1990 CEQ Annual Report: Chapter Four

Linking Ecosystems and Biodiversity

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Lead-in

In his 1940s conservation classic, *A Sand County Almanac*,[1] the American forester and ecologist Aldo Leopold memorialized those early settlers who grew hay in meadows adjoining Wisconsin marshes:

> Man and beast, plant and soil lived on and with each other in mutual toleration, to the mutual benefit of all. The marsh might have kept on producing hay and prairie chickens, deer and muskrat, crane music and cranberries forever.

But the next wave of settlers began to drain and fill the marshes:

> They did not include soil, plants, or birds in their ideas of mutuality. The dividends of such a balanced economy were too modest. They envisioned farms not only around, but *in* the marsh.

The Sand County farms failed, the prairie chickens died out, and the cranes are today endangered.

I. Introduction

Plant and animal communities, such as Leopold's crane marshes, are valuable national assets. Managing such communities as integral parts of functional ecosystems may be the most efficient--and cost-effective--way to assure survival for cranes and thousands of other U.S. species currently at risk. The long-term wellbeing of ecosystems can be ignored only at a nation's great peril. Domestically and worldwide, it is a healthy environment that makes wealth possible. And ecosystems--the functional units formed by plant and animal communities as they interact with their physical environment[2]--are the key to ecological health.

Since the first settlers began clearing the wilderness, conversion of undeveloped lands to human use has been a part of American culture. Beginning with Yosemite and Yellowstone in the last century, the United States has set aside more and more areas to preserve America's natural heritage, but scientists now recognize that ecological health depends on maintaining a diversity of living forms on developed lands as well. The current task is to manage not only scenic set-asides, but the larger regional ecosystems that such sites occupy along with developed areas. By using natural or semi-natural areas as models to understand how ecosystems function, the nation can ensure that human actions remain compatible with ecological health.

With new knowledge about ecosystems, the nation is moving from managing isolated fragments of the landscape toward an ecological

treatment of the whole. Viewing the American landscape as an intricate pattern woven from a diversity of living forms--with developed and undeveloped areas intertwined--will help meet the needs of humans and of other species on which humans ultimately depend.

Biodiversity encompasses not only the variety of distinct species and the genetic variability within them, but also the ecosystems they inhabit.[3] Changing the thinking of the nation on the place of biodiversity in the U.S. landscape will involve tradeoffs and adjustments. But policies that encourage humans to maintain biodiversity across the U.S. landscape will sustain ecosystems that in turn sustain the human species. The issue of biodiversity is that simple, and its loss can be that devastating.

The United States is a leader among nations in numbers of plant and animal community types--from tropical rainforests in Hawaii and Puerto Rico to freshwater marshes in the Midwest to arctic tundras in Alaska.[4] Today, however, the biological wealth of the United States is in decline, as is such wealth in other nations. Loss of biodiversity is thus both a domestic and a global concern. The United States can continue its tradition as a world leader in conservation by demonstrating a commitment to biodiversity at home as well as abroad.

This chapter focuses on the nature and value of biodiversity. It also explores how ecosystem management can help fulfill the diversity mandates of the National Environmental Policy Act (NEPA)

and other U.S. laws written to assure a healthy and functioning environment.

A. Loss of Biodiversity--A Domestic Concern

Mass extinctions of species and destruction of ecosystems are not problems restricted to the Tropics. A close-up look at U.S. plant and animal communities reveals the following somber facts:

- In the nearly 500 years since Columbus sailed to the New World, approximately 500 plant and animal species are known to have become extinct.[5] Today that rate--already unnaturally high--is rapidly accelerating.

- The U.S. Fish and Wildlife Service and the National Marine Fisheries Service currently list nearly 600 U.S. plant and animal species as threatened or endangered, and another 4,000 species await consideration (see Table 4-1). Within the past decade, at least 34 species have become extinct while being considered for federal protection. Other estimates place the number of plants alone facing extinction within the next decade at 700.[6]

- A recent 50-state inventory suggests that a total of 9,000 U.S. species may be currently at risk.[7] The problem is national in scope, with every region of the country reporting losses of native species (see Table 4-2). More than species are being lost. Whole plant and animal communities--integrated, resilient systems--are threatened.

- Hawaii, California, Texas, and Florida--the nation's most biodiverse states--are all experiencing declines. In Texas, nearly

one-third of the plant and animal communities recently inventoried are at risk; as are over one-fifth of such communities in California and nearly half in Florida. Hawaii faces the loss of over half of its natural communities.[8]

o Old-growth forests and tallgrass prairies--two diverse and resilient communities that once dominated the U.S. landscape --survive now only in isolated fragments.[9]

o The ecological health of the Florida Everglades is in jeopardy (see Everglades Case Study).

o The lower 48 states have lost more than half of their wetlands to conversion and construction, with seven states losing more than 80 percent of original wetlands.[10]

o Polluted sediments from rural and urban runoff are degrading vital U.S. watersheds such as the Chesapeake, where striped bass and American shad are reduced and aquatic vegetation is restricted to a fraction of its original range.[11]

o Commercial landings of fish and shellfish along Southeastern coasts have decreased by 42 percent since 1982, and between 1972 and 1988, habitat destruction and incidental bycatch reduced bottomfish levels in the Gulf of Mexico by 75 percent.[12]

o The Southeast is losing not just species but whole groups of freshwater mussels that serve as key elements in aquatic food chains.[13]

o Populations of estuarine-dependent fish species off U.S. coasts are at an all-time low, and 30 percent of the freshwater

Table 4-1.--Federal listings,* recovery plans, and critical habitats for threatened and endangered U.S. plant and animal species plus candidate species, 1990.

Category	Endangered	Threatened	Total	Species with recovery plans
Mammals	53	8	61	29
Birds	74	11	85	69
Reptiles	16	17	33	25
Amphibians	6	5	11	6
Fishes	54	33	87	44
Snails	3	6	9	7
Clams	37	2	39	29
Crustaceans	8	2	10	5
Insects	11	9	20	12
Arachnids	3	0	3	0
Plants	179	60	239	120
Total	444	153	596**	351***

Total endangered U.S. species	443	(265 animals, 179 plants)
Total threatened U.S. species	153	(93 animals, 60 plants)
Total listed U.S. species	596	(358 animals, 239 plants)
Total U.S. species with designated critical habitats	108	(83 animals, 25 plants)
Total candidate species	3,700	(1,600 animals, 2,100 plants)

* Maintained by the U.S. Department of the Interior, Fish and Wildlife Service, and the U.S. Department of Commerce, NOAA National Marine Fisheries Service, in compliance with the Endangered Species Act.

** Separate populations of the following species listed both as endangered and threatened are tallied twice: gray wolf, grizzly bear, bald eagle, piping plover, roseate tern, green sea turtle, and olive ridley sea turtle. For purposes of the Endangered Species Act, the term "species" can mean a species, subspecies, or distinct vertebrate population. Several entries also represent entire genera or even families.

*** Of the 276 approved recovery plans, some cover more than one species, and a few species have separate plans covering different parts of their ranges.

Source: Department of the Interior, U.S. Fish and Wildlife Service, Endangered Species Technical Bulletin 15(11):16 (November 1990).

fish in North America, north of Mexico, are considered at risk.[14]

o Waterfowl populations have declined by 30 percent overall since 1969; and mallards and pintails, while not federally listed as threatened or endangered, are down by half or more since mid-century.[15] In 1990 the U.S. Fish and Wildlife Service designated Florida's dusky seaside sparrow as an extinct species. This wetlands-dependent bird was a victim of pastureland conversions.

o Among the many U.S. bird species experiencing sharp population declines or local extinctions are Kentucky warblers, wood thrushes, and scarlet tanagers. The global aspect of biodiversity becomes evident, as birds that summer in the United States lose their winter habitats in the Caribbean or Central America. Fragmentation of U.S. habitats and related effects are also major factors in the decline of songbirds.[16]

At the same time that development raises the standard of living, it can contribute to a biosimplification capable of threatening that very standard. No nation can afford to lose its biological wealth--that panoply of individual species, of genetic variation within species, and of distinct physical settings each with its own complement of biota.[17] The declines described above are indicators of malfunctioning ecosystems that bode ill for the nation and for the world.

Table 4-2.--Top 20 U.S. threatened and endangered animal species and top 20 plant species in order of federal and state expenditures* for recovery, 1989.

Species	Status	Historic U.S. Range
Animals		
1. Bald eagle	E,T	43 states
2. Brown or grizzly bears	T	48 states
3. Red-cockaded woodpecker	E	South
4. American peregrine falcon	E	Alaska, West
5. Gray wolf	E,T	47 states
6. Whooping crane	E	Rocky Mountains to North Carolina and South Carolina
7. Southern sea otter	T	Washington, Oregon, and California
8. Florida manatee	E	Southeast
9. Black-footed ferret	E	West
10. Piping plover	E	Great Lakes to Caribbean
11. Kirtland's warbler	E	West Indies
12. Least Bell's vireo	E	California
13. Florida panther	E	Louisiana-Arkansas and East to South Carolina-Florida
14. Puerto Rican parrot	E	Puerto Rico
15. California condor	E	Oregon and California
16. Humpback chub	E	West
17. Mississippi sandhill crane	E	Mississippi
18. Colorado River squawfish	E	West
19. Bonytail chub	E	West
20. Atlantic ridley sea turtle	E	East Coast

Note: E=endangered, T=threatened.
* For the top 20 animal species, recovery expenditures ranged from $750,000 to $3 million per species; for the top 20 plants, the range was from $19,000 to $1 million per species.

Table 4-2.--Continued.

Species	Status	Historic U.S. Range
Plants		
1. Tumamoc globe-berry	E	Arizona
2. Western prairie fringed orchid	T	Midwest
3. Northern wild monkshood	T	Iowa, Wisconsin, Ohio, and New York
4. Eastern prairie fringed orchid	T	Midwest, Virginia, Pennsylvania, New Jersey, New York, and Maine
5. Prairie bush-clover	T	Iowa, Illinois, Minnesota, and Wisconsin
6. Aleutian shield-fern	E	Alaska
7. Missouri bladderpod	E	Missouri
8. Blowout penstemon	E	Nebraska
9. Arizona cliffrose	E	Arizona
10. Santa Ana River woolly-star	E	California
11. Minnesota trout lily	E	Minnesota
12. Todson's pennyroyal	E	New Mexico
13. Rhizome fleabane	T	New Mexico
14. Texas bitterweed	E	Texas
15. Mesa Verde cactus	T	Colorado and New Mexico
16. Palmate-bracted bird's beak	E	California
17. Large-flowered fiddleneck	E	California
18. Slender-horned spineflower	E	California
19. Knowlton cactus	E	Colorado and New Mexico
20. Swamp pink	T	Georgia to New York

Source: U.S. Department of the Interior, Fish and Wildlife Service, *Federal and State Endangered Species Expenditures: Fiscal Year 1989*, (Washington, DC: DOI Fish and Wildlife Service, 1990).

B. An Emerging Solution--Ecosystem Management

Natural resource management, even where piecemeal, has slowed the degradation of ecosystems, and the Endangered Species Act has rescued some species from extinction, but the loss of biodiversity continues. A vigorous response to the decline of individual species--based on the Endangered Species Act--remains essential, but the nation also needs new strategies to protect natural communities and U.S. biodiversity.

One such strategy is to manage sites not as isolated parcels but as part of a larger ecosystem. Such management considers the impacts of human actions on multiple scales--for instance, on an immediate site, within a larger ecosystem, and across a larger yet region of the country (see Figure 4-3). Public agencies are exploring this approach, as are conservation groups and private industries (see Private Lands Case Study). Increasingly natural resource managers are coming to view heavily altered, semi-natural, and natural areas as interdependent parts of large regional ecosystems.

Ecosystem management strives to maintain the integrity of the basic ecological unit. Piecemeal management--ignoring the interdependence of parts of an ecosystem separated by political boundaries or by lines of land ownership--can lead to environmental decline and biological impoverishment.

This phenomenon is occurring not only on lands open to development, but in America's most cherished protected areas. An

Case Study
The Florida Everglades: A Divided and Endangered Ecosystem

The Everglades is a prime example of the need to manage an ecosystem as a functional unit to maintain the integrity of its various parts. The freshwater swamp, located at the southern tip of the Florida peninsula, stands last in line in a 250-mile long watershed whose headwaters rise in the central part of the state. The Everglades has been subject to manipulation that has diminished and polluted waterflow, threatening plant and animal species and the future of the swamp itself. Conversion of land and diversion of water--without considering downstream consequences--has led to a malfunctioning of the entire ecosystem.

The watershed begins south of Orlando in a series of spring-fed lakes that drain into the Kissimmee River, which originally meandered 100 miles through marshland to the vast shallow Lake Okeechobee. Periodic lake overflow sent a 50-mile-wide sheet of water seeping through the Everglades, which originally began on the southern banks of the lake. Before the turn of the century, developers began draining the swamp, and farmers were soon calling the muck soil "black gold" for its high yields of sugarcane and vegetables.[18]

With more of the swamp disappearing each year, conservationists led by Marjorie Stoneman Douglas called for preservation of the remaining wilderness, and in 1947, the Everglades National Park was dedicated. The state set aside acreage between the park and the lake as water conservation areas. Throughout this century, increasing population pressure brought increased demands for flood control. Canals and levees were built to divert water from now-settled areas, and in 1961 the Corps began a project to replace the Kissimmee River with a wide straight canal. Flood protection encouraged additional development.

Runoff from new farms and pastures in the area added nutrients and other pollutants, and without marshlands to act as filters, the runoff flowed directly into Lake Okeechobee. When excess nutrients began to cause algal blooms in the lake, the state diverted water, which eventually reached wildlife refuges and the national park. In 1988 the U.S. Fish and Wildlife Service and the National Park Service sued the state over resulting environmental damage. The state has countersued. Meanwhile severe droughts have added to wildlife declines in the Everglades.

As Florida's population continues to grow, so does the interdependence of people and parks. A regional ecosystem view, including such efforts as reflooding the Kissimmee's former riverbeds and wetlands to restore the hydrological cycle and the purchase by the federal government of 106,000 additional acres for Everglades National Park, may help restore the ecological stability upon which the prosperity of the state depends.

example is the Great Smoky Mountains National Park, renowned for the biological richness of its forests and other plant communities --but today under siege. European wild boars, escaped from a private game preserve, have invaded the park and are damaging the forest understory and displacing native species. Further, the park is home to a healthy breeding population of black bears, but when the bears venture outside the protected boundaries, they are subject to intense hunting pressure that could threaten the population.

Park managers may confer with state officials on such management techniques as hunting seasons and licenses, but they have lacked a mechanism that would allow cooperative management of the regional ecosystem in which the park is located. This situation is changing. In 1988 Great Smoky Mountains National Park joined with other federal agencies to form the Southern Appalachian Man and the Biosphere Cooperative (see Table 4-4). Within a general zone of cooperation (Figure 4-1), public and private land and water managers can now share in joint decisionmaking on an ecosystem scale. For example, they plan to reintroduce the locally extinct red wolf, whose diet will likely include young wild boar. Reintroduction of a predator with an extensive home range would not be possible without the cooperation of all natural resource managers in the ecosystem.

Today scientists, policymakers, regulators, and natural resource managers are recognizing that managing isolated parts of

an ecosystem is ineffective. In response they are advocating cooperative management of regional ecosystems by public and private partners. Their motivation is clear:

o **Neither public lands nor protected areas alone can maintain biodiversity.**[19] Public lands constitute a third of the total land base in the United States, but many plant and animal community types are still not adequately represented,[20] and those that are do not necessarily have protected status. Even within protected areas, such as national parks and wildernesses, management can not be effective without considering the interactions between protected and multiple-use areas--public and private. Until biodiversity becomes a recognized value across large regional ecosystems, biosimplification will proceed.

o **Development is reaching the borders of protected areas.** In the past, undeveloped land surrounded many of the nation's parks and preserves, and thus entire ecosystems remained undisturbed. Today many protected areas are becoming isolated nature islands in a sea of development.

o **Piecemeal environmental management does not adequately protect ecosystems.** Separate government programs address land use, non-point source pollution, major point sources, wetlands, and a host of other environmental concerns. Failure to integrate such programs makes it difficult for land and water managers to achieve their goals.

Arguments that the nation must manage lands and waters both

for human needs and for those of other species are compelling. As plant and animal communities interact, they form diverse, stable, and resilient ecosystems that provide a sustained flow of beneficial services. Intensively managed systems, such as agriculture and forestry, can simplify the biota of a site. They can also be costly to maintain and subject to collapse under environmental stress, yet the nation depends on them. A landscape view of biodiversity can accommodate a range of land uses, including intensive management. Regional approaches that recognize the continuous interactions between altered and natural areas can help maintain biodiversity.

For many years now Congress has recognized the value of diversity and the critical role of ecosystems. The National Environmental Policy Act of 1969 (NEPA) provides the broadest such mandate, by requiring that the federal government "maintain, wherever possible, an environment which supports diversity..."[21]

In addition to NEPA, 28 other federal laws relate to maintaining diversity[22] and a host of others to conserving ecosystems. Among these are the following three examples:

o The Endangered Species Act of 1973 includes in its purpose "to provide a means whereby the ecosystems upon which endangered species and threatened species depend may be conserved...."[23]

o The National Forest Management Act of 1976 requires that management plans for the national forests "provide for diversity

of plant and animal communities,"[24] and

o The Surface Mining Control and Reclamation Act of 1977 states that mining operations shall "establish ... a diverse, effective, permanent vegetation cover of the same seasonal variety native to the area of land to be affected."[25]

II. Diversity, Ecosystems, and Biological Health

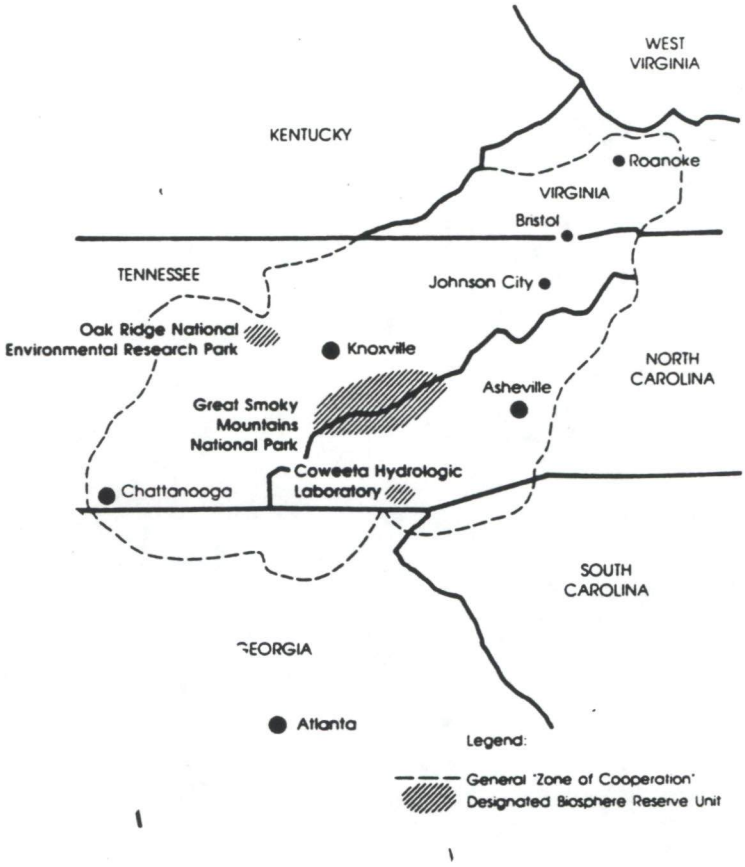
In the 1960s as scientists studied the growing problems of pollution, their respect for the resilience of natural plant and animal communities increased. They began to seek ways for humans to benefit from such communities without destroying them--for ways to use natural resources to meet human needs without disrupting the basic functioning of ecosystems. In this effort, ecologists have studied the interactions within plant and animal communities and between such communities and the environment. They have identified the diversity of living forms that facilitates these interactions across a range of scales:

o **Genetic Diversity.** Variation occurs between individuals and populations of the same species, based on the genetic traits they inherit.

o **Species Diversity.** The component parts of ecosystems are not only large and conspicuous plants, birds, fishes, and mammals but also less conspicuous species such as insects, mosses, algae, fungi, and bacteria.

o **Ecosystem Diversity.** A variety of plant and animal communities and their distinct physical settings exist across the

Figure 4-1.--The Southern Appalachian Biosphere Reserve, established in 1988.



Source: Southern Appalachian Man and the Biosphere Cooperative, "The Man and the Biosphere Program," (Gatlinsburg, TN: SAMAB, 1990).

Case Study
Private Lands: Industry Acts to Protect Biodiversity

In 1990 Waste Management, Inc., a large multinational waste management firm, issued a policy statement declaring the company's commitment to "no net loss of wetlands or other biological diversity on the Company's property."[26] The firm's Executive Environmental Committee, in consultation with public agencies and with the assistance of the World Wildlife Fund/Conservation Foundation, has developed operational procedures for its local managers. The company has employed an environmental consulting firm to prepare conservation plans for several sites.

In preparing recommendations, these consultants compiled data on the geology, hydrology, soils, environmental conditions, and ecological characteristics of the sites prior to making field inventories. Local ecologists are assisting the company in carrying out conservation plans. Two pilot sites are in the United States:

- **Port Arthur, Texas.** This 5,000-acre site contains a closed 442-acre hazardous waste disposal facility and one of the world's largest operating hazardous waste incinerators. It also has large expanses of freshwater marsh and pasturelands and is located in a central flyway for migratory birds. State and federal wildlife refuges are nearby, and various wading birds and the fulvous whistling-duck frequent the site. The company's conservation options for the site include protecting wetlands, managing grazing, and planting to improve wildlife habitat.
- **Ft. Myers, Florida.** On the southern half of a 600-acre site, Waste Management, Inc., operates an active sanitary landfill with a life expectancy of two years. The property is adjacent to a cypress slough preserve, and the northern half is a mix of cypress swamp, slash pine, saw palmetto, early successional shrub, and pasture. The company's conservation options for the Ft. Myers site include improving habitat for endangered species such as the red-cockcaded woodpecker and the bald eagle, controlling exotics such as Brazilian pepper and melaleuca trees, and expanding cypress communities.

Waste Management, Inc., and The World Wildlife Fund/Conservation Foundation also are seeking new ways to manage private lands for biodiversity. An upcoming report will emphasize strategies which private sector managers may use to:

- identify properties with fragile ecosystems that should not be acquired for development, and
- identify ecosystems on currently owned industrial properties that warrant specific management for biodiversity.

nation and the globe.

As scientists advanced the world's understanding of the value of biodiversity, the need to promote and protect it gradually became evident. In 1990 a number of federal agencies took part in a dialogue on biological diversity, organized by the Keystone Center. The dialogue resulted in a recognition of the value of biodiversity to the nation and on the need to manage regional ecosystems for it.[27]

A. Values of Biological Diversity

Advocates for protecting biodiversity often cite pragmatic reasons for their positions, and the practical consequences of biodiversity loss do promise to be severe. However for many Americans, ethical and aesthetic reasons are just as compelling. Respect for the wonder of creation and a sense of moral responsibility are strong American values, and enjoying the beauty of nature is a national pastime. Americans increasingly demand a stewardship of the environment to maintain the nation's ecological soundness.

1. Species and Genepools

Biodiversity encompasses a vast numbers of species--plants, animals, fungi, and microorganisms--many of which provide direct benefits to the nation. For example, a diversity of species here and abroad serves U.S. agriculture by providing a reservoir of genetic traits that crop and livestock breeders may need urgently in the future. The shrinkage of plant genepools available to crop

scientists may be one of the most immediate threats posed by the loss of biodiversity. Yet, even within the United States, the vast majority of domestic plants have not been examined in any systematic way for potential benefits.

Native species provide valuable products in addition to commodities such as wood and paper and crops such as cranberries and pecans. For example, in 1990 the American Cancer Society supported efforts by environmental groups to nominate the Pacific yew, an evergreen native to the Pacific Northwest, for listing under the Endangered Species Act.[28] The yew shows promise in the treatment of several types of cancer, yet its dependence on forest types under rapid conversion has led to its decline.

The yew is not an anomaly. In 1984 Americans purchased $8 billion worth of prescriptions with active elements extracted from higher plants.[29] Human dependence on diversity goes beyond the obvious. In addition to medicines, plant and animal species provide fibers, gums, spices, dyes, resins, and oils.[30] Americans also benefit directly from the productivity of coastal and estuarine systems. These ecosystems that are essential to the survival of living marine resources have an annual economic value to society approaching $14 billion, including $5.5 billion in commercial landings alone.[31] Without doubt, threats to biodiversity threaten human welfare.

Biodiversity also affords flexibility in the face of environmental change and variation. Genetic diversity can bestow

this flexibility on both managed and unmanaged systems. A genetically diverse population has a number of ways to cope with environmental change,[32] and even rare species and genes have survival value. With environmental changes unpredictable, an individual or even a species just getting by under existing conditions might thrive should those conditions change.[33] Diversity is also beneficial in stable situations. For example, different strains of ponderosa pine or Douglas-fir thrive on north-facing slopes, while other strains thrive on south-facing slopes.

Genetic uniformity associated with population decline can threaten the survival of some species. As remaining individuals interbreed, genetic defects may result that further weaken the population. Captive breeding programs to rescue endangered species now recognize this problem. A program to breed the endangered Puerto Rican parrot succeeded in increasing the numbers of individual birds, but forest managers observed genetic defects in parrot offspring.[34]

The technologies that produce genetically uniform organisms such as hatchery fish or clonal fruit and timber trees offer the benefits of controlled productivity but also the risks of uniform susceptibility to disease and changing environmental stresses. Controlled breeding and, more recently, advances in biotechnology have the capability of producing genetically diverse organisms as well, although such techniques have not been widely applied.

2. Ecosystem Services

Aside from the value of any single species or the benefits of any single product, healthy ecosystems--either natural or altered systems that retain their basic functional integrity--collectively provide life-support services free-of-charge for the nation and the planet. A sampling of these services follows.

o **Soil Building.** Soil is a living community, formed by plants, animals, and microorganisms as they move, take in food, release wastes, and reproduce--creating soil from parent rock and their once-living bodies.[35] Both managed and unmanaged ecosystems can build soil, although intensive agriculture and forestry can change soil structure and reduce fertility over time.

o **Erosion Control.** Protecting soil, the *sine qua non* of terrestrial life, is critical. Rainfall--the primary mechanism of erosion--loses its destructive force when captured by leaves or needles, cushioned by ground litter, or slowed by the thick mass of roots in ecosystems such as forests or grasslands.[36] Rainfall on exposed ground runs off directly, carrying away valuable topsoil.

o **Nutrient Availability.** Without the actions of countless organisms, many of them microscopic, the cycling of nutrients from air through living creatures and back again through soil and water could not occur. Two examples follow.

Most plants depend on intricate associations between their roots and certain soil fungi for the transfer of nutrients essential to growth. These associations, or mycorrhizae, allow the

plants to absorb far more nutrients than they could unaided. Land-use practices such as monocropping and clearcutting can disrupt these systems, making it impossible for plant communities to maintain themselves.

Nitrogen is a major plant nutrient, and shortages often limit plant growth. However, nitrogen gas in the atmosphere is useless to living organisms, until it is fixed, that is, incorporated into nitrogen-containing compounds. Healthy, diverse ecosystems contain a variety of nitrogen-fixing bacteria, in nodules on plant roots, scattered throughout the soil, and in certain lichens. These bacteria are responsible for the availability of all nitrogen except that supplied by fertilizers, and the maintenance of natural communities depends on them.

o **Carbon Storage.** Recent concern over the rate of addition of carbon to the atmosphere, based on predictions of resulting global climate change, has focused attention on the carbon-storage properties of plants. Plants absorb carbon from the atmosphere and release oxygen, and plant communities, such as forests and grasslands, store significant amounts of carbon in the form of both standing biomass, fallen leaves, litter, dead and downed trees, and underground root material--both alive and dead. Existing forests with their standing biomass, as well as reforestation and afforestation can provide carbon sinks to help control atmospheric carbon.

o **Hydrological Cycles.** Plants absorb water through their

roots and leaves and transpire it through their pores, creating a critical link in regional moisture regimes. Forests, grasslands, and wetlands regulate streamflow, filter water, and control flooding. Natural ecosystems tend to minimize both drought and flooding, and examples abound where human development has disrupted this balance with unhappy results, for instance, in the Everglades.

o **Pest Management.** Natural systems characteristically have mechanisms that control pest outbreaks; mechanisms that are missing from intensively managed systems. For instance, the majority of insects found in young forests are destructive leaf-eaters, but old-growth forests support a greater diversity of insect species, among them insects that feed on leaf-eaters. Insect-feeding birds are also most numerous in older forests.[37] With the decline of old-growth forests, the nation may be losing a reservoir of insect and bird species that feed on damaging insects. For these reasons, the removal of hedgerows and woodlots in agricultural regions may lead to less rather than more crop production.

o **Linkages.** Ecosystem services are the products of networks of relationships, not all of equal strength, and not all direct and linear. Some species--decomposers in particular--are critical links about which little is known. Others, called keystone species, play leading roles in regulating the abundance of other species in the same community. For example, starfish and sea otters have shown dramatic shifts in populations upon removal of a single species from their communities.[38]

B. Causes of Loss

Humans have had large-scale impacts on the environment with corresponding consequences for biodiversity. All of the following factors are significant in the decline of U.S. biodiversity,[39] but physical alteration is currently the most pervasive:

- **Direct Taking**, such as the large incidental fish bycatch associated with shrimp trawling;
- **Chemical Stress**, including acid deposition and excesses of ozone, nutrients, and pesticides;
- **Plastics in the Marine Environment** that trap or are ingested by fish, birds, and mammals;
- **Introduction of Exotic Species** that invade natural communities and displace native species; and
- **Physical Alteration of the Environment** both on land and in coastal and near-shore areas.

U.S. biodiversity is being threatened at all levels--genetic, species, and ecosystem. Narrowing of genetic bases and species loss often go hand in hand, and both are increasingly caused by ecosystem conversion, fragmentation, and simplification. These three forms of human alteration constitute major threats to biodiversity, both domestically and worldwide.[40]

1. Conversion

Human development has usurped places where native plants and animals once lived. Farms and subdivisions have replaced more diverse plant and animal communities; and construction and

roadbuilding have divided wildlands into smaller and smaller fragments. Conversion to farms and shopping centers has an obvious effect on biodiversity, but two kinds of partial alteration--fragmentation and simplification--are also of concern.

2. Fragmentation

Dividing a biodiverse ecosystem into isolated patches creates barriers. When a river is dammed to create a reservior, fish migrations are blocked or, at best, slowed. Clearcuts within a forest create open areas, with differing temperature and moisture regimes and reduced cover. Such alterations can function as barriers to dispersal and population mixing of some species. Fragmentation also exposes the interiors of remaining patches to external physical and biological factors called edge effects that can benefit some species but harm others. Species diversity is usually reduced not increased by fragmentation, since species adapted to conditions found in the interior of larger patches are often lost.[41]

Songbirds in newly created edge areas are subject to nest predators and brood parasites that occur in higher densities near the edge of forests than in the interior. The Kirtland's warbler, a bird that requires deep woods, has been driven to near extinction as forests are cleared in patches, allowing the edge-tolerant brownheaded cowbird to invade the forest and lay its eggs in the warblers nest.[42]

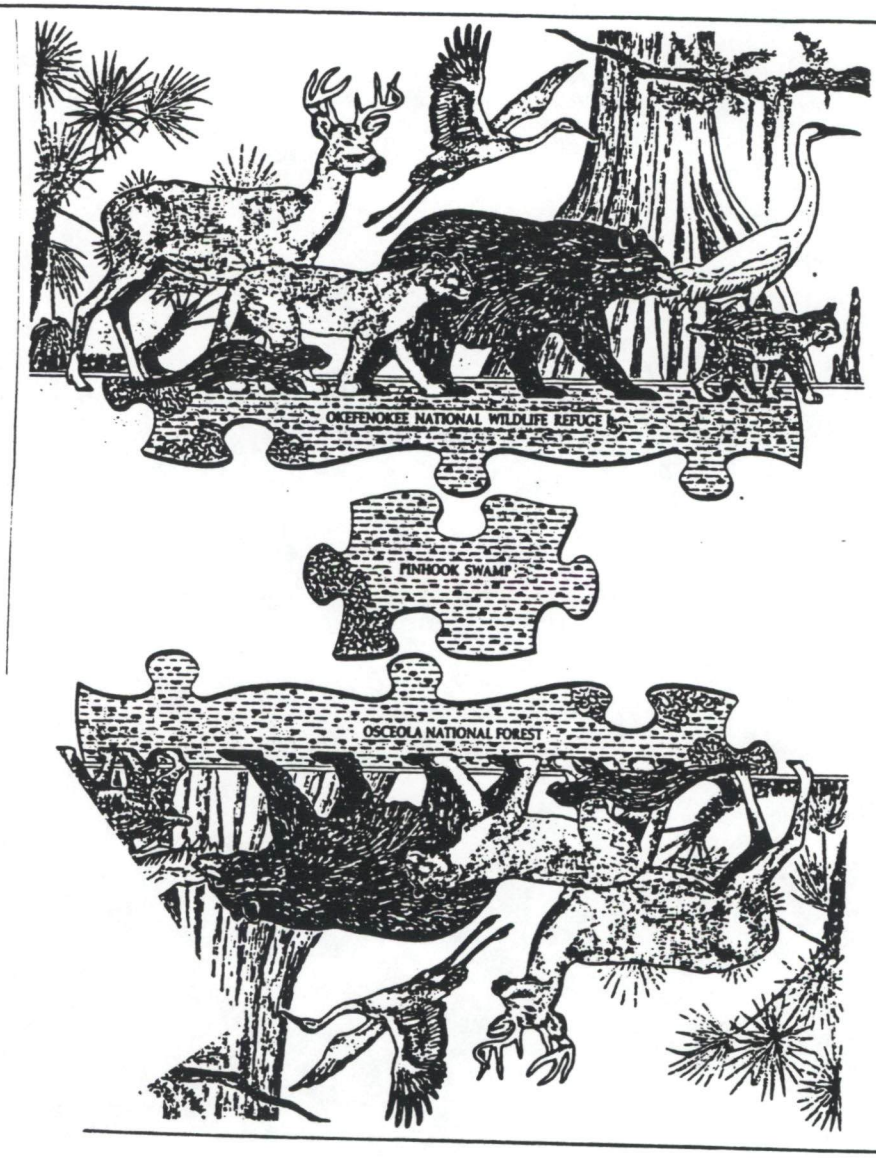
Land and water managers can alleviate detrimental edge effects

by retaining large contiguous blocks of habitat, and they may be able to mitigate some effects of fragmentation by linking separate areas with nature corridors or bridges (see Figure 4-2). In the Southwest, the Bureau of Land Management is protecting and restoring riparian corridors along streams, seeps, lakes, marshes, and large springs to connect key habitats for wildlife.[43] Ensuring the retention of such corridors and, where necessary, restoring lost linkages are emerging techniques in managing for biodiversity.

3. Simplification

Simplification is, by definition, loss of diversity. Variety in an ecosystem can take many forms: more species, more complex food webs, greater three dimensional structure. For example, a forest with many plant species can support a diversity of associated animal life.[44] Simplification can result from direct human action such as removal of fallen trees. Fragmentation also contributes to simplification, for instance, by reducing the differences between deep forest and open field. Finally conversion often equals simplification, if it involves selecting for one or a few species. Table 4-3 illustrates the loss of diversity that results from converting an old-growth forest to an intensively managed tree plantation. The comparison contrasts extremes; many managed forests are more diverse than tree plantations, and young natural forests may be less diverse than old growth.

Figure 4-2.--Pinhook Swamp Corridor purchased by The Nature Conservancy and the USDA Forest Service to provide a 15-mile land bridge between Okefenokee National Wildlife Refuge in Georgia and the Osceola National Forest in Florida.



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

Table 4-3.--Comparison of attributes of old-growth forests and intensively managed tree plantations.

Attribute	Old-growth forest	Tree plantation
Land structure		
Canopy	Uneven; many gaps	Even; dense
Tops	Often broken	Most Unbroken
Cavities in trunks	Many	Few or absent
Height of dominant trees	Uneven; often taller	Even; often shorter
Girth of dominant trees	Uneven; greater	Even; smaller
Subcanopy trees	Various heights	Absent or small
Shrub layer	Uneven; dense in clumps	Even; often sparse or absent
Herb layer	Uneven	Even; often sparse
Moss layer	Uneven	Even; sometimes sparse
Epiphytes	Abundant on trunks and large branches	Sparse or absent
Perched soils	On large branches	Absent
Snags	Uneven; small to large	Even; few or no large snags
Logs	Uneven sizes; many large, many decay classes of natural forest	Even; few or no large logs except possible remnants
Overall structure	Complex; multiple, indistinct layers; heterogeneous; much coarse woody debris	Simple; fewer but more distinct layers; homogeneous; little coarse woody debris
Carbon storage	Higher	Lower
Microclimates		
Light level at forest floor	Uneven; sunny in light gaps	Even; low
Snow depths on forest floor	Uneven; shallower	Even; deeper
Temperature and moisture on forest floor	Uneven	Even
Species diversity		
Trees	Higher	Lower; often one species
Understory plants	Higher	Lower
Animals	Higher	Lower

Table 4-3.--Continued.

Attrib	Old-growth forest	Tree plantation
	Higher	Lower
Fung-ity	Higher	Lower
Pathways of nitrogen fixation by epiphytes	Exceeds atmospheric inputs	Little or none
rom early successional rubs	High	Absent due to vegetation management
ient flow	Cyclical; many sites of nutrients capture and storage	Linear; in absence of capture and storage sites, nutrients leak from system
ce regime mage	Individual trees	Individual losses rare; large-scale blowdowns more common
r		
ge from insects and ogenic fungi	Usually individual trees or small groups	Epidemics can affect whole stands or larger areas
erall pattern of disturbance	More frequent; scattered trees	Less frequent; whole stands
Streams		
Structure (streams)		
Logs in streams	Many; some large	Few; none large
Gradient	Uneven; stair-stepped; channel habitats	Even; riffle and pools common predominate
Sediments	Diverse, from silts to cobbles	Uniform
Overall habitat diversity	Higher	Lower
Species diversity (streams)		
Invertebrates	Higher	Lower
Salmonid fishes	Higher	Lower
Amphibians	Higher	Lower
Overall species diversity	Higher	Lower

Source: Norse, E.A., Ancient Forests of the Pacific Northwest, (Washington, DC: The Wilderness Society, 1990), pages 158-159.

Natural systems can absorb a certain amount of conversion, simplification, and fragmentation. Such activities are not, in the abstract, unacceptable. It is possible, though, to overload a system.

III. An Evolution in Management Scale

Natural resource management and environmental protection have produced two recurrent trends--an increased understanding of how human actions affect the environment[45] and a maturation in how society controls those effects.

Early settlers recognized the damage caused by unconstrained market hunting when game became harder to find. Later on, city dwellers could see that uncontrolled coalburning had direct effects on human health and wellbeing.

Responses were likewise direct--states enacted bag and creel limits and restricted hunting and fishing to certain seasons. Cities adopted limits on burning, especially during certain weather conditions. Game limits were complemented by state-wide game management programs and, later, by adoption of the Endangered Species Act. Increasingly analytical and technological sophistication led governments--federal, state, and local--to adopt air pollution standards, at first designed to address direct, local effects. More recently society has come to recognize--and now respond to--acid rain.

With the recognition of such potentially catastrophic problems as loss of biodiversity, climate change, and ecosystem degradation,

society finds itself face to face with global issues that challenge human knowledge and creativity. The scope of human effects on the environment often overwhelms project-by-project attempts to understand or reduce impacts.[46]

The history of environmental protection is one of continued recognition of the value to human existence of a clean, healthy, and functioning environment. It is also the history of continued creativity in developing solutions. Even in the contentious field of endangered species management, accommodation has been possible in the vast majority of cases.[47] Creativity and the will to put solutions to work are essential traits if the United States is to reverse losses in biodiversity.

A. Current Management Approaches

Today natural resource managers are designing programs that consider the wellbeing of multiple species within an ecosystem. Environmental policies also are taking a regional focus with geographically targeted programs that address a number of issues within a particular region.

1. Species Management

The original focus of wildlife management was popular, harvestable game species. Threatened and endangered species received attention as more and more plant and animal species became extinct.[48] Although foreshadowed by the Lacey Act and the Migratory Bird Treaty Act,[49] the Endangered Species Act was the first formal, national recognition that each species has a unique contribution

to the tapestry of life on this planet, and that the nation should, when possible, avoid contributing to the tearing of that fabric.[50] Clearly, endangered species programs form an essential part of biodiversity protection.

The act recognizes the value of habitat and the need to manage at an ecosystem scale. It authorizes designation of critical habitat--areas essential to the preservation of endangered species and in need of special management[51]--and calls for the preparation of recovery plans for listed species (see Ash Meadows Case Study). However such plans are not enforceable.[52]

The endangered species problem is daunting. At present rates, it would take 50 years to list those U.S. species now considered to be in danger. The program has financial limitations as well. Full recovery for all currently listed threatened and endangered U.S. species would cost an estimated $4.6 billion, yet annual funding has been less than $10 million.[53]

The Endangered Species Act comes into play when options and alternatives are limited. Species eligible for listing are, by definition, either dangerously reduced in number or subject to strong forces that will result, if unchecked, in their extinction. Frequently, habitat for such reduced populations exists only in isolated fragments that cannot support long-term viable populations of a species. Loss of genetic diversity and lack of suitable habitat limit captive recovery efforts.

The act also comes into play when human options are limited.

Projects are often already well-defined and represent substantial program or financial investments before sponsors can identify impacts on threatened or endangered species. Lack of a comprehensive source of information on the habitat needs of endangered species means that such reviews will be undertaken on a case-by-case basis, and thus late in project development.

The nation also has devoted a great deal of effort to protecting and propagating game species. Fees on hunting and fishing equipment fund game and fish enhancement projects and statewide wildlife planning.[54] Without careful review, such projects could expand the range of game species without regard for detrimental effects on non-game species. Congress passed the Fish and Wildlife Conservation Act of 1980,[55] also known as the Non-Game Act, in response to concerns over the fate of species not valued for their recreational potential. The act authorizes federal support for state-based wildlife planning, but without an ear-marked excise tax or a constituency comparable to hunters and anglers, it has never been funded.

Both endangered species protection and game management have value in protecting biodiversity. The Endangered Species Act, in particular, is crucial as it preserves the basic elements of species diversity--distinct and unique species.

Case Study
Ash Meadows: An Ecosystem Recovery Plan

Named for the ash trees that distinguish it from surrounding creosote-bush communities, Ash Meadows is a spring-fed oasis in the midst of the Mojave Desert. Its 50,000 acres straddle the California-Nevada border northwest of Las Vegas. A series of natural springs, active since prehistoric times, supports an isolated relict biota.

The meadows' most famous inhabitant, the endangered Devil's Hole pupfish, averages about an inch in length and was the center of a controversy that led to a Supreme Court decision. Devil's Hole is an Ash Meadows spring located in a network of limestone caves that in 1952 was dedicated as the Devil's Hole National Monument, managed by the National Park Service.

In addition to the Devil's Hole pupfish, Ash Meadows is sole habitat for 27 other unique plants and animals of which 13 species are federally listed as threatened or endangered.

In the 1970s when a ranching operation in the area caused a decline in discharge from Devil's Hole, the National Park Service brought legal action. The case went to the Supreme Court, which in 1976 ruled in favor of protecting the national monument from groundwater pumping. The ranch subsequently ceased operations, but municipal development in the area continued to alter springs not protected by the Park Service. In 1984 The Nature Conservancy purchased acreage, which it resold to the U.S. Fish and Wildlife Service for the Ash Meadows National Wildlife Refuge. The Bureau of Land Management also set aside public lands for the refuge.

Today an Area of Management Concern consists of 23,094 acres, encompassing most of the habitat of the threatened and endangered species. The refuge includes lands managed by the Bureau of Land Management (9,243 acres), the Fish and Wildlife Service (12,438 acres), the National Park Service (40 acres), and private lands (1,371 acres). The Ash Meadows Recovery Plan, completed in 1990, considers the entire ecosystem, rather than focusing on each of the 13 threatened and endangered species. The first step in recovery was to secure the water-dependant habitat. Other steps include removing exotic plants and animals that have invaded the area, controlling herds of wild horses, and protecting the meadows with fencing, stream barriers, and interpretive signs. Captive breeding programs for the endangered species will supplement on-site ecosystem management.

2. Project Impact Management

Congress passed NEPA and a host of specific laws to ensure that federal agencies could both understand and control the environmental effects of human actions. While the emphasis of most such laws and regulations is on abating or avoiding specific impacts, NEPA requires that managers look at the entire array of environmental effects of their projects. By requiring such analysis along with public involvement, NEPA has fostered a greater understanding of the magnitude of human effects on the environment.

Most environmental laws focus on controlling pollution in one specific context--air, water or the disposal of waste, for example. Despite the overarching, inclusive NEPA framework, the narrow focus of these laws combined with competing interests and multiple objectives leads most project sponsors to focus on statute-driven lists of impacts. This case-by-case, issue-by-issue approach often leaves pervasive values--such as biodiversity--unprotected. In addition, lack of comprehensive information on the distribution, abundance, representation, and degree of destruction of species and natural communities in the United States significantly hampers comprehensive analysis.

3. Managing by Area Not Impact

The limitations of species-based management and narrowly focused project-by-project, permit-by-permit analysis have led to the development of geographically targeted approaches. Based on watersheds or other ecological units, rather than political

boundaries, such approaches provide the tools and conceptual structures for ecosystem management. Geographically targeted management programs often involve different levels of government with private conservation and development interests, and focus on full characterization of an area and on a variety of protective mechanisms for it.

B. The Next Step

An evolution is occurring in the scale of analysis and understanding of environmental concerns. The corresponding shift in management rests on the conclusion--reached in programs as diverse as game management and water pollution control--that, while everything may not be hitched to everything else, a narrow conception of an issue can lead managers to ignore essential elements of the system in which the issue is embedded. The result of such narrow conceptions is often avoidable impacts and unintended consequences. The ecosystem approach is proving more useful for predictive and management purposes[56] than the more narrowly focused approaches that preceded it (see the Yellowstone Case Study).

To understand human impacts on the environment, ecologists are recommending that resource managers conduct analyses at a scale sufficiently large to include the ecological boundaries of an issue. By basing risk assessments on functionally defined regions, they can account for the physical and biological processes that affect or will be affected by a human action.[57]

Case Study
The Greater Yellowstone Ecosystem: Regional Management in Action

Yellowstone National Park, with its geysers, spectacular landforms, abundant wildlife, wilderness areas, and developed recreation sites is one of the jewels of the national park system. It has been designated both a Biosphere Reserve and a World Heritage Site by the United Nations Scientific, Educational and Cultural Organization (UNESCO).

But Yellowstone is not an island. The Greater Yellowstone Ecosystem, comprising the contiguous mountain region in and around Yellowstone Park, is nearly 19 million acres, of which only 2.5 million acres are national park lands. The rest includes portions of six national forests and lands owned and managed by the Bureau of Land Management, Fish and Wildlife Service, the states of Montana, Wyoming, and Idaho, and private individuals.

Nor can Yellowstone be managed as an island. In the early 1960s the Park Service and the Forest Service each recognized the limits of their ability to meet statutory mandates without the cooperation of their neighbors, and formed the Greater Yellowstone Coordinating Committee. Other agencies participate regularly in discussions on policy for the region.[58]

Management of the Yellowstone elk herds that cross administrative boundaries as they move from summer to winter range, coordination of grizzly bear and wolf policy, ensuring the integrity of the geothermal deposits that create "Old Faithful," managing transportation and recreation, and the need to ensure a healthy and diverse economic base motivated creation of the committee.

Managing the Greater Yellowstone Ecosystem requires balancing the diversity of land ownerships, the variety of management objectives, and the difficulty in gaining acceptance of proposals that reduce management prerogatives. But a common vision and a common base of information can guide independent decisionmakers toward the goals of ensuring ecosystem integrity and maintaining biodiversity, while integrating these objectives into the fabric of economic life.

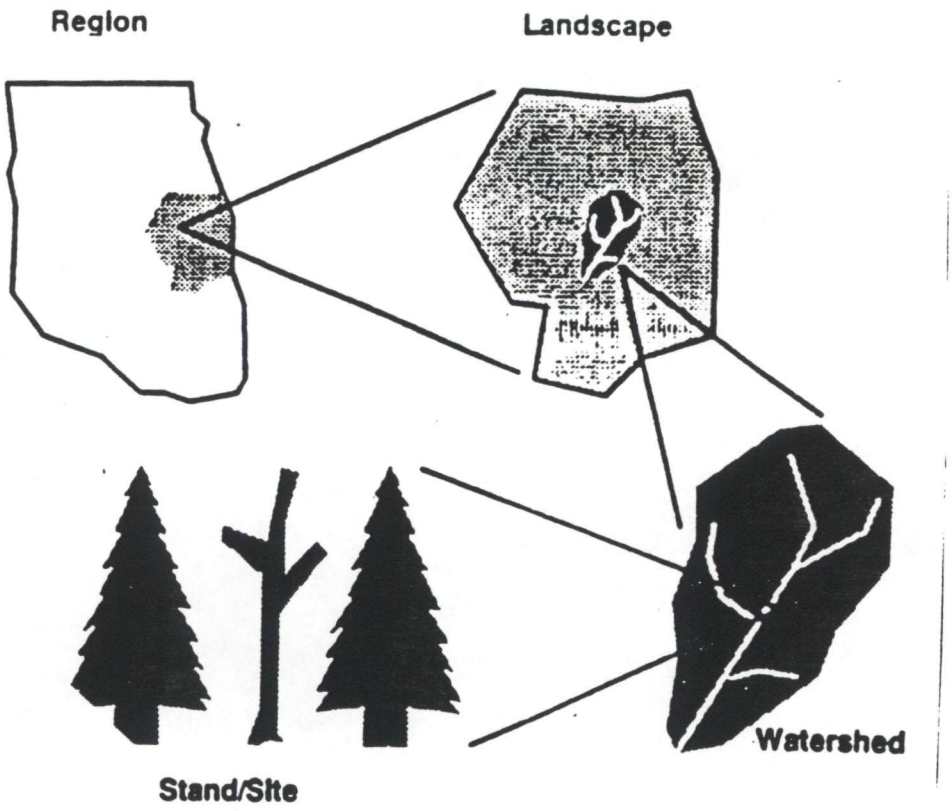
1. Ecosystem Management--An Approach, Not a Formula

Ecosystem management has aspects of both process, "conceptualization in a systems framework,"[59] as well as substance, "ensur[ing] that all plants and animals are maintained at viable populations in native habitats and that basic ecosystem processes...are perpetuated."[60]

The core concept of the approach is management in an ecosystem context. Such an approach requires that human actions--whether programs to restore the health of the Chesapeake Bay or plans for timber harvest in Mount Hood National Forest--account for the basic ecological context in which they take place. That context includes ecological composition, structure, and function--the defining elements of an ecosystem.

Employing the concept involves consideration of scale. Individual actions have effects both on an immediate site, for example, a forest stand, and as part of larger patterns of change, for example, in a watershed. Likewise, patterns of change within a watershed will have consequences for the regional landscape. Ecosystem management requires that decisionmakers at all scales--site, ecosystem, and region--be cognizant of effects of their actions in the larger scheme[61] (see Figure 4-3).

Figure 4-3--Scale in ecological decisionmaking.



Source: Adapted from Salwasser, H., "Conserving biological diversity: a perspective on scope and approaches," *Forest Ecology and Management* 35(no.):79-90 (Amsterdam, The Netherlands 1990).

Just as delineating the boundaries of an ecosystem depends in large measure upon the issue under analysis, so does the definition of what will be studied or managed. Basic to the ecosystem management approach is placement of the immediate concern in a larger context. By way of example, looking at the larger context could involve the following changes in management perspective:

o **Broadening Horizons.** Managers can track changes in ecosystems rather than merely focus on target species. For example, forests can be grown as crops, but the crop can be the forest ecosystem,[62] not merely young trees of a single age class. Or, monocultural plantations might be more fully integrated into diverse and healthy regional ecosystems. A broader view also can provide perspective on the relative occurrence or rarity of a particular species or community, in a local, national, or even global context.

o **Integrating Efforts.** Managers can make greater efforts to integrate protection programs. As an example, wetlands managers are finding that they need to integrate federal and state regulatory programs, state floodplain and water quality programs, and local zoning, planning, and sensitive area protection. Why? Because wetlands have various landowners--public and private--and unless integrated, actions and programs can neglect key influences or even work at cross purposes.

2. The Broader View

Managers in such programs as national forest planning,

endangered species recovery, and wetlands protection have good reasons for initiating and embracing techniques that require more analyses, involve more people and agencies, and integrate agency objectives with those of others. The regulated community, including many developers, likewise is embracing such approaches. For example, developers in California have welcomed the initiation of habitat conservation plans for multiple endangered species as a means of reducing the need for eleventh-hour efforts.[63] And the National Wetlands Policy Forum[64] endorsed state and regional/local wetlands planning efforts, in response to developers' needs for greater certainty in the permitting process.

The trend toward ecosystem management signals a developing consensus that a broadening of perspectives is essential to success. Whether success is framed as the ability to run a program without constant controversy--a factor that drives at least some endangered species and wetlands planning efforts--or the ability to plan development without surprises, ecology is overtaking narrowly focused decisionmaking.

Current land-use decisions involve different agencies and different levels of government--each with its own sphere of concern and corresponding area of expertise. Each of these units exerts independent authority over proposals by developers and agencies in a sequential fashion. The process is unpredictable and invites conflict and fragmented decisions.[65] Ecosystem management, by considering both natural factors and human institutions, can bring

together multiple decisions in a single framework.

Reliance upon broader, more inclusive decisionmaking will neither solve nor preclude all conflicts over allocation of resources. As the participants in the Keystone Dialogue noted, although federal multiple-use lands must continue to meet human needs, the extent, timing, and location of uses may need to change to conserve biodiversity.[66]

The threat of biodiversity loss may change the daily operations of land and water managers. The situation requires a quantum leap in cooperation and communication between interests and across sectoral lines--public/private, science/management, preservationist/developer, federal/state/local, and inter-agency. Currently such cooperation is time-consuming, difficult, and until participants gain more experience, of uncertain outcome. Statutory and regulatory frameworks--some established under earlier, narrower conceptions of the workings of the natural world--also constrain broad-view approaches. The nation may need to update management systems to ensure that meeting human needs in the short run does not preclude achieving ecological objectives vital to human wellbeing in the long run.

IV. A Sampling of Current Approaches

Though the term biodiversity may be relatively new, the recognition that native species of plants and animals are worthy of conservation is a trademark of U.S. natural resource policy. And though techniques for managing natural resources may change

with new ecological knowledge, some techniques that protect ecosystems and promote biodiversity are already in use. Not all approaches aim to preserve biodiversity across all scales, nor do they all focus on ecosystem management. Rather, efforts may be targeted toward maintaining a particular scale of diversity--genetic, species, or ecosystem. Such techniques may be categorized as either off-site or on-site,[67] and ecosystem management has evolved in a number of these programs.

Off-site approaches such as seed and embryo banks, zoological parks, botanical gardens, and captive breeding programs involve intensive intervention to maintain species or communities outside their natural environment. Off-site approaches serve conservation by, for example, providing convenient storage of germplasm for breeding programs and allowing access to samples of wild species for research and for propagating endangered species.

On-site approaches may have broad objectives, as in maintaining entire ecosystems, or focused objectives, as in ensuring the habitat of a single species within an ecosystem or perhaps across several ecosystems. In addition, some scientists and mangers are developing techniques to restore ecosystems and communities, allowing for restoration of reduced biodiversity.

The following section reviews a sampling of off-site and on-site programs and several geographically targeted programs.

A. Off-Site Maintenance

Efforts to maintain species or communities off-site support

on-site management techniques, such as ecosystem restoration.

1. National Plant Germplasm System

The Agricultural Research Service in the U.S. Department of Agriculture administers the National Plant Germplasm System to provide plant breeders and research scientists with continued access to reserves of genetic material essential to maintaining the nation's major crops.[68] The system is the world's largest distributor of plant germplasm, and each year supplies more than 230,000 samples from its collections to more than 100 nations.[69] In addition to storage, the program plants seeds on a regular basis to maintain a fresh supply. In 1990 Congress enacted new legislation to expand the scope of the National Plant Germplasm System with a National Genetic Resources Program to preserve a broader range of genetic resources, including those from animals, insects, and microbial organisms.[70]

2. Center for Plant Conservation

The Center for Plant Conservation is a private consortium of botanical gardens and arboreti, established in 1984 to rescue native plants. The Center maintains a growing national collection of over 400 species of threatened and endangered native plants and cooperates with the Agricultural Research Service on seed storage. It maintains this collection through the cooperation of member institutions, each of which has agreed to bring into cultivation and place into seed storage the most highly endangered plant species of their particular region of the United States.

3. American Association of Zoological Parks and Aquariums

This network of U.S. and Canadian zoos and aquaria conducts a Species Survival Program for native and exotic wild animals. Until the 1960s zoos and aquaria were consumers of wildlife--when an animal died, they just ordered another specimen from the wild--but today, with species at risk around the world, zoos and aquariums have become major wildlife producers. Of 156 institutional members, 128 have Species Survival Plans for threatened and endangered animals. Member institutions cooperate with public agencies such as the U.S. Fish and Wildlife Service on captive breeding programs for native species including the black-footed ferret, California condor, red wolf, thick-billed parrot, whooping crane, and Puerto Rican crested toad.[71]

4. American Type Culture Collection

The American Type Culture Collection (ATCC) is a gene library and a national repository for microorganisms. Governed by a board representing 21 scientific societies, the institute collects, propagates, preserves, and distributes cultures of microorganisms, cell lines, animal and plant viruses, and special gene and cellular products. Over 42,000 strains of microorganisms--freeze-dried or in live culture--are available for use in education, research, and various scientific and industrial applications. The ATCC provides technical information and other services to microbiologists worldwide, publishes a catalogue of its holdings, and maintains a computerized on-line database.[72]

B. On-Site Management

Both public and private sectors are managing properties in ways that can help--or hinder--biodiversity maintenance. Public land managers achieve a variety of objectives, from explicit biodiversity and ecosystem protection to broader multiple-use management that also includes strip mining, intensive forest management, grazing, military training, and nuclear energy research.

1. Protected Areas

Natural areas--public and private--help maintain U.S. biodiversity. Among the larger private programs are The Nature Conservancy reserves with over 1 million acres in 50 states and the National Audubon Society wildlife sanctuaries with 150,000 acres in 19 states. Many individual private landowners also expend considerable time, effort, and money to protect and carefully manage their land in ways that promote biodiversity. Some conservation groups and states offer registry programs that recognize private efforts and provide technical assistance. Most states and a number of cities manage state and municipal forests and parks, but the federal government is the largest single natural area manager.

a. Biosphere Reserves

One of the few programs to have biological diversity as a primary goal, biosphere reserves are part of a global network administered by the United Nations' Man and the Biosphere Program

(MAB). The MAB Secretariat in the State Department oversees administration of the 46 U.S. biosphere reserves (see Table 4-4) that include federal land, state land, university property, and private reserves. Total acreage in reserves exceeds 27 million acres. The original qualifications for designation--a core of wilderness, a buffer of limited human use, a transition area of mixed uses, a history of scientific work, and educational outreach--still apply but with the realization that management must extend across boundaries to a regional ecosystem. Biosphere reserves began as a designation program to identify outstanding natural areas and to encourage their protection, but the program may be entering a more active stage, for the network has potential to serve as monitoring sites in such fields as biodiversity and climate change.

b. Federal Natural Areas

Federal lands managed primarily for natural values include national parks and monuments, wilderness and primitive areas, and wildlife refuges. Objectives of individual units may not always coincide with protection of biodiversity. For example, the impetus for establishing many national parks was scenic beauty rather than ecological function, and the parks have a dual mandate for conservation and recreation. Many wildlife refuges operate under game management objectives that can conflict with the wellbeing of other plant and animal species, and the boundaries of many wilderness areas were established based on wilderness character rather than ecosystem functioning or biodiversity.

Federal agencies have long recognized the value of setting aside areas for the study of natural processes. For instance, the National Science Foundation administers 640,000 acres of Long-Term Ecological Research sites; the Department of Energy has 580,000 acres of National Environmental Research Parks; and the Forest Service has 224 Research Natural Areas that average 1,100 acres in size and represent most U.S. forest community types.

Although many designated natural areas are small and thus prone to detrimental edge effects and catastrophic natural events, they are nonetheless valuable elements in a conservation strategy. Federal agencies set aside natural areas designated by more than 100 different names, including the following:

- Research Natural Areas,
- National Environmental Research Parks,
- Experimental Forests and Ranges,
- Experimental Ecological Reserves,
- Ecological Research Areas, and
- Long-Term Ecological Research Sites.

2. Multiple-Use Lands and Waters

The previous section described areas set aside for preservation in their natural state, but most lands and waters--public and private--are not managed for this purpose. For instance, the Forest Service (USDA) and Bureau of Land Management (USDI) jointly manage 343 million acres or 47 percent of the federal estate under a multiple-use mandate. The Department of Defense

Table ed Nations Biosphere Reserves (46) in the United States, 1990.

	ocation	Admini-stration	Area	Biome
			acres	
	AK	USDI/FWS	110,943	Tundra Communities and Barren Arctic Deserts
	AZ	USDA/FS	111,300	Warm Deserts and Semi-deserts
	TX	USDI/NPS	283,247	Warm Deserts and Semi-deserts
	TX	USDI/NPS	34,217	Temperate Broadleaf Forests or Woodlands
nges	CA	USDA/FS USDI/BLM,NPS TNC,CA,U.ofCA HumboltSt.U.	107,600	Temperate Rainforests
th Atl.: NS and id units EF and	GA,SC NC	USDI/NPS,FWS GA,SC,NC U.ofGA,U.ofSC	490,405	Temperate Broadleaf Forests or Woodlands
earch Area	OR	USDA/FS	7,051	Temperate Rainforests
if. Coast: NP + 7 other nd federal units	CA	USDI/FWS,NPS DOC/NOAA, CA San Francisco	964,000	Evergreen Sclerophyllous Forests, Scrub, or Woodlands
Gulf Coastal Plain	FL	FL	16,402	Temperate Broadleaf Forests or Woodlands
l Plains ER	CO	USDA/ARS	6,210	Temperate Grasslands
ain-Adirondack	NY,VT	USDA/FS Adirondack Park Agency	10,378,200	Temperate Broadleaf Forests or Woodlands
Channel Islands NP	CA	USDI/NPS	7,440	Mixed Islands System
Coram EF	MT	USDA/FS	3,019	Mixed Mountain and Highland Systems
Denali NP and Preserve	AK	USDI/NPS	782,000	Temperate Needleleaf Forests or Woodlands
Desert ER	UT	USDA/FS	22,513	Cold Winter Deserts an Semi-deserts
Everglades NP	FL	USDI/NPS	566,800	Temperate Broadleaf Forests or Woodlands
Fraser EF	CO	USDA/FS	9,328	Mixed Mountain and Highland Systems
Glacier Bay-Admiralty Island	AK	USDA/FS	3,285,284	Temperate Rainforests
Glacier NP	MT	USDI/NPS	410,058	Temperate Grasslands
Guanica Commonwealth For.	PR	PR	4,000	Mixed Island Systems
H.J. Andrews EF	OR	USDA/FS	6,100	Mixed Mountain and Highland Systems
Hawaiian Islands	HI	USDI/NPS	257,832	Mixed Island Systems
Hubbard Brook EF	NH	USDA/FS	3,075	Temperate Needleleaf Forests or Woodlands
e Royale NP	MI	USDI/NPS	54,144	River and Lake Systems
Jornada ER	NM	USDA/ARS	78,297	Warm Deserts and Semi-deserts

Table 4-4.--Continued.

Reserve	Location	Administration	Area	Biome
			acres	
Konza Prairie RNA	KS	TNC, KSU	3,487	Temperate Grasslands
Luquillo EF	PR	USDA/FS	11,340	Tropical Humid Forests
Mammoth Cave Area	KY	USDI/NPS	52,420	Temperate Broadleaf Forests or Woodlands
Mojave and CO Deserts	CA	USDA/FS CA St.Parks	2,627,000	Warm Deserts and Semi-deserts
New Jersey Pinelands	NJ	Pinelands Commission	940,000	Temperate Broadleaf Forests and Woodlands
Niwot Ridge	CO	USDA/FS	1,200	Mixed Mountain and Highland Systems
Noatak NP	AK	USDI/NPS	3,035,200	Tundra Communities and Barren Arctic Deserts
Olympic NP	WA	USDI/NPS	363,379	Temperate Rainforests
Organ Pipe Cactus NM	AZ	USDI/NPS	133,278	Warm Deserts and Semi-deserts
Rocky Mountain NP	CO	USDI/NPS	106,710	Mixed Mountain and Highland Systems
San Dimas EF	CA	USDA/FS	6,947	Evergreen Sclero-phyllous Forests, Scrub, or Woodlands
San Joaquim ER	CA	USDA/FS	1,832	Evergreen Sclero-phyllous Forests, Scrub, or Woodlands
Sequoia-Kings Canyon NP	CA	USDI/NPS	343,000	Mixed Mountains and Highland Systems
South Atlantic Coastal Plain	SC	USDI/NPS	6,125	Temperate Broadleaf Forests or Woodlands
Southern Appalachian: Great Smoky Mountains NP and other federal units	NC,TN	USDA/FS USDI/NPS DOE, TVA	521,140	Temperate Broadleaf Forests or Woodlands
Stanislaus-Toulumne EF	CA	USDA/FS	601	Mixed Mountain and Highland Systems
Three Sisters Wilderness	OR	USDA/FS	80,900	Mixed Mountain and Highland Systems
Univ. Michigan Bio. Stn.	MI	U.of MI	4,048	River and Lake Systems
U.S. Virgin Islands NP	USVI	USDI/NPS	6,130	Mixed Island Systems
Virginia Coast Reserve	VA	TNC	35,000	Temperate Broadleaf Forests or Woodlands
Yellowstone NP	WY	USDI/NPS	898,347	Mixed Mountain and Highland Systems

Note: Biome=largest ecological unit, EF=experimental forest, ER=experimental range, EW=experimental watershed, NM=national monument, NP=national park, NS=ional seashore, NWP=national wildlife preserve, RNA=research natural area.
Source: U.S. Man and the Biosphere Secretariat-U.S. Department of State, Washington, DC, 1990. Biome types are based on a classification by M.D.F. Udvardy, 1975.

manages 18.7 million acres of wildlands (see Public-Private Partnership Case Study) and the Department of Energy manages 2.1 million acres of land, 95 percent of it undeveloped. Decisions regarding multiple-use lands can be among the most controversial in the natural resource field. Meeting conservation objectives such as biodiversity, while at the same time meeting other human needs, may require difficult tradeoffs and new management techniques.

a. The New Forestry

Although intensive forest management can simplify ecosystems, other forestry practices can maintain their integrity. The USDA Forest Service conducts research on the impacts of a range of management practices from wilderness management to tree plantations, as well as strategies that involve complete or partial harvest and the maintenance of patches of undisturbed forest.

Forest Service scientists at the Andrews Ecosystem Research Group in Oregon are advocating what they call the New Forestry.[73] Their focus is on maintaining complex forest ecosystems and not just on regenerating trees. To prevent soil erosion and to benefit wildlife, they recommend that standing dead trees (snags) and fallen trees remain on harvested sites, along with large living trees left to prevent erosion, supply beneficial insects to young trees, conserve soil microorganisms, and provide seedstock for regeneration. The New Forestry suggests that humans can use natural systems for commodity production in ways that maintain ecosystem health.

Case Study
Public-Private Partnerships:
Biodiversity and National Defense Lands

In 1988 the Department of Defense (DoD) and The Nature Conservancy (TNC) signed an agreement "to identify, document and maintain biological diversity on Defense installations."[74] The two groups are now sharing natural resource information and developing automated databases and related geographic information systems. DoD agreed to provide TNC access to Defense facilities and to evaluate the conservation group's recommendations regarding a natural resource inventory and monitoring guidelines. TNC studies and inventories on a host of DoD facilities have led to discoveries of rare or threatened plants, animals, and natural communities. Because training maneuvers can require large buffer areas, military lands are often the largest unfragmented properties in a region. Within the security of the military installation, species and natural communities that have been eliminated by development in surrounding areas survive.

Vandenberg Air Force Base, with 100,000 acres on the coast of southern California, is a missile testing facility that requires vast stretches of open land to minimize possible hazards from aborted missiles. More than two-thirds of the base is in a natural state, and the DoD-TNC cooperative effort has documented several endangered animals, 41 rare plant species, including 15 candidates for federal listing, 350 bird species, 5,000 acres of wetlands, 9,000 acres of undisturbed coastal dunes, relict stands of native bunchgrass, and the largest existing remnant of a globally rare plant, the Burton Mesa chaparral.[75] New management plans include protection for this diverse biota. As ecologists provide the tools for ecosystem management, federal land management agencies--even those with multiple-use objectives as demanding as the Department of Defense--are doing their part to maintain the nation's biodiversity.

b. National Marine Sanctuaries

The 1972 Marine Protection, Research, and Sanctuaries Act[76] authorized the Secretary of Commerce to designate national marine sanctuaries. The program protects areas of special significance in coastal and ocean waters, submerged lands, and the Great Lakes. In 1990 two new designations--the Florida Keys and Monterey Bay--brought the total to ten sanctuaries, ranging in size from less than 1 to over 1,000 square nautical miles. The NOAA Marine and Estuarine Management Division manages the sanctuaries that include nearshore, open water, and benthic ecosystems in temperate and tropical areas. Work is proceeding on several additional designations.

3. Geographically Targeted Management

Geographically targeted programs focus not on political boundaries, such as federal agency regions, states, counties, or municipalities, but rather on ecological units--estuaries, river basins, corridors, or the critical habitat of a species or group of species. Often not aimed explicitly at biodiversity protection, they nonetheless offer a model for such efforts.

a. National Estuary Program

In 1988 Congress established the National Estuary Program to recognize the difficulty of managing water quality in major estuaries, especially ones that border more than one state. The law authorizes the EPA Administrator to designate "estuaries of national significance" in need of additional pollution control.

The goal is to ensure the "restoration and maintenance of water quality", and "a balanced indigenous population of shellfish, fish and wildlife..."[77] Intergovernmental and potentially international management conferences assess the health of an estuary and plan for its recovery. Conferences depend on input from the public and private sectors. The program has had a promising start, with strong public-private cooperation in such areas as Narragansett Bay, Puget Sound, Buzzards Bay, and Long Island Sound.

b. River Corridor Management

In 1968 Congress passed the Wild and Scenic Rivers Act[78] to recognize the need to protect rivers of outstanding scenic, recreational, fish, wildlife, and other values. The act complements national dam-building programs and other river management. The Wild and Scenic River System now includes over 9,278 river miles on 120 rivers. A cooperative effort, the system relies on the actions of private individuals and groups, as well as all levels of government, with assistance from federal agencies.[79] Rather than setting priorities beforehand, the program elicits goals from those involved. Resulting plans recommend protecting valued environmental features, but they also recognize local needs such as housing and economic development.

c. Planning for Wetlands Protection

Wetlands are valued environmental features frequently subject to intense land-use pressure and various environmental threats. The Clean Water Act addresses this issue with its Section 404 wetlands

permitting program. The Environmental Protection Agency (EPA) and the Army Corps of Engineers, as co-managers of the program, have recognized the limitations of a permit-by-permit approach. In response, they have borrowed the concept of "special area management planning" from the Coastal Zone Management Act, and are using geographically focused planning to provide a more predictable and protective regulatory process.[80] By adding an ecosystem focus and connections with other pollution control and development planning efforts, the agencies are applying a broader view to the permitting program.

The Coastal Zone Management Act indicates that a special area management plan (SAMP), in which many interests participate to resolve environmental and development concerns, should "provid[e] for natural resource protection and reasonable...economic growth"[81] in a specific geographic area. While the SAMP process was designed for coastal areas, the Corps and EPA are using a similar process at inland sites.

SAMPs are often combined with a process called advance identification, in which EPA and the Corps examine wetlands within an area experiencing strong development pressure to determine the ecological significance of the site. The agencies may decide that certain sites are unsuitable for filling, while others may be filled with little overall harm to the ecosystem.

At present, a combined SAMP/advance identification planning process in the Hackensack Meadowlands area of New Jersey is

addressing issues including wetlands use, Superfund cleanups, transportation infrastructure development, and regional housing needs.

d. Habitat Conservation Planning

The drafters of the Endangered Species Act recognized that, at times, the needs of endangered species would conflict with otherwise legal activities. Section 10(a) of the act allows the U.S. Fish and Wildlife Service and the National Marine Fisheries Service to issue permits for "incidental" taking[82] of endangered species, as long as the action is otherwise legal, and the applicant provides a "conservation plan," often called a "habitat conservation plan" (HCP). The secretaries of Interior and Commerce may not approve such a taking without a plan showing that the action will not appreciably reduce the likelihood of survival, the applicant will minimize and mitigate to the maximum extent practicable (including review of alternatives), and the conservation plan has an assured funding mechanism.

By 1990 only about 30 habitat conservation plans were completed or in progress. The first and perhaps best known was the San Bruno Mountain plan that resulted in setting aside 87 percent of the habitat of several rare butterflies, including the federally listed Mission Blue Butterfly, in a heavily urbanized area south of San Francisco.[83]

In spite of the relatively few examples, the agencies increasingly recognize that plans need to address all or most of

a habitat for listed species in a region, encompassing a range of possible threats rather than focusing on the effect of a single development proposal. The Fish and Wildlife Service recommends that HCPs also address other species that may be listed as threatened or endangered in the future.[84]

HCPs have the potential to become vehicles for identifying--and thus encouraging--all development that could occur without clearly causing a species to become extinct. The HCP process does begin with the application for an incidental take permit--a request to in some way harm individuals of an endangered species--rather than a species recovery program. The possibility of HCPs evolving into species reduction plans rather than species protection plans calls for monitoring of the program.

C. Science, Information, and Inventory

To measure the success of ecosystem and biodiversity efforts, the scientific community must know what species, populations, communities, and ecosystems the nation has. Much data is missing, and the considerable amount that already exists needs national coordination to make it accessible.

1. A Biotic Base

The nation needs a basic understanding of the biota of the United States to ensure successful biodiversity protection efforts. That understanding does not exist.

o The United States has no comprehensive list, even of vascular plants and vertebrates.[85] Data on other less visible and

less known species are even more scarce. Beyond simple listing and identification of species, information on the abundance, distribution, and habits of the majority of species is lacking.

- The nation has no comprehensive listing of natural communities and no one scheme for cataloguing and naming these communities.
- Significant gaps exist in current knowledge of linkages between ecosystem and landscape processes.[86]
- Current understanding of the ways in which species interact to form ecosystems is inadequate, as is knowledge of the limitations of managed systems to sustain a diverse flora and fauna.[87]
- The nation lacks even regional databases of species of concern or other key ecological variables, and the tools for describing landscape patterns are experimental.[88]

The lack of a consensus on a single community or ecosystem classification system provides but one example of the problems encountered in this area. The USDA Forest Service uses a forest cover type system developed by the Society of American Foresters that classifies land by the type of natural forest actually growing on it. Another approach, known as the Kuchler system, uses potential vegetation types to describe the type of vegetation that would ultimately grow on a site if left undisturbed.

No classification system is perfect, and one system varies from another by the objectives of those collecting the data, but

the lack of consensus means continued fragmentation of effort. Gaps in genetic information also hamper conservation efforts, as demonstrated by the unsuccessful captive breeding program for the dusky seaside sparrow.[89] However new information on genetic relationships is resulting from work in the field of genetic engineering, including recombinant DNA research.

In short, the United States lacks the fundamental elements necessary to ensure that the nation's actions are in consonance with managing ecosystems and biodiversity.

2. Integration and Filling Gaps

Despite the gaps, biotic information abounds. For centuries, scientists have developed a considerable, although far from complete, body of information on the biota of the United States. That information exists in museums, universities, and other systematic institutions. Each federal land-management agency maintains information on the natural resources it manages. States maintain similar information. Private firms collect information as part of their efforts to comply with federal, tribal, state, and local laws and regulations. Private conservation organizations collect data on areas or species of concern to them.

But, no one knows what it all adds up to. No one has integrated the available information or undertaken a comprehensive effort to identify gaps in existing knowledge. Different groups and agencies use different procedures to collect data and different categories and names, even for the same phenomenon. The nation

spends large sums to assess specific projects and land-use practices. Such efforts could be more efficient and effective if supported by an accessible source of information on the nature, distribution, abundance, and interactions of organisms and communities.

An example of synthetic work that could support better decisionmaking is the Flora of North America program, now being coordinated at the Missouri Botanical Garden. The project will result in a 12-volume inventory of the plants of the United States, Canada, and Greenland, coupled with a digest of expert opinions and a database on plant characteristics.

As valuable as information and inventories might be, scientists, public and private planners, policymakers, and land and water managers must be able to locate, gain access to, manipulate, and present that data in ways that suit their particular objectives. Data sharing requires a full partnership among the thousands of individuals and institutions studying and gathering information on specific organisms or communities. Such a partnership would encompass a full range of public and private institutions--universities, museums, government efforts, and private programs such as the Natural Heritage Program established by The Nature Conservancy. Such a partnership would strengthen decisionmaking at all levels.

Scientists are developing a number of promising uses for computer technology, for example, geographic information systems

(GIS). A GIS-based technique called *gap analysis* enables biologists to integrate information regarding location, density, and diversity of species with information on factors relevant to conservation, such as planned development and protected areas. Such integration presents--in a readily understandable format--opportunities for improving protection.

V. A Strategy for Conservation Tomorrow

Conserving America's rich biological heritage is a vital responsibility, for the nation's health, wealth, and scenic beauty are at issue.

A. An Evolution in the Conservation of Natural Resources

Maintaining biodiversity requires attention to a broader array of elements within the environment and allows--perhaps forces--the nation to manage cooperatively larger units of the natural landscape. This imperative coincides with the trend in conservation toward working with ecosystems in a landscape context.

The goal of the Endangered Species Act is a grand and vital one--to prevent species from becoming extinct--but the species approach has been likened to a "911 distress line for life forms teetering on the edge"[90] or "emergency room care,"[91] with species of concern in dire straits. Most non-endangered or non-game species have no programs to monitor their condition or to avoid placing them in dire straits.

Suggestions that the United States take steps to protect biodiversity are not simply calls for a super endangered species

program--a mandate to identify and manage or to one-by-one restore every living thing on Earth--or even in the United States. Such a task would be daunting, indeed overwhelming. The situation calls for a different strategy. Preserving species--the purpose of the Endangered Species Act--is a major element in maintaining biodiversity, yet the law itself mandates the management of ecosystems on which the species depend.

Failure to address the ecosystem scale of human impact means that an increasing number of species--adapted to specific habitats--will become threatened and endangered as those habitats become damaged, isolated, or fragmented. Without adequate habitat, recovery of species now on the endangered list is difficult if not impossible. Ultimately it is not species that humans will need to manage but habitat. To accomplish the objectives of the Endangered Species Act, the nation will need to develop the ecosystem-based approach called for therein.

An integrated strategy to conserve biodiversity at all levels will include the following elements:

o Techniques that allows managers to work with a relatively small, manageable number of elements, yet achieve the broad goals of genetic, species, and ecosystem diversity. Resource managers need techniques for measuring simple properties that integrate ecological processes over large areas. For example, focused research may allow the condition of an entire watershed to be monitored by measuring specific water quality parameters in a

particular stream.[92]

o An information base that is readily available in a form and at a scale that managers can use; and

o Techniques applicable to both natural and managed landscapes. Protected lands are critical to biodiversity protection, but the landscape in which humans live, work, and play also can be diverse and ecologically healthy.

o Finally efforts to ensure the nation's continued ecological health require identification, and where feasible, restoration of elements and linkages that have been degraded or converted to other uses.

B. Ecosystem Management and Biodiversity in Policymaking

Many of the elements necessary for improving environmental management are in place.

o Scientists know much about how ecosystems work; far more collectively than is put to use.

o Natural resource managers know much about managing natural systems.

o Analysts grow increasingly sophisticated at predicting how the effects of human actions will ripple through ecosystems.

o The United States has incorporated strong environmental protection objectives into national decisionmaking.

o Significant federal resources are contributing, directly or indirectly, to the conservation of biodiversity. Efforts such as managing protected areas, surveying and monitoring, managing

species and ecosystems, maintaining germplasm banks, and biodiversity research contribute in a direct fashion. Many regulatory efforts, including the Clean Water Act's Section 404 program, conserving multiple-use lands, programs of museums and botanical and zoological gardens, and public education also contribute.

A strategy to conserve biodiversity in the United States will involve all of these elements, each of which exists to some degree in the current federal system.

But critical gaps remain.

1. A National Goal

Many U.S laws mandate conservation of some aspect of diversity, from the broad mandate of NEPA to the more specific mandates of the Migratory Bird Conservation Act or the National Forest Management Act. Many federal agencies are integrating the concept of biodiversity into day-to-day activities, ranging from staff training[93] to land management planning and assessment. Although found in many places within the federal government, these programs and statutes do not form a coherent, comprehensive framework for assessing or assuring progress toward a common goal, in part because no one has heretofore articulated such a goal.

Biodiversity is a national asset for both present and future generations that requires wise use and sustainability. Both public and private sectors in the United States have a role in maintaining and restoring biodiversity for its intrinsic worth, for healthy

ecosystems, and for human wellbeing.[94]

Such a goal need not conflict with a robust, growing economy. In the long run, a healthy economy is impossible without a healthy environment. The techniques and examples of management discussed in this chapter suggest that these two goals do not present irreconcilable conflicts.

2. Continuing Evolution

As public and private land and water managers attempt to incorporate ecosystem management and biodiversity into their planning and operations, it becomes increasingly evident that a comprehensive national biological inventory would facilitate their efforts. Such efforts can continue in its absence, however.

As private firms develop their next strategic business plan, as government program managers consider their next round of planning, and as land managers in both sectors prepare the next unit management plan, they can--within the limits of existing information--consider the broader systems within which their actions take place. They can cultivate connections between adjacent landowners. They can integrate their programs--formally or informally--to sensitize decisionmakers to the effects their actions will have on other programs.

Federal land managers and program administrators can enhance their contacts with tribal, state, and local governments and with the private sector to minimize duplication of effort, lack of attention to necessary factors, and conflict between goals,

objectives, and strategies of different participants.

Every landowner need not attempt to resolve, singlehandedly, the nation's problems of ecosystem fragmentation, conversion, and simplification. But individual decisions can either minimize or exacerbate such problems. Understanding regional patterns and recognizing that, in the long run, maintaining healthy, diverse ecosystems is vital to the wellbeing of all Americans will go a long way toward reducing conflict and improving environmental quality.

3. A National Biological Inventory

Information is critical to conservation. Without an adequate understanding of the status, numbers, distribution, and types of species extant in the United States and of the community associations on which they depend, inevitably, human actions will result in additional loss of biodiversity.

A national biotic inventory will require a more complete knowledge base than presently exists. While biological databases and the expertise they represent in institutions around the United States are impressive, major gaps remain in current knowledge. Deficits exist in understanding even major and relatively well-known groups of organisms, in addition to whole categories about which scientists know very little.

Despite the limitations of existing knowledge, cataloguing available information would be useful. Creating such a "database of databases"[95] would entail identifying and linking existing

information from public and private sources. This would provide access to the best information on a subject, even if that information is, as yet, uncertain and incomplete.

Far more important, however, is a commitment to identify gaps in knowledge and set priorities for filling those gaps, which include the following:

o **Species Classification.** With only 1 percent of domestic species characterized,[96] additional systematics research is essential; and

o **Basic Ecological Research.** Also needed is fundamental information on the distribution, abundance, and ecological relationships of domestic species and a comprehensive inventory and classification of ecosystems.

A national biological inventory would provide a mechanism to survey the millions of dollars being devoted to biodiversity in research and management. Only in this way, can the nation perform the following tasks:

o Identify and ensure adequate resources for investigations in areas where information is lacking;

o Monitor biodiversity programs; and

o Link public and private databases, laboratories, and field investigations.

4. A National Network of Bioreserves

Federal agencies have hundreds of designated natural areas that can contribute to a conservation strategy. Many private

landowners also expend considerable resources to conserve their lands. But no national effort to coordinate public actions or to identify and encourage private stewardship is currently in place.

In the 1960s land-management agencies established the Federal Committee on Research Natural Areas[97] to build a system of reserves representing the nation's natural land and water ecosystems. In 1974 the National Science Foundation and the Council on Environmental Quality joined the effort and the group became the Federal Committee on Ecological Reserves with 21 federal agency members. The goal was to establish and maintain a network of protected field sites representing a full array of the nation's terrestrial, freshwater, and aquatic ecosystems, but in recent years the committee has been inactive.

Each ecosystem contributes in its own way to the well-being of the nation, and in the closing years of the 20th century, no U.S. ecosystem should become extinct. Today, the potential loss of thousands of domestic species, primarily because of habitat alteration, demands a revitalized effort to inventory public and private natural areas across the nation, to identify gaps and, where necessary, to provide technical assistance and encouragement. Over the coming year, the Council on Environmental Quality will initiate a dialogue with committee members regarding the benefits of revitalizing this effort.

5. A Global Concern

Concern over U.S. biodiversity can not occur in a vacuum.

Around the world, scientists, policymakers, and the public are coming to understand the value of the wealth of life that surrounds and supports all human endeavor and the global threats to it. Unless the international community can reverse the current trend in global biodiversity loss, the rate of extinction worldwide over the next few decades could rise to 1,000 times the normal background rate. The result could be the loss of up to half the species on Earth.[98]

The United States is a world leader in meeting environmental challenges; biodiversity need be no different. With the knowledge and willpower Americans have devoted to other environmental matters, the United States can be in the vanguard of nations facing this critical global challenge.

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2. U.S. Congress, Office of Technology Assessment, *Technologies to Maintain Biological Diversity*, OTA-F-330 (Washington, DC: U.S. Government Printing Office, March 1987), pages 38, 314. The term *ecosystem* refers less to a specific area or location than to a functional delineation--more goes on within an ecosystem than across its boundaries. The classic example of an ecosystem is a lake, which has both inputs and outputs--springs may feed into it and a stream may flow out. A lake may receive deposition from the atmosphere and detritus carried by animals, yet it functions as a discrete unit. At the other end of the spectrum, scientists are studying large marine ecosystems--discrete oceanic areas in which recurring currents and patterns of nutrient cycling delimit functional units that are more closed than open. The lines of demarcation are not absolute, and defining where one ecosystem ends and another begins may depend on the subject of concern. An ecosystem may be as small as a log or as large as the Chesapeake watershed that extends south into Virginia and north to the

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47. In the majority of cases subject to consultation under Section 7 of the Endangered Species Act, federal agencies are able to identify a "reasonable and prudent" alternative.

48. Not only are species management efforts narrowly focused, but even within those foci, biases exist. Endangered species funding is heavily skewed toward large, visible, popular species, with little resources being devoted to many other listed species.

49. Passed in 1900, the Lacey Act prohibited the importation of certain species, including starlings and sparrows, deemed to be "injurious to the interest of agriculture and horticulture" and authorized the Secretary of Agriculture to adopt all measures necessary for the "preservation...and restoration of game birds and other wild birds." For a more complete discussion, see Bean, M.J., *The Evolution of National Wildlife Law*, (Washington, DC: Environmental Defense Fund, 1983).

50. In 1966 at the time of its enactment, the legislation was called "The Endangered Species Preservation Act."

51. Authority for designation of critical habitat is found at 16 USC 1533(b)(2). The definition of same is found at 16 USC 1532(5).

52. 16 USC 1534(f)

53. DOI, *Audit Report*, page x. Estimated costs would include plan development, implementation, and habitat acquisition.

54. The Federal Aid in Wildlife Restoration Act, 16 USC 669-669i (also known as "Pittman-Robertson Act"), and the Federal Aid in Fish Restoration Act, 16 USC 777-777k (also known as "Dingell-Johnson Act"), provide funds from federal excise taxes on hunting and fishing equipment, respectively. Although Pittman-Robertson authorizes the preparation of "comprehensive fish and wildlife plans," the term "wildlife" is undefined, and most state efforts focus on popular game species to the exclusion of others. For additional discussion, see Bean, page x.

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75. Friedman, L., and K. Wiley, "Protecting military secrets: a wealth of rare species on U.S. Department of Defense lands sparks innovative partnership," *The Nature Conservancy Magazine* vol(no):4-8, (July/August 1989).

76. 1972 Marine Protection, Research, and Sanctuaries Act citation.

77. 33 USC 1330.

78. 16 USC 1271.

79. U.S. Department of the Interior, National Park Service, Mid-Atlantic Regional Office, *Great Egg Harbor River Wild and Scenic River Study*, (city,state: NPS, November 1989), page x.

80. NOAA has authority under the Coastal Zone Management Act [16 USC 1452]. The Corps and EPA utilize the advance identification provisions of the Section 404(b)(1) Guidelines [40 C.F.R.230.80].

81. 16 USC 1453(17)

82. Take is defined in the Act (at 16 USC 1532[19]) as "harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect or to attempt to engage in any such conduct." According to Bean, page xx, taking can include activities that involve habitat destruction or other interference with a species' ability to survive, even if actual killing does not take place.

83. Beatley, page x.

84. U.S. Department of the Interior, Fish and Wildlife Service, "Draft Conservation Planning Guidelines," (Portland, OR: FWS Region 1, April 13, 1990, Draft).

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94. This goal statement, whose genesis was in the Keystone Dialogue processs, has been revised to apply not only to federal lands, but to all domestic lands; see Salwasser, page x.

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1990 CEQ Annual Report: Chapter Five

THE NATIONAL ENVIRONMENTAL POLICY ACT: INTEGRATION IN CONCEPT AND PRACTICE

[Lead-in to appear with chapter art on facing page]

A dilemma confronts many agencies of the federal government:

- How to accommodate environmental quality objectives, as developed in dozens of statutes;
- While at the same time effectively carrying out the agency's primary mission;
- When that mission, in many respects, may be at odds with those objectives.

The National Environmental Policy Act resolves the dilemma by means of an umbrella policy that *integrates* purposes and objectives and provides for choice where agency missions and environmental quality may conflict.

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Environmental quality, one of the nation's most pervasive and confounding issues, was, until 1970, considered primarily for public policy purposes in its discrete constituent parts, such as water, soil, and wildlife. The National Environmental Policy Act of 1969 (NEPA)[1] dramatically changed that one-dimensional approach to environmental management by requiring that the totality of environmental quality concerns be integrated comprehensively into federal policymaking and decisionmaking. NEPA as an integrative tool is the subject of the first part of this chapter. Subsequent parts examine recent NEPA trends and selected cases decided in the 12-month period since issuance of the last CEQ Environmental Quality report.

I. On the Threshold of a New Beginning

A. Introduction

The twentieth century, according to the late O.B. Hardison, Jr., has been characterized by sporadic "explosions of awareness," one of which unquestionably grew out of the environmental movement of the 1960s and found its ultimate expression in NEPA. "Such recurrent explosions of consciousness," Hardison observed, "do not seem accidental. They are like a volcanic eruption that suddenly releases enormous energy after a long, invisible buildup of pressure. They suggest the presence of a form of consciousness just under the surface of modern life that emerges whenever the conditions are right."[2]

1. Historical Background

In the second half of this century, the United States has witnessed not one, but two explosions of environmental awareness. The reverberations of Earth Day 1970, "the

catalyst for the creation of the modern American environmental movement," had not dissipated when, on the twentieth anniversary of that explosion, the nation experienced yet another equally powerful blast on Earth Day 1990 which developed into a "huge, global coalition determined to turn the tide in the battle to pull the planet back from the brink of ecological destruction."[3] Many of the same concerns, frustrations, and doubts that ignited the first explosion of environmental awareness more than 20 years ago persist today. Indeed, threats posed by global climate change, deforestation, soil erosion, species extinction, habitat destruction, and a host of other assaults on the environment seem to many observers more menacing today than they did in the 1960s.[4]

2. Principal Purposes of NEPA

Citizens understand now, perhaps better than they did two decades ago but still not completely, that the components of humankind's total life support system are interconnected and that, as a consequence, they cannot approach environmental problems in piecemeal fashion. And today, not unlike 20 years ago, the nation is searching for a comprehensive approach to environmental problems--an approach capable of anticipating environmentally disruptive influences and avoiding them.[5] That, however, is precisely why NEPA was enacted--to deal "with environmental problems on a preventive and an anticipatory basis."[6] But the continuing search for a comprehensive solution to environmental problems invites the question of whether NEPA represents an entirely adequate response to the apparently recurrent or ongoing conditions that spawned its enactment.

a. **Avoiding Environmental Degradation**

NEPA was not intended to respond to any particular environmental "condition;" rather, it marked "an effort for the first time to impress and implant on the Federal agencies an awareness and concern for the total environmental impact of their actions and proposed programs ... to avoid conflicts of one program objective with others through the mechanisms provided in [the act]."[7] The objectives of NEPA were to be achieved not through widespread government reorganization or through the creation of vast new bureaucracies to manage the environment; nor was Congress prepared to amend the enabling legislation of every agency of the federal government. Instead, NEPA was designed as a statutory supplement to other agency authorizations. While this legislative strategy was an invitation to parochialize administration of the act, Congress believed that existing institutions were capable of managing the environment if they operated "(1) under a coherent national policy ... and (2) with an expanded understanding of ecological facts and processes."[8] NEPA provided the former and a directive for federal agencies to equip themselves with the latter.

To guard against any tendency on the part of federal agencies to overlook environmental values in pursuing their "narrower, more immediate, mission-oriented goals"[9] Congress built into the act certain "action-forcing" provisions, including the requirement to prepare a "detailed statement" for every major federal action significantly affecting the quality of the human environment.

b. **Balancing Competing Policies**

The authorizations of most federal agencies are grounded in policies, such as agriculture, resource recovery, economic development, and the like which, on the one

hand, contribute to a high standard of living but, on the other hand, are not necessarily consistent with environmental policy objectives. Congress, however, never intended in enacting NEPA that national environmental policy should override other policies. Instead, an accommodation--a balancing of competing policies--is the goal that Congress sought. NEPA represents the government's "expressed determination to move the Nation in a comprehensive manner toward accommodation of the disparate goals of economic growth and preservation of a 'quality' environment."[10] Now Americans increasingly see that, contrary to the view advanced by many academicians 20 years ago, a clean environment and a sound economy can go hand in hand. And although the mandatory provisions of NEPA apply only to agencies of the federal government, Congress believed that achieving the act's lofty objectives is the responsibility of all branches of government,[11] at all levels,[12] as well as the private sector[13] and individual citizens.[14]

3. The Concept of Integration

Legislative efforts directed at restoring and maintaining environmental quality did not cease with enactment of NEPA, however. On the contrary, NEPA was viewed as providing "a framework for the formulation of specific legislative measures to deal with a wide variety of environmental problems."[15] The 91st Congress, which passed NEPA, also had under consideration "[m]ore than 2,000 legislative proposals ... having a bearing on environmental matters,"[16] of which 121 were passed and signed into law.[17] Granted, many of the "environmentally pertinent" statutes passed by the 91st Congress--and by succeeding congresses as well--involved so-called "interface areas such as transportation development and landscape preservation...."[18] But a number of statutes that Congress

enacted both before and after passage of NEPA[19] go considerably beyond interfacing and establish firm policies with respect to specific areas of environmental quality, all of which serves to illustrate the dilemma confronting every agency of the federal government: How to accommodate environmental quality objectives, as developed in dozens of statutes, while at the same time effectively carrying out its primary mission, a mission that in some respects appears to be at odds with those objectives. In NEPA, however, Congress provided the solution -- "[a]n overall policy for the environment ... which *integrates* [wide-ranging, statutorily mandated] purposes and objectives and which provides for choice when they are incompatible."[20]

The concept of integration is at the heart of NEPA, from its directive for the Council on Environmental Quality (CEQ) on behalf of the President to prepare and transmit an annual report to Congress, designed to integrate environmental data and trends into the legislative process, to its charge that CEQ act as public educator on environmental issues, basically for the purpose of instilling concern for the environment into the nation's social consciousness. For federal agencies, the concept of integration is evident in the act's "action-forcing" procedural requirements contained in section 102, a crucial integrative catalyst, the ultimate goal of which is to blend discordant policy parts into a more harmonious whole.[21] But integration as a goal of the section 102 procedural requirements was not an engrossing concept early in the implementation and administration of NEPA; instead, the nature and extent of the procedural requirements themselves became the cause celebre.

B. Integration as an Evolving Concept under NEPA

The conceptual evolution of integration under NEPA has had two fairly distinct stages, and as the act enters its third decade, the nation may be poised on the threshold of yet another stage. The first stage, which grew out of early congressional hearings and debates on a national policy for the environment, extended into the late 1970s when the CEQ regulations became effective. This was essentially a transitional stage in which federal agencies struggled to infuse their decisionmaking processes with the new supplemental basis for policy development--systematic ecology. And as might be expected when "dealing with a new animal,"[22] it was a period marked by controversy and great uncertainty.

Agency implementation of NEPA in the early 1970s was spotty at best and often undertaken without much forethought as to the consequences. Many agencies simply combined the procedural requirements of NEPA "with their existing procedures in the way least disruptive to those existing procedures."[23] This approach to NEPA implementation profoundly affected the act's performance during much of its first decade, primarily by allowing proposals to be developed substantially in advance of environmental analysis thereby limiting the choice among alternatives that could be more compatible with environmental quality objectives. By "adding" the NEPA procedures to, instead of integrating them with, existing agency procedures, decisionmaking was also made much more complicated. And because most existing agency procedures had a very narrow, project-oriented focus, an early pattern of attempting to achieve *policy* balance under NEPA on a non-policy, case-by-case basis, developed.

1. Congressional Intent

Initial difficulties with implementation of NEPA transcended the act's procedures. The problem, according to many observers, centered on the impact statements themselves, not the section 102 procedures which had been endorsed in congressional oversight hearings as "*bold and innovative*," having "*served to increase research, data-gathering and the development of agency analytic skills....*"[24] But NEPA did not (nor does it today) set out with specificity what it expects in terms of the form and content of the "detailed statements;" ecology, after all, had only recently been introduced as an element of federal decisionmaking. For this reason, the sponsors and supporters of NEPA knew that environmental analysis in all fields of federal activity would have to be carefully nurtured at the agency level. At the same time, however, concern was expressed by Congress "*that some agencies urgently need[ed] the development of entirely new in-house research machinery or broadened assistance of outside consultants in order to carry out adequate environmental analysis.*"[25] Satisfying that concern would require that environmental analyses contain "much more detailed information ... [delivered] in a much more timely manner to help structure the public debate...."[26]

2. Judicial Concerns

The courts, which had taken an early and active interest in NEPA through their review of agency actions subject to the act, also called for more detailed information in environmental impact statements (EISs). Although the scope of judicial review of agency actions subject to NEPA was related principally to the act's section 102 procedures,[27] courts were not reluctant to find that agencies must go beyond mere

procedural compliance and "make a sufficiently detailed disclosure so that in the event of a later challenge to the agency's procedure, the courts will not be left to guess whether the requirements of ... NEPA have been obeyed."[28] Of course, there was danger that the demand for greater detail in environmental impact statements would invite additional paperwork and cause greater delay in the decisionmaking process. But this result was viewed by many courts as "incident" to their mandate and "a concomitant of the implementation of the procedures prescribed by NEPA...."[29]

The concept of integration had not been emphasized by oversight committees of the Congress or the courts in the very early stages of implementing NEPA; nor did they have a clear understanding of just how that concept fit into the overall environmental review process under the act. Was it a purely mechanical exercise involving, for example, "integrat[ion of] the new guidelines developed ... by CEQ ... into existing, highly diversified procedures being applied by the various agencies in existing planning, evaluation and review processes?"[30] Or was more required, including an examination of "basic [agency] authorities to see how the new mandates of NEPA must be integrated?"[31] But even with respect to the more mechanical approach to integration, the role of NEPA was not well understood.

In terms of integrating requirements of existing environmental review laws, such as the Fish and Wildlife Coordination Act, the question presented was whether NEPA should be integrated into the former, as one congressional oversight committee suggested,[32] or, as the court in *Environmental Defense Fund* v. *Corps of Engineers* determined, whether compliance "with the provisions of [NEPA] in good faith ... automatically take into consideration all of the factors required by the Fish and Wildlife

Act?"[33] None of these questions was vigorously pursued, however, because most authorities considered achieving the goals and objectives of NEPA to be more a function of the quantity of information contained in the environmental impact statements as opposed to either the quality of that information or the means through which it could be integrated most effectively into the decisionmaking process.

3. **Agency Responses**

Agencies responded predictably to the demands of Congress and the judiciary for greater "detail" in environmental impact statements--they began preparing lengthy, nonanalytic documents that contributed little, if anything, to either environmental quality objectives or to their primary missions. Coupled with development of exceedingly complex systems of review (see Figure 5-1), the tendency of agencies to prepare highly "detailed" statements quickly came to be viewed as the principal source of delay in the decisionmaking process and a prime contributor to increased project costs. Agency excesses in the EIS process generated a rash of early proposals to amend NEPA[34] and provided the impetus for many hearings[35] and studies.[36] And despite the fact that knowledgeable, responsible officials maintained that NEPA did not compel the results--bloated documentation, delays, and excessive costs--about which so many complaints were then being lodged,[37] environmental impact statements nevertheless continued generally through the mid- to late-1970s to delay agency decisionmaking in part by presenting "mammoth discourses on every conceivable environmental effect...."[38]

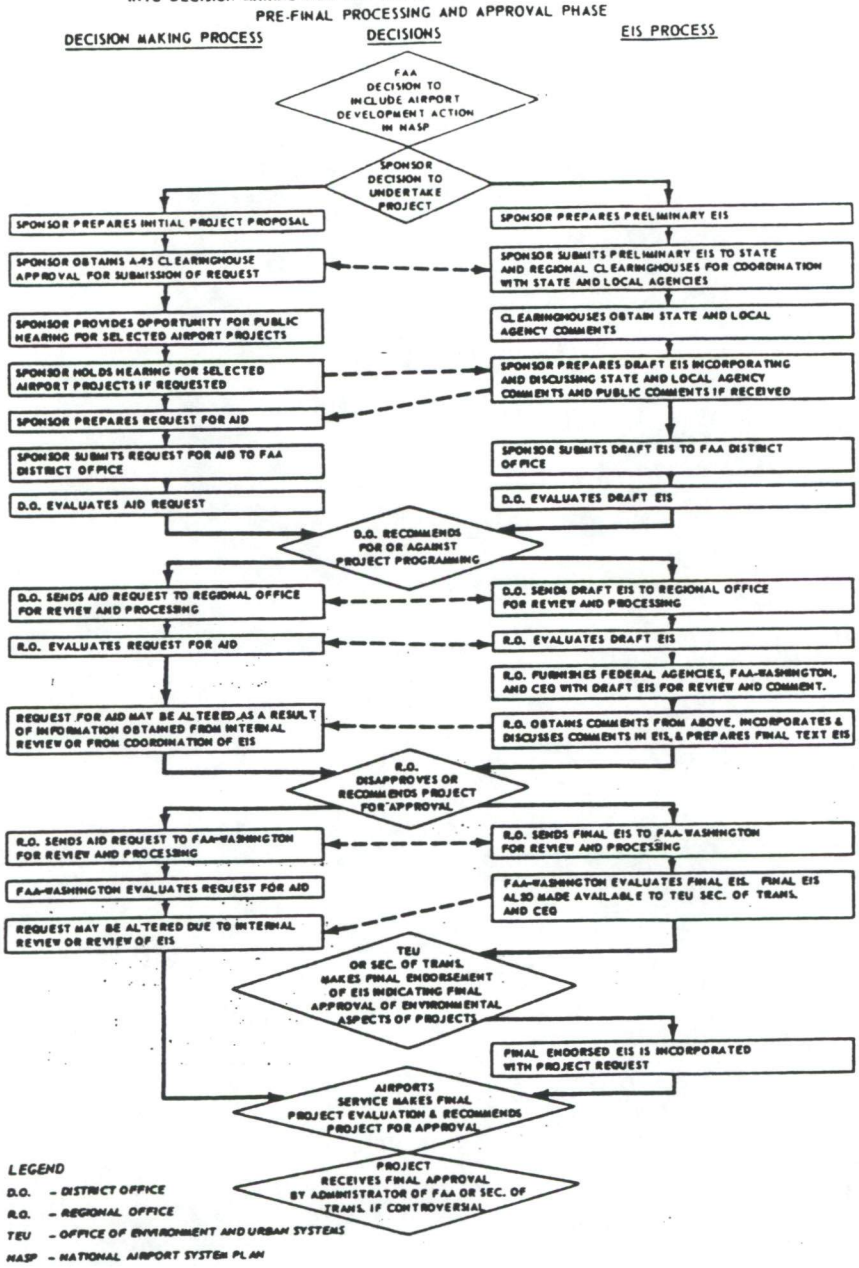
In all the early hearings, studies, and reports on NEPA, a fair amount of agreement existed concerning both the problems with implementation of the act and the solution. Environmental impact statement preparation was placing strains on the

administrative system "due to increased friction from more inputs and participants, the pressure of available environmental expertise, the awkward coordination of NEPA with the Endangered Species and Historic and Archaeological [sic] Preservation Acts, the court-prompted identification of all conceivable impacts, and, often mentioned but less important, the problems of budgeting the time and money for the EIS process."[39] The purpose of the impact statement--to aid federal officials and the public in making basic policy choices--had been obscured by a blizzard of data, the compilation of which served little or no useful purpose, being motivated more often than not "by a desire to avoid or survive court review [rather] than by a felt need to balance rationally the various factors of the decision."[40]

Despite widespread criticism of NEPA, however, relatively few officials and commentators believed that the act and its special procedures did not contribute positively to agency decisionmaking. On the contrary, "NEPA ... largely due to the implementation of section 102(2)(C), the environmental impact statement requirement," was viewed by congressional oversight committees as having been responsible for "the gain in environmental information available to the Federal Government and the public ... [and] increasing the public ability to respond to proposed actions and to recognize their relationships to public interest...."[41] Nor was NEPA, which had "borne the brunt of criticism of environmental legislation in general,"[42] really to blame. But, as is often the case with a new social force, its shortcomings, as opposed to its benefits, attracted the greatest amount of attention.

Figure 5-1 EFFORTS OF THE FEDERAL AVIATION ADMINISTRATION TO INCORPORATE SECTION 102 OF THE NATIONAL ENVIRONMENTAL POLICY ACT OF 1969 INTO DECISION MAKING FOR THE AIRPORT DEVELOPMENT AID PROGRAM (ADAP)

PRE-FINAL PROCESSING AND APPROVAL PHASE



Source: General Accounting Office, *Report to the Subcommittee on Fisheries and Wildlife Conservation of the House Committee on Merchant Marine and Fisheries, Improvements Needed in Federal Efforts to Implement the National Environmental Policy Act of 1969* App. XI, p. 88 (May 1972).

The solution to problems associated with implementation of the NEPA procedures, according to many of the same sources that targeted those problems, revolved around a single concept--integration. Thus, in responding to a request for evaluation of time delays, costs, and other effects of environmental impact statement preparation on public works projects, the Comptroller General of the United States reported:

> When EIS preparation is integrated with and completed during project planning, it helps ensure that environmental amenities and values are given appropriate consideration along with the economic and technical factors in planning and decisionmaking. At the same time, it reduces the risk of project delays due to lawsuits, public pressure, or other circumstances which can stop projects when a timely EIS has not been prepared.[43]

Integration as a means of overcoming the procedural problems encountered with NEPA had been supported by congressional oversight committees[44] and by CEQ whose guidelines specified "that agencies should prepare their draft EIS as early as possible in their planning and decisionmaking process."[45] But prior to 1978 the concept of integration had not been fully developed for practical application; nor had any elements of it ever been authoritatively set forth. This was to change, however, with the promulgation of Executive Order No. 11991 of May 25, 1977,[46] directing CEQ to issue regulations intended to make the impact statement process more efficient and more useful to federal decisionmakers and the public. CEQ responded to that directive by introducing in its new regulations the concept of "total integration," providing federal agencies with uniform, practical procedures and the flexibility to adapt them to their particular programs.

C. Prescription for Total Integration

By the late-1970s environmental review requirements applicable to federal agency activities had proliferated considerably. But the environmental process, the EIS component of which had been singled out as the principal contributor to administrative delay, was not burdened only by the sheer number of environmental review law requirements; rather, it was the multi-dimensional characteristics of those laws--their tendancy to overlap substantively, procedurally, and even across jurisdictions--that complicated agency compliance efforts. The one-dimensional add-on approach to fulfilling the requirements of NEPA that typified federal agency compliance efforts to that point was unworkable. Agencies urgently needed a more dynamic process, one that could accommodate--or consolidate--all environmental review responsibilities.

1. A Planning Instrument

The CEQ regulations, which with one change[47] remain in force today, were designed specifically to address the dilemma that had been posed by misdirected agency implementation of environmental procedures in two ways. First, they establish for the "NEPA process" -- defined as "all measures necessary for compliance with the requirements of section 2 and Title I of NEPA"[48]--reasonable quantitative and qualitative targets. For example, with respect to "[t]he text of final environmental impact statements," the regulations provide that it "shall normally be less than 150 pages"[49] and that the impact statements themselves "shall be analytic rather than encyclopedic."[50] But the establishment of targets, without more, could not assure their attainment. CEQ therefore incorporated into its regulations a system of procedures that are capable of

being adapted to the decisionmaking practices of any agency for the purpose of integrating environmental considerations meaningfully and efficiently into its more mission-oriented activities. That system relies upon the three features that distinguish effective planning--timing, coordination, and scope of review--all of which are essential to achieve integration under the act.

The procedural cornerstone of an effective NEPA process is timing. If agencies integrate the NEPA process into their decisionmaking at a stage where choices among alternative courses of action have been foreclosed, then it would matter little how well they analyze the effects of a proposal in a "detailed statement;" little or no real opportunity to influence the outcome from the standpoint of environmental quality remains at that stage. For this reason, the CEQ regulations require that agencies "integrate the NEPA process with other planning at the earliest possible time to insure that planning and decisions reflect environmental values, to avoid delays later in the process, and to head off potential conflicts."[51] Each federal agency is directed to "commence preparation of an environmental impact statement as close as possible to the time the agency is developing or is presented with a proposal ... so that preparation can be completed in time for the final statement to be included in any recommendation or report on the proposal."[52] But applying the NEPA process early in agency planning and decisionmaking achieves more than just timely completion of environmental documentation; it also makes that documentation more meaningful by promoting a more fully coordinated, focused effort on the part of all concerned governmental entities and the public.

NEPA, the most comprehensive of all environmental review laws, provides a

procedural canopy beneath which the act's requirements must be integrated "with other planning and environmental review procedures required by law or by agency practice so that all such procedures run concurrently rather than consecutively."[53] And consistent with Congress' declaration of national environmental policy, the CEQ regulations also provide that federal agencies "shall cooperate with State and local agencies to the fullest extent possible to reduce duplication between NEPA and State and local requirements"[54] and shall "[e]ncourage and facilitate public involvement in decisions which affect the quality of the human environment."[55] The early identification of pertinent authorities and agencies potentially interested in a proposed action helps structure the public "scoping process" that brings into play the other two planning features (coordination and scope of review) to frame the essentials of environmental impact statement development--from the significant issues that must be studied and the scheduling of document preparation to designation of agencies that will cooperate in the study and the nature and extent of their participation.[56] The use of other integrative procedures prescribed in the CEQ regulations, including incorporation of material by reference[57] and adoption of previously prepared environmental documentation,[58] should also be explored during the "scoping process." Upon completion of that process, government agencies, the public, and other interests will find themselves equipped with a flexible blueprint for fully integrating a concise, predictable, analytical environmental process into agency decisionmaking before work on the actual environmental impact statement is even begun.

2. **Where and How to Integrate**

In its simplest form and reduced to a schematic, the pivotal pre-EIS phase of the

NEPA process for a "major federal action" might resemble the diagram in Figure 5-2.

Of course, comparatively few major federal actions are uncomplicated for purposes of NEPA and other environmental review laws. This is particularly true of major federal actions that originate as proposals sponsored by non-federal grant or license applicants. The difficulty with applicant-sponsored proposals is that the federal approval stage generally represents one of the final steps in a planning process that often began months, and even years, before. But the CEQ regulations address this situation as well, essentially by requiring integration of environmental factors and alternatives into the prefiling planning processes of prospective applicants.

Under the CEQ regulations, federal agencies must "[p]rovide for cases where actions are planned by private applicants or other non-Federal entities before Federal involvement..."[59] In designing procedures to assist applicants sponsoring proposals for federal approval, agencies

> should include an "outreach program," such as a means for prospective applicants to conduct pre-application consultations with the lead and cooperating agencies. Applicants need to find out, in advance of project planning, what environmental studies or other information will be required, and what mitigation requirements are likely, in connection with the later federal NEPA process. Agencies

Figure 5-2. Planning for Integration of Environmental Laws

Initiation of Planning/Decisionmaking for a "Major Federal Action"

In-house Identification of Issues, Authorities, and Agencies

Publish Notice of Intent to Prepare Environmental Impact Statement
(§§ 1508.22; 1501.7; and 1506.6)*

Extend Invitation to Participate
(§ 1501.7(a)(1))

Announce Forthcoming Scoping Notice
(§ 1506.6)

Publish Notice of Proposed Scope and Invite Comment
(§§ 1501.7 and 1506.6)

Determine Scope and Significant Issues to be Analyzed
(§§ 1508.25 and 1501.7(a)(2))

Eliminate Issues not Significant to Analysis
(§ 1501.7(a)(3))

Explore Incorporation by Reference and Adoption Opportunities
(§§ 1502.21 and 1506.3)

Target Other Environmental Review Laws/Processes to be Undertaken Concurrently as well as Separate Documentation Requirements
(§§ 1502.25 and 1501.7(a)(5))

Examine Pertinent State and Local Procedures
(§ 1506.2)

Designate Lead/Joint Lead and Cooperating Agencies
(§§ 1501.5; 1501.6; and 1506.2(c))

Allocate Assignments Among Lead/ Cooperating Agencies
(§ 1501.7(a)(4))

Fix Page Limits
(§ 1502.7)

Establish Time Limits
(§ 1501.8)

Review Comments and Publish Notice of Final Scope
(§ 1506.6)

Proceed According to Plan and Schedule Established in Notice of Final Scope

* All section citations are to title 40 of the Code of Federal Regulations.

> should designate staff to advise potential applicants of the agency's NEPA information requirements and should publicize their pre-application procedures and information requirements in newsletters or other media used by potential applicants.[60]

Agencies also must provide assistance for prospective applicants by outlining data requirements where environmental reports and other material are submitted with an application.[61] Finally, to hasten the processing of applicant-sponsored proposals and to eliminate duplication of effort, the CEQ regulations permit applicants to prepare for their proposed actions environmental assessments that are subject to independent review and verification by the agency[62] or, in cases where environmental impact statements are required, to have the draft impact statement prepared in advance of application filing pursuant to a third-party contract arrangement.[63]

The CEQ regulations anticipate and provide for most of the situations that might be encountered in applying the NEPA process to federal actions. Still stumbling blocks are almost always present. One such stumbling block involves situations in which applicant-sponsored proposals are subject to multiple permitting or review requirements (such as permitting by the Corps of Engineers under section 404 of the Clean Water Act or review pursuant to section 106 of the National Historic Preservation Act). The CEQ regulations call for "[o]ther federal agencies that are likely to become involved ... [to] be contacted, and the NEPA process coordinated, to insure an early and comprehensive analysis of the direct and indirect effects of the proposal and any related actions."[64] But other federal agencies generally have their own workload and scheduling demands from which they may be reluctant to depart on a case-by-case basis, regardless of how early

they may be invited to participate in the decisionmaking process of the lead federal agency. An alternative approach in these types of situations, where recurrent filings are expected, is execution of a programmatic memorandum of agreement[65] between or among multiple permitting agencies for the purpose of establishing mutually acceptable consolidated review procedures applicable to all similar applicant-sponsored filings.

D. Integration in Practice

Neither the provisions of NEPA nor the CEQ implementing regulations function as stand-alone mandates. The NEPA process can be understood only in the context of a statutory scheme and program to which it applies. But integration of the NEPA process is not always easily achieved, as evidenced in the case studies provided below.

1. Interstate Commerce Commission: Railroad Abandonment

Abandonment of railroad lines involves a statutory scheme that is somewhat inhospitable to, although clearly within the ambit of,[66] the NEPA process. Railroad abandonment applications, submitted for approval to the Interstate Commerce Commission (ICC), are sponsored by abandoning rail carriers and involve alternatives that require the initiative of outside entities. Additionally, the entire rail abandonment application process is subject to adjudicative (trial-type) procedures and stringent statutory deadlines. In all, a better opportunity to demonstrate the versatility of NEPA in integrating environmental considerations into agency decisionmaking--especially adjudications--is difficult to imagine.