
# Natural Resource Inventory & Monitoring in National Parks

*1995*

*U.S. Department of the Interior*

*National Park Service*

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I&M Inventory and Monitoring

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From the spectacular mountain ranges and glacier fields of Alaska to the Sonoran deserts of America's Southwest, from the volcanic landscapes of Hawaii to the magnificent barrier islands of the northeastern United States, the National Park Service acts as steward for natural resources that have inspired, awed, and brought enjoyment throughout this century. Responsible for nearly 80 million acres of public land, the National Park Service preserves and protects some of the world's most scenic and important natural resources.

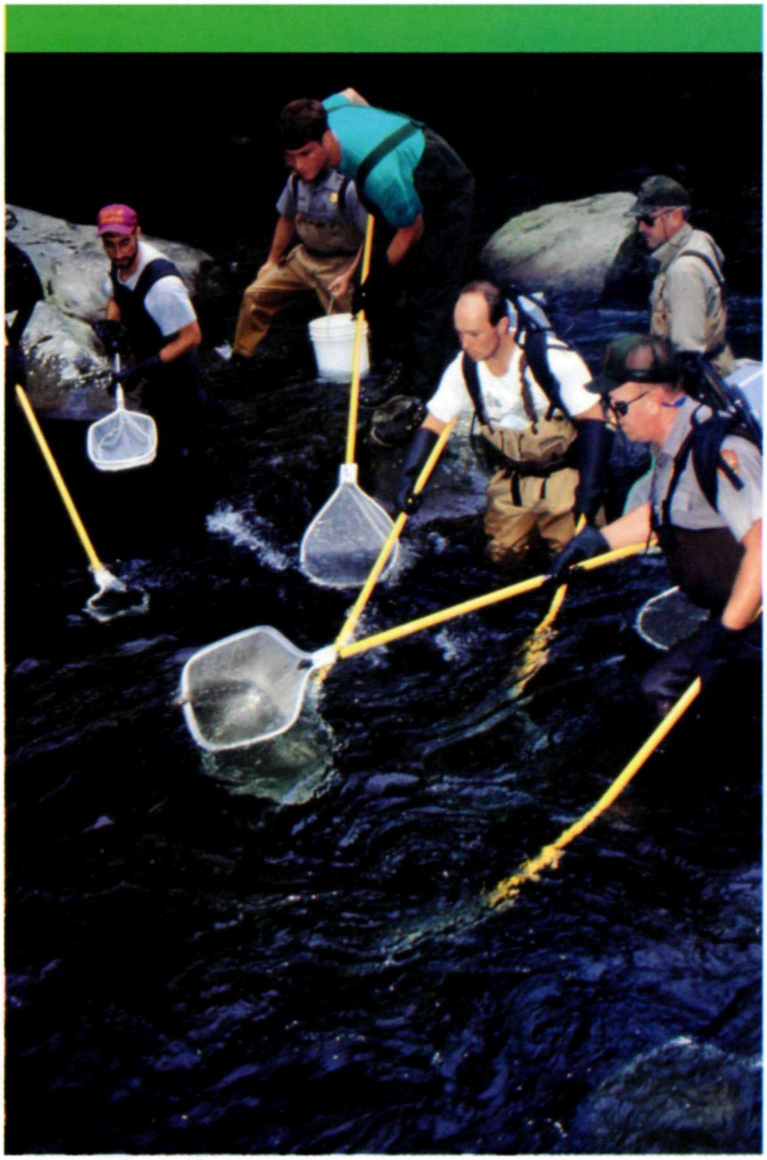
Unfortunately, many units of the National Park Service are being subjected to a wide variety of impacts and alterations. Air pollution has degraded the magnificent views of Grand Canyon, while water quality and quantity problems threaten the delicate aquatic ecosystems in Everglades. Many parks today face urban encroachment; many more suffer from the impacts of excessive visitation. Left unchecked, these factors of change could threaten the very existence of many biotic communities within the parks.

In 1991, the National Park Service published its Vail Agenda, a comprehensive strategy for serving America's noble trust into the 21st century. To meet our resource stewardship responsibilities, the Vail Agenda action plan calls for park managers and superintendents to have solid natural resource information at their disposal.

- Park managers must have com prehensive information about the nature and condition of the major biotic and abiotic natural resources placed under their stewardship.
- Park managers need to know how resource conditions change over time.

Only by having reliable scientific information can park managers take corrective actions before those impacts severely degrade ecosystem integrity or become irreversible.

Consistent with the mandates of the Vail Agenda, the goal of the National Park Service's Natural Resource Inventory and Monitoring Program is to acquire the information and expertise needed by park managers in their efforts to maintain ecosystem integrity in the approximately 250 National Park System units that contain significant natural resources.



*Large-stream electrofishing crew assesses the state of resident and exotic species of trout in the lower elevation streams in Great Smoky Mountain National Park.*

# THE INVENTORY AND MONITORING PROGRAM

Five long-term goals have been established for the Natural Resource Inventory and Monitoring Program.

**Baseline inventories** of basic biological and geophysical natural resources will be completed for all natural resource parks. To ensure availability to park managers, data collected at the park level will be maintained in the park and also used to generate regional and national summaries of selected inventory items.

**Long-term monitoring** programs will be developed to efficiently and effectively monitor ecosystem status and trends over time at various spatial scales.

**Decision Support** Geographic information systems and other tools needed to apply field data will be used to aid park managers in identifying alternative courses of management actions, assessing trade-offs, and evaluating consequences.

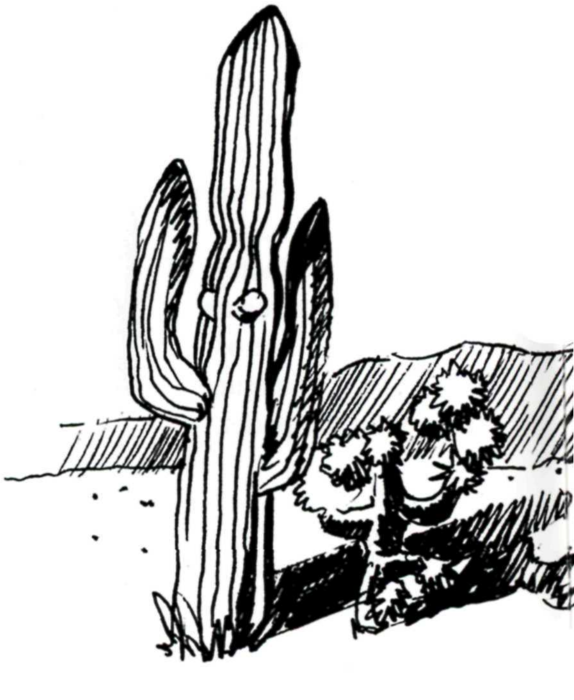
**Integration** Natural resources inventory and monitoring programs will be integrated with park planning, operation and maintenance, visitor protection, and interpretation activities in order to establish natural resource preservation and protection as an integral part of overall park management.

**Cooperation** The National Park Service is actively engaged in cooperative efforts with other federal and state agencies to share resources and achieve common goals in order to avoid unnecessary duplication of effort and expense. Every effort is being made to develop cost-sharing and technology exchange agreements with other agencies conducting inventories or monitoring activities.

To achieve the above goals, the Natural Resource Inventory and Monitoring Program is being carried out in two distinct phases. Phase I began in 1992 and will be completed over a period of approximately ten years. During Phase I, the program will complete baseline natural resource inventories for approximately 250 park units that contain significant natural resources. Also during Phase I, the Service will develop a number of "prototype" ecological monitoring programs in order to prepare for conducting ecosystem-level monitoring throughout the Service.

The primary focus of Phase II will be on operational monitoring. As we enter the 21st Century, the monitoring designs and protocols developed by the prototype monitoring programs during Phase I will be transferred to other natural resource park units throughout the Service for long-term implementation.

The Inventory and Monitoring Program creates an important foundation for effective, long-term management of natural resources throughout the Service. Resource inventories constitute a critical first step; they inform park managers about the nature of the resources held in trust. The expertise gained through prototype monitoring programs will allow park managers to more effectively detect changes and quantify trends in the condition of those resources, as well as understand the linkages between changes in resource condition and their cause. When fully operational, monitoring programs will provide important feedback between natural resource condition and management objectives, which can serve both to trigger management actions and to evaluate managerial effectiveness. By developing this type of sound technical information on park resources and ecological processes, the Natural Resource Inventory and Monitoring Program will improve our stewardship capabilities.



# NATURAL RESOURCE INVENTORIES

Baseline natural resource data is fundamental to the management of national parks. Natural resource inventories allow us to account for park resources, including the presence, class, distribution, and normal variation of plants and animals, and such important abiotic components as water, soils, landforms, and climate. Inventories contribute to a statement of the condition of park resources in relation to a standard condition, preferably the natural or unimpaired state. Inventories involve the compilation of existing information as well as the collection of new information.

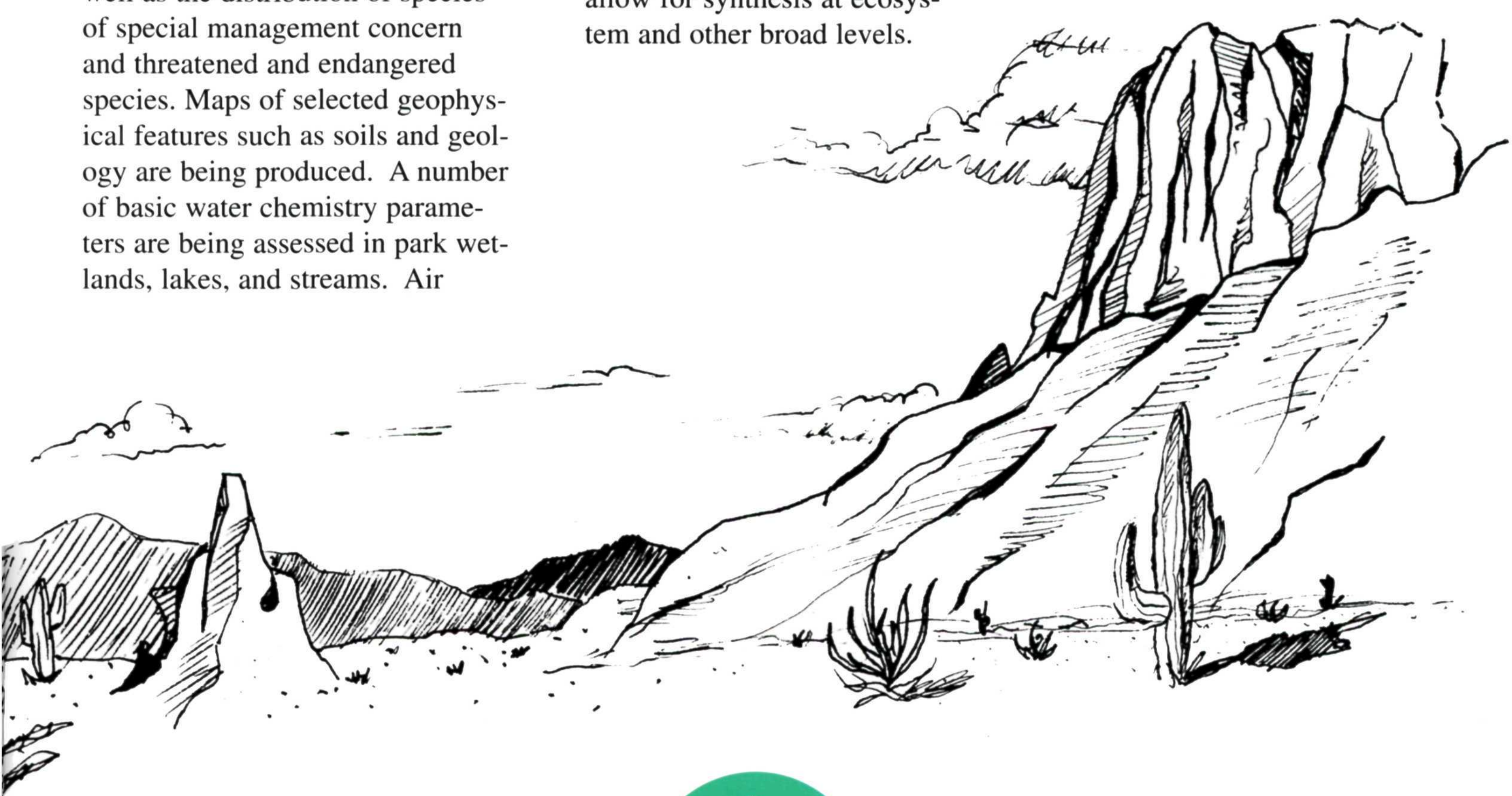
During Phase I of the Inventory and Monitoring Program, the Service is collecting information on the diversity of plants and animals in the parks, as well as the distribution of species of special management concern and threatened and endangered species. Maps of selected geophysical features such as soils and geology are being produced. A number of basic water chemistry parameters are being assessed in park wetlands, lakes, and streams. Air quality data also are gathered and evaluated.

Natural resource data collection will be closely coordinated to ensure that the inventory satisfies these important criteria:

- Data collected for each unit will contain a "core" set of data needed to deal effectively with park planning and management. Acquisition of other, specialized inventories (e.g., invertebrates, paleontology) will be the responsibility of individual parks.
- The data collected for all units will be collected and maintained in accordance with clearly defined protocols and quality-assurance standards.
- Data will be compatible to allow for synthesis at ecosystem and other broad levels.

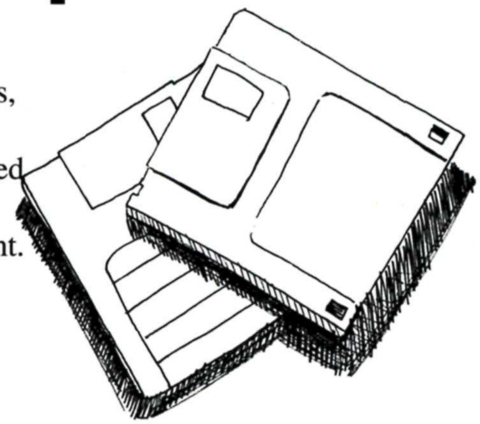
In order to reduce costs, the inventory program will cluster individual park units so that data acquisition can occur simultaneously at several locations. Costs also are minimized through active use of cost-sharing agreements with other federal agencies. For these reasons, the Phase I natural resource inventory is being conducted Systemwide with regional oversight responsive to the needs of the parks.

The basic data themes that have been identified for the Phase I natural resource inventory represent the recommended minimal data set for all natural resource parks. The following data theme descriptions are from NPS-75, the *Natural Resources Inventory and Monitoring Guideline.*



# Automated Natural Resource Bibliographic Database

To compile all of the natural resource studies that have occurred within a park's boundaries, all historical scientific material currently stored in the park, including rare event records, maps, photographs, manuscripts, specimen collections, etc., are being gathered together and incorporated into an automated program, along with procedures for keeping the information current.



# Species Lists

Lists of the biota currently known to occur within the park boundaries of all natural parks are being compiled and verified by taxonomic specialists. This information is being maintained at the park and also is used to produce regional and national summaries. Priority biota groups include: 1) vascular plants, 2) vertebrates, 3) federally and state listed threatened and endangered species, and 4) species of special concern within the park, including endemic and nonnative species as well as others identified by legislation.

Vascular plants and vertebrates have received inventory priority because they often require management actions, including actions related to threatened and endangered status. Additionally, information is likely to be more readily available in most ecosystems for both vascular plants and vertebrates. However, in parks containing significant ecosystems in which vascular plants and/or vertebrates are not the primary ecosystem components, such as in marine areas, nonvascular plants and invertebrates are being added to the basic species list requirements.

# Vegetation Maps

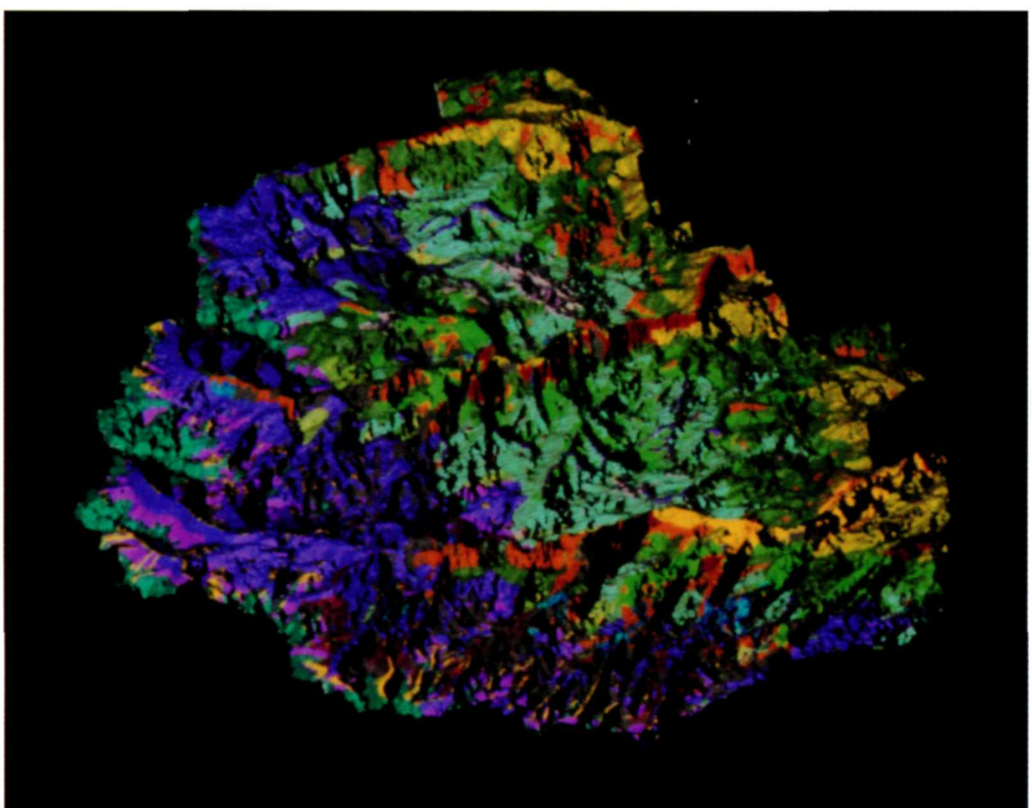
During Phase I, every park unit involved in the Natural Resource Inventory and Monitoring Program will have a vegetation map based upon aerial photography no more than five years old and suitable for input into an automated geographic information system. Vegetation maps will have a minimum unit of 1 acre or less and a 1:24,000 map base, except in Alaska, where the standard map base is 1:63,360. Vegetation classifications will be at least to the plant association level of detail, with an 80% minimum level of accuracy.

To complete the vegetation inventory, the National Park Service will develop and adopt vegetation classification schemes that not only meet park needs, but also provide maximum opportunity for linkage with databases maintained by other federal and state resource management agencies. Aerial photography and remotely sensed imagery also are being acquired in cooperative cost-saving efforts other agencies. This imagery serves to support not only the vegetation mapping project, but also soil surveys, geologic mapping, and species inventories.

# The Vegetation Mapping Program

In cooperation with other agencies, the National Park Service is developing a uniform hierarchical vegetation classification standard and methodology and generating vegetation maps for park units with significant natural resources. The vegetation data will be automated to provide flexibility in map design and production and to facilitate data management and maintenance activities. Deliverable products from the contracted effort will include a digital file of vegetation maps, a digital metadata file for each data file, textual descriptions and keys to the vegetation classes, hard copy maps, and map accuracy verification reports.

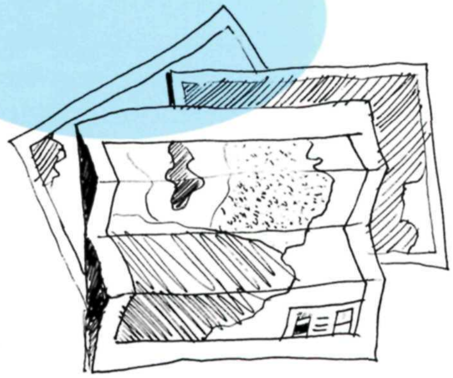
Implementation of the mapping program includes the development and documentation of standards and protocols. A national vegetation classification standard, field methodologies, and accuracy assessment procedures are being tested in representative park units across the National Park Service, to allow adjustments and refinements of the approach. Following this effort, all park units with significant natural resources will be mapped, in priority order based on identified needs for vegetation information. The vegetation data and classification system developed by The Nature Conservancy and the network of Natural Heritage programs in each state, and refined from the international standards of the United Nations Educational and Scientific, and Cultural Organization (UNESCO) forms the basis of the classification standard.



*This slide of vegetation types in Yosemite National Park uses aspect to produce a shaded relief effect. Colors indicate vegetation types and elevation (from low to high as follows). Yellow/ponderosa pine, green/white fir, aqua/red fir, purple/lodgepole pine, pink/whitebark pine.*

# Base Cartographic Information

This inventory component includes digital elevation models, digital line graphs for park boundaries, hypsography, hydrography, and transportation networks. Through a cost-sharing agreement, the U.S. Geological Survey is preparing these base cartographic maps.



# Soils and Geology Maps

The National Park Service is completing both soils and geology maps through national agreements with other federal agencies. The Service also is working with the Natural Resource Conservation Service to complete Order 3 soil surveys for all parks, except where more detailed surveys are required for park management purposes. Under a national cost-sharing agreement, the U.S. Geological Survey is preparing maps that will include both bedrock and surficial geology. As part of this cooperative effort, the Geological Survey has assembled regional teams of scientists to assist individual park managers in their efforts to define the types of geologic mapping needed to address park management issues; these teams also are advising park personnel regarding the quality and availability of existing geologic mapping.

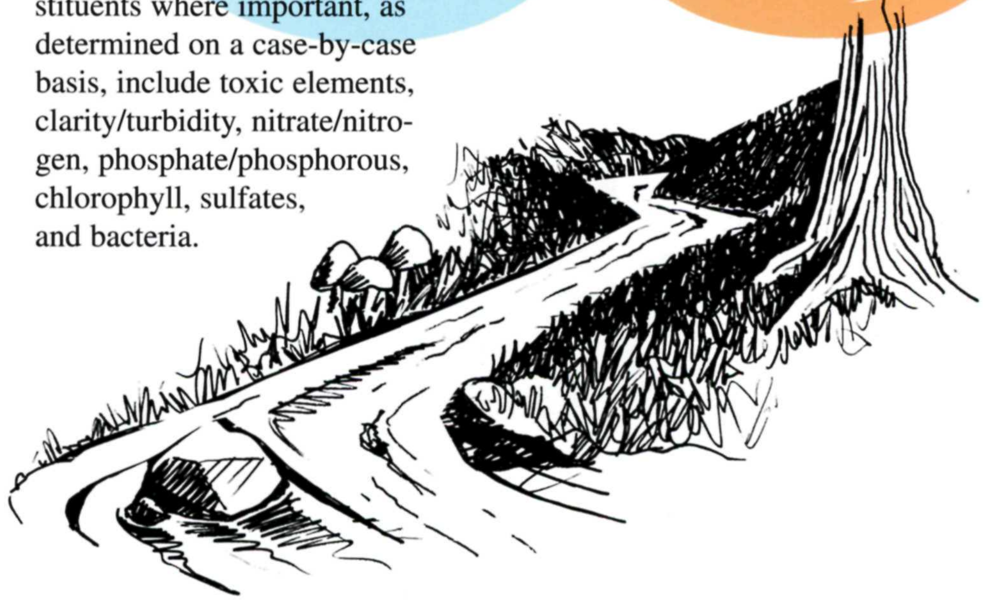
An additional partnership with the American Association of State Geologists (AASG) is gathering information from the files of state agencies and compiling an automated database on geologic and water resource maps, documents, specimen collections, and other related information.

# Species Surveys and Distribution

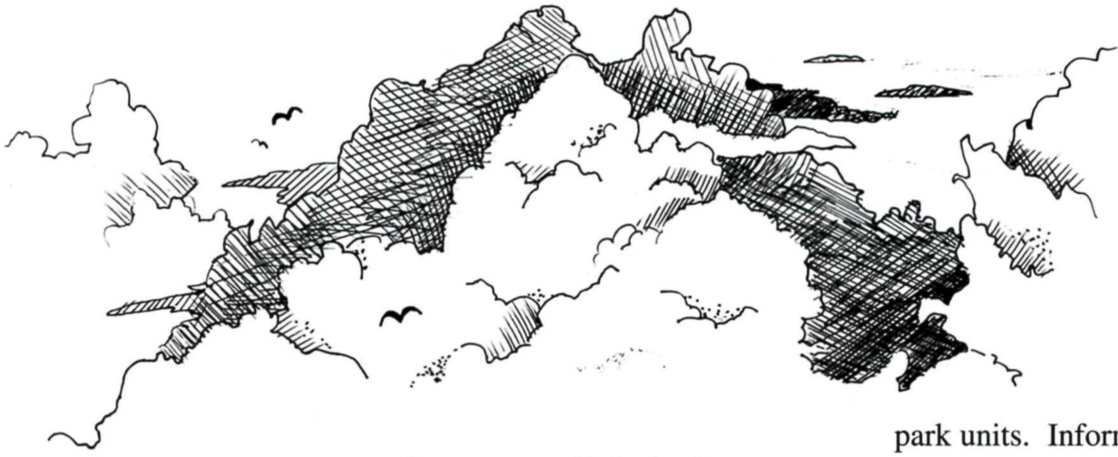
The National Park Service has set an objective of documenting the presence of at least 80% of all plant and animal species occurring within a unit's boundaries, excluding invertebrates. To achieve this objective, field surveys will be conducted to confirm the existence of currently reported plant and animal species and to document the presence of new ones. This inventory will also produce distribution maps for species of special park management concern, including threatened and endangered and nonnative species.

# Water Resource Inventory and Chemistry Data

The Servicewide inventory includes the location of streams, lakes, wetlands, and groundwater supplies. Water quality use classifications based upon the Clean Water Act are also being obtained. The Phase I water resource inventory collects several basic water quality parameters for "key" water bodies (to be determined on the basis of size, uniqueness, threats, etc.) within the park boundaries. Those water quality parameters include alkalinity, pH, conductivity, dissolved oxygen, rapid bioassessment baseline (EPA/state protocols, involving fish and macroinvertebrates), temperature, and flow. Other constituents where important, as determined on a case-by-case basis, include toxic elements, clarity/turbidity, nitrate/nitrogen, phosphate/phosphorous, chlorophyll, sulfates, and bacteria.

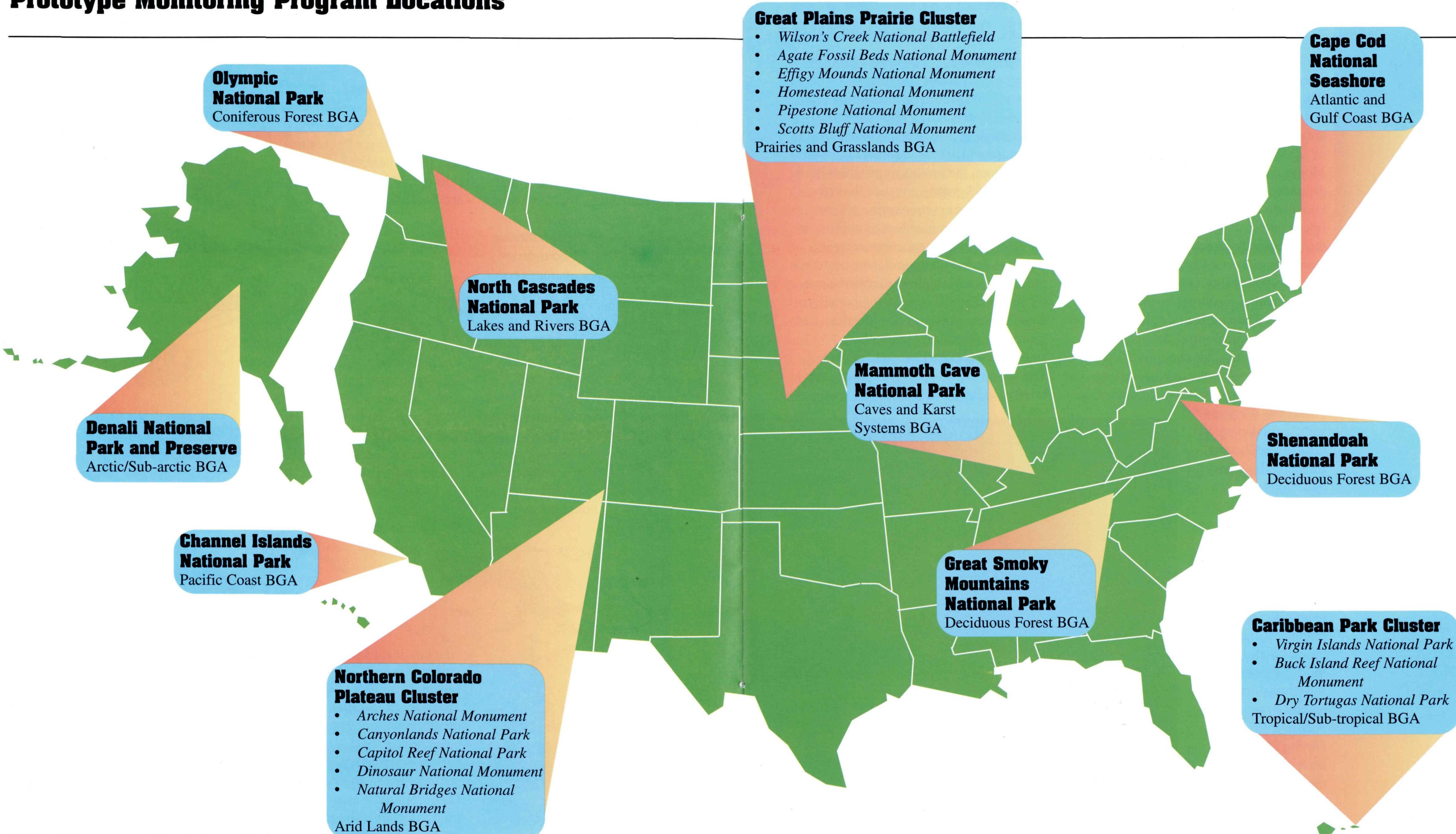


# Air Quality and Meteorological Data



The National Park Service's Air Quality Division has implemented monitoring efforts in many Class 1 units, but considerably more work needs to be done if the Service is to effectively detect and respond to threats to air resources. As part of the Natural Resource Inventory and Monitoring Program, the location of EPA air quality monitoring stations within close proximity (50-100 km) to park boundaries will be noted and summarized in an air quality atlas. Data from these stations can be used to obtain a rough assessment of air quality within individual park units. Information on visibility goals and air quality-related values will also be included in the inventory. Precipitation and meteorological data in the inventory consist of basic information on annual precipitation, relative humidity, wind speed and direction, and maximum and minimum daily temperatures.

# Prototype Monitoring Program Locations




**BGA** = **Biogeographical Association**

# LONG-TERM ECOLOGICAL MONITORING

To effectively protect natural resources, park managers need monitoring programs that detect changes in park resources and determine whether they are due to normal ecosystem dynamics or are the result of human activities. Monitoring programs must be firmly grounded on comprehensive ecological knowledge and understanding; yet as the scientific community learns more about the complexity of ecosystem management, the National Park Service's mandated responsibility to preserve and protect its natural resources becomes more complex. The number of units, and the extraordinary ecological diversity among individual units, adds even more complexity to the task of establishing an effective and comprehensive monitoring effort. For these reasons, a fundamental goal of the Natural Resource Inventory and Monitoring Program is to implement long-term ecological monitoring Systemwide as expeditiously as possible.

To meet these challenges, ten biogeographic associations or biomes that contain most National Park System natural resource units have been identified. During Phase I, at least one prototype monitoring program is being established in each of the ten biomes. Many of the ecological monitoring efforts currently being conducted in the parks are of short duration and focused on very specific resource issues and threats. Unlike those efforts, prototype monitoring programs will strive to develop a better understanding of national park ecosystem dynamics and ecological integration. In this manner, the prototype programs will augment and greatly enhance the effectiveness of current monitoring efforts. Because of the tremendous variability in the size and ecological complexity of National Park System units, the prototype programs are evaluating alternative spatial and ecological monitoring paradigms at the species population, watershed, and broad landscape levels in both single-park and park-cluster formats. The ten biogeographic associations are briefly described as follows.

# ARCTIC/SUB-ARCTIC BIOGEOGRAPHIC ASSOCIATION

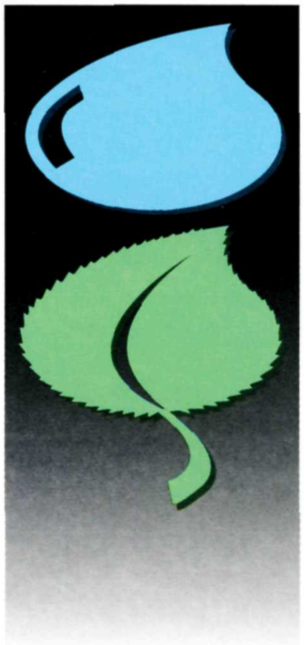
Alaska's national parks comprise more than two-thirds of the public land administered by the National Park Service. These expansive parks encompass wild and pristine terrestrial, freshwater, and marine ecosystems on a geographic scale unparalleled in the world. Glacial headwaters and flowing ice fields shape subarctic/arctic landscapes, influence ecological processes, and, ultimately, determine the biotic interactions in these harsh environments. A mosaic of separate but interrelated ecosystems extends from coastal bodies to mountainous terrains in this biogeographic association. Large reaches of the landscape are underlain by deep and often continuous layers of permafrost, a soil condition the manifests itself in the visually complex patterning of vegetation extending across boreal forest and tundra ecotypes.

Historically, Alaska's isolation was believed to protect its natural resources. Experts now suspect that pollution pressures from industrial activities both near and far away already may have produced changes in environmental quality. Locally, the effects of human intervention are evidenced by increasing industrial growth near park boundaries, consumptive uses of fish and wildlife within park boundaries, and the ever-growing numbers of visitors to the parks each year. Scientists expect global climate changes to register first in northern climes. Arctic and subarctic environments may be especially vulnerable to even slight shifts in temperature regimes.

Because of their size, their remote and protected status, and their resultant near-pristine condition, few regions offer the environmental monitoring opportunity and promise that is possible in the arctic and subarctic parks of Alaska. The relatively untouched nature of these vast parklands can provide important baselines to measure and evaluate the direction and magnitude of changes brought about by human influences on regional, national, and global scales.

*Prototype monitoring program: Denali National Park and Preserve*

# ARID LANDS BIOGEOGRAPHIC ASSOCIATION



The arid land biogeographic association groups together park units distinguished by low to moderate rainfall and the plant communities that typically occurs in such climates. Desert scrub communities predominate many of these arid areas, but communities range from desert scrub to desert grasslands to mixed conifer forests in high mountain areas. These arid regions stretch from the Southwestern United States up into Colorado and Wyoming. The following chart describes the major characteristics of each of the arid types in this biogeographic association.

The most serious threats to arid ecosystem resources are air pollution from metropolises, smelters, and fossil fuel electrical generating facilities; loss of ground and surface water to agricultural and urban concerns; threats to water quality from off-site pollution sources; minerals extraction and processing; domestic livestock grazing; invasive non-native species; harvesting of timber and woodland resources; agricultural and urban development and expansion; and off-road vehicle recreation impacts.

| Desert | Location | Area | Climate | Vegetation |
|---|---|---|---|---|
| Chihuahan | North-central Mexico, into TX and NM | 450,000 $km^2$ | Semiarid, summer precipitation, mild to cold winters | Desert scrub in lowlands; grasslands in uplands; woodlands in higher elevations |
| Sonoran | Baja CA, southwest AZ, southeast CA, and Sonora, Mexico | 310,000$km^2$ | Hyperarid to semi-arid, bimodal precipitation, mild winters | Desert scrub; columnar cacti; grassland in higher, wetter elevations |
| Mojave | Between Great Basin and Sonoran deserts | 120,000 $km^2$ | Hyperarid to semi-arid, winter precipitation, cool winters | Desert scrub in lowlands; desert scrub and Joshua Tree in uplands; woodlands in higher elevations |
| Great Basin | Surrounded by the Sierra Nevada,Wasatch Front, Colorado Plateau | 518,000 $km^2$ | Arid to semiarid, bimodal precipitation, cold to frigid winters | Desert scrub; woodland in higher elevations |
| Colorado Plateau | Northwest NM, northeast AZ, western CO, southeast UT | 400,000 $km^2$ | Arid to semiarid, bimodal precipitation, cold to frigid winters | Desert scrub with some grassland; woodland in higher elevations |

*Prototype monitoring program (one of five in cluster): Capitol Reef National Park*

# ATLANTIC AND GULF COAST BIOGEOGRAPHIC ASSOCIATION

*Prototype monitoring program: Cape Cod National Seashore*

Barrier island ecosystems from Cape Cod National Seashore in Massachusetts to Padre Island National Seashore in Texas are among our nation's most dynamic landscapes, continually shaped by storms, rising sea level, and biotic influences. Plant and animal communities find niches in diverse habitats. The long, thin barrier islands contain outstanding examples of beach and dune communities. Maritime forests often occur within the more protected barrier island landscape. Aquatic habitats such as ponds, freshwater marshes, vernal pools, and swamps are found throughout the barrier islands. Rare plants and animals are particularly dependent on these wet habitats.

Although not a barrier island unit, Everglades National Park contains one of the world's most outstanding freshwater ecosystems. Estuarine and marine ecosystems also contribute to the extraordinary diversity of the Atlantic/Gulf region with salt marshes, seagrass beds, mangrove forests and other habitats that fringe coastal park units; fish, shellfish, benthos, and coastal birds are dependent on these estuarine habitats.

Beachgoers, fishermen, shell collectors, hikers, nesting sea turtles, shorebirds, and others all compete for resources in these environments. Dune replenishment projects disrupt natural systems and funnel wave action into high energy patterns that damage barrier dunes, changing the character of bayside environs. Agricultural allocation of surface waters has had profound and potentially irreversible effects on Everglades National Park. Freshwater aquifers in coastal areas are highly susceptible to disruption and slow to recover from overallocation and draw-down. Human influences also are seen in the explosive invasions of nonnative species that compromise the fine balance of the natural coastal communities.

# CAVES AND KARST SYSTEMS

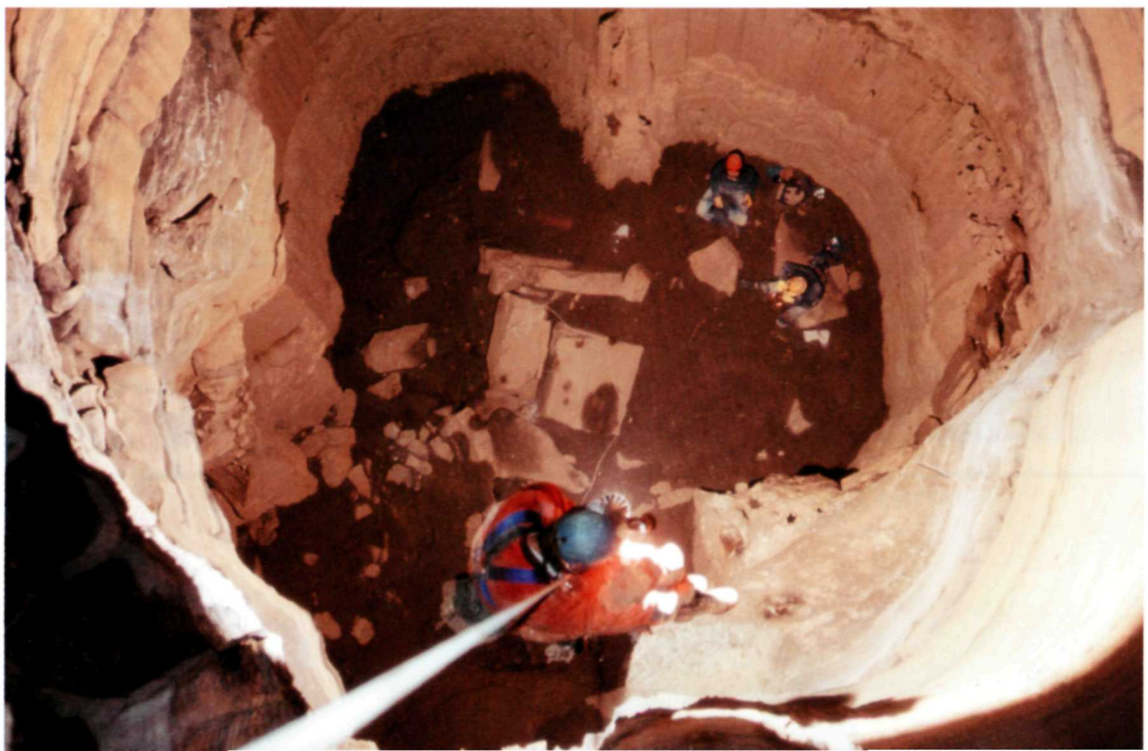
Nearly 60 national parks have caves within their boundaries, including world-renowned Mammoth Cave in Kentucky and Carlsbad Caverns in New Mexico. The intrinsic value of these caves is measured by much more than their scenic and recreational qualities. Caves harbor a number of endemic species, many endangered, and often serve as natural laboratories for the study of evolutionary processes. Well-preserved fossil remains provide a detailed view of the regional ecosystem, sometimes documenting changes taking place over many thousands of years.

Most commonly formed when groundwater containing carbonic acid dissolves limestone, caves often form networks of interconnecting passages that extend for many miles. Calcite, aragonite, gypsum, and other minerals precipitate from groundwater to produce beautiful crystal formations that attract millions of cave visitors annually. Other types of caves include the remains of lava tubes that once served as conduits for fast-moving flows, and sea caves formed by violent wave action.

The karst systems that develop in limestone regions supply more than 25% of the nation's groundwater resources. These systems are particularly vulnerable to pollution; their subsurface waters flow relatively unimpeded through open fissures and passageways, with little of the mechanical and chemical filtration provided by other kinds of aquifers.

Visitors to caves threaten the delicate speleothems and the ecosystems that support cave dwelling plant and animal species. Mining and petroleum drilling can threaten cave systems through direct physical damage and pollution. Caves can also be damaged by ill-conceived construction activity and improperly sited surface structures, which in turn can be threatened by collapse.

The Federal Cave Resources Protection Act mandates an inventory of all significant federally owned caves, which includes all caves in the National Park System. To protect caves from unauthorized entry and misuse, cave locations are protected from Freedom of Infor-mation Act requests, and are kept confidential by park superintendents.



*Prototype monitoring program: Mammoth Cave National Park*

# CONIFEROUS FOREST BIOGEOGRAPHICAL ASSOCIATION

The coniferous forest biogeographical association groups areas throughout the United States that are dominated by coniferous species. Coniferous forests occur over an enormous geographic area, from pinyon pines in the southwest to white spruce forest in the northeast. Climate, elevation, slope, and aspect all affect the type of coniferous vegetation in an area. The following chart describes four major regions of coniferous forests in the United States.

Coniferous forests are threatened by timber harvesting and post-logging fires, acidic deposition from urban and industrial sources in the northeast, and ozone damage in the western Sierras. Commercial and residential developments, fragmentation through timber harvesting, and epidemics of nonnative forest pathogens such as white pine blister rust have also had long-term consequences. Raging wildfires that devastate over-crowded, even-aged stands of timber are the result of long-term fire suppression. Recreational demands along streamsides, through mountains meadows, and above timberline on the thin-soil, short-cycle alpine tundra also destroy vegetation.

| Coniferous Forest | Location | Climate | Vegetation |
|---|---|---|---|
| Northern | South from Canadian tundra into midwest and northeast U.S. | Cold winters, moderate precipitation. | In the north, white spruce with balsam fir. Moving south, red spruce; red, eastern white, jack pine; eastern hemlock. |
| Rocky Mountain | Along the Rocky Mountains from Canada to NM. | Fire important in forest development. | From timberline down, Engelmann spruce and subalpine fir change to Douglas and white fir which blends to Ponderosa pine. Some lodgepole pine at all elevations. In Great Basin, pinyon-juniper forests extend upslope to limber and bristlecone pine. |
| Sierran | From Cascade Mountains through Sierra Nevadas to Mexico. | Most precipitation in winter. Fire important in forest development. | At lower elevations, Ponderosa pine, white or Douglas fir. Middle elevations, Jeffrey pine and red fir. Higher elevations, mountain hemlock with whitebark and lodgepole pine. Giant sequoias at mid-elevations in central and southern Sierras. |
| Northwest Coastal | From AK to northern CA along the coast and in interior mountain ranges. | Mild, wet winters, dry summers. Fire and wind important sources of disturbance. | Low and mid elevations, Douglas fir, western hemlock , western red cedar, with Sitka spruce abundant near Pacific Ocean. Higher elevations, Pacific silver and noble fir, mountain hemlock. Redwoods along CA and southern OR coast. |

*Prototype monitoring program: Olympic National Park*

# DECIDUOUS FOREST BIOGEOGRAPHICAL ASSOCIATION

*Prototype monitoring program (one of two): Shenandoah National Park*

This association includes deciduous forests throughout the eastern United States from Vermont to Georgia and Alabama. The Laurentian mixed forests of the warm continental regimes of the upper New England states are characterized by northern hardwoods of maple, birch, and beech, with notable mixes of fir. The eastern deciduous forests of the hot continental regime shift in composition to the broadleaf dominance of oaks. The Poconos represent a transition zone between two major forest habitat subzones of the larger eastern deciduous forest zone: local woodlands include both the northern hardwood association and the mixed red/white/chestnut oak association that stretches along the Appalachian Ridge from Southern New England to Tennessee. A subtropical regime from the piedmont of the mid-Atlantic, along the Carolinas, and inland into Georgia and Tennessee is dominated by the southeastern mixed forests of oak, hickory, and intermingled stands of pine.

Some of the largest blocks of old-growth forests remaining in the southeastern United States are found in the Great Smoky Mountains National Park. The ecotone between deciduous forest and spruce-fir forest encapsulates the continental transition from temperate to boreal forests in Canada. Farther south and interior from the Appalachian oak forests, the continental mixed mesophyllic forests of maple, Aesculus, beech, tulip tree, oak, and linden blend westwardly in Kentucky into oak and hickory forests. Southern mixed forests of beech, sweet gum, magnolia, pine, and oak characterize the outer coastal plains of the deep south.

Threats to the ecosystem structure and composition in deciduous forests include nonnative and native insects and diseases, nonnative species introduction, air pollution, reduction in fire frequency, and logging.

# LAKES AND RIVERS BIOGEOGRAPHIC ASSOCIATION

Rivers and lakes are important resources in the vast majority of National Park System units. In some units, like Delaware Water Gap, rivers and lakes are the principle resources defining the park's overall significance and character. Other parks have their national significance tied to lakes, such as Crater Lake. Still other parks, such as Yosemite, possess major river and lake resources in addition to other primary resources.

Because most river corridor parks encompass only very small portions of their associated watersheds, they are particularly vulnerable to land use activities occurring outside of park boundaries. The aquatic, riparian, and recreational resources associated with lakes and rivers need management and protection. In the case of major riverways, aquatic resources are integrally dependent upon physical factors such as flow regimes, water quality, floodplain and riparian condition, and channel conditions and processes. Similarly, with major lake parks, complex hydrologic pathways to areas outside of parks often offer potential for impairment. In addition, recreational use of park lakes and associated developments such as marinas may damage aquatic resources. Both lakes and rivers are susceptible to introductions of nonnative aquatic species, which also can alter overall ecosystem integrity.

Resources protection often requires that the National Park Service participate in the planning and regulatory processes of other federal, state, and local agencies. Participation in these processes is made more effective when the National Park Service can develop sound scientific information on the condition of its aquatic resources, and understand the causes of resources impairment. Solid information on lake water quality, hydrology, and aquatic resources conditions and the factors influencing those conditions are critical to effective management intervention. In addition, information on the linkages between aquatic and upland ecosystems helps the National Park Service manage and interpret the significant river and lake resources in the broader regional context.

*Prototype monitoring program: North Cascades National Park*

# PACIFIC COAST BIOGEOGRAPHIC ASSOCIATION

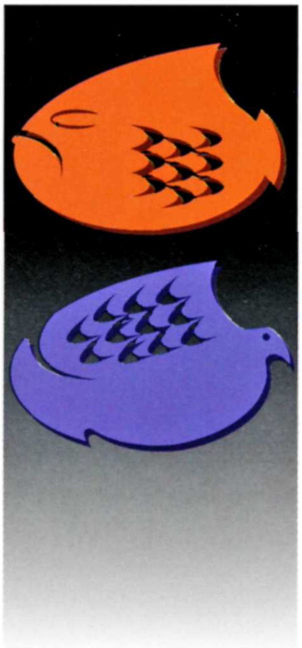
*Prototype monitoring program: Channel Islands National Park*

Biological systems along the west coast of North America from Canada to Mexico are dominated by cold Pacific Ocean waters flowing southward from the Gulf of Alaska. A biogeographical break occurs at Point Conception in central California, separating the cold temperate Oregonian Province to the north from the warmer Californian Province to the south. The link between land and sea is strong. Moisture, as precipitation and fog, comes from the sea to define and shape coastal plant communities. Coniferous forests cover northern shores from the Olympic peninsula to the California redwoods. Panoramic beaches, rolling grasslands, and coastal bluffs covered in sage and lupine break the forest canopy at Point Reyes and San Francisco's Golden Gate. South of Point Conception, the Mediterranean dry-summer subtropical climate produces scrub oak woodlands and chaparral. Rivers carry nutrients and sediment from distant watersheds into the coastal zone. Oceanic upwelling along the coast, driven by winds created by thermal differences between the land and sea, brings nutrients from the deep ocean into the sunlight of the coastal zone. The biological productivity of rich coastal waters supports long food chains that reach back up the rivers to their headwaters.

National parks, monuments, seashores, and recreation areas line the Pacific coast from Olympic National Park in Washington to Cabrillo National Monument in San Diego, California. In the middle, astraddle both the biogeographic boundary at Point Conception and the land-sea interface, Channel Islands National Park contains terrestrial Mediterranean ecosystems, coniferous forests, coastal sage and sand dune systems, as well as representative Oregonian and Californian marine assemblages of kelp forests, sea grass beds, sand flats, and submarine canyons.

People gather at the coast for recreation, food, and commerce. Population growth and economic development on the Pacific rim are among the greatest in the world. Coastal waters have been repositories for industrial wastes for centuries, and the continental shelf is a major source of mineral wealth. Unsustainable fisheries harvests, air and water pollution, grazing and competition from nonnative species, and human disturbance of isolated breeding colonies all threaten biological productivity and diversity in this region.

# PRAIRIES AND GRASSLANDS



The Great Plains of North America encompass the area of grassland or former grassland extending from the Canadian to the Mexican borders and from western Indiana to the foothills of the Rocky Mountains. The Great Plains grasslands and prairies constitute what was once the largest vegetational unit in North America. Changes in the dominant grass species accompanies decreasing moisture from east to west in the Great Plains. As a result, three major prairie subregions are distinguishable by climate and/or vegetation: tallgrass prairie in the east, mixed grass prairie in the middle, and short grass prairie in the west. At the eastern border of the Great Plains a band of oak savanna marks the transition from prairie to eastern deciduous forest. In the west the transition often is marked by the presence of upland shrubs, such as sagebrush.

National parks in the Great Plains contain high quality to degraded prairie and savanna sites with a range of management histories. Most are surrounded by agricultural land, either cropland or rangeland. All but three are too small to contain populations of large mammals or to support natural disturbance regimes. The remaining plant and animal populations in the fragmented habitats of the prairie parks are not only reduced and subdivided, but are also increasingly exposed to ecological stresses associated with edges. Restoration of missing components and management to simulate missing processes are tightly linked, and both are essential to prairie persistence.

Resource managers in these units face the same question: To what extent are the remnant and restored species, communities, and processes under their stewardship sustainable?

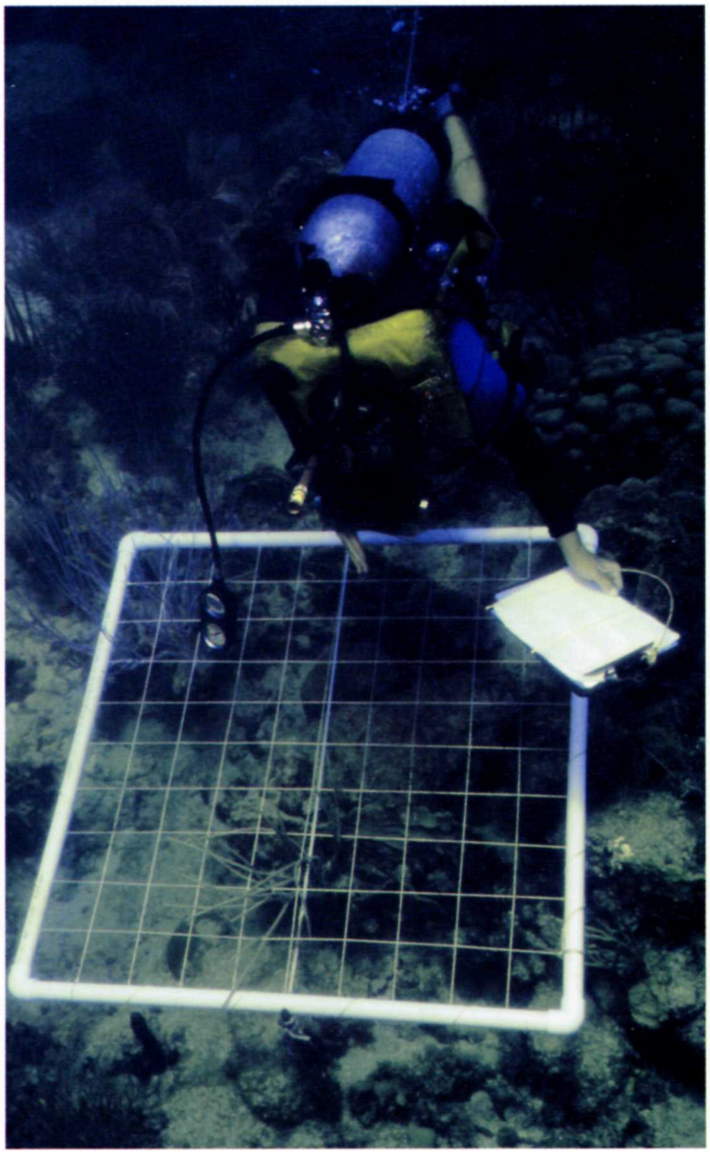
*Prototype monitoring program (one of six in cluster): Scotts Bluff National Monument*

# TROPICAL/SUB-TROPICAL BIOGEOGRAPHICAL ASSOCIATION

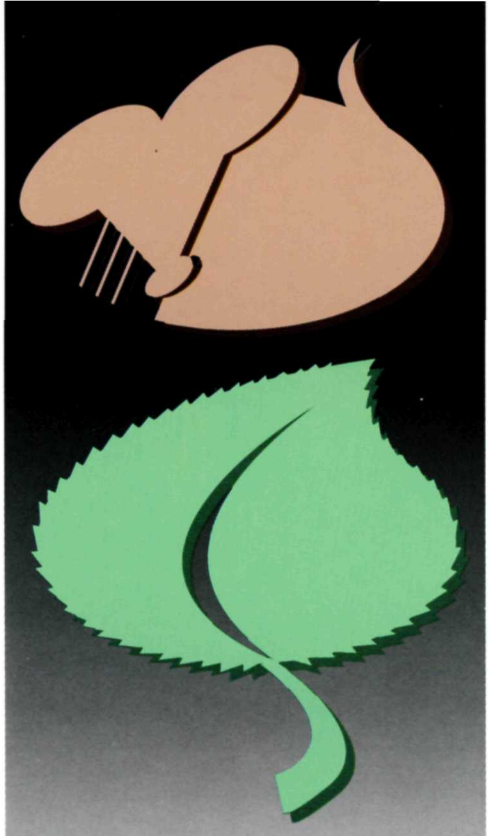
Few areas on Earth offer more spectacular beauty and ecological diversity than the National Park System units occurring within the Tropical/Sub-Tropical biogeographical association. These far-flung units are to be found among the Virgin Islands of the Caribbean, the coral reef track of the Florida Keys, and the volcanic islands of Hawaii. Across these units, climate and geography combine to create incredible species diversity. Coral reefs and associated seabeds support fishes, endangered turtles, and rare species of coral. Migrating birds as well as bird populations that stay closer to home find habitat in these areas.

The areas in this association also contain a great diversity of native plant species, from tropical forests to grasslands. Climate and geography have combined to create forests with a very high diversity of native species on the Virgin Islands. In Hawaii, volcanic geology and climate determine the composition of plant communities, which range from tropical forests to grassland to barren mountaintops. Hawaii has the second highest number of endemic species of vascular plants and the highest biological diversity per unit area in the United States. Hawaii Volcanoes National Park has been designated as an International Biosphere Reserve and a World Heritage Site.

Overuse, development, and nonnative species encroachment threaten the irreplaceable natural resources of our tropical and subtropical park units. Loss of habitat jeopardizes bird survival. Human activities place tremendous pressure on delicate coral reefs, and, thus, the species that depend upon them. All of these units face loss of their rich biodiversity through the invasion of nonnative species.



*Prototype monitoring program (one of three in cluster): Virgin Islands National Park*



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