



**U.S. Department of the Interior
National Park Service
Natural Resource Information Division**



**Prototype Ecological Monitoring
(Updated)**

November 1997

97-38

The Natural Resource Inventory and Monitoring (I&M) Program was established to help with preventing the loss or impairment of significant natural resources in more than 250 of the 376 units of the National Park System¹. Many natural resources in the system are subjected to unfavorable influences from a variety of sources, for example, air and water pollution, urban encroachment, and excessive visitation. Left unchecked, such effects can threaten the very existence of many natural communities in the units.

The principal functions of the I&M Program are the gathering of information about the resources and the development of techniques for monitoring the ecological communities in the National Park System. Ultimately, the inventory and monitoring of natural resources will become integral parts of park planning, operation and maintenance, visitor protection, and interpretation. They will enhance the preservation and protection of natural resources and improve the stewardship of natural resources by the National Park Service. The detection of changes and the quantification of trends in the conditions of natural resources are

imperative for the identification of links between changes in resource conditions and the causes of changes and for the elimination or mitigation of such causes. Inventory and monitoring provide important feedback between natural resource conditions and management

Monitoring in the prototypes varies widely by structure and function of a park. However, the monitoring of trends in species abundance, population dynamics, watershed ecology, and other indicators of environmental change tends to be uniform throughout the prototypes.

Notwithstanding, all monitoring is designed to provide ecological information that is useful for addressing questions beyond today's issues.

Protocols and expertise developed by the prototypes will be shared with other parks in similar ecological and managerial settings. The prototypes will also serve as training centers for natural-resource managers throughout the

National Park Service. A brief summary of the monitoring in the seven initiated prototypes is provided below.

Table 1. The seven initiated prototypes and the biomes they represent.

Prototype	Biome
Cape Cod National Seashore	Atlantic/Gulf Coast
Channel Island National Park	Pacific Coast
Denali National Park and Preserve	Arctic/Subarctic
Great Plains Cluster	Prairie and Grassland
Great Smoky Mountains National Park	Deciduous Forest
Shenandoah National Park	Deciduous Forest
Virgin Islands/Southern Florida Cluster	Tropical/Subtropical

and trigger specific management and evaluation of managerial effectiveness.

Prototype Ecological Monitoring

The tremendous variability in the ecological conditions, sizes, and management capabilities of national parks represents significant problems for ecological monitoring throughout the National Park Service. To deal with this ecological and managerial diversity, the I&M Program used a competitive process to select parks that represent *prototypes* for the experimental monitoring of each of 10 major biomes (Tables 1 and 2). To ensure that the broad range of managerial situations is adequately represented, three of the prototypes were selected as *clusters*, i.e., a grouping of 4-6 small units, each of which lacked the full range of staff and resident expertise for long-range monitoring on its own.

Partnerships

Prototype monitoring is being implemented in close partnership between the National Park Service and the National Biological Resources Division of the US Geological Survey (USGS). During the initial phases of research and design--usually a period of 3-5 years--funding and full-time employees are provided by the National Biological Resources Division. After completion of research and protocol designs, monitoring is considered to be operational. From then on, funding and full-time employees become the responsibilities of the National Park Service

¹ National parks and other entities of the National Park Service such as national monuments, national rivers, wild and scenic riverways, national scenic trails, and others are called *units* and collectively constitute the *National Park System*.

Program Status

Cape Cod National Seashore (Atlantic/Gulf Coast Biome)

Cape Cod is a large glacial peninsula that extends 60 miles into the Atlantic Ocean from the coast of Massachusetts. Cape Cod National Seashore was established in 1961 and consists of 44,600 acres of marine, freshwater, and terrestrial ecosystems. During the past three centuries, the ecosystems were profoundly altered by humans. Many habitats on the seashore are globally uncommon, and the species that occupy them are correspondingly rare. Monitoring was initiated in 1996 to address five major ecological communities: (1) shoreline margins; (2) barrier islands, spits, and dunes; (3) estuaries; (4) freshwater kettle ponds and vernal pools; and (5) maritime heathlands and forests. Monitoring in each community is designed to address management issues that are specifically related to the seashore and to other Atlantic coastal parks.

The seashore and its partner, the Biological Resources Division of the National Geological Survey at the University of Rhode Island, are in the early phases of research, development, and testing of protocols. Monitoring on the seashore is by a multivariate approach that combines physical, chemical, and biological information into a single matrix for examining patterns of ecological changes. Ongoing projects are addressing shoreline change, estuarine nutrient dynamics, salt marsh restoration, and the creation of a kettle pond data atlas. Full implementation of monitoring and integration of monitoring with natural resource management are defined as protocols are developed.

Channel Islands National Park (Pacific Coast Biome)

The Channel Islands National Park off the coast of California has conducted prototype ecological monitoring since 1992. Monitoring is based on the belief that organisms exhibit the effects of a vast array of ecological factors, including predation, competition, and

other environmental factors that are expressed in changes in population dynamics such as abundance, distribution, growth rate, and mortality. A conceptual model of the park's ecosystems was used to identify mutually exclusive system components for monitoring. Protocols for monitoring weather, air quality (ozone), water quality, kelp forests, rocky intertidal communities, sandy beaches or lagoons, terrestrial vegetation, seabirds, pinnipeds, land birds, and visitor numbers have been established. Monitoring in the park is fully operational. The natural resource management staff of the park conducts the monitoring and manages related data.

In addition to monitoring in 1997, the park also completed a peer review of its kelp forest monitoring and subsequently updated its monitoring handbook and data entry procedures. Vegetation monitoring was extended to the recently purchased 6000 acres of eastern Santa Cruz Island. Because monitoring revealed a drastic decline of the abundance of the island fox (*Urocyon littoralis littoralis*) on San Miguel Island, the park drew blood samples from several foxes to determine whether diseases may be the cause of the decline. Monitoring of the kelp forests confirmed the decline of red abalone (*Haliotis rufescens*) for several years. The information was instrumental in convincing the California legislature to close southern California to harvesting of red abalone.

Denali National Park and Preserve (Arctic/Subarctic Biome)

In 1992, the Denali National Park and Preserve was selected for prototype ecological monitoring of communities and ecosystems by watershed in large Alaskan parks. Techniques that are developed in one watershed will eventually be replicated in other watersheds to track resource trends in major terrestrial habitats, aquatic systems, and climate regimes in the park. The structures of vegetative and aquatic communities, the dynamics of vegetative communities, and chemical and geophysical parameters, including water and soil characteristics, are monitored in a

series of permanent plots in the Rock Creek watershed. Data are also collected from weather stations in associated plots and from grids and stations where the productivity of small mammals and birds is sampled.

During Fiscal Year 1997, the Biological Resources Division of the US Geological Survey coordinated the peer reviews of the protocols for monitoring weather, air quality, stream channel morphometry and water chemistry, glaciers, vegetation, small mammals, and land birds (2 protocols) and the protocol for data management. National Park Service staff conducted field operations in the Rock Creek watershed and on glaciers and continued the development of protocols for the monitoring of soils and benthic macroinvertebrates. Park staff also began to organize, verify, and validate information about water chemistry, hydrology, and vegetation. Long-term ecological monitoring of golden eagles (*Aquila chrysaetos*), wolves (*Canis lupus*), moose (*Alces alces*), caribou (*Rangifer tarandus*), and Dall sheep (*Ovis dalli*) that present concerns for management was continued. Two milestones in resource inventories were reached: the analyses of data from a park-wide, 3-year inventory of water chemistry were completed, and an inventory of soils was started. Data from the inventories will permit stratification of watersheds throughout the park.

Great Plains Cluster (Prairie and Grassland Biome)

The first of three clusters was established in 1994 when monitoring in the Great Plains Prairie Cluster was funded. Monitoring is conducted in a cluster of six small prairie park units in the Midwest. Wilson's Creek National Battlefield in southwestern Missouri is the leading park for the cluster. The overall goals of the monitoring are the assessment of the effectiveness of resource management and the detection of degradation from external threats. The protocols address three high-priority management issues: (1) sustainability of small remnant and restored prairie ecosystems, (2) the effects of external land use and watersheds on small-prairie preserves, and (3) the effects

of fragmentation on the biological diversity of small-prairie parks.

Monitoring in the Great Plains Cluster is still in the initial phase of protocol design and development and is therefore primarily funded and staffed by the Biological Resources Division of the US Geological Survey. Protocols are currently developed for monitoring macroinvertebrates of prairie streams, weather and local climate, prairie plant communities, rare plants, prairie butterflies, and grassland birds.

*Great Smoky Mountains National Park
(Deciduous Forest Biome)*

The Great Smoky Mountains National Park, which encompasses approximately 550,000 acres in the states of Tennessee and North Carolina, became a prototype in 1992. The floral and faunal species richness in this park is one of the greatest in the National Park System. However, this richness is threatened by the invasions of exotic forest insects, diseases, plants, and vertebrates; by high ozone and nitrate depositions at upper elevations; by fire suppression; and by the destruction of habitats on the peripheries of the park.

Long-term monitoring in very large parks presents a special problem because of spatial scales. Therefore, monitoring in the Great Smoky Mountains National

Park is structured in a hierarchy of five spatial scales: landscapes, ecosystems, watersheds, communities, and species. Within these spatial levels, 13 key ecosystem processes and components are monitored. The monitoring at the landscape level primarily serves to determine the effects of air pollution and climatic change on the structure and dynamics of the spruce-fir (*Picea-Abies*) forests. At the species level, the population dynamics of the black bear (*Ursus americanus*) and the white-tailed deer (*Odocoileus virginianus*) are monitored. The monitored components in the park also include water quality, rare plants, exotic plants and animals, and

brook trout (*Salvelinus fontinalis*) populations.

Monitoring in the Great Smoky Mountains National Park is fully operational. All research and designs were completed, and the monitoring was integrated into natural resource management

*Shenandoah National Park
(Deciduous Forest Biome)*

Shenandoah National Park is in the northern Blue Ridge Mountains. It is the largest protected area in the mid-Atlantic region (196,000 acres) and the site of the historic Skyline Drive. Because of the park's long narrow shape and proximity to large metropolitan areas, protection of its resources is challenging.

Prototype inventory and long-term ecological monitoring has been fully integrated into the Resource Management Plan of the park. Monitoring results are integral components of interpretation, education, and resource protection. In 1997, I&M data were used:

review are still used to refine inventory and monitoring protocols.

*Virgin Islands-Southern Florida Cluster
(Tropical and Sub-tropical Biomes)*

In 1997, the draft of a plan for prototype inventory and monitoring of natural resources in the tropical and subtropical biomes of the Virgin Islands-Southern Florida Cluster was completed, the protocol for monitoring coral reefs with analog and digital videos was improved and tested, and protocols for monitoring water quality were finalized and implemented. Monitoring on four permanent transects revealed several, as yet unclassified diseases of coral reefs. Research into the potential connection between these diseases and bacterial contamination from Sahelian dust is being proposed. Coral reef fish populations, the effects of terrestrial erosion and sedimentation on coral reefs, and tropical dry forests are monitored when possible.

Future Prototypes

Four parks are targeted as prototypes (Table 2) to represent four major biomes. Monitoring will be initiated in these parks as soon as funding can be appropriated.

Table 2. The four National Park System units in which prototype monitoring will be implemented and the biomes that these units will represent.

Prototype	Biome
Mammoth Cave National Park, Kentucky	Caves
Olympic National Park, Washington	Coniferous Forest
North Cascades National Park, Washington	Rivers and Lakes
Northern Colorado Plateau Cluster, Colorado and Utah	Arid Lands

- to revise fishing regulations in the park
- to evaluate large-scale effects of flooding
- to determine the health of hemlocks (*Tsuga* spp.) that are threatened by the introduced pest woolly adelgid (*Adelges piceae*), and
- to support information in adult seminars that are coordinated by the interpretation and education office.

Immediately prior to Fiscal Year 1997, the I&M Program in the park was critically reviewed. The results of the

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