively managed, as well as protected, areas through the reduction of impacts and the promotion of restoration.

The National Environmental Policy Act (NEPA) provides a mandate and a framework for federal agencies to consider all reasonably foreseeable environmental effects of their actions. To the extent that federal actions affect biodiversity, and to the extent that it is possible to both anticipate and evaluate those effects, NEPA requires federal agencies to do so.

To assist federal agencies in fulfilling their responsibilities under NEPA in the context of biological diversity, the Council on Environmental Quality (CEQ) held a series of conferences to explore biodiversity science and its application to the implementation of NEPA and consulted with a wide range of both federal and non-federal practitioners and experts to review the most current thinking in this field. This report provides material on the components of biodiversity, the major causes of the loss of biodiversity, general principles for its protection, and the appropriate scale for considering biodiversity.

The report summarizes emerging biodiversity concepts and practices and how they may be applied to NEPA analyses. It is intended to help agencies identify situations where consideration of biodiversity under NEPA is appropriate, and to strengthen their efforts to do so.

Chapter I

Biodiversity

Biological diversity, or biodiversity, is a general term referring to an extremely complex ecological issue. It is often defined simply as "the variety and variability of life" or "the diversity of genes, species, and ecosystems." In fact, biodiversity **does** comprise the variation between and among major ecological elements, but the significance of that diversity is not communicated by these definitions.

What is Biodiversity?

Biodiversity is a new and more explicit expression of one of the fundamental concepts of ecology, popularly stated as "everything is connected to everything else." Emerging concern about biodiversity reflects an empirically based recognition of the fundamental interconnections within and among various levels of ecological organization. Ecological organization, and therefore biodiversity, is a hierarchically arranged continuum, and reduction of diversity at any level will have effects at the other levels.

Fundamental to our understanding of biodiversity is the recognition that the biological world is not a series of unconnected elements, and that the richness of the mix of elements and the connections between those elements are what sustains the system as a whole.

In the past, biologists relied upon measurements of species diversity or species richness—simple measures of the number or distribution of species in a given area—to describe biodiversity. However, these measures do not consider the issues of ecosystem and genetic diversity and typically treat all species alike, whether native or introduced, common or rare.

Concern for biodiversity is often misinterpreted as a desire to maximize the diversity (usually species diversity) of every area. In fact, managing for maximum diversity might actually impoverish natural biodiversity. For example, introducing small-scale habitat disturbances might increase local biodiversity by favoring the spread of opportunistic, "weedy" species. However, the same activity may decrease the available habitat for species at risk regionally, and regional or global biodiversity may be diminished.

Why Is Biodiversity Important?

Biotic resources are important, both ecologically and economically. At the ecosystems level, maintenance of structural diversity and functional integrity is essential to the

Components of Biological Diversity

- **Regional ecosystem diversity:** The pattern of local ecosystems across the landscape, sometimes referred to as "landscape diversity" or "large ecosystem diversity".
- **Local ecosystem diversity:** The diversity of all living and non-living components within a given area and their interrelationships. Ecosystems are the critical biological/ecological operating units in nature. A related term is "community diversity" which refers to the variety of unique assemblages of plants and animals (communities). Individual species and plant communities exist as elements of local ecosystems, linked by processes such as succession and predation.
- **Species diversity:** The variety of individual species, including animals, plants, fungi, and microorganisms.
- **Genetic diversity:** Variation within species. Genetic diversity enables species to survive in a variety of different environments, and allows them to evolve in response to changing environmental conditions.

The **hierarchical nature** of these components is an important concept. Regional ecosystem patterns form the basic matrix for, and thus have important influences on, local ecosystems. Local ecosystems, in turn, form the matrix for species and genetic diversity, which can in turn affect ecosystem and regional patterns.

Relationships and interactions are critical components as well. Plants, animals, communities, and other elements exist in complex webs, which determine their ecological significance.

continued provision of important ecological services, such as regulation of hydrologic cycles, carbon and nutrient cycling, and soil fertility. Healthy, functioning ecosystems are necessary to support commercially and recreationally important fish and wildlife populations. Furthermore, the aesthetic, ethical, and cultural values associated with unique forms of life lend additional support to the establishment of biological conservation as public policy.[1]

The diversity of species and genetic strains provides a pool of critically important resources for potential use in agriculture, medicine, and industry; the loss of wild plant and animal species that have not been tested, or in some cases not yet described, would deprive society of these potentials. Access to genetic resources contributes about $1 billion annually to U.S. agriculture through development of improved crops. The development of livestock and other sources of protein benefits from this access as well. About 25 percent of our prescription drugs are derived from plant materials, and many more are based on models of natural compounds. Native species themselves are essential as foodstuffs and are valuable as commodities such as wood and paper. Marine biodiversity, in particular, plays a major role in meeting the protein needs of the world.

Biodiversity is not simply a problem of tropical rainforests and coral reefs, although that is where much attention has been focused. The decline of biological diversity is also a major problem in the United States, as it is elsewhere in the temperate zone. In the United States, nearly 600 plant and animal species are listed as threatened or endangered under the Endangered Species Act and another 4,000 species are candidates for listing. It has been estimated that 700 plants may become extinct during the next decade. A recent inventory suggests that 9,000 plant and animal species may be at risk. In many cases, entire plant and animal communities are threatened. In Texas, nearly one-third of the plant and animal communities are at risk, as are more than one-fifth of such communities in California, nearly one-half in Florida; and more than half in Hawaii.

Factors Contributing to the Decline of Biodiversity

Effective analysis and management of biodiversity requires a thorough understanding of the factors that contribute to its loss. The following major activities and impacts may cause the degradation or loss of biodiversity:

Physical alteration

Physical alteration, as a result of resource exploitation and changing land use, is the most pervasive cause of biodiversity loss. Ecosystem alteration includes habitat destruction, simplification, and fragmentation. When natural areas are converted to industrial, residential, agricultural, military, recreational, or transportation uses, ecosystems are disrupted and biodiversity diminished. Beyond the direct removal of vegetation and natural landforms in local areas, development of sites for human use fragments larger ecosystems and produces isolated patches of natural areas. Activities such as timber harvesting and grazing also may fragment natural areas but, more importantly, they result in simplification of ecosystems. Traditionally, timber production and grazing practices involve management for a few desired species that results in the reduction of physical heterogeneity and the disruption of species interactions and ecosystem processes.

Pollution

Pollution impacts on ecosystems include direct lethal effects, sublethal and reproduction effects (and those resulting from bioaccumulation), and degradation of habitat through eutrophication, acidification, salinization, thermal pollution, and ultraviolet (UV-B) exposure.

Overharvesting

The impacts of overfishing and other overharvesting include reduction of target populations below levels at which they can recover or compete successfully, and indirect effects through impacts on other species with which they naturally interact, thereby disrupting ecosystem functioning.

Introduction of exotic species

The introduction of non-native, or exotic, species can result in the elimination of native species through predation, competition, genetic modification, and disease transmission. Exotics pose a serious threat to biodiversity in states such as Florida, California, and especially Hawaii, where 75% of the native land birds have been lost to exotic species.

Disruption of natural processes

Natural processes can be disrupted even when many components of the ecosystem appear intact. Resource management activities may alter ecosystem dynamics through fire suppression, modified flow regimes, and altered predator-prey relationships. In turn, these effects can have dramatic impacts on community composition, succession, and ecosystem integrity.

Global climate change

Over the long run, global climate change presents a potentially major — some would say **the** major — threat to biodiversity. Should current global climate change projections (such as those discussed by the United Nations Intergovernmental Panel on Climate Change) be realized, many organisms and natural systems would not be able to function in their current ranges. Sea level rise and increased temperatures would force the present pattern of biodiversity to adapt to new conditions or to disperse to colonize new areas. Plants and animals attempting to adapt would face rates of change many times that needed to evolve or even to migrate for many species (e.g., trees). The ability of ecosystems to shift their locations would be further hindered by fragmentation of the natural landscape that places inhospitable environments between current and future ranges.

Chapter II

Biodiversity in Environmental Management

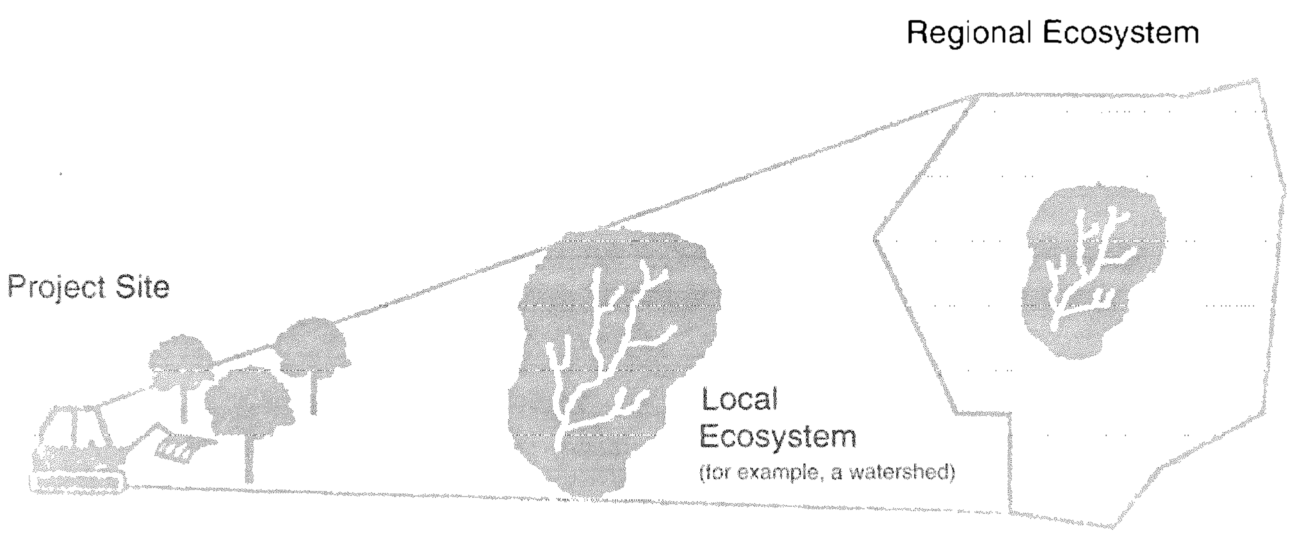
An understanding of the definition and components of biodiversity, and of the factors leading to its loss, allows for the identification of general principles for incorporating consideration of biodiversity into management. These principles are not rules; biodiversity conservation cannot be reduced to rules that are applicable in all situations. Rather, what is presented here are generalized statements or guiding principles that can help managers and planners identify biodiversity concerns and seek solutions in specific situations as agencies pursue their diverse mandates. The principles can be used to shape practices to conserve biodiversity; to understand the effect of any activity or project on biodiversity; to assist in developing mitigation; and to guide environmental analyses, including those carried out under NEPA.

- **The basic goal of biodiversity conservation is to maintain naturally occurring ecosystems, communities, and native species.***

- **The basic goals when considering biodiversity in management are to identify and locate activities in less sensitive areas, to minimize impacts where possible, and to restore lost diversity where practical.**

THE "BIG PICTURE"

How Local impacts should be considered in the context of local and regional ecosystems



Source: Adapted from Salwasser, H., "Conserving biological diversity: a perspective on scope and approaches "Forest Ecology and Management 35:79-90 (Amsterdam The Netherlands, 1990).

* Conservation of ecosystems and species in the natural environment, or *in situ* conservation, is a preferred, cost-effective method of maintaining biodiversity. However, there are many other methods such as gene banks, germ plasm banks, zoos, nurseries, botanical gardens, aquaria, and the like. Referred to collectively as *ex situ* methods, these methods complement *in situ* activities, but are typically very costly and focus primarily on the genetic and species aspects of biodiversity. *Ex situ* methods are not treated in this report.

General Principles[2]

1. Take a "big picture" or ecosystem view

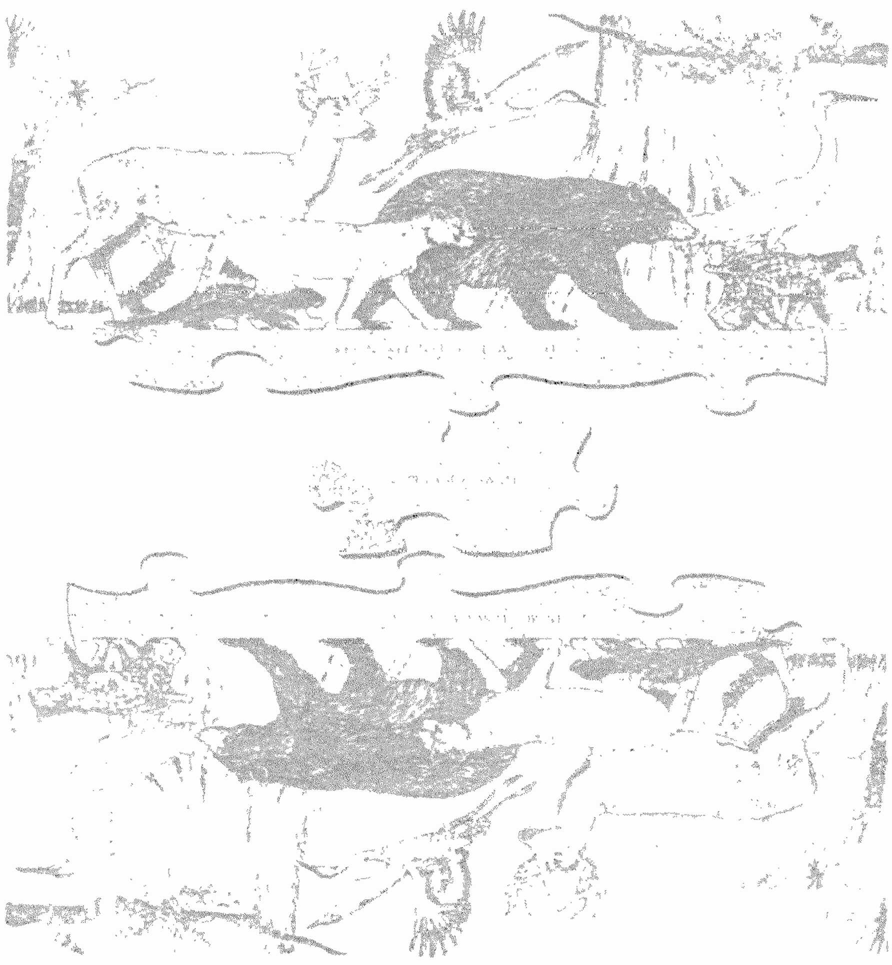
No site exists in ecological isolation. Rather they exist within a context defined by regional and local ecosystems. Understanding the potential effects of an action requires looking beyond local impacts, with an eye toward the relationship of the site to the local ecosystem and to larger regional systems. Biological resources must be protected and managed at a geographic scale commensurate with the scale of the systems that sustain them.

2. Protect communities and ecosystems

Biodiversity conservation must look beyond species to the ecological units that sustain them. Working with these larger elements ensures protection for a large number of species and their interrelationships. This is especially true if one considers the myriad of insects, fungi, and microorganisms that collectively are responsible for a significant portion of ecosystem function. This approach, often called ecosystem management, also provides for maintenance of natural processes such as carbon, nutrient, and hydrologic cycling, and vegetative succession.

Ecosystem management can help avoid future listings under the Endangered Species Act, and can be an important element of management planning for listed species. However, for species that are already threatened or endangered, strategies that specifically address their needs remain critical. Therefore, ecosystem management complements, but does not replace, recovery and management planning for individual listed species.

Pinhook Swamp corridor purchased by The Nautre Conservancy and the USDA Forest Service to provide a 15-mile land bridge between Okefenokee National Wildlife Refuge in Georgia and the Oscaola National Forest in Florida.



Source: Illustration by M. R. Clark, copyright 1990 Defenders of Wildlife, printed with permission.

3. Minimize fragmentation. Promote the natural pattern and connectivity of habitats.

In general, larger blocks of natural habitat are better at conserving biodiversity than smaller ones, and connected blocks are better than isolated ones. Larger areas and linked smaller areas reduce the genetic isolation of individual populations; support wide-ranging species and those requiring isolation from external influences; allow natural flows of organisms, energy, water, and nutrients critical to ecosystem functioning; and enhance the ability to withstand disturbances.

Natural areas, especially large ones, should be preserved wherever possible. Natural corridors and migration routes should be protected or restored. In contrast, artificial barriers should be avoided as they segment habitats, increasing mortality rates and disrupting normal movement, and provide avenues for colonization by weedy, exotic or parasitic species. Roads, powerlines, and other linear features should utilize existing developed areas wherever possible rather than cross relatively undisturbed areas.

Avoid removal of natural barriers which have allowed particular systems to evolve in isolation. Removal of such barriers may lead to invasion by non-native species or interactions between formerly isolated populations, thereby reducing genetic diversity.

4. Promote native species. Avoid introducing non-native species .

Biodiversity depends upon the variety of species adapted to a specific ecosystem. In spite of the fact that some introduced species provide important benefits, non-native species can out-compete native species, resulting in an overall reduction in diversity. Non-native species may carry disease, or may be pests themselves for which native species have no defense. In addition, they may interbreed with native species, thereby reducing overall genetic variation.

The introduction of non-native species, with their potential for adverse ecological effects, must be avoided to ensure the viability of populations of native species, and prevent declines toward extinction.

5. Protect rare and ecologically important species.

By definition, rare species are more vulnerable to extinction. Species with naturally limited ranges or those facing extinction (including species not formally listed under the Endangered Species Act or on state threatened and endangered species lists) clearly require special attention. Similarly, the loss of certain "keystone" species—species that provide important food, habitat, or other ecological values—will affect a large number of other species and can affect overall ecosystem structure and function.

6. Protect unique or sensitive environments.

Areas that are unique or substantially different from their surroundings in terms of vegetation, terrain, soils, water availability, or other factors may be ecologically critical, i.e., a large number of species may be affected by their disturbance. These areas may include stream banks and other wetlands, areas that are particularly species-rich, or areas sensitive to nutrient enrichment. Areas that are ecologically simple, i.e., lack functional redundancy, also may be particularly sensitive to disturbance.

These areas should not be disturbed. Buffers are a principal method of avoiding impacts to sensitive areas, and also provide an opportunity to retain connections (corridors) between natural areas.

7. Maintain or mimic natural ecosystem processes.

Ecosystems cannot function without the internal processes that shape and maintain them. Particular attention should be directed to the role of fire, vegetative succession, hydrologic regimes, nutrient flows, and inter-species relationships such as predation, competition, and symbiosis.

8. Maintain or mimic naturally occurring structural diversity.

Each ecosystem is characterized by a variety of physical locations and conditions to which native species have adapted for food, shelter, and other activities. Activities that change the naturally occurring number and type of these "niches" should be avoided.

9. Protect genetic diversity.

The genetic diversity of a species reflects its unique evolution and enables it to adapt to existing variation and future changes in conditions. To preserve genetic adaptations, species should be maintained in natural habitats across their natural ranges, and plants and animals for reintroduction should be selected from ecologically similar areas as close to the restoration site as feasible.

10. Restore ecosystems, communities and species.

Significant reductions of biodiversity have occurred, and many opportunities, techniques, and federal authorities exist to reverse these losses. Ecosystem restoration should be encouraged and the reintroduction or restoration of viable populations of plants, animals, or natural communities that are rare, at risk, or have been lost from parts of their range should be pursued. In doing so, appropriate experts should be consulted, since restoration and reintroduction are complex activities, and the extent of restoration experience and success is limited for some systems. Adaptive management and monitoring are especially important.

11. Monitor for biodiversity impacts. Acknowledge uncertainty. Be flexible.

Consideration of biodiversity impacts is hampered by information gaps and the inherent complexity and uncertainty of biological systems, all of which limit predictive capacity.

Project planning should recognize this uncertainty and monitoring should be an inherent part of project planning and implementation. Biodiversity monitoring can serve to test assumptions and thus improve future predictions, to identify unintended or unpredicted consequences, and to inform adaptive management. Monitoring should address both project effects and mitigation success. Phased implementation and adaptive management, with revision based on early monitoring results, are valuable means for reducing impacts.

An Ecosystem Approach

Ecosystem management includes the analysis of both the elements and the interrelationships involved in maintaining ecological integrity. This approach uses a local-to-regional perspective that considers impacts at the appropriate scale within the context of the whole system. Even at the project-specific or site-specific level, analyses should extend to the regional ecosystem scale to consider adequately impacts on biodiversity.

The implementation of an ecosystem framework must include (1) selection of the appropriate scales of analysis, and (2) establishment of goals and objectives for the protection of biodiversity, based on (3) an adequate information base.

Determining the Appropriate Scale

Scale is a central issue in the ecosystem approach. The appropriate boundary is one that ensures adequate consideration of all resources that are potentially subject to non-trivial impacts. For some resources, that boundary can be very large. The long-range atmospheric transport of nutrients and contaminants into water bodies such as the Great Lakes and Chesapeake Bay transcends even the boundaries of their vast watersheds. At the other end of the spectrum, significant contributions to biodiversity protection can be made by identifying and avoiding small sensitive areas, such as rare plant communities. Determining relevant boundaries for assessment is guided by informed judgment, based on the resources potentially affected by an action and its predicted impacts.

The most obvious opportunities for agencies to address biodiversity on an ecosystem scale occur where one agency is responsible for managing large tracts of public lands or waters, such as the U.S. Forest Service, Bureau of Land Management, National Park Service, and National Marine Fisheries Service.[3] Even these agencies may not have jurisdiction over entire ecosystems. Management of entire ecosystems may require the cooperation of several agencies or levels of government. An example is the Greater Yellowstone Ecosystem, which includes lands managed by the National Park Service, Bureau of Land Management, U.S. Fish and Wildlife Service, U.S. Forest Service, three states, and private landholders. Regional ecosystem planning for Yellowstone is conducted through the Greater Yellowstone Coordinating Committee.

Separate jurisdictions and competing missions may make it initially more difficult to engage in cooperative ecosystem management. However, clear benefits are to be gained from sharing expertise, technical capabilities, and information; such sharing will lead to improved environmental decision-making. Agencies need not sponsor regional ecosystem planning efforts to benefit from them, and agencies whose primary mission does not involve natural resource management can nonetheless make good use of existing efforts sponsored by other agencies or organizations.

Establishing Goals and Objectives

In order to understand biodiversity impacts, it is important to establish or consider concrete operational goals for the maintenance or restoration of biodiversity, based on an ecosystem perspective. Although the general goal of biodiversity conservation is to protect or restore the diversity of natural organisms and natural ecosystem processes, there is no one objective that will apply to all situations, and in some

Consideration of Biodiversity on a Regional Scale

A number of pioneering planning efforts are applying ecosystem management at the regional scale. These efforts recognize that the solution of individual environmental problems requires consideration of the context in which they occur and the interrelationships that exist among them. Examples of these include the following:

California Bioregions Initiatives[4]

In California, a path-breaking exercise is underway to design a statewide strategy to conserve biodiversity, and to coordinate implementation through regional and local institutions, based on the concept of bioregions – coordinating resource management by regions of biological similarity. On September 19, 1991, a Memorandum of Understanding (MOU) on biological diversity was signed by the Resources Agency of California and nine state and federal land management agencies – the California Departments of Fish and Game, Forestry and Fire Protection, and Parks and Recreation; the California Lands Commission; the University of California Division of Agriculture and Natural Resources; and the U.S. Forest Service, U.S. Fish and Wildlife Service, National Park Service, and Bureau of Land Management. Representatives of these agencies sit on an Executive Council; individual bioregional councils will be established in each of the eleven bioregions. At the time, Resources Agency Secretary Douglas Wheeler said, "Our objective is to bring California's varied resources management programs together in a way that assures the long-term sustainability of our rich natural heritage. Rather than focusing protection efforts on specific sites at specific times, we plan to identify entire biological and geographical areas for protection and conservation. . . . By doing this, we can save more of our environmental resources and do so in a manner that is socially and economically viable." In June 1992, the Sierra Summit Steering Committee published 18 recommendations to address the Sierra Nevada bioregion on the following three topic areas: the need for better information, improving coordination in the management of natural resources, and sustainable economic development.

Minnesota Integrated Resources Management Initiative[5]

The Minnesota Department of Natural Resources is piloting an integrated resource management approach to maintain biodiversity over entire watersheds, landscapes, and ecoregions. Under this approach, the management focus will shift from jurisdictional entities, such as state forests, to ecological land units. A first step in the process – for which the goal is to sustain entire ecological systems – has been to identify high-priority landscape areas such as large watersheds, forest areas, and prairie/farmland landscapes. These areas are then the focus of integrated management efforts involving state and federal agencies, local governments, and the private sector. While this initiative is in its early states, there are indications that the State's efforts to reorganize its major natural resources agency along ecosystem lines may provide an important catalyst. One such example is the Prairie Stewardship Partnership, which seeks to motivate environmentally sound and sustainable economic development, while protecting the productivity and diversity of natural ecosystems in the northern tall-grass prairie, more then 99% of which has already vanished. It has been estimated that at least 1,000 acres of continuous grassland are needed to sustain viable populations of species such as prairie chickens or upland sandpipers. Yet, most reserves protected by the Department of Natural Resources are less than 100 acres in size. To maintain the spectrum of prairie diversity, the Department is seeking means to link its preserves to other biologically important lands within the larger prairie/farmland landscape. The objective is to maintain these conservation areas within a matrix of multi-use pasture and haylands, and cropland.

Chesapeake Bay Program[6]

A historic Chesapeake Bay Agreement was signed in 1983 by Virginia, Pennsylvania, Maryland, District of Columbia, Chesapeake Bay Commission (an interstate legislative coordinating body), and U.S. Environmental Protection Agency to develop and implement plans to improve and protect the water quality and living resources of the Chesapeake Bay estuarine system. In 1987, a Second Bay Agreement included 29 commitments to actions that outlined steps to be taken in six areas: living resources; water quality, population growth and development; public information, education, and participation; public access; and governance. The agreement clearly established that the productivity, diversity, and abundance of the estuary's plants and animals (referred to as living resources) would be used as the ultimate measure of the Chesapeake Bay's condition. At present, a Living Resources Subcommittee is charged with providing a permanent body of scientists and managers to guide living resource restoration. This group consists of 11 workgroups in such areas as waterfowl, wetlands, submerged aquatic vegetation, fishery management plans, fish passage, habitat objectives, living resources monitoring, exotic species, and ecologically valuable species. The subcommittee has recently completed a multi-volume *Habitat Requirements for Chesapeake Bay* that will support an ecosystem-based approach to further refine understanding of the complex linkages which bind the Chesapeake ecosystem.

cases biodiversity objectives will conflict with other agency objectives. Because they may represent important social choices, the establishment of goals and objectives based on the principles outlined in this report must be undertaken with care. For example, for federal actions, the lead agency should involve not only the public, but other agencies that may be responsible for managing the affected natural resources. This will help identify those instances where other parties have developed operational goals and objectives relevant to biodiversity.

General objectives for the protection of biodiversity can be developed by identifying the relevant guiding principles outlined in this report. For example, measures to minimize landscape fragmentation, or to link blocks of originally connected habitat through landscape corridors, can often be assumed to benefit biodiversity without quantifying the specific biodiversity goal to be achieved. Agencies may have to limit their biodiversity objectives to such general guidelines in the case of programmatic environmental impact statements (EISs) if more specific objectives cannot be identified. Subsequent project-level EISs or environmental assessments, tiered from the programmatic assessments, can specify more detailed measures.

A more specific approach to the establishment of biodiversity objectives is to identify quantifiable environmental attributes for which a baseline can be established and subsequent monitoring done. Under the Great Lakes Water Quality Agreement between the United States and Canada, an ecosystem objective with associated indicators for Lake Superior was adopted, and a commitment was made to develop objectives and indicators for each of the other Great Lakes.[7] These objectives are primarily biological in nature, in contrast to the chemical objectives that had previously been the central focus of water quality efforts. The approach involves identification of (1) broad ecosystem goals, (2) objectives designed to ensure attainment of the goals, and (3) measurable indicators of progress toward meeting each objective. Societal values are reflected in the goals and objectives following consultation with competing users of ecosystem resources. Although this program has not been designed to address biodiversity *per se*, the indicators represent specific assessment elements that agencies should consider in the NEPA process with respect to activities that could affect the Great Lakes.

A wide variety of objectives and measurement approaches are potentially useful. For example, Appendix B summarizes a hierarchical approach that incorporates elements of ecosystem composition, structure, and functioning at four levels of organization: regional landscape, community-ecosystem, population-species, and genetic.[8]

Setting Biodiversity Goals and Objectives

The designation of appropriate biodiversity goals and objectives is critical for the formulation of regional management plans of all types. The following gives three examples of goals and objectives developed for natural resource management efforts:

Regional Biodiversity Goals of the Rocky Mountain Regional Guide for National Forests[9]

The Rocky Mountain Biological Diversity Assessment discusses the major elements of biodiversity, and includes recommendations for maintenance of biodiversity that could be applied during the revision of Forest Management Plans for National Forests and Grasslands in the Rocky Mountain Region. Selected examples of specific attributes are as follows:

- **Riparian Areas** – Manage for mod- to upper-seral successional states.
- **Wetlands** – Maintain the present size and quality of wetlands.
- **Tallgrass Prairie** – Provide for no acreage reduction.
- **Shortgrass Prairie** – Provide for no acreage reduction.
- **Aspen** – Increase the acreage of aspen. Increase the diversity of structure and age classes.
- **Lodgepole Pine** – Diversify age classes of lodgepole pine in homogeneous landscapes.
- **Old Growth** – Increase the acreage of old growth ponderosa pine as the major forested ecosystem present on the forest. Distribute old growth management areas to prevent or correct fragmentation.
- **Ecosystem Protection** – Provide for the protection of select special habitats, such as caves, cliffs, talus slopes, springs, seeps, and bogs.
- **Landscape Linkages** – Evaluate the need for linkages and corridors to provide for movement of organisms.

The Guide also recommends that individual Forest Management Plans document population objectives and provide habitat for wildlife and fish species selected as management indicator species.

Biodiversity Indicators for Alternative BLM Resource Management Plan (Eugene, Oregon District)[10]

In considering the environmental consequences of seven alternatives in their Eugene RMP/EIS, the BLM evaluated effects on biological diversity by estimating the changes in the following 10 indicators of biodiversity:

- Seral Stages
- Fragmentation
- Special Habitats
- Special Areas
- Riparian Zones
- Species Mix and Hardwoods
- Snags
- Dead and Down Material
- Special Status Animals
- Special Status Plants.

Acknowledging the uncertainties in evaluating effects on biodiversity, the BLM analysis is based on the extent to which management actions or resource protection would retain or depart from the natural, evolved state that existed before active forest management and protection activities began. Effects on each of the indicators were evaluated for both the short-term (10 years) and long-term (100 years) with regard to the impact on genetic, species, ecosystem, and landscape diversity.

Great Lakes Ecosystems Objectives[7]

Under the Great Lakes Water Quality Agreements of between the United States and Canada, the following ecosystem objective with associated indicators was adopted for Lake Superior:

"The lake should be maintained as a balanced and stable oligotrophic ecosystem with lake trout as the top aquatic predator of a cold-water community and the crustacean, *Pontoporeia hoyi* as a key organism in the food chain." Indicators for Lake Superior are lake trout [productivity greater than 0.38 kg/ha and stable, self-producing stocks, free from contaminants at concentrations that adversely affect the trout themselves or the quality of the harvested products.] and the crustacean *Pontoporeia hoyi* [abundance maintained throughout the entire lake at present levels of 220-320 per m^2 (depths less than 100 m) and 30-160 per m^2 (depths greater than 100 m.)].

Gathering Ecosystem Information

Successful application of an ecosystem framework also requires sufficient ecological information. Agencies should begin by assembling information from existing sources. Efforts are currently under way to establish a National Biodiversity Center[11] in cooperation with the Smithsonian Institution that would improve access to biodiversity information, assess existing information, and improve and standardize information management. Many federal and state agencies have already developed inventories of the distribution of biota and the ecological conditions in areas under their jurisdiction. The following are several potentially useful sources of ecological information.

Natural Heritage Programs

State Natural Heritage Programs and Conservation Data Centers provide the most extensive biodiversity information in usable form.[12] This system contains organized inventories on the distributions of species and communities, as well as other related information on a statewide basis in the form of integrated computer databases, manual files, maps, and aerial photography. The system is particularly useful for biodiversity analysis because, in addition to providing information on the distribution of organisms and communities, it ranks them according to their degree of endangerment (see box on page 13).

GIS — Geographic Information Systems

A geographic information system (GIS) is a collection of computer hardware, software, and geographic data that can capture, store, integrate, edit, retrieve, manipulate, analyze, synthesize, and output all forms of geographically referenced information. GIS provides tools that can help solve complex spatial questions (such as the local and regional habitat impacts of new development) that could be more difficult, time consuming, or even impossible to solve using traditional analytical methods. Specifically, a GIS[13] can accomplish the following:

- Collect, store, and retrieve information based on its spatial location
- Identify locations within a targeted environment that meet specific criteria
- Explore relationships among data sets within that environment
- Analyze the related data spatially as an aid to making decisions about that environment
- Facilitate the integration of data into analytical models to assess the impact of alternatives

• Display the selected environment both graphically and numerically.

GIS has enormous potential for supporting public policy decisions related to biodiversity. For example, GIS can be used to analyze the spatial relationships between species ranges and land use patterns. This approach is critical to identifying adequate buffer areas and potential biodiversity corridors for the maintenance of ecosystem integrity. The design of a GIS should involve coordination among a variety of federal and non-federal entities to ensure that the information base is comprehensive.

Gap Analysis

The U.S. Fish and Wildlife Service, in cooperation with a number of state and federal agencies, Natural Heritage Programs, and others, has initiated a program referred to as "gap analysis," to determine what portion of the Nation's biological diversity currently exists in protected areas such as parks and wilderness areas. Gap analysis projects are underway in 22 states, and plans exist to extend the program nationally.[14]

Using computers to integrate information on land use, vegetation, and animal species distributions, researchers from the Idaho Cooperative Fish and Wildlife Research Unit are able to identify landscapes with high biological diversity. Program scientists study large tracts of forest and rangeland ranging from 10 to 1,000 square kilometers. Areas with high biological diversity that are not under protective management are called "gaps"— hence the program's name. At minimum, gap surveys include the following:

• Vegetation types.

• Terrestrial vertebrate distribution, including identification of centers of species-richness for native vertebrates in management groups (e.g., non-game mammals, waterbirds, uncommon species); analysis of species in each vegetation type and province; centers of endemism; and species-by-species protection status.

• Terrestrial invertebrate (butterfly) distribution including centers of native species-richness, centers of endemism, and species-by-species protection status.

• Areas of species-richness for threatened, endangered, and sensitive species.

• Distribution of other taxa, when databases are available or can be readily assembled.

Together, these *themes* make up the gap analysis database. Using geographic information systems (GIS), which assemble, store, retrieve and manipulate electronically generated maps, species, communities, and ecosystems can all be viewed as integrated components.

Gap analysis makes it possible to assess how much of the nation's biodiversity is protected and enables natural resource planners and managers to focus on high-priority conservation actions. It is a potentially powerful tool for use in environmental impact assessment at the landscape scale and can be used to identify measures to mitigate the impacts of a proposed federal action.

Missouri Biodiversity Task Force

Where they exist, state biodiversity inventories, ecosystem classifications, and conservation databases can provide an enormous amount of information to meet the ecosystem management needs of the region. For example, in the State of Missouri, a Biodiversity Task Force representing the Missouri Department of Conservation, the U.S. Forest Service, and three universities recently published *The Biodiversity of Missouri*.[15] This report provides considerable information on the status of biodiversity in Missouri. Plant species, animal species, and natural communities are discussed from an ecosystem perspective that recognizes the contributions of both the biotic and abiotic components of the State's biodiversity. The report's approach to biodiversity conservation is top down, seeking first to protect ecosystem diversity, and then to protect lower levels such as species and genetic diversity. This biodiversity conservation effort in Missouri is an example of an ever-growing number of state initiatives that can be invaluable to agencies evaluating the biodiversity impacts of their proposed actions.

Fish and Wildlife Information Exchange

The Fish and Wildlife Information Exchange is an extension of the cooperative Multi-State Project among the U.S. Fish and Wildlife Service, Bureau of Land Management, International Association of Fish and Wildlife Agencies, Virginia Department of Game and Inland Fisheries, and Virginia Polytechnic Institute and State University. This unit is a clearinghouse and technical assistance center to state and federal fish and wildlife agencies in the area of fish and wildlife databases and computer applications. Since 1984, a computerized clearinghouse called the Master Species Files has been developed to facilitate data sharing. Currently, the file contains more than 4,500 species accounts representing more than 3,000 marine, terrestrial, and freshwater vertebrate and invertebrate species found in North America. States typically use this file, and their own species information systems, to address impacts of development projects, as well as statewide and coastal zone planning. Seven state databases are available from the Fish and Wildlife Information Exchange, as are the Breeding Bird Survey, Endangered Species Information System, National Fisheries Resource Inventory, and National Reservoir Research Database.

The Natural Heritage Network[16]

State Natural Heritage Data Centers have been established in all fifty states as cooperative ventures of The Nature Conservancy (TNC) and various state agencies. Satellite data centers operate in several staffed preserves, including two National Parks, and in various offices of cooperating state and federal agencies and private institutions. A number of federal agencies, including DOD and the U.S. Forest Service, have agreements with TNC to collect and manage data through the Heritage Network.

Heritage data centers focus on natural community types and individual species. The idea is that major natural communities will act as a "coarse filter" to capture populations of the majority of species, including invertebrates and other small organisms too numerous to inventory individually, while focus on populations of known rare species will act as a "fine filter" for these uncommon elements.

All Heritage programs also amass and organize data on land ownership, existing preserves and protected areas, secondary information sources (including publications, repositories, individual experts, institutions), and key individual contacts (key data users, agency personnel, mailing lists).

A large degree of standardization of terminology, methods, formats, and systems has been achieved and maintained among the many Heritage programs. This facilitates the exchange of information, efficient methodological research and technical support, consistent communication with users, and the combination of information from many programs.

Fundamental information available in this system includes the following:

Species:

Each Heritage data center tries to maintain information on all the vascular plants and vertebrate animal species in its state or area of coverage along with information on a limited number of invertebrates and non-vascular plants believed to be particularly rate or otherwise of conservation interest. A systematic ranking process is employed to ascertain the relative degree of biological endangerment of each species including, and this is documented in element ranking records. Each species is ranked as to its status on a global and state basis using consistent criteria of rarity (the estimated number of occurrences of each element) and threat (vulnerability to human disturbance or destruction). Using this system, the highest priority would be given to species with a ranking indicating threats at both global and state levels. Rankings consist of a letter — G for global and S for state — and a number — with 1 indicating the highest threat level. A G1S1 ranking would indicate that the species or community is critically imperilled both globally and regionally (typically five or fewer occurrences or extremely vulnerable to extinction due to biological factors). Originally, Heritage programs only dealt with rare species, but it was gradually found desirable to include at least limited amounts of information on all vertebrates and vascular plants. However, for efficiency's sake, total inventory effort is still allocated among species in proportion to their relative endangerment.

Communities and Ecosystems:

Each state Heritage data center develops a taxonomic classification of natural community types known within its geographic area. In places where there is a well-developed local tradition of community classification, the local system is adopted as a beginning point and modified as knowledge and perspective accumulate. In other places, a new classification is developed. Efforts are now underway to ensure regional and national consistency among these efforts. Heritage data centers attempt to include occurrences of all community types. Communities are ranked according to a set of criteria similar to the species ranking system.

Other Biological Information:

Other types of biological information can include anything that merits inventory and conservation planning, such as areas of seasonal wildlife concentration, breeding colonies of common species, outstanding individuals (such as champion trees), and areas of historical field work.

Managed (or Protected) Areas:

All State Heritage programs gather and organize information on all protected and semi-protected areas in their states, regardless of ownership. This information can provide a comprehensive picture of protected natural land and habitat for each state.

Chapter III

The Role of NEPA

The Earth's biological diversity is being reduced at a rate without precedent in human history and the loss of biodiversity has become recognized as a major global and national environmental problem during the last decade. The federal government has a major role in stemming the loss of natural biota. Federal agencies are stewards on more than 720 million acres of land and waters. Decisions concerning the use of these federal resources can promote the conservation of biological diversity and ecological restoration. Federal agency decisions also can affect millions of acres of non-federal land and waters through agency responsibility for the construction of infrastructure, regulation of environmental pollution, and provision of resources to state and local governments, as well as their influences on private sector investment strategies.

With the passage of NEPA in 1969, Congress recognized that technological and socioeconomic forces were inducing profound influences on the quality of the human environment. Section 101 of the act sets forth national policies that were intended to stem the deterioration and restore environmental and natural resource damages already inflicted by the federal government.

> . . . it is the continuing policy of the Federal Government, in cooperation with State and local governments, and other concerned public and private organizations, to use all practicable means and measures, including financial and technical assistance, in a manner calculated to foster and promote the general welfare, to create and maintain conditions under which man and nature can exist in productive harmony, and fulfill the social, economic, and other requirements of present and future generations of Americans . . . .
>
> (b) In order to carry out the policy set forth in this Act, it is the continuing responsibility of the Federal Government to use all practicable means, consistent with other essential considerations of national policy, to improve and coordinate Federal plans, functions, programs, and resources to the end that the Nation may . . .
>
> (4) preserve important historic, cultural, and natural aspects of our national heritage, and maintain wherever possible, an environment which supports diversity and variety of individual choice. . . .
>
> National Environmental Policy Act, Section 101

The act was prescient in its anticipation of the future environmental problems facing the nation, and while the environmental goals in Section 101 are broad policy mandates, they are also specific enough to serve as a blueprint for the consideration of a wide range of environmental effects of federal actions. Section 102(2) provides the necessary tool to ensure that decisionmakers are aware of the Section 101 policies and the environmental consequences of federal proposals.

> . . . [A]ll agencies of the Federal Government shall —
>
> (A) Utilize a systematic, interdisciplinary approach. . . in planning and decisionmaking . . .
>
> (B) Identify methods and procedures, in consultation with the Council on Environmental Quality . . . which will insure that presently unquantified environmental . . . values may be given appropriate consideration . . .
>
> (C) Include in every recommendation . . . on proposals for . . . major Federal actions significantly affecting the quality of the human environment, a detailed statement . . . on . . . the environmental impact of the proposed action . . . (i) any adverse impacts . . . (ii) alternatives to the proposed action [and] (iii) the relationship between local short-term uses of man's environment and the maintenance and enhancement of long-term productivity. . . .
>
> (H) Initiate utilize ecological information in . . . planning and development . . . .
>
> National Environmental Policy Act, Section 102

The full potential of NEPA as a means to address the conservation of biodiversity lies in the effective linkage of Sections 101 and 102. NEPA's combination of broad consideration of environmental impacts and a specific mechanism to address them provide an opportunity for significant improvement in biodiversity protection.

The procedures set forth in Section 102(2)(C) and subsequent implementing regulations issued by CEQ provide the framework under which federal agencies evaluate the effects of their programs and projects on the environment. The Section 102(2)(H) requirement that agencies use ecological information is relevant because biodiversity and its conservation are currently the major focus of ecological research and applications.

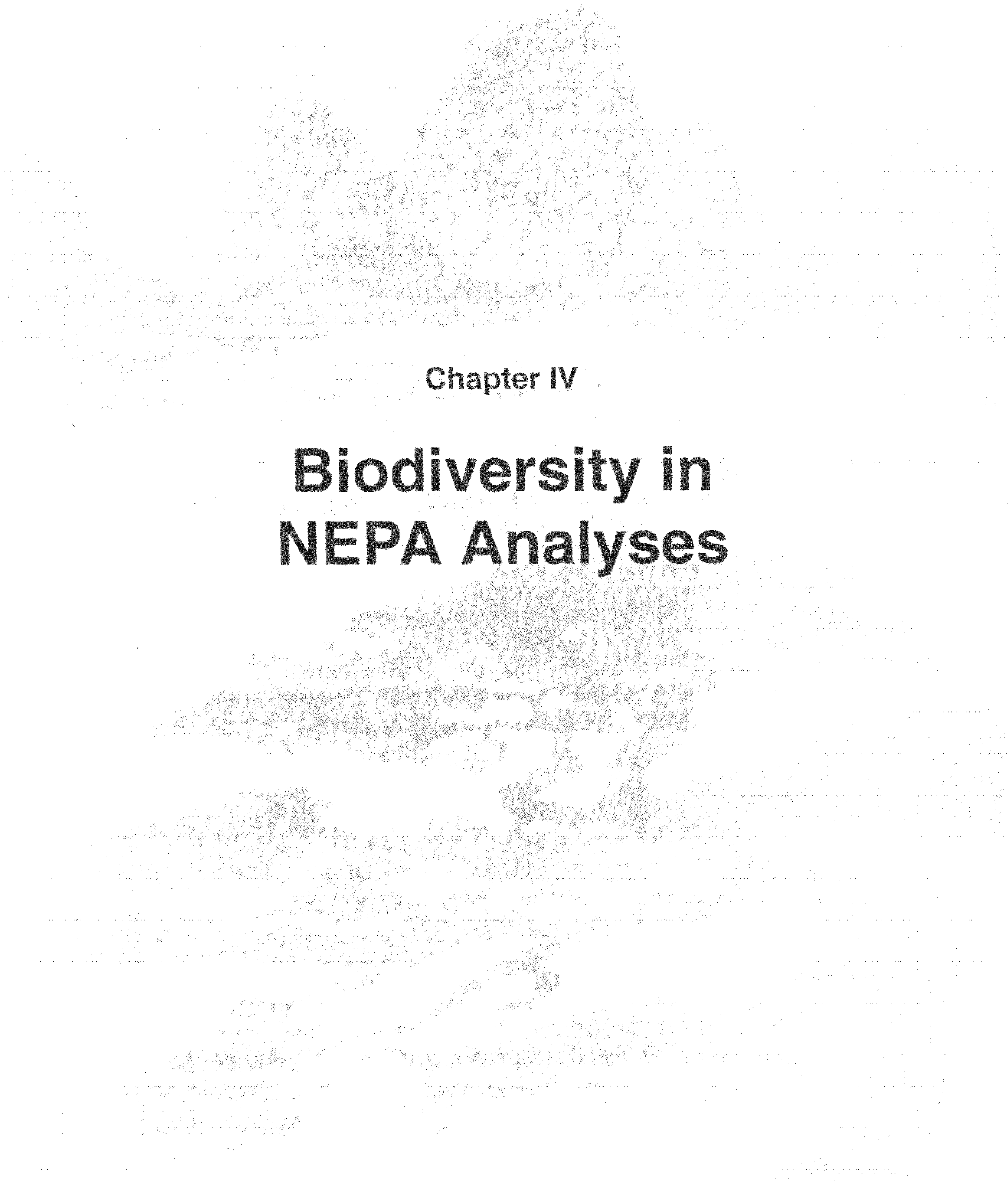
An important aspect of the NEPA process is that it can serve to coordinate consideration of substantive requirements of other environmental statutes, including laws designed to protect special species or areas (such as the Endangered Species Act, Marine Mammal Protection Act, and Wilderness Act). In addition, proper application of the NEPA process can reduce conflicts over resource management now burdening the Endangered Species Act by providing a mechanism for consideration of overall ecosystem health issues and of the needs of specific species prior to their becoming threatened or endangered. NEPA also requires a broad examination of environmental effects, including those not specifically addressed by other laws; this integrated assessment is particularly well suited to the consideration of biodiversity. Although federal agencies have routinely evaluated the effects of their proposed actions on certain specific resources (primarily wetlands and endangered species) in their NEPA analyses, they have not usually included the full range of effects or the appropriate scale required for adequate consideration of biodiversity. With the growing recognition of biodiversity losses, a few federal agencies have begun to incorporate consideration of biodiversity in their NEPA assessments. Most have not yet done so.

In addition to broadening their NEPA analyses to include biodiversity, many agencies need to strengthen the effectiveness with which they utilize the NEPA process. The ultimate effectiveness of NEPA depends upon the degree to which federal agencies use it to integrate environmental objectives into their planning and decisionmaking processes. NEPA should be used as a planning tool, not simply as a mechanism for tabulating impacts of projects that are already in the design stage. The degree to which agencies accomplish this varies widely among agencies.

The extent to which biodiversity in considered in future NEPA analyses of federal actions will strongly affect whether biodiversity is adequately protected in the coming decades. It is critical that federal agencies understand and take into account general principles of biodiversity conservation in their decisionmaking. However, biodiversity cannot be adequately conserved on the federal level alone. Even though federal lands and resources play a major role, the protection of biological resources will require concerted efforts by all levels of government and the private sector. NEPA addresses the effects of federal actions whether or not they involve federally managed lands or resources.

Chapter IV

Biodiversity in NEPA Analyses



Successful implementation of the principles of biodiversity management requires that they be effectively integrated into the NEPA process. The principles and approaches outlined in this report are intended to be sufficiently flexible to be considered in all aspects of environmental impact analysis under NEPA.

It is important to stress, however, that this report should **not** be interpreted as requiring that every NEPA document contain a perfunctory biodiversity section, whether or not there are likely impacts on biodiversity.

Determining the Appropriate Extent of Analysis

For any potential impact, including those on biodiversity, determining the extent and nature of analysis under NEPA involves consideration of both the context and intensity of likely effects. CEQ regulations state that, in environmental impact statements,

> [I]mpacts shall be discussed in proportion to their significance. There shall be only a brief discussion of other than significant issues. . . . [t]here should be only enough discussion to show why more study is not warranted. 40 CFR 1502.2(b)

In most cases, determination of the level of discussion on biological diversity should, as with all impacts, be made during the scoping process. While scoping is mandatory only for the preparation of EISs, some agencies, such as the U.S. Forest Service, find it valuable to engage in an appropriate level of scoping for actions subject to the preparation of environmental assessments. The scoping process should be used to identify whether biological diversity will be an important consideration in the environmental analysis, and

Implementation of the NEPA Process

Integrating environmental concepts into decisionmaking demands that the NEPA process start early in an agency's planning process. The CEQ regulations implementing NEPA require an agency to begin the preparation of a NEPA analysis as close as possible to the time the agency is developing or is presented with a proposal. NEPA analysis must not be a justification for a decision already made.

Each federal agency promulgates its own NEPA procedures, consistent with the CEQ regulations, which address how NEPA is to be applied to that agency's activities. Among other things, the agency procedures identify the appropriate level of environmental analysis required for the agency's normal activities. Actions which typically have a significant impact on the quality of the human environment require preparation of an EIS. Actions which may or may not have a significant environmental impact, depending upon the situation, are the subject of briefer documents known as environmental assessments (EAs). Agencies usually follow EAs by either a Finding of No Significant Impact (FONSI) or a decision to prepare an EIS. Actions which normally do not have, either individually or cumulatively, a significant environmental impact, are categorically excluded from NEPA documentation.

In NEPA analysis, the agency must fully consider the proposed action and its environmental consequences and all reasonable alternatives and their environmental consequences. The alternatives section is generally known as the "heart of the EIS."

Public participation is a critical element of the NEPA process. The process of preparing an EIS commences with the publication of a Notice of Intent which contains some basic information about the agency's proposal and set's forth the schedule for the agency's scoping process. Scoping involves interested federal, state and local agencies, private organizations, members of the public, and it applicable, the applicant. During the scoping process, the important issues for analysis is an EIS are identified, as well as other environmental review requirements. All members of the public, as well as interested agencies, are afforded at least a 45-day review and comment period upon publication of the draft EIS. The responsible lead federal agency must then respond to all substantive comments in the final EIS.

When an agency makes a decision on a proposal requiring an EIS, the agency must demonstrate that it has adequately considered environmental values by preparing a Record of Decision (ROD) no sooner than 30 days after publication of the final EIS. The ROD must state what the decision was, identify all alternatives considered by the agency in reaching its decision, specify the alternative which was considered to be environmentally preferable, and state whether all practicable means to avoid or minimize environmental harm from the selected alternative have been adopted and if not, why not.

also to allocate assignments for any special studies and analyses in that regard. Scoping is also the point at which an agency should determine which issues do not warrant further attention in the NEPA process.

Current NEPA Practice

The NEPA process has contributed significantly to the protection of biological resources. For example, agencies have evaluated the effects of their programs and projects on (1) threatened and endangered species, (2) sensitive habitats such as wetlands, and (3) protected areas such as parks and refuges. In many cases, NEPA analyses have helped protect these resources by identifying the need to avoid or otherwise mitigate the most serious impacts. At the same time, the focus on a limited set of statute-driven or regulation-driven elements (e.g., endangered species) has significantly lessened the ability of NEPA analyses to consider the full range of biodiversity issues.

Examples of the weaknesses found in current NEPA analyses are given in the box below. Such weaknesses result from a tendency to address only parts of the biodiversity problem (e.g., impacts to endangered species, wetlands, and preserves) or from a lack of effectiveness in conducting rigorous biological assessments. Current NEPA analyses often (1) focus on species, rather than ecosystems; (2) address the site scale, rather than the ecosystem or regional scale; and (3) concentrate on immediate short-term impacts, rather than likely future impacts. Because of these weaknesses, major impacts may be missed, as in the case of indirect effects arising from biodiversity components or interactions not considered in the assessment. For this reason, agencies would benefit from giving explicit consideration to biodiversity goals and strategies against which they can assess the impacts of their programs and projects.

Levels of Analysis and Decisionmaking

NEPA documents can address three scales of federal activity: the national, regional, and project levels. When agencies undertake NEPA analysis at any of these levels,

Examples of Weakness in Current NEPA Practice

• **Inadequate consideration of "non-listed" species**. Agencies should address the requirements of the Endangered Species Act in EISs and EAs. Certainly, impacts to threatened and endangered species directly affect biodiversity. However, only about 600 U.S. species are officially listed as threatened or endangered, which estimates indicate that as many as 9,000 species may currently be at risk. Reliance on listed threatened and endangered species is likely to address only a small portion of the nation's imperiled biodiversity.

• **Inadequate consideration of "non-protected" areas.** While NEPA documents may give adequate recognition to impacts on areas that have been set aside as parks or refuges, or are already identified as meriting special protection (e.g., wetlands), they often do not consider areas that have not been so designated, but that are equally important to biodiversity.

• **Inadequate consideration of "non-economically important" species.** The potential effects on species of recreational and comercial importance are also often considered. However, some practices intended to maximize protection or production of these species conflict with wider biodiversity objectives. For example, the impoundment of salt marshes to create waterfowl habitat can reduce estuarine biodiversity. The stocking of rainbow trout for sport and commercial fisheries has resulted in the replacement of wild brook trout in Appalachian streams, and the endangerment of native squawfish, chubs, and suckers in the Colorado River system. The creation of forest openings and edge habitat favoring game species is now recognized as causing severe impacts to interior forest-dwelling species.

• **Inadequate consideration of cumulative impacts.** Finally, and perhaps most importantly, the majority of EISs and environmental assessments deal only with project-specific considerations. If effects on biodiversity are to be adequately assessed, it must be done on an ecosystem or regional scale, taking into account cumulative effects. Avoidance or mitigation of impacts at the project level (such as redesigning a highway to avoid damaging a sensitive bog, or modifying a coal lease to protect a raptor nesting area) has been, and will continue to be, critically important in minimizing biodiversity losses. Yet, in the absence of protection at the larger scale, ecosystem patterns and processes so important to biodiversity will not be sustained over the long term.

they should consider whether the reduction in biodiversity is likely to be a relevant and significant issue. Not all federal actions subject to NEPA procedures will affect biodiversity. However, for actions where non-trivial impacts on biodiversity may occur, the responsible agency should address the impacts of the proposed action, each alternative action, and any mitigation measures.

National

Proposed agency policies, programs, and regulations can significantly affect biodiversity, and programmatic EISs can effectively consider these impacts. Agencies can assess whether a proposed program is likely to result in the widespread application of practices known to reduce diversity, or whether the activity encourages measures favorable to the protection of biodiversity. Programmatic EISs can be useful in estimating the total cumulative impact on biodiversity, especially where programs consist of a number of projects that individually may have insignificant effects on biodiversity. While such evaluations are necessarily general, they can result in policy that guides more specific consideration of biodiversity conservation in subsequent tiered, project-level analyses. Although the number of national programmatic EISs is relatively small, and the loss of biodiversity may not be a relevant issue for some, programmatic EISs for major new federal programs provide an invaluable opportunity for setting the framework through which an agency can evaluate and articulate policy guidance concerning biodiversity.

Regional

Analyses at the regional scale can most easily employ the principles of ecosystem management needed to protect biodiversity over the long term. The most obvious opportunities for the use of NEPA assessments to address biodiversity at this scale occur when the NEPA process is integrated into the planning process of an agency responsible for managing large areas of public land or waters. Examples have been cited of the management plans and associated environmental impact statements being prepared by the U.S. Forest Service and the Bureau of Land Management.

U.S. Forest Service Northern Goshawk Guidelines [17]

Possible declining populations and reproduction of the goshawk, a forest habitat generalist, in western North Amerca has been associated with tree harvests, as well as other factors. This prompted the U.S. Forest Service to prepare *Management Recommendations for the Northern Goshawk in the Southwestern United States* (August 1992). These guidelines, for which no NEPA analysis has been conducted, will be used to develop national forest plans in the 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.

The study emphasizes that both a large-scale geographic approach and an ecosystem perspective are necessary for managing a wide-ranging high-level predator such as the goshawk. The Northern Goshawk Scientific Committee (GSC) established by the U.S. Forest Service developed a set of "desired forest conditions" estimated to sustain goshawk populations in the Southwestern Region. Declining goshawk numbers have been attributed to the effects of human influence in these forests, including loss of a herbaceous and shrubby understory, reduction in the amount of older forests, and increased areas of dense tree regeneration. Key objectives of the GSC guidelines are to provide (1) nesting, post-fledging, and foraging areas for goshawks, and (2) habitat to support abundant populations of 14 primary goshawk prey. An important goal is to dampen extreme fluctuations of goshawk populations caused by fluctuations in prey abundance by providing for a wider variety of prey species. Therefore, the "desired forest conditions" include maintenance of specific habitat attributes utilized by important prey species, such as snags, downed logs, woody debris, large trees, openings, herbaceous and shrubby understories, and an intermixture of various forest vegetation structural stages. Management prescriptions include thinning trees in the understory, creating small openings, and conducting controlled burns to meet the desired forest conditions. Because of the need to manage for a wide variety of species to sustain goshawk populations, the GSC used a landscape ecology approach that considers habitats and food chains for many wildlife species. The approach also provides for other elements of a functioning ecosystem—recurring fires, productive soils, forest productivity and health, genetic diversity, woody debris, large snags and downed logs, microorganisms, invertebrates, and vertebrates. These recommendations represent a shift from single-species and stand-level management to management of ecosystems and they are, in essence, recommendations for maintaining biodiversity, that will, at the same time, maintain healthy, productive forests relatively safe from catastrophic fires and pests.

Federal land management plans are not the only opportunities for addressing biodiversity on a regional scale. For example, a number of agencies have prepared regional programmatic EISs for federal leasing or regulatory actions. Typical examples are Minerals Management Service EISs for oil and gas leasing, Bureau of Land Management regional coal leasing EISs, and Federal Energy Regulatory Commission hydropower licensing and relicensing EISs. Federal water resource development and management plans, developed for entire watersheds or river basins, and fisheries management plans for marine areas also afford important opportunities to incorporate biodiversity concerns into NEPA analyses at a regional scale.

It is both ineffective and inefficient for multiple individual agencies to duplicate the task of describing the biota and ecosystem processes of the same geographic area for the purposes of environmental analysis.

A more effective and less costly approach would be for several agencies to pool resources and information to describe the biological resources of the affected environment on a regional or ecosystem scale. Such coordinated efforts can provide input to planning and analysis for all participating agencies. NEPA is sufficiently flexible to allow for various configurations in developing such regional frameworks, and agencies should be innovative in pursuing such opportunities.

Site-Specific

Most NEPA analyses are prepared for individual projects. Therefore, it is critical that federal agencies develop the capabilities to evaluate project-level activities within the context of clearly defined regional biodiversity goals. As a first step, agencies can strengthen the evaluation of biodiversity in their project-specific EISs and EAs by applying the general principles set forth in this report. As a second step, information from projects of the same general type can be assembled to provide more specific guidelines on likely biodiversity impacts.

Agencies need to consider the bigger picture when assessing the effects of individual actions. The cumulative and indirect impacts of individual projects should be evaluated in the regional or ecosystem context. Agencies should carefully consider whether regional resource management plans or analyses already exist that will enable them to evaluate the effects of their individual projects within a broader, regional perspective.

Even in the absence of regional plans that include biodiversity goals, efforts should be made to identify any specific ecosystems, communities, or species that are particularly jeopardized within the geographic region in question. There are losses of special concern in almost every ecoregion, such as bottomlands hardwoods, old-growth forest, wetlands, free-flowing streams, and native prairie. Identification of these problems through scoping, review of existing literature and databases (such as the Natural Heritage Network), and querying experts is an important step in placing project-specific losses in an ecosystem context. In some cases, state or regional studies of biodiversity can help provide this bigger picture.

Components of NEPA Analysis

Throughout the NEPA process, the general principles outlined in this report can be applied. Specifically, agencies can incorporate biodiversity considerations into each step of their NEPA analyses: scoping, analysis, mitigation, and monitoring.

Scoping

During the scoping process, the lead agency should determine whether the proposed action may affect biodiversity. If so, the agency can begin to identify sources of information on the distribution and characteristics of potentially affected species, communities, and ecosystems to establish a baseline of existing biodiversity conditions. The characterization of ecological resources also facilitates the development of an ecosystem framework for further data gathering and subsequent analysis of potential project impacts. Included in the development of the ecosystem framework is the identification of ecological goals and objectives. The lead agency also can ask other agencies with special expertise or jurisdiction by law to be cooperating agencies and to prepare portions of the EIS.

It is important that information be collected on the distribution and status of entire ecosystems or habitats that could be impacted by the proposed action. Assessment of potential impacts at the ecosystem level will aid in the protection of the majority of the animals, plants, and microorganisms. Information on species populations and communities that are rare, sensitive, or otherwise in need of special protection (e.g., small, endemic populations confined to localized areas) is essential as well.

Many agencies already possess substantial natural resource information. Others are conducting new research or entering cooperative arrangements to increase their data sources. In addition, nongovernmental and academic institutions can provide a wealth of useful information. As previously stated, clear benefits are to be gained from sharing expertise, technical capabilities, and information, leading to improved environmental decisionmaking. Agencies need not sponsor regional ecosystem planning efforts to benefit from them, and those agencies whose primary mission does not involve natural resource management can nonetheless make good use of existing efforts sponsored by other agencies or organizations.

Analysis of Impacts

Once the necessary background information has been obtained, the potential direct, indirect, and cumulative impacts on biodiversity of each of the proposed actions and alternatives can be determined. This task requires the careful evaluation of the effects of the proposed action on attaining ecological goals and objectives. Biodiversity analyses should consider both the factors contributing to loss of biodiversity discussed in Chapter I of this report and the general principles for conserving biodiversity presented in Chapter II. A wide range of techniques can be used to evaluate these ecological impacts including checklists, matrices, mathematical models, and cartographic displays. No one technique is suitable for all situations.

Agencies seeking to consider biodiversity in their project-level environmental analyses must address the same problems faced in other cumulative impact analyses. A basic problem is the disparity between administrative and ecological boundaries, that is, differences between the scope of the project decision and the scale of potential impacts in both time and space. There are also difficulties in estimating possible future actions on the same resource, and the additive or synergistic effects of multiple stresses. This report suggests a number of ways in which agencies can seek to establish a broader, ecosystem context to help address this issue.

For many situations, assessment of cumulative impacts on the regional scale, which is so important to understanding threats to biodiversity, poses major difficulties. Frequently the region-specific data necessary for such assessments are lacking, particularly within the time and resource constraints often involved in preparing environmental analyses. This emphasizes the need for federal agencies to cooperate in developing regional baseline information. Even for small projects, it should always be the objective of the environmental document to analyze impacts at the largest relevant scale, based on the affected resources and expected impacts.

Mitigation

Appropriate mitigation measures should be identified in response to potential impacts on biodiversity. Mitigation measures should be developed within the ecosystem framework and should consider the possible impacts of the mitigation itself. Agencies may identify measures through the NEPA process that can be implemented through direct management of federal lands and resources, or through the use of regulatory authority, economic incentives, and other mechanisms.

Monitoring

Monitoring is essential to understanding the effects of a project. It is likewise critical to evaluating the degree of implementation and success or failure of mitigation efforts. Effects observed through monitoring can help modify project management or improve future decisionmaking on projects with similar impacts, or in similar areas. It is unlikely that adequate information on project effects and mitigation implementation and success will be obtained unless it is provided for in the monitoring program

Many of the elements necessary for adequate monitoring will have been developed as part of project planning and environmental analysis. These include the following[18]:

- Gathering data.
- Establishing baseline conditions.
- Identifying ecological elements at risk.
- Selecting ecological goals and objectives.
- Predicting likely project impacts.
- Establishing the objectives of mitigation.

The following additional monitoring-specific steps can build upon these elements:

- Formulate specific questions to be answered by monitoring.
- Select indicators.
- Identify control areas/treatments.
- Design and implement monitoring.
- Confirm relationships between indicators and goals and objectives.
- Analyze trends and recommend changes to management.

The breadth and specificity of the monitoring program will be determined by the biodiversity goals and objectives established as part of project planning and environmental analysis.

Obstacles

As the steps required to attain biodiversity goals and objectives become better defined, a number of obstacles emerge. Science, institutional behavior, and policy and decisionmaking processes may pose challenges that, at least for the present, can hinder agencies' ability to fully embrace and implement policies, procedures, and activities that would enhance the conservation of biological diversity.

Lack of recognition of the issue.

Managers and analysts may not be familiar with the concept of biodiversity, understand its importance, or recognize the fact that there are practical steps that may be taken to incorporate it into planning, analysis, and decisionmaking.

Lack of information.

There are major gaps in knowledge concerning the status and distribution of biota and ecosystems in the United States.

Lack of awareness of existing information.

Valuable information that has been collected may be effectively unavailable because its existence is not widely known or because it has not been organized or made readily accessible. While real gaps do exist, there is a wealth of valuable information in federal, state, and local agencies, nongovernmental organizations, and academic institutions.

Lack of understanding.

Incomplete understanding of certain conceptual and practical aspects of ecosystem management and biodiversity conservation can serve as a barrier to greater incorporation of these issues into decisionmaking. There is much to be learned concerning how ecosystems function. There is a lack of overall consensus about the selection and assessment of ecological indicators. Improvements in predicting the effects of stress on ecosystems are needed, as are better general methods for establishing the spatial and temporal boundaries of impacts and analyses.

Disparity between administrative and ecological boundaries.

Agency jurisdictional boundaries rarely conform to ecological boundaries. Consequently, there are often differences between the scope of a project decision and the scale of potential impacts in both time and space. This problem tends to reveal itself in inadequate analyses of indirect and cumulative impacts.

Institutional infrastructure.

Separate jurisdictions, differing missions, and compartmentalization of disciplines within and among agencies make it very difficult to establish an ecosystem-based approach to protecting or conserving biological diversity. For the most part, agencies (and units within them) are not organized, formally or informally, around an ecosystem model. There is little experience in bringing together the necessary components for successful ecosystem approaches such as expertise, information, technical capabilities, and appropriate mandates.

Absence of regional ecosystem plans.

A real need exists for cohesive regional ecosystem plans and strategies that provide specific biodiversity goals and objectives against which the impacts of proposed activities can be assessed. Such plans would serve as focal points around which government agencies at all levels could coordinate their activities in an effective, efficient, and non-redundant manner.

Despite several examples, such plans are, at present, much more the exception than the rule (see the box on p. 9). The process of developing interagency, intergovernmental, or public-private relationships to gather information and address concerns across such boundaries can be initially time-consuming and costly, despite both the need and the potential for making better and more efficient decisions.

Finding ways to stem current losses of biodiversity raises many complex science and policy questions. There are no easy answers. However, the challenges and obstacles discussed here do not preclude serious consideration of biodiversity in NEPA analyses within existing institutional arrangements and with presently available information.

Chapter V

Recommendations for Improving Consideration of Biodiversity in NEPA Analyses

RECOMMENDATIONS FOR IMPROVING CONSIDERATION OF BIODIVERSITY IN NEPA ANALYSES

This report summarizes an important body of current ecological thinking on biodiversity conservation. It also describes a framework and general principles for considering, under NEPA, the effects of federal actions on biodiversity. Practical approaches to biodiversity conservation are continuing to evolve rapidly. CEQ will continue to monitor progress in this field.

The National Environmental Policy Act (NEPA) provides a mandate and a framework for federal agencies to consider all reasonably foreseeable environmental effects of their actions. To the extent that federal actions affect biodiversity, and that it is possible to both anticipate and evaluate those effects, NEPA requires federal agencies to do so.

The basic conclusion to draw from this report is that conceptual frameworks, analytical tools and information are currently available to support such analysis.** A few agencies have already made progress in doing so; others have not yet begun to address the issue.

1. Acknowledge the conservation of biodiversity as national policy and incorporate its consideration in the NEPA process.

Agencies should ensure that both staff responsible for conducting environmental impact analyses and decision-makers responsible for considering the findings of those analyses are familiar with the importance of the biodiversity issue and its relevance to their work. Agency-sponsored environmental training courses should discuss biodiversity and how best to consider it in the NEPA process and in all planning, design, and management.

2. Encourage and seek out opportunities to participate in efforts to develop regional ecosystem plans.

Regional ecosystem frameworks are a critical element of conserving biological diversity. Such regional efforts can provide an ecosystem framework for evaluating the impacts of individual projects on biodiversity, and provide a common basis for describing the affected environment. Both will save time and financial resources in preparing NEPA documents.

Agencies should investigate and consider participation in efforts that may be already in progress in areas where they have jurisdiction or interest.

Some regional frameworks exist that do not explicitly address biodiversity. In such cases, agencies should consider establishing specific goals and objectives for the conservation of biodiversity, within those frameworks.

Finally, where such efforts are lacking entirely, agencies should consider initiating them.

3. Actively seek relevant information from sources both within and outside government agencies.

While information on the status and distribution of biota is incomplete, a great deal of information is available from a wide variety of sources. Agencies should look to each other, to state agencies, and to academic and other non-governmental entities. By doing so, agencies can benefit from the resources and technical capabilities of others and reduce the costs associated with collecting and managing information on which ecosystem and biodiversity analyses depend.

4. Encourage and participate in efforts to improve communication, cooperation, and collaboration between and among governmental and non-governmental entities.

Improved communication, cooperation, and collaboration will enormously improve the prospects for overcoming the barriers described earlier. Working with others can help to identify common interests and overlapping or complementary missions, and can lead to mutual sharing of information, technical capabilities, and expertise. Efforts to do so will require support at the management and policy-making levels within agencies, as well as at the level of the staff responsible for carrying out NEPA analyses.

Such efforts also can enable agencies to focus their research and data collection efforts on real information gaps rather than duplicating the efforts of others. The inventory and analysis being undertaken by the Federal Coordinating Council on Science, Engineering, and Technology's Subcommittee on Environmental Biology will improve communication concerning biodiversity research and reduce duplication.

** CEQ regulations at 40 CFR 1502.22 provide a framework for agencies to proceed when faced with incomplete or unavailable information.
*** The Federal Coordinating committee on Science, Engineering and Technology (FCCSET) is coordinated by Office of Science and Technology Policy (OSTP) within the Executive Office of the President

5. **Improve the availability of information on the status and distribution of biodiversity, and on techniques for managing and restoring it.**

Agencies that support or sponsor research and development efforts that will improve our ability to evaluate and manage for biodiversity should ensure that the information they obtain is maintained in a format that is useful and is readily accessible.

Agencies should consider opportunities to cooperate with and benefit from the National Biodiversity Center, presently in the planning and design stages. A key role of the Center will be to identify existing ecological information and make it more readily available for use in environmental planning and assessment.

6. **Expand the information base on which biodiversity analyses and management decisions are based.**

Basic research is needed into a host of issues relating to both ecosystem management and biodiversity conservation. These include ecosystem functioning; selection of indicators; prediction of the effects of change on ecosystems; and establishment of spatial and temporal boundaries for impacts and analyses.

Agencies should recognize the research opportunities afforded by projects, and consider sponsoring or cooperating with academic institutions, private industry, and others on research to advance ecological understanding.

Appendices and References

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The report was reviewed in draft by a group of distinguished individuals with recognized expertise in the relevant areas of science and policy. The reviewers provided valuable input and suggestions for revisions, but bear no responsibility for the final product.

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Examples of Biodiversity Indicator Variables

Indicator variables for inventorying, monitoring, and assessing terrestrial biodiversity at four levels of organization, including compositional, structural, and functional components; Also includes a sampling of inventory and monitoring tools and techniques.

	Indicators			
	Composition	**Structure**	**Function**	**Inventory and Monitoring Tools**
Regional Landscape	Identity, distribution, richness, and proportions of patch (habitat) types and multipatch landscape types; collective patterns of species distributions (richness, endemism)	Heterogeneity; connectivity; spatial linkage; patchiness; porosity; contrast; grain size; fragmentation; configuration; juxtaposition; patch size frequency distribution; perimeter-area ratio; pattern of habitat layer distribution	Disturbance processes (areal extent, frequency, or return interval, rotation period, predictability, intensity, severity, seasonality); nutrient cycling rates; energy flow rates; patch persistence and turnover rates; rates of erosion and geomorphic and hydrologic processes; human land-use trends	Aerial photographs (satellite and conventional aircraft) and other remote sensing data; Geographic Information System (GIS) technology; time series analysis; spatial statistics, mathematical indices (of pattern, heterogeneity, connectivity, layering, diversity, edge, morphology, autocorrelation, fractal dimension)
Community-Ecosystem	Identity, relative abundance, frequency, richness, evenness, and diversity of species and guilds; proportions of endemic, exotic, threatened, and endangered species; dominance-diversity curves; life-form proportions; similarity coefficients; C4:C3 plant species ratios	Substrate and soil variables; slope and aspect; vegetation biomass and physiognomy; foliage density and layering; horizontal patchiness; canopy openness and gap proportions; abundance, density, and distribution of key physical features (e.g., cliffs, outcrops, sinks) and structural elements (snags, down logs); water and resource (e.g., mast) availability; snow cover	Biomass and resource productivity; herbivory, parasitism, and predation rates; colonization and local extinction rates; patch dynamics (fine-scale disturbance processes), nutrient cycling rates; human intrusion rates and intensities	Aerial photographs and other remote sensing data; ground-level photo stations; time series analysis; physical habitat measures and resource inventories; habitat suitability indices (HSI, multispecies); observations, censuses and inventories, captures, and other sampling methodologies; mathematical indices (e.g., of diversity, heterogeneity, layering dispersion, biotic integrity)
Population-Species	Absolute or relative abundance; frequency; importance or cover value; biomass; density	Dispersion (microdistribution); range (macrodistribution); population structure (sex ratio, age ratio); habitat variables (see community-ecosystem structure, above); within-individual morphological variability	Demographic processes (fertility, recruitment rate, survivorship, mortality); metapopulation dynamics; population genetics (see below); population fluctuations; physiology; life history; phenology; growth rate (of individuals); acclimation; adaptation	Censuses (observations, counts, captures, signs, radio-tracking); remote sensing; habitat suitability index (HSI); species-habitat modeling; population viability analysis
Generic	Allelic diversity; presence of particular rare alleles, deleterious recessives, or karyotypic variants	Census and effective population size; heterozygosity; chromosomal or phenotypic polymorphism; generation overlap; heritability	Inbreeding depression; outbreeding rate; rate of genetic drift; gene flow; mutation rate; selection intensity	Electrophoresis; karyotypic analysis; DNA sequencing; offspring-parent regression; sib analysis morphological analysis

Source: Noss, R.F. 1990. Indicators for Monitoring Biodiverstiy: A Hierarchical Approach. *Conservation Biology*. 4(4):355-364

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