Interpreting Biological Diversity:

A Handbook for

National Park Service Communicators

BIOLOGICAL DIVERSITY

Makes a World of Difference

National Park Service

Biological Diversity

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A Message from the Assistant Director for Interpretation and the Chief, Division of Interpretation

Not often in one's professional career do moments and issues come along which fire enthusiasm and stimulate creativity. We find Biological Diversity and its associated issues -- Clearing The Air and Global Change -- to have provided such a moment in the National Park Service.

The energy which these issues has generated must continue and grow -- in order to do so it needs focus, direction and depth. The Biological Diversity Interpretive Initiative Task Group recommended in its plan that an interpreter's manual be developed "to serve as both a training document and a resource for interpretive and educational activities."

The Task Group knew that in order to make biological diversity an active part of our lives and programs, we were going to need a primary source to study and a place to accumulate additional information and ideas as we learned them. This Biological Diversity Handbook is such a source and place.

We hope you find the material stimulating and we welcome your comments and suggestions for future revisions.

This Handbook should not take up space on your shelf. Carry it with you. Take it apart and read it in sections. Make marginal notes. Turn down the pages. Ask questions about the material. Discuss the issues at lunch. Make the Handbook your own.

Some of you have already been interpreting threads of biological diversity themes. Ahead of us lies the opportunity to create new weaves in our programs so the public will understand both the many facets of biological diversity and why it is important to each of us that biological diversity on the planet be preserved.

Kenneth Raithel, Jr.
Assistant Director for Interpretation

Michael D. Watson
Chief, Division of Interpretation

FROM THE DIRECTOR

Throughout the world, we are witnessing an unprecedented loss of our biological heritage as a result of human influences. Some of the influences, like habitat destruction and poaching, involve direct physical disturbance. Others, like air pollution and the "greenhouse effect", act indirectly by affecting natural processes.

The earth's incredible wealth of natural ecosystems, species and gene pools -- which we call biological diversity -- is an inexhaustible reservoir for human progress. Natural biological diversity benefits us all by providing ecological services like clean air and water, aesthetic landscapes for our enjoyment, and foodstuffs, medicines, and products on which the quality of our lives depend. Each of us has a personal stake in protecting biological diversity.

Biological diversity is central to our mission. Our national parks are natural reservoirs of biological diversity. Our role must be to maintain this natural biological heritage - from microbe to Sequoia. We must communicate the basic morality of Nature so we can foster ethical conduct based on respect for nature and natural laws. We must provide perspectives on the benefits of biological diversity to society and the causes of the accelerating losses. We must explain how cultures of the past have utilized and depended upon biological diversity. We must show how human welfare and our options for the future are linked to and depend upon biological diversity.

Interpreting biological diversity in its true fullness -- explaining all the natural, cultural, economic and aesthetic connections which depend upon biological diversity -- is fundamental to what the National Park Service is all about. This is an area in which we can exercise real leadership.

Many divergent groups and perspectives can be brought together and linked by interpreting biological diversity. Effective communication can broaden our constituency by showing that protecting parks in a natural state is in everyone's best interest.

Interpreting biological diversity is not a one year program. Biological diversity must become an interwoven, fundamental part of our on-going interpretive and management programs. Like Clearing The Air, which you have already learned about, and Global Change, which you will be hearing more about -- Biological Diversity must be made a part of us. These inter-related issues must be a part of how we approach decisions and planning. They must be woven into our programs in a way that makes them hit home with the public.

The challenge before us is great -- the issues are vital and exciting ones. I wish you well in your studies of what biological diversity is all about and, most of all, in making biological diversity come alive for everyone you meet.

William Penn Mott, Jr.
Director, National Park Service

Biological Diversity

To: All Biological Diversity Communicators

From: Richard Cunningham,Chairperson, Biological Diversity Interpretive Initiative Task Group

Subject: Hope is NOT an Endangered Species

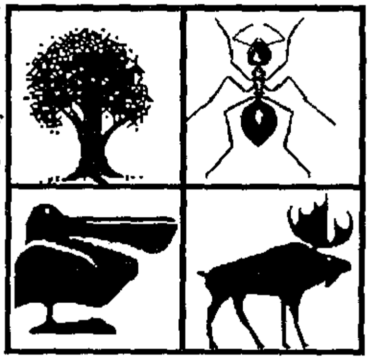
Our planet is in trouble.....so we are increasingly being informed by the news media. It is a theme that they have recently discovered, but has been of concern to ecologists and "environmentalists" for many years. It has been stated that the loss of biological diversity is second only to nuclear war in its threat to humans and other life on this planet.

Under these circumstances it is easy to develop doom-and-gloom scenarios. It then becomes easier to be very pessimistic about the future of life on this beautiful little planet we inhabit. When pessimism rises, despair and apathy set in and hope vanishes.

But there is hope. There has to be hope! And that hope lies in you and me, and in people just like us. We are people who care and share a common commitment to express and extend our caring for life to others. The "Right to Life" movement, concerning human abortion, is one of the most sensitive and political issue of our time. But there is another right-to-life issues that needs to be communicated. This issue deals with the rights to life of the fellow organisms, plant and animal, with which we share in common Planet Earth.

We often overlook how much power there is in interpretation. The power to reach inside and affect, or change, people's ideas, emotions, and values. But with that power comes a heavy responsibility. A responsibility for accuracy and honesty. Without those two elements, interpretation is nothing and means nothing.

The task before us is a great challenge and a great opportunity. I feel our job as biological diversity communicators will become both easier and more difficult. . . two sides of the coin. As more and more media attention, through television, newspapers, and magazines, is focused upon biological diversity and environmental issues, the general public will become more aware and knowledgeable. That will make our job easier. But at the same time it will make our job more difficult simply because of communicating to a better educated public. Therefore, our interpretive messages must be of the highest quality of factual information, accuracy, and honesty that is possible.



Only when enough people in enough countries understand and care will change take place. Our role as communicators is to help people understand. I recently came across the following quote from Baba

Dioum, an African ecologist:

In the end,
We will conserve only what we love,
We will love only what we understand,
We will understand only what we are taught.

Most of all, never feel that the task before you is so overwhelming that it's not worth the effort. Granted, you may not be able to save the whole world, but you can help to save a part of it. For me personally, doing whatever I can, within my own real limitations, has become a mission central to my being. It's easy, because I care and I know you do too. That is why we work for this organization.

Don't ever forget — **One person can make a difference!**

About This Handbook

We at The Ohio State University have enjoyed the opportunity to conduct the survey entitled "Interpreting Biological Diversity in the National Parks" and to coordinate the development of your handbook. Our charge was to work cooperatively with the Division of Interpretation the Biological Diversity Interpretive Initiative Task Group and the Division of Wildlife and Vegetation in Washington to develop a reference handbook for National Park Service(NPS) communicators.

As you read this document, please keep in mind that this handbook was not designed to be a cookbook, an instruction manual or an edict. It was developed as a tool to assist a highly productive group of professionals to be even more productive in the area of biological diversity.

This handbook is organized into the following sections.

Section 2: Section 2 contains summaries of technical papers on biological diversity.

Section 3: Section 3 consists of papers written by a number of NPS professionals on topics addressing biological diversity.

Section 4: Section 4 contains content materials you may need to develop your biological diversity communications program. Twenty-six fact sheets on related topics were designed to provide you with an overview of the many facets of biodiversity. Each of these fact sheets has been reviewed by a panel of university researchers, NPS scientists and interpreters, and outside agency delegates. For more information, or clarification, please consult those references listed at the end of each fact sheet. Although these fact sheets appear to cover separate topics, they are as interrelated as is our environment. Select article references and some reprints are provided at the end of this section as sources of further information.

Section 5: Section 5 consists of sample biological diversity programs as examples to help you develop your own programs. Each program sheet contains a general program idea designed for a variety of different audiences, interpretive techniques and park resources. These programs are developed around 12 of the 26 fact sheet topics. At the end of each general program is an example program, on the same topic, that was written by an NPS employee or other contributor. Many of these examples were only in the development stage at the time of printing. Please contact the credited individual for more information.

Section 6: Section 6 provides a place for you to develop your park's own biological diversity program. The article, *Planning Your Biological Diversity Program*, was designed to give you guidance in this area.

Section 7: The final section includes a glossary, book and article bibliography with abstracts, and a listing of resource materials, teaching aids, and audio-visual resources complete with sources and prices where available.

This handbook is merely a beginning. We at the University have made our input, various Divisions have planned, and Task Groups have reported. The bottom line, and the ultimate determinant of the degree of success, is the effort that individual parks and communicators make towards this initiative. Each park, whether natural, cultural, historical or recreational in orientation, has numerous possible biological diversity messages. The degree to which each park chooses to participate is an individual decision. As an NPS cooperator, we are convinced that all members of the conservation community— government agencies, private organization, universities, mass media, etc.— must recognize the real threat and missed opportunities associated with the loss of biological diversity and work to stem the tide.

It has been our pleasure to work with you on this project. We appreciate any feedback and are available to assist you whenever possible. Our phone number is (614) 292-2265.

Thank-you.

Gary W. Mullins

Gary W. Mullins, Ph.D.
AssociateProfessor
and Project Coordinator

Kim A. Palmer

Kim A. Palmer
Graduate Research Associate and
Project Administrator

Rosanne W. Fortner

Rosanne W. Fortner, Ed.D.
Associate Professor
Principle Investigator

Pamela A. Wright

Pamela A. Wright
Graduate Research Associate and
Project Administrator

School of Natural Resources
The Ohio State University
2021 Coffey Road
Columbus, Ohio 43210

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Project Coordinators

Martha Aikens — NPS
Richard L. Cunningham — NPS
John G. Dennis — NPS
William P. Gregg — NPS
Roseanne Fortner — OSU
Gary W. Mullins — OSU
Kimberly A. Palmer — OSU
Michael D. Watson — NPS
Pamela A. Wright — OSU

Contributors

William Anderson — NPS
Kimberly A. Baker — OSU
Warren Bielenberg — NPS
Ann Bowman— NPS
Philip Bruek — NPS
Peter Brussard—Montana State U.
Faith Campbell—NRDC
Diane Chalfant — NPS
Glenn Clark — NPS
Gene Cox — NPS
Muriel Crespi, Ph.D. — NPS
Raymond F. Dasmann—U. of California
Margaret Dill — OSU
Dominic Dottavio— NPS
Milford Fletcher — NPS
Kathy Freas —Stanford University
Global Tomorrow Coalition
Francisco Gomez-Dallmeier
Susan M. Halaburda — NPS
John W. Hanna — OSU
Richard V. Harris — NPS
Judy Hart — NPS
Ron Hiebert, Ph.D. — NPS
Dan Hugg, Ph.D. — NPS
Robert Huggins — NPS
Gary Johnston, Ph.D.— NPS
William R. Jordan, III — U. of Wisconsin
Andrew Kardos — NPS
John Karish — NPS
Judy Kauffeld — OSU
Glen Kaye — NPS
Bruce Kilgore — NPS
Cynthia Kryston — NPS
Bill Laitner — NPS
James Larson — NPS
Vicki Jo Lawson — NPS
Al Lovaas — NPS
Jean F. Mathews — NPS
Robert Manasek — NPS
Nancy Marx — US F&W
Theresa McDonald — OSU
Nora Mitchell — NPS
Dennis Murphy — Stanford University
Barbara Nelson-Jameson — NPS
Larry Norris — NPS
Margery L. Oldfield
Bruce Paige — NPS
Tom Pierre — OSU
David Pugh — NPS
John Roth — NPS
Allen B. Rowland— OSU
Michael Ruggerio — NPS
Hal Salwasser — US FS
School of Natural Resource Staff — OSU

Mark L. Shaffer—US FW
Napier Shelton — NPS
Stanwyn Shetler — Smithsonian Institute
Lisa Simpson — NPS
Kim Sikoryak — NPS
Christine M. Shonewald-Cox. — NPS
Russ Smith — NPS
The Smithsonian Institute
William Sontag — NPS
Michael Soukup — NPS
Carol J. Spears — NPS
William Springer — NPS
Charles Stone — NPS
Kimberly Tassier — NPS
Richard Tobin — US FS
Richard Vance — NPS
Robert Whistler — NPS
Peter S. White — University of North Carolina
David Wilcove — The Wilderness Society
World Wildlife Fund
Richard Wilt — NPS

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2.0 Technical Reports

Biological Diversity

Technical Report Summaries

Management Policies Relating to Biological Diversity

U.S. Department of the Interior—National Park Service
NPS Management Policies 1988

Biosphere Reserves. Individual park ecosystems of park lands that are components of regional ecosystems believed to be internationally significant examples of one of the world's natural regions may be nominated for designation as biosphere reserves. General guidance for the international biosphere reserve program is provided by the United Nations Education, Scientific and Cultural Organization (UNESCO) through the Man and the Biosphere (MAB) program. Working within the U.S. MAB program, the National Park Service will assist in determining the suitability and feasibility of including parks in U.S. biosphere reserve nominations, participate in research and educational activities, and furnish information on its biosphere reserves for inclusion in domestic and international information systems.

The designation of park lands as international biosphere reserves will not alter the purposes for which the parks were established or change the management requirements. To the extent practicable, superintendents of parks participating in the international network will incorporate biosphere reserve objectives into statements for management, general management plans, action plans, and park interpretive programs. Superintendents will pursue opportunities to use the biosphere reserve network as a framework for local, regional, and international cooperation.

World Heritage Sites. Natural areas believed to possess outstanding universal value as part of the world's natural heritage will be nominated to the World Heritage List. U.S. recommendations are approved by an interagency panel chaired by the Assistant Secretary for Fish and Wildlife and Parks, based on criteria promulgated by the World Heritage Committee. These criteria and the rules for U.S. participation in the Convention Concerning the World Cultural and Natural Heritage are published in 36 CFR 73. Once an area is designated a world heritage site, the National Park Service will recognize the designation in public information and interpretive programs.

Protection of Native Animals. The National Park Service will seek to perpetuate the native animal life (mammals, birds, reptiles, fish, insects, worms, crustaceans, etc.) as part of the natural ecosystems of parks. Management emphasis will be on minimizing human impacts on natural animal population dynamics. The native animal life is defined as all animal species that, as a result of natural processes, occur or occurred on lands now designated as a park. Any species that have moved onto park lands direct or indirect as the result of human activities are not considered native. Native animal populations will be protected against harvest, removal, destruction, harassment, or harm through human action. Individual animals within a population may be removed only when:

- hunting and trapping are permitted by law.
- fishing is not specifically prohibited.

• control of specific animal populations is required for the maintenance of a healthy park ecosystem.

• removal or control of animals is necessary for human safety and health or to protect structures or landscaped areas.

• removal is part of an NPS research project described in an approved resource management plan or is part of research being conducted by others who have been issued an appropriate collection permit.

• removal will restore native populations in other parks or cooperating areas without diminishing the viability of the populations from which the animals are taken.

Population Control. Natural processes will be relied on to control populations of native species to the greatest extent possible. Un-natural concentrations of native species caused by human activities may be controlled if the activities causing the concentrations cannot be controlled. Non-native (exotic) species will not be allowed to displace native species if this displacement can be prevented by management.

Animal populations or individuals will be controlled in natural, cultural, and development zones when they present a direct threat to visitor safety and health, and in cultural and development zones when necessary to protect property or landscaped areas. The decision to initiate a control program will be based on scientifically valid resource information obtained through research. Planning and implementation of control actions will comply with established planning procedures, including provisions for public review and comment. Where persistent human/animal conflict problems exist, a determination will be made of whether or not curtailing or modifying visitor use and other human activities might be a more desirable alternative. The need for, and results of, controlling animal populations will be evaluated and documented by research studies and in the natural resource management plan. Such studies will assess the impacts of the control methods on nontargeted as well as targeted components of the ecosystem.

Other management measures that may be used as necessary, separately or together, include live trapping for transplanting elsewhere, gathering of research specimens for NPS and cooperating scientists, public hunting on lands outside the park, habitat management, predator establishment, sterilization, and destruction by NPS personnel or their authorized agents. In controlling wildlife populations, highest priority will be given to encouraging public hunting outside the parks and live trapping within parks for transplanting elsewhere.

The National Park Service will consult, as appropriate, with other federal land-managing agencies, the U.S. Fish and Wildlife Service, state agencies, native American authorities, and others regarding programs to control populations of fish and wildlife, research programs involving the taking of fish and resident wildlife, and cooperative studies and plans to guide public hunting outside park boundaries.

In cases where individual animals are removed from park populations consistent with these provisions, carcasses may be left in natural zones to decompose, or live animals or carcasses may be removed from parks, according to provisions of applicable laws, agreements, and regulations, including the giving of preference to native Americans.

Management of Migratory Animals. Many species of vertebrates and invertebrates regularly travel from one location to another at yearly or other intervals. Such species have at least two significant habitat areas, and those that spend time in route may have three or more. Where those species occur in a park, park habitats generally provide only one of the major habitat needs, and the survival of the species in the parks is also dependent on the existence and quality of habitats outside the park.

Parks having native migratory species (bats, caribou, geese, marine turtles, elk, frogs, salmon, whales, and butterflies, to name a few) will ensure the preservation of their populations and their habitats inside the park and will cooperate wherever possible with others to ensure the preservation of their populations and habitats outside the park. Management actions may include:

• participation in regional land use planning efforts and cooperation with states and native American authorities in the setting of game harvest regulations for lands outside the park (useful for managing short-distance seasonal migrants, such as elk).

• monitoring to develop data for the U.S. Fish and Wildlife Service and National Marine Fisheries Service (useful in international negotiations for far-ranging seasonal migrants, such as geese, whales, and marine turtles).

• presentation of information about species' life cycles, ranges, and population dynamics in park interpretive programs (useful for managing all species that frequently move into and out of parks).

Management of Harvested Species. Hunting and trapping wildlife will be allowed only in parks where such use is specifically authorized. In areas set aside with legal authorization for hunting, trapping, fishing, subsistence use, or other harvest of native wildlife, the National Park Service will still seek to perpetuate native animal life and to protect the integrity of natural ecosystems. Management programs directed toward the restoration and maintenance of habitats supporting such animals (including fish, amphibians, insects, mammals, birds, molluscs, echinoderms, and crustaceans) will be conducted through cooperative efforts with individual states under memoranda of understanding. The restoration of habitat will generally include treatment to return a damaged area to its natural condition, which will then be self-perpetuating. It will not include the continued artificial manipulation of habitat to increase the numbers of a harvested species above natural levels, except where directed by Congress.

Fisheries Management. Fishing may be restricted in certain waters and at certain times if it is determined such actions are needed:

• to protect rare, threatened, or endangered plant or animal species in the waters or in adjacent habitat.

• to meet park objectives for scientific study, interpretation, environmental education, appreciation of fish and other aquatic life, or other public benefits.

• to provide opportunities for depressed fisheries to recover.

• to protect spawning grounds of endemic fish species.

• to maintain natural distributions, densities, age-class distribution, and behavior of fish or of native wildlife species that use fish for food.

• to protect the natural integrity of aquatic areas within natural zones.

In natural, cultural, and park development zones, fisheries management will seek to preserve or restore natural aquatic habitats and the natural abundance and distribution of native aquatic species, including fish, together with the associated terrestrial habitats and species. Artifical stocking of native fish will be employed in natural zones only to reestablish native species in their historic ranges; stocking of exotic fish species will not be permitted in natural zones. Stocking of native or exotic species will be permitted in cultural zones only where there is a special need associated with the historic events or individual commemorated and where an exotic species, if used, could not spread to natural zones or waters outside the park. Stocking with native species, but not with exotic species, will be permitted in park development zones. Stocking programs for other purposes in these zones will be discontinued or phased out except where therre is congressional intent expressed in law or a House or Senate report accompanying legislation.

Resevoirs, and in some cases channelized or otherwise manipulated rivers and streams, in special use zones represent altered environments that may reduce populations of some native species of fish and encourage others. The National Park Service may cooperate with state fish and game officials to work out programs of stocking reservoirs and other altered waters, where authorized, for purposes of recreational fishing, using either exotic or native species, or both. Active fishery management programs will be encouraged in such waters.

The new ecological environments and niches created by the alteration of natural waterways may be most successfully filled by exotic fish species; nevertheless, management activities will give precedence to native fish species over exotics wherever native species are adaptable to the altered environment. Rivers and streams in special use zones may be stocked with exotic species of fish only when it has been determined that exotics already are present and established and where scientific data indicate that introducing additional exotics would not diminish native plant and animal populations and that the exotics could not spread to natural zones or to waters outside the park.

Landscapes and Plants. The National Park Service will seek to perpetuate native plant life as part of natural ecosystems. Landscapes and plants may be manipulated only when necessary to achieve approved management objectives. These objectives will vary according to management zones, as described below.

To the maximum extent possible, plantings in all zones will consist of species that are native to the park or that are historically appropriate for the period or event commemorated. Only native species will be allowed in natural zones. Use of exotic species in other zones will conform to the exotic species policy. In any zone, landscapes and plants may be manipulated to maintain habitat for threatened or endangered species, but in natural zones only native plants may be used if additional plantings are done, and manipulation of existing plants will be carried out in a manner designed to restore or enhance the functioning of the plant and animal community of which the endangered species is a natural part.

Natural Zone. In natural zones, landscape conditions caused by natural phenomena, such as landslides, earthquakes, floods, hurricanes, tornadoes, and natural fires, will not be modified unless required for public safety or for necessary reconstruction of dispersed-use facilities, such as trails.

Terrain and plants may be manipulated where necessary to restore natural conditions on lands altered by human activity. Management activities may include, but will not be restricted to:

• removing constructed features, restoring natural gradients, and revegetating with native park species on acquired inholdings and on sites from which park development is being removed.

• restoring a natural appearance to areas disturbed by activities such as fire control and hazard-tree removal.

• rehabilitating areas disturbed by visitor use.

• maintaining open areas and meadows where they were formerly maintained by natural processes.

Wherever possible, revegetation efforts in natural zones will use seeds, cuttings, or transplants representing species and gene pools that are native to the ecological portion of the park in which the restoration project is occurring. Where a natural area has become so degraded that a restoration with native species has proven unsuccessful, improved varieties or similar native species may be used.

In localized, specific areas defined as special management subzones of natural zones, screen plantings may be used to protect the natural zone from undesirable impacts of adjacent land uses so long as it does not result in the invasion of exotic species.

Cultural Zone. Trees, other plants, and landscapes in a cultural zone generally will be managed to reflect the historic designed landscape or the scene that prevailed during the historic period, except that soil erosion will be prevented wherever possible.

Where appropriate, efforts may be made to extend the lives of specimen trees dating from the historic period. An individual tree of historic value that poses a safety hazard or is diseased beyond recovery will be removed and replaced. While unique trees or shrubs are still healthy, provisions will be made to eventually replace them with their own progeny grown from seeds or propagated through some form of vegetative reproduction, such as cuttings. Cultivated crop plants may be maintained for allowed livestick or agricultural uses that are part of the cultural scene, authorized by federal law, or retained as a property right.

Park Development Zone. Landscapes and plants in park development zones may be manipulated as necessary to achieve the purpose of the zone. Landscapes and plantings adjacent to natural or cultural zones will use native or historic species and materials to the maximum extent possible. Certain native species may be fostered for esthetic, interpretive, or educational purposes. Use of exotic species or materials will conform with the exotic species policy. In subzones classed as landscape management areas, vegetation may be intensively manipulated to enhance esthetic quality, facilitate interpretation, or promote public use and enjoyment.

Special Use Zone. NPS natural resource management activities in special use zones will be directed toward achieving the defined park objectives and minimizing the impact of these zones on the rest of the park. Vegetation may be manipulated to achieve these objectives.

Genetic Resources. The National Park Service will strive to protect the full range of genetic types (genotypes) native to plant and animal populations in the parks by perpetuating natural evolutionary processes and minimizing human interference with evolving genetic diversity.

The introduction of native plants and animals will be accomplished using organisms taken from populations as closely related genetically and ecologically as possible to the park populations, preferably from similar habitats in adjacent or local areas, except where the management goal is to increase the variability of the park gene pool to mitigate past, human-induced loss of genetic variability. Transplants for purposes of restoring genetic variability through gene flow between native breeding populations will be preceded by research on the genetic compatibility of the populations.

The need to maintain appropriate levels of genetic diversity will guide decisions on what actions to take to manage isolated populations of species or to enhance populations of rare, threatened, or endangered species. All resource management actions involving planting or relocating species, subspecies, or varieties will be guided by knowledge of local adaptations, ranges, and habitat requirements and detailed knowledge of site ecological histories.

When individual plants or animals must be removed for any reason—hunting, fishing, pest management, or culling to reduce excess populations resulting from human activities —the National Park Service will consider the need to maintain appropriate levels of genetic diversity in the residual park populations.

Restoration of Native Plants and Animals. The National Park Service will strive to restore native species to parks wherever all the following criteria can be met:

• Adequate habitat to support the species either exists or can reasonably be restored in the park and, if necessary, on adjacent public lands and waters, and once natural population level is achieved, it can be self-perpetuating.

• The species does not, based on an effective management plan, pose a serious threat to the safety of park visitors, park resources, or persons or property outside park boundaries.

• The subspecies used in restoration most nearly approximates the extirpated subspecies or race.

• The species disappeared, or was substantially diminished, as a direct or indirect result of human-induced change to the species population or to the ecosystem.

Such programs will be carried out in cooperation with other affected agencies, organizations, and individuals.

Any necessary confinement of animals in small fenced areas during restoration efforts will continue only until the animals have become thoroughly accustomed to the new area or they have become sufficiently established to minimize threats from predators, poaching, disease, or other factors.

Threatened or Endangered Plants and Animals. Consistent with the purposes of the Endangered Species Act (16 USC 1531 et seq.) the National Park Service will identify and promote the conservation of all federally listed threatened, endangered, or candidate species within park boundaries and their critical habitats. As necessary, the National Park Service will control visitor access to and use of critical habitats, and it may close such areas to entry for other than official purposes. Active management programs will be conducted as necessary to perpetuate the natural distribution and abundance of threatened or endangered species and the ecosystems on which they depend. The U.S. Fish and Wildlife Service and the National Marine Fisheries Service are the lead agencies in matters pertaining to federally listed threatened and endangered species. The National Park Service will cooperate with those agencies in activities such as the delineation of critical habitat and recovery zones on park lands and will participate on recovery teams.

The National Park Service also will identify all state and locally listed threatened, endangered, rare, declining, sensitive, or candidate species that are native to and present in the parks, and their critical habitats. These species and their critical habitats will be considered in NPS planning activities. Based on an analysis of the status of state and locally listed species throughout their native ranges and throughout the national park system, the National Park Service may choose to control access to critical habitats or to conduct active management programs similar to activities conducted to perpetuate the natural distribution and abundance of federally listed species. The Park Service will cooperate with the agencies responsible for state or locally listed species.

Plant and animal species considered to be rare or unique to a park will be identified, and their distributions within the park will be mapped.

All management actions for protection and perpetuation of special status species will be determined through the park's natural resource management plan.

Exotic Plants and Animals. Exotic species are those that occur in a given place as a result of direct or indirect, deliberate or accidental actions by humans (not including deliberate reintroductions). For example, the construction of a fish ladder at a waterfall might enable one or more species to cross that natural barrier to dispersal. An exotic species might also be introduced through seeds in the droppings of an animal that has fed on an exotic species outside the park. The exotic species introduced because of such human action would not have evolved with the species native to the place in question and, therefore, would not be natural components of the ecological system characteristic of that place.

Introduction of New Exotic Species. Decisions on whether to introduce an exotic species will be based on the purposes and designated zones of the park and will be undertaken only after rigorous review of the proposal. Non-native plants and animals will not be introduced into natural zones except in rare cases where they are the nearest living relatives of extirpated native species, where they are improved varieties of native species that cannot survive current environmental conditions, where they may be used to control established exotic species, or when directed by law or expressed legislative intent.

In cultural zones, non-native plant and animal species may be introduced in rare cases as described for natural zones. In addition, non-native species that are a desirable part of the historic scene being represented in a cultural zone may be introduced, but only if they are controlled by such means as cultivating for plants or tethering, herding, or pasturing for animals. In such cases the exotics used must be those which are known either to have existed in the park during its period of historical significance or to have been commonly used in the local area at that time, except in cases where agricultural permits allow other crops.

In park development and special use zones (particularly landscape subzones), exotic species of plants and animals may be introduced to carry out NPS programs consistent with park objectives only when all the following conditions exist:

- Available native species will not meet the needs of the management program.

- Based on scientific advice from appropriate federal, state, local, and nongovernmental sources, the exotic species will not become pests.

- Such introductions will not spread and disrupt desirable adjacent natural plant and animal communities and associations, particularly those of natural zones.

- The exotic species is superior in maintainability.

Management of Exotic Species Already Present. Control of populations of exotic plant and animal species, up to and including total eradication, will be undertaken whenever such species threaten park resources or public health and when control is prudent and feasible. Examples of threatening situations include:

• posing a public health hazard as determined by the Centers for Disease Control or a hazard to public safety.

• disrupting the accurate presentation of a historic scene.

• damaging historic or archaeological resources.

• interfering with natural processes and the perpetuation of natural features or native species (especially those that are endangered, threatened, or otherwise unique).

• significantly hampering the management of park or adjacent lands.

High priority will be given to the management of exotic species that have a substantial impact on park resources and that can reasonably be expected to be successfully controlled; lower priority will be given to exotic species that have almost no impact on park resources or that probably cannot be successfully controlled. The decision to initiate a management program will be based on existing and, where necessary, newly acquired scientific information that identifies the exotic status of the species, demonstrates its impact on park resources, and indicates alternative management methods and their probabilities of success. A management plan will be developed and implemented according to established planning procedures and will include provisions for public review and comment, where appropriate. Care will be taken that programs to manage exotic species do not result in significant damage to native species, natural ecological communities, natural ecological processes, or historic objects.

In national recreation areas and preserves where the enhancement of fish and game species for hunting and fishing is authorized, preference will be given to enhancing native species. However, where stocking of exotic fish and game species has historically occurred, stocking for the same species may be continued unless it is known to be damaging native resources.

Collecting Natural Products. Collecting natural products for personal use or consumption is governed by NPS general regulations and by the Special Park Uses Guidelines. A superintendent may designate certain fruits, berries, nuts, or unoccupied seashells that can be gathered by hand for personal use or consumption, including traditional use by native Americans, upon a written determination that such an activity will not adversely affect park wildlife or the reproductive potential of a plant species or otherwise adversely affect park resources.. The collection of minerals or rocks will be allowed only when specifically authorized by federal law or treaty rights.

While campfires are a traditional element of camping and the park experience, gathering firewood will be prohibited except where subsistence use is authorized by federal law or in specific areas designated by a superintendent where dead and down wood may be collected for campfires. Natural resource products that accumulate as a result of site clearing for development, hazard tree removal, vista clearing, or other management actions will be recycled through the ecosystem wherever practicable. Where recycling is not practicable, the products may be disposed of. Disposal may be accomplished by contract, if the result of work done under contract and the value is calculated in the contract cost, or by sale at fair market value in accordance with applicable laws and regulations. Wood that accumulates as a result of management actions described above may also be used for park purposes such as heating public buildings or offices or for interpretive campfires programs.

A Summary of

"The Role of theNational Park Service in Protecting Biological Diversity."

By Gary W. Mullins — The Ohio State University

This report to the Director of the National Park Service was produced by a Task Force chaired by Christine Schonewald-Cox and was submitted March 1987. The task force sought to define the role of the National Park Service in protecting biological diversity and to suggest methods for its implementation. The following materials are excerted or paraphrased from that task force report. This report is a set of recommendations to the director and is not a statement of NPS policy.

The task force opened the report with the premise that based upon the legislated mandates and unique characteristics of the National Park Service (NPS), national parks within or containing natural areas should, first, protect biological diversity and underlying processes that maintain and generate natural biological diversity. Just about any park (national or other) can be made adequate for preserving tourism, but no national park can be made adequate for preserving biological diversity without a superior investment in protection.

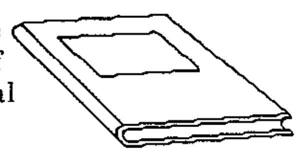
National Park Service lands are increasingly unique. They must be treated as relatively undisturbed areas imbedded in grossly disturbed systems that can contribute to the erosion of natural biological diversity of national parks and of the nation.

Consequently, the protection of biological diversity remaining within the national park system, including supporting ecological and evolutionary processes, should be institutionalized as the increasingly unique leadership role of the NPS.

Because national parks are not by themselves capable of preventing extinctions, the task of protecting biological diversity is beyond the scope of the NPS working alone, or the capabilities of any single agency. Accomplishing this role will require a mandate for inter-organizational cooperation.

Formed within the opening of the report are eighteen general definitions with abbreviated discussions. These materials, for the most part, are reflected in other portions of the National Park Service Communicator's Handbook on Biological Diversity and are not repeated herein. Seven other topical areas are found in the report along with a set conclusion. Each of the seven topics will be briefly reviewed in turn and concluding recommendations of the task group will be offered in full. Lastly the eight summary observation and recommendation are listed as they appear in the report.

Legislative and International Initiatives. There is consensus on the following statement: Consistent with the World Conservation Strategy, management of visitors and their requirements should be subservient to the goal of maintaining environmental system integrity.



Legislative initiatives should be generated to assist interagency efforts to predispose national parks and adjacent federal land holdings (at the very least) toward a biosphere reserve model. The NPS should be a lead agency in the effort, and cooperation should be mandated.

Legislative initiatives may be necessary to shift the priorities of the NPS away from short-term actions into stewardship of biological diversity by inventory, monitoring and long-term research. The latter is not equivalent to monitoring. Such initiatives will require special funding and possible increases in resources management and science personnel. Subject-specific centers and inventory and monitoring eco-region centers may need to be established to support inventory and monitoring activities.

Policy Regarding Natural Resources Management. Legislatively, current NPS policies should be reinterpreted by reexamining existing legislation. New legislation is needed to specify NPS priorities and make more explicit the requirements for protection of biological diversity. The welfare of the United States is dependent upon a conservation strategy, and NPS can help to formulate that strategy.

The National Park Service must lead a cooperative effort to achieve its goal of preserving biological diversity nationally; this includes biological diversity existing externally to the parks upon which national parks also depend. Management of NPS should be part of the biological diversity plan and should be subservient to it, not vice versa.

The key word in all policy and management is flexibility. Management especially should recognize that species and populations are dynamic and to some extent adaptable.

To effectively develop and carry out a biological diversity policy NPS must help formulate legislation, take leadership in the cooperation and protection of biological diversity and perceive and act on its administrative obligations to biological diversity.

The 1963 "Leopold Report." The 1963 "Leopold Report," which was well ahead of its time, is still considered valid by most people working in or with national parks. Starker Leopold himself recognized that there would be problems when the NPS made a policy document out of a consultation document without compensating for language and breadth of coverage.

Because of the controversies that have arisen concerning objectives, priorities, and methods of protection, the task force decided to make some generalized comments on language adjustments and reinterpretation. Additionally, changes in knowledge and attitudes among ecologists, conservationists, etc. during the last two decades have changed and support the need for a reexamination. Recognizing that the director's blue ribbon panel will make an in-depth analysis, this group concentrated on material relevant to the objectives of the Biological Diversity Task Force.

This section of the task group's report is a generalized summary with some comments delivered by task force members regarding the report. Some participants gathered comments from NPS personnel who were more familiar with the "Leopold Report" and its impact on the NPS than most task force members.

In summary, the task force felt that the Leopold report focuses on internal matters, and does not look at the park in the context of itssurrounding lands and land use practices. There is too much emphasis on the manipulative aspects of protection, although the task force recognizes that new needs for manipulations have arisen that are not necessarily the kind that prevailed more than 20 years ago.

The group agreed that it is not practical, and is potentially damaging to manage for any point in time. Rather, the focus should be on maximizing particular conditions.

Processes are dynamic, and include natural extinction as well as diversification. So, while extinction is natural, it is the rate of current extinction that is unnatural. The influences of U.S. settlement culture should be minimized except in historic or other cultural areas.

Administration, Management and Research. To protect biological diversity NPS will be required to revamp priorities, engage extensive planning and enhance the agencies overall capabilities in this area. Revamping priorities requires that biological diversity and related objectives be given higher priority. Planning called for entails conferences, seminars and workshops on biological diversity to assist in planning, training and increasing the extent of scientific exchange. Planning will require the re-thinking of both short- and long-term orientation and application of this thinking to product planning, staff reorganization, research and the setting or priorities.

Enhancing the agencie's capabilities for protecting biological diversity addresses monitoring of funds so earmarked, improves technological capabilities, and trains existing NPS personnel to plan, carry out, and maintain inventory and monitoring activities throughout the National Parks System. The agency must emphasize that resource management programs should be enhanced with information synthesis, exchange programs and with additional training and internships.

Leadership and Cooperation. No national park is an entire ecosystem well insulated from external changes. Its protection is dependent on both external and internal forces. For the most part parks are fragmented portions of ecosystems that are inadequate in size and shape to properly protect biological diversity.

The agency must enhance leadership and cooperation simultaneously. Cooperating with programs such as MAP-8 and National Science Foundation can greatly improve NPS's capabilities the leaderships and cooperation in the area of biological diversity. NPS, because of its access to natural resources, can easily attract cooperation and offer leadership.

Inventory and Monitoring. It is our (task force's) impression that most national parks do not understand why we need to inventory and then monitor. There is an unclear perception on the part of the NPS staff of how to inventory and then monitor, and of what value inventories and monitoring have on the functioning of the national parks and the future of the nation.

For NPS to enhance its capabilities in these areas a clearly defined inventory and monitoring process must be established, systematic inventories must be expanded, and monitoring must be better systemized and routinized. It is suggested that NPS petition for additional legislation to ensure that direction and sufficiency of funds to carry out these essential functions.

Training, Interpretation and Public Education. Training in methods of protecting biological diversity and raising awareness of national park dependence upon cooperation (at all levels) will be required, especially for park staffs. This includes training for superintendents and for professional as well as non-professional staff who engage in activities that affect protection of biological diversity (resource management, interpretation, enforcement, construction, etc.). These will be the people who implement protection and communicate their knowledge to visitors and the public.

Training opportunities should be expanded, and all staff should take at least one short course in biological diversity, efforts should be made to improve NPS's science image and highly technical biological diversity materials should be compiled and prepared for park personnel review.

Interpretation should be expanded in scope and depth. Complexities of management and protection and damages in the ecosystem should not be hidden but described, visited and utilized to raise public consciousness about the difficulties of modern protection. This and public education programs should be more aggressive, including television advertisements and specialized video programs.

The NPS should concentrate its efforts and cooperate with other organizations (including agencies) to teach the public about its dependence upon biological diversity and the complex problem of protecting that diversity. This should be done at both national and state levels through public education and promotion. The NPS should attempt, for example, to incorporate such education into school curricula, broadcast channels (radio and television programs), and advertisements.

Concluding Recommendations. With respect to "natural" parks and natural areas within parks:

- The NPS should seek to protect biological diversity at all levels of its organization.

- The NPS should officially recognize that the loss of biological diversity in the United States and globally is a major concern.

- One of the primary NPS missions should be to maintain and restore native biological diversity.

- Conservation of biological diversity must become the central and overriding principle for organizing management and administration of NPS "natural" parks and zones.

- Because parks are too small, scattered, and otherwise inadequate to achieve this goal, cooperation between the NPS and federal, state, local, and non-governmental organization is mandatory.

- We affirm the general trust of the "Leopold Report" with modifications of language that reflect advances in our current knowledge of biological systems.

- We also affirm the importance of maintaining natural ecological and evolutionary processes similar to those in pre-settlement times.

- Currently, the NPS obtains insufficient technical information on the conservation of biological diversity, and there appears to be no focus on biodiversity.

- The NPS has inadequate inventory and monitoring capabilities.

- This mission is so fundamental that training and translation within the Service and interpretation to the public are mandatory.

Summary Observations and Recommendation. The task group summarized their work with the following statements and recommendations:

U.S. National Parks, as they are currently organized and managed, are destined to loose biological diversity. The National Park Service must use science, cooperation, training, and new management methods to document, monitor, research, and protect biological diversity and underlying processes within and adjacent to its national parks.

1. Problems exist with regard to the size and shape of national parks. While size may affect the number of diverse habitats and species, or the sizes and structure of their respective populations, shape affects their stability and exposure to adjacent pressures.

2. National parks are too small, and the NPS too poorly funded and trained, to maintain the biological diversity of the national parks. The national parks will depend upon increased funding, training, and cooperation with adjacent land owners and other non-adjacent protected habitats to reduce losses in diversity.

3. Natural ecological and evolutionary processes should be emphasized in protection; this includes processes of natural extinction as well as speciation. However, most extinctions are caused or accelerated by humans, and can be counteracted only by intervention. Too much intervention can create imbalances among natural processes. Thus a careful balance must be struck between intervention and non-intervention to counteract unnecessary losses of populations and species while still protecting natural ecological and evolutionary processes.

4. Managers of U.S. National Parks are unaware of the nature and stability of the biological diversity contained in the national parks, and are even less aware of changes that affect this diversity. Major shifts among priorities need to be made favoring inventory and monitoring of biological diversity.

5. The National Park Service has too few resource managers, and they are not trained to inventory, monitor, or protect biological diversity. These managers should be trained and provided with input from the scientific fields that contribute to the protection of biological diversity.

6. Too little use is made of existing knowledge and of scientists, both within and external to the NPS, who can convey that knowledge and assist management. Furthermore, there is no funding source to which U.S. scientists may turn to pay for research having to do with the documentation or protection of biological diversity.

7. The distribution and condition of biological diversity is neither assessed nor taken into consideration in the planning of land purchases, nor in most zoning, construction, or restoration operations affecting national parks.

8. The public, as well as the NPS, is largely unaware of the difficulty and complexity of the task of protecting biological diversity in national parks, and should be made aware of the purposes of national parks and the complex and expensive requirements for stewardship.

A Summary of

NPS Draft Biological Diversity Plan

By Gary W. Mullins — The Ohio State University

The National Park Service (NPS) is working to develop a plan for the protection and maintenance of biological diversity. As of February 1989, the plan was in draft status with coordination of the effort in the Office of the Regional Chief Scientist — Southeast Region.

Planning efforts began at a "Joint National Science Foundation/National Park Service/ Society for Conservation Biology Workshop on Biological Diversity" held in the Great Smoky Mountains National Park in May 1988. The task force at that meeting was charged with defining the role of the NPS in protecting biological diversity.

The following materials were abstracted from the draft report that resulted from the May 1988 meeting:

The loss of biological diversity due to clearing of land, pollution, and other human activities may well represent the most significant issue facing humankind as the twentieth century draws to a close. Although the losses are most serious in tropical developing countries, significant losses have occurred in the United States. Until recently, our national parks were widely considered safe havens for plants and wildlife by virtue of their protection and generally remote locations. We now know that even the most isolated areas are threatened by human encroachment. Most parks are too small to sustain healthy populations of wide-ranging animals within their boundaries. New approaches and unprecedented cooperation will be required if the trends of recent decades are to be reversed and our future opportunities for using and enjoying our biological heritage preserved.

The actions set forth in this plan provide an aggressive approach to enhancing biological resources by fostering coordination with existing NPS programs as well as other governments and agencies, strengthening the participation of the scientific community, and implementing specific actions at the park level.

The plan is currently organized around six major goals:

1. Clearly establish the NPS role in conserving biological diversity.

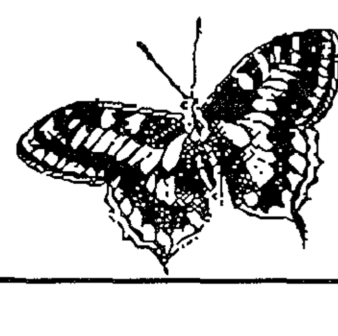
2. Develop cooperative approaches to preserving biological diversity.

3. Develop the capability to understand and preserve biological diversity.

4. Integrate a biological diversity conservation management plan into ongoing park operations.

5. Provide a leadership role in interpreting biological diversity both internally to NPS staff and externally to our different publics.

6. Demonstrate leadership in protecting biological diversity.



For each goal, specific objectives are listed and tasks to carry out the objectives are identified.

The plan calls for seven major actions:

1. Research funding for biological diversity should be expanded to encourage new research directions and greater cooperation between parks, Cooperative Park Study Units (CPSU) and university scientists.

2. Greater park ecosystems and corridor projects are encouraged for the purpose of emphasizing regional management strategies in order to maintain at least minimum viable populations.

3. Performance standards for park managers and regional directors should include biotic diversity management as a key element.

4. Revisions of the National Natural Landmark program are necessary to ensure that the program plays an even greater role in the protection of biotic diversity.

5. A committee to work with the National Science Foundation (NSF) on other non-NPS organizations should be established by NPS to ensure that NPS participates in any funding distributions from pending legislation, and is involved in other interagency scientific committees.

6. An inventory and monitoring budgetary initiative should be developed now and the conservation of biological diversity should be a part of future budget strategies.

7. The leadership role of the National Park Service in conserving biological diversity may be inadequate in guiding the service in the future as it deals with increasingly complex concerns related to biological diversity, especially those external to park boundaries.

The plan provides a suggested time table for FY 89 - FY 93 and includes budgetary information.

Although the plan is in draft form, it provides real direction for action. Following formal review, revision, and adoption the plan will be made available to the field.

A Summary of

"Interpreting Biological Diversity in the National Park System: A National Park Service Initiative Plan"

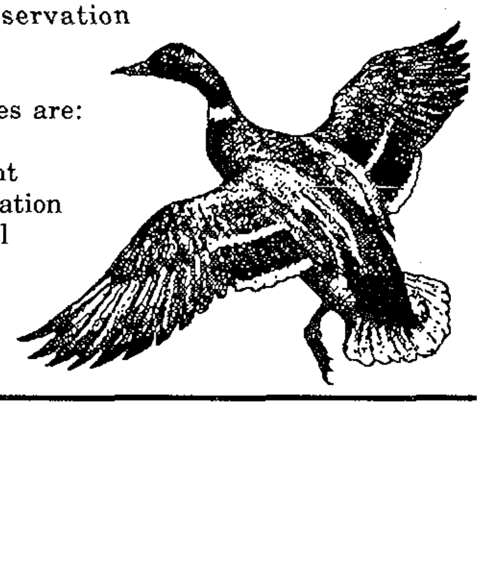
By Gary W. Mullins — The Ohio State University

The plan, prepared by the Biological Diversity Interpretive Initiative Task Group, chaired by Richard Cunningham, was in response to the NPS decision to designate 1989 as the start-up year for the Biological Diversity Interpretive Intitiative. The following is the summary of the Task Group's April 1988 report.

Protection of biological diversity in the National Park System is critical to preservation of the basic biological elements for which many parks are established and is central to the mission of the National Park Service. The Biological Diversity Interpretive Initiative on Biological Diversity has been called for and given direct support by the Director of the National Park Service. This plan provides for a service-wide interpretive/educational effort on biological diversity. Although some aspects of biological diversity are currently being interpreted in the parks, this plan provides an integrated approach to communicating a critical resource issue — the loss (and maintenance) of biological diversity. The plan recognized that a threat as great as the loss of biological diversity can not be dealt with through a fragmented approach.

The formal program begins in FY 1989 and will be an on-going program because the loss of diversity is an on-going phenomenon. All units of the National Park system are expected to participate at an appropiate level determined by their parks' themes, goals, objectives, research capabilities and funding. Many parks established for cultural resources protection, for their historical significance, or as a recreational sites have significant biological resources and most can readily tie their themes to the diversity of nature. The plan is a challenge to those in the field, for the success or failure of the initiative rests with individual parks and individual NPS communicators.

The plan proposes, first, to educate National Park Service communicators and then increase public awareness of biological diversity issues. Primary target audiences are park visitors, local communities, and schools; secondary audiences are the general non-visiting public, mass media users, special users groups, other agencies, legislators, state and local governments, cooperating associations, park concessionaires, academia, and conservation organizations.



The major activities are:

- plan development
- program presentation
- peer review of all materials
- National Park Service staff training

- interpretive material development
- park interpretive activities
- external educational activities
- biological diversity workshops
- establishment of interdisciplinary coordination
- funding strategies and sources
- program evaluation

Many of the activities require little or no additional cost. This is because the basic, traditional interpretive services offered by the National Park Service will be the most effective methods to communicate information on biological diversity. These services include guided walks, talks and campfire programs — settings in which the visitor is in actual contact with biological diversity and ecosystem processes.

Certain items essential to the program include a communicator's handbook on biological diversity, a biological diversity slide repository for service-wide use, two slide-tape programs (converted into videotape), a brochure and a travelling exhibit. Specific products that are requested to be funded in 1989 or in subsequent years are:

- Development plan
- Servicewide survey
- Director's presentation
- Peer review panel
- Training videotape
- Interpreters' handbook
- Brochure
- Slide repository
- Smithsonian traveling exhibits
- NPS exhibit panel
- Generic sound/ slide program
- Generic videotape
- Western hemisphere sound/slide program
- Western Hemisphere sound slide program
- Materials for cooperating associations/materials for concessionaires
- General Interpretive programs
- Staff-written articles
- Children's programs
- Park seminars
- On-site environmental education
- Special emphasis activities
- Model regional programs
- Media presentations
- Environmental education curricula
- Environmental education package
- Biological diversity workshops

To develop and utilize these materials properly, biological diversity must be recognized as interdisciplinary and multidisciplinary. Biological diversity must encompass all organizational levels in the National Park Service. In order to effectively coordinate, manage and interpret the Biological Diversity Interpretive Initiative, close cooperation between NPS research, resources management and interpretation units will be needed. Research and resource management should take responsibility developing, disseminating to the field and evaluating, the content of interpretive materials and programs. Training and professional consulatation must exist as part of all three units work.

Because of the importance of this special initive, and the additional workload it imposes, a temporary staff person should be brought into the Washington Office Division of Interpretation. This person would assist in carrying out this plan and serve as liaison between interpretation, research and resources management. Total integration will be required to maximize the opportunities to achieve the objectives of this plan.

The education and cost effectiveness of this program should be continuously evaluated and necessary adjustments made. Members of the task group, selected National Park Service communicators, and selected specialists from outside the Service should be involved in various aspects of evaluating interpretive program activities, educational media, accuracy of content and results.

Preservation of biological resources for future generations is central to the mission of the National Park Service. Therefore, this program must not be viewed as merely an interpretation and education effort — all units in the service must be involved. Public understanding and support for preservation of biological diversity is not only in the best interest of the National Park System, but also in the best interest of the American people to preserve their natural biological heritage.

"Interpreting Biological Diversity in the National Park System" Survey

Executive Summary

Gary W. Mullins, Associate Professor
Rosanne W. Fortner, Associate Professor
Kim Palmer, Research Associate

School of Natural Resources
The Ohio State University
2021 Coffey Road, Columbus, Ohio 43210

and

Office of Sponsored Programs
The Ohio State University Research Foundation
1314 Kinnear Road, Columbus, Ohio 43212

for

The National Park Service
U.S. Department of Interior
Washington, D.C.

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Introduction

The U.S. National Park Service (NPS), by its legislative mandate to protect resources, is and has been involved in protecting, managing and interpreting biological diversity for many years. The topic, per se, has been given special attention both in and out of the agency in the past decade. Likewise, total national and international concern has been heightened.

In an attempt to assess the National Park Service's role in the biological diversity effort, a number of actions have been taken. One thrust was the assessment and subsequent report to the NPS Director by a Biological Diversity Task Force (March 1987). An NPS biological diversity symposium, which provided direction for action, was held in the Great Smoky Mountains National Park in May 1988. Formal proceedings are forthcoming. Both of the inquiries pointed to the need to expand efforts by NPS to train personnel in biological diversity issues and expand the role of interpretation and public education related to biological diversity.

To begin implementation of this initiative the NPS Director designated FY89 as the startup year to emphasize interpreting biological diversity. A Biological Diversity Interpretive Initiative Task Group was appointed; Richard Cunningham, Chief of Interpretation, Western Region, was selected as task group chair. That group was to develop a set of recommendations for biological diversity interpretation in national parks. These recommendations were reported in "Interpreting Biological Diversity In The National Parks," which was released in April 1988. The executive summary contained herein is the result of the survey conducted by the Ohio State University under the direction of the Biological Diversity Interpretive Initiative Task Group, Division of Interpretation, and the Division of Wildlife and Vegetation, U.S. National Park Service.

Background

For the purpose of the survey, biological diversity was defined as the sum of diversity within and between species, between communities and between higher taxonomic levels. Biological diversity includes genetic diversity, species diversity, community diversity and ecosystem diversity.

The unit directing the survey, The Ohio State University's School of Natural Resources, utilized existing NPS reports, scientific and popular literature and personal interviews to better understand biological diversity issues under consideration by NPS. Terminology chosen for the survey and this report tended to be those terms that appeared most often in biological diversity literature.

Need for the Survey

Responding to a directive such as expanding biological diversity interpretation requires change on the part of park personnel and the production of new materials. To accomplish this a baseline understanding of the individuals and units subject to change and the associated visitor needs should be addressed. Thus, modeling on the

NPS "Clearing the Air" five-year interpretive initiative, a survey was deemed appropriate. A survey conducted in 1987 proved useful to a "Clearing the Air" task group in setting a direction for that initiative. That survey provided managers and developers of materials with greater insight to field personnel's attitudes, perceptions and desires relating to the interpretation of acidic deposition and air quality issues in the National Park Service. Therefore, "Clearing the Air" support materials and training programs were matched to the needs of the field and to the needs of the visitor. The survey reported herein replicated portions of the "Clearing the Air" survey.

Objective

The survey reported herein was designed to assess the extent of NPS interpretive activity on the subject of biological diversity. The four levels of assessment were:

- the current status of interpretation
- the interest of interpreters in new programs, portions of programs, exhibits and other materials about biological diversity
- attitudes of interpretive managers toward interpretation of biological diversity
- barriers to the interpretation of biological diversity

Method

An eight-page survey instrument, designed by project cooperators at The Ohio State University, was modeled on the "Clearing the Air" survey instrument and utilized existing NPS literature as an overview of the biological diversity issue in NPS. Input was provided by the Biological Diversity Interpretive Initiative Task Group, NPS Division of Wildlife and Vegetation, and the NPS Division of Interpretation — WASO. The final instrument was completed, pilot tested and approved in February 1988, and mailed to 301 NPS sites. A total of 225 responses were received by May 1988. Data were tabulated and a preliminary report was made in May 1988.

Each park received a cover letter signed by Ken Raithel, Assistant Director for Interpretation, the eight-page questionnaire, a paper entitled "Some Thoughts on Biological Diversity," by Dick Cunningham (NPS) and a sample biological diversity program sheet entitled "Nature's Medicine Cabinet," by Kim Palmer (OSU).

The questionnaire consisted of a cover letter from the researchers explaining the project and seven pages of questions, which required approximately 15-30 minutes to complete. The letter from the researchers, the biological diversity article by Dick Cunningham and the sample program by Kim Palmer were designed to help the respondents gain a better understanding of biological diversity. The questionnaire was designed and sequenced to serve as an instructional tool. The first question asked, "what are you interpreting in terms of biological diversity" and "what questions are you receiving regarding biological diversity." Respondents were to reply under four broad headings — genetic diversity, species diversity, community diversity, and ecosystem diversity. Under the four headings were a total of 24 categories to help the respondent better comprehend the array of biological diversity topics. Additionally, the 24 items had examples or explanations given where appropriate to further clarify the meaning of that aspect of biological diversity.

Question II, taken directly from the "Clearing the Air" survey, asked at what site or by what means did you receive questions about biological diversity. Question III provided five categories of communication technologies — personal services, nonpersonal services, exhibits, media outreach, and community/environmental education — for each of the 24 biological diversity topics. Respondents indicated the communication technologies they were currently using to interpret the 24 biological diversity topics. Although Questions I and III overlapped, the complexity of the questioning required this approach.

Question IV provided an opportunity for respondents to list which type of media, by topic, they would like to support their biological diversity interpretive programming. Question V addressed training needs and Question VI queried "the three most useful types of support your park could receive to aid in interpreting biological diversity." Questions VII and VIII addressed attitudes and perceptions of respondents towards the biological diversity initiative. The data for Questions VII and VIII were pooled and will only be reported as a service-wide response. Respondents were requested to include their name, title, and unit as well as thematic background for their park. Written comments were also requested.

Report Format

This executive summary is designed to provide the reader a relatively concise overview of the research. Full reports are available in the Washington and regional offices. The authors may be contacted concerning specific questions that any NPS personnel or unit may have.

Service-wide data and MAB parks data are summarized. Service-wide data pertaining to attitudes and perceptions are presented in tabular form. Regional data are not included due to the lengthiness of reporting about each region.

Primary resource data are presented in the same format as the full report to provide parks with an opportunity to assess their park in relation to other parks with the same primary resource.

Results of Service-wide Response

Question I in the survey asked park managers to indicate programs they were currently presenting relating to biological diversity. The topics that were presented in the survey questionnaire are shown in Figure 1. Under genetic diversity, 60% of the parks addressed ecological communities; 24-29% of the parks had programs pertaining to the other genetic diversity topics.

Programming pertaining to species diversity included 14 topics. Topics in which more than 50% of the parks had programs were: edible plants and animals (62%), ecological communities (60%), endangered and threatened species (56%), and charismatic species (50%). All other topics had less than 50%.

Community diversity was being interpreted by 52% of the parks via ecological process messages, 46% via unmodified natural communities messages and 31% via community level messages. Two topics under ecosystem diversity were being interpreted by more than 50% of the parks: restoration of ecosystems (51%) and conservation versus preservation (60%).

Question I also asked at what level parks were receiving questions about the various topics. Topics in which 50% or more parks were receiving questions were ecological communities (52%), charismatic species (52%), edible plants and animals (62%), endangered and threatened species (51%) and conservation versus preservation of natural resources (52%).

Question II investigated the location or medium through which questions were received. The following is a rank order of these with the first listed being the most frequented site for questions: interpretive programs, visitor desk contact, roving interpretation contact, environmental education programs, community/off-site programs, telephone inquiries, and written inquiries.

Question III asked respondents to indicate interpretive technologies that they were utilizing in their park to communicate biological diversity topics. Extensive programming by category (genetic diversity, species diversity, community diversity and ecosystem diversity) using a variety of media (personal service, community/environ mental education programs, non-personal services, exhibits and outreach programs) was reported as being carried out.

Question IV asked interpreters what type of information and materials they need to assist their efforts. Species diversity was the most sought-after information, followed by genetic diversity, ecosystem diversity, and lastly, community diversity. Personal services materials was the most desired type of information, followed by non-personal services materials, outreach program materials, community/environmental education materials, and lastly, exhibits.

Questions V asked about training needs and materials. Packets of materials were the most sought-after item, followed by self-study courses, in-park staff training, regional skills team courses, training courses at Mather or Albright Centers, videotapes, and lastly, no additional training needed was listed by nine parks.

Question VI asked parks to list the most useful support aid they could receive to better interpret biological diversity. Resource materials was the number one item requested by a wide margin, followed by training, funding, audio visual materials, handouts, brochures, news releases, traveling exhibits, support and clarity of objectives from the Washington office, and lastly, resource materials specifically for cultural parks.

Question VII asked the respondent to provide the answer that most accurately reflects the staff's attitude. Choices for answers were Strongly Agree (1), Agree (2), Neutral (3), Disagree (4), or Strongly Disagree (5). The mean or arithmetic averages were calculated for each question using these numerical values. Data are presented in Table 1.

Table 1: Manager's perception of staff's attitude toward biological diversity initiative.

Mean Score	Question	Frequency of Response				
		SA (1)	A (2)	N (3)	D (4)	SD (5)
1.837	The biological diversity initiative is appropriate for fulfilling the NPS mission.	84	101	27	6	3
1.941	The biological diversity initiative is useful in fulfilling the NPS mission.	74	100	36	8	3
3.332	A new initiative should continue to be proposed each year.	10	41	69	66	34
2.100	If such initiatives are to be proposed, they should be developed by special committees composed of a cross section of NPS experts.	51	110	48	8	3
1.774	If such initiatives are developed, special materials and program support should be coordinated by the Washington and regional offices.	91	102	20	3	5

Question VIII was a list of statements to which respondents were asked to provide the answers that most accurately reflected their attitude. Choices for answers were Strongly Agree (1), Agree (2), Neutral (3), Disagree (4), or Strongly Disagree (5). Using the numerical values the mean or arithmetic average was calculated for each question. Frequency of response and means are presented in Table 2.

Table 2: Manager's perception of the biological diversity initiative.

Mean Score	Question	Frequency of Response				
		SA (1)	A (2)	N (3)	D (4)	SD (5)
3.57	I feel my staff has time to develop biological diversity programs.	9	49	23	85	54
3.723	I feel my staff is large enough to effectively implement biological diversity programming.	7	38	26	87	62
2.06	I feel my staff has enough to do already.	72	76	57	11	2
2.29	I feel my staff should be interpreting biological diversity.	55	88	46	23	9
3.32	I feel my staff already adequately interprets biological diversity.	5	46	65	80	23
3.54	I feel my staff has access to current research on biological diversity within my park.	3	45	39	91	39
2.528	I feel researchers investigating biological diversity issues are unwilling to share findings with my staff.	19	86	93	14	4
2.926	I feel research findings available to my staff are outdated.	9	56	99	48	5
2.949	I feel my staff is uninformed about current biological diversity issues and research within my park.	19	66	50	69	12

Table 2 cont.

Mean Score	Question	Frequency of Response				
		SA (1)	A (2)	N (3)	D (4)	SD (5)
3.8	I feel biological diversity is too complex for visitors in my park to understand.	5	20	38	111	45
2.973	I feel visitors to my park do not care about biological diversity.	28	59	38	85	12
1.86	I feel visitors should become aware of biological diversity.	70	118	31	1	2
2.57	I feel the biological diversity initiative is a valuable program area for my park.	48	67	52	40	14
3.635	I feel biological diversity is not applicable to my park.	22	25	31	78	66
1.919	I feel the biological diversity initiative is appropriate for fulfilling the NPS mission.	62	126	25	5	3
2.087	I feel that appropriate funding is not available.	70	76	60	10	3

Question IX asked respondents if they would contribute, if requested, materials such as program outlines, photo copies of materials, or photographs to support the biological diversity efforts. Responses are reported in Table 3.

Table 3: Number of parks willing to contribute materials.

Response	Number of Responses
Yes	23
Yes, if time permits and staff is available	150
No	44

Question X sought background data from the respondents. Table 4 shows the number of parks responding by region.

Table 4: Number of parks responding by regions.

Region	Number of Parks Responding
Midwest	25
Rocky Mountain	28
North Atlantic	18
Southwest	28
Western	32
Mid-Atlantic	24
Southeast	35
Pacific Northwest	15
National Capitol Parks	9
Alaska	11

Discussion of Results from Service-wide Response

The data found herein, even though reported as discrete numbers in most cases, should be viewed in terms of relationships and rank ordering. Asking persons to recall specific numbers by topic, over time, is subject to some level of error as is all research that asks respondents to recall events over a relatively long period. The value in these data, however, is to help all persons involved in the biological diversity effort gain a better understanding of how their colleagues perceive the situation and what their perceived needs are.

The data reported by the respondents in this study provide a valuable basis for decision making and have been and will continue to be applied to the biological diversity initiative. In addition to this report a number of specific statistical routines will be conducted to help guide the development of very specialized materials. An additional master's research thesis has been developed utilizing Questions VII and VIII. That thesis will assess attitudes and perception of respondents. The thesis is authored by Kim Palmer at The Ohio State University.

The specific service-wide data provided by respondents serve as a basis for the following discussion. From Question I, it is evident that NPS is actively engaged in biological diversity interpretation. All four major categories — genetic diversity, species diversity, community diversity, and ecosystem diversity — are included in programming as they should be. Gene pool and genetic diversity in a population seem to have less of a thrust than most other categories. Even though those areas are complex to understand and even more complex to interpret, they do serve as the basis for helping the visitor understand biological diversity. A category that scored relatively low is the global concept. Given the linkages that most parks have to migrating birds, global concerns could be expected to be more prominent in NPS programming. Migrating birds and our personal behavior of consuming certain imported products at the expense of decreasing biological diversity can serve as links for interpreting global issues.

Questions asked by park visitors about biological diversity seemed for the most part to be fairly far-ranging. The paucity of questions related to global concepts should be of concern to interpreters.

Responses to Question II indicate that the face-to-face contact in interpreting biological diversity is extremely important. It is of interest to note that visitor desk personnel received almost as many questions as were received at programs. Community and off-site programs appear to play an important role in communicating with NPS clientele.

Question III indicates which biological diversity topics are currently being interpreted and by what means. However, the extent or depth to which they are being interpreted is not known. Question IV identifies where the needs lie. The data have provided the Biological Diversity Interpretive Initiative Task Group and materials developers a clear direction of what is desired. The individual units desires now must be matched with the overall thrust of the agency to ask which of the existing programs plus the desired programs fulfill the needs identified for the total organization.

Question V indicates that packets of materials are the key training need. The Biological Diversity Interpretive Initiative Task Group is seeking to meet that need by publishing an "NPS Communicators Handbook on Biological Diversity." The in-park training, self-study course, and regional skills courses are important items to address. To an extent the self-study course will be partially fulfilled by the handbook, but reading materials such as those distributed by NPS for "Clearing the Air" may be necessary.

Question VI calls for resource materials as the first priority need. Training and funding are second; both may require an outlay of funds beyond those immediately available. The lack of funds make the needs no less important. Of interest in this question is the request for support and clarity from the Washington office; increased communication between the Washington office, regional offices, and the field is desired. Also of interest is the low ranking of 8, the least desired item, for resource information specifically for cultural areas. A greater interest was expected, given that 113 parks, which have primary themes of history and culture, responded.

Questions VII and VIII referred to the attitudes of the staff and the interpretive manager concerning the initiative. The staff's attitude was a perception of the manager. The results indicated that the majority of the parks' staffs agreed that the biological diversity initiative was both appropriate and useful for fulfilling the NPS mission. Most also agreed that if initiatives are proposed, they should be developed by special committees composed of a cross-section of NPS experts and that special materials and support should be coordinated by the Washington and regional offices. Concerning a new initiative each year 51 respondents were in agreement that a new initiative each year should be proposed; 69 respondents were neutral, and 100 respondents opposed the idea.

The managers' attitude questions were categorized into four groups: perceptions of staff interest and needs, perceptions of availability of resource information, perceptions of visitors' interests and needs, and perceptions of managers toward the biological diversity initiative.

Sixty-five percent of these respondents agreed that their park staff should be interpreting biological diversity; only 15% felt their staff should not be interpreting biological diversity. Only 25%, though, felt that their staffs had enough time to develop biological diversity programs, and only 20% of the respondents felt that their staff was large enough to effectively implement the initiative. Likewise, in their perceptions of the availability of resource information, only 22% of the respondents felt that their staff had access to current research on biologi cal diversity within their parks. Over 70% of the respondents agreed that biological diversity was not too complex for the visitors to understand. Nearly one-half of the respondents felt that visitors do care about biological diversity.

Fifty-one percent of the respondents felt that the biological diversity initiative is a valuable program area for their park; 24% of the respondents felt that it was not a valuable program area for their park, and 25% were neutral. While 85% of the respondents agreed that the initiative is appropriate for fulfilling the NPS mission, 67% felt that appropriate funding was not available to implement the program, and 27% were unsure about the status of funding.

Questions IX and X are self explanatory; data are shown in Tables 3 and 4.

Results of Regional Response

Select data for each region was tabulated. Those data are intended for comparison of region to service-wide data and not for region to region comparison due to the differences in regions. Even when comparing individual regional data to service-wide data regions should consider how closely their region's mission, primary resources, and themes are representative of the total service. Those who are interested in the region responses are directed to the Division of Interpretation (WASO) or to the Regional Chiefs of Interpretation for a full report entitled "Report on Interpreting Biological Diversity in the National Park System" by Mullins, Fortner and Palmer (April 1989).

Results of U.S. National Parks with MAB Designations

Twenty-two of the U.S. National Parks with Unesco/Man and the Biosphere (MAB) status participated in this survey. Select data are summarized in this section.

MAB programming data from Question I indicated that a relative range of 20% to 40% more MAB parks had programs concerning each of the 24 biodiversity categories than was found for the service-wide norm.

MAB parks had a higher relative level of questions from the public about biological diversity topics when compared to service-wide figures. Personal interpretation, in the MAB parks, was the primary reason for questions.

Training needs requested by MAB parks are as follows, with the fist listing the most desired and the last listing the lowest priority: packets of materials, in-park staff training, regional skills, team courses, self study courses, courses at NPS training centers, and video tape.

Discussion of Results for U.S. National Parks with MAB Designation

If response is an indication of interest in the topic, MAB parks exhibited an overwhelming interest, with 88% of their surveyed parks responding. Comparison between the service-wide data and MAB data indicates that for most biodiversity topics a much higher percentage of MAB parks are interpreting biological diversity than is the service-wide norm.

MAB parks had a much higher relative percentage of their parks reporting questions from the public about the different biological diversity topics than was reported in the service-wide figures.

MAB parks chose packets of information as their primary technique for training, with in-park staff training as the next most popular method of gaining a greater insight into biological diversity. Regional skills training courses were the third choice, with a self study course listed as number four. The same four items occupied the top four preferences in the service-wide response.

Resource materials were the most useful support for interpreting biological diversity according to the 22 MAB parks that responded. Resource materials were the top choice in the service-wide tabulations as well as for each region. MAB parks requested funding as their second support item and training as their third. Training and funding occupied the number two and three preference, respectively, for service-wide data. The number four item ranked by MAB parks, travelling exhibits, was chosen as the sixth most desired support service-wide.

Overall, MAB parks are somewhat different from the service-wide norm. Special considerations may be necessary.

Results by Primary Resource

Parks were divided by primary resource — natural, recreational, cultural, historical — and select data were analyzed by primary resource. This section provides tabular data to assist NPS personnel with understanding the role various primary resource parks are playing. The number of parks reporting by their primary resource was: natural (n=97), recreational (n=15), cultural (n=27), historical (n=86).

Biological Diversity Programming. Data collected through Question I of the survey, concerning the extent of biological diversity programming by primary resource, are reported in Table 5.

Questions Relating to Biological Diversity. Table 6 presents topics of questions by primary resource type parks where the questions are being asked. Numbers within the table are the number of parks reporting having questions asked "sometimes" or "frequently" about the topic/category.

Location or Medium of Question. Question II in the survey sought the location where or medium through which questions were being asked concerning biological diversity. Table 7 presents those data by primary resource parks.

Training Needs. Table 8 lists the expressed training needs of parks by primary resource.

Desired Support. Table 9 lists the number of parks by primary resource desiring a specific type of support for the service-wide biological diversity initiative. A rank order within each column (primary resource) is provided in parentheses.

Discussion of Results by Primary Resource

The number of programs presented in all primary resources categories varied greatly (see Table 5). As would be expected, the natural category had a far higher number of programs than did the other three categories. Although the numbers of topics presented seem large in some categories there would appear to be opportunity for inclusion of more biological diversity messages in all primary resource categories. With inclusion of more biological diversity messages in existing and new programming, an accompanying increase in questions would be expected. Table 6 points out that questions from the public are limited to nil under many topics and primary resource categories. If visitors do not come with biological diversity questions, NPS communicators should encourage questions through inclusion of biological diversity messages. Table 7 indicates that interpretive programs and visitor desks are the primary locations for receiving questions.

Packets of information and self-study were the most desired training for all categories except in the recreational category, which voiced a stronger need for in-park training than for self-study (see Table 8). Given that many recreational parks have a strong natural resource management program, specialized in-park training should be considered.

Resource materials and funding, as shown in Table 9, tended to be the top choices of support desired by all primary resources categories except recreational, which chose resource information for cultural areas as their second choice. Special attention should be paid to the needs of recreational areas.

Table 5: Programs currently being implemented by primary resource

Category/Topic	Primary Resource/Number of Parks natural n(%)	rec. n(%)	cult. n(%)	historic. n(%)
Genetic Diversity				
Gene pools	47(49)	3(21)	11(41)	4(5)
Ecological community	81(84)	11(79)	27(100)	15(17)
Genetic diversity within a population	39(41)	0(0)	9(33)	5(6)
Species Diversity				
Ethical issues	52(54)	8(57)	15(56)	5(6)
Intensive management of select species	56(58)	6(43)	16(59)	7(8)
Charismatic species	66(69)	8(57)	26(98)	10(12)
Economically important species	47(49)	2(14)	21(78)	7(8)
Impact of consumer behavior	45(47)	7(50)	12(44)	7(8)
Origin of crop species	12(13)	0(0)	18(67)	9(11)
Medically important species	44(46)	7(50)	22(81)	14(16)
Edible plants and animals	81(84)	10(71)	26(98)	21(25)
Keystone species	36(38)	3(21)	14(52)	3(4)
Native versus exotic species	85(88)	11(79)	17(63)	27(32)
Extinct species	49(51)	4(29)	13(48)	7(8)
Extirpated of species	46(48)	4(29)	10(37)	5(6)
Socioculturally significant species	59(62)	10(71)	18(67)	14(16)
Endangered or threatened species	76(79)	13(93)	22(81)	14(16)
Community Diversity				
Natural communities unmodified by human behavior	68(71)	7(50)	19(20)	9(11)
Ecological processes	73(76)	8(57)	22(81)	12(14)
Biological diversity at the community level	48(50)	2(14)	13(48)	5(6)
Ecosystem Diversity				
Biological diversity as a global concept	34(36)	3(21)	7(26)	0(0)
Conservation versus preservation of natural resources	94(98)	10(71)	17(63)	15(17)
Evolutionary processes	41(43)	2(14)	11(41)	2(3)
Restoration of ecosystem	80(83)	9(64)	14(52)	12(14)

Table 6:Topics of questions by primary resource.

Category/Topic	Primary Resource/Number of Parks natural (n)	rec. (n)	cult. (n)	historic. (n)
Genetic Diversity				
Gene pools	29	9	35	15
Ecological communities	72	8	22	15
Genetic diversity within a population	14	4	0	5
Species Diversity				
Ethical issues	47	7	6	5
Intensive management of select species	57	4	10	7
Charismatic species	74	9	22	13
Economically important species	44	8	16	8
Impact of consumer behavior	32	6	5	5
Origin of crop species	11	0	16	11
Medically important species	27	2	13	10
Edible plants and animals	45	12	63	20
Keystone species	23	4	4	2
Native versus exotic species	54	8	18	13
Extinct species	13	4	6	10
Extirpation of species	34	4	3	4
Socioculturally significant species	62	10	22	16
Endangered or threatened species	74	11	12	13
Community Diversity				
Natural communities unmodified by human activities	5	4	13	4
Ecological processes	57	5	20	4
Biological diversity at the community level	26	1	4	2
Ecosystem Diversity				
Biological diversity as a global concept	10	2	2	0
Conservation versus preservation of natural resources	61	9	34	12
Evolutionary processes	27	3	3	2
Restoration of ecosystems	54	7	20	4

*number of parks represent those parks that report having "sometimes" or "frequently" asked questions about the listed category or topic relating to biological diversity.

Table 7: Location or medium for biological diversity questions by primary resource.

Location or Medium		Primary Resource/Number of Parks natural (n)	rec. (n)	cult. (n)	historic. (n)
Genetic Diversity					
Interpretive programs	1*	3	0	25	3
	2*	20	7	26	10
	3*	65	5	17	10
	w(rank)**	238(1)	29(1)	128(2)	53(2)
Visitor desk	1	15	4	18	4
	2	41	8	28	7
	3	37	1	26	13
	w(rank)	208(2)	23(4)	152(1)	57(1)
Roving interpretation	1	21	5	21	4
	2	47	8	34	15
	3	19	0	11	6
	w(rank)	172(3)	21(6)	122(3)	52(3)
Environmental education program	1	13	4	31	7
	2	32	4	10	6
	3	28	5	10	3
	w(rank)	161(4)	27(3)	81(4.5)	28(6)
Off-site programs	1	32	4	35	12
	2	29	6	17	7
	3	20	4	4	1
	w(rank)	150(5)	28(2)	81(4.5)	29(5)
Telephone inquiries	1	63	8	35	14
	2	19	4	12	4
	3	1	2	0	0
	w(rank)	104(7)	22(5)	59(7)	22(7)
Written inquiries	1	45	10	45	18
	2	36	2	13	6
	3	6	1	0	0
	w(rank)	135(6)	17(7)	71(6)	30(4)

*1 means rarely a location or medium by a specific category/topic of a question; 2 means sometimes a source and 3 means frequently a source.
**weighted scores (w) are the sum of the products of weights times the number of responses. Rank order (rank) is for each primary resource.

Table 8: Training needs by primary resource.

Training Method	Primary Resource/Number of Parks			
	natural n(rank)*	rec. n(rank)	cult. n(rank)	historic. n(rank)
Packets of information	80(1)	11(1)	67(1)	22(1)
Self-study courses	59(3)	6(5)	44(2)	21(2)
In-park training	61(2)	10(2)	31(4)	11(4)
Regional course	55(4)	8(4)	32(3)	9(4)
Training at Mather/Albright	34(5)	9(3)	23(5)	7(5)
Video tape	7(6)	2(6)	4(7)	2(6)
No training	2(7)	0(7)	7(6)	0(7)

* rank is by primary resource (column).

Table 9:Weighted scores and rank order* of most useful support by primary resource.

Support	Primary Resource/Number of Parks			
	natural w(r)*	rec. w(r)	cult. w(r)	historic. w(r)
Resource materials	207(1)	29(1)	126(1)	55(1)
Training	59(4)	10(3)	47(3)	6(5)
Funding	105(2)	7(4)	74(2)	26(2)
Audio visual materials	0(-)	0(-)	12(7)	5(6)
Handouts, brochures, news releases	6(3)	6(5)	34(4)	23(3)
Traveling exhibits	25(5)	5(6)	31(5)	6(5)
Support and clarity of objectives from Washington	19(6)	7(4)	21(6)	7(4)
Resource information specifically for cultural areas	17(7)	12(2)	11(8)	1(7)

*Weighted scores were derived by assigning weighted values to the first, second and third most useful support desired. Items of a third preference were weighted as one, items of a second preference were weighted as two, and items of a first preference were weighted as three. Weights were summed with the largest weighted score receiving the number one rank. Rankings by primary resource are ranked in column within the parentheses.

Conclusions

A number of conclusions can be drawn from the data. These are presented in four different sections — service-wide, region, MAB parks, and primary resource.

Service-wide

• The National Park Service has numerous interpretive programs and materials that touch upon biological diversity issues. The programs and materials provide a basis for expanding the interpretation of biological diversity.

• Parks report receiving a wide range of questions about topics relating to biological diversity, but given the importance of the issues to NPS, the numbers indicate that the agency is missing opportunities for heightening public awareness about this critical resource management issue.

• Interpretive programs and the visitor desk tend to be the primary sites for visitor questions about biological diversity.

• Parks make extensive use of both personal services and media/materials to convey interpretive messages.

• Parks can make use of and desire a full range of programs, media and materials to support their efforts to interpret biological diversity issues. Materials to assist with personal programs were of greatest demand, followed by nonpersonal services materials and media, outreach program materials and exhibits. Lastly, community/environmental education programming materials were desired.

• Packets of materials, followed by self-study courses and in-park staff training, are the primary modes of desired personnel training.

• The interest of parks in resource materials specifically for cultural and historical primary resource parks and the written comments from cultural parks indicate that some of these areas see little relevance of biological diversity to their themes, goals and objectives.

• Resource materials were considered the most useful support item, followed by training and funding, respectively.

• A new initiative is not desired each year.

• Initiatives should be developed by special committees with a cross section of NPS expertise, and the field should be supported by regions and the Washington office in the form of specially designed programs and materials.

• A majority of park managers feel they do not have the time, funding, or staff to institute a special initiative.

• A majority of park managers feel that biological diversity should be interpreted in their park.

• The consensus was that park personnel do not know as much about biological diversity as they need to and do not have ready access to materials and data.

• According to park managers, park visitors can comprehend biological diversity concepts, are interested in the topic, and should become more aware of the topic.

• Parks are willing to assist with materials gathering.

• The extent to which biological diversity is addressed was perceived as a park-specific perogative in which each park should participate at the level it deemed appropriate to its goals, objectives, and themes.

• Biological diversity interpretation is viewed as appropriate and useful in fulfilling the NPS mission.

Regions

• Regions reflect national trends for the most part.

• Where regions do differ from service-wide norms, special care should be taken by the respective regional offices to meet those needs.

MAB Parks

• MAB parks are interpreting a higher percentage of biological diversity topics proportionally than are occurring service-wide.

• MAB parks have special characteristics and needs that require special consideration.

Primary Resource

• Parks with a primary resource of natural have the greatest number of biologicaly diversity programs, both proportionally and literally.

• Questions about biological diversity, even in the more natural parks, are fewer than would be expected.

• Parks with different primary resources may need specialized training, especially recreational resource parks.

Recommendations

Recommendations made by the authors are based on the data found in this report, other NPS reports on this topic, personal interviews, NPS reviewers' feedback, experience with the "Clearing the Air" project, and education and management theory.

• Although the National Park Service is engaged in interpretation of biological diversity issues and does receive a significant number of questions on the topic, the service's effort is minimal and fragmented given the gravity of the problem — the loss of biological diversity nationally and globally. Greater emphasis, coordination, and support for a long term biological diversity interpretive initiative should be considered.

• Parks are functioning on a short-term basis, concerning themselves with funds, personnel, and immediate tasks as opposed to looking at the future and the larger issues and threats to the parks. Biological diversity is rated as an important issue but the pressures of day-to-day issues results in the "we just do not have time to add this new initiative" position. The recognition of the importance of the topic is there; all levels of management and field personnel must plan and work together to address the real issues and threats to parks in a timely manner.

• Personal programming is the primary mechanism for visitor feedback in terms of questioning. More personnel must be trained and made available to the public if NPS is to have a significant impact.

• To fulfill the objectives of a biological diversity initiative, field personnel need materials and in-park training in a timely manner. Materials beyond the "Handbook," and training beyond the 1988-89 critical resource issues courses should be planned.

• Confusion seems to exists over a new initiative each year. NPS should consider simply promoting a new professional education topic each year but not limiting the thrusts to any time span.

• Greater emphasis and coordination at the Washington and regional office levels for the professional education topics are needed. Additional personnel or reallocation of time may be necessary.

• NPS must place additional emphasis on support for increasing the knowledge and capabilities of NPS communicators to more effectively interpret critical resource issues.

• Special effort is needed in the Washington and regional offices to help recreational, historical, and cultural areas more clearly identify their roles in the biological diversity interpretive initiative.

• The level and format of critical resource issues programming should be a park-level decision; standards by which parks are evaluated should assess if the efforts made by the park to interpret the new concepts are adequate given the park's themes, goals, objectives, and resources. This should be a part of the formal evaluation of all appropriate personnel.

• Improved communications concerning forthcoming professional education topics and interpretive thrusts are needed. A two-year lead time should be considered with allocation of funding, establishment of committees and awarding of contracts in support of the topics.

• Regions have, in several cases, special needs and desires. Each region should mount a special effort to provide its personnel with materials and support beyond what is currently proposed. With a two-year lead time there is greater chance of this being accomplished. This report provides a basis for understanding some aspects of regional needs.

• MAB parks, although more extensively involved in biological diversity interpretation than the service-wide norms, should be more heavily engaged in biological diversity interpretation. Special program thrusts among the MAB parks should be considered along with a greater recognition that MAB is the ideal mechanism for increasing public awareness about critical resource issues. Special funding and consideration for the effort in the MAB parks should be considered.

• Parks with different primary resources should be treated as potentially different in terms of their needs associated with special initiatives.

The NPS has the mandate and biological resources with which to address biological diversity. With increased training and support the NPS can develop the capabilities to mount a major interpretive thrust in biological diversity. A parallel program in the protection and maintenance of biological diversity is also required. The tasks are complex; it cannot be an issue for interpreters alone. To truly succeed all units of the NPS and all levels of NPS management must accept the loss of biological diversity as a paramount problem.

A short-term thrust will not solve the problem nor will it significantly change public or political attitudes towards global deterioration of our biological resources. Only an effort mounted over many years with both external and internal biological diversity information transfer will make a difference.

Just as the Yellowstone fires and Mt. St. Helens reawakened a nation to impacts of natural processes, we can utilize current events to demonstrate the importance of ecological processes and the relationship to the maintenance of diversity in nature. Only when our society understands and takes action regarding the interrelationships between polluted air and water, declining forests, loss of biological diversity and an eroding quality of life can the special NPS thrust be brought to an end.

NPS is in the unique position as one of the world's leading conservation agencies to set a precedent by addressing critical resource management issues, publicly and forthrightly. The service has the land resources, mission and professional ethic — the greater world society can afford nothing less than our best effort.

Biological Diversity

OTA Report Brief

Technologies To Maintain Biological Diversity

The Earth's biological diversity is being seriously reduced, and the losses are likely to accelerate over the next several decades. The most optimistic view of the consequences of reduced biological diversity is that resources that otherwise might improve the quality of human life will not be available. At worst, reductions could mean a serious disruption of the ecological processes on which civilization depends. To avert such adverse consequences, the United States needs to strengthen its commitment to global conservation efforts.

In the past, diversity among ecosystems, species, and genes was maintained without specific conservation efforts. But as natural areas continue to be disrupted by human activities, maintaining biological diversity increasingly depends on the development and use of specific conservation measures. Of particular concern are those highly diverse ecosystems such as moist tropical forests, coral reefs, and Mediterranean type environments, with high numbers of unique species.

Two complementary approaches are necessary to conserve biological diversity. One approach, called "onsite maintenance," is to maintain parks and other natural areas to preserve plants and animals in the areas where they occur naturally. The other approach, called "offsite maintenance," is to preserve diversity apart from natural habitats in places such as seed banks or zoos. Onsite maintenance is the best means of maintaining a broad range of biological diversity in the long term. Offsite maintenance is the most economical method for preserving a small but critical component of genetic diversity such as the thousands of plant varieties important to agriculture. As threats to biological diversity increase, greater interaction between the two approaches will be required.

Maintaining global biological diversity will require greater coordination of conservation efforts by the United States and other countries. Several government and private programs in the United States and elsewhere address narrow conservation objectives such as protecting migratory species or genetic resources of importance to agriculture. Generally, these programs are uncoordinated, underfunded, and too narrow to address the biological diversity issue effectively. Furthermore, the ad hoc conservation programs that currently exist do not cover the broad scope of areas that are important to maintaining biological diversity.

To improve knowledge about the extent and rate of loss that is occurring, more emphasis should be placed on the collection of additional data. One of the challenges for the U.S. Congress and other policymakers is to strike a balance between using resources to collect better data on rates of loss and analyze likely consequences on the one hand, and implementing specific conservation efforts to meet known threats on the other.

> **What Is Biological Diversity**
>
> Biological diversity refers to the variety and variability among living organisms and the ecological complexes in which they occur. Diversity can be defined as the number of different items and their relative frequency. For biological diversity, these items range from complete ecosystems to the chemical structures that are the molecular basis of heredity. Thus, the term encompasses different ecosystems, species, and genes, and their relative abundance.
>
> The term also provides a common denominator for various groups concerned with loss of biological entities. Despite the broad range of concerns, the problem to date has been presented almost exclusively in terms of the extinction of species. Although extinction is perhaps the most dramatic aspect of the problem, it is by no means the whole problem.

The ability to maintain diversity will increasingly depend on the availability of useful, affordable technologies and on programs designed to apply these technologies to a broader range of species or ecosystem types. At present, technologies and programs to conserve or enhance biological diversity are limited in their application. The application of science to conservation is a relatively recent event, and a formal discipline in this area is only just emerging. Further progress will depend on promoting and encouraging institutions and researchers to place greater emphasis both on the synthesis of research results and on technology development and transfer in support of resource managers.

The Role of Congress

A range of options is available for Congress to maintain diversity in the United States and throughout the world. They are summarized on the reverse side.

Copies of the OTA report, "Technologies To Maintain Biological Diversity," are available from the U.S. Government Printing Office, Superintendent of Documents, Washington, DC 20402-9325; (202) 783-3238. The GPO stock number is 052-003-01058-5; the price is $15.00. Copies of the report for congressional use *are available by calling 4-8996. Summaries of reports are available at no charge from the Office of Technology Assessment.*

The Office of Technology Assessment (OTA) is an analytical arm of the U.S. Congress whose basic function is to help legislators anticipate and plan for the positive and negative impacts of technological changes.
Address: OTA, U.S. Congress, Washington, DC 20510-8025. Phone: 202/224-9241. John H. Gibbons, *Director*.

Summary of Policy Issues for Congressional Action Related to Maintenance of Biological Diversity

Issue	Finding	Options
Strengthen national commitment	*Adopt a comprehensive approach to maintaining biological diversity*	Establish a national biological diversity act Prepare a national conservation strategy Amend appropriate legislation of Federal agencies
	Increase public awareness of biological diversity issues	Establish a national conservation education act Amend the International Security and Development Cooperation Act
Increase ability to maintain biological diversity	*Improve research, technology development and application*	Direct National Science Foundation to establish a conservation biology program Establish a national endowment for biological diversity
	Fill gaps and inadequacies in existing programs	Provide sufficient funding for existing maintenance programs Improve link between onsite and offsite programs Establish new programs to fill specific gaps in current efforts
Enhance knowledge base	*Improve data collection, maintenance, and use*	Establish a clearinghouse for biological data Enhance existing natural heritage network of conservation data centers
Support international initiatives	*Provide greater leadership in the international arena*	Increase support of existing international programs Continue oversight hearings of multilateral development banks' activities
	Promote the exchange of genetic resources	Examine U.S. options on international exchange of germplasm Amend the Export Administration Act to affirm U.S. commitment to free exchange of germplasm
Address loss in developing countries	*Amend Foreign Assistance Act*	Adopt broader definition of biological diversity in Foreign Assistance Act
	Enhance capability of the Agency for International Development	Direct AID to adopt strategic approach to diversity conservation Increase AID staffing of personnel with environmental training
	Establish alternative funding sources for biological diversity projects	Create special account for natural resources and the environment Apply more Public Law 480 funds to effort

SOURCE: Office of Technology Assessment, 1987.

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Biological Diversity-Related Legislation

Abstracted by Pamela A. Wright — The Ohio State University

There is currently no legislation directly related to biological diversity, however, 1989 legislation (HR 1268), has been proposed that will relate directly to biological diversity. The Office of Technology Assessment's book, Technologies to Maintain Biological Diversity, *discusses the existing legislation, and international treaties that have some impact on biological diversity in detail. Related legislation is summarized below.*

Federal Mandates

Federal laws primarily govern the protection of species and habitat, *in situ*. Federal laws for *ex situ* maintenance of biological diversity, with the exception of the Endangered Species Act, center primarily on plant species that demonstrate potential economic value. These laws are summarized in Table 1.

— *The Endangered Species Act* prohibits the import and export of species listed as endangered and most species listed as threatened.

— *The Lacey Act* prohibits the import of species that have been taken, possessed, transported, or sold in violation of foreign law. Many countries now completely ban or strictly limit wildlife trade.

— *CITES*, a comprehensive wildlife treaty signed by nearly 100 countries, including the United States, that regulates and in many cases prohibits commercial imports and exports of wild animal and plant species that are threatened or endangered by trade.

— *The Marine Mammal Protection Act* prohibits the import of marine mammals and their parts and products. These species include whales, walruses, narwhals, seals, sea lions, sea otters, and polar bears.

Biological Diversity Bill (HR 1268)

The National Biological Diversity Conservation and Environmental Research Act proposes four major elements; a national policy for the conservation of biological diversity, a national research center, an amendment to the National Environmental Policy Act (NEPA) to make biological diversity an explicit part of environmental impact statements, and a coordinated federal strategy for maintaining and restoring biological diversity.

International Treaties

International laws "govern relations between countries" (OTA) and consequently have varying levels of power. *Hard* laws are those that bind two or more countries in terms of treaties or international law while *soft* laws are those which have little legal binding force but rather may carry persuasive influence. In general, international laws deal only indirectly with biological diversity. Many related laws have broader conservation objectives that are "commonly focused on protection of single species, groups of species, or habitats" (OTA).

Global Conventions

Global conventions, of which five are related to biological diversity, are only partially effective because they are often not

Table 1. Federal Laws Relating to Biological Diversity Maintenance

Common name	Resource affected	U.S. Code
Lacey Act of 1900	wild animals	16U.S.C. 667, 701
Migratory Bird Treaty Act of 1918	wild birds	16U.S.C. 703
Migratory Bird Conservation Act of 1929	wild birds	16U.S.C. 715
Wildlife Restoration Act of 1937 (Pittman-Robertson Act)	wild animals	16U.S.C. 669
Bald Eagle Protection Act of 1940	wild birds	16U.S.C. 668
Whaling Convention Act of 1949	wild animals	16U.S.C. 916
Fish Restoration and Management Act of 1950 (Dingell-Johnson Act)	fisheries	16U.S.C.777
Anadromous Fish Conservation Act of 1965 (Public Law 89-304)	fisheries	16U.S.C. 757
Fur Seal Act of 1966 (Public Law 89-702)	wild animals	16U.S.C.1151
Marine Mammal Protection Act of 1972	wild animals	16U.S.C.1361
Endangered Species Act of 1973 (Public Law 93-205)	wild plants/animals	7 U.S.C. 136 16U.S.C. 460, 668,715, 1362,1371, 1372,1402,1531
Magnuson Fishery Conservation and Management Act of 1977 (Public Law 94-532)	fisheries	16U.S.C. 971, 1362,1801
Whale Conservation and Protection Study Act of 1976 (Public Law 94-532)	wild animals	16U.S.C. 915
Fish and Wildlife Conservation Act of 1980 (Public Law 96-366)	wild animals	16U.S.C.2901
Salmon and Steelhead Conservation and Enhancement Act of 1980(Public Law 96-561)	fisheries	16U.S.C.1823
Fish and Wildlife Coordination Act of 1934	terrestrial/aquatic habitats	16U.S.C.694
Fish and Game Sanctuary Act of 1934	sancturies	16U.S.C.694
Historic Sites, Buildings, and Antiquities Act of 1935	natural landmarks	16U.S.C.461-467
Fish and Wildlife Act of 1956	wildlife sanctuaries	15U.S.C. 713 16U.S.C. 742
Wilderness Act of 1964(Public Law 88-577)	wilderness areas	16U.S.C.1131
National Wildlife Refuge System Administration Act of 1966 (Public Law 91-135)	refuges	16U.S.C.668
Wild and Scenic Rivers Act of 1968 (Public Law 90-542)	river segments	16U.S.C.1271 -1287
Marine Protection, Research and Sanctuaries Act of 1972 (Public Law 92-532)	coastal areas	16U.S.C.1431 -1434 33U.S.C.1401, 1402,1411 -1421,1441-1444

(Federal Laws Continued)

Common name	Resource affected	U.S. Code
Federal Land Policy and Management Act of 1976 (Public Law 94-579)	public domain lands	7U.S.C.1010-1012 16U.S.C. 30U.S.C.50, 40U.S.C.319 43U.S.C.
National Forest Management Act of 1976 (Public Law 94-588)	national forest lands	16U.S.C.472,500,513 515,516,518,521,576 581,1600,1601-1614
Public Rangelands Improvement Act of 1978 (Public Law 95-514)	public domain lands	16U.S.C.1332,1333 43U.S.C.1739, 1751-1753, 1901-1908
Offsite diversity mandates:		
Agricultural Marketing Act of 1946 (Research and Marketing Act)	agricultural plants and animals	5U.S.C.5315 7U.S.C. 16U.S.C. 42U.S.C.3122
Endangered Species Act of 1973 (Public Law 93-205)	wild plants and animals	7U.S.C.136 16U.S.C.460,668,715, 1362,1371,1372,1402, 1531
Forest and Rangeland Renewable Resources Act of 1978 (Public Law 95-307)	tree germplasm	16U.S.C.1641-1647

SOURCE: Adapted from Office of Technology Assessment, 1986.

Table 2. International Treaties and Conventions (On-site Maintenance)

Title	Established	U.S. signed
Global conventions		
Convention on Wetlands of International Importance Especially as Waterfowl Habitat	1971	pending
Convention Concerning the Protection of the World Cultural and Natural Heritage	1972	1973
Convention on International Trade in Endangered Species of Wild Fauna and Flora	1973	1975
Convention on the Conservation of Migratory Species of Wild Animals	1979	
Convention on the Law of the Sea	1982	not signed
Regional conventions		
Convention on Nature Protection and Wildlife Preservation in the Western Hemisphere	1940	1942
African Convention on the Conservation of Natural and Natural Resources	1968	NA
Convention on the Conservation of European Wildlife and Natural Habitats	1979	NA
Convention on the Conservation of Antarctic Marine Living Resources	1980	1982
ASEAN Agreement on the Conservation of Nature and Natural Resources	1985	NA
Convention for the Protection of Mediterranean Seas Against Pollution	1976	NA
Kuwait Regional Convention for Cooperation on Protection of Marine Environment and Pollution	1978	NA
Convention for Cooperation in the Protection and Development of the Marine and Coastal Environment of the West and Central African Regions	1981	NA
Convention for the Protection of Marine Environment and Coastal Areas of Southeast Pacific	1981	NA
Convention for the Conservation of Red Sea and Gulf of Aden Environment	1982	
Convention for Protection and Development of Marine Resources of the Wider Caribbean Region	1983	1983
Convention for Protection and Development of the Natural Resources and Environment of the South Pacific Region	1985	pending
Species-oriented treaties		
Birds		
Convention for the Protection of Birds Useful to Agriculture (Europe)	1905	NA
Convention for the Protection of Migratory Birds (Canada/U.S.A.)	1916	1916

(International Laws Continued)

Title	Established	U.S. signed
Convention for the Protection of Migratory Birds and Game Animals (Mexico/U.S.A.)	1936	1936
International Convention for the Protection of Birds (Europe)	1950	NA
Benelux Convention on the Hunting and Protection of Birds (Europe)	1972	NA
Convention for the Protection of Migratory Birds and Birds in Danger of Extinction and their Environment(Japan/U.S.A.)	1972	1972
Convention for the Protection of Migratory Birds and Birds Under Threat of Extinction and on the Means of ProtectingThem (U.S.S.R./Japan)	1973	NA
Agreement for the Protection of Migratory Birds in Danger of Extinction and Their Environment (Japan/Australia)	1974	NA
Convention Concerning the Conservation of Migratory Birds and Their Environment (U.S.S.R./U.S.A.)	1976	1976
Directive of the Council of the European Economic 1979 Community on the Conservation of Wild Birds (EEC)	NA	
Polar bears		
Agreement on the Conservation of Polar Bears	1973	1976
Seals		
Interim Convention on the Conservation of North Pacific Fur Seals	1957	1957
Agreement on Measures To Regulate Sealing and to Protect Seal Stocks in the Northeastern Part of the Atlantic Ocean	1957	
Agreement on Sealing and the Conservation of Seal Stock in the Northwest Atlantic	1971	
Convention for the Conservation of Antarctic Seals	1972	1978
Vicuna		
Convention for the Conservation of Vicuna	1969	NA
Convention for the Conservation and Management of Vicuna	1979	NA
Agreement Between the Bolivian and Argentinian Governments for the Protection and Conservation of Vicuna	1981	NA
Whale		
Convention for the Regulation of Whaling	1931	1935
International Convention for the Regulation of Whaling Whaling	1946	1948

SOURCE: Adapted from Office of Technology Assessment, 1986.

completely implemented. Some common problems include lack of representation by some countries, inadequate funding to implement the laws, weak compliance incentives, and little enforceable power. Summaries of these laws are taken directly from the OTA report.

— *The Convention on International Trade in Endangered Species of Wild Fauna and Flora* (CITES), established in 1973, controls international trade in wild species of plants and animals listed in the convention appendices as endangered or threatened. As of March 1987, 91 countries were members.

— *The Convention of Wetlands of International Importance Especially as Waterfowl Habitat* (RAMSAR), passed in 1971, established a wetlands network and promotes the wise use of all wetlands with special protection for those on the List of Wetlands of International Importance. As of mid-1985, there were 40 contracting parties to the convention and about 300 wetland sites, covering some 20 million hectares. Once a site is on the list, the party concerned has a legal obligation to conserve the site.

— *The Convention Concerning the Protection of the World Cultural and Natural Heritage*, signed in 1972, established a network of protected areas and provides a permanent legal, administrative, and financial framework for identification and conservation of areas of outstanding cultural and natural importance. It organized a World Heritage Committee, a World Heritage List, a List of World Heritage in Danger, and a World Heritage Fund to help achieve convention goals.

— *The Convention on the Conservation of Migratory Species of Wild Animals* (Bonn Convention), passed in 1979, provides strict protection for migratory species in danger of extinction throughout all or a significant part of their range, and encourages range states to conclude agreements for management of species that would benefit from international cooperation. Fifteen countries were party to the convention as of 1984.

— *The Convention on the Law of the Sea*, adopted in 1982 and yet to come into force, identifies a number of general obligations relevant to conservation. Article 192 imposes an obligation on countries to protect and preserve the marine environment. Coastal countries are obliged to ensure through proper conservation and management measures that living resources in their exclusive economic zones are not endangered by exploitation.

Regional Conventions

Regional conventions have for the most part, "emphasized conservation of habitat through creation of protected areas" (OTA). The major conventions include:

- Convention of Nature Protection and Wildlife Preservation in the Western Hemisphere (1940)
- African Convention on the Conservation of Nature and Natural Resources (1968)
- Convention on the Conservation of European Wildlife and Natural Habitats (1979)
- ASEAN Agreement on the Conservation of Nature and Natural Resources (1985)
- Convention for the Protection and Development of Marine Environment of the Wider Caribbean Region(1983)
- Convention on the Conservation of Antarctic Marine Living Resources (1980)

Declarations and Resolutions (Soft-Laws)

— *Declaration on the Human Environment* (UNEP-UNESCO 1972) addresses conservation of the Earth's biological resources:

"The natural resources of the earth including the air, water, land, flora and fauna, and especially representative samples of natural ecosystems must be safeguarded for the benefit of present and future generations through careful planning or management as appropriate."

— *The World Conservation Strategy* (WCS developed by IUCN, UNEP, WWF, FAO, UNESCO), was launched worldwide in 1980 in 30 countries. It provides broad policy guidelines for determining development priorities to secure sustainable use of renewable resources, and it links conservation and development.

— World Charter for Nature (1982 - UN) includes several principles related to biological diversity.

Other Declarations

— UNESCO *Action Plan for Biosphere Reserves*
— IUCN *Bali Action Plan and Recommendations*
— IUCN *General Assembly Resolutions*

Two other pieces of international law fall underneath a category that relates to off-site maintenance. The International Patent Law resulted in the *International Union for the Protection of New Varieties of Plants* (IUPOV) that deals with the availability of germplasm for plant patenting. The *International Plant Protection Convention* (IPPC) of 1951, discusses rules, actions and procedures of quarantine to prevent entry of pests or pathogens.

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3.0 Informational Papers

Biological Diversity

Interpreting Critical Resource Issues For The Public

By Pamela A. Wright and John W. Hanna — The Ohio State University

"Don't Worry — Be Happy" just doesn't cut it when it comes to acid deposition, global warming, desertification, and loss of biological diversity. As the voices for the ailing environment, we must go beyond traditional interpretation, and jolt our visitors into reality.

William Penn Mott, at the 1986 Conference on Science in the National Parks stated, "It is not enough for us to gather knowledge. It is not even enough for us to apply that knowledge. It is essential that we share our knowledge with the people of the nation and this world."

Incorporating critical resource issue interpretation into your program schedule involves seven major stages: identifying the problem, educating yourself, understanding global relationships, building your own park specific resource base, planning the program, interpreting and evaluating.

Identifying The Problem

Critical natural resource issues spring forth from findings made by scientists and resource managers (Whatley and Sikoryak, 1988). The problems related to biological diversity are numerous: genetic erosion within species, ecosystems and populations caused by an incredible number of processes. These biological diversity related problems do not exist in isolation, however. Each problem is linked to other major problems such as acidic deposition and global warming. Finding the links between issues makes interpretation more holistic.

Education

The most critical stage of interpreting critical resource issues begins with your own basic science education. You, and later the audience, need to have a thorough knowledge of the basic scientific principles and ecological relationships around which the critical issues revolve. A superficial understanding of these principles is not adequate—in order to relate to the audience you must understand. Discoveries and advancements in scientific issues such as these are astounding. While popular books and textbooks may provide general background information on the topic, most factual results will be out of date before you read them. This manual will provide you with that general background information. However, you should refer to the journals and other publications listed in the reference section for further clarification and details. Some good current sources are: BioScience, American Forests, Parks, The Nature Conservancy News and National Wildlife. Also, use members of your local scientific community as sources for information and verify your findings with NPS scientists.

Understand Global Relationships

Interpreting critical resource issues provides us with "opportunities to explore the universal concepts of the diversity of life in the parks' unique stories and to relate how each park's resources are connected with national and global resources" (Spears, 1989). To effectively interpret your park's biological diversity story, you must understand the relationships between that story and what is happening globally. This is where you will establish importance or significance in the visitors' minds.

Building Your Own Park Specific Resource Base

Once you have your issue clearly identified the problem and have built your own personal knowledge base, start the search for resources to help you interpret the issue to the public. Gather all the scientific studies conducted in your park or in a similar park and build a set of park-specific fact and program sheets. Programs developed at other parks are also an excellent source of ideas.

Planning Programs

Planning your critical resource issue program goes beyond the use of regular program principles outlined by Tilden, Sharpe and various others. **Your goal goes beyond entertainment to high impact education**. That is not to say that interpreting critical resource issues cannot be enjoyable, but just enjoyment is not your focus. **Target your message to those who it suits most**. Consider planning programs with heavy content and high involvement for those visitors who already have a thorough understanding of your park environment. Many of these individuals will already be aware of the issue and some of its ramifications. Your programs developed for these individuals cannot therefore be simplistic, they need to be detailed and specific. For the un-initiated, try weaving your issue into a more general program or simply use one or two examples of issue-related material in your program. As the awareness level of these individuals increases, they will be more willing to accept specialized programing on the topic. No matter who your audience is, the concepts you need to present are difficult and may be controversial. To assure understanding, develop a tangible recurring message element or analogy to weave throughout your program. Field test your ideas on other park staff, friends or casually with visitors. For issues that may be controversial, Tweed (1988), provides the following advice. "The interpretation of controversial subjects is not fundamentally different from other interpretive efforts, but special concerns do come into play. The most important of these is the rigorous pursuit of accuracy. Information presented by interpreters should always be accurate, of course, but another level of discretion is required here. This discretion needs to come in at least two forms. The first is the careful collection and presentation of certified facts. The second level of discretion unavoidably appears when the time comes to draw conclusions (and especially value judgements) from the facts presented. The concept here is that interpreters should "plant" problems in visitors minds, and then let the visitors' minds move independently to value-judgement maturity."

Interpreting

"What sets critical natural resource issue interpretation apart from other traditional forms, is that it focuses more extensively on problems and their solutions" (Whatley and Sikoryak, 1988).

From knowledge comes awareness, from awareness comes attitudes, and from attitudes come behavior. Unfortunately, the links between knowledge, awareness attitudes, and behavior are not perfectly correlated. While many of our interpretive programs suggest an action that visitors may take to learn more about a situation or to promote a certain cause, the follow-through by visitors is often minimal. Critical resource issue programs need to be **heavily activity- oriented**. While background material is necessary for understanding, much of the other program content can be communicated best in an applied setting. With a large portion of your program devoted to an actual activity, your program will be more enjoyable and visitors will obtain a feeling of accomplishment. Once inspired with the knowledge that they can make a difference, they will be more likely to perform favorable behaviors.

In Cuyahoga National Recreation Area's Monarch Migration Tagging program, visitors find themselves participating in an international scientific study that illustrates several facets of biological diversity. Visitors temporarily capture the strking orange and black butterflies, then with their fingers gently rub off the iridescent scales in a small patch on the wing. A numbered sticker is placed there, and the monarch released (Spears, 1989).

Evaluating

Consider including pre-assessment, formative and summative evaluation into your interpretive planning process. Two books that are excellent sources for evaluative ideas are Interpretive Views (Machlis, 1986) and On Interpretation (Machlis and Field, 1984) .

Don't worry — be happy! Just get involved in high impact education with heavy activity orientation for results in interpreting critical resource issues for the public.

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Biological Diversity

Informational Papers

Some Interpretive Thoughts on Biological Diversity

By Richard L. Cunningham — National Park Service

Biological diversity is simply the diversity of life and includes species diversity, genetic diversity, and ecosystem diversity.

If you asked the "average" person what he or she thinks of the problem of disappearing species, a typical response may be that it is not very important not important when compared to the "real problems" of nuclear arms, nuclear power, poverty and starving people, overpopulation, the economy, drugs, crime and scandal in government, etc.

The problem of disappearing species is one of the great "sleeper" issues of our time. It also presents us, as interpreters, with one of our greatest challenges and opportunities for park interpretation. We have the chance to ring the "wake-up" bell.

There is one estimate that at least one million species of plants and animals will become extinct by the end of this century. On a worldwide basis, people are daily consuming more foods, more medicines, and using more industrial products that come from wild species of plants and animals. We don't know what new needs will arise in the future from extant species.

Over 1,000 species of animals are currently recognized as under the threat of extinction. This is only a fraction of the multitude of species that have yet to be identified and classified — let alone to be considered as threatened or endangered. Among the plants these could number over a quarter million species. Among the animals, particularly the insects, the total could run into the hundreds of thousands or even the millions of species.

Why should the public be concerned? Why should we save species of animals and plants? To me there are at least four reasons why: (1) other organisms have a right to existence — compassion calls for their preservation; (2) species should be preserved because of their beauty, their symbolic value (i.e., Bald Eagle), or their intrinsic interest; (3) species should be preserved for their actual or potential economic uses; other species provide direct benefits to humans; (4) species are living components of the ecosystems in which they live.

Thus we have four primary arguments for the preservation of species: ethics, esthetics, economics, and ecological. Hopefully, to the already confirmed "conservationist", there is understanding and agreement with the ethical, esthetic, and/or ecological arguments. For the "general public" though, the need for preservation of species comes down to "What's in it for me?"

- ☑ Ethics
- ☑ Esthetics
- ☑ Economics
- ☑ Ecology

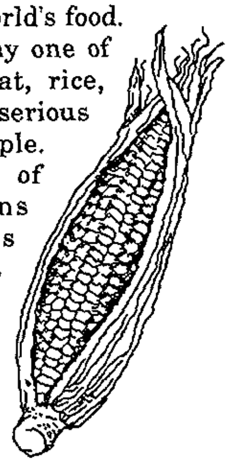
I think the economic or utilitarian reasons for species preservation is the interpretive "hook" by which we can capture the interest of the average person. This is so because this "hook" or argument answers the question "What's in it for me?" or "Why should I care about some plants and animals I've never even heard of?"

I would like to list a few examples of economic or utilitarian values of species. I urge you to add to your personal and park libraries. Two books by Norman Myers —

The Sinking Ark and A Wealth of Wild Species, The Value of Conserving Genetic Resources by Margarey Oldfield and Extinction by Paul and Anne Ehrlich also all contain excellent material on the economic or utilitarian uses of wild species.

Preservation for Agricultural Uses

About 80,000 possible edible plants are known to exist on earth. At one time or another man has used at least 3000 plants for food, but only about 150 of these have ever been cultivated on a large scale. Today less than 20 different plants produce 90% of the world's food. A major disease affecting any one of the four major crops (wheat, rice, corn, potatoes) would have serious implications for many people. Without sufficient stocks of genes from wild strains modern agriculture is threatened by new diseases and resistant insect pests. Wild plants provide original gene resources for revitalizing and improving the strains of food plants we grow.



Preservation for Medical Uses

Plant and animal species offer many benefits to medicine and public health. They contribute to a wide range of drugs and pharmaceuticals, including antibiotics, analgesic pain-killers, anti-leukemia drugs, anticoagulants, etc. About one-half of all prescription drugs in the United States each year contain a drug of natural origin. The United States is dependent upon imported plant materials, especially from tropical forests, needed for medicines.

Alkaloids are an extremely valuable group of drugs, occurring in about 20% of all plant species. Alkaloids include strychnine and narcotics such as morphine, nicotine, and cocaine. Pain-killers, cardiac and respiratory stimulants, blood-pressure boosters, anti-malarials, muscle relaxants and anti-leukemia drugs are all derived from plant alkaloids. Only about two percent of the Earth's 300,000 flowering plants have been tested for alkaloids.

The rosy periwinkle comes originally from Madagascar, an island that has had an incredibly high rate of extinction. Today it is grown in many parts of the tropics and in California as an ornamental plant. A total of 75 alkaloids have been discovered in the rosy periwinkle, two of which are extremely important. Vincristine and vinblastine are developed from the plant stems and leaves. They have led to a breakthrough in the fight against cancer, especially Hodgkin's Disease. Vincristine has become a major treatment for children with acute leukemia. Had the rosy periwinkle been exterminated before 1950 we would have suffered a loss in treating cancer, without even knowing it.

How many other "rosy periwinkles" are now verging on extinction, or have already been lost, that might contain a chemical with even more effective anti-cancer properties. With the continuous advances in medical science, a species considered to be of no value today, may prove to be extremely valuable in the future.

Many animal species also contribute to our medical needs. The study of elephant physiology may shed light on atherosclerosis. Desert pupfish show remarkable tolerances to extremes of temperature and salinity, a condition that could aid research on human kidney disease. Armadillos may eventually hold the key to a cure for leprosy; it is the only animal other than humans to contract the disease. The blue blood of horseshoe crabs contains a chemical extract which clots upon contact with endotoxins. This extract is used for diagnosis of spinal meningitis, bubonic plague, and Legionnaire's Disease. Yet millions of horseshoe crabs have been killed by commercial fishermen, or by pollution, or for fertilizer and chicken feed. Horseshoe crabs have not yet been bred in captivity and must be harvested from wild populations. Caribbean sea squirts are undergoing clinical tests for a chemical with antitumor potential.

Preservation of species for industrial and other uses (such as bee's honey used to monitor air pollution for heavy metals) are further subjects you may wish to investigate. At Organ Pipe Cactus National Monument bee's honey is being studies for accumulation of pesticides.

There is another important reason for the preservation of biological diversity. This could be called "ecosystem services." Examples would include the production of oxygen; the maintenance of the chemical composition of the atmosphere; the natural self-cleansing of water; the critical action of decomposers; the role of ecosystems in watershed storage, prevention of flooding and soil erosion; and climate modification. In other words, ecosystems and their component organisms maintain the habitability of the earth.

It has been stated that our knowledge of biological systems is so superficial that there is not a single species for which it can be said with complete confidence that we know it in its entirety. We simply do not know enough to dismiss any species as having absolutely no value at all. Fungi, mites, and other soil organisms may well be more ecologically important than such more visible species as birds, butterflies, and deer. Therefore we should be preserving as many species as possible, regardless of how insignificant they may seem to be.

Present scientific thinking sees the best solution for biological diversity in the creation of "genetic islands" or gene preserves. These would be natural areas where healthy and diverse species populations of plants and animals could be maintained. Areas such as national parks may be the saving grace for biological diversity, now and especially in the future.

Interpretation of biological diversity offers us a unique opportunity to provide the personal "hook" to the "Why should I care?" crowd. It offers us the opportunity to extend ourselves beyond our park boundaries, beyond our regional and national boundaries, to develop within our visitors an awareness and concern for true global environmental issues that can and will affect each one of us.

Don't let me mislead you into thinking that I place the value of species/ecosystems preservation solely, or most importantly, on the utilitarian or economic aspect. Personally, I feel the ethical aspect — that other species simply have the right to live — as the most important. However, from the interpretive perspective, I do feel the utilitarian/economic aspect is the most effective and dramatic approach and the quickest means to reach the public's heart and mind. It has the greatest potential for an emotional appeal to the individual. From that insight, it is hoped that the awareness of the ethical, esthetic, and ecological reasons will then develop.

When father's high blood pressure, or mother's cancer, or your best friend's kidney disease are all related to treatment by a chemical derivative from a living wild plant or animal, species preservation hits home in a very personal way. Who knows? Perhaps the future cure for cancer or AIDS lies in some currently unknown plant or animal precariously living in the tropical rain forests of Central or South America.

Examples of the importance of biological diversity can be easily interwoven into our already existing interpretive activities. I'm sure you still get questions, as I did when I was in the field, on "What's the value of a mosquito, coyote, weed, tree, etc., etc.?".

Knowledge of the utilitarian and ecological role of organisms will help to answer this question. I encourage you to develop specific interpretive programs on biological diversity, relating them to the significance of your park.

Interpretation of biological diversity certainly ties in with what national parks are all about and what our role as interpreters should be. It gives us an opportunity for communicating global conservation awareness and the values of parks, wherever they are.

The fascination, and challenge of interpretation lies in the opportunities it presents to us. Here, I feel, is a wonderful opportunity for not only interpreting biological diversity and the importance of national parks and ecosystem preservation, but also the opportunity to communicate the concern for life itself.

I urge you to become knowledgeable in this matter. It truly affects each one of us, not just as professional interpreters, but as responsible, caring human beings.

(During the exact time Dick Cunningham was writing this article, totally unknown to him, his father was dying of stomach cancer, 3000 miles away. There was no "miracle cure" for Dick's father. How many potentially life-saving biological resources are we losing for present and future generations? Species preservation does indeed hit home in very personal ways. Dick's father died five days after this article was completed.)

Biological Diversity

Informational Papers

National Parks and The Preservation of Biological Diversity

A Briefing Paper for Interpreters

By Napier Shelton - National Park Service

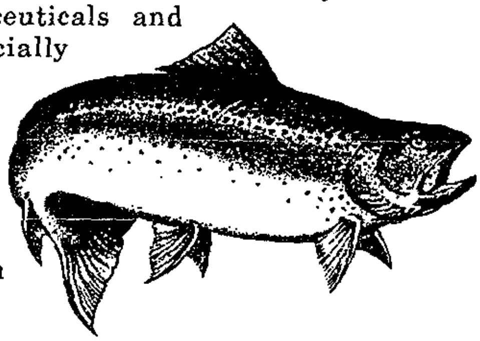
Most Americans think of natural national parks as beautiful places to go for a vacation. This recreational, renewing role of parks is important, of course, but so are other, less appreciated values. One such value is the role of national parks in maintaining the biological diversity of our country—a function that grows more important as undisturbed natural habitat outside protected areas shrinks. This is a message that interpreters should get across to the public, for the sake of parks and the sake of species.

This briefing paper provides background information at global and national scales. You can bring the subject to the level of your own park with local examples, using this material in any way appropriate for your audiences.

Definition of biological diversity. In its broadest sense, the term "biological diversity" includes diversity of ecological communities, of species, and of the genetic variation within species. An ecological community is the group of species characteristic of a given physical setting. A species consists of individual organisms that can interbreed and produce fertile offspring. These in turn may be separated into local populations. Genetic variation, or differences, occurs both within and between different local populations. It is important to conserve genetic variation within a species because this gives individuals of a species a better chance of surviving changes in their environment.

This paper focuses largely on species and the ecological communities, or habitats, within which they live because those are the levels of biological diversity most obvious and best known to the public. But conservation of these ultimately rests on maintaining the genetic resources within species, as well as maintaining the integrity of basic ecological processes.

Why conserve biological diversity? Many, and perhaps most, people who give money to preserve species and their habitats do so because they feel an emotional attachment to wild plants and animals and feel it is morally wrong to allow any species to become extinct through human actions. Many societies have cultural or religious ties to nature. Emotional/moral/cultural reasons for maintaining biological diversity are of course important, but there are practical reasons as well. For one, we have an immense economic dependance on wild species, especially for food, medicine, and industrial uses. This dependance is direct, as with wild plants that are eaten, used as medicine, or supply oils and other products for industrial processes; and it is indirect, as wild species that are used to genetically improve domestic crops or animals or as chemical models for the development of synthetic pharmaceuticals and other commercially valuable compounds. A voluminous literature now documents the economic value of wild species in monetary terms,

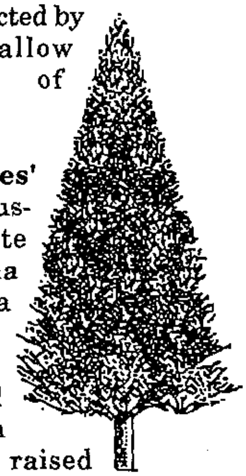


including money spent on recreation involving wildlife.

Biological diversity in the form of ecosystems provides services necessary for keeping the earth habitable. Cleaning of human wastes, maintenance of the atmosphere's chemical composition, protection against soil erosion, and regulation of climates are among these.

The worldwide loss of species and gene pools. No one knows how many species there are in the world. Recent guesses, based on discovery of great numbers of new insect species in the canopies of tropical trees, run to 30 million or more. And no one knows how many species are being lost each year, primarily because most extinctions probably are occurring through destruction of poorly studied tropical forests, with their great species richness and high degree of local endemism. Some scientists think one quarter or more of existing species will be gone by the end of this century. Many populations of remaining species, with their particular genetic resources, will disappear too. With these species and populations will go untold value—economic, ecological, scientific, and spiritual.

Habitat loss is the main cause. While direct human exploitation and other factors are responsible for some loss of species and populations, most is due to destruction or disturbance of habitats. We have replaced vast areas of forest, grassland, and even desert with crops, highways, and settlements, as well as bare ground that won't grow anything. Much of the natural habitat that remains has been altered—by logging, grazing, pollution, and other human impacts. And much of this habitat has been fragmented into island-like patches of various sizes, some of which are too small to support some formerly present species. The value of remaining natural habitat depends on the size and internal character of patches, their degree of isolation from each other, the spatial arrangement of habitat types (since many species need more than one type to live and reproduce), and the degree to which habitat patches are connected by natural corridors that allow movement or migration of individuals and their genes.



Habitat change and species' needs. Species vary tremendously in their ability to tolerate alteration of habitat. Savanna sparrows nest happily in alfalfa fields that replace their original grassland habitat. Mallard ducks can live and breed in city parks as well as on prairie sloughs; pairs have raised young on a small pool in front of the Interior Department in Washington, D.C. for some years now. On the other hand, the Oregon silverspot butterfly, once found at 17 locations in Oregon and Washington, now survives at only three sites on the Oregon coast and one in Washington. It requires meadows, particularly those with western blue violets, for the larval stage and adjacent shrubs or Sitka spruce forests for adult feeding and mating. Housing developments, and plant succession in forest openings due to fire suppression and local elimination of grazing elk, have severely reduced the habitat available for this highly specialized species. Generally speaking, species that need habitats that are very specialized and scarce are much more prone to extinction that are those with broader tolerances.

What are viable population sizes? How many individuals must there be to assure survival of a species? This question cannot be answered precisely for any species, because all the influences on populations cannot be accurately predicted. There is uncertainty due to: (1) random events in the survival and reproduction of individuals; (2) changes in weather, food supply, and other elements of the environment; (3) the unpredictability of natural catastrophes; and

(4) random changes in genetic make-up (Mark Shaffer, see Literature Cited). Furthermore, the question must be asked: minimum viable population size for what period of time, with what degree of security? Are we talking about 100 years or 1000 years? Fifty percent probability of persistence or 95 percent probability?

Despite the uncertainties, a few general conclusions can be made. The more individuals and populations there are of a species, the less likely it is to become extinct. High numbers and multiple populations usually mean more reproducing individuals and more genetic variation. This provides more opportunities for adaptation, less vulnerability to the effects of inbreeding, and less likelihood that all individuals will be killed by an epidemic or other natural calamity. In terms of actual numbers, probably hundreds or thousands are required to maintain most species for 100 years with a high degree of probability of persistence. This assumes, of course, that human threats are removed and only natural factors are operating.

How much area is needed to maintain viable populations? Since habitat is the critical factor in maintaining species and populations, we need to know how much of it is required to keep any species in existence. But since minimum viable population size is only an educated guess, the area requirement is also an educated guess. Generally, large carnivores have the greatest space requirements. Studies cited as examples in Genetics and Conservation (Schonewald-Cox 1983, pp. 423, 424, 427) found the following densities: grizzly bears in Yellowstone National Park, 1 per 4,991 hectares; elephants in Queen Elizabeth National Park, Kenya, 1 per 48 hectares; white-footed mice in Pea Ridge National Military Park, Arkansas, 1 per 0.14 hectare. A demographic unit of the checkerspot butterfly *Euphydryas editha bayensis* monitored from 1960 to 1975 on an area of 0.6 hectare near Stanford University reached a population size of several hundred one year, but also twice went extinct because of climatic influences on food plants (Schonewald-Cox, p. 153). Changing quality of habitat over time thus can have large population effects, as can differences in habitat quality from one place to another.

Returning to the question posed above, we can see that grizzly bears in Yellowstone (180 estimated on 898,350 hectares) are in more danger of extinction that are white-footed mice at Pea Ridge (12,006 estimated on 1,740 hectares), on the basis of population size and reproduction rate.

A large, 20-year project in the Amazon north of Manaus, Brazil, is seeking answers to the question of "minimum critical size" of reserves for tropical forests. Here, the Brazilian government and the World Wildlife Fund-U.S. have arranged to leave islands of forest ranging from 1 to 1000 hectares in an area being cleared for agriculture. Populations of selected organisms, such as beetles, birds, and primates, are measured before and after the forest area becomes an island. It will take much longer to evaluate changes in the larger plots, but already it is evident that the smallest plots lose species rapidly, particularly among mammals, the nonmigratory one, and the edge effect has a negative impact on forest interior species. The small plots, therefore, are almost worthless as reserves. Practical aspects prevent establishment of national park-sized plots, but the study is providing much information on area requirements of smaller organisms and the processes of population loss.

Migratory species have a special problem. They are vulnerable to habitat restriction and alteration at either end of their migration routes as well as along them. Elk migrating to lowland ranches in winter, warblers migrating to ever-shrinking tropical forest areas, and well traveled monarch butterflies in their dense southern wintering clusters are familiar examples. The endangered gray bat of southeastern United States travels up to 200 miles between its summer and winter caves, which must meet very specific temperature and roost requirements. The scarcity of suitable caves for hibernation, restricted feeding ground requirements, sensitivity to human disturbance, and possibly pesticide poisoning have seriously reduced gray bat population levels.

Efforts to halt the loss of biodiversity. Now that we have considered some of the principles governing the maintenance of species and populations, let's get down to the practicalities, especially those that relate to national parks. *In situ* conservation—maintaining species in natural habitats—is generally more effective than *ex situ* conservation—such as storage of plant materials in gene banks, zoo-keeping, and captive breeding. Ex situ conservation complements in situ work and is crucial in some cases, such as captive breeding of California Condors, but it is expensive, impossible for some species, and removes organisms from the evolutionary forces of their environments, which might be changing. Laws governing harvest or protection of individual species may be helpful, depending on the degree of enforcement, but in the end we get back to the matter of habitat. Many species can live in the environments of farms and towns, but many others cannot tolerate such drastic and rapid alteration of their natural habitat. Species like the grizzly bear, red-cockaded woodpecker, and small whorled pogonia will depend more and more on protected areas such as national parks, which provide a wide range of natural habitats where evolutionary change can occur at its own slow pace. Protected areas will be even more critical in the tropics than in the temperate zone, because of the much greater number and higher proportion of rare, specialized species in the tropics.

The worldwide network of protected areas. The International Union for Conservation of Nature and Natural Resources (IUCN) classifies protected areas into ten categories. These range from strictly protected scientific reserves and nature reserves (Category I) that are generally closed to public access, to multiple-use areas (Category VIII) in which the principal objective is sustained yield management of natural resources. Biosphere reserves (Category IX) can contain both a protected core and multiple-use areas. World Heritage Sites (Category X) and, usually, biosphere reserves were designated originally as a national park or other type of protected area. IUCN periodically publishes a list of protected areas by country, but thousands of small areas, such as those maintained by The Nature Conservancy or the National Audubon Society in the United States, are not included.

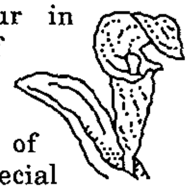
National parks (Category II) are especially important for the maintenance of biological diversity because of their size, number, and degree of protection. IUCN's 1985 list included more than 3,500 areas totaling 4.25 million square kilometers. The majority of those areas are national parks. The world's largest, by far, at 70 million hectares, is Greenland National Park. National parks in the U.S. range from historical areas of less than 100 hectares to Gates of the Arctic National Monument, which covers 3,034426 hectares.

Biodiversity in U.S. National Parks. To what extent does our national park system protect the range of our country's biological diversity? We should try to answer this question at a number of levels of diversity, beginning with ecosystem, species, and population. Unfortunately, the information that is readily available allows only crude approximations.

The best assessment at the ecosystem level for federal lands was developed by overlaying maps of potential natural vegetation by A.W. Kuchler (48 states) and the U.S.D.A. Forest Service (Alaska and Hawaii) and of federal lands by the National Geographic Society (Crumpacker et al. 1988). This showed that of 135 Kuchler vegetation types, 90 (67 percent) were represented in the national park system. This does not, however, cover areas of less than 3,292 hectares, which might raise the percentage covered, not does it consider the actual presence or condition of vegetation types, which would slightly lower the percentage.

At the species level, a data base called NPFLORA has been established to record all vascular plant taxa (including varieties of species) known from units of the national park system with a "natural area" of at least 100 acres. As of the end of 1988, data had been entered for 148 NPS units, representing about 95 percent of the NPS acreage outside Alaska. Of the 23,821 total native plant taxa for North America, Hawaii, and the Caribbean, about 50 percent have been found in the 148 NPS units. With the inclusion of other parks in NPFLORA and increased botanical knowledge of those parks already represented in the data base, the percentage of U.S. taxa found in the national park system should rise somewhat further.

Comparable information for animal species is not yet available. William Newmark, studying species extinctions in western North American national parks (Newmark 1986), determined that 90 percent of all non-exotic, non-flying mammal species whose ranges overlap the Rocky Mountains, Sierra-Cascades, and Colorado Plateau between Jasper National Park to the north (in Canada) and Wupatki National Monument to the south are located within at least one of the 24 national parks and park assemblages he studied in this region. One hundred percent of marsupials (opossum), lagomorphs (hares, rabbits, pikas), carnivores, and artiodactyls (deer, elk, sheep, etc.) found in the region occur in the parks; 89 percent of rodents; and 74 percent of insectivores (shrews, moles). Rodent and insectivore species are more narrowly distributed (occur in fewer parks) than members of the other groups.



Rare or endangered species of plants and animals are of special concern. The National Park Service has conducted a survey of federally listed endangered or threatened species that occur in NPS units. A total of 120 species and subspecies are known to occur in the national park system—24 percent of the 491 that were listed for the United States, including Pacific and Caribbean islands, as of July 1988.

Local population sizes are estimated for some species, usually large mammals, in some parks, but population sizes of most species, and the genetic variability within them, are seldom known. Where a small population of a rare species becomes isolated in a park, such information could be vital for successful management.

Can U.S. parks maintain the species within them? It appears likely from the foregoing analysis that over half of North America's vascular plant taxa and vertebrate species occur in the national park system. It is not so certain that all these species can be maintained in the park system. Increasing encroachment on parks due to adjacent development, restriction of populations because of small park size or narrow shape, and activities within parks all will put pressure on some species. Climatic change due to the greenhouse effect will probably become an important factor in the next century.

The question boils down to whether species' populations can remain high enough to maintain adequate genetic variation and to withstand natural catastrophes, normal population fluctuations, and human influences. This question in turn is closely tied to the matter of park size and habitats available in parks.

Populations in parks, as elsewhere, are generally lowest for carnivores (both large and small) and species with highly specialized food or habitat requirements. Carnivore populations are normally low because their food sources are widely dispersed and often not easily obtained; recall the estimate of 180 grizzly bears in Yellowstone. The endangered red-cockaded woodpecker of southeastern United States is scarce because of its need for large stands of old pines. Each breeding pair, often assisted by male offspring from previous years, nests and forages in an area of some 100 to 2450 acres which it defends from other such "clans." Modern forestry practices and hardwood growth resulting from fire suppression have greatly reduced this species' habitat. Big Cypress National Preserve has about 24 clans. Great Smoky Mountains National Park, with much less old-pine habitat, has just a few clans.

Habitat within a park may be fragmented by natural features such as rivers, canyons, or mountain ranges, or by human developments such as roads and buildings. These barriers may stop movement of some species, thus creating isolated, possibly small populations. A park's fire policy can have a significant effect on the amount and distribution of early successional vegetation, thus influencing the population size of species dependent on this type of habitat.

The Park Service has, for much of its history, mostly followed a hands-off policy with respect to species and ecosystem management, letting nature take its course. But in recent years there has been a trend toward more active management. Most notable has been the institution in some parks of prescribed burns to restore earlier vegetation and fuel conditions, although natural fires are also allowed to help achieve this under certain conditions. In some midwestern parks, prairie restoration is underway. Species management is exemplified by restoration of extirpated species, such as the ruffed grouse at Buffalo National River, and the removal of exotic species, such as feral goats in the Hawaiian national parks. New steps are being taken to aid endangered species. Attempts are being made to reestablish breeding peregrine falcons by "hacking"—human raising of young birds in wild settings by special methods—at Rocky Mountain National Park and elsewhere. Understory hardwoods in pine stands at red-cockaded woodpecker colonies are being removed by prescribed burning in Big Cypress and by hand-cutting around nest trees in the Great Smokies. Nesting sea turtles at Canaveral, Cape Lookout, Cape Hatteras, and other places are being assisted by screening of nest sites from predators or by other protection. As more is learned about endangered species in our national parks, we can expect more management on their behalf. Where a population of any species of concern has become dangerously small, introduction of new stock, perhaps with more genetic variety, may be attempted.

Such activities are further prompted by the fact that our parks have lost species. William Newmark (1986) analyzed the lagomorph, carnivore, and artiodactyl faunas of 24 western North American parks and park assemblages. He found that, among the 14 parks that had adequate records at the time of establishment, all but two had lost species, although three parks had also gained one species. Subsequent, more intensive checking of records of parks and adjacent national forests has shown that some of these "lost" species are still present in the park or very nearby, but the fact remains that losses do occur.

U.S. national parks and national efforts to maintain biodiversity. With only 3 percent of the total United States, NPS units obviously cannot do the whole job of maintaining the nation's biological diversity. Nor were they intended to. Fortunately, there are numerous other public and private areas that can contribute to this goal.

National Forests and National Grasslands, administered by the Forest Service, comprise 10 percent of the total U.S. area. These lands are primarily in mountainous parts of the West, with smaller areas in the East and coastal Alaska. The Multiple Use Sustained Yield Act of 1960 required the Forest Service to manage its lands for outdoor recreation, range, watershed protection, wildlife, and fish as well as timber. Large Wilderness Areas and smaller Research Natural Areas are maintained in a nearly pristine state, but much wildlife also can live in sections managed for time production. Numerous laws, especially the National Forest Management Act, passed in 1976, set standards for maintaining biological diversity in the national forests. Policy regarding timber cutting in old-growth forests is of special concern to conservationists, as many species are restricted to such habitats. The National Forest System has samples of 73 percent of the Kuchler U.S. vegetation types, according to the Crumpacker study mentioned earlier.

Public lands managed by the Bureau of Land Management constitute more than 12 percent of the total U.S. area. Located primarily in the western states and Alaska, this jurisdiction consists of public domain not claimed by homesteaders or converted to national forests, national parks, or other federal designation. Much of it is dry, and 97 percent of the area in the lower 48 states is classified as rangeland. Besides grazing, the land is managed under a multiple use concept for minerals, timber, wildlife, and recreation. A very small part of BLM's 300 million acres has been designated as wilderness, but 25 million additional acres were under study in 1985. Special management attention is accorded Areas of Critical Environmental Concern; by the end of FY85, 1.75 million acres had been placed in this category. Some 80 federally listed threatened or endangered plant and animal species have been found on BLM land, and, when the large additional public or private areas on which BLM supervises mineral operations are included, 109 species (70 animal, 39 plant) had been identified by the end of FY85. Although grazing dominates BLM concerns, the agency conducts numerous wildlife programs, and its vast acreage of desert, grassland, forest, and tundra constitutes an important bank for genetic resources and biological diversity. BLM lands represent 53 percent of the Kuchler vegetation types.

The Fish and Wildlife Service's National Wildlife Refuge System, with more than 430 units totaling nearly 90 million acres, represents another 3.4 percent of the United States. Although 85 percent of this land and water is in Alaska, the System is ecologically fairly diverse, with units throughout the country. It includes areas representing 47 percent of the Kuchler vegetation types. Managed primarily for production and conservation of fish and wildlife, especially migratory waterfowl, the national wildlife refuges harbor more than 220 species of mammals (nearly two-thirds of those recorded in the U.S.), 600 species of birds (over half of the U.S. total), 250 species of reptiles and amphibians (two-fifths of the U.S. total), and 200 species of fish (about one tenth of the U.S. total).

When Department of Defense lands (another 25 million acres, with 40 percent of the Kuchler vegetation types, Indian Lands (47 percent of the Kuchler types), state lands receiving some protection, such as forests and parks, and private reserves, such as Nature Conservancy and National Audubon Society sanctuaries, are added, you can see that a sizeable proportion of the country—more than one third, in fact—is under management that can contribute significantly to the maintenance of biological diversity. The major constraints on effectiveness of these lands, other than management priorities for consumptive uses on much of the area, are their distribution (heavily western) and the size of individual areas and habitat patches within these. The total amount of habitat might be sufficient to maintain a given species, but its spatial arrangement might doom many species to eventual extinction through fragmentation of local populations.

For this reason natural corridors become important. By linking habitat patches, thus allowing the movement or migration of plants, animals, and their genes, corridors in effect enlarge the size of patches. Brushy fence rows on a small scale, and forested riparian strips on a larger scale, are two important types of corridors. Information on use of natural corridors by individual species is limited, however; this is an interesting research opportunity. (See Harris 1985 for a proposed plan for natural corridors in Florida).

Cooperation between adjacent blocks of public or private areas that maintain natural habitat also can increase the value of each for biodiversity. A frequently cited example is the Greater Yellowstone Region, which consists largely of Yellowstone and Grand Teton national parks and several surrounding national forests. The area within Yellowstone NP may turn out to be too small to maintain a viable population of grizzly bears, for instance, but the Region might be sufficient if managed partly for this purpose, which it is. Other species, such as migratory elk, would benefit too. Biosphere reserves, such as Yellowstone, emphasize this kind of cooperation and thus are especially important for maintaining biological diversity.

Cooperation between widely separated areas, including the United States and other countries, is required for many migratory species. A particularly difficult problem exists for bird species that winter in Latin American forests, especially the rapidly disappearing forests of Central America. Some species, such as wood warblers adapted to the forest interior, are likely to suffer severe declines.

Thus far, we have no national plan for maintaining biological diversity in the United States. Several types of inventories of species and/or natural communities are underway, however. The Natural Heritage Program, a cooperative venture between The Nature Conservancy and individual states, inventories and records by location rare and uncommon species of plants and animals. As of December 1988, every state except Alaska was in this program. Now The Nature Conservancy is integrating data from all these states to establish a national inventory and rank species and natural communities by the degree to which they are in danger of extinction.

The U.S. Fish and Wildlife Service's (USFWS) Endangered Species Program identifies and officially lists species that are endangered or threatened and develops "recovery plans" for their rescue. The Service's annual Breeding Bird Survey, conducted by volunteers, both amateur and professional, detects trends in populations of a large part of the U.S. bird fauna. The USFWS also surveys colonial water bird colonies and shorebirds. State breeding bird atlases, completed or underway in many states, further document bird distribution and abundance.

The National Park Service is administering a project of the Man and the Biosphere Program to inventory all protected areas larger than 5,000 acres in the United States, recording for each its ecological community types and management practices. This too will help us know where our country stands with regard to protection of biological diversity. When we know where we stand, we can take steps to get where we ought to be.

You the interpreter, by sharing with park visitors your concern for and knowledge of the condition of living things, can help ensure that all species will have a chance, not only in American but throughout the world.

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Integrating Biological Diversity into Cultural and Historical Interpretation

By Gary W. Mullins and Pamela A. Wright—The Ohio State University

Biological diversity interpretation is a needed, useful and applicable to the National Park Service mission, but is it a concept more appropriate at natural resource parks? Is it really appropriate for cultural and historical resource based parks?

Interpreting biological diversity is really interpreting all of the parts of the biosphere and how they fit together—at the genetic, species, community and ecosystem levels. When we walk through an historical interpretive site or present a cultural program, almost every concept we interpret and every item we use is directly linked to the living world. Making the link is the challenge!

A favorite environmental education activity for fifth grade students is to analyze the contents of a peanut butter and jelly sandwich. The students are asked to draw a mural depicting the evolution of that sandwich starting with sunlight. Murals often get pretty complex when trying to graphically illustrate these linkages. When walking through a Lewis and Clark exhibit or visiting their winter fort, does the visitor make all of the linkages in their mind? Are they trying to draw a mental mural? Can the interpreter facilitate the visitor's learning not only of what happened historically at that site, but how did the coming of a new culture change the Pacific-Northwest region forever? How did species composition change? How were the various ecological communities impacted? Can that ecosystem of then be compared to the present day ecosystem?

Certainly the oil spill in Valdez Alaska in the spring of 1989 and the 1988 Yellowstone fires are events which tie our culture and our biologically diverse environment together. These big ticket interpretive items continue to be interpreted in such a manner as to broaden our various publics awareness of, and actions relating to, biological diversity. Perhaps what is more difficult is how to incorporate the biological diversity messages of an 1800's seed bank at an historical site into the themes, goals, and objectives of that site.

May Watts book, Reading the Landscape: An Adventure in Ecology, chronicles an old prairie plowing match,an event that may have taken place on any number of our mid-west historic sites, illustrating the influence of our natural biological diversity on our cultural and historical resources.

We had time to inspect the new marker while the plowmen were having their "drawing for lands."
"This, to me, is Illinois," rolled out a seasoned voice beside me, and I turned to see one of our local politicians making an inclusive gesture with his cigar.
My eyes followed the arc of his gesture.
"Illinois? Just exactly where?" I wondered.
Not the granite marker. That was Vermont.
Not the expensive evergreen planing that had been hastily installed. Than consisted of Mugo pine from the mountains of Switzerland.
Not the big basket of garden flowers set at the base of the marker. The flowers were marigolds and zinnias and dahlias, whose

ancestors all came to us from Mexico, by way of Europe...
Not the sparrow that alighted long enough to mark the marker. He was English.
Not the freshly clipped grass at our feet. That was bluegrass from Eurasia.
Not the weeds in the grass... chiefly dandelions and plantain... both from Europe...

The messages are there. The links can be made. The underlying question seems to be: To what extent do I, the interpreter, make the links? What do I leave out if I include biological diversity? and, Does this biological diversity message dilute the cultural and historical story the park was established to tell?

Perhaps this set of question' is no different than the set of questions that surround every interpretive park, each program, and each type of media. Usually, the specific themes, goals, and objectives are established under a superordinate set of NPS themes, goals and objectives. Interpreters and their supervisors are left to utilize their professional judgment on how to best format the message.

When the illegal removal of cacti from the desert Southwest and air pollution impacts the giant Saguaro cacti, what is the impact on interpreting the Native American past and present of the Southwest. What is the impact of a radically altered greater Everglades when we are trying to tell the stories of the Native Americans of the Southeast. Does the decline of native rubber tappers in South America have a role in the story of Thomas Edison or the rubber industry in the United States. The answer is unequivocally, yes.

Historical and cultural areas, with all of their tangible objects and with the ease with which we humans of the present can relate to our ancestors, are in an excellent position to foster the interpretation of biological diversity. Historical and cultural interpretation is housed in environmental imperatives. The bottom line is, will we only interpret the house or, will we go the next step and help the visitors understand the foundation of the story. Perhaps more importantly, will we help the visitors understand the environmental foundation upon which our future history is to be built — a foundation that each of us has a hand in building. As we help the visitor fully comprehend the past we can also help them understand their options in influencing the future.

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"Global Linkages and Biological Diversity"

By Richard L. Cunningham — National Park Service

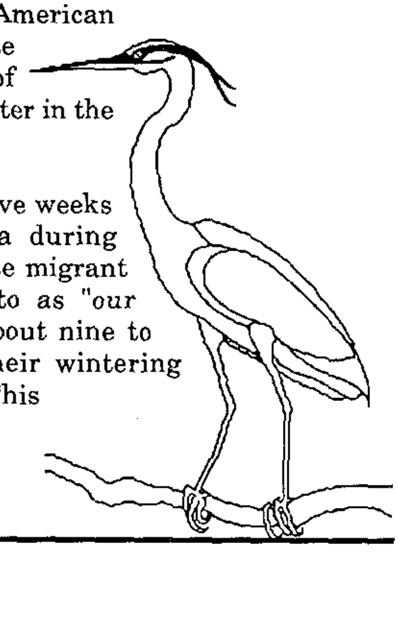
> *"It was a spring without voices. On the mornings that had once throbbed with the dawn chorus of robins, catbirds, doves, jays, wrens, and scores of other birds there was now no sound; only silence lay over the fields and woods and marsh."*
>
> *(Rachel Carson, Silent Spring, 1962)*

I can recall standing on the boat dock at Fort Jefferson National Monument, in the Dry Tortugas, Florida. It was May 1962. As I looked out across the waters of the Gulf of Mexico I could see a small bird approaching. It was flying barely above the water and mustered up just enough strength to fly up and land on the dock.

The bird was a male Blackpoll Warbler. It was on its northward migration, heading for its northern breeding grounds. Its northern migration is through the West Indies and the Florida peninsula.

The male Blackpoll landed about thirty feet from me. It was obviously exhausted as it immediately closed its eyes and was fast asleep. I walked toward it, taking photographs through my 400 mm telephoto lens. Soon I was so close the telephoto lens was no longer useful. I slowly reached out and touched the warbler with the tip of a finger...no movement. Then I reached down and actually picked up this little feathered migratory machine. It opened a half-cocked eye, which soon closed, and the bird went back to sleep. I set it down on the dock and photographed it from several angles, picking it up and arranging it however I wanted. After resting for some time, the Blackpoll weakly flew to the nearby beach and began foraging for the meager ration of insects occurring on the Dry Tortugas. Later that day I observed a migrating Cattle Egret capture and swallow a male Blackpoll Warbler that was feeding on the beach. Though I'm not positive, I believe it was the same bird that I had held earlier. Thus the perils of migration.

Perhaps as many as 80 percent of the approximately 650 species of birds that breed in North America migrate to at least some degree. Some species may travel only short distances, such as moving from higher to lower elevations. Many other species, such as the Neotropical (New World Tropical) migrants, may travel several hundred to several thousand miles annually. Some 332 (51%) of the 650 North American breeding species migrate beyond the boundaries of the United States and winter in the Neotropics.



Except for the ten to twelve weeks spent in North America during the breeding season, these migrant species (often referred to as "our birds") actually spend about nine to ten months either on their wintering grounds or migrating. This corresponds to almost two-thirds of their lives being spent outside of the

United States and Canada.

Because of their colors, songs, ability to fly, and fascinating habits, birds capture the human imagination and interest. Birds provide an excellent barometer of environmental change. They remind us that change, especially accelerated, unnatural change, can be destructive to all types of life. This is as true for human beings as it is with all the other organisms with which we share this planet. Thus changes in the status of migratory birds provide clues to the quality of earth's environments. They are truly symbols of the diversity of our planet and can as a strong icon fortell the story of global linkages and biological diversity.

Linkages

The loss of breeding, stopover, and wintering habitats offers National Park Service interpreters excellent opportunities for educating the American public about the plight of North American migratory birds. It is fitting and proper that the National Park Service be the primary Federal agency in communicating this critical conservation story.

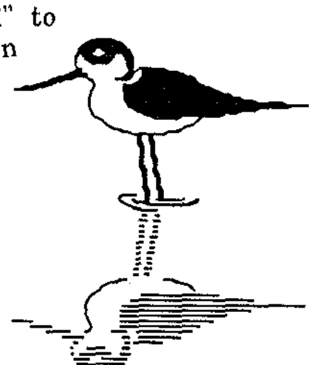
A suggestion was put forth by this author in "North American Migratory Birds and The National Park System: Some Interpretive Thoughts" (Dec. 1988) that a series of "linkage parks" be developed across the National Park System. This technique would link two different National Park sites together. A breeding area park would be linked to a stopover area park. The "linkage" will consist of two representative migrant species that occur in each of the two parks.

The two parks should exchange a few representative slides, a bird checklist, and their park brochures. Each park's interpretive program would not only discuss the significance of their park for habitat preservation for breeding (or for stopover migration) but would also relate the significance of their "linkage park." For example, Great Smoky Mountain National Park and Everglades National Park might chose the black-throated blue warbler and the rose-breasted grosbeak as their linkage birds.

The two representative Neotropical migrants should be interpreted as to such things as: breeding range, breeding biology, food habits, interesting behavioral traits, migratory routes, wintering range and conservation status. This information can be easily compiled from three primary sources: Terres (1980): Ehrlich, Dobkin, and Wheye (1988); and Bent (1919-1968)—see "Selected References."

Fire Island, Assateague Island, and Cape Hatteras National Seashores are three critical stopover areas for many water birds, shorebirds and land birds. All three parks also have a significant variety of breeding species during summer. Fort Jefferson National Monument, in the Dry Tortugas off Florida, is one of the most important migratory stopover areas within the National Park System. Over 280 species of birds, predominately migrants, have been recorded from these isolated islands. These are excellent examples of linkage parks.

Because there are more northern breeding ground parks than there are southern stopover parks, some of the southern parks will have to be "linked" to more than one northern park.



Ecological Ramifications of Loss

Interpreters must focus on the ecological ramification of loss. For example, an important aspect of the migratory bird issue is the role of insectivorous birds in forest ecosystems. Migrant passerines, especially warblers, may be important predators of spruce budworms and other forest insect pests. The role of insect-eating forest birds may be as one of constant suppressors of insect pests rather than actual controllers. Thus birds may be beneficial in suppressing potential outbreaks of insect pests.

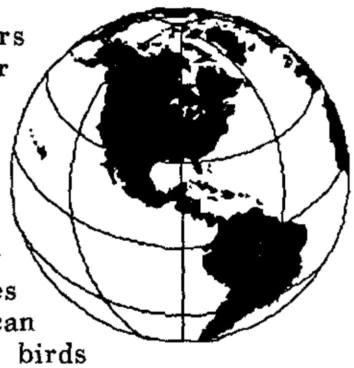
The actual role of individual bird species in forest ecosystems is not well known. Loss of species or continued decimation of populations on breeding grounds could possibly have serious implications for future forest and fire management in the national parks and national forests.

For the interpretive story, emphasis should be placed on how little we really know about the role of migratory birds in forest ecosystems—another example of how we are losing biological resources without understanding the long-term ecological ramifications.

Teaching Geography

Recent public surveys undertaken for the National Geographic Society revealed a poor understanding of geography by the American public. This deficiency included the geography of the United States, North America, the Western Hemisphere, and the rest of the globe in general.

The migratory birds issue offers an exciting opportunity for communicating environmental conservation, bird biology, and geography. By the use of maps or slides of maps, breeding range, migratory routes, and wintering range (in Latin America or Caribbean) can be illustrated. The depiction of "linkage parks" also illustrates geography.



This approach offers exciting possibilities for environmental education activities with local schools. In fact, creative teachers could take this an extra step beyond geography by teaching social sciences about the Latin American countries where these birds winter.

An interesting footnote on history is the relation of migrating birds and Columbus' discovery of the New World. Columbus' log of his first voyage contains many references to birds seen as they approached the Americas. Sunday, October 7, 1492: "God did offer us, however, a small token of comfort: many large flocks of birds flew over, coming from the north and flying to the SW. They were more varied in kind than any we had seen before and they were land birds, either going to sleep ashore or fleeing the winter in the lands whence they came. I know that most of the islands discovered by the Portuguese have been found because of birds. For these reasons I have decided to alter course and turn the prow to the WSW." (Fuson, R.H. 1987. The Log of Christopher Columbus. Camden, Maine: International Marine Publishing Co., p. 71). Columbus changed his course and with it the course of history changed.

Educational Programs and Outreach

Educational programming potentials abound when discussing birds and biological diversity. The following are suggestions for developing both on-site and off-site interpretive/educational activities.

- Give campfire/auditorium slide talks on-site.

• Give off-site slide talks to special interest groups.

• Develop an "Adopt a Migratory Bird" exhibit for visitor center use.

• Develop a special Volunteer in Parks field observer's team for monitoring bird populations in park.

• Write articles on migratory birds issues for local newspaper.

• Write articles for park newspaper.

• Hold a special "Bird Migration Day" at your park featuring talks, bird walks, banding demonstrations by qualified banders, display of bird books, etc.

• Work with local Audubon Society chapters or bird clubs to develop special emphasis activities.

• Conduct USFWS official Breeding Bird Survey.

• Conduct bird walks on a regular basis.

Conclusion

Each interpreter has the opportunity to seize the moment. Biological diversity is a window of opportunity that should not be missed. More importantly, we as conservationists and resource managers can not, on behalf of the greater world community, ignore the opportunity and the need to interpret the loss of diversity in nature.

This paper has stressed that birds and their migration are an excellent link that weaves geographically and culturally throughout the New World. Capturing this natural theme offers tremendous opportunities to communicate. On the other hand, the breadth and depth of the knowledge about biological diversity challenges interpreters to be devoted students of the environment. We must understand in order to help others understand.

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4.0 Fact Sheets

Biological Diversity as a Global Concept

Opening Local Eyes to Global Issues

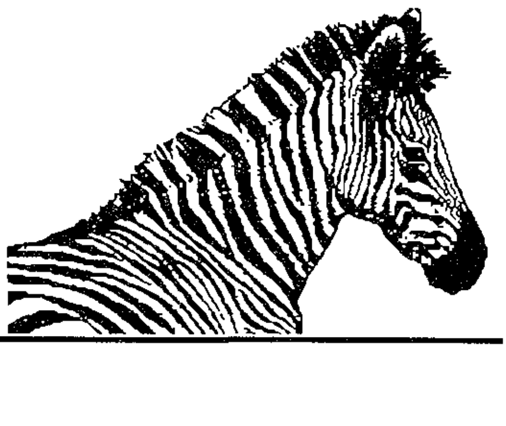
By Kim A. Palmer — The Ohio State University

Interpreters have many avenues available to relate the importance of global biological diversity to visitors' lives. Facts about medically valuable species can relate audiences to the destruction of tropical rainforests, ocean dumping, over-development and erosion. Madagascar's Rosy periwinkle offered us the vinca alkaloids that were eventually our first modern anticancer "wonder drugs"; a Caribbean sea sponge that was a source of the chemical compounds that are now synthesized to produce Ara-C, an anticancer drug, and Ara-A, the antiviral compound most used to fight *Herpes simplex* (veneral herpes), or an Asian butterfly that contains promising anticancer compounds are all examples of how nations and issues thousands of miles away do affect our daily lives. (Oldfield, 1984)

Economically important species such as the rubber trea *(Hevea brasiliensis)* of the Amazonian rainforest that supports the world's natural rubber industry or the wild *Antheraea* silkworm species used by the multi-million dollar Chinese and Indian tasar silk industries can add up to visitor interest in global issues affecting biological diversity. (Oldfield, 1984)

Stories about charismatic species such as the greater panda, grizzly bear, wolf, African elephant and humpback whales can inform visitors about ecological conditions of over-harvesting, habitat destruction, and poaching around the world.

One strategy involves some of our most ubiquitous species: birds. There are not many people who have not seen a bird or do not appreciate these species in some capacity. Familar birds can offer visitors a tropical connection leading to global awareness. The future of the whip-poor-will that provides a wake up call for rural residents, the blue-winged teal favored by many sportsmen, and a number of other species from cuckoos to warblers depends upon the fate of tropical ecosystems of Central and South America. More than 200 of the 650 species of birds that breed in North America migrate southward to spend the winter in the tropics (Steinhart, 1984).



Current estimates of the rate at which tropical forests are destroyed are staggering. Between 25 and 100 acres are being destroyed every minute (Cunningham, 1987). In Colombia alone, 2,000 species of birds, approximately one–fourth of the world's total, are dependent on a forest that is disappearing at the rate of 2 million acres per year (Cumingham, 1987). In addition to this accelerated deforestation, loss of coastal wetlands and estuaries through development along migratory bird flyways threatens shorebirds and some waterfowl (Steinhart, 1984.) The use of DDT by developing nations still threatens migratory birds of prey such as the Peregrine Falcon.

These species are not North American birds "vacationing" in the tropics as many people think. They are an integral part of tropical ecosystems, more likely tropical birds that have extended their ranges north during the breeding season (Steinhart, 1984). Many species have even evolved ecological adaptations to cope with life in two worlds. A tubular tongue has evolved in the Cape May warbler which allows it to take advantage of a fruit diet in the tropics while in its breeding ground in spruce forests of Canada it eats insects, Likewise, Eastern Kingbirds form large flocks and feed on fruit during their winter in the tropics. The Kingbirds lead a solitary life hunting insects during the summer in North America. These bird species as well as many others, now perched precariously on the disappearing tropical forests, will disappear with the forests unless public awareness and action increases.

Deforestation, pesticides, and habitat destruction are not just problems in the tropics of Central and South America. They are part of a worldwide environmental situation that is a disaster in the making. We are all part of both the problem and the solution. As interpreters, we have several effective tools to help open visitors' eyes and increase global awareness.

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Charismatic Species

By Popular Demand

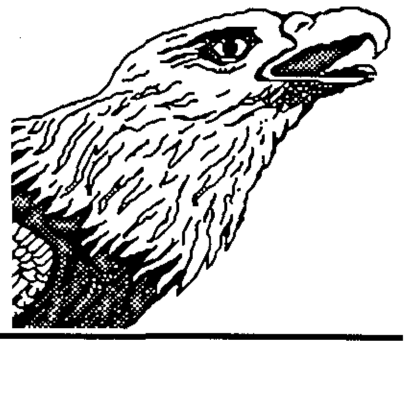
By Kim A. Palmer — The Ohio State University

"Where can we see the bears?" "What time do the whales start showing up?" "How far up the trail do we have to go to see the really big redwoods?" These questions, asked over and over by thousands of visitors to national parks, can easily become a source of great annoyance for any interpreter.

To an avid ecologist or nature enthusiast, this "popular demand" for the exciting big or conspicuous species may seem superficial and even trite. These questions are, however, a reflection of the popular perceptions of our national parks. Unique wildlife and spectacular scenery are drawing cards for millions of national park visitors each year. Charismatic or popular species that everyone would like to photograph or catch a glimpse of can play a valuable role in increasing environmental awareness and conservation within our parks and throughout the world.

A charismatic species is one that is culturally popular. From an educational standpoint, popular plants and animals can be used as the spoonful of sugar to make the environmental message go down. For example, most interpreters giving directions to good wildlife viewing areas also explain to visitors why the areas are important to key species.

As hundreds of Bald Eagles gather along a short stretch of McDonald Creek in Glacier National Park, anxious eagle watchers are reminded of the tenuous relationship between these birds of prey, the salmon and the water quality of the area. Thus the popular bald eagle is acting as an ecological shoe-horn to ease visitors into awareness.



This awareness can often lead to action in conserving critical habitat for non-charismatic as well as charismatic species. As popular species receives legal protection, so too do the less conspicuous and potentially more biologically important species that are part of its community.

Certainly this idea was the impetus for the creation of many of our national parks. Would Sequoia and Kings Canyon National Parks have gained such recognition for preservation had it not been for the charismatic species *Sequioadendron giganteum*, the Giant Sequioa? Another charismatic species, a close relative of the giant sequioa, the Coastal Redwood, caused the preservation flag to be raised for Muir Woods National Monument, Redwood National Park, and a number of state parks along the coast of California. In preserving popular trees, other less well known (flora and fauna) species have also been preserved.

Off the coast of Vancouver Island, British Columbia, killer whales, or orcas, that reside in the area were the charismatic species that halted timber harvesting in a large section of the northern part of the Island. The whales used the shallow waters and a beach in a secluded bay as a "rubbing beach" and a critical resting area. Timber harvesters on Vancouver Island wanted to use that bay as a staging area for the recently cut logs. This would have certainly altered the whales' behavior and could have seriously affected their habitat in an recreational and commercial area. Biologists and other concerned citizens prompted the Canadian government to designate the area a national park.

The national park not only protected the whales, but also the old growth spruce, hemlock and Douglas fir. Since the staging area could not be established in the Park, the timber industry could not economically harvest and transport timber from that particular area.

The old-growth forest in the Pacific Northwest is critical habitat for the Northern Spotted Owl as well as a multitude of other species. The trees themselves are part of the shrinking temperate rainforest of North America. These old-growth trees may also hold the key to our understanding of global climate changes. By studying growth rings of trees hundreds of years old, we may soon learn more about the intricacies of our changing climate.

Throughout the world, popular species designated as endangered or threatened have helped save critical habitat. The mountain gorillas of Parc National des Volcans in Rwanda were the stimulus for the creation of this park. In addition to the preservation of this crucial rainforest area, the successful program is a model for other nations interested in preserving habitats while gaining income through carefully managed tourism (Crouse, 1988).

It is not always the warm fuzzies or enormous species that attract popular sentiment and fascination. Oftentimes an unlikely species will become a source of pride for a community and citizens will rally behind the preservation of a threatened species' habitat. In Santa Cruz and Monterey counties in California, a subspecies of the long toed salamander is one such species.

The Santa Cruz long-toed salamander *(Ambystoma macrodactylum croceum)* is endangered and the few small ponds that support this population are protected by law (Behler, 1979). The people of Santa Cruz affectionately refer to this endangered amphibian as "Santa Cruz Sal."

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Conservation and Preservation

Alternative Management Strategies

By Pamela A. Wright — The Ohio State University

Maintaining our global biological diversity is a critical task. A number of management strategies, aimed at maintaining biological diversity, are used in different countries and within different situations and agencies in the United States. In the United States, resource administration and conflicting land use often dictate the management strategy that will be employed. Placed on a continuim with biological diversity maintenance as the goal, these alternative management strategies would range from "unregulated use" to "conservation" to "conservation biology" to "preservation." The distinctions between these management strategies are often confusing, however.

Within the United States, our National Parks provide us with the opportunity to preserve portions of our natural environment for their inherent value. In 1916, Congress created the National Park Service in the Department of the Interior to:

> *promote and regulate the use of the Federal areas known as national parks, monuments, and reservations . . . by such means and measures as conform to the fundamental purpose of said parks, monuments and reservations, which purpose is to conserve the scenery and the natural and historic objects and the wildlife therein and to provide for the enjoyment of the same in such manner and by such means as will leave them unimpaired for the enjoyment of future generations. (NPS organic act, 16 USC 1)*

These familiar words provide the strongest federal legislation in the United States by which to preserve our biological diversity yet while unimpaired implies true preservation, the term conservation is also used in the organic act statement. Regardless, the NPS is the most viable preservation agency in the United States.

The newly emerging field of conservation biology provides us with a new way of examining and organizing our environment from a biological diversity perspective. It provides us with a third alternative for management of our natural resources. Conservation biology is a discipline that is a reorganization and synthesis of theoretical knowledge from a variety of fields with the goal of providing "principles and tools for preserving biological diversity" (Soule, 1985). It is distinguished from other natural resource management strategies by three characteristics: holism, integration, and purpose.

Conservation biology works for the protection of the entire community or ecosystem rather than a specific feature. By using the combined knowledge of a variety of different disciplines, from biology to sociology, it can choose from the best of possible solutions. Finally, conservation biology places less emphasis on aims such as esthetics, maximum yields and profitability and more on achieving long-range viability, including evolutionary potential, of an entire ecosystem. Its application may prove beneficial in solving species-specific problems such as the grizzly bear in the Yellowstone region, black-footed ferrets in Wyoming, old-growth Douglas-fir forests in the Pacific Northwest and condors in California (Soule, 1985). The conservation biology strategy is similar to the management strategy employed in the management of Biosphere Reserves.

Conservation is defined as the wise use of natural resources; the planned management of a natural resource to deter or prevent overexploitation, irreversible destruction, or neglect (Oldfield, 1984). Conservation implies that humans will also benefit from this wise use. Conservation areas in the United States, such as BLM lands and Forest Service lands, provide us with an opportunity to use natural areas for a variety of purposes. Conservation is a compromise between preservation and use and it may result in some species' demise. Many of our National Parks, such as Yellowstone and Redwoods, are areas of preservation adjacent to conservation areas. While these two alternatives can exist in the United States and provide a range of benefits, many countries, faced with critical issues like starvation and lack of shelter, may only have a conservation or use option open to them.

The urgency for protection of our global biological diversity necessitates using the broadest range of alternatives. Preservation, conservation biology, conservation, and unregulated use provide a spectrum of strategies from which governments and resource managers can develop a protection strategy that is fitting with the needs and capabilities of the nation.

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Cultural Transfer of Biological Diversity

The Key To Knowledge

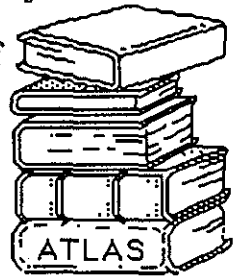
By Pamela A. Wright — The Ohio State University

Why do many of us in the U.S. plant or hang Indian corn near our doorways? What prompted the recent popularity of herbal teas on our dinner tables? How did we discover muscle relaxants, drugs to treat cancer and, natural pesticides that repel the potato beetle? Medicine men, storytellers, pictographs, petroglyphs, and, ancient writings— all communicators of native culture— are the sources of this knowledge. Today, most of us use libraries as the source of knowledge and enrichment. Traditional cultures hold the key to understanding and preserving biological diversity. These cultures are our biodiversity libraries. But, these cultures are vanishing, and with them the keys to our knowledge.

> *"The connections between culture and development, between culture and nature, and between development and conservation are the key to understanding and preserving the natural world today" (Robert McCormack Adams, Secretary of Smithsonian Institution, D.C.)*

Rain Forest Librarians

There is a saying in the rain forests of Surinam that "in the jungle, the Indian knows everything" (Myers, 1984). This knowledge was necessary for the traditional cultures to survive in a harsh competitive environment. To unlock this knowledge required hundreds of years of searching by trial and error, with this knowledge being passed cumulatively from generation to generation. If we attempt to learn about the uses of the resources ourselves, we would have to do random testing of plants, something that would take years to accomplish. Unlocking this knowledge today is better done using traditional cultures as the keys. Tapping these cultures for their knowledge will not only help us discover economically important uses for species, but may also teach us the value of helping to preserve the very cultures themselves.



The World Wildlife Fund and the IUCN are consulting with local experts in a number of nations in an effort to learn about the use of various plants and animals by the traditional societies. In Tanzania, a tree that was useful in curing toothaches was discovered. During a recent study of Amazonian rain forests, two US scientists, with the help of the local people, were able to identify more than 1000 plants and their uses. Among other things, six of the plants were used locally as contraceptives, others for curing fungus skin infections, and another, a high-protein coconut fruit, that could be used for food, fertilizer, soap and many other things. (Myers, 1984)

Here in the United States, North American Penobscot and Cherokee Indians helped discover a drug that can be used to treat testicular cancer, fight off a number of human viruses and repel potato beetles, largely due to the cultural transfer of knowledge they had about uses of the mayapple plant. (Myers, 1984)

Culture to Promote Conservation

This unlocked knowledge can also be useful to the traditional cultures themselves, providing them with economic incentives that not only preserve local biological diversity but preserve the traditional culture.

Several African and Asian nations have begun to encourage the development of traditional medicines as an important part of public health care. These "tribal healers" use medicines that are relatively cheap, readily accessible and widely accepted by the local populations.

In Thailand and Nepal, foreign exchange has been bolstered by more than one million dollars yearly by encouraging the development of medicinal plants for export.

A conservation program in Sri Lanka was designed to protect elephants by domesticating them for farm use instead of shooting them when they raid crops. The local farmers are paid by the government for capturing wild elephants and auctioning them for domestic use. This program was the result of the understanding of the interrelationships between culture and conservation. The elephant is deeply rooted as a symbol in the Buddhist religion and literature as a valuable resource. The impetus for the program was a march for conservation that emphasized conservation through Buddhist writings. (Cohn, 1988)

Debt for nature swaps are also an example of interrelated culture and conservation. Money raised by conservation groups in the United States and elsewhere is used to help pay off a portion of a developing nation's international and or commercial debt. In return, the country, with the help of international conservation organizations then promotes local conservation projects. (Cohn, 1988)

In Brazil, a program for the conservation of the golden lion tamarins instilled in the traditional cultures a sense of national pride. These small, brilliantly colored orange and reddish monkeys from coastal rain forests survive on the remaining two percent of their forest habitat. From the 300-400 tamarins that remained in the forests, captive breeding and habitat conservation programs were encouraged. In 1984, zoos in the United States and around the world began sending captive-born tamarins back to Brazil for release in their natural habitat. (Cohn, 1988)

Traditional cultures are also a source for knowledge about how natural systems function. Brazilian Indians modify, yet maintain, tropical rain forests by clearing forest patches to grow vegetables, planting fruit trees in open areas to attract animals they hunt, and sowing flower and medicinal herb seeds along pathways and other easily accessible areas.

Encouraging the cultural transfer of biological diversity helps us to unlock the keys to the rich and biologically diverse library we call planet earth. This information not only provides practical food and medicines but it also helps promote cultural identity and enriches our lives.

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Biological Diversity

Ecological Processes

Natural Processes As Natural Managers

By Pamela A. Wright — The Ohio State University

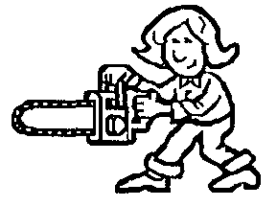
Within an undisturbed environment, the job description for a natural manager would incorporate the skills of forester, fire fighter, garbage collector, geneticist, pesticide applicator, rejuvenator, construction worker, doctor and many others. The duties of the natural manager are shared by a variety of processes and creatures from fires to floods to insects and diseases.

The summer of 1988 and the Yellowstone fires provided us with an excellent opportunity to view one of nature's best managers at work. As long as there have been forests and prairies there have been fires. Fire creats new habitat. Old-growth timber, diseased trees, and litter buildup are removed, providing the opportunity for lush new growth and making room for shade intolerant species. The resulting new plant life provides excellent habitat and forage for a variety of animal species. The remaining mosaic of burned areas and unburned areas creates a greater diversity of habitats that usually leads to an increase in animal populations. Fire is also the mechanism needed to regenerate certain species such as Lodgepole pine and Jack pine, which require heat and an ash-coated ground to nourish new seedlings. Forest and prairie fires also ensure that plant communities are not dominated by one age or plant group and consequently allow for the development of a more diverse plant habitat that in turn supports more species. (Zumbo, 1988).

Two other natural processes that work as natural managers are floods and weather. For years, annual floods in the Nile Basin dispersed nutrient-rich sediment to renew the soil andsupport natural plant life and agricultural communities. The newly enriched soils created excellent habitat that ensured plant growth and diversity could be maintained. Humans attempts to manage this system have failed dismally. River-damming on the Nile, the Mississippi, and elsewhere has stopped the vital soil rejuvenation that is necessary to maintain a healthy riverine ecosystem.

While the role of climatic extremes as natural managers is less understood, we know that weather extremes, be they droughts or increased rainfall, weed out the less resistant species providing opportunities for new species, to grow. (Myers, 1984).

Two other natural managers, often called pests by humans, are insects and disease. In a naturally functioning environment, insects function as geneticists, foresters, doctors and construction workers. Insects pollinate plants, trees and are an irreplaceable food source for a variety of other animals. Natural cyclical increases in insects work to thin forests, promote hardier species, and build homes to create a more diverse environment. Insect infestations can defoliate, girdle and damage a tree to the extent that it may eventually die. Some dead trees create snags that provide excellent homes for wood ducks, hawks, woodpeckers, owls, and squirrels while others are blown down, creating forest openings and edges that provide room and sunlight for other plant species to grow. Insects are most successful in forests dominated by one age or tree type and thus are a natural force in ensuring that monocultures give way to more diverse habitats. In increased proportions, insects provide a bigger food base for predators such as birds, allowing these populations to also strengthen and diversify.



Disease often works in conjunction with insects or any of the other natural managers since it gains a stronger foothold when species are weakened by other sources. Diseases have a pronounced effect as doctors and geneticists not only in plants but also in animals. Species that are weakened by another natural manager or age are more susceptible to diseases and will die out quickly. In a naturally functioning environment, disease maintains a genetically strong population and can be a strong natural selector.

As those somewhat removed from the natural environment, Humans distrust Nature's ability to manage the environment. This distrust, however, is the result not of nature's inadequacies in performing these management responsibilities, but of human interference in this management. Humans' attempt to manage the natural environment interferes with the natural managers and the job is often left undone. Human interference in the natural environment has progressed to the state that the natural managers may never again be able to regulate the environment as they did in the past. A better understanding of the natural processes of these natural managers may encourage a complementary relationship between natural processes and human technology.

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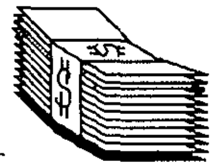
Biological Diversity

Fact Sheet 6

Economically Important Species

Biological Diversity: We're Banking On It.

By Kim A. Palmer — The Ohio State University

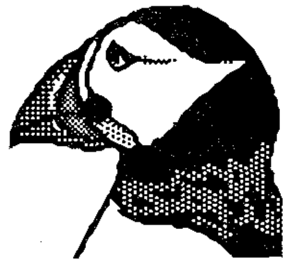


The economic benefits of preserving biological diversity are staggering. Stop for a moment and think of how almost everything around you is related to the natural world. Your cereal or toast in the morning is made of one of the three species of grasses that is the principal food base of the world. The tires on your car or bicycle may contain rubber from the sap of the tropical tree *Hevea* or the shrub Guayule. Other plar products in our lives include tanning agents, a variety of dyes, fibers such as cotton, flax and hemp, insecticides such as pyrethum and rotenone, perfumes, lotions such as witch hazel and aloe, waxes, gums, cosmetics, meat tenderizers, preservatives, turpentine, fertilizers, baskets, and gutta-perch, which is used for insulation and waterproofing.

Of course, everything we eat comes from some type of organism. Without wild strains of corn, rice and wheat to add genetic variety, the foundations of our food industry would be extremely vulnerable to disease or pests. The same holds true for our animal food products. Genetic diversity is the key to maintaining the cattle, pigs, turkeys, chickens, ducks, geese, sheep, and goats that have been domesticated for our use. Wild animal species can be directly used as sources of food or indirectly as breeding stock for genetic improvement of closely related domesticated species. World trade from timber products, mostly from wild trees, is currently worth almost $40 billion annually (more than $16 billion a year for the United States). Fish and shellfish provide the most significant direct contribution of wild species as a food source. Almost $12 billion annually is made worldwide from the sale of wild fish and shellfish, with more than $4 billion worth for the United States alone. (Prescott-Allen and Prescott-Allen, 1986). These figures make the distance between Wall Street and wetlands a lot shorter!

Where would we be without the insects and birds and bats that pollinate crops? These pollinators were responsible for $4 billion worth of crops in 1967 (Oldfield, 1984). Wild insects are also valuable as biological control agents. A good example is the ladybird beetle that feeds on aphids and scale insect. In the late 1800s the California citrus industry would have become extinct through infestation of trees by scale insects, but the ladybird beetle (*Vedalia cardinalis*) brought the scale insects under control and gave the industry a second chance.

Sea bird colonies provide guano (bird excretions) for fertilizer. Off the southwestern coast of Africa, gannet populations produced guano that was sold for $7.10 / 200 pound bag. When one seabird colony can produce 200,000 pounds of guano annually, this can add up to an important part of some nations' economy. Such is the case in Peru and South Africa.



Plants and animals also contribute substantially to the $40 billion dollar medical industry worldwide. From a recreation standpoint, wildlife means big bucks. Millions of dollars are spent each year in this country alone on hunting and fishing licenses. Birdwatching is estimated to bring in millions of dollars each year to Point Pelee National Park in Ontario. Similar economic estimates have been made for other areas of interest to wildlife watchers.

Nature influences our technology as well. The amazing velcro that is used as buckles for shoes and jackets was modeled after the hooks and barbs of bird feathers; the gigantic hewletts, metal arms used to load and unload ships, are modeled after grasshopper legs; and the U.S. Air Force is studying the flight of the great horned owl to better understand the mechanics of flight.

The natural world not only supplies us with our bread and butter, but **is** our bread and butter. Directly and indirectly, the world's economy is dependent upon the health of our planet.

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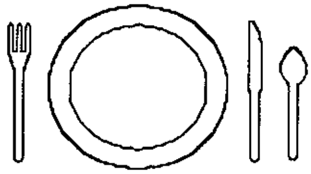
Edible Plants and Animals

Eating Ourselves Out of House and Home

By Pamela A. Wright — The Ohio State University

Food chains are a concept we are all familiar with and yet a process we often view ourselves apart from. Our technology separates us from daily involvement in the life and death struggle of the global food chain. In the industrialized nations our exposure to these global linkages has been distanced even more. To most of us, it is as if we are not so much linked in a balance among trophic layers but the overseer of that cycle. Although we rely on plants and animals for food sources, our dependence on individual species is lessened by the knowledge that we have the ability to adapt. As our ability to adapt is threatened because of loss of species and our involvement with critical food chains in less developed nations increases, our place in these global linkages becomes more apparent. If we look at the status of the food chain and at our behavior, we will realize that as a nation, and as a people, we are eating ourselves out of house and home.

Loss of habitat, genetic erosion, alien competitive species, and monocultural farming practices are partially at fault for the decline, and sometimes the disappearance, of food producers. Over-harvesting and increased consumption are also critical factors. While we might expect to associate less developed nations with over-harvesting, we would do well to examine our own dinner plates and full bellies as well.



• Lake sturgeon, once an abundant fish species in the Great Lakes, is now endangered by overfishing.

• The eskimo curlew, a small northern shorebird from Alaska and Northern Canada, is endangered because of over-harvesting.

• The great auk, a valuable source of meat and eggs in the North Atlantic area, became extinct in 1844 due largely to over-harvesting.

• The tule white-fronted goose, hunted for food and sport, is now listed as rare in the United States.

• Blue and humpback whales, valuable food sources, are endangered, and the fin whale is listed as vulnerable. (Source: Oldfield, 1984)

These species are only a few examples of the decreasing biological diversity we may trace back to our stomachs. Numerous plants and animals in the United States and throughout the world are suffering similar fates. In a national park setting, we have the opportunity to bring visitors closer to an understanding of food chain linkages by sharing with them the wonders of nature's edible wilds or of predator/prey relationships. These occasions are also opportunities for us to share the status of our linkages in the global food chain and expose visitors to the critical case of preserving global biological diversity.

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Biological Diversity

Fact Sheet 8

Endangered Species

Emphasize The Ecosystem

By Kim A. Palmer — The Ohio State University

An endangered species is defined by Congress as a species that is "in danger of extinction throughout all or a significant portion of its range." A threatened species is one not yet endangered but whose populations are heading in that direction.

The Endangered Species Act became law in 1966 and was strengthened by Congress in 1973. Since then, the Act has gone through several reauthorizations including one in 1988. This law has been called one of the "toughest pieces of environmental legislation ever enacted." (Iker, 1987) and requires all federal agencies to make certain that their activities (or those funded or authorized by them) neither jeopardize the existence of an endangered species, nor destroy or adversely modify its critical habitat (Iker, 1987; Revelle and Revelle, 1988).

As of 1987, the U.S. Fish and Wildlife Service had listed 946 species as endangered or threatened (Scott, et al. 1987). An additional 3000 species are listed as category 1 (organisms with sufficient information to propose listing as endangered or threatened and species that may have recently become extinct) or category 2 (species that are thought to be endangered or threatened but for which more data are needed to justify listings) (Scott, et al. 1987).

The Endangered Species Act has contributed significantly to the conservation of habitat for species. Because of this, there are species existing today that would not have survived encroaching development and human impacts. Species such as the Kirtland's warbler, grizzly bear, whooping crane and many others have been given a degree of protection that is critical to their survival. Special refuges have been established to protect endangered or threatened species. One such refuge is the 11,000-acre Ash Meadows Refuge on the Nevada-California border. This area is home to at least 26 animals and plants found no where else in the world (Iker, 1987). The widespread public support for the federal law has made "endangered species" a household word (Iker 1987).

While the Endangered Species Act has been the catalyst for preserving critical habitat and saving some species on the brink of extinction, many scientists feel it is only part of the challenge of truly conserving biological diversity on earth. These scientists argue that while monitoring and conservation efforts for rare species address the immediate need of protecting these rare species, no framework for analysis of long term trends in biological diversity has been established (Scott, et al, 1987).

This type of crisis conservation management is analogous to emergency room treatment for the critically ill (Scott, et al. 1987). Most of the economic and emotional support for the protection of biological diversity goes into a few species which may be beyond the scope of recovery meanwhile allowing still viable populations to slip downward toward and endangered status. This species-by-species approach to conservation leads to another problem. Maximizing benefits for one endangered species may threaten another. (Scott, et al, 1987). Examples have been noted in Calfornia where improving the water supply for the Owens pupfish resulted in the near loss of a snail found only in Fish Slough in the Owens Valley. Scientists critical of the ESA argue for a systems approach to preserving biological diversity to address the entire spectrum of diversity.

The ESA is not, however, the only legislation or method by which to manage endangered species. The United States currently employs a comprehensive systems approach that includes: NEPA (National Environmental Protection Agency), ESA, the Clean Water Act, State Fish and Wildlife Regulations, National Parks, National Forests, Wildlife Refuges and Nature Conservancy Reserves to name a few. While the integration and cooperation between the agencies, regulations, and resources needs strengthening, they are the reason the United States has such a rich and diverse fauna and flora still remaining (Salwasser, 1988).

As researchers develop more sophisticated techniques for understanding species relationships and the intricacies of our natural world, an ecosystems approach developed for the conservation of biological diversity will supplement the protection of individual endangered species and help us clarify for park visitors the interdependence of all living things.

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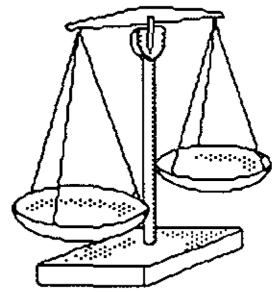
Biological Diversity

Ethical Issues and Species Preservation

Who Has The Right To Tip The Scales?

By Pamela A. Wright — The Ohio State University

In its natural state, our diverse planet is like a balance scale that maintains a fragile equilibrium. When the scale tips in favor of one side or one species, natural environmental controls occur, sometimes in the form of extinction of species. Initially, human involvement in the balanced planet faced the same controls and fate as any other species. As reasoning, intelligence, and technology increased, humans developed the ability to control and manipulate that scale. Today the scale is badly out of balance. Humans have become the dominant species, greatly accelerating the rate of extinction for other species and furthering the cause of the human species to the detriment of all other species, and ultimately, ourselves.



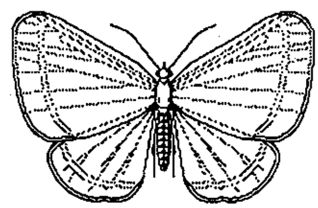
We are finally beginning to realize that our fate will be determined by the degree to which we can rebalance the planetary scales. Daily we are faced with decisions that require value judgments. To maintain the global biological diversity necessary to balance the scales, we must develop an environmental ethic that recognizes the value of a species. Although the development of any ethic is an individual action, we can attempt to understand the severity of the problem by examining possible motivations for species preservation, and situations that require environmental decisions.

Unfortunately, the reasons for species extinction, and the prevention of these extinctions, are complex. Many variables, including habitat destruction and over-harvesting, combine to cause extinction and it is often difficult to isolate concrete reasons for the extinctions. The more complex the issue, or the further humans are removed from the threatening variables, the harder it is to convince people that they need to, and can help preserve species. In order to rebalance the scale, and develop an environmental ethic, we need to determine the worth of individual species preservation, and global biological diversity.

Four common arguments for species preservation are economic value, esthetic value, interdependence and intrinsic rights (Ehrlich, 1981).

Economically, the preservation of species provides us with life-saving and life-sustaining tools that are necessary "for agricultural, forestry and fisheries production, to keep open future options . . . and as the raw material for much scientific and industrial innovation" (International Union for Conservation of Nature and Natural Resources, 1980). Both plant and animal species are present and future food sources and many contain an element or the information to produce a life-saving drug.

Esthetically, individual species and biological diversity also have great value. Bird watching, butterfly collecting, and keeping tropical aquaria are some of the most popular North American hobbies, providing economic as well as esthetic rewards. In New Guinea, tribesmen use butterfly wings as hair decorations while many North Americans grow potted tropical plants for pleasure (Ehrlich, 1981). Species, such as the American bald eagle, also have great symbolic value. The diversity of our environment increases our pleasure, broadens our horizons, and enriches our daily lives.



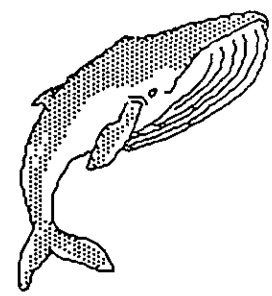
Interdependence of our environment suggests that we examine species preservation and global biological diversity carefully. While many species have seemingly little purpose, their value to the environment may simply be unknown. These species, along with countless others that have yet to be discovered, may possess unique edible or medical properties that may someday be of use. Likewise, relationships between species are so intricately designed that the extinction of a species starts chain reactions that upset the environmental balance and may cause the extinction of other species. By allowing extinctions to occur, we may be ultimately causing our own extinction.

Finally, intrinsic values of species dictate their preservation and the preservation of global biological diversity. The independent right of a species to exist, the right to life, is contrary to the anthropocentric viewpoint, and is therefore hard for many to accept. The more we come to understand and accept that as humans we are only one of thousands of species that share the planet, the easier it will be for people to accept a specie's right to exist.

Choices and decisions about species preservation are based on the environmental ethics of the decision makers themselves. When the choice for species preservation is between a species and an object, such as a dam, the options are clearly polarized. If human survival is not dependent on that dam and a species will suffer extinction because of loss of that habitat, a balance can usually be achieved. When the choice for preservation is between two species, there are no clearly defined sides and the scales cannot be balanced.

In Alaska and the Canadian Arctic, a continuous battle between species is being fought. The harvesting of marine mammals by indigenous northerners is a way of life, a culture. Prior to European contact, the Inuit hunted seals, whales, and other marine mammals for clothing, food, heat, tools, and religious purposes. All species, humans and marine mammals alike, existed in a balanced environment. Not until European contact brought incredible trade quotas and advanced technology did the scales unbalance. The scales crashed toward the Europeans while both the Inuit and the marine mammals were propelled close to extinction — cultural extinction for the former and physical extinction for the latter.

Changes in fashion, outrage at needless slaughter, and a growing environmental awareness has seen the gradual recovery of some of the marine mammals. Right whales, blues, humpbacks, and grays are not recovering and are nearing extinction. In 1972, the U.S. Congress passed the Marine Mammal Protection Bill to protect marine species from commercial hunting, and in 1983, the European Economic Community banned import of all marine mammal products. Protectionist measures such as those in an International Whaling Commission declaration have not been totally successful. In spite of signatures from over thirty nations on the declaration, those countries that have yet to sign are the primary consumers of whale meat and other products.



For the Inuit in the Baffin Island area of Canada, the seal "is the staff of life" (Revelle and Revelle, 1988). Seasl provide the basic food, clothing and fuel needs for the people and structures their economic and cultural systems. Denying the Inuit right to continue to provide for themselves in this traditional manner would be akin to cultural genocide. However, when the Canadian and U.S. governments choose to allow subsistence hunting of particular marine mammals for indigenous people, they reduce their bargaining power in their push for an international moratorium on commercial hunting of these animals. The means necessary to ensure species preservation and, ultimately, global biological diversity require decisions based on sound environmental ethics and careful examination of the options available to balance the scales. As decision makers, politicians make the final choices in balancing the environmental scales. Their environmental ethics, and the ethics supported by the resulting legislation, often come under scrutiny when this happens.

The Endangered Species Act is one such piece of legislation designed to ease the individual decision maker's burden in ensuring the balance of the environmental scale and to assist in the preservation of species. The law ensures that activities by federal agencies neither jeopardize the existence of an endangered species, nor destroy or modify its "critical habitat" (Erlich, 1981).

One of the Act's best known tests occurred in 1978. Construction of the Tellico Dam, a multi-million dollar project in Tennessee, was halted when officials learned that the waters involved in the damming project were potentially the last acceptable habitat for a type of snail darter, a seemingly insignificant three-inch fish. Public debate over the Act pitted a "useless" species against a public that feared loss of jobs, loss of public works improvement, and loss of economic progress. The law brought to a head questions on the worth of a species and forced those who felt that the loss of a species was more important than economic progress to take action. The snail darter, a species with undiscovered economic value, interdependence, and beauty represented a decision by many that species preservation and global biological diversity had value and that species extinction had to stop somewhere. In the end, the snail darter lost.

That decision to balance the scales has occurred before and will continue to occur as people recognize a species' right to life and their value. A pure strain of dusky seaside sparrow, was probably extinct when a group of concerned conservationists and the Walt Disney Corporation joined together to support a project designed to back-cross related sparrow species in order to produce a the purest strain possible of the extinct bird and reintroduce it. This project, along with attempts to revive, from near extinction, the California condor, are multi-million dollar projects that, on the basis of economic expenditures, may not be worth the cost. Yet to those involved, the dusky seaside sparrow and the California condor are symbols of the battle to save global biological diversity.

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Biological Diversity

Fact Sheet 10

Evolutionary Process

Keeping The Sink Full

By John W. Hanna — The Ohio State University

A Park Service Parable

For almost 100 years national park areas were created primarily with regard to their natural or historical values. A system gradually evolved permitting the inclusion of a broader base of areas like national monuments, but most of those included still possessed nationally significant natural or historical values. This gradual change might be compared to what ecologists refer to as linear species change when discussing evolution. This gradual change process was abruptly jolted in the 1960s when national recreation areas appeared on the scene. Their importance more often was measured in terms of meeting recreational demands of a growing population. Ecologists might have referred to this as speciation.

So, we have two methods of evolution within a system: single line of descent and speciation. Both result from and, bring about change. Evolution via linear species change brings about a gradual change or transformation such as mosquitoes might develop resistance to a bug spray. Evolution via speciation brings about change by splitting such as the mammals who evolved from reptiles as teeth specialized and scales transformed to hair. (Ehrlich, 1981)

Linear Species Change

A linear species change involves gradual change within a species over a period of time. Sometime this can occur over a short period of time, as in our mosquito example above. Other times, the transition may occur over millions of years. The gradual transformation of *Australopithecus* into the modern human being involved the gradual development of larger brains and more complex cultures through *Homo erectus* to *Homo sapiens*. (Ehrlich, 1981)

Speciation

Speciation accounts for the broad diversity of organisms that populate our planet today. Speciation transforms a single organism into two or more new kinds of organisms. The evolution of the mammals from dinosaurs has produced an incredible diverse number of new species from whales, to horses, to people. Speciation is generally a very slow process. It has been over a century since Darwin started biologists thinking about speciation, yet the production of a new species is still to be documented. (Ehrlich, 1981)

Natural Selection

Fundamental to both processes of evolution is the process of natural selection described by Darwin. For example, within the single line of descent, those mosquitoes more resistant to a insecticide are more likely to reproduce and the insecticide-resistant genes will become more predominant in the "gene pool" of the mosquito. (Ehrlich, 1981)

In the speciation process, the most important reason for splitting of a species is environmental variation. Geographic variation results when a population expands geographically and the organisms adapt to their new environment through natural selection. This variation is often recognized by biologists through the designation of subspecies. Over many generations, this variation may become so great that the subspecies become incapable of interbreeding, especially if they are geographically separated. This reproductive isolation becomes the primary criterion for establishing a new species. Darwin's finches of the Galapagos Islands provide an example of geographic variation. The islands were most likely originally populated by a few finches blown in by a severe storm. Since finches do not normally elect to fly over large water bodies, they stayed and populated the archipelago. Over time, the finches adapted to the individual island environments varying in color, shape and size of beak, and feeding habits. Today, there are fourteen diverse species. (Ehrlich, 1981)

Twenty-three species of honeycreeper have evolved in Hawaii in a similar manner, demonstrating the value of isolation as a tool of evolution. Conversely, a lack of isolation might explain why *Homo sapiens* has not undergone geographic speciation even though it shows abundant geographic variation. The migratory Monarch butterfly is another example where very little isolation is likely to occur and, therefore, almost no geographic variation has resulted. (Ehrlich, 1981)

The Evolutionary Balance

Speciation is the balance for extinction. It is like a giant sink with a faucet running new species into the sink all the time. Extinctions are represented by dying species flowing out the overflow drain. Today, humanity has upset the balance. The drain at the bottom of the sink has been opened much wider by wiping out entire populations, reducing habitat for others, introducing alien species, and other factors. In the last decade of this century, it is predicted that one-fifth of the earth's species may vanish — and remember, we haven't documented a single new replacement since Darwin proposed natural selection. (Ehrlich, 1981)

Implications for National Parks

The survival of species and speciation is dependent upon maintaining healthy diverse populations. The national parks and other preserves worldwide represent the remaining gene pools for many species. Where populations become both small and isolated, the likelihood of greater incidence of harmful recessive genes dominating is ever present. (Ehrlich, 1981)

On Isle Royale, the gray wolf population has reached a recent low of 12 individuals. The wolves may be threatened if a disease such as *Canine parvovirus* takes root on the island. This could easily happen if a private boater inadvertently brings a dog to the island. Forty years of genetic inbreeding in the wolf population may have reduced the wolves' resistance to such a disease. On another preserve, Wichita Mountains National Wildlife Refuge, the wild longhorn cattle population is periodically interbred with other herds of longhorn cattle to retain the genetic vitality and historic integrity of the species.

Badlands National Park has also implemented a similar program. Concerned about the genetic integrity of the bison population due to interbreeding, Badlands received the necessary authorization to import surplus animals from Colorado National Monument. These animals came from a different genetic stock than the Badlands animals and trades such as this will help to increase the genetic variability within the stock. (Blinn, 1984)

Keeping the sink full and balancing speciation with extinctions requires the protection of our biological diversity and the natural processes of evolution. Efforts such as those on park lands and other preserves illustrated above will be increasingly needed to protect dwindling populations of many of the species our national parks and other preserves have been enabled to protect.

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Extinction

It's Happening Right In Our Own Backyards

By Kim A. Palmer — The Ohio State University

To many people extinction means the disappearance of the dinasours or ancient animals of long ago. But what most people do not realize is that extinctions are occurring right here and now at a staggering rate. As huge tracts of rainforests are cleared to make way for grazing and development, species disappear forever. This scenario is not restricted to rainforests, however, and the notion of extinct marmosets and orchids, tropical hardwoods and parrots is not as distant as it first appears. Extinctions are occurring right in our own backyards!

Extinction is defined as the cessation of existence for a given life form, or a previous loss of a given form (Schonewald–Cox, 1987). While extinction is a natural process, the dramatic rate at which it is occurring is not. Some scientists have estimated this rate at one species each year, but this does not include invertebrates. Others suggest a more comprehensive estimate of two to three species each day. Estimates are difficult to make because we simply do not know how many molds, fungi, plants, and animals currently share the earth with us.

At this time, approximately 1.4 million living species have been described (Wilson, 1988). This picture is still quite incomplete, and it becomes more and more difficult to piece together as species disappear as a result of our population growth and our increased demands on our biological resources.

In North America, the Labrador duck, Atlantic Gray Whale, and the Great Lakes' Blue Pike, Great Auk, Passenger Pigeon, Carolina Parakeet, Sea Mink, Steller's Sea Cow, as well as many other animals and plants, have all disappeared because of human actions.

Humans have contributed to extinction in several ways: direct harvesting or killing, habitat destruction and multiple factor extinctions (Kauffman and Mallory, 1986). For thousands of years humans have killed animals for food, clothing, recreation and to protect themselves, their property and their domestic animals. Late Stone Age hunters are the likely cause of the extinctions of the mammoth, giant ground sloth and nearly thirty other types of large mammals (Kauffman and Mallory, 1986).

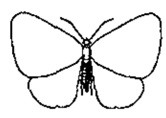
More recent times have been witness to the disappearance of the Stellar's sea cow, heath hen, great auk, Eastern and Merriams elk and the well-known passenger pigeon. The Carolina and Louisiana parakeets literally died for fashion. Both species were hunted for their feathers, for pets and at times, for the protection of fruit crops. While many animals and plants have been hunted or gathered to extinction, by far the most devastating and frequent threat to species today is the destruction of habitats.

A habitat is the natural home or dwelling place of an organism (Steen, 1971). Physical alterations of habitats can be seen just about everywhere. These alterations include clearing of vegetation and cultivation of the land, commercial and residential development, draining and filling of wetlands, stream channelization, dams and water diversion structures (Kauffman and Mallory, 1986).

Chemical alterations are a little more difficult to notice, but still contribute to habitat degradation. One popularly known form of chemical pollution is acidic deposition or acid rain. Other chemical pollutants include improperly treated organic waste, pesticides, high concentrations of heavy metals, and toxic wastes. These chemicals can destroy the biological components of ecosystems (Kauffman and Mallory, 1986).

Biological alterations of an ecosystem can result from introducing an alien or non-native species to the ecosystem. These non-native species prey on native animals, compete for food and space and may even interbreed with them. A good example of habitat disruption from an alien species is the story of the Gypsy moth and its effect on our eastern forests. As the larva of this species defoliates many key tree species it alters the forest composition. The once shaded forest floor is now exposed to sunlight and changes begin to take place in the vegetation. Fruit production from the damaged trees is altered and therefore affects the availablity of food to squirrels, deer and other animals. With the introduction of one small species of moth, our eastern forests are undergoing some big changes.

In many cases, species become extinct because of multiple factors, such as a combination of overharvesting, habitat destruction and the introduction of an alien species into its habitat.



The Great Lakes are the backdrop for one of the best documented cases of multiple factors causing extinction. The commercial fishery which began in the early 1800s, quickly grew as it harvested almost 20 percent more fish each year until 1890 (Kauffman and Mallory, 1986). Blackfin cisco, deepwater cisco, longjaw cisco and blue pike were valuable species for the fishery.

But just as the fishery enjoyed rapid growth, so too did the communities on the surrounding shorelines. Soon the problems of pollution, siltation, drainage of wetlands that provided valuable spawning and feeding areas for the fish, and the damming of tributary streams plagued the Great Lakes. The fishing industry began to decline as the Great Lakes ecosystem became more and more stressed due to the actions of humans. The final straw was the arrival and establishment of alien fishes such as the sea lamprey, alewife and rainbow smelt in the 1900s. These factors combined to culminate in the extinction of four Great Lakes fish species: blackfin cisco, deepwater cisco, longjaw cisco and blue pike.

These recent backyard extinctions serve as a powerful reminder that extinction is not a distant event. It is current, dramatic and occurring at an increased rate due to human actions.

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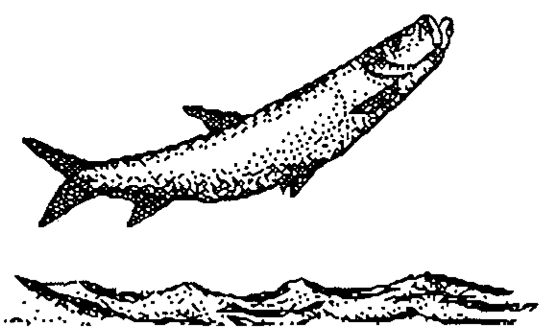

Biological Diversity

Fact Sheet 12

Extirpated Species

" I Remember When..."

By Kim A. Palmer — The Ohio State University

My grandmother often told me stories about her childhood days in the mountains. She usually started each one with the phrase, " I remember when..." and then shared with me memories of river otters playing in the stream riffles, pink ladyslipper orchids dotting the forest floor with spring color and the bald eagles raising their young in the white pines along the lakeshore. The stories made me feel as if the mountains in my childhood were completely different from those of my grandmother's. These flowers and animals she spoke of were no longer common in the area; they were, in a sense, extinct.

Local extinction of a species is known as extirpation. It simply means an organism has been driven out of its habitat for various reasons such as newly introduced competitors or human disturbance. Throughout the nation, many species have been pushed to extinction, surviving only in small, isolated populations. As alien (introduced non-natives) species are accidently or intentionally released, they compete with or prey on local populations. Human actions such as conversion of forests to other land uses, production of industrial waste, development, and pesticides have already contributed to the reduction of the Kemp's ridley sea turtle, red wolf and the plants and animals of the tallgrass prairie. The story of pesticides and peregrine falcons is a case study of how human–produced chemicals contribute to the local extirpation of a species.

The peregrine palcon is a migratory raptor with a worldwide distribution. There are nineteen subspecies and *Falco peregrinus anatum* is the subspecies native to the United States and southern Canada. Peregrines nested in mountainous regions or on rocky cliffs overlooking rivers such as the Connecticut, Hudson, Susqehanna and Mississippi (Tietjen, 1984). The 1950s saw an increase in the use of pesticides for widespread agricultural use and a decrease in the number of peregrine falcons in the east.

One pesticide used was chlorinated hydrocarbon known as DDT. DDE, a breakdown product component of DDT, was found to cause thin shells in the eggs of many bird species. DDE prevented peregrines from completing incubation because the shells broke under the weight of the adult. By the mid 1960s, the eastern (peregrine) population had been extirpated and populations of the other 18 subspecies were severely reduced (Tietjen, 1984). Raptor species such as bald eagles, merlins, kestrels and osprey were also extirpated in many areas. Luckily, the plight of the peregrine is improving.

In the early 1970s, DDT was banned in the United States and Canada and the peregrine falcon was placed on the Federal endangered species list. Today, we are able to witness the peregrine falcon in flight over the areas where it once had been extirpated. Through the cooperation of several agencies and organizations, intensive captive breeding, reintroduction and monitoring programs have been implemented.

From Acadia and Great Smoky Mountains in the East to Crater Lake and Sequoia–Kings Canyon in the West, at least twelve of our national parks have peregrine falcon reintroduction projects in progress or had them in the recent past (Shelton, 1988). Many of the parks of the Rocky Mountain and Southwest regions have large numbers of peregrines and very active restoration programs. Eastern cities are finding their highrise buildings are homes for these birds of prey–the most famous being the nesting site of a falcon on the 33rd floor ledge of the U.S. Fidelity and Guarantee office building in Baltimore, Maryland.

Although Peregrine restoration is a success, the complexities of ecosystems make reintroduction of a species no simple task for resource managers. Many questions arise as researchers learn more about the various parts of complex communities. Such questions include the effects of newly re-established species on prey species that may also be endangered or threatened. Another piece of the peregrine puzzle is the effect of DDT use by Latin and South American nations on wintering peregrines and their prey.

The story of the almost extirpated peregrine parallels that of numerous other species throughout the world. As resource managers and researchers discover the intricacies of complex ecosystems and as the public develops awareness of how we all influence these ecosystems, we may be hearing more species success stories rather than "I remember when" stories.

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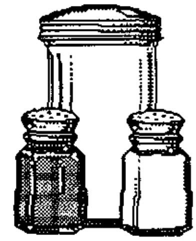
Biological Diversity

Fact Sheet 13

Genetic Diversity



Variety is the Spice of Life

By Kim A. Palmer — The Ohio State University

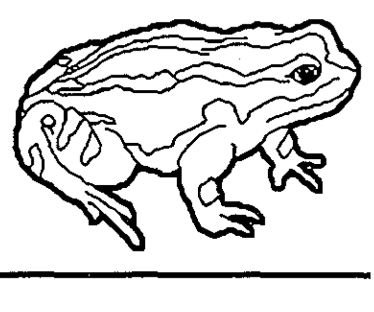
Genetic resources and the habitats that sustain them may soon be recognized as our most important economic and political assets. These resources consist of genetic materials contained within and among populations of living organisms (Oldfield, 1984). Without these resources and their corresponding habitats, no human civilization can survive.

Genetic diversity is "the variety of genes within a particular species, variety or breed" (OTA). Genetic diversity can also be defined as the inheritable variation within and among populations of a species. This variation is created, enhanced and maintained by evolutionary forces such as mutation, migration, selection and genetic drift.

The long-term health and viability of a group of organisms is dependent upon the genetic diversity within that population. For example, imagine a population of strawberry plants with only a few individuals of that plant population having the genetic potential that makes them resistant to frost. If this population were located in an area where frost may occur, these few individual plants would survive and reproduce while those that were not frost-resistant would not survive to reproduce and therefore would not pass on their variation to offspring. This genetic variation allows populations to adapt to a changing environment while genetic uniformity increases the vulnerability of individuals and populations.

Genetic diversity may seem unrelated to today's industrialized world. In the midst of everyday issues such as unemployment problems, healthcare issues, defense and commerce crisis, the thought of conserving natural systems seems a luxury, something that should be taken care of after all the other social issues have been resolved.

Although it is often difficult to readily identify the valuable socioeconomic role of our biological resources, genetic resources and the habitats that sustain them contribute billions of dollars worth of raw materials to the U.S economy each year (Oldfield, 1984). Without these raw materials, many basic products would not exist, nor would the jobs that are associated with the manufacturing of these products.



Products directly dependent on our biological diversity are abundant in the pharmaceutical and health services sector. Two- fifths of all modern U.S. pharmaceuticals contain one or more naturally derived ingredients (Oldfield, 1984). One such plant is the red periwinkle, *(Catharanthus roseus*), which produces the drug vinblastine sulfate for treatment of Hodgkin's disease. Another example is the opium or white poppy, *Papaver somniferum,* that provides morphine sulfate that reduces pain due to terminal cancer, internal hemorrhaging and traumatic shock and is also the source of naloxone, a lifesaving drug given to infants of heroin addicts. Naturally occurring biochemicals are also used as blueprints in the production of synthetic drugs.

Other examples of the socioeconomic value of genetic diversity are found in the world's food crops. Surprisingly, two-thirds of the world's grain crops rely on only three species of plants—corn, wheat and rice (Oldfield, 1984). With the dependence of the world on such a few crops, it is essential to maintain and enhance diversity. The potato famine in Ireland of 1845 to 1850, in which over one million people died and another million emigrated due to the destroyed potato crop, is a painful example of the dangers of a monoculture (a vast stand of only one or a few crop varieties). A second reminder of the vulnerability of genetic uniformity within food crops was the corn blight that destroyed one-fifth of the U. S. corn crop in 1970. Disasters such as these can be avoided by utilizing gene resources of wild plants to revitalize and improve domesticated crops. Tomatoes, melons, cucumbers, sugar cane, oats, wheat, rice and corn have all been improved by introducing genetic materials from wild gene pools. More examples of socioeconomic values of genetic resources can be found throughout this handbook.

What are we really losing when we reduce habitat or lose a species to extinction? A species is not just another player on the field. Acccording to Wilson (1985), that species represents a "unique population of organisms, the terminus of a lineage that split off thousands or even millions of years ago." Each species is an invaluable storehouse of unique information— a library. Consider the house mouse, *Mus musculus*. According to Wilson (1985), each of its cells contains four strings of DNA, each of which comprises about a billion nucleotide pairs organized into a hundred thousand structural genes. If the information contained on the DNA strings was translated into ordinary sized printed letters, this information would just about fill all fifteen editions of the Encyclopedia Britannica published since 1768 (Wilson, 1985).

We are losing a great deal when we reduce genetic diversity, not only products but also information. Genetic diveristy enables organisms to adapt to a changing environment and is the basis of survival and evolution. In preserving natural diversity we are preserving options (Roush, 1977).

Genetic resources can be lost in two major ways:

- when a species or its distinct populations are over -exploited; or

- through destruction or extensive alteration of the specific habitats on which that population depends. This includes the disruption of ecological relationships with other species, (e.g., pollinators, seed dispersers) which help mantain the populations.

The current rate of species loss estimated by the International Union for Conservation of Nature and Natural Resources (IUCN) is one species of vertabrate each year, and it is predicted that by the year 2000, twenty percent of all species may be extinct (Freeman, 1986). In addition, countless species may become extinct before they can even be discovered and named.

The most dramatic loss of genetic diversity is occurring in tropical rainforests. Today the rainforests occupies about 3.5 million square miles and is being cut down at an annual rate of 0.7% (Wilson, 1985). That is, 25,000 square miles, an area the size of West Virginia, is lost every year.

While many previous conservation efforts have focused on preserving species, their losses are not the only danger. "Among the surving species, many populations will be lost, taking with them much of the genetic diversity upon which long-term survival and evolution depend" (Ledig, 1988).

Our National Parks provide protected habitats in which species and populations, and their genetic diversity can be preserved. National Parks also provide opportunities for interpreters to communicate to the general public, the critical issues of preservation of biological diversity. In doing so, the fight against genetic loss is strengthened.

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Biological Diversity

Fact Sheet 14

Genetic Diversity: Community

Nature's Intricate Tapestry

By Kim A. Palmer — The Ohio State University

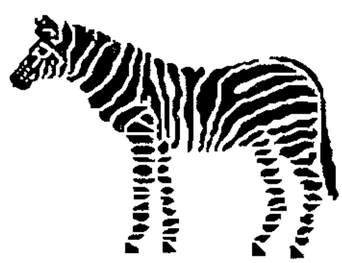
To even the most casual observer of the natural world, it becomes obvious that organisms are not grouped randomly. Instead, populations of organisms characteristic of a particular type of environment are organized into a community. This community includes all the living organisms interacting in a particular environment (Revelle and Revelle, 1988).

Therefore, a community can be defined as "a group of populations that are ecologically and geographically interconnected, and represent a few to many species. Such a group constitutes an assemblage of plants and animals living in a common home, under similar conditions of environment, or with some apparent association of interests" (Schonewald-Cox, 1987).

To understand the interactions of organisms within these communities it is also important to understand the concepts of habitat and niche. An organism's physical surroundings, where it lives, is its habitat. For example, the habitat of the Maryland darter (*Etheostoma sellare*) is the riffles of Deer Creek above the confluence with the Susquehanna River in northeastern Maryland; the deer mouse habitat is temperate zone woods; and the habitat of the Kirtland's warbler (*Dendroica kirtlandii*) is forests of young Jack Pine (*Pinus banksiana*) in Michigan.

An organism's niche is its ecological function, that is, what it does. This includes such things as whether it is a predator, prey or parasite, how much sunlight it requires or whether it is active during the day or night, etc. The niche is the organism's way of life.

Generally, two species cannot occupy the same niche, at least not for very long.When this does occur the competition between the species should cause some type of change in one of the species. This change may be in some aspect of the lifestyle of that species— it may move to another area or it may eliminate that species. It is often easy to see several species that seem to be living in the same habitat and eating the same food. After further observation though, factors such as predators or parasites keeps either of the species from occupying all of the habitat, or eating all of the food within that community.



The interactions of living organisms can vary. In some communities the interdependence is so great that the various species could probably not survive without one another (Revelle and Revelle, 1988). An example of this type of community is that of the Serengeti grasslands of Africa. In this commuity zebras feed on the tall grasses, exposing the sheath portion of the grass. This part of the grass is the major food source of the wildebeest. The wildebeest continue to crop the grasses even further, allowing sunlight to reach the ground surface where it stimulates the growth of small herbs, the primary food of Thompson's gazelles. The removal of one of these species could seriously affect the others (Revelle and Revelle, 1988).

In addition to benefitting each other, the grazers are imperative to the survival of the grassland itself. Grazing encourages the continued growth of the grasses. If this grazing were discontinued, the grassland would succumb to natural succession and would gradually be replaced by a woodland community.

A Complex Tapestry

A similar situation occurs in Yellowstone National Park. When beaver build dams in streams, the rate of flow from spring runoff is reduced, which in turn discourages erosion and siltation, thus keeping the water clear for trout to spawn.In addition, the ponds built by beavers provide habitat for mink, waterfowl and otter. The accompanying elevated water table levels add moisture and promote the growth of broad leaved plants like aster, yarrow and clover that are significant to other animals in the community such as bears (Houston, 1982; Craighead, 1980).

The increased moisture also encourages the growth of trees like willow and aspen that are essential for the survival of elk and deer. These animals, known as ungulates, require a diet of cellulose and nitrogen. The stalks of plants provide cellulose and, in the summer, green grasses provide a compound containing nitrogen. Nitrogen is necessary for the digestion of cellulose. The nitrogen feeds the microflora present in ungulate's stomachs and the microflora then multipy. These microflora then help digest the cellulose. Without the nitrogen, an elk could have a stomach full of plant stalks but die of starvation because it was unable to digest the cellulose (Houston, 1982).

Willow and aspen store nitrogen in the tips of their branches and in their bark and provide elk and deer with this element during the winter when the brown grass cannot offer nitrogen to complete their diet. Without the beaver to manipulate the streams and water tables, the rest of the community could be seriously affected.

The organisms in this community are woven in a complex tapestry. Each strand depends upon the other for support and strength. The diversity within the community is necessary for its health. Maintaining diversity at the community level helps ensure the survival of individual species. (Houston, 1982).

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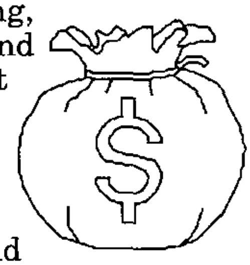
Impact of Consumer Behavior

$$ Wildlife For Sale $$

By Pamela A. Wright — The Ohio State University

Take a close look around you. Almost everything you are wearing, eating and surrounded by is a derivative of some part of the plant and animal kingdom. Now look again. How many of the things that people use daily can you trace back to a species under stress? Consumer behavior has a devastating impact on biological diversity.



In all aspects of our lives, we assign value to what is rare. Gold and precious metals are rare and thus they have become the basis for our economy. Precious stones, such as diamonds, have not only great monetary value but great emotional value. When consumers perceive the rarity or uniqueness of a species or its products, they are more willing to pay a higher price to possess that item than they are to accept a more economic substitute (Oldfield, 1984). This cycle of supply and demand is the reason why consumer behavior impacts the state of our biological diversity.

The wild chinchilla (*Chinchilla laniger*) from South America was one of the first endangered species for whom the spiral of supply and demand could be equated. In the 1920s and 1930s consumers were willing to pay large sums for products made out of chinchilla. Prices were said to be as high as $100,000 for a single coat and thus suppliers were motivated to obtain chinchilla at any price. The wild chinchilla populations were completely exterminated from the lower altitudes of the Andes and by 1943, only a few isolated colonies remained in the upper elevations. The chinchilla was lucky, however. Fashion trends changed, trade legislation was imposed and the chinchilla, a species with a relatively high reproductive rate, was no longer a highly sought after species and today there is almost total recovery (Oldfield, 1984).

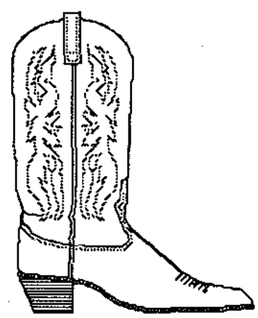
The chinchilla was, however, an unusual exception. Most of the endangered species,such as the blue whale (*Balaenoptera musculus*), have relatively slow maturing and reproductive rates.

Once consumer demand has been established, the spiral of demand and supply continues. It is a no-win situation. If trade bans are not imposed on endangered species, legal trade will proceed until the animal or plant has reached extinction. If trade bans are imposed, the illegal trade market will grow because of the tremendous profit to be made, until the animal or plant reaches extinction. Unfortunately, those who supply the endangered species to the consumer usually have no alternate source of income and consequently there is great economic incentive to engage in poaching and other illegal trade practices. The only way to beat this cycle is to change consumer perceptions. Consumers need to be made more aware of the role they play in determining the fate of our biological diversity. If they voluntarily reduce their demand then not only will the survival of a species be ensured but the conservation and enforcement costs for that species can be differed to another species in need.

While changing consumer perception can be difficult, there have been some successes. During the late 1800s and early 1900s, a feather fashion craze led to the killing of a great variety of birds, including pheasants, ostriches, hummingbirds, birds of paradise, herons, egrets, parrots, doves, ibises, and a variety of waterfowl. As some of the species became vulnerable or endangered, organized groups of conservationists in the United States and other countries started a massive campaign to change public perceptions. The campaign was successful and "public outcry" reached such heights that consumer demand was changed and, with support of some protective laws nearly all of these endangered species still exist (Oldfield, 1984). More recently, attempts to change consumer demand for sealskin products by changing consumer perceptions have also been successful.

An alternative to changing consumer perceptions is to maintain captive breeding stocks to meet demand. This alternative is often unsuccessful, however, because it is hard for authorities to regulate the import of non-captives because it is difficult to distinguish between captive and wild individuals.

A number of laws and international treaties play an important role in regulating the import or export of endangered species or their products. The three most prominent laws in the United States are the U. S. Endangered Species Act of 1973 and the Lacey Act (the law's amendment), the Migratory Bird Treaty, and the Marine Mammal Protection Act. One of the most promising international treaties is the Convention on International Trade in Endangered Species of Wild Fauna and Flora— CITES. This international treaty had obtained over 78 member nations by 1982. Unfortunately, this convention is unenforceable and many nations that produce or consume wildlife products have not signed the CITES declaration yet.



Popular Products and Problems

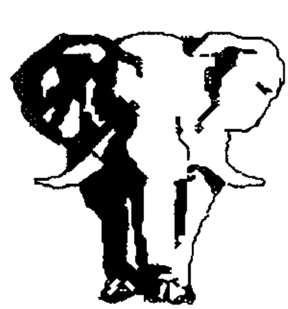
Rare Leather Goods — Reptiles, whose products are used for jewelry, hides, and food, as well as for sport hunting, are some of the creatures most impacted. Crocodile leather, priced at $13/lb in 1970, escalated to $71/lb by 1978. Products made from the leather reach even higher prices. In 1981, American alligator skins boots were going for $2,000 a pair. Yet up to fifty percent of hides that are sold are commercially useless due to inadequate hide preservation techniques. (Oldfield, 1984)

Jewelry— The hawksbill turtle (*Eretmachelys imbricata*) is prized for its fine tortoise shell that is used for jewelry, hair pins and artwork. In the 1930s it was thought that new technologies in plastic might provide an economic substitute for tortoise shell. Unfortunately, the imitations did not possess the beauty of the original tortoise shell and today the hawksbill is an endangered species. (Oldfield, 1984)

Hides— Almost all species of spotted and striped cats, seals and river otters are subject to hunting and poaching to obtain hides for fashion. At least two species of cats are extinct and almost all of the rest are rare or endangered.

Tourist Curios and Collector Items— This grouping of items includes some of the most bizarre and wasteful products whose demand encourages the devastation of a variety of species. Elephant feet wastebaskets, stuffed birds of paradise, and mounted gorilla hands are just a few of the ridiculous curios that exist. Butterfly, shell and coral collecting are also popular habits that threaten the survival of numerous species. Butterfly collecting in Taiwan is a business that supports over 20,000 people. Although Japan is the primary importer, the United States and a number of European countries also contribute heavily to the devastation of species. (Oldfield, 1984)

Ivory Trade— Both raw and worked ivory from Atlantic and Pacific walruses (*Odobenus rosmarus*), African elephants (*Loxodonta africana*), and Asian elephants (*Elephas maximus*), have endangered all these species and amounts to a multi-million dollar business. Prices for elephant ivory have risen from $25/lb in 1920s to $50/lb in '70s. In 1976, consuming nations imported 2.75 million lbs of raw ivory from an estimated 72,300 elephants, at least one-third of which were poached. The United States, also a culprit in this terrible trade, imports up to about 3% of this total, amounting to more than $4.6 million dollars annually. (Oldfield, 1984)



Live Animal Trade— Trade in live animals involves a variety of species, the most common of which are birds, fish, reptiles and amphibians. Over 5.5 million wild birds and several hundred million fish, reptiles and amphibians are traded every year. Not only does trade in these species diminish the species itself but they can also pose threat to human health and endanger native plants and animals. An outbreak of one disease carried in cage birds in 1971 and 1972 in California and New Mexico spread to domestic fowl and the U.S.D.A. had to destroy 12 million chickens and other poultry and pay over $56 million for clean-up of the disease. (Oldfield, 1984)

Plant Trade— Animals are not the only species that are threatened by consumer demand. Plants are also very popular. Check the plants in your windowsill or garden for species such as some cacti and succulents as well as transplanted wildflowers or rare flowering species— you may be contributing to the problem. At the top of the list, are ten species and ten varieties of cory and pincushion cacti, along with two species and eight varieties of hedgehog cacti now endangered or threatened in United States. While some plants, such as ornamentals and barrel cacti are transplanted from their native habitat by individual plant lovers, plant dealers also make an incredible impact. In the southeastern United States, many species of carnivorous plants have been depleted due to over-harvesting. One such dealer decimated one of major populations of green pitcher plants (*Osarracenia oreophila*). In attempting to meet consumer demand for these plants, the dealer managed to eliminate 25% of the known stands of this plant species during one raid on a state park in Alabama. (Oldfield, 1984)

Substitution— Sea turtles, such as the olive ridley (*Lepidochelys divacea*) have only recently been subject to the whims of the spiral of demand. Trade in leather from this species was insignificant until the 1960s when crocodile skins were becoming scarce. The more the supplies of crocodile skins diminished, the more intense became the demand. Sea turtles shared similar skin characteristics as the crocodile and thus they were used as substitutes. (Oldfield, 1984)

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Biological Diversity

Integrated Development

Cooperation is the Key

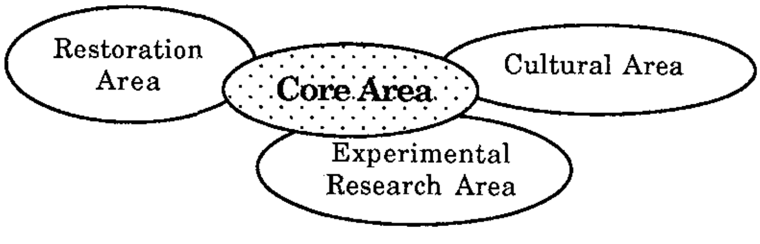
By Pamela A. Wright — The Ohio State University

Preservation of global biological diversity requires the integrated development of a system or network of areas designed to meet the needs of all species. Integrated development is a relatively new concept. Of the few strategies being used, the United Nation Educational, Scientific and Cultural Organization Man and the Biosphere (MAB) system of biosphere reserves is one of the most sophisticated.

The biosphere reserve network is a "coordinated network of protected areas that can conserve biological diversity and demonstrate the value of conservation in improving human well being" (Gregg & McGeans, 1986).

The biosphere reserve concept is structured around a series of zones. The core zone is the backbone of the reserve and is an undisturbed, self-sustaining landscape that exhibits a diverse biological environment. The core zone is used as a baseline for ecology monitoring and as a global benchmark and is often made up of a national park or similar area. To date, eighty percent of all biosphere reserves are composed solely of the core zone area. (Gregg and McGeans, 1986)

Surrounding the core zone are a series of satellite zones including the rehabilitation area, traditional use area, experimental research area and multiple use area. Rehabilitation areas are lands on which managers can demonstrate methods of restoring degraded landscapes. On traditional use areas, conservation and the study of harmonious land uses by indigenous peoples are studied. Experimental research areas may be manipulated and research on managed ecosystems may be studied. The multiple use area hosts cooperation that may include a range of human settlements, forests, range lands and other uses and is managed to achieve the greatest possible harmony with the purpose of the biosphere reserve (Gregg and McGeans, 1986).

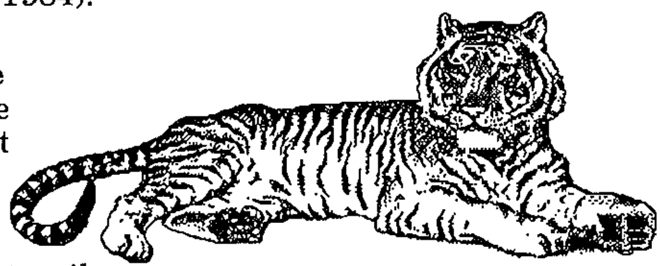


The biosphere reserve has in common, nationwide, a "cooperation among people," locally, regionally with nearby reserves and internationally. This cooperation is the key to the biosphere's success. The endangered desert tortoise, a resident of Mexico's Mapimi Biosphere Reserve, was recently threatened by local campesinos who hunt the turtles for meat. With government and scientific support, a program was developed to improve locals means of subsistence in turn for assistance in conservation (Gregg and McGeans, 1986).

Other strategies of integrated development being used include the 1980 World Conservation Strategy and a few very successful grassroots efforts.

The World Conservation Strategy was a cooperative effort of the International Union for the Conservation of Nature, World Wildlife Fund, United Nations Environment Program, Food and Agricultural Organization and United Nation Educational, Scientific and Cultural Organization organizations. The strategy was based on three propositions: 1) species and populations must be helped to retain their capacity for self-renewal; 2) basic life-support systems of the planet, including climate, the water cycle and soils must be conserved intact if life is to continue; and 3) genetic diversity is the major key to the future and it must be monitored (Myers, 1984). Although fewer than 30 countries ever adopted the strategy, some countries like Nepal are actively involved in implementing the World Conservation Strategy. Nepal proposes a reorganization of its government in order to integrate conservation with development and hopes to accomplish at least three specific things: tap natural resources to generate hydroelectric power to reduce fuelwood dependency; apply new technology to increase agricultural productivity; and reforest land for fuelwood and to prevent soil erosion. The Royal Chitwan National Park in Nepal, another element of the new conservation strategy, was designed to protect such species as the rhino, tiger and gharial. In addition, planting of thatch grass throughout the park slows down river bank erosion and supplies a profitable harvest for local people (Myers, 1984).

In the Northern Philippines, terraced rice combined with tree-lined roads in an atte increase biological diversity and prevent soil erosion. Roadside plantations in progressive heights provide excellent habitat for game species and lift the wind away from the fields in order to prevent soil erosion (Myers, 1984).



One of the most successful stories of integrated development can be credited to the Chinese who are not only making great steps in protecting elements of their natural biological diversity but also feeding their once starving populations. The Chinese model employs a system of "ecological agriculture," which among other things has introduced alternate cropping and symbiotic cropping on a national scale. Plant productivity is up, and dependence on harmful fertilizers and pesticides is down dramatically (Myers, 1984).

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Biological Diversity

Fact Sheet 17

Intensive Management

Doing the Most for the Least

By John W. Hanna and Pamela A. Wright — The Ohio State University

The people who drafted "to preserve and protect in such manner and by such means as to leave them unimpaired for the enjoyment of future generations" probably did not have in mind embryo transfer, artificial insemination, cryobiology, gene banks, or captive population management. But today those and other actions are increasingly called for to protect endangered species and hopefully lead to their reestablishment in national park areas and other preserves.

Intensive management of select species involves the widest variety of management techniques and biological advances to save remnant patches of habitat or last individuals of endangered species. It often becomes a case of doing the most for the least in terms of raw numbers. But, in terms of importance to ecosystems it often is the only hope for return to a naturally functioning ecosystem.

A major function of zoos is the captive breeding of endangered animals. Many arboretums cultivate endangered plant species. Preserves are set aside in many cases to protect endangered species. Today, our tools are becoming more sophisticated and interest and involvement in management of select species is much broader based.

As you look around a parking lot you are likely to see a bumper sticker with a panda or a decal with a sea turtle. Your mail is likely to bring an appeal from the "Save the ______" fund. Most governmental natural resource agencies and many associations have gotten into the business of intensively managing select species.

Save the Whales

The Who's Who of select species relevant to the national parks reads like a bitter memory giving away to cautious hope. Here's a list of some of the species receiving intensive management in the U.S.:

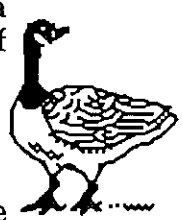
- California condor
- black-footed ferret
- red wolf
- musk oxen
- tule elk
- desert bighorn
- peregrine falcon
- Gila trout
- Kemp's Ridley sea turtle
- nene

Black-footed Ferrets (*Mustela nigripes*)

The Black-footed ferret is receiving a great deal of attention. This small weasel-like animal lives in ground burrows, eating prairie dogs and the like. Thought to be extinct in 1965, this creature was supposedly driven to extinction by a reduction in food and poison set out by ranchers for prairie dogs. In 1981, hope for the Black-footed ferret was resurrected when one dead animal was found. Now, the population, which is suspected to number around twenty-two animals, is the target of an intensive wildlife preservation effort. The combined efforts of the U.S. Fish and Wildlife Service, the local Wyoming Fish and Game department and a private group of researchers are tracking down these elusive creatures and attempting to provide suitable habitat. Under the Endangered Species Act, a joint team of Wyoming Fish and Game employees, landowners, state officials, federal land managers, biologists and statisticians are working to protect land in critical areas, and using telemetry to monitor and learn more about the ferrets status and life cycle. Each year, more and more ferrets are sighted and although the uphill battle is steep progress is being made. (Nice, 1983)

Nene - Hawaiian Goose

The Nene, the state bird of Hawaii, is undergoing intensive management both inside and outside Haleakala and Hawaii Volcanoes National Parks. The Nene, whose closest living relative is the Canada Goose, is a non-migratory species whose numbers have plummeted because of its popularity as a food source and the introduction of alien species. Alien species are not only competitors for food but are also direct predators. Although populations of this goose were originally found on several of the Hawaiian Islands, it became extinct on Maui in 1890 and in 1950 there were only 30 remaining birds on the big island of Hawaii. Several captive breeding programs both in Hawaii and in Slimbridge, England have been fairly successful with over 2000 young raised in captivity from four breeding pairs. And although more than five hundred of these birds have been released in the wild, only one-third are still alive. Habitat loss, alien competition and introduced predators still plague the Nene. In 1972, the National Park Service began managing those Nene released in Haleakala and Hawaii Volcanoes National Parks. Trapping predators and fencing boundaries from feral animals are a few of the methods being used in the attempt to save the Nene from extinction. (Boll, 1987)



Red Wolf (*Canis rufus*)

The red wolf was declared an endangered species in 1967 due to loss of habitat and bounty-prompted killing. This wolf, whose species or sub-species status is often questioned, faces a severe problem because of inbreeding with the coyote.

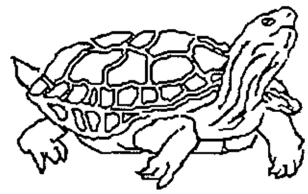
The gene influx from crossbreeding has threatened the genetic integrity of the remaining animals and made management of this species incredibly difficult. In 1972, the U.S. Fish and Wildlife Service decided on a recovery plan that included captive breeding in order to control inbreeding. Five hundred of the remaining animals were captured and brood stock was selected carefully. Of those captured, only 40 animals were deemed pure strain *Canis rufus*.. These were bred and of the resulting 220 pups, one-third were considered hybrids and one third died. The original breeding program at Point Defiance Zoo in Tacoma, Washington, distributed the healthy red wolf pups to a number of different zoos and breeding areas to ensure that the population would not be wiped out if an epidemic struck. Experimental releases of captive bred animals on Bulls Island in South Carolina in 1976 and 1978 were very successful and so a search began for a proper release site and protected area. Prudential Insurance donated 118,000 acres of excellent habitat in North Carolina. This area of land, the Alligator River National Wildlife Refuge (1984), was the site of several successful reintroductions of red wolf. The red wolf's future is still tenuous. Good land for other populations is hard to find for the unpopular wolf and the coyote still pose a significant threat. (Cohn, 1987)

Gray Wolf (*Canis lupus*)

A second wolf species, the gray wolf is currently the subject of an intensive management project in Yellowstone National Park. Gray wolves were all but eliminated from the park as of 1927 under a national policy of extermination. Listed in 1973 as an endangered species in all areas of the United States except Minnesota, studies suggested that the remaining creatures in Yellowstone were not sufficient to maintain a viable population. The Yellowstone project included the development of the Northern Rocky Mountain Wolf Recovery Plan that works on the principles of management by zoning. The development of the management plan and its implementation requires intensive public involvement and education. To date, a number of studies examining concerns of local inhabitants and support for the wolf recovery program have been conducted. (Bishop, 1987)

Kemp's Ridley Sea Turtle (*Lepidochelys Kempii*)

The Kemp's Ridley sea turtle is the smallest, rarest, and most endangered of all sea turtles. It is suspected that fewer than 1000 adults are alive. A highly migratory species, these turtles take 7-10 years to reach reproductive maturity and then return to their hatching area to lay eggs. Padre Island National Seashore is participating in intensive management of this species for ten years in cooperation with the Mexican government. In the typical cycle that has been going on for ten years, eggs are gathered from turtles in Mexico and hatched at Padre Island. Hatching success varies from year to year and although they have yet to confirm the return of any mature turtle to Padre Island, the first batch of hatchlings would just be reaching maturity this year. (Shaver, et al., 1987)



Success Stories

Two subjects of intensive management, the Musk Ox and Gila Trout, provide hope for other species. The Musk Ox, over-harvested in the 1800s and extirpated from the Alaskan tundra in 1865, is now successfully being returned to its original range. Thirty-four animals were acquired from Greenland and were bred on Nunwak Isle, a federal reserve in Alaska. These hardy creatures are very successful breeders and to date over 750 of them have been transplanted to a number of locations were they are being carefully managed (Newsom-Brighton, 1984). The Gila trout, found only in the Gila River in New Mexico has been listed since 1973 as an endangered species. Introduction of non-native brown and rainbow trout species created competition for food and habitat and reduced the trout to 5% of its historic range. Intensive management of this species has involved enhancement of the population by hatchery rearing of four of the five remaining populations. These fish were then transplanted into suitable habitat in order to build the population. The Gila trout is the only wild native trout in the Gila and Aldo Leopold Wilderness areas and it is hoped that the population will eventually be healthy enough to support fishing. It is expected that the trout's status will be down-listed to threatened species by April of 1989. (US-F&WS, *The Gila Trout* 1986)

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Keystone Species

By Kim A. Palmer — The Ohio State University

Many times during an interpretive program it is easy to point out animals and plants that play significant roles in an ecosystem. People are familiar with popular animals like the wolf, grizzly or bald eagle as predators, brightly colored fungi helping to decay logs and leaves or deer, antelope or moose as integral links in the food chain. Often, however, an interpreter or communicator is stumped by the visitor question "but what good are ticks?" or "would we really miss bats?" The John Muir quote "when we tug on one thing in the universe we find it attached to everything else" may be too abstract to satisfy these inquiries.

What if the "bat we really wouldn't miss" is the cornerstone of a $120 million dollar industry? Or if the disappearance of one species could result in the collapse of an entire ecosystem? A new theory exploring the roles of keystone species may help visitors better understand the importance of all parts of our planet.

Many scientists are concluding that while all living things in a natural community are interdependent, a few plants and animals hold a more vital position in their communities than others. These organisms are called keystone species by some scientists because they are critically linked to a number of other organisms. If one of these critical species were to become extinct it might lead to profound change within an ecosystem.

To put it another way, think of each species of plant, animal, fungus, mold, etc. as a rivet in the body of an airplane. Some rivets can be removed without much effect on the overall performance of the plane. However, pop one rivet that is located at a critical junction and the passengers are no longer safe.

Some species of bats are keystone species for many tropical areas. These important mammals are critical pollinators and seed dispersers for wild avocados, bananas, cloves, cashews, breadfruit, figs, dates and mangoes (Sunquist, 1988). In southeast Asia, the local people harvest millions of dollars worth of the strange-smelling durian fruit from wild and semi-wild durian trees (Sunquist, 1988). The flowers of this tree open only at night and are pollinated almost exclusively by the dawn bat. Without this keystone species, the local economy and the ecosystem on which it is based would no longer exists as we know it.

Closer to home is another example of the importance of keystone species. The sand hills of the southeastern United States would be inhospitable territory for the majority of animals if it were not for the local excavator. The gopher tortoise, while digging its own burrow, provides shelter for residents ranging from the temporary tenant grey fox to the permanent leasees like the Florida mouse and gopher frog. Other burrow borrowers include diamondback rattlesnakes, crickets, indigo snakes and oppossums (Sunqist, 1988). In areas where the gopher tortoise has been extirpated, 37 species of invertebrates no longer exist and the gopher frogs and Florida mice are few and far between. Recognizing the significant role of this "dinner-plate sized reptile" (Sunqist, 1988), the Florida Game and Fresh Water Fish Commission designated the gopher tortoise as a "species of special concern." New regulations as a result of this special designation ban commercial sale and hunting of this valuable digger and a permit is now required to keep the tortoise as a pet.

Another example of a "critical rivet" is found along the Pacific Northwest coast. The once deteriorating kelp forests and sea grass beds are beginning to make a comeback thanks to the reintroduction of a keystone species. Sea otters, hunted to the brink of extinction for their fur and maligned by the abalone industry, played an essential role in marine pest control by dining on the sea urchin (and other shellfish such as abalone, crab and mussels). The sea urchin thrived with the depletion of the sea otter population, thus rapidly munching away at the kelp beds and sea grass beds–critical areas for spawning, feeding and shelter for many marine organisms (Sunqist, 1988). Now, with the return of this critical keystone species, the sea otter, these valuable plants are growing over once barren areas and the marine invertebrates, fish, harbor seals, sea lions, bald eagles and osprey have returned.

Not all biologists agree with the concept of keystone species because of its oversimplification. Many believe that as we become more aware of the details of each species and its role, we will find that all species are keystone. We simply do not have the information to categorize species as expendable or keystone (Sunqist, 1988). With the majority of the species still unknown, the best we can do is to save "all the rivets."

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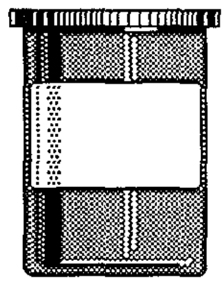
Medically Valuable Species

By Kim A. Palmer — The Ohio State University

One of the most frequently heard arguments for the preservation of biodiversity is the medical value of plant and animals. This argument is effective because about half of the world's medical compounds are derived from natural ecosystems. As an issue, this touches just about everyone's life. Few people have never reached for aspirin or needed a pain killer at one time or another. In addition to the medical contributions, these plant-derived drug products are major contributors to the human health services sector of our economy—this contribution is estimated at $8 billion in U.S. and $40 billion worldwide (Oldfield, 1984). This estimate does not include the non-prescription drug market, veterinary medicines or illegal drugs.



A fungus among us is cause for celebration when discussing medically valuable biological resources! Throughout history people have used molds and fungi for their curative powers. Chinese and European midwives used ergot (*Claviceps purpurea*), sometimes called smut-of-rye, to speed delivery and to inhibit hemorrhaging associated with childbirth (Oldfied, 1984). Although ergot is no longer approved in the United States, its alkaloids, especially ergonovine, are valued for the treatment of hemorrhaging after cesarean operations.

Moldy bread for a bandaid may not be considered "healthy" by today's standards, but ancient Egyptians applied moldy bread to open wounds for centuries and the Chinese recognized the value of green (blue) molds for festering ulcers. It wasn't until the 20th century that *Penicillin* molds were utilized as a source of antibiotics. This very familiar antibiotic was derived originally from *Penicillium notatum* but with the onset of WWII, the demand for penicillin could not be met. Luckily, a cantaloupe harboring *Penicillium chrysogenum* was found by a U.S.D.A. researcher. This species is much more productive.

Our forests abound with medical wonders and probably even more are yet to be discovered. In temperate forests, the National cancer institute has made progress in developing anti-cancer drugs from yew, *Taxus spp.,* and may apples, *Podophyllum peltatum*. American hellebore (a lily), *Veratrum viride*, was used by pioneers and native Americans for curative purposes. Now an alkaloid mixture or powdered rhizome from this plant is used to treat hypertension and in emergency situations such as hypertensive toxemia during pregnancy or pulmonary edema (fluid in the lungs). The temperate forests of central and southern Europe are home to wooly foxglove (*Digitalis lanata*) which is a source of digitoxin. It is estimated that three million people suffering from heart disease use digitoxin as treatment.

The tropical forests of our world are truly an untapped medicine chest. Already hundreds of plants have contributed to improving our health. Wild stands of mexican yams, *Dioscorea spp.,* produce 95% of our hormonal drugs (Oldfield, 1984). Familiar drugs in this category include cortisone, hydrocortisone, oral contraceptives, and six hormones (ie: androgens, estrogens and progesterogens). The opium poppy, *Papaver somniferum*, produces opiates used as ancient painkillers. Today, codeine and morphine derived from this poppy species, are contained in about two percent of U.S. prescriptions. *Brucea antidysenterica* is a small tree growing throughout the tropical African highlands, but is only abundant in Ethiopia. This tropical plant is the source of the anti-cancer compound *brucia antid.* (Oldfield, 1984)

Probably the most well-known tropical plant to contribute to modern anti-cancer drugs is the red or Madagascar periwinkle, *Catharanthus roseus.* First researched as a treatment for diabetes, the red periwinkle is now the source of vinblastine and vincristine. These drugs are treatments for testicular, cervical and breast cancers, Hodgkin's disease, Wiln's tumor, malignant melanoma and childhood leukemia. (Oldfield, 1984)

Recent exploration of our oceans has lead to exciting and very valuable medical discoveries. A Caribbean sea sponge, *Cryptotethya crypta*, is a source of adenine arabinoside or Ara-A, which offers relief for pinkeye and other virally induced eye infections such as those caused by *Herpes simplex vinisea.* Due to their long relationship with the marine environment, the Japanese have used sea life forms in their folk medicine for centuries. Tetrodotoxin, a drug 160,000 times as potent as cocaine for blocking nerve impulses, is extracted from certain puffer fish, porcupine fish and ocean sunfish. It is currently used in Japanese clinics as a muscle relaxant and local anesthetic for terminal cancer and neurogenic leprosy patients (Oldfield, 1984).

Many other toxic marine animals have been investigated for their pharmaceutical value. A great number of warm-water toxic marine animals such as sea anemones, sea squirts, sea cucumbers and nudibranchs are providing us with substances that produce antiviral, antibiotic, antitumor, analgesic and other medically valuable effects.

Terrestrial animals also contribute to such pharmaceutical uses as well. In the early 1970s, anticancer activity was found in four percent of the extracts of 800 species of insects, spiders, crustaceans, millipedes and centipedes! The Asian butterflies, *Prioneris thestylis* and *Catopsilia crocale*, along with a Taiwanese stag beetle, *Allomyrina dichomotus,* offered the most promising anticancer compounds (Oldfield, 1984).

Animals also provide us with valuable research opportunities. While many groups argue the humaneness of this practice, many important medical breakthroughs have been discovered by using animals for research. Elephant seals at Ano Nuevo Point Reserve in California may offer insight in how to treat infants at risk for Sudden Death Syndrome (SIDS). By observing these seals' metabolism, heartrate, blood chemistry and brain waves during sleep, important applications for treating sleep-related breathing disorders in humans may be discovered (Steinberg Gustafson, 1988). Cotton–topped marmoset monkeys are excellent experimental animals for developing vaccines against a cancer similar to Hodgkin's disease that is caused by a Herpes virus. Fruitflies, mice, Guinea pigs, wasps, salamanders, sea urchins and butterflies are just some of the many animals that enabled scientists to understand genetics and embryology. This information has helped fight birth defects and diseases such as mongolism, Tay-Sachs disease and sickle-cell anemia (Ehrlich, 1981).

Certainly the use of animals for the aid of human health raises many moral issues that not all biologists, scientists, doctors or concerned citizens agree upon. Exploitation of animal and plant resources needs careful monitoring.

Many species act as "miner's canaries" due to their sensitivity to environmental changes. These indicator species include lichens that are highly sensitive to air pollution, sensitive aquatic insects like the mayfly and caddis fly species affected by water quality. The loss of these species can be, as explained by Paul and Anne Ehrlich in Extinction, "...like letting the batteries in your smoke alarm run down."

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Natives vs. Alien Species

Alien Invaders: Nothing Fails Like Success

By John W. Hanna — The Ohio State University

Contrary to the old saying "Nothing succeeds like success," it seems like species introduced into new environments often succeed to the point they fail—they replace the natives. Introduced species are often referred to as exotics or aliens. They occur in a given place, area, or region as the result of direct or indirect, deliberate or accidental introduction of the species by humans. The introduction permits the species to cross what previously was a natural barrier to its dispersal.

The alien species has not always been the target for natural resource managers that it is today. Alien introductions have often been viewed as salvation for problems brought on by changes in habitat. The conversion of the prairies from grassland to cropland spelled near doom for the prairie chicken. The Chinese ring-necked pheasant served as a useful replacement for hunters.

Introductions of aliens are not always a result of a contemplated action. They are often failure related to some other action. The blue pike, blackfin cisco, deepwater cisco, and longjaw cisco are all now extinct due in part to the inadvertant introduction of the alewife, rainbow smelt, and sea lamprey to the Great Lakes. Environmental assessments were not required as a part of the lock and canal projects that linked the lakes and permitted the introductions. Competition and predation by these introduced species put an end to the four native species and contributed to the decline of the Great Lakes fishery.

Organisms living on isolated islands are another testimony to our saying "Nothing fails like success." Hawaii is littered with the successful failures of Captain Cook and others. With Cook's arrival in 1778, the islands were soon infested with cattle, sheep, pigs, goats, horses, cats, and rabbits that had been released by the sailors. Grazing and the clearing of the virgin forests for agriculture destroyed habitat and the newly introduced predator, the cat, might be said to have upset the balance. Of the approximately 70 known endemic species and subspecies of Hawaiian birds, 24 are now extinct and 30 are endangered. (Culliney, 1988)

While not this extreme, most of the national parks have problems with alien species. The NPS policy on aliens states: "Non-native plants and animals are discouraged in national parks and as a general policy, exotic [alien] species should continue to be discouraged until they are eradicated. Special circumstances may require short- term tolerance or use of non-native species." The policy and treatment of non-natives within ecosystems, out of necessity, often has to be flexible. In some cases, the non-natives have developed an important ecosystem function that no other native species can provide. Protection of a non-native species may even be required where it supports endemic, rare or endangered species.

The tamarisk or salt cedar was introduced to the United States from Africa for erosion control. It quickly spread and now forms dense thickets throughout the Southwest along creek bottoms and lake shores at low elevations. The habitat it forms is thought to have accounted for the tremendous increase in small bird populations in Glen Canyon NRA. This appears to have accounted for a substantial population of naturally reproducing peregrine falcons in the area. If the tamarisk is shown to be increasing along with the small bird population and peregrines, which takes priority—control of an alien or naturalized enhancement of the habitat/prey base for an endangered species?

Other situations with aliens in national park areas are a bit easier to answer but just as difficult to manage. In the U.S. Virgin Islands' Buck Island Reef National Monument, introduced Norwegian rats and mongoose prey on endangered sea turtles and other native species. The rats arrived in the Caribbean as early as the 1500s with timber harvesters. In the late 1800s, sugar plantation owners introduced the mongoose to control the rat. Surprise! The rat's nocturnal lifestyle was almost perfectly compatible with the mongoose's diurnal/crepuscular schedule and the two preyed happily away. Today, their egg robbing habits and taste for sea turtle hatchlings result in a survival rate of 1%. Rat-specific poisons and trapping are necessitated to control this successful failure. (Mills, 1987)

Purple loosestrife has invaded marshy areas of Acadia National Park. This native of Europe was introduced in the 1800s and having no natural controls has done extremely well. Its tendency to spread quickly means it crowds out the native plants valuable to waterfowl and other wildlife. Eradication is painstaking. When the plant is mechanically pulled, roots sprout and grow many more plants. EPA approved herbicides are used on a plant by plant application basis for control. (Hazen, 1988)

Kudzu is not just a cartoon character in the newspapers. This plant seems to eat roads, buildings, and telephone lines. Anything that gets in the way of this Japanese ornamental gone astray gets covered. Do not turn your back on this one. Kudzu can grow 12 inches per day and 50-100 feet in a season smothering vegetation that wildlife depended on in the process. Most southeastern NPS areas either host or can expect Kudzu. (Freeman, 1988)

Shenandoah N.P. and other eastern areas are the recipients of another highly successful immigrant, this one from Europe. The gypsy moth was introduced in the mid-1800s and is gradually spreading throughout eastern Canada and the United States. The caterpillars repeatedly defoliate Shenandoah trees like the oaks and hickories. Losing their leaves is similar to humans going on a one-month fast every year. Eventually, it's going to take its toll. Tree mortality is up, wind and ice storm damage has increased, and mast production is drastically reduced. This threatens the survival of mast-dependent species like squirrels and deer (Lindsay, 1987. Biological insecticides have been used with some success by the Ministry of Natural Resources in Ontario and other areas. But, what will the long term effect be of this type of control? Does the present risk to an ecosystem like Shenandoah warrant taking the long-term unknown risk? In Shenandoah N.P. they have decided not to take the risk but control of aliens constantly poses this type of question.

In many cases, where the decision to control aliens has been made, the results have been satisfying and the environment has been moved toward a more "natural" condition. Through stringent controls on anglers, many western waters like those in Rocky Mountain National Park remain free of the Eastern brook trout after treatments. Native populations of greenbacks and cutthroat have been restored to some park areas. The control of burros in Grand Canyon may eventually permit the desert bighorn sheep to reestablish their former numbers if human emotional attachments to the "cute" burros can be overcome.

The repeated successes of aliens have traditionally pinpointed our failure to anticipate, regulate, and manage. Today, the recognition of those failures influences our actions in the complex decisions ahead.

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Biological Diversity

Origin and Distribution of Crop Species

Our Agricultural Supermarket

By Pamela A. Wright — The Ohio State University

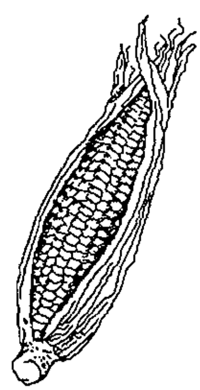
Imagine your supermarket had only one brand of each product. Diverse human requirements like allergies, diets, tastes, religious requirements, or cost could not be addressed. Free markets have responded to avoid this monopolistic supermarket and we have even passed laws to further ensure a diversity of products on our supermarket shelves. Unfortunately, we have failed to apply these same principles to ensure a diverse agriculture. A supermarket that contained our present day food crops would show little variety. If we fail to respond to maintaining our genetic crop diversity, our food crops will disappear, one by one, from these supermarket shelves.

Of the approximately 350,000 plant species on the earth, one out of four possesses potential food value; out of those, we use only one of thirty; out of those we only cultivate one of twenty. That leaves only about 150 commercially cultivated plant species worldwide.

Plant geneticists have determined that almost all of our present day food crops have ancient origins that can be traced back to specific crop gene centers. These gene centers, of which seven are in or around the Middle East and five are in or around Central America, are areas that contain evidence that these are the origins of the plants' oldest relatives.

Most of these plants were domesticated starting around 10,000 B.C. As the wild species were domesticated and the crops were transferred from environment to environment, the genetic diversity of the crops actually increased (Wilson, 1988).

This means that the plant species differed in a variety of physiological characteristics including: the amount of sunlight needed (photoperiodicity), salinity, resistance to drought, pests and disease, and the reproductive or breeding mechanisms (Wilson, 1988). The variation within these species and their relatives, both wild and weedy, allowed the plants to adapt to a variety of environmental conditions.



Since 8,000 B.C., however, we have been narrowing our food producing options. While over 80,000 plant species may have potential as food producers, many of these have become extinct or endangered. Of some of those that remain, the variation in the population may have been reduced so greatly that cultivation of these species, in different environmental conditions, may never be successful. Until today, industrialized countries, such as the United States, have encouraged an agricultural monoculture because it is simpler and more economical in terms of pesticide and fertilizer application, watering requirements, planting, harvesting and manufacturing. Even worldwide, agriculture depends almost entirely on 30 major crops of which seven of these; wheat, rice, corn or maize, potatoes, barley, sweet potato and cassava, are the staple foods of the world. We have become "utterly dependent on the genetic integrity and continuing evolution of only a few crop plant species" (Oldfield, 1984). While the elimination of habitat is responsible for eroding some of the genetic diversity of crops, the survival of these crops are also threatened by the monocultural system we allow to dominate our fields.

Our history shows us the devastating effects of dependence on a monoculture to perpetuate. The European and Irish potato famines in the 1840s were caused by a disease that affected only one species of potato. The death of over two million people, and the emigration of several million more to the United States and other nations was caused by the development of a potato monoculture.

More recently, and closer to home, a corn leaf blight in 1970 led to a one billion dollar loss and a reduction in productivity of over 710 million bushels of corn (Oldfield, 1984). This blight was severe because three-quarters of the corn crop land within the United States was planted with one economically efficient variety of corn, which was also highly susceptible to one particular disease (Oldfield, 1984).

Each time an epidemic, such as the potato famine or corn leaf blight, has hit, we have turned to our stored stocks of plant genetic resources to revitalize agriculture. Time, however, is running out for these vital storehouses.

The future of wheat (*Triticum spp.*), one of our most important staple foods, is now threatened because we have allowed the extinction of the plant's wild and weedy relatives. These extinctions mean that we have seriously limited the plant's genetic resources and our ability to improve wheat varieties and to extend its growing range. Future global climatic changes may have a grave effect because of our dependence on wheat.

It's not just wheat that is in serious trouble. Within the United States alone, more than 160 wild relatives of crops and 150 relatives of forage plants are listed as endangered or threatened (Oldfield, 1984).

The International Board for Plant Genetic Research (IBPGR), part of the the Food and Agricultural Organization, is one agency devoted to halting this genetic erosion by maintaining gene banks and conservation centers of 50 major crops (Wilson, 1988). These gene bank resources are used in agriculture in order, to select particular species or varieties of plants to adapt for domestication and to genetically improve these plants and others (Oldfield, 1984). For example, gene resources from a newly discovered weedy relative of the tomato were recently crossbred with the common tomato. The result was a new tomato variety with significantly elevated sugar content that makes it more nutritious and flavorful and also more resistant to disease and other pests (Wilson, 1988).

We must work to maintain our agricultural equivalent of a diverse supermarket. Preserving the genetic diversity of our present food crops, their relatives, and other potential food crops will enable us to maintain crop variety and subsequently, crop vitality and health.

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Biological Diversity

Fact Sheet 22

Planetary Maintenance Systems

Biological Diversity Building Blocks

By Pamela A. Wright — The Ohio State University

At the base of every house, school, church and skyscraper is a foundation. Similarly, there are building blocks that started and maintain life on our planet. These building blocks are not composed of cement, brick, or stone but rather of biological diversity. Plant and animal species comprise the very structures which make human life on this planet possible. No one species provides any or all of the elements of this foundation. Rather, they work somewhat like a set of tinker toys, erector sets or linkin-logs. If all the basic building blocks are present, in the right proportions and right arrangement, the remainder of the structure can be constructed and will remain solid.

Photosynthesis

Photosynthesis is a biochemical process whereby green plants use the heat energy of the sun to make simple sugars and oxygen out of carbon dioxide and water. In turn, animals breath oxygen, release carbon dioxide and store the energy, passing it up the food chain until it is returned to the soil for plants. Blue green algae, the first photosynthesizer in the evolutionary process, released oxygen into the atmosphere. The oxygen not only allowed for other species to live but it formed a protective layer of ozone around the earth that shields us from harmful ultraviolet rays.

Nutrient Cycle

The energy created in the process of photosynthesis, progresses through successive layers of the environment. The primary producers of this energy, the photosynthesizers, are consumed by secondary and tertiary consumers in the ecosystems. Because energy is neither created nor destroyed, the energy produced by the photosynthesizers makes its way to the top species until it inturn dies. The decomposers make the final link by breaking down the species and returning the energy and elements to the soils and waters where they will be recycled.

Water Cycle

As much as 97 percent of the water on earth is saltwater and of that which is freshwater, most is stored in an icy state. The remaining one percent of freshwater is circulated by the power of the sun. Plants transpire some water, some runs into ground water storage while the remainder runs back into the oceans. The flow of the water, is regulated by the vegetation. Remove the vegetation and a cycle of flood, erosion, and drought will follow among other equally life-threatening events.

Nitrogen Cycle

Nitrogen is a necessary element of life. Although there is a huge store of atmospheric nitrogen, it is inaccessible to most creatures. Life on earth depends on a small bacterial algae that fixes the atmospheric nitrogen and converts it to ammonia. The ammonia can then be used by animals and plants to build amino acids and then proteins. Finally, decomposers break down the nitrogen again and denitrifying bacteria release the free nitrogen into the system.

A significant loss of our biota in numbers or in populations would create an effect similar to removing the supporting structures of a building. Small scale illustrations of this fragility foreshadow our possible fate if we continue to allow the destruction of our biological diversity.

In Etoska National Park in southern Africa, a small disturbance in the foundations had huge ramifications. Gravel pits, dug within the park boundaries to permit road construction, filled with rainwater and became stagnant and alkaline. Anthrax bacteria began to thrive there and wildebeest and zebra who came to the new watering holes sickened. These creatures became easy prey to lions and spotted hyenas who in turn saw a massive increased in numbers. Anthrax resistant eland populations and declined from the increase in lion populations while springboks, also anthrax-resistant, increased in numbers because of lack of competition for grazing habitat. A seemingly small-scale disruption turned this ecosystem upside down. Fortunately, the anthrax bacteria will die out and the environment will probably return to near normal conditions. (Durrell, 1986) But what about the bigger picture? Threats to our planetary blocks would create situations much more severe.

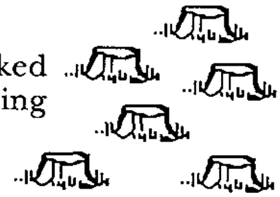
Soil Loss — It can take 500 years to create just one centimeter of soil, yet improper conservation techniques, lack of run-off controls and wind breaks can sweep away that soil in less than a year. It is estimated that 13 million hectors of arable land are lost world-wide annually through erosion. (Durrell, 1986)

Deforestation — The plant cover of forested areas not only creates habitat for a variety of species but also produces oxygen, controls erosion and regulates run-off. Deforestation in all countries, not just tropical rainforests may lead to global climate change. (Durrell, 1986)

Pollution — Pollution refers to those substances not normally occurring in the environment or at high levels in the environment. Substances such as DDT, Dieldrin and a variety of other insecticides as well as heavy metals, aluminum and mercury. Species are not accustomed to the presence or levels of these substances and have no natural defense against them. (Durrell, 1986)

Eutrophication — Nitrogen, phosphorous and a variety of other elements help plants and animals grow. In the wrong places, however, these elements can have severe impacts. Fertilizer, vehicle exhaust, and sewage effluent all add large concentrations of these elements to the water runoff. The effects of these concentrated levels are algae blooms, discoloration of water, odors and diseases, and decreased levels of water oxygenation. (Durrell, 1986)

Desertification — A variety of factors including climate change, overworked lands, salinated lands, deforestation, altering of water tables and overgrazing cause desertification. A large area of land in the tropical and subtropical zones of the earth, totaling approximately 28 percent of all ice-free land, is currently threatened by desertification. (Durrell, 1986)



Greenhouse Effect — Increases in CO-2 caused by deforestation and the burning of fossil fuels create a layer around the earth that traps more heat and subsequently increases the earth's temperature. (Durrell, 1986)

Genetic Erosion — Genetic material is used to discover new medicines, foods, products and cross-breed our crops. Maintaining our genetic erosion is an "insurance for our future" (Durrell, 1986).

Maintaining our biological diversity is paramount to maintaining a healthy foundation for our planet. The IUCN World Conservation Strategy's three objectives—to maintain the essential life support systems of the planet, to preserve genetic diversity, and to ensure sustainable use of species and ecosystems—provide a global framework from which to work to maintain our planet's foundation. Individual action, not just governmental action, is required.

"Life itself controls the physical and chemical conditions of the Earth's surface, the atmosphere and the oceans, to make and keep them fit for living" GAIA Hypothesis

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Biological Diversity

Restoration of Ecosystems

By Pamela A. Wright — The Ohio State University

Several hundred years of human settlement have drastically altered ecosystems. In some places, entire plant and animal communities within these ecosystems have been changed. In other areas, keystone species, those that play a pivotal role in regulating an entire ecosystem, has been removed (Johnson, 1984). Introduced species, differing land management techniques, over-harvesting, and habitat loss have altered ecosystems to such a degree that these species can no longer function in their original ecosystem. The restoration of these ailing ecosystems not only helps preserve our biological diversity but may also be necessary to maintain the health of the local environment. The process is however, very difficult. Ecosystem restoration is like taking the trampled parts of a watch and putting them back together to make a working watch when some of the parts are missing or lost. Failure to reconstruct any part of the watch, or an ecosystem correctly will cause it to function improperly. (Bradshaw, 1980)

Natural Habitat Recovery

In the western grazing lands of Montana, overgrazing by range cattle on stream banks is causing severe erosion. Streams deepen into gullies, water tables drop, surface soils dry up and ranges become parched, and the increased sedimentation creates habitat unsuitable for native rainbow and cutthroat trout. The situation is so bad that only two percent of the stream banks in the area still exist in their natural state. Wildlife biologist Greg Munther, of the U.S. Forest Service, is using a simple and inexpensive technique to revitalize and restore the riparian ecosystem. The solution is a former resident and nature's architect, the North American beaver (*Castor canadensis*). Beavers dam the streams and create soft mucky banks that are not susceptible to erosion. The cattle skirt the edges of the streams and find more lush forage in the surrounding moist meadows. These expanded streams create a mosaic of habitat that invites the return of other natives like muskrats, birds, moose, and the caddis flies, which serve as food for trout and other fish.

Although this particular restoration process is relatively easy, it is not without its own battles. Beavers have received wide-spread bad press in the past and biologists must work to convince landowners that this 'nuisance animal' may save their range lands. Additionally, some of the stream beds where the beavers were to be introduced did not have the appropriate food and resources for dam building. Initially, biologists imported aspen trees. However, the industrious beaver was just as satisfied with the a later resource for building — old tires !! (Johnson, 1984)

National Park Restoration

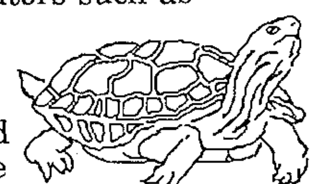
Restoration of ecosystems in our National Parks is not a new phenomena. The earliest project, in 1902, restored bison to Yellowstone National Park and several elk projects followed in 1913 and 1914 in a variety of parks including Rocky Mountain, Mesa Verde, Wind Cave and Crater Lake.

One of the oldest restoration projects in the United States is taking place at Homestead National Monument in Nebraska. This restoration project, which was started in 1930, is concerned with prairie restoration. Complex cycles of plantings and periodic burnings are being used to restore the native prairie and remove the exotic weeds. Prairie restoration projects are fairly popular — at least nine other parks, most of them cultural, are working to develop and maintain prairie vegetation. (Shelton, 1988)

By far the largest restoration project, the restoration of redwood forests in Redwood National Park and surrounding lands has attracted enormous public attention and federal monetary support. Over 36,000 acres of land had been logged and the erosion from the haul roads was causing increased siltation in streams that was hindering spawning, raising the water table and threatening the park's redwoods. Congress authorized the expenditure of $33 million over a ten to fifteen year period to help repair the damaged ecosystem. As of 1987, over half of the 220 miles of haul roads had been stabilized and the streams were on the road to recovery. (Shelton, 1988)

Peregrine falcon restoration projects are underway in at least twelve parks from Acadia and the Great Smoky Mountains in the East to Crater Lake and Sequoia-Kings Canyon in the West. Two different processes are often used in peregrine restoration. Where peregrines have poor hatchling success, eggs are sometimes removed from the nest and incubated at special facilities. After the hatchlings are born, they are returned to their parents. In parks where nesting no longer occurs, peregrine young are raised by humans in hack boxes near ideal sites. If successful, a nesting pair can be established in about three years. (Shelton,1988)

Several parks are also engaging in sea turtle restoration projects. Canaveral National Seashore is screening nests to protect loggerheads, greends and leatherbacks from marauding racoons. Nest relocation projects at Fort Matanzas National Monument, Cape Hatteras and Cape Lookout National Seashores are underway to protect turtles from maurauding predators such as the racoon as well as human ORV traffic.



Ecosystem restoration projects sometimes face incredible challenges because of the enormous amounts of land required, and public opposition to species such as grizzly bears and wolves. The Florida panther project is an example of the loss of habitat problems. The panther numbers between 20 to 50 animals in the South Florida area. Although Everglades National Park and Big Cypress National Preserve provide excellent habitat for the panthers, they do not contain enough range. In order to successfully restore the Florida panthers, both park lands and private lands must be used. While there is some opposition in the private sector, landowners are generally favorable to the plans. In spite of this cooperation, the restoration project still faces big hurdles. Biologists are concerned with the amount of habitat, the quality of the habitat, the size of the prey base, disease susceptibility, human impacts and depressed genetic viability due to the small numbers of creatures (Shelton, 1988).

Prior to the restoration of a species, resource managers need to determine if the species was an actual native of the area and what subspecies or particular variety inhabitated that area. Studies need to be conducted to determine if adequate habitat and food are still present and if the political climate is favorable to the restoration. (Shelton, 1988). One such study is being conducted at Voyageurs National Park to determine the possibility of restoring that ecosystem. Three native species, the woodland caribou, elk (wapiti), and wolverine are absent from the parks ecosystem and several others, including the moose, Canada lynx, bobcat, porcupine and pine martin are less abundant than normal. The study suggests that a four stage process may help restore this ecosystem. The initial stage involves creating a mosaic of forest vegetation, through practices such as controlled burns. In the next two stages, viable populations of caribou, moose or elk would be introduced and these would establish food for the native carnivores. Finally, natural water fluctuations would be approximated in order to create and maintain the appropriate habitats. (Cole, 1982)

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Species of Socio-Cultural Significance

Significant Others

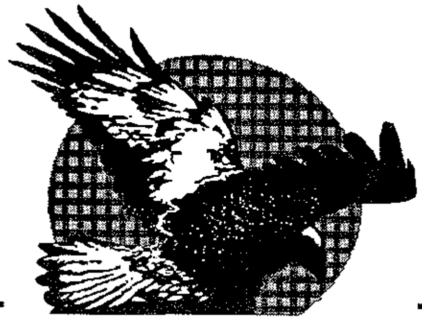
By Pamela A. Wright — The Ohio State University

Species that may be considered of socio-cultural significance are those species that have had a special relationship with humans. Just as the species vary, so does the significance they have for humans. For some, this significance may be based on economics, while for others it may be based on religion, symbolism, or lifestyle. The significance varies from culture to culture as does the species.

Species that are ascribed some particular socio-cultural significance often have strong symbolic meaning. In particular, "members of the animal kingdom are what fascinate and propel us, particularly those predators that embody aggression, pride and invincibility" (Telander, 1989, p. 15). Take animal mascots of sports team for example. How about the bulldogs, wildcats, Bengal tigers or wolves?

One particular species retains significant importance for those of us in the United States — we probably all carry one with us every day in our pockets or in our wallets. The American bald eagle, *Haliaeetus leucocephalus*, has been the official American national symbol for over 200 years, and for longer than that it has been held sacred by native Americans. We are not unique, however, in our selection of the eagle as a significant species.

The eagle has been used since Paleolithic (Old Stone Age) times to symbolize power, courage, freedom and immortality. In many cultures past and present it is used as a national, military, heraldic and religious symbol. Babylonians, Egyptians, Russian czars and Napoleon are among those who held the eagle in high regard. Some native North Americans used the eagle as a symbol of ancestral immortality on totem poles while others, such as the Cherokees, allowed only approved warriors to don the feathers of this sacred bird. When the 'bird of freedom', was adopted as a national emblem on June 20, 1782, it quickly became popular. Today, we see the eagle used as an ornament on buildings or statues, perched on top of flag poles, on government letterheads, on coins, as an insignia on naval uniforms, on treaties and as the highest symbol for the Boy Scout organizations—the Eagle scout.



Other species of socio-cultural significance are those that have a long-standing integrated relationship with humans. These are species that humans relied on as a source of food, tools, clothing and economic benefits. The Alaskan Eskimo and the Canadian Inuit still rely on marine species as the mainstay of their culture. In the past, creatures such as the bowhead whale provided food, tools, weapons, clothing, domestic utensils and toys. These creatures were held in high regard and kills were regulated to ensure the perpetuation of the species. As time passed, human population pressure and technology changed, so has the relationship between the native culture and the animals. While subsistence hunting of some species is still allowed in limited numbers, these cultures have been forced to become less dependent on the species. In spite of this, these animals are still a focal point in the community life, they are a centerpiece of history, a source of legends, and now an expression of art.

Bears are another animal that have strong socio-cultural significance to humans. Bears are large, fast, and powerful and have thus captured the imagination of people throughout time. Most of the native peoples that lived in areas where bears were found included the bear in some aspect of their culture. Native cultures held the bear in great awe. To kill such a fast and powerful animal took great courage and skill. The human-like attributes of bears allowed people to feel a close kinship with them. In North America, certain Indian tribes referred to bears as their cousins, grandfathers, or brothers. Some Inuit believed that bears possessed souls. The bear was not only felt to be physically strong, but also thought to hold great spiritual powers. Some tribes believed that their shamans could turn into bears and take possession of their power. If killed in his bear form, the shaman would quickly come back to life. The Haida, a Canadian west coast Indian tribe, referred to bears as "the bear people." They believed that if you made fun of bears, or mutilated a bear after having killed it, you would be lured away by the bear people and become their slave. Today, many tribal bear clans still consider the bear as their sacred animal. (Clarkson and Sutterlin, 1983)

Early explorers and settlers in North America were impressed by their contacts with bears. Much of the historical literature is riddled with accounts of sightings and encounters. In parks, the history of bear-human relationships has been one of roller coaster events. At first bears, especially the grizzly, where forced out of our national parks, some were even shot. Bears were also occasionally exhibited in side-show fashion and were publicly fed. Today, bears have regained their revered status and are protected in the parks and are managed in areas outside the parks to help ensure that they remain a part of our natural heritage. (Clarkson and Sutterlin, 1983)

Just as charismatic species can provide the interpreter with a way to introduce concepts of biological diversity to an audience, so can a species of socio-cultural significance. These species provide links from the natural biological world to the human-centered world.

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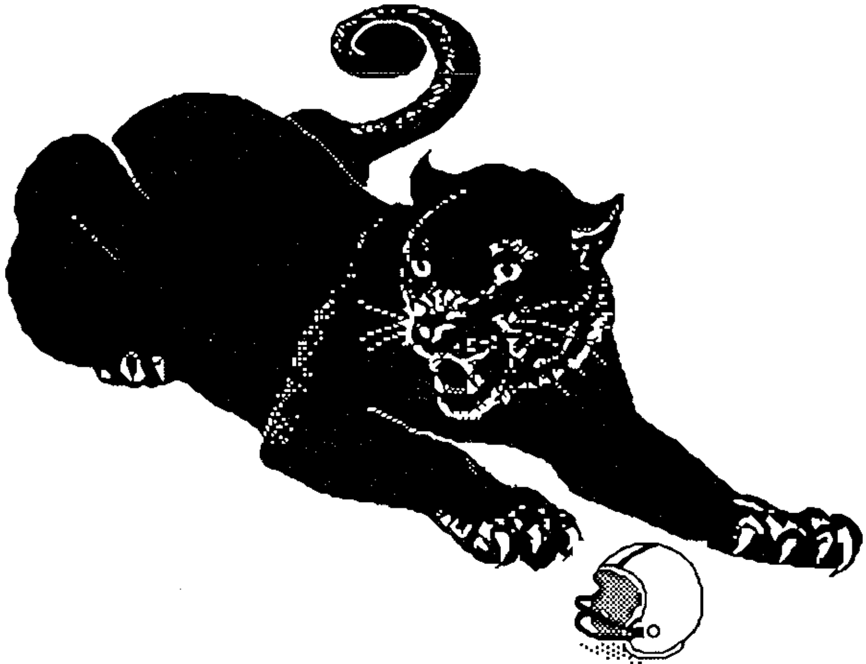

Unmodified Natural Communities

By Pamela A. Wright — The Ohio State University

Each of our national parks has a unique resource base. In some parks, this uniqueness centers around remnant prairie lands, while in others it may center around dune complexes, giant redwoods, or remnant apple orchards. Compared to the rest of the country, those areas not protected in national parks or similar conservation designations—our national parks are relatively unmodified natural communities.

A true unmodified natural community might be comprised of old growth forests or true remnant prairies. Very little of this type of unmodified habitat remains. There may be "long cycles of change even in 'climax' ecosystems" (ReVelle and ReVelle, 1988).

The Leopold Committee, an advisory board on wildlife management created by Secretary of the Interior Stewart Udall in 1962, described the status of the national parks in the following manner.

> Many of our national parks—in fact most of them—went through periods of indiscriminate logging, burning, livestock grazing, hunting and predator control. Then they entered the park system and shifted abruptly to a regime of equally unnatural protection from lightning fires, from insect outbreaks, absence of natural controls of ungulates, and in some areas elimination of normal fluctuations in water levels. Exotic vertebrates, insects, plants, and plant diseases have inadvertently been introduced. And of course lastly there is the factor of human use—of roads and trampling and camp grounds and pack stock. The resultant biotic association in many of our parks are artifacts, pure and simple. They represent a complex ecologic history but they do not necessarily represent primitive America.
>
> Restoring the primitive scene is not done easily nor can it be done completely . . . . Yet if the goal cannot be fully achieved it can be approached. A reasonable illusion of primitive American could be recreated, using the utmost in skill, judgment, and ecologic sensitivity. This in our opinion, should be the objective of every national park and monument.
>
> (Leopold Committee)

The National Park Service (NPS) Biological Diversity Initiative provides us with an opportunity to revitalize our efforts to achieve some of the very ends that the Leopold Committee called for. Today in our national parks we battle alien species, attempt to restore ecosystems, and walk the thin line between preservation and extinction. More than any other single federal agency in the

United States, the National Park Service has the capability to restore and then maintain relatively unmodified communities.

These unmodified communities serve as *in situ* genetic reserves —natural systems that provide a means to preserve our future against extinctions (Freeman, 1986). Preservation of these unmodified communities provides all the benefits of the issues discussed in other fact sheets. Genetic reserves provide places for preserving the gene pool that is a source for knowledge about medicinal and economic properties of species, and provides a place for the preservation of species. Additionally, the parks provide a place and a resource that can be used to communicate to visitors about issues such as the value of preserving biological diversity, consumer impacts on biological diversity, integrated development and cultural transfer of biological diversity.

Each park, with its own special resource base, is a storehouse for the future. In their relatively unmodified state, parks provides an opportunity for preservation and observation of the natural forces that can be found in very few other places.

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Biological Diversity

Fact Sheet 26

Unique Aggregations

Lessons From The Islands

By John W. Hanna — The Ohio State University

Our isolated national parks are island landscapes that share similar histories and fates with biologically diverse oceanic islands. Preservation and study of these island aggregations may provide us with insights to help maintain the biological diversity of our national parks.

Unique oceanic islands, the most prominent of which are Madagascar, the Hawaiian Islands and the Galapagos Islands, are mini-continents that are living laboratories for studies of biological diversity. These island groups are all located a significant distance from neighboring continents and contain a number of diverse habitats and a hospitable climate.

These conditions are optimal for an evolutionary process called adaptive radiation to occur. Individual species, through natural selection, evolve and diverge into a number of very different forms and behavioral patterns. If these forms and behaviors are distinct enough, the species evolves into a number of unique species that may be found nowhere else in the world.

Madagascar

Madagascar, a Texas-sized island 240 miles off the coast of eastern Africa, was described in 1771 as "the naturalist's promised land" (Mittermeier, 1988). The island's isolation from continental Africa created conditions where "nature seems to have retreated into a private sanctuary, where she could work on different models from any she has used elsewhere" (Mittermeier, 1988).

Although the number of original species that survived getting to the island was probably very limited, adaptive radiation on Madagascar has progressed such that the number of endemic species (species found only only on this island and nowhere else in the world) on the island is unmatched in the rest of the world (Mittermeier, 1988). Ninety-three percent of all the islands primates, 43% of birds, 233 of 250 reptiles, 131 of 133 frogs, 8 of 9 carnivores and 29 of 30 hedgehog-like terrecs are endemic species. Similarly in plants, 98% of all palms and 76% of all flowering plants on the islands are endemic and many more species are being discovered daily.

Four distinct environments occur on the island: rich tropical rain forests, spicy deserts, dry forests and central plateaus. Adaptive radiation on the island has been so prolific that the lemurs (primates) have evolved to fill every available niche in these four environments on the island including the aye-aye, an arboreal lemur, a mammal with woodpecker traits (Jolly, 1988).

The incredible biological diversity of Madagascar does not just provide scientists with answers to evolutionary questions, but also directly impacts our daily lives here in the United States. Many of the plants and animals on the island provide us with useful knowledge or byproducts to enhance our lives. The rosy periwinkle, an herb that grows only in Madagascar, provides us with a drug that is effective in the treatment of childhood leukemia and Hodgkin's disease. Over 50 wild relatives of coffee, one of our most popular beverages, are native only to Madagascar including a naturally caffeine-free variety. And while more and more species are discovered daily and uses for these species are uncovered, time is running out for Madagascar. (Mittermeier, 1988)

Once largely forested, native vegetation now covers only ten percent of the island. Cutting forests for agriculture, firewood and charcoal has produced a barren eroding landscape that has caused the extinction of numerous species including two species of giant tortoise, the pygmy hippo, an aardvark, six genera and 14 species of lemur, and the elephant bird, the largest known terrestrial bird.

Today, the only hope for Madagascar lies in the protection of the few remaining lands and the enforcement of strict management practices. One national park (Ranamafana) and a 600-hectare reserve, both the brainchildren of American scientists, have been established through work with the local populations. In trade for donated lands or management cooperation, the locals receive agricultural aid. To date, 11 nature reserves, open only to scientists, and 20 supplemental reserves, open only to subsistence hunting and fishing, have been developed using this kind of cooperation. Additional attempts are being made by the Madagascar government and the United Nations to establish a biosphere reserve to protect additional species (Mittermeier, 1988).

Hawaiian Islands

The Hawaiian Islands are the largest and most isolated group of islands anywhere in the world. Similar to Madagascar, species that survived travel to the islands (colonists) prior to human discovery had "unlimited opportunities to adapt to the various environments available" (Howarth et al., 1988). The 270 original plant colonists gave rise to over 1000 species of flowering plants and between 300 and 400 original insect colonists gave rise to 10,000 insect species.

To us, the Hawaiian Islands are a paradise but to the species who live there, the islands are anything but that. Species extinctions since humans discovered Hawaii have included two-thirds of all birds, all of the flightless birds, 50 percent of land snails and an undetermined number of insects and plants. Thirty percent of the remaining native flora are listed as endangered (Howarth et al., 1988).

One particular group of islands, the Leewards, part of the Hawaiian Islands National Wildlife Refuge, consists of small cays, sandbars and mini-islands. These islands provide the only nesting areas for four species of endangered birds, homes for the last surviving populations of Hawaiian monk seals and the last major nesting site of green turtles.

Alien species threaten to erode the remaining biological diversity. Feral pigs root for specific native plant species, aid in spreading alien plants, increase erosion and create pools of standing water in which the vector for avian malaria breeds. Mongoose run rampant and have endangered at least eight native bird species, while dark-rumped petrels have been reduced drastically by a number of alien species. The NPS is attempting to restore the Hawaiian national parks to their natural state. Where alien species cannot be eradicated, they are harvested, or in some cases, fenced out of protected areas. (Wexler, 1983)

Galapagos Islands

The Galapagos Islands, an archipelago of Darwinian fame located off the coast of Ecuador, share similar characteristics with the Hawaiian Islands. Fortunately, human impact on these islands has not been so severe, as over 88% of the islands are protected within national park boundaries.

The largest single problem facing the Galapagos Islands is their vulnerability to alien species. Browsing and trampling by herbivorous mammals, predation by rats and ants, competition for habitat, and disease are some of the most severe threats that aliens species cause. In the Galapagos, feral goats and pigs, introduced as a food source for humans, eat turtle eggs and plants and are responsible for many plant extinctions. Feral dogs and cats eat young fur seals, birds, penguins and marine and land iguanas. Intensive management of these aliens species has removed feral goats from five of the Galapagos islands and feral pigs and other introduced species face a similar fate. Where these species can not be totally eradicated, they are harvested. Management like this has resulted in recovery of some native vegetation and the successful reintroduction of captive-bred iguanas.

Studies and comparisons of the management of Madagascar, the Galapagos, and Hawaiian Islands provide lessons to help guard against future invasions on the islands. The knowledge gained from study of these islands teaches us the devastating impacts that alien species have on the natural environment, and some of the successful methods used to restore these environments. Additionally, study of the islands teaches us that adaptive radiation and endemism on islanded landscapes, similar to our national parks, is restricted by the size of the environment and the niche diversity present in these landscapes. This size related information is useful for park planners to help them determine optimum sizes for national parks. These unique and diverse island environments are living laboratories that provide us with ongoing evidence of evolution and with valuable food and medical supplies. The knowledge gained from experiences on these islands aid in the development of the theory and practice of conservation " that will help us preserve our continental nature reserves as they become more fragmented " (Wexler, 1983). These are island lessons for our national parks.

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Biological Diversity

The Death of Birth

THE PROBLEM: Man is recklessly wiping out life on earth

BY EUGENE LINDEN

Before Brazil's great land rush, the emerald rain forests of Rondônia state were an unspoiled showcase for the diversity of life. In this lush territory south of the Amazon, there was hardly a break in the canopy of 200-ft.-tall trees, and virtually every acre was alive with the cacophony of all kinds of insects, birds and monkeys. Then, beginning in the 1970s, came the swarms of settlers, slashing and burning huge swaths through the forest to create roads, towns and fields. They came to enjoy a promised land, but they have merely produced a network of devastation. The soil that supported a rich rain forest is not well suited to corn and other crops, and most of the newcomers can eke out only an impoverished, disease-ridden existence. In the process, they are destroying an ecosystem and the millions of species of plants and animals that live in it. An estimated 20% of Rondônia's forest is gone, and at present rates of destruction it will be totally wiped out within 25 years.

Around the globe, on land and in the sea, the story is much the same. Spurred by poverty, population growth, ill-advised policies and simple greed, humanity is at war with the plants and animals that share its planet. Peter Raven, director of the Missouri Botanical Garden, predicts that during the next three decades man will drive an average of 100 species to extinction every day. Extinction is part of evolution, but the present rate is at least 1,000 times the pace that has prevailed since prehistory.

Even the mass extinctions 65 million years ago that killed off the dinosaurs and countless other species did not significantly affect flowering plants, according to Harvard biologist E.O. Wilson. But these plant species are disappearing now, and people, not comets or volcanoes, are the angels of destruction. Moreover, the earth is suffering the decline of entire ecosystems—the nurseries of new life-forms. For that reason, Wilson deems this crisis the "death of birth." British ecologist Norman Myers has called it the "greatest single setback to life's abundance and diversity since the first flickerings of life almost 4 billion years ago."

Nearly every habitat is at risk. Forests in the northern hemisphere have fallen to lumbering, development and acid rain. Marine ecosystems around the world are threatened by pollution, overfishing and coastal development. It is in the tropics, though, that the battle to preserve what scientists call biodiversity will be won or lost. Tropical forests cover only 7% of the earth's surface, but they house between 50% and 80% of the planet's species.

But should people in developed countries care about the survival of tropical species never seen outside a rain forest? Yes, they should. Variety is the spice of life, goes the saying. Biologists would go further and argue that variety is the very stuff of life. Life needs diversity because of the interdependencies that link flora and fauna, and because variation within species allows them to adapt to environmental challenges. But even as the world's human population explodes, other life is ebbing from the planet. Humanity is making a risky wager—that it does not need the great variety of earth's species to survive.

Despite the alarm with which scientists view this trend, biodiversity has just surfaced on the world's political agenda. The troubles of high-profile animals such as the tiger and rhino grab public attention, while most people hardly see the point of worrying about insects or plants. But extinction is the one environmental calamity that is irreversible. As these lowly species disappear unnoticed, they take with them hard-won lessons of survival encoded in their genes over millions of years.

Only 1.7 million of the estimated 5 million to 30 million different life-forms on earth have been cataloged. Since hundreds of thousands of species may be extinct by the year 2000, the world has neither the scientists nor the time to identify the yet uncounted. "It's as though the nations of the world decided to burn their libraries without bothering to see what is in them," said University of Pennsylvania biologist Daniel Janzen at the TIME conference. Harvard's Wilson called this profligacy the "folly" that future generations are least likely to forgive.

Humanity already benefits greatly from the genetic heritage of little-known species. Some 25% of the pharmaceuticals in use in the U.S. today contain ingredients originally derived from wild plants. Hidden anonymously in clumps of vegetation about to be bulldozed or burned might be plants with cures for still unconquered diseases. "I know of three plants with the potential to treat AIDS," said Janzen. "One grows in an Australian rain forest, one in Panama and one in Costa Rica."

Nature's diversity offers many opportunities for agriculture, especially now that genetic mapping and engineering have given biotechnology firms the potential power to improve crops by transferring genes from wild strains. According to Wilson, biotechnology can transform a plant into a "loose-leaf notebook" from which scientists can select a particular page. Among the possible results: drought- and frost-resistant crops, and natural fertilizers and pesticides.

Diversity is the raw material of earth's wealth, but nature's true creativity lies in the relationships that link various creatures. The coral in a reef or the orchid in a rain forest is part of an ecosystem, a fragile, often delicately balanced conglomeration of supports, checks and balances that integrate life-forms into functioning communities. Given the complex workings of an ecosystem, it is never clear which species, if any, are expendable.

In the tropics the crucial question is how large a forest must be to sustain itself. If a park or protected area is too small to support some of its animal and plant life, the ecosystem will decline even with protection. As yet, no one knows the minimum critical size of a rain forest, but in 1979 Thomas Lovejoy, now at the Smithsonian Institution, set up a 20-year experiment with the cooperation of the Brazilian government to determine just that for the Amazon region. Among the findings: the smaller the forest, the faster the decline of insects, birds and mammals.

Biologists have identified numerous "hot spots" where ecosystems are under attack and large numbers of unique species face an immediate threat of elimination. Among the troubled areas: Madagascar, where more than 90% of the original vegetation has disappeared; the monsoon forests of the Himalayan foothills that are being denuded by villagers in search of firewood, building materials and arable land; New Caledonia, 83% of whose plants occur nowhere else; the eastern slope of the Andes, as well as forests in East Africa, peninsular Malaysia, northeast Australia and along the Atlantic coast of Brazil.

Since less than 5% of the world's tropical forests receive any protection, the stage is set for mass extinctions. Many plants and animals are doomed, no matter what measures are taken. Some researchers estimate that at least 12% of the bird species in the Amazon basin, as well as 15% of the plants in Central and South America, can be counted among what Janzen calls the "living dead." Many tropical mammals and reptiles face only bleak survival under what amounts to house arrest in game parks and zoos.

Why are so many species and environments threatened? The main reason is that throughout the tropics, developing nations are struggling to feed their peoples and raise cash to make payments on international debts. Many countries are chopping down their forests for the sake of timber exports. In Central America forests are giving way to cattle ranches, which supply beef to American fast-food chains. The pressures on forests have led Janzen, who has spent 26 years struggling to save Costa Rica's woodlands, to conclude that "everything outside parks will be gone, and everything inside the parks is threatened."

Efforts to stop the destruction run into moral as well as practical obstacles. How can developed nations demand onerous debt payments and ask the debtors to preserve their forests? How can countries worry about biodiversity when their people are concerned with feeding themselves?

To begin with, the rich nations must reduce the debt burden of the poor. But just as important is a concerted campaign to convince the people of developing countries that it is in their own long-term interest to preserve their environments. Wiping out forests may make developing nations momentarily richer, but it is bound to produce a poorer future.

Experience has shown the Third World that destruction of forests can have disastrous consequences. Forests are vital watersheds that absorb excess moisture and anchor topsoil. Deforestation contributed to the recent droughts in Africa and the devastating mud slides in Rio de Janeiro last year. In Costa Rica topsoil eroded from bald hills has greatly shortened the life of an expensive hydroelectric dam. Alvaro Umaña, Costa Rica's Minister of Industry, Energy and Mines, estimated that the surrounding watershed might have been protected 20 years ago for a cost of $5 million. Now the government must reforest the watershed at ten times that price.

Halting the assault on biodiversity will not be easy, but there are many actions that governments can take. First, they should develop and support local scientific institutions that train professionals in conservation techniques. More money should flow into educational programs that alert people to the irreversible consequences of a loss of genetic diversity. An international, environmental version of the Peace Corps could spread conservation expertise to the Third World.

Throughout the developing nations there are encouraging stirrings of local environmental activity. In Malaysia blowgun-armed Penan tribesmen have joined forces with environmentalists in an effort to stop rampant logging. And in Brazil, which has some 500 conservation organizations, environmentalist José Pedro de Oliveira Costa organized a coalition of legislators, conservationists, industrialists and media barons to stir public support to preserve Brazil's remaining Atlantic forests. "The threats to the forests remain," said Costa, "but now at least there is a network in place to scream when a threat arises."

But environmental protection must

Dividends From Diversity

Few Americans realize how often exotic plants and animals yield unexpected benefits. Some examples:

■ **Squibb used the venom of the Brazilian pit viper to develop Capoten, a drug for high blood pressure.**

■ **By transplanting genes from tropical tomatoes, the NPI biotech firm increased the density of U.S. tomatoes 2%, promising catsup manufacturers extra profits.**

■ **Scientists believe that arcelin, a natural protein in wild Mexican beans that repels insects, might protect some U.S. crops without poisoning soil and water.**

■ **Future newspapers may be printed on paper from kenaf, an African plant that can produce five times as much pulp an acre than the trees normally cut for newsprint.**

make *economic sense. and development must go hand in hand* with preservation. Development should be sustainable. meaning that it should use up resources no faster than they can be regenerated by nature. Governments and private firms should organize projects to show that forests can be used without being obliterated. If trees are cut selectively. forests can yield profits and survive to produce more money in the future. Another way to harvest cash from forests and other habitats is to set up tours and safaris to attract animal lovers and photography buffs. Long a moneymaker in Africa and the Galápagos Islands. this "ecotourism" is spreading to such places as Costa Rica.

For *sustainable development* to work. observed Paulo Nogueira-Neto. environmental adviser to the Brazilian Ministry of Culture. governments will have to devise comprehensive national zoning plans so that their countries can achieve the right mix of preservation and economic growth. Local residents can be encouraged to earn a livelihood in the more robust areas, while habitats that are fragile can be protected. Sustainable development can proceed, noted Kenneth Piddington, director of the environmental department of the World Bank. "right up to a park's boundary."

Financial as well as political leverage can be used in the cause of preservation. Governments should force local lending institutions to review the environmental consequences of proposed loans. No bank, *for example, should be allowed to lend* a company money to set up a cattle ranch if the operation would destroy too large a section of an endangered forest.

Finally, the unfortunate reality is that many habitats are not going to be saved. To prevent the genetic legacy of those areas from being extinguished. as many species as possible should be preserved in zoos, botanical gardens and other "gene banks." There. scientists can study a small percentage of threatened organisms and have the options of later returning them to the wild or transplanting some of their genes into other species.

But the best place to preserve the earth's biodiversity is in the *ecosystems that gave rise to it. Man must abandon* the belief that the natural order is mere stuff to be managed and domesticated, and accept that humans, like other creatures, depend on a web of life that must be disturbed as little as possible. ■

Biological Diversity

Back from the Brink

by David S. Wilcove

IN THE TOWN of Mio, Michigan, stands a monument to the Kirtland's warbler, a ten-foot tribute to a six-inch bird. The Kirtland's warbler is one of the world's rarest birds, so rare in fact that every one of them could probably perch on the monument and still leave room for a pigeon or two.

Mio is a good place to begin pondering the complexities of saving endangered species. From the center of town it's only a short drive to the pine barrens where the warblers live. A number of years ago some friends and I went there for the sole purpose of seeing a *bona fide* Kirtland's warbler in the wild.

"Listen. You want to be extinct? You want them to shoot and trap us into oblivion? ... *We're supposed to be the animals*, so let's get back out there and *act* like it!"

We stood along a dirt road, six bird watchers scanning an almost endless expanse of young jack pines, each one no bigger than a Christmas tree. From somewhere in the midst of the pines came a loud, cheerful song that seemed curiously out of place in such a bleak landscape. We waited impatiently as the sound drew closer, until the songster, a blue-gray and yellow Kirtland's warbler, was visible. It flitted from tree to tree, hunting insects, not at all concerned about our presence.

We on the other hand were very concerned about its presence, for the Kirtland's warbler is one of a growing number of species whose survival—to borrow a phrase from Tennessee Williams—depends upon the kindness of strangers. These birds nest solely in stands of young jack pines that are not too closely packed. Consequently, any single stand is acceptable habitat for only a few years. As the trees mature, the warblers abandon the site. Today, federal and state officials are selectively burning and cutting older stands of jack pine to create new habitat for the warblers. They are also trapping and removing abundant brown-headed cowbirds, which parasitize the warblers' nests.

THERE IS A POPULAR misconception about saving endangered species—that it's always a "hands-on, high-tech" business. Perhaps because the popular media delights in showing us scenes of scientists placing radio collars on Florida panthers or of helicopters transporting whooping crane eggs from the wilds of northwest Canada to incubators in Maryland, we have come to view the recovery of endangered species as a technological challenge. In fact, most imperiled species are saved by the straightforward expediency of protecting their habitat. In this respect, species like the Kirtland's warbler or the whooping crane represent a minority of the planet's growing roster of endangered species; the Devil's Hole pupfish is more typical.

To the best of our knowledge, this tiny fish has never occurred anywhere else but in a single spring-fed pool in the Ash Meadows oasis of the Mojave Desert. When an agricultural operation began pumping groundwater out of Ash Meadows, it appeared as though the pupfish might be wiped out. Fortunately, a Supreme Court decision established a minimum allowable water level for the pool, and the oasis itself is now protected as a national wildlife refuge (thanks in large part to The Nature Conservancy). Although the Devil's Hole pupfish will never be a common species, it is now as secure as nature apparently intended it to be. And the only "high-tech" involved in saving this species was found in the word processors on which the various legal documents were drafted.

Regardless of the steps involved, saving endangered species is no easy task. The recipe for success calls for scientific knowledge and liberal infusions of time and money. Moreover, the list of species in need of help is constantly growing, and the failures usually outnumber the successes. So why do we bother? A good question, and not an easy one to answer.

One could answer with the litany of reasons usually given for saving *any* species—potential benefits to medicine, agriculture, and industry, ethical considerations, and so forth—but to do so would miss the point of the question. For when we talk about "recovering" an endangered species, we are implying the restoration of a healthy population in the wild. In other words, an aviary full of Kirtland's warblers, loudly singing and busily reproducing, would not constitute a "recovery" of this species—not so long as the Michigan pine barrens harbor so few of them. At issue is not the value of a species *per se*, but rather the value of actively restoring and perpetuating a species in its natural habitat. In this context I can think of a number of reasons to recover endangered species.

ENDANGERED SPECIES play important ecological roles. Plants and animals do not live their lives in isolation; rather they form interacting assemblages of species—"communities" in the parlance of ecologists. The loss or endangerment of one species often affects other members of the community as well. Perhaps this point is most obvious to those of us who have spent a lot of time in the eastern United States. At one time or another I have lived in New York, Connecticut, New Jersey, Virginia, and Maryland. In all of these states, white-tailed deer are ubiquitous, in part because their natural predators—principally the panther and gray wolf—were exterminated long ago. Not so in northeastern Minnesota, where a remnant population of gray wolves persists, protected under the Endangered Species Act.

Wolves selectively remove the sick, the old, and the unlucky from prey populations. I have wondered how a Minnesota deer herd might differ from one in New Jersey as a result of the natural selection imposed by wolf predation. And what about the plants? With wolves preying on the deer, is there less of a browse line in the Minnesota forests? Do the edible seedlings have a higher survival rate because there are fewer deer to munch on them? I have no delusions that we could ever bring wolves back to crowded states like New Jersey or Connecticut. But I wish the Minnesota wolves well. And I suspect both the deer and the forests of Minnesota are better off with them than without them.

RECOVERING endangered species often produces unintended benefits for other species. Because most species become imperiled through habitat destruction or degradation, "recovery" typically involves saving whatever suitable habitat is left, or repairing the damage that has already been done. Other plants and animals that share the habitat with the endangered species become the incidental beneficiaries of the recovery program.

Consider Pendleton Island, a Conservancy preserve on the Clinch River in southwestern Virginia. Here the riffles, pools, and shoals surrounding the three wooded isles collectively called Pendleton Island harbor nine species of globally endangered and federally protected mussels. These mussels, members of the family *Unionidae*, are among the most sensitive of all aquatic organisms to water pollution. In other parts of their ranges, they have fallen victim to dams, river channelization projects, siltation from coal mines, and industrial and agricultural pollutants. If the state of Virginia and the Conservancy succeed in protecting the water quality around Pendleton Island (no easy task, of course), they will preserve not only the federally listed mussels but 36 other mollusk species (11 of which are candidates for federal protection) as well as countless species of turtles, fishes, insects, and crustaceans. The vast majority of these other species are not endangered—not to the extent the mussels are, at any rate—but their aggregate presence certainly is, for undammed, unsilted, unpolluted stretches of southern Appalachian rivers are few and far between.

Perhaps there is even a moral here. Without its endangered mussels, a place like Pendleton Island would receive none of the protection it now enjoys. The entire aquatic community has benefited from its weakest links. Like the kid off the bench who drives in the winning run, it's the classic "underdog-saves-the day" story.

AN ARGUMENT occasionally given for not restoring endangered species is that they are unfit, poorly designed, and dying relicts of some bygone era. Of course the reasoning is a tautology, but because it is couched in pseudo-scientific jargon, borrowing Darwinian terms, it somehow seems plausible. In fact, endangered species are an irreplaceable source of insights about the ecological and evolutionary forces that have crafted the biological diversity of this planet over the past three-and-a-half billion years. Nowhere is this point more obvious than in the Hawaiian Islands.

The species at issue are all members of the Hawaiian honeycreeper family, a group of closely related birds found only in the Hawaiian Islands. To look at them, one would never guess they were all relatively recent descendants from a single common ancestor, so different are their appearances. Some have stout, seed-cracking bills of the sort usually found on cardinals and grosbeaks. Others sport long, decurved bills suitable for probing deep within flower blossoms. And still others have shorter, slender bills reminiscent of wood warblers, or stout, hooked ones like parrots. To a biologist, these little birds are an endless source of riddles. How did so many species evolve from a single ancestor in the space of only a few million years? Where did the "original" honeycreeper come from, and what did it look like? How do the various species differ in behavior? Why are some species found on particular islands and absent from others? And on and on—questions to last many lifetimes.

Unfortunately, in addition to their ancestry, another thing the honeycreepers have in common is a poor relationship with humans. Of the 45 or so species known to science, at least 18 were exterminated by Polynesian settlers who, upon arriving about 1,500 years ago, cleared the lowland forests and brought with them rats, dogs, and pigs. Europeans landing in 1778 cleared still more of the native forests and introduced goats, cattle, mongoose, more pigs, additional rats, and other mammals to the islands. They also brought with them birds infected with avian malaria—a disease to which the native birds are very susceptible—as well as mosquitos that spread the malady. At least eight more species of honeycreepers have vanished since the arrival of European settlers, and most of the remaining ones are now on the official federal list of "Endangered and Threatened Wildlife and Plants."

The bright side to this story is the continuing efforts by federal agencies and private organizations to safeguard and restore the critical habitats of the surviving species. Through its Endangered Hawaiian Forest Bird Project, for example, The Nature Conservancy has protected the habitat for 14 of the islands' imperiled forest bird species, among them ten honeycreepers. Few conservation endeavors are more worthy of support. The wild honeycreepers, feeding, singing, fighting, nesting—simply living—within the irreplaceable forests of Hawaii have many more secrets to reveal. No collection of caged or stuffed honeycreepers, no honeycreeper paintings or historical accounts, could tell us as much.

AND FINALLY, there is the matter of historical value. As Aldo Leopold once observed, civilizations are very much the products of the natural world upon which they are built. The settling of the American West may have been fueled by people's desires for independence and personal fortune, but the people themselves were fueled by the bison, antelope, and prairie chickens they ate along the way. If the Midwest boasts the best farmland in this country, it is the legacy of countless generations of prairie plants that enriched the soil—plants now largely restricted to abandoned cemeteries, railroa rights-of-way, and a handful of small preserves.

I have never understood why, as a nation, we are so willing to protect and preserve the human artifacts of our civilization, yet so reluctant to extend a similar concern to the natural artifacts. Recently, Americans spent hundreds of millions of dollars to restore the Statue of Liberty, and when the work was finished, we celebrated the event with fireworks, parades, and speeches. Few people, I dare say, would argue that the money was not well spent, or that we should have done anything less than everything to restore the statue. I only wish we could muster a similar enthusiasm for reestablishing the greater prairie chicken, green-blossom pearly mussel, red wolf, Florida torreya, and hundreds of other endangered species in this country.

One autumn day in 1984, at a time when the Statue of Liberty was still enshrouded in scaffolding, a friend and I set out in search of California condors. Leaving Los Angeles in the predawn hours, we traveled north into the mountains, to an overlook at the edge of Los Padres National Forest. As the sun warmed the land, creating invisible air currents, the birds of prey began to appear. A prairie falcon flashed by, slicing the air with its powerful, angular wings. Two red-tailed hawks flew overhead, followed by a golden eagle. We waited and watched.

From out of nowhere the condor materialized. Passing along the side of the mountain, the great bird sailed out across the valley. Now this ancient bird, one whose ancestors picked the bones of mastodons mired in the La Brea tar pits, is fading from sight. Today, the condor is extinct in the wild, and only 27 survive in zoos, where plans exist to breed them and release their progeny. When and if the condors return to the mountains, I suppose there will be no fireworks, no parades, no speeches. There should be.

Biological Diversity

Why Save Diversity ?

By G. Jon Roush

The mission of The Nature Conservancy is to protect American's natural diversity by finding and protecting rare and threatened habitats, natural areas, and natural features. Why is it important to do so? What difference does it really make if we hasten the processes of extinction and lose some species of clam, or if we plow the last remaining example of a kind of prairie?

The reasons for protecting natural diversity are complex, and not everyone agrees in each instance, but everyone should be able to agree on four basic premises, any one of which makes the preservation of natural diversity an imperative of the most serious order. The four premises are these: diversity promotes the stability of ecosystems, diversity increases the possibility of future benefits, diversity is a source of human delight, and protecting diversity is an ethical necessity.

Diversity and Stability

What's the use of alligators? For ages, alligators have snoozed, bred, and fed in "gator holes," large depressions scooped out of the ground by the alligator, which fill with water to form permanent pools. Each of these pools houses its own world of algae, ferns and other plants, fish and amphibians, some of them nourished by droppings and bits of food left by the alligator. In dry years these gator holes and trails between them form the only sanctuary for many of the everglades' creatures, which will move out again to repopulate the area when the rains return. Near the gator hole itself, the female alligator makes a large nest of sticks and mud every year, and over the years, these nests can build up to form dry islands, supporting trees that provide nesting places for herons and other birds. Although the gator at the bottom of the tree may eat an occasional chick, it is also an unwitting sentinel, keeping tree-climbing predators away.

When the alligators themselves feel prey to man's whim to have shoes and handbags made from their hides, this ancient arrangement wasupset. Gator holes filled in and dried up, no longer serving as centers of life. The area's hydrology suffered, and the whole system was weakened. Meanwhile, fishermen complained that fishing in the Everglades was not what it used to be. Bass and other sport fish were being devoured by spotted gar fish, whose numbers were increasing every year. What had been keeping the gar in check? Its natural predator, the alligator.

It is the diversity of the Everglades system that holds it together and sustains it through lean years. Remove any element of that diversity, and the system may be wakened. Remove a key element like the alligator, and the system falters disastrously.

A stable ecosystem is one that can withstand changes without going haywire. Diversified ecosystems tend to have many overlapping systems of checks and balances so that the system as a whole is buffered against the impact of any particular change. When American farmers a hundred years ago replaced diverse native prairies with vast monocultures of single species of corn and grain, they helped set the stage for the dust bowl of the 1930s. In parts of the Midwest it was only the remnant areas of diverse natural prairie land that kept any soil intact during that terrible drought.

Indeed, the reduction of diversity is almost always expensive. When we spray a neighborhood for mosquitoes, for example, killing or driving away many of the mosquitoes' natural predators and breeding a race of mosquitoes resistant to the insecticide, we have set ourselves up as the perpetual guardians of that area, responsible for expending out time, money, and ingenuity to keep the mosquitoes down and the system going. We are driven by the well-grounded fear that if we ever let our guard down -- now that the natural mosquito controls have been reduced -- the mosquitoes will return tenfold and more savage than ever.

But if we are ever to reestablish health in systems that we have impoverished, we will need a reservoir of genetic resources to draw on. Once extinct, a species cannot be re-created. Consequently, The Nature Conservancy devotes much of its effort to protecting species and ecosystems that are rare and endangered. although an area oar endangered species habitat may not be particularly diverse by itself, it protects a part of the future diversity of the planet.

Diversity and Future Benefits

France's finest grapes grow on root stocks imported from America. This root stock produces its own grape that is inferior for eating or wine making and Americans were in the process of eradicating it when a virulent rust attacked the roots of native vines in Europe. the American stock was found to resist this rust, and so the European vines were grafted onto it, saving the European wine industry.

Such ecological rescues are not unusual, nor are the discoveries of totally new possibilities. The potential utility of living species is so great that the U.S. Department of Agriculture has established a separate unit, the Medicinal Plant Resources Laboratory, to identify new, useful plant substances. For example, some species of the Ethiopian plant genus Maytenus produce substances called maytensines, which show promise for the treatment of cancer. Unfortunately, the Ethiopian plants produce this substance in such minute quantities that researchers had trouble collecting enough for experimentation. They searched for another species that might produce maytensines in more quantity, and they found it in Kenya, in a rare plant that happened to be protected in a forest preserve. Now the tests could be continued, and they were more promising than ever, but still a more productive source of maytensines had to be found. Once again a forest reserve yielded the right plant, but in South Africa. This time the plant was of the closely related genus Putterlikin , again rare but a better producer of maytensines. This species, which the world would never have missed if it had become extinct five year ago is now a major target for conservation.

Usually the easiest, most efficient, and surest way to conserve a species is to preserve its habitat. In fact, it is most useful to preserve a diverse set of habitats to accommodate variations within species and evolution of new species.

For example, a family of Hawaiian birds known as the Honeycreepers (Drepanididae), contained 22 distinct species when Europeans began to settle the islands in the early 19th Century. Some looked like finches, others like woodpeckers, warblers, or parrots. All of these species were apparently descended from one common species, a finch-like bird that arrived in the islands about a million years ago. Each descendant species found its own ecological niche on the islands. Each adapted to a particularhabitat with distinct food and territory, permitting all the final species to get the most from the islands with minimal competition among themselves.

Moreover, two or more ecosystems can interact with each other to support diversity, even when they are not physically connected. Studies of islands have shown that the species count on any island is related to its distance from other islands or mainland. The closer two island ecosystems are to each other, the more the migration of species from one island to the other, the slower the extinction rates, and the greater the diversity.

In fact, natural diversity of any sort tends to further species diversity. Protect a representative array of ecosystems, and you have dramatically improved the chances of all the species that inhabit them. The undeniable yet unpredictable utility of living species is sufficient grounds for mankind's caring about such things, for a species is truly "useless" only when it is extinct.

Diversity and the Quality of Life

It is reasonable to assume that the capacity to enjoy natural diversity is innate in every human being, that indeed every human being has a genuine need for natural diversity, and that to be deprived of that diversity pains even the staunchest lover of cities, consciously or unconsciously.

Early man evolved in a diversified savannah-forest habitat. As many anthropologists have pointed out, the evolution of Homo sapiens required the prior appearance of plants that produce seeds, with their concentrated food value to fuel the high metabolism of mammals, especially primates, with energy-consuming brains. Early man, who fed on seed-feeders and eventually learned to cultivate seed-bearing plants himself, was especially fit for and predisposed to live in the diversified environment at the edge between forest and grassland. That predisposition lives on in modern man. When our forefathers, for example, moved west into the American wilderness, they made clearings in the forest and planted trees on the plains, as if re-creating our original habitat.

In other words, we may have good genetic reasons for liking a field of grasses and wildflowers, for preferring the biologically diversified habitat that nourished and protected us as a species and provided the earliest arena for the exercise of our physical and mental flexibility. Today any natural place that people call beautiful is almost certain to be a diversified, healthy ecosystem, whether it be a marsh, a tallgrass prairie, a desert, or an alpine meadow. Variety does seem to be the spice of life.

Probably the more complex human civilization becomes, the more diverse the set of natural resources needed to sustain it. Unfortunately this need is often hidden, because we see only the products manufactured from those resources. Yet even if we could substitute a totally artificial environment for the natural one, something would be missing. What would it be like to adapt totally to the products of other human minds? For most of us it would be a nightmare, because we need to perceive a permanent, autonomous reality of which we are a part. As one of Berthold Brecht's characters put it, "We city-dwellers get dazed from never seeing anything but use-objects;. . . trees, ... at any rate, have something independent about them outside myself." Anyone who has felt a mountain's indifference to human events will understand those words. It is as if our awareness of our very dispensability reassures us that the basis of being is itself firm and real. Such reassurance depends on the presence of natural diversity, which manifests the complexity and mystery of natural reality.

We build great libraries to house the diverse elements of our cultural heritage; why not do the same for the elements of our natural heritage? Not everyone would avail himself of the opportunity, just as not everyone uses libraries. But those who did would be enriched. Only by directly experiencing an ongoing culture can one become part of it, and only by directly experiencing diversified nature can one sense one's own peculiar fitness in it. Fortunately, in most of us the impulse toward diversity seems to be still strong. When people talk about going to "the country" for vacation, they do not mean simply getting out of town; they mean finding more version of diversity. A corn field is "natural" and out of town, but it is also fairly monotonous and hardly anyone vacations there.

For reasons of their own sanity and well being, people need a holistic, organic perception of their milieu and their place in it. Prolonged monotony of any sort produces neurosis, for which cultural and natural diversity are the only effective buffers.

The Ethics of Diversity

Even if natural diversity could be shown to have nothing to do with sustaining life on earth, even if we could identify certain species as once and for all useless to us, and even if we decide that we have no inner need for the presence of diversity, we would still have an ethical problem to face before we could countenance the reduction of natural diversity.

As a natural species, Homo sapiens is under the same ecological constraints as any other species. If we ignore the ecological facts of life and really try to act as if we had "conquered" nature, sooner or later nature will get even, because no human is that smart. Our best strategy with nature is to adopt the attitude of humility and respect. That is the message of the Land Ethic. That attitude allows us both to be true to ourselves as natural creatures in a natural environment and to exercise human, rational choice in the most prudent way. "In short," says Aldo Leopold, "a land ethic changes the role of Homo sapiens from conqueror of the land-community to plain member and citizen of it. It implies respect for his fellow member, and also respect for the community as such."

A workable land ethic calls for a serious commitment. It requires that we understand the consequences of our actions for other living things, that we accept responsibility for them, and that before we intervene in the functioning of an ecosystem we make sure we have adequate justification. It further requires, as Leopold also pointed out, that we acknowledge the right of other species to continue their existence, "and, at least in spots, their continued existence in a natural state."

Of course someone could argue that ethics only apply to people. Nevertheless, because the web of diversity connects us all, the ethical problem persists. If a farmer drains a marsh in order to replace its abundant diversity with a monocultural empire of soybeans, then quite possibly he has done me some ecological harm. I am entitled to ask by what right he does so and why his rights should supersede mine in this case. If, in addition, the soybean industry happens to cause the extinction of a species or two, it has denied the rest of us an irreplaceable geneticresource. The obliteration of an element of diversity can be a violation of the rights of a great many people.

What is more, the rights that are violated are not ours alone but those of future generations as well. It is not easy to describe the extent of our obligation to posterity, and the whole question can get buried under a mountain of probabilities and "what ifs." What should we save? What will future generations need or want? What would they miss? How much will they want it, so that we know how much we should be willing to sacrifice in order to save it? On the other hand, what if they will not deserve our beneficence? They may be a pack of wastrels themselves, or a race of technocratic automations, or extinct.

The best we can do in the face of the uncertainties of the future is to recall the land ethic, summon up our humility and respect, and like Leopold's tinkerer who does not understand the machine he is trying to fix, save all the pieces. In fact what is likely to happen is what has always happened. We will save what we love, partly because we want the things we love to endure and partly because we assume that our children will be like us and will love the things we value too. In preserving natural diversity, we are preserving options, the full spectrum of present possibilities, in case one or another is important to someone later. And we are preserving chances for future evolution as yet unrevealed, including perhaps those of Homo sapiens. We have inherited a world of extraordinary variety and complexity in which people have survived and flourished for eons. If we love that kind of world, we have no choice but to try to preserve its diversity.

Biological Diversity

DRAINING THE GENE POOL

Animals that appear to be thriving may be facing genetic trouble

By Richard Wolkomir

If you can stand the din, visit California's coastal islands when the elephant seals are mating. You will see a species almost literally returned from the dead.

Bull seals are bulbous-nosed giants, often as big as pickup trucks. They lunge and roar as they protect their harems from rivals. A visitor who sees—and hears—them bellow by the thousands finds it hard to believe that, by 1900, the elephant seal had been hunted almost to extinction. Just one group remained, fewer than 50, on a remote Mexican island.

Protected, the seals rebounded. Those few survivors, reproducing among themselves, generated the thousands of seals basking in the Pacific sunshine today. Conservationists should be delighted, and they are.

But they also are worried. What troubles them about the elephant seals is a danger facing more and more species: loss of genetic diversity. In fact, genetics is fast becoming a major concern in wildlife management, and the elephant seal shows why. As Christine Schonewald-Cox, a National Park Service zoologist, puts it: "Even though the elephant seals are apparently thriving, their survival is not insured."

Despite rippling muscles, the animals have a weakness: they are too much alike. The reason for this is that each seal's genes are virtually a carbon copy of those few survivors' genes. Any new disease, parasite, or change in climate that proves fatal to one seal may be fatal to all.

Genes—microscopic specks in the nucleus of every living cell—are the arbiters of heredity. One arrangement of genes beaded along a threadlike chromosome spells "raccoon," another spells "blueberry." Changes in a few genes may mean a raccoon with larger paws, smaller paws, or hairier paws. By changing such traits, down to whisker length or the precise tint of a feather, genes determine how well a creature will cope with life's changes.

Each animal gets half its genes from its mother, half from its father. Usually, different types of genes are mixed throughout a breeding group like raisins in a cake. If a rare gene becomes necessary for species survival in response to environmental change, that gene will become more common in future generations due to natural selection. In this way, genetic diversity helps species adapt to new conditions and survive.

The elephant seals' problem began when they dwindled to only about 50 individuals. That created a "genetic bottleneck" as the seals inbred, relatives mating. With no "new blood," they could pass on only a limited array of genes to their pups. And their pups, in turn, could pass on only the same limited set of genes to *their* offspring. As a result, today's seals may lack built-in adaptability to environmental change.

Species by the hundreds are now passing through such genetic bottlenecks. Hundreds more are disappearing altogether. Biologists worry that, with all these withdrawals from the biosphere's "gene pool," evolution itself may be impoverished. As T. N. Khoshoo, director of India's National Botanical Research Institute, recently put it: "Gene erosion is very dangerous because genetic diversity is the backbone of evolution."

He is not the only worrier. In fact, loss of genetic diversity has become an international issue.

In 1981, the U.S. Department of State and the U.S. Agency for International Development sponsored a conference on genetic diversity, attended by scientists from many countries. There, the researchers made a startling prediction: at today's pace of habitat destruction, a million more species—plants, animals, insects, fish, birds—will become extinct within 20 years.

One speaker quoted Harvard entomologist Edward O. Wilson: "The one process ongoing in the 1980s that will take millions of years to correct is the loss of genetic and species diversity by the destruction of natural habitats. This is the folly our descendants are least likely to forgive us."

Such a loss will be more than aesthetic, the scientists stressed. What if, for example, the wild ancestors of our cultivated crops had vanished? Then, if a blight obliterated our grains or legumes, which are even more genetically uniform than elephant seals, we would have no hardy stocks to tap for rebreeding. To prevent such disasters, countries around the world are building large "gene banks" where seeds of important plants are kept frozen in readiness for future use. As Undersecretary of State James Buckley noted at the conference, 40 percent of our medicines now come from wild plants and animals. So, it is feared that allowing species to die could deprive humankind of medicines not yet discovered.

"What might be the impact of the destruction of Brazilian rain forests on the production of wheat in Kansas some 50 or 100 years from now?" asked Buckley. His answer: "We don't know."

What wildlife managers do know is that genetic diversity is a key to species survival. "It's important because the environment is always changing," says Steven Chambers, a biologist at the U.S. Fish and Wildlife Service's Office of Endangered Species. "If the environment changes gradually, and the species has enough variation in its genes, the species can adapt—otherwise, it may die out."

Chambers cites the *Anopheles* mosquito, which received an environmental shock in the 1950s—the advent of the insecticide dieldrin. "At first, dieldrin was an effective insecticide on these mosquitoes," says Chambers. But some mosquitoes carried dieldrin-resistant genes. They passed their resistance to their offspring. Eventually, through this process of natural selection, many populations of the species became resistant to the insecticide. Thus, an odd gene enabled these mosquitoes to sidestep environmental calamity.

Or consider the robin, far more numerous in North America today than it was before European colonists chopped down the forests. It is conceivable that variants in the robin gene pool helped the birds adapt to a deforested landscape.

As the Park Service's Christine Schonewald-Cox observes, the kind of inbreeding that was forced on the elephant seals by their near-extermination is risky even if the environment is stable. That is because all species carry destructive genes, just as humans have latent genes for such disorders as cystic fibrosis. "By not breeding with relations, species keep those genes recessive," she says. "But if the population becomes genetically uniform because of inbreeding, these deadly things will come out—it's like hemophilia in the royal families of Europe."

For biologists working with the world's troubled species—the California condor, the peregrine falcon, the snow leopard—genetics offers information of unprecedented precision on the species they manage. The price is added complexity, requiring a sophisticated understanding of gene transactions.

Schonewald-Cox cites the Pacific coast's remaining elk populations, with which she works. "In a small group the dominant male will mate with the most females, making most of the offspring half brothers and sisters," she says. Females, the first to mature sexually, are apt to mate with their fathers. Later they mate with their half brothers. The result is intense inbreeding.

Some of California's rare tule elk suffer from short lower jaws, which impedes feeding. Schonewald-Cox suspects this may be an unwelcome effect of inbreeding that arose because the biologists who established the herd started with too few individuals.

As biologists learn more about the transmission of particular genes in particular species, they hope to reduce the number of such mistakes. Aiding them is the extreme precision of new genetic tests. For example, a team headed by marine mammal biologist Burney Le Beouf, of the University of California in Santa Cruz, used advanced blood tests to determine that elephant seals have too little genetic variation. One test, known as "electrophoresis," separates for identification the different proteins in an animal's blood. (Proteins are the building blocks of life that are constructed from the genes' DNA code.) Another test, "karyotyping," enables biologists to make direct comparisons of the threadlike, gene-bearing chromosomes found in various living cells.

How might wildlife managers use such information?

Electrophoresis has shown, for example, that elk in Washington's Olympic Peninsula are genetically different from elk in eastern Washington, Oregon, or British Columbia. As zoologists study the elk further, it could turn out that one herd in one part of the country has an enzyme for digesting a particular local grass that elk from a distant site lack. Thus, where sometimes augmenting one herd with elk from elsewhere might be favorable, in some conditions it could be a mistake.

"Chromosome studies of barking deer and Soemmering's gazelles have shown that just because two animals look the same does not mean they *are* the same," says Schonewald-Cox, "and you must take that into consideration before you move animals from one area to another or interbreed them."

Indeed, two otherwise identical garter snakes may, in different parts of their range, have inherited different genes that cause them to have different diets. Other species that look identical, yet vary genetically, are certain flycatchers, such as the western and Traill's flycatchers, or the willow and alder. "They're virtually indistinguishable except by differences in song and habits. For detecting the presence of such similar species, today's blood or chromosome tests can be important," says Chambers. "If you're mistakenly managing two species as if they were one, you're going to get into trouble.

"It would be nice if we didn't have to worry about genetics," adds Chambers. "Many people might wish biologists could just let nature take its course." However, he says, society is so disruptive of the natural world that "even doing nothing is a management decision—the decision *not* to intervene should be based on good data."

Many species' habitats have now shrunk to a single wildlife preserve. For some, extinct in the wild, their world is a zoo cage. For them, biologists *must* consider genetics.

"In managing dwindling wildlife populations, we'll have to ask such questions as, how many individuals are necessary to maintain genetic diversity?" notes Chambers. "To find out, managers must consider behavior—do the animals bunch together in small groups, for instance, and how much movement exists of individuals from one group to another?"

On islands, where gene pools are limited because plants and animals are cut off from others of their kind by the ocean, biologists have found that local species sometimes decline because they cannot cope with change. A classic example was the flightless St. Stephen's wren, a species limited to a small New Zealand island. The entire species was wiped out by the lighthouse keeper's cat. Other island species that were too genetically uniform and became extinct include New Zealand's ten-foot-tall moa bird, Madagascar's 1,000-pound elephant bird, and the dodo of Mauritius Island in the Indian Ocean.

"Island studies are important in wildlife management because, in certain situations, a wildlife preserve can act as if it were an island," adds Christine Schonewald-Cox. "If their preserve is surrounded by urbanization, or a desert, plants and animals may be cut off from others of their kind almost as if they were surrounded by ocean."

In fact, less than five percent of the world's wildlife preserves are large enough to maintain genetically viable populations of large mammals, such as lions, elephants and antelope. In the future, wildlife managers may in some cases have to understand how much genetic diversity a given species requires to thrive. They will also use genetics in other ways. Wild turkeys are a case in point. The birds were nearly extinct in the 1950s, when Pennsylvania biologists began releasing trapped wild turkeys in suitable habitats. Soon, they spread to New York. Vermont imported 31 of the New York turkeys in 1968; today, the Vermont population numbers more than 10,000. States from Maine, New Hampshire, and New Jersey to Michigan and Mississippi have similarly added to their stock. "It was highly successful, but if we had taken genetics into consideration then, it might have been even easier," says Chambers.

Today, biologists believe that much larger breeding stocks should be used in similar efforts, to ensure genetic diversity. Observes Chambers: "I'd also frequently add wild individuals to the breeding stocks, because captive populations become domesticated. For example, a more docile tiger might survive better in a zoo, while a more active, alert tiger might do better in the wild. Over time, the captive tigers will become a more docile strain, while the wild animals will continue to be genetically selected for alertness."

Today too, biologists intent on introducing new stocks to replace an extinct population would study records of the pre-extinction group to identify the area's "ecotypes"—local variations that give species a survival edge in a particular place. In Florida, for example, mice living on the beach have evolved whiter coats than their cousins in the grass, acquiring better camouflage against the sand. Observes Chambers: "When releasing breeding stocks, I'd look for variations that matched ecotypes in the original population."

Some zoologists are now arguing for the establishment of "embryo banks" to preserve the fetuses of vanishing animals, in case their habitat should reappear in the future. One active genetic bank is located at the Jackson Laboratory in Bar Harbor, Maine.

A large private research center, the Jackson Laboratory is a world leader in the study of mammalian genetics. In 1980, for example, Jackson researcher George Snell won a Nobel Prize for discovering the genes that control the body's acceptance or rejection of organ transplants. Jackson scientists work with mice so inbred that all the individuals in any strain are genetically identical. To prevent the loss of these scientifically valuable mice, which are vulnerable to disease, Jackson has "banked" the genes of each strain.

Frozen rock-hard in special freezers at the laboratory are 217,000 mouse embryos, including discontinued strains, preserved for future scientists who might need them for experiments today's scientists cannot envision. When biologists implant these embryos in the wombs of live mice a century or two hence, mice conceived in the 1980s will be born in the 21st century.

Preserving the genes of vanishing species may one day be routine. Meanwhile, the genetics revolution has already changed the way we look at wildlife. Oxford University zoologist Richard Dawkins put it this way: "We are all survival machines for the same kind of replicator—molecules called DNA—but there are many different ways of making a living in the world, and the replicators have built a vast range of machines to exploit them. A monkey is a machine which preserves genes up trees; a fish is a machine which preserves genes in the water; there is even a small worm which preserves genes in German beer vats."

The new genetic techniques make possible more sophisticated maneuvers than ever before in the effort to conserve species. The result may be that at least some animals and plants, headed for extinction, will be saved. Notes Steven Chambers: "The smaller the habitat gets, the more important genetics becomes." ▣

Vermont journalist Richard Wolkomir wrote about the aggressive nature of some plants in the August-September issue of National Wildlife.

Biological Diversity

Redefining Development Priorities: Genetic Diversity and Agroecodevelopment

KENNETH A. DAHLBERG

Department of Political Science
Western Michigan University
Kalamazoo, Michigan 49008

Abstract: *Recent research on genetic and biological diversity suggests that they underlie, and are the source of renewable resources—which are themselves more fundamental than nonrenewable resources. However, recognition of this is hindered by various Western cultural and analytic biases that have generally led to the neglect of informal and natural systems. Significant implications flow from this recognition.*

Analysis and models at the global level—as well as their resource, environmental, and population components—will need to be considerably broadened to include the fundamental role of genetic and biological diversity. When this is done, the "limits to growth" debate takes on greater urgency, and the focus shifts. Agriculture is then seen as the key interface between natural and social systems. In addition, the whole notion that Third World countries should model their societies along current industrial lines is fundamentally challenged.

At the national level, both industrial and developing countries will need to give priority to developing regenerative rural and agricultural systems. To do this, industrial countries will need to move toward "food systems" approaches, while developing countries will need to conserve and build upon existing agroecosystems. This will require new development theories and practices that are more contextual and recognize the nonneutrality of Western technologies and economic theories.

Finally, the larger threats posed by modern industrial society to the maintenance or creation of more sustainable and regenerative systems need to be included in any analysis. These include both the threat of nuclear war and the larger "war against nature" in which modern industrial society is engaged. New concepts of "national security" are suggested along with corresponding shifts in national priorities.

Dahlberg, K. Redefining development priorities: genetic diversity and agroecodevelopment. Conservation Biology. 1(4): 311-322, 1987.

Introduction

In analyzing the nature and sources of the various threats to, and losses of, genetic and biological diversity, a recent series of conferences, reports, and publications has stressed their fundamental importance to the operation, resiliency, and continued evolution of natural systems (U.S. Department of State 1982; National Academy of Sciences, *in press*; Soulé & Wilcox 1980; Ehrlich & Ehrlich 1981; Myers 1983; U.S. Office of Technology Assessment (1987). In addition, general concern has been expressed about the differential impacts and implications of these losses and threats between the rich industrial countries of the temperate zones and the generally poorer, developing countries of the tropics, semi-arid, and arid zones (Walsh 1984, Caufield 1985, Dahlberg 1983).

As valuable as this and the more specialized literature on specific regions and species is, there are three broad areas of neglect. First, there has been relatively little attention paid to the important ways in which demand in industrial countries for Third World products puts pressure upon Third World species and habitats (Dewalt 1983, Nations & Komer 1982, Myers 1981). Second, there has been little detailed analysis of the impact of large-scale, human-generated environmental disruptions—such as acid rain, carbon dioxide and ozone buildups, ocean pollution—upon genetic and biological diversity. Third, little attention has been given to the implications of the general loss of genetic and biological diversity either for agriculture or, more generally, for development processes. This paper explores these implications and outlines the changes needed in our thinking and priorities if we are to address them adequately.

Several cultural assumptions and biases must be discussed first because they strongly shape what we *see* or do not *see* when we seek to understand the various phenomena surrounding and interacting with genetic and biological diversity. These include Western assumptions that man's basic relationship with nature is one of separation and dominance (Leiss 1972). Also crucial is the belief that progress is pursued through ever-increasing applications of science and technology. Both of these assumptions have contributed to the growth and development of industrial society and its associated infrastructural and institutional patterns, which have become increasingly formalized and centralized over the past several decades.

Three mutually reinforcing types of bias or filtering are involved. First, there is a general emphasis and focus upon formal institutions to the neglect of the informal sectors of society and the natural world. This has meant that much more attention has been given to natural areas that have some sort of formal or legal status—such as national parks and wilderness areas—than to those without such status. Thus, many undesignated areas—as well as coastal systems and wetlands—have been largely neglected in the literature on genetic diversity. Second, there is a pervasive urban bias in modern industrial society that derives both from its utopian mythos and the structure of its political economy (Mumford 1959, Lipton 1977). This has led to a general neglect of rural matters and to a particular neglect of traditional agricultural systems and practices and how they relate to genetic conservation. Third, there is much more focus on man-made artifacts and technologies than upon nature and natural systems. Indeed, most conceptions of nature and natural systems are both anthropocentric and utilitarian and emphasize natural resources and their value to humans. Little or no consideration is given either to how the health of larger natural systems relates to the health of human societies or to the intrinsic value of these systems (Ehrenfeld 1978).

This neglect of important phenomena—which derives from cultural assumptions and biases—is compounded by both the scale and modes of analysis that are conventionally used. While the scope of industrial society and its impacts has become global, most data and analysis are national or subnational, as well as being divided into disciplinary and sectoral domains. The ongoing debate regarding global "limits to growth" illustrates the differences between those using large-scale-system approaches and those using more traditional disciplinary and sectoral approaches (Meadows et al. 1972, Mesarovic & Pestel 1974, Council on Environmental Quality 1980, Simon & Kahn 1984). In terms of genetic and biological diversity, this has meant that although there is an abstract acceptance of the idea that they are the ultimate source of life, natural regeneration, and evolution, relatively few analysts or policy makers see their current and projected losses as posing an imminent threat either to larger natural systems and processes or to human societies. Those who do see their loss as a threat include those researchers and analysts who have extensive expertise and interest in natural systems and/or have larger concerns regarding the long-term viability of these systems.

The conventional view—expressed more in terms of the lack of action and the continuance of current practices than in formal opposition or questioning—is that scientific and technological advances and fixes will buy modern industrial societies enough time to overcome whatever difficulties are created by losses of genetic and biological diversity. Buttressing these views are those of extreme technological optimists, who assume that is will be possible for some chosen elite to move on to the "new frontier" of space by creating sustainable ecosystems in permanent space colonies (O'Neill 1974, Robinson 1975, Oberg 1982). Rather than seek to rebut these views, the remainder of this paper will assume that the current scale and intensity of industrial operations (including agriculture) pose imminent threats to genetic and biological diversity at all levels, up to and including the biosphere itself, and that this, in turn, threatens the very basis of modern society. Working from this assumption and its corollary—that the conservation and regeneration of genetic and biological diversity is the most fundamental element in any strategy to reduce these threats—the main focus will be upon the new conceptions of resources, development, and agriculture that flow from these assumptions.

Redefining Resources

If one examines the historical evolution of the concept of resources and also takes into account the cultural and analytic biases mentioned above, it becomes clear that new conceptions and definitions are needed (Dahlberg & Bennett 1986). In particular, there is a need to understand resources both at different levels and so as to include their linkages with *invisible* and informal systems. This is the case even if one employs only anthropocentric and utilitarian criteria. As implied above, there is a conceptual dividing line between formal institutions, sectors, disciplines, and "resources" on the one side and informal social systems, ecosystems, and "nature" on the other. Genetic and biological diversity have been largely outside the purview of the former, although there has been a long-standing interest in specific plant and animal species and their economic potential. The process of *discovering* what are seen to be *new* biological resources is really a process of *commodification*. That is, species that previously either were outside of human awareness or were drawn upon by indigenous peoples in ways that acknowledged a mutual symbiosis, rather than a one-way exploitation, are transferred to and incorporated into formal and utilitarian systems.

Part of this process may involve what is often referred to as "the tragedy of the commons," but it involves more profound changes. While Hardin (1968) had larger ecosystemic concerns in mind, the *commons* has largely come to be a concept dealing with resource issues in terms of different types of ownership and management. That is, the area within which particular resources or species have been managed through customary and communal practices and *ownership* is partitioned and *privatized*. The debate thus becomes couched in terms of which type of system (a *commons* approach or private ownership) provides the best long-term protection and productivity for the resource. Concern about the viability of the larger habitat and other species is secondary.

Such a focus on specific species and their various uses combines easily with specialized disciplinary and economic analysis. The result, however, has often been to ignore higher level and larger scale systems, the complexity of their interactions, and how they support or impinge upon smaller scale systems and sectors (Iltis 1967). The same neglect has been recently noted within ecological/biological theory (Ricklefs 1987). Hierarchical models are clearly needed if we are to sort out what happens at different levels and scales. Interdisciplinary and systems approaches are needed if the informal as well as the formal dimensions are to be included. And in addition to developing abstract models, there is a need to describe and analyze the structures and operation of existing systems.

A final and basic point is that there must be a much greater recognition that there are genuinely different—and incommensurable—types of resources. While conventional resource economics does distinguish between renewable and nonrenewable resources (and recognizes that renewable resources can be lost through overexploitation and/or mismanagement), there is still an underlying assumption of substitutability among resources that derives from economic theory, not ecological reality. Of course, in this regard, resource economics reflects the larger lack of a physical/ecological underpinning that is characteristic of most schools of economic theory (Georgescu-Roegen 1971).

Biological theory offers one path to clarification. Both its theories and structural concepts are hierarchical and systemic. In analyzing the viability or resiliency of a given system, at least two factors are involved. First, there is the question of the operation and health of the system itself. Next, and more important, there is a need to examine the ways in which the system depends upon the viability of both its subsystems and the larger surrounding systems of which it is a part.

The trophic or ecological pyramid offers one example that combines these theoretical and structural components. Another involves the energy and mineral cycles that are involved in ecosystems. Both ways of illustrating natural systems are combined in Figure 1 (inspired by Davis 1979). In a parallel manner, the agricultural and industrial components of modern economic systems are depicted.

Figure 1 suggests that each higher category of life directly depends upon the lower and more fundamental categories as well as their genetic and biological diversity. It also suggests that the agricultural and industrial subsystems of modern economic systems are also structured hierarchically, although each depends upon a very different resource base. While industrial subsystems are newer and provide supplemental resources and inputs for agriculture, the fundamental base of agriculture—and thus that of the overall economic system—is still biological and thus ultimately dependent upon natural systems and their genetic and biological diversity.

Biological theories and concepts thus clearly suggest that genetic and biological diversity are the *source* of resiliency and regeneration of natural living systems. They are thus both prior to and more fundamental than what are termed renewable *resources*, which, in turn, are more basic than nonrenewable *resources*. The term *source* (Myers 1984) stresses not only that genetic and biological diversity are prior to and more fundamental than *resources*, but also that unlike the latter, they fall outside of a purely utilitarian and economic calculus. They are not solely means to societally defined ends. Rather, they are the ultimate source of regeneration for societies and their resource hierarchies—as can also be seen from a cultural evolutionary perspective; that is, although human societies that have minimally exploited nonrenewable resources have existed, none has existed without relying upon renewable resources.

Thus, while resource economics—and other ways of analyzing resources—has important uses, it should be applied to phenomena and processes that transcend both its conceptual and methodological assumptions only with caution and a full awareness of its limits. Unfortunately, this has rarely been the case, as can be seen in the way in which resource economics has tended to focus upon a single species (cattle, pine trees, codfish, etc.) and has sought to determine its "maximum sustainable yield" within a given area. While such an approach does not preclude an analysis of relevant ecological interactions, it is only in recent years that attempts have been made to include them. In any case, the management goal remains one of exploiting one or two species and seeking to maximize their yields over the longer term.

Curiously, resource economics has not been applied much to agriculture. This may owe in part to the fact that is has focused primarily upon species with multiyear life cycles, whereas most crops are annuals. The type of economic analysis applied to agriculture focuses more upon maximizing income for any given year than upon what might offer the "maximum sustainable yield" for a farm over a 15- or 20-year period. Another difference in focus can be seen here: that in resource economics concern is with the maintenance of the populations and habitats involved as well as with the economic returns available from them, whereas in agricultural economics, the assumption, once again, is one of substitutability among different crops, and that, consequently, the only questions relating to maintenance or sustainability are those involving such matters as soil erosion or the draw down of water tables.

It is hoped that the above discussion illustrates that when resource and other economists use the term *renewable* they are really talking about maintaining specific populations of a relatively small number of species, plus those aspects of their habitats that bear directly upon those populations. The underlying reproductive and regenerative process of the myriad species and populations in any given ecosystem—upon which the maintenance of the target populations and processes depend—are not directly analyzed nor dealt with, nor are the larger ecosystemic processes. As indicated above, interdisciplinary and systems approaches are needed to understand these matters fully. In addition, the various cultural biases outlined need to be addressed and included. Beyond this, and perhaps most important, if there are to be changes in institutional and individual behavior regarding these sources of life, resiliency, and evolution, there will also have to be significant ethical transformations.

Global Implications

Work done at the global level has great relevance for development theory and practice—even though few of its substantive or methodological implications have been pursued in the literature on development. Let us review some of the key dimensions. First, work on global issues has been more interdisciplinary- and systems-oriented than most. This can be seen in the various reports and models that have been a central part of the "limits to growth" debate. Next, the substantive focus of the debate to date has been upon the question of whether or not industrial societies can be maintained given rapidly increasing rates of population growth and resource use, and their accompanying environmental impacts. This very question, however, challenges one of the fundamental assumptions of most developent theories: that industrial society is the model that Third World countries should seek to emulate in pursuing modernization and development.

This is not to say that the models and assumptions of the various global studies—even though they represent important interdisciplinary efforts—are not without their own problems. Besides the lack of adequate knowledge and data regarding many processes such as deforestation and desertification (which derives in part from the previously noted lack of attention to informal and

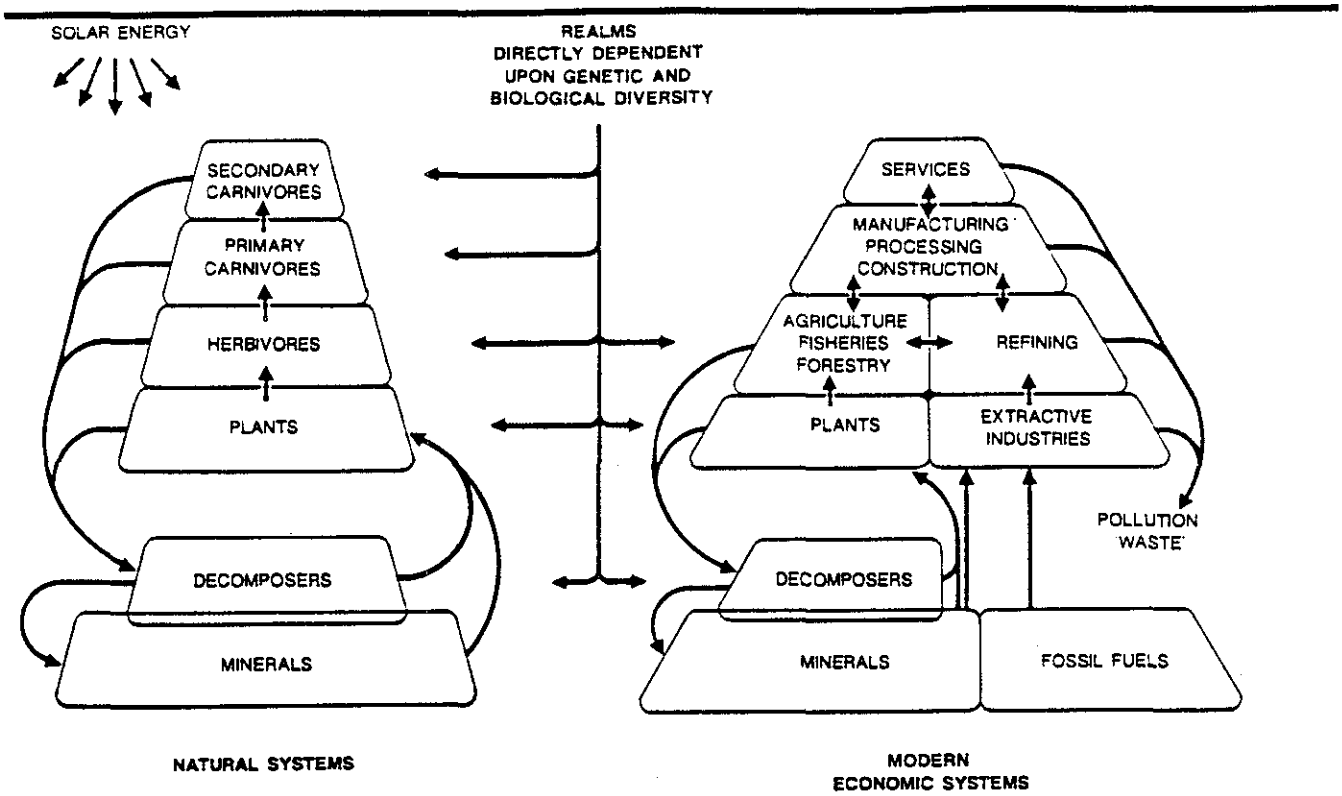

Figure 1. The hierarchical and ecosystemic dimensions of natural and modern economic systems and their dependence upon genetic and biological diversity.

natural systems), the conceptions of resources used in most global models are very similar to those critiqued above and involve many postulated—rather than demonstrated—interactions among population, resources, and environment.

This postulation is not surprising given the relative newness of global modeling. However, we must be equally critical of the assumptions and of the limitations of the data in each subfield if we are going to be able to evaluate the global models better and to help develop larger scope concepts that can better integrate the subfields. For example, some have challenged the anthropocentric focus of demography, arguing that it needs to include livestock and wildlife populations as well as human populations (Borgstrom 1967). Regarding resources, we not only need to examine aggregate resource availability—particularly of fossil fuels—but also how demand for those resources is distributed by region, country, and economic sector. Environmental impacts have been discussed primarily in terms of those pollutants that affect humans in fairly direct, immediate, and visible ways, particularly those that cause health damage, degradation of important habitats and soils, and climate change.

Beyond recognizing the above limitations, the more fundamental need is to recognize that the viability of each of these three subsystems ultimately depends upon genetic and biological diversity for its continuation and regeneration. To the degree to which we are able to incorporate this recognition into our models and understandings of global processes, the "limits to growth" debate can be expected to shift its emphasis from the availability and substitutability of conventional resources to the resiliency and regenerative capacity of different-scale systems.

The recent U.S. Office of Technology Assessment report (1987) takes a modest step in this direction in its attempt to analyze the requirements for maintaining genetic and biological diversity at three different levels: the individual level, the species level, and the ecosystem level. However, there are different-scale ecosystems, and the larger the scale, the less well equipped we are—either conceptually or in terms of data—to describe and to analyze interactions and relationships. At the global level, literature is emerging on the biosphere as a living system—the so-called Gaia hypothesis—that seeks to understand global interactions (Lovelock 1979, National Audubon Society 1986). However, it is still in its infancy, as is the literature on a *nuclear winter* (London & White 1984, Ehrlich et al. 1984).

In summary then, the implications of redefining resources at the global level are: 1) genetic and biological diversity are the ultimate sources of the maintenance, regeneration, and evolution of the biosphere and its various subsystems; 2) they are therefore more fundamental than either *renewable* or *nonrenewable* resources; 3) these ultimate sources of life (neglected because of Western cultural and analytic biases) are severely threatened by the operation and extension of industrial processes and practices; 4) as a result, new concepts, priorities, and practices will be needed at *all* levels—particularly national levels—to establish more regenerative and sustainable systems.

Redefining Development

At the national level, development is the key concept needing redefinition. Similar biases, gaps, and areas of neglect to those found at the global level exist in its basic conception and approaches, although there are additional ones as well. These relate to the specific evolution of development theory since World War II, which essentially has provided a series of a priori prescriptions and post hoc rationales for the rapid expansion of Western industrial systems (whether capitalist or socialist) into the Third World. In addition, there has been a type of dialectic, whereby each major critique of development theory has been acknowledged—verbally, if not always substantively. In this sense, the United Nations mega-conferences of the 1970s and early 1980s can be seen as a catalog of problems and issues not adequately dealt with in development theory; among them are the environment, population, food, women, energy, desertification, water, habitat, and the sharing of the resources of the seas.

In each case, either there was no specialized agency to address these issues or the issues were seen to be systemic and to transcend the narrow approach of any given agency. Each conference exhibited a tension between economic conceptions of development (which assume the necessity and desirability of continued economic growth) and other conceptions that include other goals and seek to recognize various environmental and resource limits. The doctrine currently seeking to reconcile this tension is *ecodevelopment*, which essentially says that the Third World countries will gain both economically and ecologically by learning from the mistakes of the industrial countries and by designing industrial and agricultural systems that are less polluting and less degrading of renewable resource systems (Riddell 1982).

Conventional development theory has yet to address fully the ideas and assumptions upon which *ecodevelopment* is based. In part, this owes to the presence of large vested interests that would be affected by the policy changes it would require. However, it also derives from a lack of awareness of the various cultural biases mentioned at the beginning of this paper. The result is that both development theory and practice overemphasize formal, urban, and industrial institutions and approaches. Reinforcing this is another Western cultural bias particularly visible here: the belief that technologies are neutral in and of themselves—while at the same time Western technologies are assumed to be superior to indigenous and locally adapted technologies developed over centuries of trial and error. In part, this belief in technological superiority may simply echo similar beliefs regarding the superiority of Western religion, culture, and institutions that accompanied and helped to rationalize eighteenth- and nineteenth-century Western expansionism, colonialism, and imperialism (Bodley 1982). While the literature on appropriate technology has offered an important challenge to these assumptions, the full implications of recognizing the nonneutrality of technologies are rarely realized or spelled out, either for the developing countries (Diwan & Livingston 1979, Dahlberg 1979) or for the industrial world (Lovins & Lovins 1982, Winner 1986).

Finally, conventional development theory does not recognize that those areas that are neglected—the natural, the informal, the rural, the female—generally constitute a much larger proportion of Third World than industrialized economies. If one combines these recognitions with the redefinition of resources illustrated in Figure 1, the clear implication is that national development strategies in the Third World need to be revised in four fundamental ways. 1) They need to be based on the top priority of maintaining the fullest possible extent of a country's genetic and biological diversity as well as conserving its renewable resources. 2) In pursuing this goal, it will be important to seek a greater appreciation and understanding of the ways in which indigenous practices and technologies—particularly those found in the rural and informal sectors—have historically served to conserve genetic and biological diversity, as well as cultural heritages (Brush 1981, Altieri et al. 1987). 3) There will have to be much more emphasis upon agriculture in general—and upon indigenous agricultural and pastoral systems in particular—since they form the main interface between natural and social systems in the Third World. (However, as discussed below, this will require different conceptions and approaches to agriculture than current Green Revolution ones.) 4) All of this will require a great increase in the financial and institutional resources devoted to rural areas and agriculture as well as a re-evaluation of urban and industrial goals and priorities.

These changes are not something that the developing countries can be expected to pursue and accomplish on their own. The momentum and power of current institutions—both national and international—is such that there will have to be significant changes within the industrial countries and in international trade and financial structures as well. As implied in the discussion of the limits to growth debate, the various global threats that the industrial countries are generating for themselves may impel more changes than the needs and pressures emanating from the developing countries. The direction of some of these changes can be seen in post-OPEC oil embargo proposals that have sought to move industrial countries toward what has been termed either a *conserver society* (Valaskakis et al. 1979) or a *soft energy path* (Lovins 1977).

These proposals have focused primarily upon resource and energy conservation and upon reducing pollution. Even though they have tended to use conventional definitions of resources, they have placed a much higher priority upon renewable resources than is typical—perhaps because of the longer time horizon they employ. They contain little discussion of the power and momentum of international trade, financial, and military infrastructures and institutions and how these might impede movement toward their goals. Also, while they exhibit a general awareness of global resource, population, and environmental trends, there is little specific reference to the fundamental importance of preserving genetic and biological diversity.

What about the role of agriculture in these discussions of alternative paths? Given general urban/industrial biases, it is not too surprising that the primary focus has been upon the industrial sectors and that agricultural and rural matters—whether national or international—have been included only as tangents. Also, there is little analysis of the important trade, financial, and corporate linkages between First and Third World agriculture, much less their impact upon genetic and biological diversity. What little analysis there is of the increasing incorporation of Third World agriculture into an international nexus is to be found in either structural or world systems analyses (Polanyi 1957; Wallerstein 1974, 1978; de Janvry 1981). However, neither this nor conventional development literature notes that the conscious restructuring of traditional rural and agricultural systems so as to bring them into the formal sector also leads to the loss of many practices and customs that have helped to conserve genetic and biological diversity (Brush 1981).

In turning to the more specialized literature that deals with agriculture at a national level, it must be noted that very different assumptions underlie conventional approaches to industrial, as contrasted with developing, country agriculture. The assumption in the industrial countries is that they are already "developed" and that the problems of agriculture are to be dealt with by working within and through existing institutions, which are accepted as given and legitimate. In contrast, the view of agricultural problems in the developing countries—a largely Western view as noted above—is that major institutional, policy, and structural changes are needed both nationally and within the agricultural sector in order to *modernize* and *develop*.

Important critiques of these conventional views are emerging, both within the industrial and developing countries. Each suggests a much more important role for agricultural and rural matters, although the goals that they suggest are rather different—reflecting a type of mirror image of the conventional assumptions. I will review each of these two bodies of literature below and then attempt to show how they relate to the larger need to conserve and to maintain genetic and biological diversity.

Sustainable/Regenerative Agriculture in Industrialized Countries

Recent farm crises have generated extensive literature, both conventional and critical, on the problems of agriculture in the industrial countries. Part of the criticism is based upon the increasing awareness of the importance of the energy, environmental, health, and social dimensions of agriculture, and it has stressed that these important *externalities* have not been adequately integrated into agricultural research, analysis, or policy making (Dahlberg 1986*a*). There has also been an increasing interest in what is variously termed *sustainable* or *regenerative* agriculture. While both concepts suggest alternatives to conventional agriculture, there are as yet no generally accepted definitions of their meaning or their basic goals.

The differences between conventional and these alternative approaches lie primarily in their emphasis upon natural systems and the importance of sustaining them. This has meant that much of the science that underlies these approaches—as distinct from either faith or practical experience—draws upon either ecosystem theory or energetic analysis (Lowrance et al. 1984, Pimentel & Pimentel 1979). Both are more interdisciplinary than conventional approaches and both challenge the dominance of economic modes of thought. In stressing the importance of *sustainability* or *regeneration*, both employ much longer time horizons than is typical. And, of course, ecosystems theory is clearly compatible with larger evolutionary approaches and understandings.

However, in important ways these alternative concepts suffer from some of the same limitations that conventional concepts do: that is, they tend to focus upon what happens at the farm level and demonstrate relatively little concern for how a *sustainable* or *regenerative* agriculture would relate to the larger structures and pressures of modern industrial society (or whether the latter might have to be changed to make possible the former) (Dahlberg 1986*b*).

There is also little analysis of the nature and momentum of the larger sociotechnical systems that have increasingly encapsulated farming. Thus, there is little awareness or discussion either of how one might need to move from rural-, sectoral-, or economic-based concepts of agriculture to what might be termed a *food-systems* approach, which would include how food in a specific area or region is produced, processed, distributed, and cooked; how it is understood culturally and what its symbolic and/or status functions are; how healthy and nutritious it is; which groups have access to what kinds of it; and how the various "wastes" produced throughout the system are handled.

Equally, there is little discussion of how one might regenerate the social and technological systems integral to agriculture, much less their larger supporting systems and infrastructures. For example, there is the question of how one might seek to regenerate farm families. Serious consideration of this involves matters ranging from inheritance laws to tax laws, to educational curricula, to the presence or lack of a genuine rural culture (as distinct from a dominant urban culture), and how the mass media affect this. In terms of technological systems, there is the question of how long we will be able to sustain (much less regenerate) fossil-fuel-based inputs and cultivation systems. Yet, it must be stressed that in spite of these various gaps and weaknesses, these alternative approaches are both epistemologically and structurally much more open than conventional ones to the kinds of rethinking and restructuring suggested here.

Agroecodevelopment in Third World Countries

It was suggested earlier that different concepts of both agriculture and development would be required to conserve the ultimate regenerative base of Third World societies—their genetic and biological endowment. Let us now examine in somewhat more detail what would be involved in pursuing what might be termed *agroecodevelopment*. A variety of changes—cultural, infrastructural, technological, and political—will be required, and at different levels.

As indicated in the discussion of the four basic revisions I have offered, there will have to be a much greater awareness of the extent and importance of all types of resources within a country. While conventional industrial resources are typically fairly well mapped, agricultural systems (and biological systems more generally) are not well understood, mapped, or otherwise cataloged, in part because of the various cultural biases outlined earlier. Besides developing detailed profiles of the distribution and status of its genetic and biological diversity, each country also needs to survey and better understand the various indigenous agricultural technologies and cultural practices that tend to maintain and/or conserve them—based as they are upon careful observation of the relationships and interactions of complex and locally adapted systems (UNCTAD 1986). An essential part of this is much greater recognition of the role of women in traditional and peasant agricultural and food systems (Fortmann & Rocheleau 1985).

It is particularly in this regard that the various national and international agricultural research centers have been weak in their approaches to collection. Reflecting the essentially engineering approach of plant breeders, as well as the general cultural belief in the neutrality and transferability of technologies, little in the way of ethnobotanical data has been collected along with germplasm, which would describe the cultivation and/or gathering techniques employed; the taste, color, and nutritional preferences of the users; possible medicinal uses; or the economic role (if any) of the particular plant or animal. More fundamentally, such ethnobotanical data can be crucial in seeking to understand better the ecological and cultural interactions that are involved (Nabhan 1985).

The reference to animals (as well as plants) points to another set of biases. As stressed in the recent U.S. Office of Technology Assessment (1987) study, much more attention needs to be paid to indigenous livestock and game, both in terms of genetic conservation and pursuing a more locally adapted and integrated agriculture. As consideration is given to establishing systems for their conservation—whether national or international—the need to include systematic ethnographic surveys and information is crucial. Finally, it will be important to recognize consciously and include the much greater efficiency of internally managed indigenous systems and to develop methods to maintain or to strengthen their integrity and viability.

All of this will require at least two fundamental shifts in belief. The first involves rethinking Western concepts of economic efficiency and productivity. In addition to the weaknesses of the conventional economic theories I have noted—their lack of inclusion of informal and nonmonetized activities and their lack of recognition of the fundamental differences between resources—there are other difficulties that involve the basic differences in the relative cost of the different production factors. In agriculture, measures of efficiency and productivity have tended to be defined in purely economic terms, which reflect the relative cost of the production factors found in the industrial world, where there has been relatively little available labor in comparison to available land (natural resources) and capital (including technology). In most developing countries very different balances exist, with large pools of labor available as compared to land or capital. Thus, even in purely economic terms, different definitions of efficiency and productivity are suggested, as is clear in the literature on appropriate technology.

The second shift in belief involves the very different pictures of both modern industrial and traditional agriculture that emerge when neglected ecological and energy factors are included. It then becomes clear that industrial agriculture achieves high levels of production through large fossil fuel subsidies, which really means that it achieves high crop production and productivity at the cost of low energy efficiency (Steinhart & Steinhart 1974, Pimentel & Hall 1984). Traditional agroecosystems, which only recently have become the subject of careful examination and detailed analysis, are much more energy and resource efficient (Mitchell 1984, Altieri 1983, Klee 1980), and sometimes—as with certain rice systems—almost as productive (Bayliss-Smith 1984).

In addition, there is a need to develop more comprehensive approaches that include the neglected social and technological systems mentioned above. While there has been critical social analysis, it has tended to come out of studies either of the political economy of the Green Revolution or the role of land tenure and reform in development. And while there has been a great deal written on appropriate technology, most of it focuses upon household- or village-level technologies, and only a few works explore its systemic dimensions and seek to sort out what is appropriate at higher levels (Diwan & Livingston 1979). Thus, there is a clear need to seek better analytic and theoretical means for combining and integrating the three basic subsystems involved in traditional agriculture—the ecological, the social, and the technological. However, it is crucial that a recognition of the fundamental importance of conserving genetic and biological diversity be included. This combination offers the basis for a new way of evaluating development plans and priorities.

Summary and Implications

The argument in this essay has been complicated for several reasons. One is that several different bodies of literature critiquing modern industrial society have been reviewed. These critiques are made at different levels, from the local to the global, and stress different topics, ranging from energy to environment to economics to resources. The critiques have themselves been critiqued on the basis of their Western cultural assumptions (typically shared with conventional approaches) and on the basis of a redefinition of resources. This redefinition of resources is fundamental and draws upon, but goes beyond, most of the literature seeking to understand the importance of genetic and biological diversity.

Rephrased, the argument goes as follows. Western cultural assumptions regarding man's relation to nature, the role of science and technology in generating progress, and the belief in the neutrality of technology have combined with the growth of industrial society in ways that influence how we perceive the world and the ways in which we structure it. Progressively more intensive applications of science and technology to society—something that has required increased levels of energy throughput as well as ever larger and more centralized infrastructures and institutions—have increased both environmental and social stress upon a variety of systems, many of which are informal and thus largely "invisible" in conventional analyses.

Various critiques and alternative approaches have been more sensitive to these stresses, but they still miss many of the informal dimensions. These informal systems tend to be found more in the Third World than the industrial world, more in rural than urban areas, and more in female- than male-dominated activities. As with conventional analyses, very few critiques seek to understand technological systems as systems. And while there is usually much more in the way of interdisciplinary work involved in these critiques, it is typically within the natural or social sciences, not between them. The humanities—particularly in relation to questions of ethics, values, goals, and priorities—have been largely left out. Similarly, few critiques systematically seek to place themselves within a larger context that examines how the system critiqued has evolved historically and how it interacts with and depends upon sub- and suprasystems.

Most critiques still draw upon conventional definitions of resources, although they tend to stress the importance of renewable resources much more than traditional approaches and also tend to employ much longer time horizons in their evaluations. If one takes into account the larger parallels between natural and modern economic systems (Fig. 1) and adds to that the basic ways in which genetic and biological diversity underlie both, then a new understanding or definition of sources *and* resources emerges: one based upon a hierarchy where genetic and biological diversity are more fundamental than renewable resources, which in turn are more basic than nonrenewable resources.

This hierarchy illustrates sharply one of the deepest long-term stresses and threats to industrial society: that its use and dependence upon the least basic of these resources—primarily fossil fuels—is destructive not only of the renewable resources upon which it will have to depend more in the future, but also of the sources of life and evolution that keep those renewable resource systems viable. The basic question thus becomes: Can we restructure industrial society or guide its evolution in ways that will be more sustainable and regenerative? In suggesting an approach for dealing with this question, the basic argument has been twofold. First, the clear implication of recent research—that there is a crucial need to restructure and to transform industrial systems in ways that will progressively reduce their destructive impacts upon genetic and biological diversity at all levels—has been accepted as an operating assumption. Second, it has been argued that restructuring agriculture in regenerative and sustainable ways is the key task. This is both because of the basic role agriculture plays in social systems (as compared to other types of economic activity) and because it depends more directly and immediately upon the presence of genetic and biological diversity.

Just how much and what types of genetic and biological diversity are required to maintain sustainable and regenerative agricultural systems is not clear. However, given the importance of global and regional systems of diversity for local diversity (Ricklefs 1987), as well as the neglect of informal social and natural systems in the literature, it is clear that much more than the current system of national and international seed banks, zoos, and nature reserves is needed.

The suggestions made here on how to encourage this restructuring relate more to rethinking and reconceptualizing, rather than to specific policy or institutional prescriptions. There are several reasons for this, including the lack of space and the basic differences in context that exist between specific climatic zones, countries, and sociotechnical systems. In addition, it will be hard for anyone to do more than to outline general approaches and strategies until studies of specific countries and localities are conducted that incorporate the neglected types of data and systems noted above. Particularly, there is need to identify the extent and dynamics of genetic and biological diversity, to survey biological and agricultural systems and their cycles, and to study and analyze indigenous agricultural practices and technologies, such as how they interact with eocsystems, in particular agricultural regions.

At the same time, the industrial countries have a great deal to learn about how to move toward more regenerative systems from the work that has been done on traditional agroecosystems. Their resilience and sustainability (at least within certain population limits) derive mainly from trial and error experience often extending over centuries, as well as from cultural understandings of, and respect for, environmental limits and symbiosis. Here, again, the importance of including ethnographic understandings along with the analysis of other systems becomes clear. Indeed, one of the major conclusions that can be drawn from the above analysis is that there is a parallel and equally important need to study, understand, conserve, and maintain indigenous agroecosystems as there is to study, understand, conserve, and maintain genetic and biological diversity.

It is important to contrast these two sources of life and regeneration with the major sources threatening their destruction. The most obvious and dramatic source is the threat of nuclear war—whether in its immediate violence or its longer term consequences. Related to this, but less obvious, is the complex of beliefs, perceptions, vested interests, and priorities that result in a technological and military search for security, which is not only risky in and of itself, but also diverts the public policies, the financial resources, and the institutional capabilities of most countries away from saving our most fundamental and life-giving endowments.

Finally, there is the threat of industrial society to itself. While most of us see *civilian* technologies as either neutral or peaceful, they are often not so in regard to nature. As Raymond Dasmann noted in his address on the occasion of Georg Borgstrom's retirement, the Third World War—the war against nature (and ultimately humankind)—is already well under way, and that on the front lines of the tropical forests nature is suffering grievous losses from attacks by bulldozers, chain saws, and defoliants. There are also many other and more general attacks from air and water pollution, as well as from the destruction of unique habitats.

While it may not be fully intentional, this war against nature is built into the current structures and belief systems of industrial society. Perhaps only if we come to understand the full value and importance of what we are destroying will we then realize that not only do we need to rethink development, but we must also reconceptualize *national security*. Increasing losses of genetic and biological diversity ultimately threaten the welfare, viability, and thus the *national security* of most states. Yet, to suggest seriously that a modest 10 percent of each country's national defense budget be reallocated to defending and protecting genetic and biological diversity gives one some idea of the magnitude of the conceptual, institutional, and political obstacles.

Yet, on the positive side, it should be recognized that we have many resources to draw upon in facing these questions and dilemmas. It is hoped that the industrial societies will be able to learn and practice the wisdom of millennia of peasants and farmers; that is, that in addition to finding ways to get along with one's neighbors, the ultimate sources of security lie in conserving one's fields, animals, and especially each year's heritage of regeneration—the seed corn.

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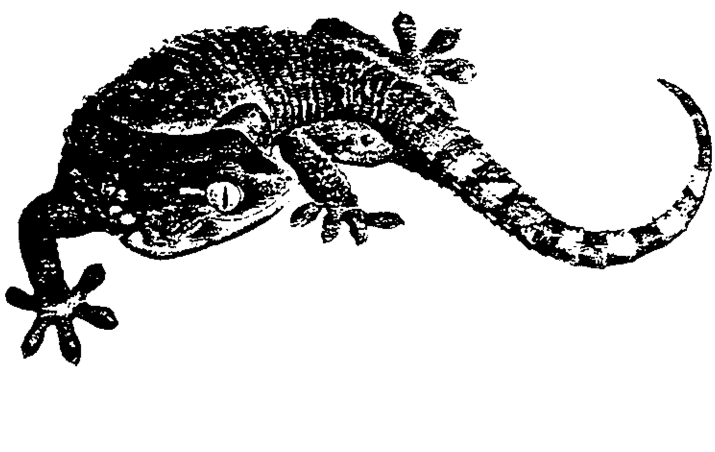

Biological Diversity

Culture and conservation

A greater sensitivity to local culture could increase the success of both conservation and development projects

Local people's access to resources may be the crucial, but often unrecognized, conflict undermining efforts of both conservationists and developers. More consideration of the interests of local human populations could improve the outcome of conservation biologists' efforts to preserve the world's wildlife and wildlands, according to speakers at a recent two-day symposium sponsored by the National Zoological Park in Washington, DC.[1] The meeting was the latest in a series of zoo symposia on human understanding and protection of animals.

"The connections between culture and development, between culture and nature, and between development and conservation are the key to understanding and preserving the natural world today," said Robert McCormack Adams, secretary of the Smithsonian Institution in Washington, DC. "We cannot coexist with developing countries if our priorities emphasize conservation and theirs [emphasize] catching up with our development. We cannot expect them to support conservation if they perceive it as us trying to prevent them from achieving economically what we already have."

With that introduction, speakers and participants analyzed how local culture can be integrated into both development and conservation plans. For example, in Brazil a golden lion tamarin program has instilled a sense of national pride in the conservation of these animals. The golden lion tamarin is a small, brilliantly colored orange-and-reddish monkey from Brazil's coastal rain forests. Only two percent of those forests remain, and only 300-400 tamarins are still found in the forests. Since 1984, the national and other US zoos have sent captive-born tamarins to Brazil for release in the wild to bolster declining populations (*BioScience* 38: 315).

by Jeffrey P. Cohn

Local people's access to resources may be the crucial, but often unrecognized, conflict

"Without the collaboration of the people in the region where golden lion tamarins live, all other efforts, while essential, will have limited results for the long-term conservation of the species," said Lou Ann Dietz, a World Wildlife Fund (Washington, DC) program officer and coordinator of the national zoo's conservation education project in Brazil.

Dietz told the symposium audience how she and her Brazilian colleagues and volunteers have addressed schools, universities, government meetings, community groups, and anyone else willing to listen. They have arranged for a Brazilian foundation to fund a traveling exhibit and to sponsor television spots—even the poorest people in areas without electricity use car batteries to power television sets. The group also has taken local conservation clubs and other interested individuals to see golden lion tamarins in the wild. As a result of such efforts, these animals are rapidly becoming a symbol of wildlife conservation in Brazil, Dietz said.

Cultural bias and politics

If habitat is to be preserved for golden lion tamarins and other animals, conservationists will have to overcome the cultural view of tropical rain forests as jungles to be conquered, said Stuart Hudson of the National Wildlife Federation in Washington, DC. Moreover, he said, in seeking to preserve natural habitats and ecosystems, conservationists too often forget about the politics of issues.

"We charge up the hill on behalf of conservation causes without first looking around to see if anybody is following us," Hudson said. He encouraged conservationists to find political constituencies in the United States and developing countries that will support their programs and policies. "There are people who are willing to stand up for environmental issues," he said.

The watchwords of conservationists today are "biological diversity" and, more importantly, "sustainable development," said David Western, acting head of the New York Zoological Society's Wildlife Conservation International in New York City. Western cited human population growth (tenfold in his native Kenya alone in the last century) as the greatest development problem and as, ironically, a clue to some of its solutions.

"Animal populations should have declined by 90% in Kenya given the number of people now living there," Western said, "but they have dropped by only 30–50%. The animals and people can survive together by a more

[1]The symposium Culture: the Missing Element in Conservation and Development was held 8-9 April 1988 in Washington, DC.

intense use of resources."

One species that is not surviving, Western noted, is the black rhinoceros. The animals are on the verge of extinction in Africa because poachers kill them for their horns, which are made into dagger handles and sold in the Middle East. However, while dead rhinos are worth about $8000, Western said, alive they can bring in $400,000 a year as a tourist attraction.

"Those benefits have to be distributed to local people if we are going to change their attitudes about the value of rhinos," Western said. "To do that we have to consider that different societies and different peoples have different cultures, outlooks, and values."

One way to tie local conservation efforts, cultural values, and economic development in recent years has been so-called debt-for-nature swaps (*BioScience* 37: 781). The practice uses money raised by conservation groups in the United States and elsewhere to help pay off a portion of a developing nation's international and/or commercial debt, and then promotes local conservation projects with the financial resources generated. "The only way conservation will work is if it is tied up with local people and with economic development," said Charles Steele of Conservation International in Washington, DC, an organization that has arranged debt-for-nature swaps in Bolivia.

The idea and practice of debt swaps is largely symbolic, Steele admitted, because only a small percentage of a developing country's debt can be retired this way. Nevertheless, the practice can "catalyze a cooperative effort for conservation whose long-term success will make pale the actual dollars involved," he added. "We have created a partnership with organizations abroad that will help strengthen them and their efforts to protect biological diversity."

Using culture to promote conservation

Culture can be used to conserve specific species as well as habitats, said Katy Moran, a Smithsonian researcher and the symposium's coordinator. She described how traditional elephant domestication in Sri Lanka, for example, is protecting animals endangered by agricultural development.

Farmers who cultivate lands formerly within the elephants' natural range often shoot the animals when they return to raid crops. But by promoting domestic uses of elephants as traditionally practiced in Sri Lanka, at least some animals that otherwise might be killed can be saved, said Moran. Officials are now encouraging farmers to capture wild elephants. The farmers are paid from the proceeds of auctioning the captured animals for domestic use. "Elephants can be an investment rather than just a pest," Moran said.

The cultural view of elephants as a valuable resource has deep roots in the Buddhist religion and literature of Sri Lanka, said Rudy Rudran, a National Zoo conservation officer and native Sri Lankan. The challenge in that island country, he said, is to renew "an important but often ignored basis for promoting the conservation of wildlife"—the value traditional culture places on plants and animals.

Rudran described a "march for conservation" program in Sri Lanka. Begun in 1980, the program uses Buddhist writings on the value of forests and wild animals to renew conservation awareness among all Sri Lankans, not just educated urbanites. "What is required now," Rudran added, "is that local culture be emphasized more often."

The culture of primitive peoples can also be used to promote conservation, said anthropologist Darrell Posey of Brazil's Nucleo de Etnobiologia in Belem. "They have a knowledge of nature and natural systems that is often missing in conservation," he explained. "A lot of our western way of thinking about ecosystems simply doesn't work."

Posey cited an example of Brazilian Indians who modify yet maintain their tropical rain forest environment by clearing forest patches to grow vegetables, planting fruit trees in open areas to attract the animals they hunt, and sowing flower and medicinal herb seeds along pathways and other easily accessible areas. "These people have a lot to teach us," he said.

If we are to learn from indigenous people, Posey said, we have to conserve the people as well as their environment. "We have had a much greater success saving land and endangered monkeys than we have had saving primitive peoples," he said. "We seek to impose our own concepts of order, progress, and culture on them."

The differing cultural views of natural systems has sometimes led to conflicts between indigenous groups and governments in the frozen northlands as well as in Brazil's Amazonia. Northern subsistence hunters manage wildlife to obtain food for their entire group, said anthropologist Harvey Feit of McMaster University in Hamilton, Canada. Because animals such as caribou may be available only a few times a year, these subsistence hunters have to both hunt efficiently and preserve the resource for future use.

Conservationists have to overcome the cultural view of rain forests as jungles to be conquered

The result, Feit said, is often conflict between native Indians in northern Canada and wildlife managers who cater to recreational hunters. Restricted hunting seasons and bag limits appropriate for recreational hunters may interfere with the Indians' meeting their subsistence needs, while other restrictions designed by Indians may be too limited for recreational hunters. These include prohibitions against shooting lead caribou for fear the herd will not return to traditional feeding grounds without its leaders. Lead caribou are usually older males with large sets of antlers, precisely the animals that are most desired by hunters. "We need to find a link between two wildlife management systems that often work at cross purposes to the detriment of both indigenous peoples and [other] wildlife managers," Feit concluded.

Who has access to natural resources?

Similar problems have arisen when techniques designed to manage land in the United States are applied to other lands and peoples. "We tend to underestimate the productivity of other management systems,"said Jere Gillis, a rural sociologist at the University of Missouri in Columbia who has studied semiarid land management in the United States and in subsaharan Africa. "We see our way of managing resources as universally applicable. But most developing countries lack the time, money, personnel, and technical sophistication to use our methods as we use them." For this reason, Gillis adds, management systems that have successfully allowed large herds of cattle and sheep to graze on semiarid American prairies, for example, have largely failed when applied to semiarid lands in other countries.

A theme that surfaced repeatedly at the symposium is the importance of understanding the cultures of indigenous peoples, and involving the people in conservation. In subsaharan Africa, Gilles pointed out, the people already control grazing animals by migrating from place to place as seasons change. This strategy requires knowing what plants animals eat, what combination of species can graze an area without destroying the vegetation, how many animals an area can support, and what season to graze a particular area.

As an example in the United States, Benita Howell described citizen participation in planning and managing two formerly strip-mined areas of Appalachia. Such involvement can help reconcile competing needs of conservation and economic development, said Howell, a University of Tennessee anthropologist.

Howell cited the creation of a national recreation area at Mt. Rogers in southwestern Virginia as a case where local involvement helped government planners become more sensitive to environmental concerns. Contributions of local foresters, conservationists, and inhabitants caused the US Forest Service to modify plans for Mt. Rogers. Development was reduced but not eliminated, and environmentally compatible uses, such as hiking trails, were expanded.

In contrast, the US Army Corps of Engineers, responding to political pressures to build a hydroelectric dam on the Cumberland River to bolster industrial development in eastern Tennessee and Kentucky, used outside contractors and developers and made little use of local people in its planning process for a national recreation area in the region. The result, Howell said, was conflict between developers and local inhabitants, who felt they were being called in only to hear the Corps announce its predetermined plans.

Society needs to decide who owns or has access to resources, said Michael Pointer of the Institute for Development Anthropology in Binghamton, New York. Moreover, he said, conservationists and developers have to work together to resolve such questions. "Conservationists have acquired a heightened appreciation that human beings are part of the environment they seek to protect," Pointer said, adding: "Developers have learned that short-term economic growth achieved by depleting the resource base on which long-term livelihoods are based is of doubtful benefit. Building actions on these improved understandings implies soliciting greater participation by those affected by conservation and development [actions]."

Nevertheless, Pointer said there are obstacles to involving local people. Conservationists tend to view habitat loss as arising from conflicts between people and the environment rather than between people with different opinions of appropriate access to natural resources.

For their part, developers treat local populations as if they were homogeneous in terms of their goals and how they will be affected by development, Pointer argued. When a project goes awry or encounters local opposition, developers seek to improve the project's design, management, or communications. Developers rarely consider, he said, that "they may have communicated perfectly well the benefits of their project, but that those benefits may conflict in a fundamental way with the interests of a significant portion of the local population."

Summing up his talk and, perhaps inadvertently, the symposium itself, Pointer said that too often both conservationists and developers fail to recognize and address the issue of who has access to resources. The extent to which they do, he said, may mean that "their activities will be at best palliatives that do not get at the crux of issues of environmental destruction or sustainable development, and at worst could have the impact of intensifying [environmental] degradation and [economic] impoverishment." □

Jeffrey P. Cohn is a Washington, DC-based science writer who specializes in zoos and conservation.

Biological Diversity

Species Richness

A geographic approach to protecting future biological diversity

J. Michael Scott, Blair Csuti, James D. Jacobi, and John E. Estes

Extinction of species, a major focus among conservationists, is a worldwide problem. An estimated 1000 species are becoming extinct each year, and that rate could reach 5000 per year in the near future (Myers 1979). If these estimates are anywhere near correct, simply determining what species are at risk represents a formidable task. Even currently abundant species may rapidly become extinct.

Geographic information systems (GIS) technology offers a new opportunity to perform such analyses. These systems were developed to assemble and analyze diverse data pertaining to specific geographic areas, with spatial locations of the data serving as the basis for the information system (Figure 1). Having, as the primary source of input, data referenced by spatial or geographic coordinates (Estes 1987), GIS can assemble, store, retrieve, and manipulate data on species distributions. These data can be used to present information to a resource manager in an easily analyzed form.

J. Michael Scott is the unit leader of the Idaho Cooperative Fish and Wildlife Research Unit, College of Forestry, University of Idaho, Moscow 83843. Blair Csuti is a conservation fellow with the Center for Conservation Biology, Department of Biological Sciences, Stanford University, Stanford, CA 94305. James D. Jacobi is a research botanist with the US Fish and Wildlife Service, Patuxent Wildlife Research Center, Laurel, MD 20708. John E. Estes is the head of the Geography Remote Sensing Unit, Department of Geography, University of California, Santa Barbara 93106. They all are interested in conducting research and implementing management actions that will preserve biological diversity into the next century.

Geographic information systems technology offers a new opportunity to determine what species are at risk of extinction

The scope of the problem

The US Fish and Wildlife Service (USFWS) lists 946 taxa as endangered or threatened (USFWS 1987). An additional 3000 taxa are listed as category 1 (taxa with sufficient information to propose listing as endangered or threatened and species that may have recently become extinct) or category 2 (taxa that are thought to be endangered or threatened but for which more data are needed to justify listing). Since 1620, over 500 species and subspecies of native plants and animals have become extinct in North America (Opler 1976). And there have been far more massive losses in tropical rain forests (Myers 1986, Simberloff 1986).

History gives us many examples of widespread and common, if not abundant, species that are now extinct or endangered. Who would have predicted the extinction of the passenger pigeon (*Ectopistes migratorius*), so numerous it obscured the sky in the mid-1800s? The plains bison (*Bison bison* bison), once widespread across North America, has been virtually eliminated from its natural habitat and exists today only in small herds in parks, refuges, and game farms. More recently we have seen the dusky seaside sparrow (*Ammodramus maritimus* nigrescens) decline from perhaps 2000 birds in 1968 to only 6 males (5 in captivity, 1 in the wild) in 1980 (USFWS 1980a). The last captive bird died recently. If history is any guide, without appropriate systems-level conservation actions, a number of species currently abundant will soon join the ranks of the endangered or extinct taxa.

With our current knowledge, we are not even able to begin assessing our species losses. Public and private data bases commonly restrict themselves to monitoring either the rarest ten percent or less of all species or those species that are hunted. Monitoring efforts for rare species, while addressing the immediate need of protecting these rare species, provide no framework for analysis of long-term trends in biological diversity. The Nature Conservancy, for example, recognizes that the protection of individual populations of rare species is only part of its challenge (Nature Conservancy 1975). Natural communities, complete with their assemblages of common plants and animals, must also be protected to address the entire spectrum of diversity.

A conservation movement dedicat-

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ed to the protection of natural diversity has grown considerably in this century. National parks and wildlife refuges, initially selected for their scenic beauty or concentrations of game species, have certainly preserved millions of acres. Yet, as scores of endangered species approach extinction, public and private organizations have been forced to use heroic measures to save, on remnant patches of habitat, the last individuals of endangered species (Temple 1978, USFWS 1976–1987). But, while the list of candidate endangered species grows into the thousands, no assessment of the distribution of biological richness relative to management areas exists from which to determine the scope of the conservation need in North America and elsewhere.

The majority of animal species are not endangered; they range from abundant and widespread to uncommon and localized (Williams 1964). Given changing patterns of land use, we cannot estimate with any confidence how many will survive to the year 2100. Worse, we cannot identify the minimal areas whose protection would ensure the survival of 98%, 90%, or even 50% of today's species. No one has analyzed the distribution of plant and animal species in a way that would identify the number occurring on existing preserves or the number that could be saved through the intelligent planning of future development.

The efforts of many conservation groups have been largely restricted to protecting areas harboring unique communities or a single species recognized as endangered. The Nature Conservancy, however, has recently begun adopting a systems approach for the preservation of biodiversity and has done much to protect major biotic communities (Roush 1985). If the erosion of biological diversity is to be arrested in the coming century, conservation efforts for critically endangered species must be supplemented by a systems approach to species protection. Wilson (1985) stated the need for a national inventory of biological resources. However, in the absence of a complete inventory, we can make more sophisticated management decisions using available data and geoprocessing technology.

As a framework for conservation actions, the battles for species preservation are fought at six levels—landscape (Noss 1983), ecosystem, community, species, population, and individual. Management costs per species increase, and the probability of successful recovery decreases, as conservation actions are focused on lower levels of this hierarchy.

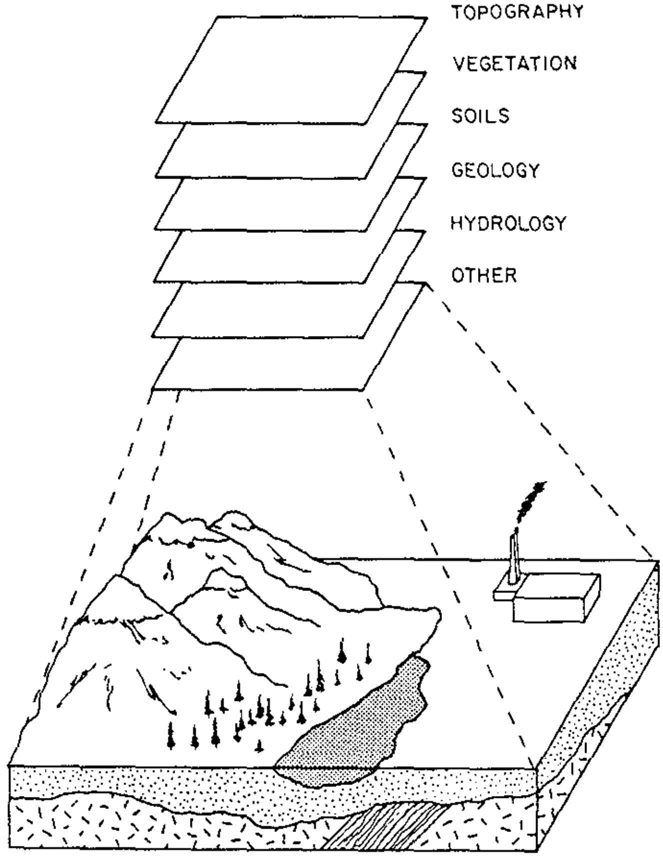

Figure 1. A geographic information system consists of a collection of layers of thematic data (e.g., soils, geology, and hydrology) in point, line, surface, or polygon form that have been registered to a common coordinate system. This figure depicts the general layering possibilities.

Reevaluating conservation priorities

By the time a species reaches the US Endangered Species list it is, by definition, "in danger of extinction throughout all or a significant portion of its range" (US Congress 1983). The motivation to rescue otherwise doomed species rests upon philosophical as much as biological grounds, and may be compared to emergency room treatment for the critically ill. Endangered species are the focus of much of the effort to save species today, and elaborate and costly recovery plans have been written for more than 200 taxa (USFWS 1976–1987), many of them for species numbering less than 100 individuals.

It is a sad commentary that the current widespread practice of "Emergency Room Conservation" channels most of the economic and emotional support for the protection of biological diversity into those few species least likely to benefit from it. While heroic efforts are sometimes successful in reversing the downward trend of a rare species (e.g., Owens

River pupfish [*Cyprinodon radiosus*] [Moyle 1976] and whooping crane [*Grus americana*]), their cost is often staggering and fraught with the potential for failure (e.g., California condor, *Gymnogyps californianus*, and black-footed ferret, *Mustela nigripes*). The last members of these critically endangered populations may be eliminated by a chance event (Raffaele 1977, Wetmore 1925).

More importantly, as Pitelka (1981) so eloquently stated, such efforts suffer a lack of perspective when measured against the objective of preserving overall biological diversity on the planet. This latter objective is better served by applying the tools of conservation biology and modern geoprocessing technology to the analysis of the majority of the earth's species to determine how and where they might persist in relatively unperturbed situations, and then managing those ecosystems rather than individual species (Nisbet 1978). A major difficulty lies in knowing where to focus the management efforts.

What is required is a program to determine how many species are encompassed by existing preserves and where future preserves would protect the maximal number of species. This objective could be met by a GIS in which data on species distributions are combined with data on boundaries of existing preserves (Figure 2). Such a system, properly constructed and incorporating the appropriate data layers, could significantly improve our understanding of the long-range effects of multispecies management practices. This information, when combined with data on historical trends in the populations of interest and changing land use patterns, should allow us to anticipate endangerment of a population, species, or community.

Multispecies management

As more species within the same ecosystem require emergency recovery efforts, we will find that maximizing benefits to one endangered species may further threaten another. Examples have already been observed in California. Improving the water supply for the Owens pupfish resulted in the near loss of one of two populations of a snail endemic to Fish Slough in the Owens Valley of California.[1] Enhancing the habitat of the Morro Bay kangaroo rat (*Dipodomys heermanni* morroensis) by shrub clearing appears to reduce habitat for the banded dune snail (*Helminthoglypta walkeriana*).[2]

There is less expense and more chance of success if we fight extinction in the long term by maintaining self-perpetuating populations of more common species. We must act now to prevent species from becoming endangered, rather than waiting until each has been reduced to a few hundred individuals. Prevention is cheaper than treatment. For example, in the 7200-hectare Sacramento National Wildlife Refuge there are 257 vertebrate species, 170 with resident populations. The populations of many of these species number in the tens of thousands. The annual cost of managing this system, estimated at one million dollars, is less than the annual expenditures on the recovery effort for the critically endangered California condor.

Several different methods have been used to identify areas for protection. Most commonly, areas with large numbers of individuals or species of interest are selected. More recently, Diamond (1986) used biogeographical zones to identify centers of endemism that, if set aside, would protect the vast majority of vertebrate species in Irian Jaya (the western half of the island of New Guinea).

A related approach involved plotting the ranges of land birds endemic to Colombia and Ecuador and identifying the greatest concentrations of endemic species. Terborgh and Winter (1983) proposed that these areas would be optimal for future preserves.

To assess adequacy of protection, Hawaiian researchers mapped the ranges of endangered bird species and plotted their distribution in relation to existing preserves. They found that existing preserves included few areas

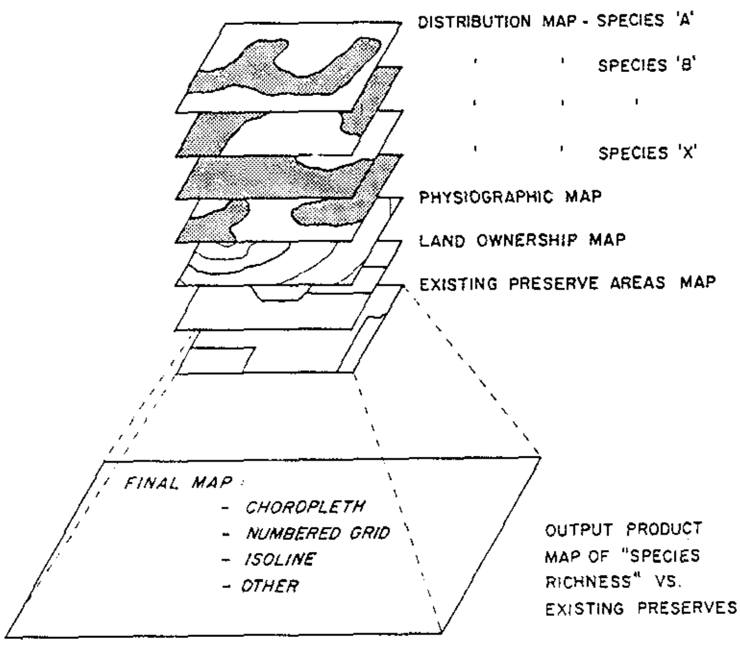

Figure 2. By superimposing species distribution information with data on land ownership and preserve locations within a GIS, maps of the relationship between species richness and existing preserves could be produced in a variety of formats.

[1]E. P. Pister, 1983. Personal communication. California Department of Fish and Game, Bishop, CA.

[2]L. Eng, 1986. Personal communication. Natural History Section, Department of Fish and Game, Sacramento, CA.

high in species richness and even fewer areas with high population densities of endangered bird species (Figure 3). Researchers and conservationists in Hawaii used information on range, population density, vegetation types, and habitat response to identify potential preserve areas for endangered communities of forest birds (Scott et al. 1987).

Klubnikin[3] used Küchler's (1977) vegetation types plotted against existing preserves to determine the acreage of each vegetation type in California and the percentage of each in existing preserves. This simple but powerful method revealed some unexpected results. There was very uneven protection of the 31 vegetation types in the state. For example, 95% of alpine habitats were in reserves, but less than 1% of the species-rich riparian habitat was protected. It is not known how much area is needed to protect each of these habitat types.

Based on previous results and current trends in endangered species protection, there is a need to balance crisis management on individual species with a systems approach to the problem of preserving biological diversity. Research and development efforts in this area could augment ongoing conservation efforts while providing a perspective on past successes and future objectives.

Geographic information systems

A geographic information systems approach, which analyzes species richness relative to existing preserves, is a simple but powerful approach. Even where applied on a limited scale (Kepler and Scott 1985), it has led to results different from the conventional wisdom. It also offers a practical way for identifying the needs for ecosystem preservation identified in the International Union for the Conservation of Nature's world conservation strategy.

Patterns of species richness could be plotted for species of all major vertebrate taxonomic groups as well as butterflies; these are the groups for which we have the best information on distribution. The next step would be categorizing species according to their abundance (abundant, common, uncommon, or rare) and their occurrence in different habitat types (occurs in only one habitat type, two to three habitat types, or more than three habitat types). The habitat occurrence could be further refined by documenting those species that occurred regularly in habitats that had been significantly altered by man.

In evaluating these patterns of species richness, less concern would be necessary for those abundant species that are commonly found in heavily modified environments outside existing preserve areas. In contrast, preservation of the areas of high species-richness for rare species, found in a few undisturbed habitat types, would have the greatest effect on the preservation of biological diversity in the 21st century.

The opportunity exists to assess patterns of species richness on a wide scale, for example, throughout the United States and Canada. Equally valuable analyses could be done at lower cost on the state or county level, especially where good databases already exist. While cost is related to the resolution, even at the

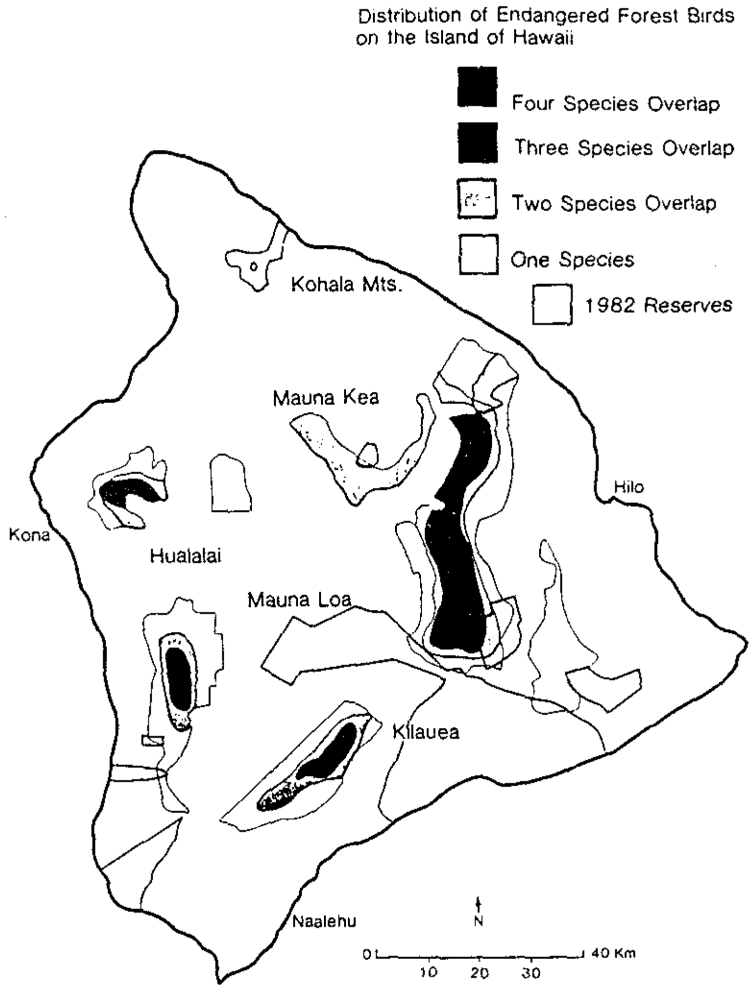

Figure 3. Distribution of endangered forest birds in relation to existing nature reserves on the island of Hawaii in 1982 (Kepler and Scott 1985).

[3]K. Klubnikin, 1979. Unpublished manuscript. California State University, Fullerton.

scale of the existing natural vegetation maps (1:3,168,000) (Kuchler 1964) identification of biologically significant units is possible. While such a GIS analysis would most easily be undertaken in regions possessing good biological inventories, the concept has global applications.

Because of their common biogeographic histories, the distributions of many species are largely coincident (Armstrong 1972, Miller 1951, Udvardy 1969). Any continental area can probably be subdivided into faunal (and perhaps floral) regions upon analysis of patterns of species distributions. Since the ranges of many species are restricted to particular biological regions, an analysis of patterns of species distributions will identify nodes of regional species richness that, if collectively protected, would capture the vast majority of continental biological diversity.

In suggesting this approach we are not obviating the need for gathering more detailed data as has been proposed by Wilson (1985) and initiated for island ecosystems by the International Council for Bird Preservation (Moors 1985). These data, when available, could provide additional inputs for fine tuning existing methods of preserve selection and design.

The straightforward process of plotting species richness or habitat types with overlays of land ownership and management practices into a GIS can provide a relatively inexpensive but powerful land-use planning tool. Raw data required include range maps for well-documented species, vegetation maps, land ownership maps, and boundaries of existing preserves.

Questions that might be addressed using this systems approach include:

- What percentage of the nongame species occur within existing preserves?
- What percentage of each vegetation type is found within existing preserves?
- Are the areas with highest species richness for uncommon species found within existing preserves?
- What percentage of endemic taxa are found within existing preserves?
- What percentage of the ranges of threatened and endangered taxa are found within existing preserves?
- What percentage of the ranges of rare and category 1 and 2 species are found within existing preserves?

If areas of high species-richness for native species other than those that have adapted to man-altered environments are found to be largely outside existing preserves, then those areas should be examined in detail at 1:24,000 scale and desirable preserve areas identified.

A coordinated digitized base of geographic information would facilitate land-use planning processes for the foreseeable future. If population density were included in the data base, increasingly sophisticated questions could be asked concerning single species and groups of species. For example, the problem of what percentage of a species range is included in a preserve is important, but perhaps more important is that core population centers be included and that, at the very least, a minimal viable population of each species be included within a preserve (Frankel and Soulé 1981, Scott et al. 1987, Shaffer 1981, Soulé and Simberloff 1985).

Maps and methods

Over the past several decades fine-scale distributional information has become available for terrestrial and freshwater vertebrate species throughout much of the United States (Jones et al. 1983, Lee et al. 1980, Nussbaum et al. 1983, Oberholser 1974). Today the distribution and habitat requirements of many of the more than 2400 vertebrates in the 48 conterminous states are known, often at a level of resolution similar to that used for major land-use planning decisions. Murphy and Wilcox (1986) stated that "vertebrates provide an adequate umbrella for invertebrates at most levels," so that most invertebrates would be protected if areas adequate to protect vertebrates were set aside.

Mapping patterns of species richness for butterflies would provide further safeguards in the attempt to protect future species richness. The distributions of most species can be refined by reference to the distribution of vegetation found in their specific habitat types. The distribution of mammal species, for example, can be predicted from that of their preferred habitat types. The species for which we have the poorest predictions of occurrence are those that are the rarest (Wiens 1981), and conservation of many of these species is already addressed on a location-by-location basis. For some species, especially birds, seasonal differences in distribution add an additional layer of complexity, but this is far from being an insurmountable problem given current technological capabilities.

Integrating vegetation data into the analysis serves a threefold purpose. First, species' ranges can be refined according to habitat preference. Second, vegetation types and their distribution provide a supplemental level for the analysis of natural diversity. And, third, unique or rare habitat types likely to harbor especially significant concentrations of plant and animal species can be identified.

In some areas the mapped vegetation represents a seral stage of recovery from a recent perturbation, such as a forest fire or range fire. In these cases, it would be useful to further modify the predictive species-richness model for the area by anticipating the potential vegetation for the area if normal succession is allowed to proceed.

It is widely believed that world vegetation types are well mapped. But accurate maps depicting actual vegetation cover are virtually nonexistent for large areas of the globe (Botkin et al. 1984). Estimates of the area of major classes of land vegetation vary widely. Current precision of global estimates of land vegetation is limited by inaccuracies in mapping the extent of vegetation types. Mapping error may range from 50% to 200% (Cosentino 1986).

Most current small-scale maps of vegetation (e.g., Kuchler 1964; a 1:3,168,000 map) are based on a variety of sources that typically predict what vegetation would be in an area if climate were constant and there were no human interference. Such vegetation maps do not depict accurately the current state of vegetation and represent little more than an informed guess as to what might be (Botkin et al. 1984).

Remotely sensed data from both aircraft and spacecraft are improving our ability to map vegetation over large areas (Colwell 1983). Both the National High Altitude Aircraft Program and the Landsat Series Satellites are improving our understanding of actual vegetation types, patterns, and temporal dynamics. While it may be possible to construct state-level vegetation maps from Landsat data on the order of 43 Landsat frames and 970 million 57 m × 80 m picture elements (pixels) for California alone, the task of mapping North America (approximately 2400 frames and 55 billion pixels) is still formidable. Yet, such information is important, and researchers are working on this problem (Cosentino 1986, Hofter et al. 1979, Strahler 1981).

The mapping, storage, retrieval, and manipulation capabilities of GIS for research that relates to the ranges of large numbers of species of different taxonomic, foraging, or nesting groups offers much opportunity for biogeographic analysis. Our knowledge of limiting factors is simplistic at best, but we can say that the physical environment (rainfall, temperature, soils, and aspect), the biotic environment (competitors, predators, and distribution of resources in time and space), and the historic milieu (past climates, faunal movements, chance extinctions, and dispersal) all play roles in determining species distributions as individual as human fingerprints.

Vertebrate species-richness used as an indicator of overall natural diversity integrates a host of community-related parameters into the analysis. Vertebrate niches are shaped by a complex of biotic, abiotic, and cultural factors, such as the complexity of the community food web, total available biomass, and vegetation structure and productivity. Besides representing the most readily available and quantifiable indicator of biotic diversity, the major role played by vertebrates in community interactions argues for a high correlation between vertebrate species-richness and overall natural diversity. However, areas of low vertebrate-species-richness may have assemblages of invertebrates and plants of special interest. The use of detailed vegetation types and the methods of Klubnikin[4] can determine whether these particular areas are adequately protected.

Simpson (1964), Cook (1969), and Kiester (1971) have mapped broad patterns of species richness for North American mammals, birds, and amphibians and reptiles, respectively. These studies led to valuable insights on continental biogeography, but employed such a low level of resolution that no practical conservation guidelines could be drawn. By measuring species-density patterns generated from a study of squares 240, 245, and 160 km on a side, the authors restricted themselves to describing regional patterns of distribution.

As Kiester (1971) pointed out, a major problem with quadrant analysis of species distribution is habitat patchiness within quadrants. A quadrant size of 240 km on a side, for example, could include portions of the Central Valley of California, the Sierra Nevada Mountains, and the Great Basin environments of the Owens Valley. By registering recent distributional accounts for vertebrates and butterflies to a vegetation map, it should be possible to resolve species' distributions at the resolution of a square with 16-kilometer sides for many states and perhaps all of North America. This resolution is an order of magnitude finer than earlier attempts.

Use of this cell size opens the way for an analysis that is both quantitatively and qualitatively different than previous efforts. Many topographic features, such as mountain ranges and intervening valleys of the western United States, can now be resolved. The ordinary dispersal range of a host of mammals, reptiles, and amphibians also falls within this order of magnitude, implying that most patches of suitable habitat within the cell will be occupied if the species occurs anywhere within the cell. Finally, this cell size is appropriate to both public and private conservation activities, with many protected areas of 25,000 ha or larger already included in the national set of managed areas. It is also small enough that smaller refuges could be mapped.

Analysis of patterns of species richness for North America at this scale offers the opportunity for the first time to provide a data set from which predictions of retained biological diversity under alternative growth patterns could be made. Further, such an analysis would generate a baseline of information about the location and magnitude of current national species richness for state, regional, and national planning purposes.

Outlook for diversity

In the final analysis, the success of efforts to retain biological diversity will be judged on the number of surviving species in the year 2100, not on whether we save the California condor or black-footed ferret in the next decade. We need to act now to identify species-rich areas so that we can initiate management actions that will reduce the number of species made critically endangered in the next century and beyond. "The time to save a species is when it is still common" (R. Edge, as cited in Myers et al. 1987, p. 4).

Focusing on species-rich areas offers the most efficient and cost-effective way to retain maximal biological diversity in the minimal area. Given the inevitability of further habitat loss, this strategy may be the only way to resolve conflicts between development and the preservation of genetic and species diversity. While not abandoning the concept of protecting individual endangered species, there is an urgent need for the conservation movement to supplement current programs with an ecosystems approach to the preservation of biological diversity. A systems approach offers the best chance of saving the greatest number of the "cogs and wheels" that keep the earth's mechanism turning (Leopold 1953).

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[4]See footnote 3.

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Biological Diversity

The Biological Diversity Crisis

Despite unprecedented extinction rates, the extent of biological diversity remains unmeasured

Edward O. Wilson

Certain measurements are crucial to our ordinary understanding of the universe. What, for example, is the mean diameter of Earth? 12,742 km. How many stars are there in the Milky Way? 10^{11}. How many genes in a small virus particle? 10 (in ϕX174 phage). What is the mass of an electron? 9.1×10^{-28} grams. How many species of organisms are there on Earth? We don't know, not even to the nearest order of magnitude.

Of course, the number of *described* species is so impressive that it might appear complete. The corollary would be that systematics is an old-fashioned science concerned mostly with routine tasks. In fact, about 1.7 million species have been formally named since Linnaeus inaugurated the binomial system in 1753. Some 440,000 are plants, including algae and fungi; 47,000 are vertebrates; and according to one meticulous estimate published in 1985 by R. H. Arnett, 751,012 are insects. The remainder are assorted invertebrates and microorganisms.

But these figures alone grossly underestimate the diversity of life on Earth, and its true magnitude is still a mystery. In 1964 the British ecologist C. B. Williams, employing a combination of intensive local sampling and mathematical extrapolation, projected the number of insect species at three million (Williams 1964). During the next 20 years, systematists described several new complex faunas in relatively unexplored habitats such as the floor of the deep sea. They also began to use electrophoresis and ecological studies routinely, enabling them to detect many more sibling species. A few writers began to put the world's total as high as ten million species.

> **The pool of diversity is a challenge to basic science and a vast reservoir of genetic information**

In 1982 the ante was again raised threefold by Terry L. Erwin (1983) of the National Museum of Natural History. He and other entomologists had developed a technique that for the first time allowed intensive sampling of the canopy of tropical rainforests. This layer of leaves and branches conducts most of the photosynthesis and is clearly rich in species. But it has been largely inaccessible because of its height (a hundred feet or more), the slick surface of the trunks, and the swarms of stinging ants and wasps that break forth at all levels. To overcome these difficulties, a projectile with a line attached is first shot over one of the upper branches. A canister containing an insecticide and swift-acting knockdown agent is then hauled up into the canopy, and the contents are released as a fog by radio command. As the insects and other arthropods fall out of the trees (the chemicals do not harm vertebrates), they are collected in sheets laid on the ground. The numbers of species proved to be far greater than previously suspected because of unusually restricted geographical ranges and high levels of specialization on different parts of the trees. Erwin extrapolated a possible total of 30 million insect species, mostly confined to the rainforest canopy.

If astronomers were to discover a new planet beyond Pluto, the news would make front pages around the world. Not so for the discovery that the living world is richer than earlier suspected, a fact of much greater import to humanity. Organic diversity has remained obscure among scientific problems for reasons having to do with both geography and the natural human affection for big organisms. The great majority of kinds of organisms everywhere in the world are not only tropical, but also inconspicuous invertebrates such as insects, crustaceans, mites, and nematodes. The mammals, birds, and flowering plants of the North Temperate Zone, on which natural history research and popular writing have largely focused, comprise relatively few species. In one aggregate of 25 acres of rainforest in Borneo, for example, about 700 spe-

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Edward O. Wilson is Baird Professor of Science and Curator in Entomology at the Museum of Comparative Zoology, Harvard University, 26 Oxford St., Cambridge, MA 02138. His best-known books include *The Insect Societies, Sociobiology*, and *On Human Nature*. This article has been modified from an article published in *Issues in Science and Technology* [2(1): 20–29, Fall 1985] with permission from the editors.

cies of trees were identified;[1] there are no more than 700 native tree species in all of North America. Familiarity with organisms close to home gives the false impression that the Linnaean period has indeed ended. But a brief look almost anywhere else (for example the Australian fauna illustrated in Figure 1) shows that the opposite is true.

Why does this lack of balance in knowledge matter? It might still be argued that to know one kind of beetle is to know them all, or at least enough to get by. But a species is not like a molecule in a cloud of molecules. It is a unique population of organisms, the terminus of a lineage that split off thousands or even millions of years ago. It has been hammered and shaped into its present form by mutations and natural selection, during which certain genetic combinations survived and reproduced differentially out of an almost inconceivably large number possible.

In a purely technical sense, each species of higher organism is richer in information than a Caravaggio painting, Bach fugue, or any other great work of art. Consider the typical case of the house mouse, *Mus musculus*. Each of its cells contains four strings of DNA, each of which comprises about a billion nucleotide pairs organized into a hundred thousand structural genes. If stretched out fully, the DNA would be roughly one meter long. But this molecule is invisible to the naked eye because it is only 20 angstroms in diameter. If we magnified it until its width equaled that of a wrapping string to make it plainly visible, the fully extended molecule would be 600 miles long. As we traveled along its length, we would encounter some 20 nucleotide pairs to the inch. The full information contained therein, if translated into ordinary-sized printed letters, would just about fill all 15 editions of the *Encyclopaedia Britannica* published since 1768.

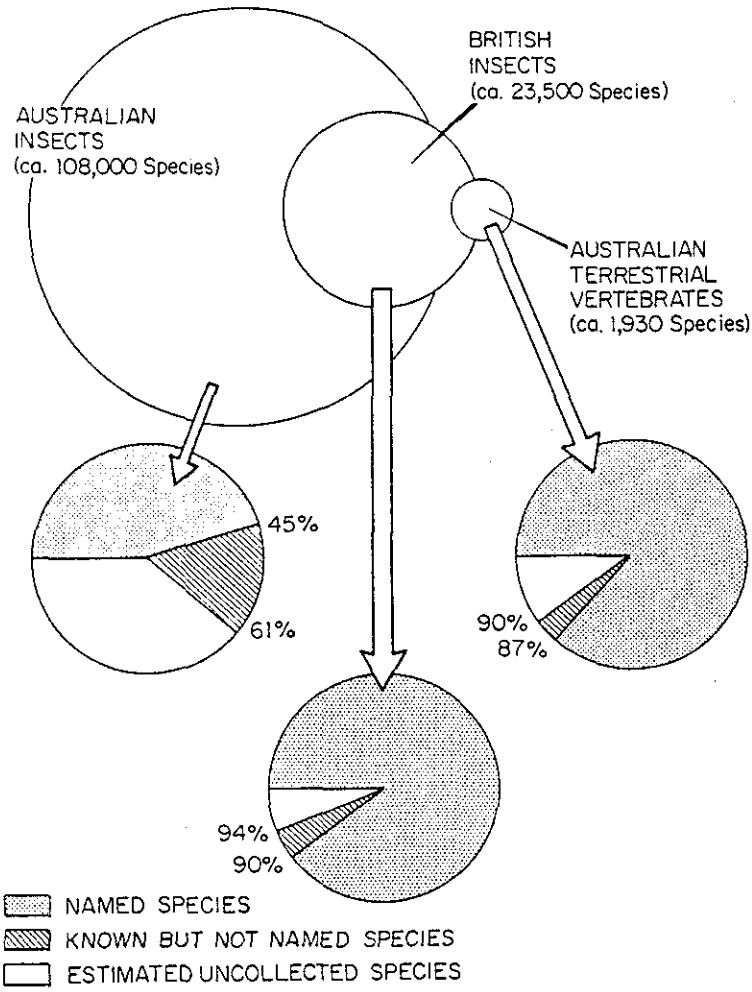

Figure 1. The status of research on diversity is illustrated in this comparison of the estimated sizes of Australian insect, British insect, and Australian terrestrial vertebrate faunas (top) and the levels of taxonomic knowledge about them. Modified from Taylor (1983).

Perhaps because organic diversity is so much greater and richer in history than previously imagined, it has proved difficult to express as a coherent subject of scientific inquiry. What *is* the central problem of systematics? Its practitioners, who by necessity limit themselves to small slices of the diversity, understand but seldom articulate a mission of the kind that enspirits particle physics or molecular genetics. For reasons that transcend the mere health of the discipline, the time has come to focus on such an effort. Indeed, if one considers other disciplines that depend directly upon systematics, including ecology, biogeography, and behavioral biology, an entire hierarchy of important problems present themselves.

But one problem stands out, for progress toward its solution is needed to put the other disciplines on a permanently solid basis. For taxonomy, the key question is the number of living species. How many exist in each major group from bacteria to mammals? Where is each found, and how does it differ from related species? I believe that we should aim at nothing less than a full count, a complete catalog of life on Earth. To attempt an absolute measure of diversity is a mission worthy of the best effort from science.

[1]Peter S. Ashton, 1985, personal communication. Arnold Arboretum, Harvard University.

The magnitude and cause of biological diversity is not just the central problem of systematics; it is one of the key problems of science as a whole. It can be said that for a problem to be so ranked, its solution must promise to yield unexpected results, some of which are revolutionary in the sense that they resolve conflicts in current theory while opening productive new areas of research. In addition, the answers should influence a variety of related disciplines. They should affect our view of humanity's place in the order of things and open opportunities for the development of new technology of social importance. These several criteria are, of course, very difficult to attain, but I believe the diversity problem meets them all.

To this end, the problem can be restated as follows: If there are indeed 30 million species, why didn't 40 million evolve, or 2000, or a billion? Many ramifications spring from this ultimate Linnaean question. We would like to know whether something peculiar about the conformation of the planet or the mechanics of evolution itself led to the precise number that does exist. At the next level down, why is there an overwhelming preponderance of insect species on the land, but virtually none of these organisms in the sea? Hot spots of disproportionately high diversity of plants and animals occur within larger rainforests, and we need to know their contents and limits. Would it be possible to increase the diversity of natural systems artificially to levels above those in nature without destabilizing them? Only taxonomic analysis can initiate and guide research on these and related topics.

The relation of systematics research to other biological disciplines becomes clearer if one considers the way diversity is created. A local community of plants and animals, of the kind occupying a pond or offshore island, is dynamic in its composition. New colonists arrive as old residents die off. If enough time passes, the more persistent populations evolve into local endemic species. On islands as large as Cuba or Oahu, the endemics often split into two or more species able to live side by side. The total play of these forces (immigration, extinction, and evolution leading to species multiplication) determines the global amount of diversity. To understand each of the forces in turn is automatically to address the principal concerns of ecology, biogeography, and population genetics. Our current understanding of the forces is still only rudimentary. The science addressing them can be generously put at about the level of physics as it was in the late nineteenth century.

There is in addition a compelling practical argument for attempting a complete survey of diversity. Only a tiny fraction of species with potential economic importance has been used (Myers 1983, Oldfield 1984). A far larger number, tens of thousands of plants and millions of animals, have never even been studied well enough to assess their potential. Throughout history, for example, a total of 7000 kinds of plants have been grown or collected as food. Of these, 20 species supply 90% of the world's food and just 3—wheat, maize, and rice—constitute about half. In most parts of the world, this thin reservoir of diversity is sown in monocultures particularly sensitive to insect attacks and disease. Yet waiting in the wings are tens of thousands of edible species, many demonstrably superior to those already in use.

The case of natural sweeteners serves as a parable of untapped resource potential among wild species. A plant has been found in West Africa, the katemfe *(Thaumatococcus daniellii)*, that produces proteins 1600 times sweeter than sucrose. A second West African plant, the serendipity berry *(Dioscoreophyllum cumminsii)*, produces a substance 3000 times sweeter. The parable is the following: Where in the plant kingdom does the progression end? To cite a more clearly humanitarian example, one in ten plant species contains anticancer substances of variable potency, but relatively few have been bioassayed. Economists use the expression "opportunity costs" for losses incurred through certain choices made over others, including ignorance and inaction. For systematics, or more precisely the neglect of systematics and the biological research dependent upon it, the costs are very high.

Biological diversity, apart from our knowledge of it, is meanwhile in a state of crisis. Quite simply, it is declining. Environmental destruction, a worldwide phenomenon, is reducing the numbers of species and the amount of genetic variation within individual species. The loss is most intense in the tropical rainforests. In prehistoric times, these most species-rich of all terrestrial habitats covered an estimated 5 million square miles. Today they occupy 3.5 million square miles and are being cut down at an annual rate of 0.7%, that is, 25,000 square miles or an area the size of West Virginia. The effect this deforestation has on diversity can be approximated by the following rule of thumb in biogeography. When the area of a habitat is reduced to one-tenth, the number of species that can persist in it indefinitely will eventually decline to one-half. That much habitat reduction has already been passed in many parts of the tropics. The forests of Madagascar now occupy less than ten percent of their original cover, and the once teeming Brazilian Atlantic forests are down to under one percent. Even great wilderness areas are giving way. If present levels of deforestation continue, the stage will be set within a century for the inevitable loss of about 12% of the 700 bird species in the Amazon Basin and 15% of the plant species in South and Central America (Simberloff 1984).

No comfort should be drawn from the spurious belief that because extinction is a natural process, humans are merely another Darwinian agent. The rate of extinction is now about 400 times that recorded through recent geological time and is accelerating rapidly. Under the best of conditions, the reduction of diversity seems destined to approach that of the great natural catastrophes at the end of the Paleozoic and Mesozoic Eras, in other words, the most extreme for 65 million years. And in at least one respect, this human-made hecatomb is worse than any time in the geological past. In the earlier mass extinctions, possibly caused by large meteorite strikes, most of the plant diversity survived; now, for the first time, it is being mostly destroyed (Knoll 1984).

A complete survey of life on Earth may appear to be a daunting task. But compared with what has been dared and achieved in high-energy physics, molecular genetics, and other branches of "big science," it is in the second or third rank. To handle ten million species even with the least efficient old-fashioned methods is an attainable goal. If one specialist proceeded at the cautious pace of an average of ten species per year, including collecting, curatorial work, taxonomic analysis, and publication, about one million person-years of work would be required. Given 40 years of productive life per scientist, the effort would consume 25,000 lifetimes. That is not an excessive investment on a global scale. The number of systematists worldwide would still represent less than ten percent of the current population of scientists working in the United States alone and fall short of the standing armed forces of Mongolia and the population of retirees in Jacksonville. Neither does information storage present an overwhelming problem, even when left wholly to conventional libraries. If each species were given a single double-columned page for the diagnostic taxonomic description, a figure, and brief biological characterization, and if the pages were bound into ordinary 1000-page, six-centimeter-wide hardcover volumes, the 10,000 or so final volumes of this ultimate catalog would fill 600 meters of library shelving. That much is far below the capacity of some existing libraries of evolutionary biology. The library of Harvard's Museum of Comparative Zoology, for example, occupies 4850 meters of shelving.

But I have given the worst scenario imaginable to establish the plausibility of the project. Systematic work can be speeded many times over by new procedures now coming into general use. The Statistical Analysis System (SAS), a set of computer programs currently running in over 4000 institutions worldwide, permits the recording of taxonomic identifications and localities of individual specimens and the automatic integration of data into catalogs and biogeographic maps (La Duke et al. 1984). Other computer-aided techniques rapidly compare species across large numbers of traits, applying unbiased measures of overall similarity, the procedure known as phenetics. Still others assist in sorting out the most likely patterns of phylogeny by which species split apart to create diversity, or cladistics. Scanning electron microscopy has speeded the illustration of insects and other small organisms and rendered descriptions more accurate. The DELTA system, developed and used at Australia's Commonwealth Scientific and Industrial Research Organization, codes data for the automatic identification of specimens (Dallwitz 1980, Taylor 1983). Elsewhere, research is being conducted that might lead to computerized image scanning for automatic description and data recording.

In North America, about 4000 systematists work on 3900 systematics collections (Edwards 1984 and personal communication). But a large fraction of these specialists, perhaps a majority, are engaged only part time in taxonomic research. More to the point, few can identify organisms from the tropics, where both the great majority of species exist and extinction is proceeding most rapidly. Probably no more than 1500 trained professional systematists in the world are competent to deal with tropical organisms. Their number may be declining from decreased professional opportunities, reduced funding for research, and assignment of higher priority to other disciplines (National Research Council 1980). To take one especially striking example, ants and termites make up about one-third of the animal biomass in tropical forests. They cycle a large part of the energy in all terrestrial habitats and include the foremost agricultural pests, which cause billions of dollars of damage yearly. Yet there are exactly eight entomologists worldwide with the general competence to identify tropical ants and termites, and only five of these are able to work at their specialty full time.

It is not surprising to find that the neglect of species diversity retards other forms of biological research. Every ecologist can tell of studies delayed or blocked by the lack of taxonomic expertise. In one recent, typical case, William G. Eberhard consulted most of the small number of available (and overworked) authorities to identify South and Central American spiders used in a study of web-building behavior. He was able to obtain determinations of only 87 of the 213 species included, and then only after considerable delay. He notes that "there are some families (e.g., Pholcidae, Linyphiidae, Anyphaenidae) in which identifications even to genus of Neotropical species are often not possible, and apparently will not be until major taxonomic revisions are done. On a personal level, this has meant that I have refrained from working on some spiders (e.g., Pholcidae, one of the dominant groups of web spiders in a variety of forest habitats, at least in terms of numbers of individuals) because I can't get them satisfactorily identified."[2]

If systematics is an indispensable handmaiden of other branches of research, it is also a fountainhead of discoveries and new ideas, providing the remedy for what the biologist and philosopher William Morton Wheeler once called the dry rot of academic biology. Systematics has never been given enough credit for this second, vital role. Every time I walk into a fresh habitat, whether tropical forest, grassland, or desert, I become quickly aware of the potential created by a knowledge of classification. If biologists can identify only a limited number of species, they are likely to gravitate toward them and end up on well-trodden ground; the rest of the species remain a confusing jumble. But if they are well trained in the classification of the organisms encountered, the opportunities multiply. The known facts of natural history become an open book, patterns of adaptation fall into place, and previously unknown phenomena offer themselves conspicuously. By proceeding in this opportunistic fashion, a biologist might strike a new form of animal communication, a previously unsuspected mode of root symbiosis, or a relation between certain species that permits a definitive test of competition theory. The irony is that successful research then gets labeled as ecology, physiology, or almost anything else but its *fons et origo,* the study of diversity.

Systematics is linked in such a manner not only to the remainder of biology but to the fortunes of the international conservation movement, which is now focusing its attention on the threatened environments of the tropics. Plans for systems of ecological reserves have been laid by the International Union for Conservation of Nature and Natural Resources (IUCN), UNESCO, and a growing number of national governments from Australia and Sri Lanka to Brazil and Costa Rica. The aim is to hold on to as many species as possible within the limits imposed by population pressures and the cost of land purchase. The long-term effects of this enterprise can only be crudely predicted until systematics surveys are completed, country by country. In the United States a proposal for a National Biological Survey (NABIS) has been presented to Congress [see p. 686]. The program would establish a survey to describe all the plants and animals, fund basic taxonomic studies to this end, and produce identification manuals, catalogs, and other practical aids (Kosztarab 1984). If multiplied across many countries, such efforts could bring the full assessment of biological diversity within reach.

Systematics surveys are cost-efficient and provide large proportionate yields with small absolute increments in support. In fiscal 1985, the National Museum of Natural History, the largest organization of its kind in the United States, spent $12.8 million to support 85 scientists engaged partly or wholly in taxonomic studies. In the same year, the Program in Systematic Biology of the National Science Foundation granted $12 million for basic taxonomic research, while other programs in the NSF and Department of Interior provided $13.8 million for support of museum services, studies of endangered species, and other activities related to systematics. The worldwide support for basic tropical biology, including systematics and ecology, is only about $50 million. Just 1000 annual grants of $50,000 devoted to tropical organisms would double the level of support and revitalize the field. To illustrate the difference in scale, the same amount added to the approximately $3.5 billion spent on health-related biology in the United States would constitute an increment of 1.4%, causing a barely detectable change.

In case such an investment, which approximately equals the lifetime cost of one F15 Eagle fighter-bomber, might seem removed from the immediate interests of the United States, let me close with an observation on the importance of biological research to foreign policy. The problems of Third World countries, most of which are in the tropics, are primarily biological. They include excessive population growth, depletion of soil nutrients, deforestation, and the decline of genetic diversity in crop and forest reserves. It is no coincidence that Haiti and El Salvador, which force themselves on our attention at such frequent intervals, are the most densely populated and environmentally degraded countries in the Western Hemisphere, rivaled only by Grenada (another trouble spot) and three other small Caribbean island-nations. Virtually all reports on the subject released by the National Research Council and Office of Technology Assessment during the past ten years agree that the intricate economic and

[2]Letter from W. G. Eberhard. 1985. Universidad de Costa Rica, Ciudad Universitaria.

social problems of tropical countries cannot be solved without a more detailed knowledge of the environment. Increasingly, that must include a detailed account of native faunas and floras.

Congress has addressed this problem in limited degree through the 1980 amendment to the Foreign Assistance Act, which mandates that programs funded through the Agency for International Development include an assessment of environmental impact. In implementing this policy, AID recognizes that "the destruction of humid tropical forests is one of the most important environmental issues for the remainder of this century and, perhaps, well into the next," in part because they are "essential to the survival of vast numbers of species of plants and animals" (Department of State memorandum *1985*).

Moving further, AID set up an Interagency Task Force in 1985 to consider biological diversity as a comprehensive issue. In its report to Congress, *US Strategy on the Conservation of Biological Diversity* (AID 1985), the task force evaluated the current activities of the dozen federal agencies that have been concerned with diversity, including the Smithsonian Institution, the Environmental Protection Agency, and AID itself. The most important recommendations made by the group, in my opinion, are those that call for the primary inventory and assessment of native faunas and floras. In fact, not much else can be accomplished without this detailed information.

AID also supports research programs in which nationals of the recipient countries are principal investigators, and US citizens serve as collaborators. This arrangement is a proven way to build science and technology in the Third World and is particularly well suited to tropical biology. Studies of diversity are best conducted at sites of maximum diversity. They are labor-intensive and require less expensive instrumentation than most kinds of research. Perhaps most important, their relevance to national identity and welfare are immediately obvious.

To put the matter as concisely as possible, biological diversity is unique in the evenness of its importance to both developed and developing countries and in the cost-effectiveness of its study. The United States would do well to seek a formal international agreement among countries, possibly in the form of an International Decade for the Study of Life on Earth, to improve financial support and access to study sites. To spread technical capability where it is most needed, arrangements can be made to retain specimens within the countries of their origin while training nationals to assume leadership in systematics and the related scientific disciplines.

In *Physics and Philosophy*, Werner Heisenberg suggested that science is the best way to establish links with other cultures because it is concerned not with ideology but with nature and humanity's relation to nature. If that promise can ever be met, it will surely be in an international effort to understand and save biological diversity. This being the only living world we are ever likely to know, let us join to make the most of it.

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Biological Diversity

The Conservation of Diversity in Forest Trees

Why and how should genes be conserved?

F. Thomas Ledig

Deforestation, pollution, and climatic change threaten forest diversity all over the world. And because forests are the habitats for diverse organisms, the threat is extended to all the flora and fauna associated with forests, not only forest trees. In a worst case scenario, if the tropical forest in Latin America was reduced to the areas now set aside in parks and reserves, 66% of the world's plant species would go extinct, along with 69% of the birds and correspondingly high proportions of the other fauna (Myers 1984).

But immediate loss of species is not the only danger. Among the surviving species, many populations will be lost, taking with them much of the genetic diversity upon which long-term survival and evolution depend. A really alarming thought is: What if the loss of biological diversity does irreversible damage to our planetary life-support system?

At the root of this threat is human population growth. And to support our expanding population, we concentrate our agriculture on just a few species—20 species supply most of the world's food (US Committee on Genetic Vulnerability of Major Crops 1972). In these species, the genetic base is greatly reduced, both purposefully, to facilitate management, and by chance. This reduction leads to another problem of gene conservation: the uniformity and, therefore, vulnerability of our food and fiber supply.

F. Thomas Ledig is the director of the Institute of Forest Genetics, Pacific Southwest Forest and Range Experiment Station, USDA Forest Service, 1960 Addison St., Berkeley, CA 94704.

The need is clear, but the task is enormous, and time is running out

Therefore, three different objectives are included under the rubric of gene conservation:

- Protection, particularly of domesticated plants, from genetic vulnerability—a uniformity that leaves them vulnerable to new environmental or biotic challenges
- Protection of endangered species
- Preservation of genes for future use.

These three objectives, in fact, have a common thread—the maintenance of genetic diversity.

My objective in this article is to outline the scope of gene conservation in relation to wild plants and, most particularly, forest trees. The important questions are: why conserve, what should be conserved, and how can it be conserved?

Vulnerability

The question of genetic vulnerability is most pertinent for domesticated crops, not wild plants. National attention was focused on genetic vulnerability by the corn blight of 1970 (US Committee on Genetic Vulnerability of Major Crops 1972). In the United States, 75% of the corn crop was descended from a single mutant that was susceptible to the corn blight fungus.

In all the major crops in the United States, a few varieties account for most of the acreage. Seed companies or public agencies lower their cost if they can conduct one breeding program rather than many. In addition, there is a legitimate demand for crop uniformity to facilitate management and reduce the costs of cultivation, handling, and processing.

The corn blight was not the first instance in which uniformity had led to epidemics. World history has been altered by similar events, such as the Irish potato famine of the 19th century. Potatoes were the staple crop of Ireland. They were vegetatively reproduced, and most of the country grew a single clone (US Committee on Genetic Vulnerability of Major Crops 1972). When late blight struck, thousands of people died and others emigrated. The first great postcolonial wave of immigration to the United States (in the 1840s) was a result of that famine.

Breeding has not yet resulted in dangerous uniformity in forestry. Most tree breeders strongly emphasize the maintenance of variability (Zobel 1978). Usually, breeding programs in forest trees begin with selections from wild, undomesticated populations. Breeders have restricted these initial selections to one per wild stand and brought the selections from different stands together in seed orchards where they intercross, generating more variability than would be found in natural stands (Zobel et al. 1972). In advanced generations, breeders plan to maintain multiple populations to reduce the problem of inbreeding and counter genetic uniformity (Burdon et al. 1978). Given the commitment of breeders to maintain variability and prevent inbreeding, one might believe that there is no threat that tree crops will become as vulnerable as most agricultural crops are. However, dangers do exist. Some lines and clones are so outstandingly superior in favorable environments (Zobel et al. 1972) that growers could decide to plant crops of restricted parentage, or even single clones, in a gamble to maximize profits. Thus, the results of breeding can be misused.

Species preservation

International concern about species diversity is a result of three major considerations—*economic*, *ecologic*, and *esthetic*. Some conservationists may add a fourth concern, *ethical*.

Economic concern is apparent because the loss of a species means the loss of not one gene, but a whole genetic library. Many of our medicines, insecticides, herbicides, and other chemicals come from plants or are based on plant models. Of all prescription drugs, 25% come directly from plants (Farnsworth and Soejarto 1985). But most plants have not yet been investigated for potentially useful compounds. The National Cancer Institute took 25 years to test 35,000 species for antitumor activity. Tests for antitumor activity use crude extracts and reveal nothing about other potential uses of the plant chemicals. At the present rate of extinction, thousands of species will be gone before they can be evaluated. The extent of consequent economic loss is not predictable, but potentially enormous (Oldfield 1984).

Ecologic concerns arise because the loss of species could mean the loss of entire ecosystems through a cascade effect (Ehrlich and Ehrlich 1981). Terborgh (1986) provided an example from the tropics. Less than one percent of the local plant diversity in the Amazon of Peru seems to support almost all of the frugivores for three months of the year. The frugivores include the primates, birds, and rodents. If these keystone plant species—the palms, figs, and a few nectar sources—were lost, the frugivores would be lost. And if the frugivores were lost, most of the other plant species that depend on them for seed dispersal would be lost. Thus, if a few keystone species are removed, a whole ecosystem could collapse. And if we drastically modify or destroy an ecosystem, will we disrupt the biogeoclimatic cycles that support all life on Earth?

The third reason for protecting endangered species is esthetic (for a discussion of the cultural importance of biotic diversity, see Office of Technology Assessment [OTA] 1987). Esthetic reasons are the hardest to pin down, but I believe that diversity is necessary to the health of humanity. Some sense of diversity seems necessary for sanity. Even if I never see a highland gorilla or an African lobelia, I feel better knowing they are still there. And I feel diminished knowing that the wild California condors are now gone.

Concerns for the safety of endangered species are great enough that they have sparked legislation applicable to the conservation of biological diversity. The Endangered Species Act was passed in 1973, in part as a result of economic and ecologic factors, but mostly in response to esthetics. In the continental United States, only two tree species are formally listed as endangered. Information on another four species supports proposing them for endangered status, and another nine species and two varieties need further study (US Fish and Wildlife Service 1985).

The Endangered Species Act was closely followed by the Forest and Rangeland Renewable Resources Act in 1974 and the National Forest Management Act in 1976 (Norse et al. 1986). These latter acts require the national forests to prepare land management plans that "provide for diversity of plant and animal communities." The plans are being released for comment now by each of the 156 national forests. They are written with a 50-year planning horizon, but they will be revised every 15 years. Within the past year the Sierra Club Legal Defense Fund and other groups have brought several suits under the National Forest Management Act, charging that some national forests have failed to provide for diversity.

At present no laws provide specifically for protection of populations or genes. Only named taxa (species, subspecies, or varieties) are addressed in the forest management plans. But, the National Forest Management Act could be used to justify the conservation of genetic resources on the intraspecific level.

Preservation of genes

Why preserve genes? They are the raw materials for breeding and continued evolution. Although markets may change and new pests may appear, breeders will not be able to respond without a pool of genes. An example of a change in market conditions is the increased demand for tissue, newsprint, and printing paper from southern pines (Zobel and Talbert 1984). Initially, the major paper product from southern pines was kraft bags and corrugated boxes. Breeders selected trees that had wood of high specific gravity because they gave good pulp yields and resulted in bags with desirable properties (e.g., high tear strength). But wood of somewhat lower specific gravity is preferable for tissue and printing papers. Fortunately, trees that had been selected for growth and form before they were known to have low specific gravity, had been clonally propagated and preserved in research orchards, called clone banks, and therefore were available to breeders when demands changed.

The literature is full of examples of new pests, either introduced, like chestnut blight (McKay and Jaynes 1969), or those that arose in response to agricultural practices, such as native insects that became significant pests of introduced crops (Holling and Goldberg 1971). And recall the terrible new diseases that have appeared in our own species in the last 20 years—Legionnaires disease, Lyme disease, acquired immunodeficiency disease (AIDS), and Tahoe disease.

What genes do we want to save? All if we could, because it is impossible to predict what may be useful in the future. Preservation of genes takes on special importance now that they can be transferred between virtually any organisms using recombinant DNA technology.

How do we save these genes? Will we save enough genetic information if we save one individual? One population? Many populations? Our options are to systematically sample or to launch studies of a species' genetic architecture to identify representative and unique genetic resources.

Systematic samples. Without specific information, our best approach is to preserve samples systematically—both from representative populations and from extreme or unusual populations. For example, when the Institute of Forest Genetics undertook a major collection in sugar pine (*Pinus lambertiana* Dougl.), the scientists knew only that elevational variation was pronounced (Harry et al. 1983). So they sampled from various elevational transects in the Sierra Nevada, systematically covering the latitudinal range, and they sampled the Transverse Ranges and a few sites in the Klamath Mountains—all as representative of the body of the species. But they also sampled from Junipero Serra Peak in Alta California and the Sierra San Pedro Martir in Baja California (Figure 1) as unusual sites, representing relictual populations or populations that were, perhaps, adapted to special conditions. In fact, sugar pine from both areas proved unique. Sugar pine from Junipero Serra had an unusually high frequency of a major gene for blister rust resistance, and the Baja sample is unusually blue in foliage color, which might be useful in breeding for droughty conditions.

Unfortunately, representative populations have already disappeared from the ranges of many wild species. Forests have been eliminated at lower elevations, and the land converted to agriculture. West of the Cascades in Washington and Oregon, forest land has decreased five percent since 1952 (Harris 1984). And even where forests were not eliminated, early loggers selectively removed the best trees, a practice that may have eroded the genetic resource. It is especially unfortunate that low-elevation populations were eliminated, because those were the populations likely to carry genes for high productivity under domesticated conditions (i.e., adapted to fertile soils). But they were lost before anyone even considered their genetic value.

Genetic architecture. So far, conservationists have been forced to proceed with little data on the distribution of genetic variation and have followed a common-sense, systematic scheme for sampling genetic resources. But we do have the technology to get information on the distribution of genetic variation quickly, refine efforts, and decide where the representative genes are and where unique genes or gene combinations exist. That technology is the electrophoretic separation of proteins and the analysis of variants called isozymes to quantify gene frequencies (Conkle and Adams 1977). Most of the rapidly accumulating information on wild species of plants and animals comes from isozyme analysis.

Several conifers have already been subjected to genetic analysis, but unfortunately, generalizing results to new species is difficult. Species of limited distribution have a tendency toward little variation and widespread species tend to have greater variation (Ledig 1987). But the exceptions are striking. Loblolly pine (*Pinus taeda* L.) has a wide range and is highly variable (Conkle 1981), but red pine (*Pinus resinosa* Ait.) also has a wide range and is genetically depauperate (Fowler and Morris 1977). Torrey pine (*Pinus torreyana* Parry ex Carr) is restricted to two small populations, each of which is completely depauperate but genetically unique (Figure 2; Ledig and Conkle 1983). Santa Lucia fir (*Abies bracteata* D. Don.) has a small, fragmented range and is almost depauperate also, but its populations are not unique (Ledig 1987).

Great Basin bristlecone pine (*Pinus longaeva* D. K. Bailey) also has a fragmented range. It is restricted to mountaintops, but it has high levels of diversity with no differences among populations. Over 90% of the total variation can be found on any one mountaintop (Hiebert and Hamrick 1983). Even more complicated patterns have emerged: western white pine (*Pinus monticola* Dougl.) is uniform across most of its range but highly variable in California (Steinhoff et al. 1983).

Electrophoresis provided a tool to locate genetic resources. But we can not yet generalize from plant species to plant species, and the number of species that remains to be studied is huge. For trees alone, there are 684 native species in the continental United States (Little 1981). Even with isozyme electrophoresis, it will be a long time before they are all adequately studied, let alone all the temperate herbaceous flora or the far greater botanical riches of the tropics.

Conservation efforts

Identifying genetic resources is only part of the job. Once identified, how do we save them? Conservation efforts are usually classed as *in situ* and *ex situ*, meaning in the natural position (or in place) and out of the natural position, respectively.

Ex situ preservation. *Ex situ* preservation is accomplished in botanical gardens, test plantations, seed orchards, clone banks, seed storage banks, tissue cultures, and DNA libraries. The major problems are a lack of long-term, continuous funding and adverse changes in the preserved materials.

Botanical gardens and arboreta are common, but they preserve too small a genetic base, usually maintaining single trees, or, at the most, a few specimen trees of any given species.

Provenance, or seed source, tests use a common garden environment to compare offspring from a range of populations. They maintain a broader genetic base than arboreta, but are usually restricted to commercial or potentially commercial woody plants. In addition, they have a lifetime of only 50 to 100 years, and are not self-perpetuating. No provisions are made for replacement once test results are complete. Another problem is that selection takes place in an environment alien to most of the sampled populations; therefore, genes for which a population was saved may be lost by mortality.

For example, the Institute of Forest Genetics sampled Coulter pine (*Pinus coulteri* D. Don) throughout its range from the Sierra de Juarez of Baja California to the San Francisco Bay Area of Alta California. Seeds from several populations were sown and the progeny were raised in research gardens in Placerville, California, at a latitude near the northernmost limit for native Coulter pine. The seedlings were then planted in a replicated, randomized test. First-year survival in the progeny from Chalk Peak, which is south of Monterey, was only 24%, but in progeny from San Benito Mountain, 87%. Selection among populations is already obvious, and it is likely that mortality within populations was also selective, eliminating the very diversity we should hope to preserve.

Seed orchards are plantations established for the production of commercial quantities of seed of important timber species. These orchards frequently are established with grafted clones. For species like loblolly pine, these orchards preserve hundreds of clones. However, in an active breeding program, a seed orchard lasts only about 20 years before it is replaced by the next generation of breeding.

Clone banks, like seed orchards, are another tool of the breeder but have a broader base and a longer life. Like seed orchards, clone banks are usually established with grafted clones. Unlike seed orchards, the purpose of clone banks is long-term preservation. Over 8000 clones of loblolly pine alone are preserved in clone banks in the southeastern United States (McConnell 1980). However, because of their costs, clone banks are generally established only for the most important commercial species.

Seed storage is more important for conservation of most species. It is the most obvious way to preserve samples of the genetic resource, yet is not without limitations (Roberts 1975). The most important limitation is that not all seeds can be stored. For example, seeds of poplars (*Populus* spp.) or oaks (*Quercus* spp.) remain viable for only a few weeks to a year. Poplars and oaks alone represent approximately 20% of all tree species in the continental United States. In the tropics, species that can be stored as seed are even less common (Ellis et al. 1985). Conifer seed can be stored for decades, but eventually seed must be renewed by growing new trees, a second limitation. The process of growing plants to produce fresh seeds is expensive, and, during the process, selection may modify the genetic resource in the same way that selection modifies provenance tests. A third limitation is that not even stored seeds are immune to change. Mutations accumulate rapidly, even at low temperatures (Roberts 1975).

Finally, adequate facilities for long-term seed storage of forest trees do not yet exist (Belcher 1980). The National Seed Laboratory in Fort Collins was established for crop plants such as small grains, cotton, tobacco, and soybeans. The storage conditions used, open containers at 4°C, would be unsuitable for most tree species. The National Tree Seed Laboratory at Macon, Georgia, uses better conditions—sealed containers at −7°C. But it can handle only 5900 samples, and those mainly for a short term. Crop species in the National Seed Laboratory are represented by many samples (e.g., more than 40,000 seed samples for the grain crops—wheat, barley, oats, rye, rice, sorghum, and maize; White and Hyland 1973), so 5900 samples are too few to cover the 684 tree species native to the United States. The National Tree Seed Laboratory's primary functions are to test seed and act as a clearing house for seed exchange. Therefore, we are left with no long-term seed storage facility for forest trees or for the much greater number of woody shrubs and other wildland plants.

Tissue culture is promising, but genetic change occurs at even more rapid rates in unorganized tissue or cells than in seeds (Chaleff 1983, D'Amato 1975). Another problem with tissue culture is that we cannot yet regenerate whole plants from cultured tissues of most species. Only a few species have been regenerated successfully.

What about DNA libraries? DNA of forest trees can be fragmented and the fragments incorporated in bacterial DNA and perpetuated in bacterial cultures (Kinlaw et al. in press). But that would require maintenance of 10^6 to 10^7 cultures to preserve the DNA from a single tree. Therefore, the possibility of maintaining DNA from a large sample of trees is unthinkable.

The alternative is to read the DNA sequence to provide a blueprint for its reconstruction, and thus make the bacterial cultures superfluous. However, reading the DNA and making sense of it is a monumental task. Consider the current proposal to sequence the entire human genome. That project, if approved, could take as much as 30,000 person-years and upwards of two billion dollars (Roberts 1987). The human genome has three billion nucleotide pairs, while conifer genomes have many more. The sugar pine genome is 5.5 times longer than the human genome (Dhillon 1980). Can we imagine sequencing the DNA of even one tree, let alone the range of variation within one tree species or representatives of all our tree species and wildland plants?

To summarize, all *ex situ* techniques have disadvantages. For example, genetic change is a problem in provenance tests, seed banks, and tissue culture. But the major problem is continuity. *Ex situ* conservation depends on continuity in policy and funding. If we establish a seed bank today, will it continue to be funded five years from now? How much faith can we place in governments, their stability, and consistency? The same questions may be asked of *in situ* conservation, but *in situ* reserves are often less costly.

***In situ* conservation.** The best solution for most species is to leave them *in situ*. *In situ*, the problem is not to preserve samples of genes; whole coadapted gene complexes and biological communities must be preserved. Whatever keeps the population functioning as a viable, natural unit must be intact. This task requires protection, and perhaps management, of the whole support system—for example, the pollinators, seed dispersal agents, and the characteristic patterns of disturbance.

At first glance it would seem that many categories of public lands already function as *in situ* gene banks in the United States. About 28.5 million ha of federal land is in national parks, monuments, and preserves.[1] Another 11.5 million ha are in 327 wilderness areas (US Forest Service 1985a). Together these public lands cover a large area, but the problems of conservation are not solved.

These lands are almost invariably a biased sample of the resource. They are concentrated at high elevation. And while high mountain areas may be our greatest scenic treasure, biologically they are least diverse (Harris 1984). In addition, the restrictions on management of national parks and wilderness areas may preclude measures necessary for preservation of the genetic resource. For example, seral species may require disturbance in order to regenerate themselves, but protection has reduced the incidence of fire, often the primary agent in retarding succession.

Research Natural Areas (RNAs) are more suitable for conserving genetic resources in some ways. RNAs are a network of field sites established on federal lands for ecological research (Federal Committee on Ecological Reserves 1977). One of their stated functions (US Forest Service 1985b) is to "preserve and maintain genetic diversity." The areas are systematically located to preserve representative plant communities; therefore, they are not concentrated at high elevations. The minimum size of an RNA is 121.4 ha (300 acres), but the 150 established by the Forest Service, as of 1985, averaged 470 ha.[2] The Bureau of Land Management has 326 more, but these are not as well documented or protected.

One problem with RNAs is their small average size. First, species extinction is likely in small reserves. Second, if surrounded by plantation forest, pollen contamination may be a problem for the tree component; i.e., the native genetic resources may be modified or swamped by gene migration from surrounding plantations. Third, some foresters have opposed establishment of RNAs. Many of the national forests are under administrative pressure to increase timber harvest, and RNAs reduce the land base for timber production. Therefore, forest supervisors are reluctant to designate RNAs in areas of prime timber types, and this reluctance has slowed establishment (Henson and Nelson 1986). The record of other agencies, such as the Bureau of Land Management, has been no better. I single out my own agency because it is most familiar to me, but in fact it is generally responsive to criticism.

Botanical areas are another category of reserve. However, few of these

[1]Edward R. Haberlin. 1986. Personal communication. National Park Service, San Francisco, CA.

[2]Russell M. Burns. 1986. Personal communication. Research Natural Areas Program, USDA Forest Service, Washington, DC.

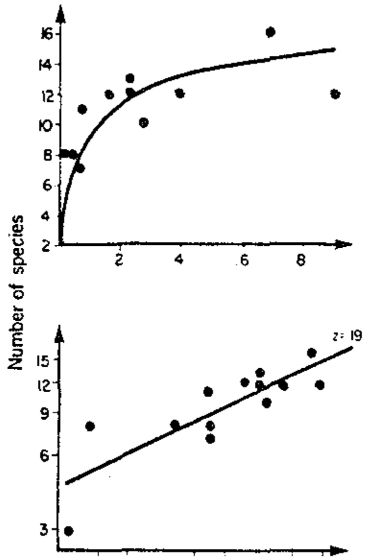

Figure 3. Species-area relationship for arctic-alpine plant species (after Riebesell 1982): numbers of species and the areas of the alpine ecosystem in the Adirondack Mountains, New York (top—arithmetic scale; bottom—logarithmic scale).

are established on federal land, and they can be extremely small, perhaps only a few square meters in area. The Ancient Bristlecone Pine Forest in the White Mountains of the Inyo National Forest is a large botanical area that is an exception to the rule; it includes 11,732 ha (of which 42 ha are private land). Other species are protected in state parks and forests, in wildlife refuges, and in private natural areas, such as those of The Nature Conservancy. Finally, some wildland plants exist in roadside and streamside leave-strips, mandated under various state and national forest regulations, and on railroad right-of-ways.

While many types of set-asides preserve natural forest-, shrub-, desert-, and wet-lands and their associated species, the major question regarding *in situ* preserves is: Are they really adequate? Probably not. Gaps are likely in the distribution of reserves. Furthermore, the theory of island biogeography indicates that small habitat fragments are susceptible to loss of species and, of course, genes (Harris 1984). As the size of reserves decreases, so do the number of species (Figure 3). This relationship is linear when transformed to a logarithmic scale. Also, the adequacy of a reserve depends on surrounding land use (see Schonewald-Cox, page 480 this issue). If there is no adjacent source of immigrants, species collapse will be rapid and continue to erode the resource (Wilcox 1980).

To offset some of these problems, I argue for a new category of management unit, a large unit to be called a Genetic Resource Management Unit (GRMU) (suggested by Krugman 1984). A GRMU would have as a primary function the protection of genetic resources, either single species or an entire community, but could be used for other economic benefits, such as grazing or timber harvest, as long as the other uses did not threaten the primary function.

Timber harvest is not necessarily incompatible with conservation of genetic resources. If gene conservation was established as the primary function of a unit, timber could still be harvested in a way that assured adequate regeneration with seed from the *in situ* populations, including the entire diversity of woody and herbaceous species present. Preferably, natural regeneration would be used, but planting with seedlings from the native stand might be acceptable if done at high density, providing an opportunity for natural selection. Timber production would be less than that under intense culture with "improved" seed orchard stock, but not reduced so much that it would generate the type of opposition that has characterized the establishment of RNAs on some national forests. Conservation efforts will be more successful if conservation and development go forward together (see Dasmann, page 487 this issue).

Since GRMUs would not be removed from production, they could be large enough to reduce the impact of pollen contamination from artificially regenerated sites. Conservationists should inventory and evaluate the present network of natural areas to determine where it is inadequate and persuade federal and state land management agencies to establish GRMUs to fill the gaps. The California Forest Genetic Sources Catalog prepared for the University of California's Wildland Resources Center represents a first step in this direction (Genetic Resources Consultants [GENREC] 1987).

A global outlook. Most of the preceding discussion applied to the United States, which has a tremendous genetic resource in its forest species. These US resources are important to the economy of many other countries. The United States is a great exporter of genes. Monterey pine (*Pinus radiata* D. Don.), loblolly pine, slash pine (*Pinus elliottii* Engelm.), and Douglas-fir (*Pseudotsuga menziesii* [Mirb.] Franco) from the United States are grown around the world. More than 350,000 ha are planted to Douglas-fir in Europe (Hermann 1987); 2,800,000 ha are planted to loblolly and slash pines in Asia, Africa, and Latin America (McDonald and Krugman 1986); and more than 3,000,000 ha are planted to Monterey pine alone, mainly in Chile, New Zealand, Australia, and Spain.[3] This dependence confers a tremendous responsibility on us: the responsibility to protect the genetic resources upon which the wealth of other nations, as well as our own, may depend.

But deforestation is a global problem. How does the situation in other countries compare, particularly developing countries? Our nearest neighbor, Mexico, can be taken as an example. According to the most recent authoritative account (Martinez 1948), Mexico has 107 species of conifers (when varieties are included, there are 143 named taxa). Some of these are the major tropical pines, such as Caribbean pine (*Pinus caribaea* Morelet), Ocote pine (*Pinus oocarpa* Schiede), and Mexican weeping pine (*Pinus patula* Schiede and Deppe), which have been exported to Asia, Africa, and Australia and become important in plantation forestry.

New species and populations of rare species are still being discovered, although it has been nearly a half millennium since the Conquest and the exploration of Mexico by Spain. The Institute of Forest Genetics is working with Chihuahua spruce (*Picea chihuahuana* Martinez), discovered in the Sierra Madre Occidental

[3]A. R. Griffin, 1988. Personal communication. CSIRO, Canberra, A.C.T., Australia.

only in 1942 (Martinez 1948). Other spruces have been found even more recently (Figure 4). As little as 20 years ago, only nine populations of Chihuahua spruce were known (Gordon 1968). Today there are 27, and in the last few years the species has been found in the Sierra Madre Oriental. Taxonomic status of the Mexican spruces, and Mexican conifers in general, is uncertain. And the oaks seem to be even more numerous, more variable, less studied, and more difficult to classify. Botanical exploration and taxonomic investigations are sorely needed. In contrast to Mexico, the United States is well explored and has only 96 species of conifers (Little 1981), although we have five times the land area (925.5 million ha vs. 197.2 million ha).

Mexico trails the United States in protecting its genetic resources. *In situ* reserves are one measure of comparison. The United States has 39.9 million ha in national parks and wilderness areas, or four percent of its total area. Mexico has only 0.8 million ha, or 0.4% its total area, in *in situ* reserves. Proportionally, it has put aside only one-tenth as much land to protect even greater botanical riches than those of the United States (OTA 1984).

In most other developing countries, the situation is worse—a particularly tragic fact because developing countries are the centers of the world's genetic resources. Tropical moist forest covers only 7% of the land area, but it is the habitat for 40% of all species (Myers 1984). Species are being eliminated before they are even discovered.

Kenya is one of the few developing countries that has set aside major areas for conservation. It has put six percent of its land into national parks. But it is extremely difficult to protect parks against population pressures. In Kenya, population growth averages seven children per woman. This population growth, if unchecked, means that parks in Kenya and elsewhere could turn out, in Norman Myer's (1984) words, to be merely "paper parks." Single-use preserves that lock people out are in jeopardy, so the GRMU concept may be of value in developing countries as well as in the United States. As Dasmann (page 487 this issue) notes, local communities must support reserves, not be displaced by them, if reserves are to fulfill their function efficiently. In the United States, as in developing countries, conservation must be integrated with other land-use practices.

As for *ex situ* conservation, only two organizations are dedicated to conservation of tropical trees in Mexico. The Central America and Mexico Coniferous Resources Cooperative (CAMCORE) is headquartered at North Carolina State University. The Oxford Forestry Institute is a division of Oxford University in England. Both concentrate primarily on conifers. In addition to these organizations, the Institute of Forest Genetics (with aid from USDA Office of International Cooperation and Development) has begun a cooperative program with the Mexican Centro de Genetica Forestal to map genetic resources using isozyme electrophoresis. But this effort is pitifully small, and it leaves the tropical hardwoods, a much larger group than the conifers, almost totally unprotected. The need is clear, but the task is enormous, and time is running out.

Conclusions

Nevertheless, there is still time to save the majority of the world's forest species, even in the tropics. With active intervention to maintain viable populations, perhaps even controlled breeding and restocking, small areas of a few hundred hectares could function as preserves. However, a few hundred hectares is too small, in isolation, to prevent associated fauna, especially large carnivores, from going extinct. Some other solutions to deforestation are to be found in plantation culture, habitat restoration, and integration of conservation with nondestructive use. Plantation culture of fast-growing timber, pulp, and fuelwood species has already helped to meet local needs and reduce the rate of deforestation (Rocca Caliennes 1985); Janzen (1988) is demonstrating the feasibility of forest restoration in Costa Rica; and GRMUs may provide a mechanism for conserving genetic resources and simultaneously providing economic benefits. Certainly, exploitation without conservation leads to a situation in which no one benefits for long (Gentry and Vasquez 1988). Measures that both conserve resources and provide economic benefits can forestall the collapse of our natural ecosystems and buy the world precious time to attack the root of the conservation problem—population growth and concomitant poverty.

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Biological Diversity

Preparing for climate change

Major changes in global climate are virtually certain by the mid-21st century; researchers are beginning to explore ways we can adapt

The greenhouse effect is not controversial. In fact, according to Stephen H. Schneider of the National Center for Atmospheric Research in Boulder, Colorado, the phenomenon is "one of the best-established theories in atmospheric science." At least a century ago, Schneider says, scientists knew that while carbon dioxide (CO_2) and other "greenhouse gases" freely allow solar radiation to enter a planet's atmosphere, these gases permit only a portion of the infrared radiation produced to escape back to space. The greenhouse effect explains, for example, why Venus, which has a dense CO_2 atmosphere, is very hot; why Mars, with only a thin CO_2 layer, is ice-cold; and why temperatures on Earth have been ideally suited for plant and animal life.

Scientists also have long known that human activities, particularly the burning of fossil fuels, are artificially increasing the volume of greenhouse gases in the earth's atmosphere and that this increase eventually will make the planet the hottest it has been in human history. What remains controversial about the greenhouse effect, says Schneider, is the rate of this global warming, its regional distribution, and, most of all, what to do about the problem.

Schneider spoke at a recent conference, the First North American Conference on Preparing for Climate Change: A Cooperative Approach. The meeting addressed two problems—the greenhouse effect and stratospheric ozone depletion.[1] John C. Topping, Jr., president of the Washington, DC-based Climate Institute, which organized the conference, said that the meeting was the largest gathering ever on the subject of adapting to climate change. More importantly, he said, it was the first time that climatologists and "climate impact scholars" (those who study the effects of climate change) had met with a broad array of policy makers, including representatives of state and federal government; electric utilities; chemical, oil, and gas industries; forestry and agriculture; automobile makers; and leading environmental organizations.

Most participants left the meeting feeling optimistic, Topping said, because the program focused on specific actions to address a problem far too often viewed fatalistically. He said, "People came away seeing that they could divide the issue into chewable pieces and start working on those pieces right now."

Gigantic environmental experiment

As far back as the turn of the century, a few scientists had already begun to worry that massive amounts of CO_2 being released as a result of the Industrial Revolution would change the world's climate.[2] In the 1950s, these concerns were supported by measurements demonstrating that atmospheric CO_2 was in fact increasing. In recent years, both data and worries have proliferated, coming to a head in 1985 when a distinguished international group of scientists issued dire warnings following a conference sponsored by the International Council of Scientific Unions, the World Meteorological Organization, and the United Nations Environment Programme.

At a hearing the following year before the Senate Committee on Environment and Public Works, Wallace S. Broecker of Columbia University in New York City echoed the concerns of many scientists. "The inhabitants of planet earth are quietly conducting a gigantic environmental experiment," Broecker said. "So vast and so sweeping will be the impacts of this experiment that, were it brought before any responsible council for approval, it would be firmly rejected as having potentially dangerous consequences."[3]

Levels of CO_2 have already increased approximately 25% since 1900. Today most atmospheric scientists agree that, even if fossil fuel emissions are reduced somewhat, CO_2 levels will double by the second half of the 21st century. This doubling will powerfully affect not only global temperatures, but also other physical phenomena, including rainfall, winds, ocean currents, sea level, and storm patterns.

Because the effects of doubled CO_2

by Laura Tangley

[1]The conference was held 27–29 October 1987 in Washington, DC. Although it addressed both the greenhouse effect and stratospheric ozone depletion, this story will focus only on the former. For a review of the ozone issue, see *BioScience* 37: 647–650.

[2]Scientists now know that there are many greenhouse gases in addition to CO_2; these include methane, nitrogen oxides, and chlorofluorocarbons. Although levels of these gases also are increasing and, taken together, may be as important as CO_2 in accelerating the greenhouse effect, they often are omitted from discussions of the problem because they have complicated biogeochemical interactions about which little is known.

[3]The conference and Senate hearing were described in *A Matter of Degrees: The Potential for Controlling the Greenhouse Effect*, a report by Irving M. Mintzer of the World Resources Institute (Washington, DC, 1987).

cannot be studied directly, researchers have relied on global climate models—mathematical representations of the atmosphere that simulate, on computers, climate change under various scenarios. These models generally predict that a doubling of CO_2 levels will cause global mean temperatures to rise between 2° and 5° C.

One of the most widely used climate models was developed at the Goddard Institute for Space Studies (GISS) in New York City. According to James E. Hansen, one of the creators of the GISS model, support for the predicted 2°–5° C warming comes from empirical as well as theoretical evidence. For example, he said, recently developed paleoclimate records—which show fluctuations in atmospheric CO_2 over the past 100,000 years and correlate these fluctuations with various climate parameters—have provided "remarkable confirmation" of the models' predictions.

Still, many uncertainties remain. Oceans, for example, have a tremendous capacity to store heat. Their ability to delay global warming, while considered in the models, remains somewhat uncertain. Clouds are another important yet unpredictable variable. Changes in global temperature and precipitation patterns will certainly alter the number, distribution, and kinds of clouds, yet the precise changes and how they will affect climate are unknown. There also are many uncertainties concerning human behavior, said Schneider. These include population growth, per capita fossil fuel consumption, deforestation and reforestation rates, and the possibility of new technology to mitigate CO_2 build-up.

Despite these uncertainties, Schneider says, "there is no disagreement that large climatic changes are highly probable and at rates that are fast relative to rates that have caused significant ecological changes in the past." These changes will dramatically affect both human and natural systems, threatening such crucial activities as agriculture, forestry, fisheries, pollution control, and the protection of parks and preserves. At the conference, scientific panels considered the effects of climate change on these and more than a dozen other activities. It was clear that researchers are just beginning to understand the effects of greenhouse climate changes; it will be many years at least before they are able to tell society how to prepare for those changes.

Agriculture and forestry

Perhaps more than any other human activity, agriculture depends on and is extremely vulnerable to climate. Food crops respond strongly to changes in not only temperature, but also precipitation amounts and patterns, winds, and storm frequency. CO_2 by itself directly affects crops by increasing their photosynthetic rate. Most experts agree, however, that increased yields resulting from this phenomenon would be insufficient to offset decreases from CO_2-created climate changes, particularly higher temperatures (which increase plant respiration rates) and reduced water availability. Members of a conference panel looking into the effects of greenhouse climate change on North American agriculture did not agree on how damaging those effects would be.

Using the GISS global climate model, R. B. Stewart of Agriculture Canada in Ottawa has studied the effects of climate change on spring wheat production in Saskatchewan. He reported that climate changes predicted by the model would reduce wheat production by 6%–28% annually. More importantly, Stewart said, the greenhouse effect is likely to increase both the frequency and severity of droughts. Although farmers may be able to switch to less drought-sensitive crops, the implications for the Canadian economy are serious. Spring wheat is Canada's most important grain crop, bringing $2.96 billion in cash receipts to the country's prairie regions. Global warming "could have major repercussions for both prairie agriculture and the Canadian economy in general," said Stewart.

Basing her studies on the GISS model also, Louise Arthur of the University of Manitoba painted a more optimistic picture. Doubling of CO_2 levels would bring about climate changes, Arthur agreed, but "even if those changes were here right now, we have the technology to adapt."

Daniel Dudek of the Environmental Defense Fund in New York was most concerned about water availability. "The issue is not whether we're going to starve," he said. Yet increased summer dryness in the western United States—predicted by some of the models—could boost irrigation water demand by 30%. "It would not be possible to meet this demand without new technology or new water management policies," Dudek said.

Despite a lack of consensus on the effects of climate change, panelists took a first pass at adaptation strategies. They predictably recommended more research, with a focus on variables such as heat waves, frost, drought, and violent storms that are expected to be more significant than average temperatures in determining agricultural yields. Some panelists urged plant breeding for tolerance to heat and drought stress. "If climate change comes rapidly, and it might, we'll need a wide range of new cultivars," said Norman Rosenberg of Resources for the Future in Washington, DC.

Greenhouse warming also will affect commercially important tree species. "Trees, being both stationary and long-lived, would be particularly vulnerable to climate changes," said Carl H. Winget of the Canadian Forestry Service in Quebec. Moreover, because many commercially valuable species occur in unmanaged ecosystems, "we'll be forced to accept the changes imposed on us," he said.

Winget expressed particular concern about secondary effects of global warming such as changes in fire incidence and the hardiness of pests, including the spruce budworm and gypsy moth, whose destructive effects are now limited in part by temperature and moisture. Pests and disease-causing microorganisms will adapt to climate change faster than trees; other stresses such as air pollution and acid precipitation could exacerbate the damage. Winget deplored the uncertainties that make today's management strategies "purely speculative." Nevertheless, he said, "the need to plan is urgent even at minimal rates of climate change." Winget proposed as a first step that forest managers consider climate change when preparing management plans and that genetic improvement programs focus more on "selecting stock having reasonably rapid growth over a broad range of conditions" than on maximal growth under ideal conditons.

Fisheries

The effects of greenhouse climate change on fish are more uncertain.[4] All physical changes predicted for oceans in the models have the potential to dramatically influence fish and thus commerical fisheries. These potential physical changes include, in addition to surface warming, alterations in global circulation patterns, storms, upwelling, salinity, pH, turbulence, and the amount and distribution of sea ice. Shifts in species ranges resulting from such changes could create new community associations and either enhance or limit access by commercial fishermen. Moreover, fish, even more than trees, inhabit basically unmanageable ecosystems. "We'll be mere spectators in the adjustments to climate change," said Jim Titus of the US Environmental Protection Agency (EPA) in Washington, DC. "People will have to adapt to whatever the fish decide to do."

[4] A one-and-a-half-day symposium on the impact of climate change on fisheries immediately followed the conference. The symposium was the first in a series that will explore the effects of climate change on various human activities. It was organized by the Climate Institute and sponsored by the US Environmental Protection Agency.

Most marine ecosystems are less well understood than terrestrial systems. Skip Livingston of Florida State University in Tallahassee asked, "How can we predict climate-change effects on ecosystems we know so little about now?" Thomas Sibley of the University of Washington in Seattle agreed. Scheduled to speak on the "Impact of climate change on North Pacific and Alaskan fisheries," Sibley said he was "surprised to see the title of my talk. We're nowhere near being able to say what those effects are." Nonetheless, he ventured several "guesses," including geographic shifts of many commercially valuable species toward the poles. These shifts could benefit some northern fishing economies at the expense of southern regions, Sibley said.

A few researchers have attempted laboratory studies of the impact of particular climate change predictions on fish. Robert C. Worrest of Oregon State University in Corvallis, for example, has studied the effects of increased ultraviolet radiation (UVB), a consequence of the current thinning of the earth's ozone layer. Worrest reported that larval forms of fish and shellfish will be most vulnerable because they inhabit surface layers where the impact of higher UVB will be greatest. In his research, Worrest has found direct UVB damage to phytoplankton, copepods and other primary consumers, and larvae of several fin and shellfish species. The indirect results, he said, could be "severe economic losses" to fishing economies.

One of the most troubling likely consequences of global warming is sea-level rise, which would result from the expansion of upper layers of the ocean and from the melting of mountain and polar glaciers. EPA's Titus said that sea level will probably rise 50–200 centimeters globally by sometime in the 21st century. This rise could produce inundation of wetlands, which are nurseries for most commercially important fish species; erosion; increased flooding; and higher salinity and pollution levels. Titus says that if sea level rises 200 centimeters, 80% of US coastal wetlands could be lost.

Edward LaRoe of the US Fish and Wildlife Service in Washington, DC, disputed Titus's predictions. "The issue of sea-level rise and wetlands loss has been marked by conjecture and anecdotal evidence," he said. Most scenarios have been based on wetlands losses in coastal Louisiana, which has lost about half of its freshwater wetlands over the past two decades. Although sea-level rise is one explanation for the loss, said LaRoe, the most important causes have been human interference, including oil and gas development, which has caused land to subside, and an extensive system of levees along the Mississippi River that have prevented sediments from replacing those naturally lost at the river's mouth. Louisiana's marshes are different from those found in most US coastal areas, said LaRoe, "and there is a great deal contributing to their loss other than sea-level rise."

Biological diversity and parks

Predictions about how natural ecosystems might respond to greenhouse climate changes have come primarily from observations of present plant and animal distributions—and how they correspond to temperature and moisture patterns—and from studies relating species distributions determined from fossil pollen grains and animal bones to climatic conditions of the past. "These kinds of observations tell us that plants and animals are very sensitive to climate," said Robert L. Peters of the Washington, DC-based World Wildlife Fund and The Conservation Foundation. Peters, who led a conference panel on the "Likely effect of climate change on biological diversity," said that "if global warming occurs during the next 50 years, it is likely to change the ranges of many species, disrupt natural communities, and possibly cause species extinctions."

From an ecological viewpoint, an average change of just a few degrees is "tremendous," said Peters. "It would create conditions that the natural biota has not had to contend with in 100,000 years." For example, during the last ice age, when much of North America was completely covered with ice, the earth was only about 5° C colder than it is today. Future climate changes will be more stressful to species than in the past, said Peters, because the changes will be large and will occur very quickly, and because human development has fragmented species into small, vulnerable populations. Species will be facing—in addition to temperature increases—changes in rainfall patterns, soil chemistry, sea level, and community composition. "The most optimistic thing that could be said about the future of natural systems under a regime of warming climate," said Peters, "is that a great deal of rearrangement would occur."

Because most species will have a tendency to migrate northward, eventually squeezing out those at the top, and because global warming will be most extreme at higher latitudes, plants and animals living near the poles are in more jeopardy than those living closer to the equator. Calling arctic ecosystems "surprisingly diverse," Sylvia Edlund of the Geological Survey of Canada in Ottawa, Ontario, said "the response to even small changes would be dramatic." Arctic species tend to be poor competitors, and as tree species migrate northward in response to global warming, arctic ecosystems could be reduced from one-third to one-quarter of Canada's land area, she said.

Also at special risk are rare species living in parks and reserves. Such species are confined to habitats that many biologists feel are already too small to ensure long-term survival. Climate change would probably force reserve species to migrate, yet few would find suitable habitat because of barriers such as cities, roads, reservoirs, and farm land. "Few animals or plants would be able to cross Los Angeles on the way to the promised land," said Peters.[5] Herman Cole of the Adirondack Park Agency in Ray Brook, New York, fears that parks will receive the lowest priority when people struggle to adapt agricultural and other "essential" ecosystems to global climate change.

[5]For an in-depth discussion of this problem, see *BioScience 35*: 707–717.

Buying time

Some atmospheric scientists say that past emissions of greenhouse gases have already committed the earth to heat up 0.5°–1.5°C. "If we can't stop the greenhouse effect," said Schneider, "maybe we can slow it. We shouldn't minimize the importance of this, if it's all we can do." Slowing climate change, he added, "would buy time" to better understand the effects and devise strategies to adapt.

Slowing greenhouse warming will be difficult, however. Unlike many environmental problems, "there is no single villain" in the climate change issue, said Topping. Countless human activities, from agriculture to energy use, emit compounds that are contributing to the greenhouse effect. Similarly, no single law or set of regulations can solve the problem.

Policy makers are already active in many arenas. Several US senators and representatives, for example, have taken a special interest in the issue and have held hearings over the past few years; two senators, George Mitchell (D–ME) and John Chafee (R–RI), served as honorary cochairmen of the climate conference. In 1986, eight senators, including Mitchell and Chafee, asked EPA to conduct two comprehensive studies—one focusing on the climate change effects on various human and natural systems and the other examining policy options for stabilizing greenhouse gas emissions. The reports are expected by October 1988. Other federal agencies, including the US Department of Energy and the National Oceanic and Atmospheric Administration's US National Climate Program Office, are also studying the climate change problem.

Many scientists say that, despite the uncertainties, it is time to move beyond the research stage. Howard Ferguson, head of Canada's Atmospheric Environment Service in Ottawa, noted the tremendous lag time between the planning of any significant environmental action and that action's implementation. "I am convinced," he said, "that we will eventually need a 'Global Law of the Atmosphere' to solve this problem." Toward that end, several US senators, including Mitchell and Chafee, plan to introduce a resolution calling for an international convention on the global climate change issue. A much-heralded September 1987 international agreement to limit chlorofluorocarbon emissions to protect the earth's stratospheric ozone may catalyze such efforts.

Short of an international agreement, there are many smaller steps both public and private policy makers could take to slow greenhouse warming. To decide among these possibilities, Schneider recommends using the "tie-in strategy"—choosing actions that also have other obvious benefits. Shifting away from fossil fuel energy sources, for example, would reduce our dependence on foreign oil and lessen the acid rain problem even in the unlikely event that the greenhouse effect "turns out to be an 'infrared herring'." Similarly, there are many compelling reasons to slow tropical deforestation, which also contributes significant amounts of CO_2 to the atmosphere.

The dilemma of deciding when to act on the climate change problem, Schneider said, boils down to "our need to gaze into a very dirty crystal ball . . . the tough judgment to be made is precisely how long to clean the glass before acting on what we think we see inside." □

5.0 Programs

Biological Diversity

General Biological Diversity

Lyceum Series — We're Banking On It

By Pamela A. Wright — The Ohio State University

Audience: Adults, some with little science background while others may have a more technical education in the topic.
Duration: 1.5 hours
Interpretive Technique: Indoor illustrated lecture by a guest speaker
Park's Primary Resource: All — excellent for National Recreation Areas
Materials Needed: Guest speaker, overhead projector, slide projector, extension cord, screen, copies of handouts if necessary.
Objectives: Program participants will be able to:

- define biological diversity
- explain the roles that the Department of Transportation and the University play in preserving biological diversity
- explain the role of the seed bank
- list two ways that they can help in the seed bank efforts

Program Description:

A number of parks use a Lyceum or lecture series as a forum for in-depth discussion of a particular topic. This kind of program differs from a regular interpretive program in content: most often you schedule a guest to do the presentation, and in style— the program will be more lecture oriented. Finding someone to speak on a specific subject is a lot easier than it may sound. Look for presenters within your own park staff, i.e. park scientist, people from neighboring parks, local universities or other resource-related agencies or active and interested townspeople.

You may find you want to use a number of people from a variety of agencies or viewpoints and have a round-table discussion. When selecting your speakers make sure both parties have a good idea of who the audience will be, what resources are needed, the length of time for the presentation, your general objectives and goals and the content being presented. It is a good idea to ask to see a draft of the program, or an outline of the speaker's program enough in advance so that you can ask for some changes. Assist the speaker in preparing audiovisual materials so that you can liven up the presentation as much as possible. Additionally, promote your program for what it is—a fairly technical, issue-specific program, not part of the regular program series.

Here is an imaginary program that you might use as a model yours after. The topic is the conservation of genetic material—seed banking in particular. The program is being held in a round-table format and the interpreter will act as a moderator. Guests involved in the panel are: a representative from the local Department of Transportation (DOT) who is currently involved or is considering replacing highway seed with natural prairie species along roadsides; and a representative from a local conservation project—perhaps a municipal or private conservation area or an Army Corps of Engineer Project that is currently raising prairie seed varieties at their site and would consider being a seed donor to the DOT. You may wish to bring in an additional representative from your park to talk about the role the park might play, the impact on the park or other related issues.

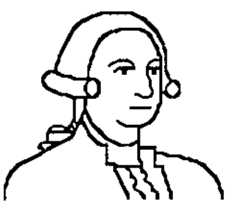
The interpreter should start the session by giving a brief introduction of the speakers and then introducing the topics. You may wish to use some audiovisual support for this section, especially if the round-table discussion is without visuals. Although you don't need to spend a lot of time on this subject, you must quickly bring all audience members to the same level of understanding. Use your questioning skills to involve the audience as much as you can at this point. After the introduction, allow each of the speakers to talk about his or her project. If you have a plan drawn up ahead of time of the topics to be covered and the flow of these topics, it will help you to move the speakers along in the right direction. After their presentations, allow plenty of time for audience questions and speaker answers. Have a few questions prepared ahead of time that you might throw out into the audience to help prompt them towards some issues they might want to have the speakers address (i.e. taxes), just in case they sit there blankly with nothing to say. Close the session by briefly summarizing the session and thanking the speakers and if the conservation organization has not made a point of explaining how the regular citizen or park visitor can help aid in the process (for example volunteering on prairie seed picking days), do so yourself.

Suggested Evaluation:

Schedule a related activity or hike on the same topic in the near future and see how many of the same people come to assist.

George Washington Memorial Parkway Lyceum Program

George Washington Memorial Parkway has developed a unique method of reaching urban audiences with the biodiversity message. This program consists of a series of four films and talks on international conservation issues such as tropical deforestation and the greenhouse effect. These 1.5 hour evening programs held at the Potowmack Landing Restaurant include a film and guest speakers. Although reservations are required, admission is free and each evening is concluded by a reception. These events are sponsored by George Washington Memorial Parkway and Recreation Equipment, Inc. (REI). In addition to the film and lecture series, Parks concessioner, Guest Service, Inc., has provided a biological diversity exhibit that will later be circulated to Sequoia and Kings Canyon National Parks and Mount Rainier National Park. For more information, contact: Joanne Mishalovic, (703) 285-2600. Following is an example lyceum topic.



INTERNATIONAL CONSERVATION ISSUES

Tropical Deforestation

Film: "Our Threatened Heritage," produced by the National Wildlife Federation

Speakers: Dr. Robert Goodland and Dr. Jan Post, Ecologists, World Bank

Date: Thursday, February 2, 7:00 PM - 8:30 PM

This film describes the causes and effects of tropical deforestation and examines potential solutions to the problem.

The speakers will address the influences of world lending institutions on the development of tropical rain forests.

Biological Diversity

Program Sheet 2

Biological Diversity as a Global Concept

Global Linkages

By Pamela A. Wright — The Ohio State University

Audience: Visitors using self-guided trails in the park
Duration: Five minutes
Interpretive Technique: Brochure Insert
Park's Primary Resource: All
Materials Needed: Brochure insert placed inside self-guided trail brochures.
Program Objectives:

- Visitors who read the brochure insert will be able to explain how biological diversity is a global concept.
- Visitors who read the brochure insert will be able to list at least one way in which species discussed are globally connected with another country.

Program Description:

Brochure inserts are an easy way to update your trail brochures and make them issue specific. The material on these brochure inserts is supplementary and topical and will probably not be related to specific locations on the trail. Single color brochure inserts printed on heavy stock with text and line drawings or computer graphics front and back can be reproduced for approximately one cent per copy — less if you are printing in large quantities. The text can be related to almost any topic and can be written from resources in this notebook and in your park. You may choose to design your insert as a supplementary take-home item, sort of a reward for walking the trail. These inserts can be designed for any age and interest level.

The example brochure insert provided on the next page was designed with one side for adults and one for children. It was created to interpret the rather complex topic of global biological diversity.

Program Evaluation:

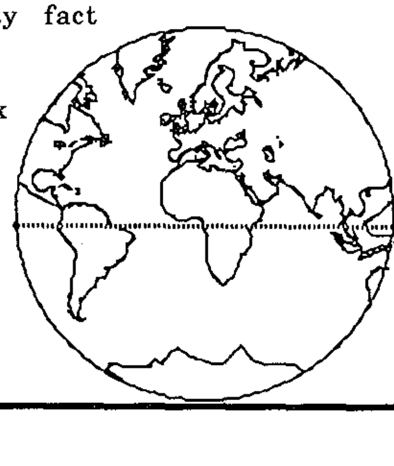
Design some part of your brochure insert to be interactive. You may pose questions in the text and refer visitors to your visitor center for the correct answers. If you have pre-scheduled programming for your season —you may refer interested visitors to a specific program or program series. You can ask at the beginning of these programs how people found out about the program and if any had seen the brochure insert. Also, casually question visitors completing the trail and look for discarded inserts at trail heads or ends.

References:

Biological diversity fact sheets

Other general park information

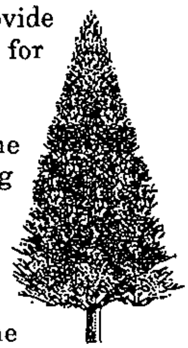
Simple artwork or clip art that is readily available



Opening Eyes to Global Issues

Forests are something most of us take for granted. Our national parks provide us with opportunities to enjoy forests and other natural habitats and they will continue to do so forever — or will they?

Daily we read in the newspaper or hear on the television about the devastation of tropical forests in other countries. Between 25 and 100 acres of tropical forests are being destroyed every minute. Tropical forests in Central and South America, and elsewhere in the world, are harvested for timber and fuel wood, and areas are cleared to provide places for ever expanding cities and for places to graze cattle and grow crops.



As each tree is cut, our chances for the discovery of a new lifesaving drug disappears, habitat for birds and animals shrink, and our climate faces irreversable changes. Tropical forests provide habitat for an incredible diversity of species like the Rosy periwinkle. Found only in the tropical forests of Madagascar, the Rosy periwinkle provides a substance that is one of the few treatments for leukemia. Birds such as the peregrine falcon, migrate to countries in South America for wintering range and breeding. Loss of habitat, and agricultural chemicals such as DDT, threaten the survival of this species. And trees produce oxygen, hold moisture in the environment and keep temperatures constant. As tropical forests disappear, temperatures may become hotter and hotter.

So even if we're not in danger of destroying the trees in our national parks, our forests are threatened. Next year the birds that migrate to South America may not return. And it becomes harder and harder to ward off threats like pollution and acid deposition in our own country. Our parks are not shielded from these effects — their boundaries are vulnerable. Preserving the biological diversity in tropical rainforests is just as important as preserving the biological diversity in our national parks — these are global linkages.

Just For Kids

Many of the plants and animals we find in our National Park rely on resources from other countries. Have your parents explain the information on the front of this card and then try and solve the following puzzle.

WORD SEARCH

P	N	E	R	I	W	I	N	K	L	E
Y	I	D	I	S	R	E	V	I	D	H
S	A	V	K	E	R	S	T	U	N	D
V	R	D	E	B	B	V	O	E	E	N
H	D	D	B	R	A	C	N	L	G	T
R	I	T	F	U	J	I	D	E	Y	A
H	C	H	P	A	R	K	S	M	X	T
K	A	M	E	G	V	N	G	G	O	I
D	O	S	E	N	E	A	B	A	H	B
T	E	R	O	P	I	C	A	L	J	A
E	V	B	M	R	L	L	W	V	E	H
C	P	I	L	F	O	E	H	I	V	X

Find:

The home of a plant or animal.
A poison.
A flower that can be used to treat a disease.
Something that trees produce that humans need.
Biological _____________.
A type of forest that has a large number of different plants and animals in it.
A bird that migrates to South America.
Places in the United States that preserve our natural environment.
One threat to our National Parks.

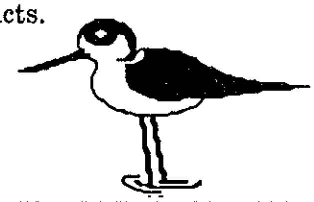
Padre Island National Seashore

Richard V. Harris

The Bird Island Basin Environmental Study Area guide is a primary resource for biological diversity interpretation and public education at Padre Island.

The study guide contains background information, pre-trip planning information and exercies, and activities. Although these activities are best suited for field trip experiences at the park, they may be conducted in the classroom or at other natural areas. A variety of activities are included ranging from a geology and physical sciences activity that examines the geologic origins and present geologic activity at Padre Island to a program entitled "tracks in the sand" that examines the less frequently observed inhabitants of the Island.

Other lesson modules cover topics such as plants, invertebrates, underwater resources, shorelines, food chains, birds, adaptations, and human impacts.



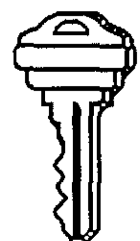
Cultural Transfer of Biological Diversity

The Key to Knowledge — Unlocking Biodiversity

By Pamela A. Wright - The Ohio State University

Audience: Family
Duration: 1 hour
Interpretive Technique: Evening program consisting of an activity and story-telling
Park's Primary Resource: Natural or Cultural
Materials Needed: Example objects such as herbal teas, muscle relaxants, coconut, Indian corn. stories to be told, world map, string, push pins or overhead marking pen, supporting slides if desired, costuming and set of a T.V. game show if desired. Large cardboard cut-out of a door key, actual doors or simulation
Program Objectives: Program participants will be able to:

- explain what is meant by cultural transfer of biological diversity.
- list at least two items that have undergone transfer from culture to culture.
- list methods in which biodiversity knowledge or items can be transferred.
- tell how cultural transfer of biological diversity can promote conservation.



Program Description:

This program can be conducted in two segments. The first segment involves the audience in an activity that can be based on a game show theme, while the second segment is more of a an interpretive story-telling function. You may wish to carry the game show analogy through the second portion of the program. Slides or a supporting movie can be used to enhance any part of the program.

Activity — Begin with an introduction to your program that discusses how we have learned valuable information about the uses of certain plants and animals from other cultures. Have some actual objects with you (some suggestions include: herbal teas, seaweed, muscle relaxant, coconut, Indian corn, and a toothache medicine) and a large world map or an overhead of that map. Have your audience help you to identify the country from which the item originated—you may also be able to narrow down a time frame of when that item was first used. Mark the transfer of that item on your overhead with a marker or on your map with string and push pins. As you look at each item, have your audience help you discuss the value of that item to the country of origin and to the country of transfer (medical benefits, economic benefits, enrichment of tradition or culture). If you like, turn this part of the program into a mock T.V. game show. Play on the concept that biodiversity is the key to knowledge. Audience members would be chosen to use the magic 'key' (a cardboard cutout) to unlock a door (as in "behind door number one"). The doors would reveal the items listed above and then if the contestant (you may want to work with teams) could correctly guess where the item came from (you could provide clues) and any other information, they would win a prize.

Storytelling — Ask your audience to help you identify some of the methods by which items, such as those above, might have been transferred from culture to culture. Talk about the following methods: pictographs, petroglyphs, ballads, poems, songs and stories, archaeological evidence, personal conversation, and direct sales or marketing. Discuss that fact that cultures that have a close relationship with their natural biological diversity are like librarians — these people hold the keys to knowledge about our global biological diversity that we can use to unlock its secrets.

Illustrate the transfer of knowledge by telling a story that illustrates these points. You may be able to make up a story based on the resources and experience of your park or you may find an appropriate natural history book (see reference list below).

Suggested Evaluation:

You may wish to conclude your program and role as the research librarian by asking your participants to think of any other examples of items or knowledge that has been culturally transferred. Or use this time to have the audience ask the librarian questions.

Extensions:

• Obtain a copy of the movie, *The Teaching Rocks,* which traces the history of pictographs and petroglyphs through a storytelling approach.
• Cover a large table with brown mailing paper and provide crayons for children or adults to draw their own pictographs. You may provide children with a paper that asks them to draw a story picture about some element of the park's natural environment.

References:

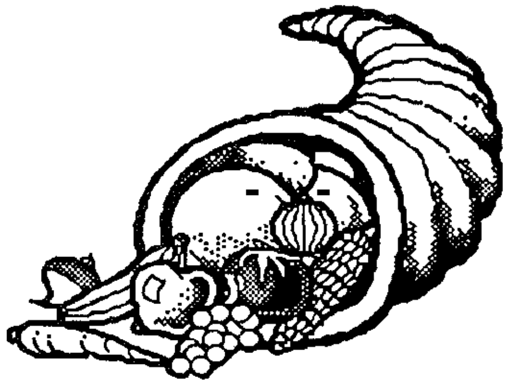
Gard, Wayne. 1959. The Great Buffalo Hunt. Lincoln: University of Nebraska Press.

Stefferud, Alfred, Editor. 1966. Birds in Our Lives. USDI— Bureau of Sport Fisheries and Wildlife.

Fact Sheet — Cultural Transfer of Biological Diversity

Other native history books

Movie — The Teaching Rocks, Ontario Ministry of Natural Resources



Cuyahoga Valley National Recreation Area

Susan M. Halaburda

This program was developed as part of a Critical Natural Resource Issues for Interpretation workshop. The text and ideas were originally developed for a guided hike but Susan also feels that they may be developed into a slide program for use in the winter. The program is designed to tell the story of biological diversity found in the Cuyahoga Valley and how it has been a source of food and fiber, medicine and goods to a variety of human societies for 12,000 years. The program relates strongly to the cultural transfer of biological diversity and includes objectives such as: to name sources of fiber, medicines and food used by early inhabitants of the CVNRA area; to name three benefits of the natural world of present users of the CVNRA; and to predict three benefits of the natural world for the future visitors to CVNRA. Excerpts from the text are included.

12,000 Years of Partnership

Throughout the wooded terrain in front of you is a grocery store, pharmacy, and department store all combined. People today rarely see the warehouse of supplies available to us out in the wild. Yet, the biological diversity found in the CVNRA has been a source of food, fiber, medicine and goods to a variety of human societies for 12,000 years. The natural world was and continues to be a way of living and surviving for many people over the ages.

By using your imagination, let's pretend we are time travelers. As we travel back in time we will unfold the relationship of human societies to the natural world. (Time traveling device is a compass fitted with different era coordinates taped on it, that lead the group to different stops along the trail.)

Our first stop in our travels takes us back to the year 8,000 BC. The land had been scarred by glaciers, but as the glaciers retreated, plants and animals, and trees spread over the land. People were nomadic types, following the herds of animals and moving from place to place with the seasons. We watch from a distance as a Paleo-Indian tribe prepares and sets out for a hunt. Mastedons and mammoths, giant elk, giant beavers, musk oxen, horses and tapir roam the area. Since hunting is a major way of life and survival, how do you suppose these people are able to hunt them so readily? They depended on what was available around them. Look at the land in front of you for what sources you can find for tools or weapons that might have been used by the Paleo-Indians. (At this point let the group look for objects and discuss finds including rock, wood and bone).

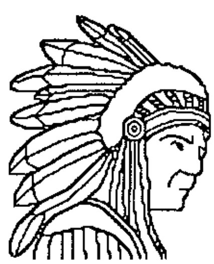
(These time travels continue for several stops and time periods until ...)

. . . Our travels through time eventually leads us to the present time. We are brought back home to a time when modern conveniences of grocery stores, pharmacies, and department stores have taken over and the wild natural sources of food and medicines are long forgotten . . . Modern technology has given us a false sense of security that we are self-sufficient and no longer need the ties our ancestors had to the land. It is during this time that we need to think about preservation of our past and of the rich and abundant lands we depended on for subsistence. Technology may not sustain us forever.

(Interpreter discusses the benefits of the natural environment of CVNRA)

. . . Our final stop in our travels through time projects us further into the future. Here we must stop to think about what might be. What do you think will be future benefits of visitors to the CVNRA? If our society continues on its present course of global environmental degradation, what will the future generations of humans have left to supply the essentials of life?

. . . We have completed our adventure today. Now it is time to set our time compass for home and the year 1989. As we travel back, we recall all the wonders of the natural world that people have used over the years and we hope that these natural wonders will be here for us to enjoy in the future as well.



Threatened or Endangered Species

Pave Paradise?

By Amy Holm

With permission of The Global Tomorrow Coalition, Inc. 1986.

Audience: children or children and parents
Duration: 40 minutes
Interpretive Technique: Instruction and Activity
Park's Primary Resource: All
Materials Needed: paper, pens, tape, chairs, record player or tape recorder and music, Face the Facts Cards and Species Cards (a few examples are provided for your inspiration —try to make some park specific)
Program Objectives: Children will be able to:

- define species
- define habitat
- describe three causes of habitat destruction
- define endangered and extinct
- describe three means of restoring or preserving habitat

Program Description:

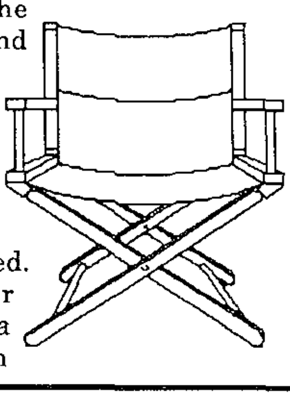
Preparation — 1) count the number of children and place the same number of chairs in a circle facing inwards (18 max.). On the backs of these chairs, tape a sign designating that chair as either a land, air, or water habitat. A fairly even representation of each of the habitats works best for the game.

2) Copy and cut the Species and the Fact cards. Count out the same number of Species Cards as there are children, making sure that there is a mix of species representing the three types of habitat.

Procedure — 1) Define species. Ask children, "What species are we?" Different species live in different homes. Define habitat. Give examples of familiar species and their habitat, e.g. polar bears in the Arctic. Ask the children to describe their habitat.

2) Tell the children that during the next activity they will be acting as another type of species. Ask how many have ever played musical chairs. This activity is played the same way. The circle of chairs represents the Earth. Each chair has a sign on it — either land, air or water — that describes one general type of habitat that animals and plants depend on to survive.

3) Read the following directions: "You will be receiving a Species Card. Please read it and identify the proper habitat for your species. The game will start when everyone is scattered around the inside of the circle and the music begins. You will walk around the circle clockwise until the music stops. Then you are to find a seat with the appropriate habitat sign."



After the first round, the interpreter will read a Fact Card, that describes an actual cause of habitat destruction and one chair will be removed. After each round, whoever cannot find a seat will read a Fact Card to the others. Then another chair will be removed and the music will begin again.

4) Distribute the Species Cards and begin the activity. End the game when all three of the habitats are no longer represented, even if chairs remain in the circle. Explain that species cannot live on Earth without a complete ecosystem, (e.g. whales live in the oceans but need air to breathe).

Conclusion and Evaluation:

Ask the children to list reasons for habitat destruction based on the information from the Fact Cards. Define endangered and extinct. Relate how the destruction of habitats contributes to endangered or extinct species of plants and animals.

Brainstorm with the children ways to preserve habitats or to reconstruct habitats. With each suggestion, return a chair representing a habitat to the circle until the Earth is a complete and healthy ecosystem again.

Species Cards

I am a California Condor. My wingspan is 9 feet across. — AIR

I am a wolf. Have you ever heard my howl? — LAND

I am a Blue Whale. I grow to be larger than a school bus. — WATER

I am a Bald Eagle, the symbol of the United States. — AIR

I am a Rainbow Trout, because my scales shine with many colors. — WATER

I am a PANDA, a black and white bear. I eat bamboo shoots. — LAND

Face The Facts Cards

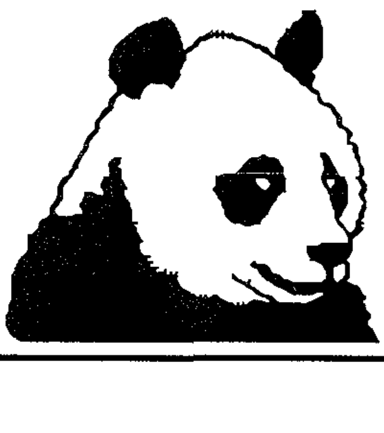
In 1985, the use of pesticides for farming polluted a bird refuge area in California — Remove a chair marked AIR

An oil spill covered 800 sq. miles off the California coast in 1969. — Remove a chair marked WATER.

Every year, tons of soil are eroded from farmlands in our country. — Remove a chair marked LAND.

DDT, a dangerous pesticide banned in the United States in 1972, is still used by other nations. — Remove a chair marked AIR.

(Make your own species and fact cards —you may want the issues to be more general and more familiar to the children.)



Shenandoah National Park

Napier Shelton

A prepared slide presentation entitled, "Shenandoah's Tropical Connection" was designed to interpret the fate of threatened and endangered species. This program ties the status of biological diversity within our national parks to the more familiar threatened biological diversity in tropical rain forests. Below are selected excerpts from this slide program.

Shenandoah's Tropical Connection

Message: Shenandoah is linked to the American tropics by birds that migrate there for the winter. Protecting these birds means also protecting the habitats, especially forests, in which they winter.

[Forest glade with wildflowers] Summer in Shenandoah. There are many nesting birds (over 100 species). The park provides a large area of good habitat for them, especially the forest dwellers. This is part of the diversity of life the park protects.

[Migrating birds] But over half of the park's bird species migrate south for the winter, in most cases south of the United States. Therefore, the park can't totally protect the migrant species. What conditions do they find on their wintering grounds, where they spend more of the year than they do in Shenandoah? We'll find out in a moment. But first, let's get acquainted with a few of our summer birds of the forest.

[Slides and narrative on birds of Shenandoah]

[Central American forest] Besides nesting in Shenandoah, these birds have something else in common — they winter in the forests of Central America or the West Indies. Here they set up territories, which they defend against other individuals of their species, just as they do on their summer grounds. With them in the tropical forest are not only many species from North America, but also many others that live all year in these tropical forests.

[Cutting, burning of tropical forest] These four species from Shenandoah have another thing in common — they are becoming scarcer. Why? No one knows for sure, but one likely cause is that the forests they winter in are becoming scarcer. All over Central American and the West Indies, forests are being cut.

Our bald eagles, brown pelicans, and peregrin falcons, for instance, were in a serious downslide until we stopped the use of this pesticide. Unfortunately, we still sell it abroad.

[Slide of U.S. Agency for International Development (AID) or World Bank Project] What can we do to help remedy these matters? Mostly, support efforts to help these countries develop in environmentally sound ways. The U.S. AID and the World Bank are two important avenues for such help.

[Series of slides of Shenandoah forest, Latin American forest] So Shenandoah National Park has a tropical connection. An important, much-loved part of the natural diversity of Shenandoah could be lost if tropical environments to the south continue to be cut and poisoned. Awareness on both sides of the border is the first big step toward healing.

Ethical Issues and Species Preservation

Debating Diversity

By Pam Wright — The Ohio State University

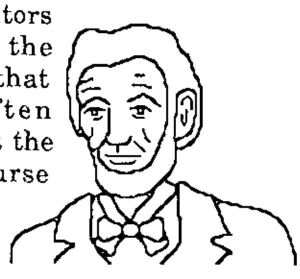
Audience: Adult visitors
Duration: 2-6 minute spot talk
Interpretive Technique: Spot talk
Park's Primary Resource: Historical
Program Objectives:

- Participants will be able to list four ethical issues for the preservation of a species.

Program Description:

Particularily tricky subjects such as ethics are often hard to visualize as interpretive programs. There are no right or wrong answers and everyone is entitled to his or her opinion. Developing an entire hour-long program on a topic such as this will not only stretch your imagination but it may stretch the material. On the positive side, however, topics such as ethical issues and species preservation can just as easily be incorporated into historical or cultural resource parks as natural environment parks. Ethics are based on sets of beliefs and as such, are difficult to teach; some say in fact that they should not be taught. Ethics however, should be integrated into all programing you do. For example, a program on aquatic life that involves collecting samples for study should teach an environmental ethic through the interpreter's behavior — releasing species sampled into their natural habitat upon completion of the exercise. Perhaps one of the best methods of handling this subject is to handle it as an unresolved dilema: a mystery or a debate. In this manner, participants become exposed to a range of issues relating to the topic but, are left to decide their own position on the topic. This example program will be used as a short exerpt in a regularily scheduled program at a historic site—we will use Lincoln Birthplace National Historic Site (ABLI) as an example. The interpreter will not actually teach ethics, but rather model ethical behavior and reveal the reasons for that behavior.

Visitors to a historic site such as ABLI may participate in a building tour, examining artifacts and objects along the way and hearing vignettes and stories of life as it was. One of the many topics for these tours is to interpret what in Lincoln's upbringing may have led him to become a president. When interpreters and visitors reach the dining room the interpreter may mention that Lincoln's father often challenged him to debates at the dinner table—these of course strengthened his analytical skills and speaking skills. If the interpreter has other staff members at his/her disposal he/she may choose to have the following scenario become a small play. If staff are not available, the interpeter could use members of the audience, perhaps prompted with written cues.



Lincoln's father, looking up from his dinner, reveals the following information to his son. "Abraham, there was considerable debate at the town meeting the other night over whether or not to cut down that old oak in the town square. I can not see that it serves any purpose so why on earth should it not be cut down?

Lincoln's response should highlight four reasons for the preservation of a species: economic value, esthetic value, interdependence of ecosystems and intrinsic rights for life. At the end of this discourse, the interpreter can continue his/her regular tour.

Evaluation and Summary:
At the end of the home tour, have the audience help summarize the reasons that may have led Lincoln to become president. Highlight the debate and ask what some of the issues were that Lincoln used to defend or debate a species standing. Use this to lead into an introduction about another program — more related to biological diversity that is offered at the site or, use it as a technique to talk about the NPS system as a whole. For example, "the NPS maintains a number of historic sites like the ABLI to help you understand and appreciate your American heritage - this is part of a broader network of national parks such as Yellowstone, the Grand Canyon and Great Smoky Mountains. These parks were designed to preserve that same biological diversity that Lincoln may have defended at the dinner table with his father. We encourage you to attend the program ______ on biological diversity here at the Boyhood Home or to visit one of your other national parks to learn more about this topic. After all, we ourselves, not just presidents like Lincoln, need to know about these important issues."

Shenandoah National Park

Napier Shelton

As part of a sourcebook for interpreting biological diversity at Shenandoah, Nape Shelton formulated some ideas for guided walks designed to communicate the value of a species. Excerpts from one of these walks are listed below:

What Is a Tree Worth?

This walk looks at several trees, either of the same species or of different species, to contemplate values ranging from economic to spiritual and intrinsic.

Values to be demonstrated or discussed at stops include:

Economic: value for lumber, veneer, etc. Give dollar values if possible.

Ecological: food and home for other organisms. Look for birds, insects, fungi, squirrels, etc. in or on the tree, including cavities. You could pick one tree just for a discourse on the value of cavities. [Binoculars are useful here.]

Environmental: Discuss the tree's role in holding soil, reducing the impact of rain, creating a cooler, moister environment beneath it, regulating atmospheric processes by taking in CO_2 and transpiring water vapor.

Scientific: What could be learned by studying just one tree? For example, look at the amount and variety of insects on a single tree and how they are related to it.

Esthetic: Get people to express their reactions to individual trees — beauty, ruggedness, peculiarity, etc. If this tree were a person, what kind of a personality would it have?

Intrinsic: Get people to discuss whether a tree should have a standing in court. Does it have value simply because it exists?

Conclude with comments on the immense value represented by all the trees in Shenandoah, each with its own individuality and genetic makeup. The park is here to protect such values.

[A number of environmental education guides will suggest activities that are tree-related that might be integrated with this program — how about creative expression through haiku or other poetry, or adopt-a-tree activities.]

Biological Diversity

Program Sheet 6

Evolutionary Processes

Let's Split

By Pamela A. Wright — The Ohio State University

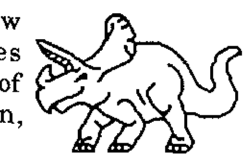
Audience: Family Groups
Duration: 30 minutes
Interpretive Technique: Activity
Park's Primary Resource: Natural
Materials Needed: Slides or pictures of select species (e.g., elk), cut-outs of different size antlers, recipe cards or markers.
Program Objectives:
- participants will be able to explain the balance of extinction and evolution
- participants will be able to explain at least one reason why speciation may occur

Program Description:

This activity can be used as part of a larger program on the role of evolution and extinction in biological diversity, or it may be incorporated into other programs: e.g., *restoration of species, ecosystem restoration,* species-specific programs, children's activities. The activity was designed for people of all ages and can involve as little or as much activity as you wish. If your audience is made up of children, you might want to adapt the activity into some kind of relay race. If your audience consists primarily of seniors, everyone can remain seated for most of the activity and you can do the moving. You can easily substitute another animal of your choice—the elk has been used here because it is common to a number of parks.

Tell your audience that the planet and the parks remain in a careful balance of extinctions and evolution. If we have one without the other, the planet will become overbalanced. While most of us will see (or be present for) many extinctions during our lifetime, we probably will not be able to witness the evolution of a new species.

Evolution is a very slow process, and may take hundreds of thousands of years for it to occur. Why do we have evolution? Because species continually adapt to new situations. With adaptation comes change and speciation—the creation of a new species. Without evolution, there is only extinction.



Ask your audience to name one very famous extinction—give enough clues so they guess dinosaurs. Explain that while there are many different thoughts as to why dinosaurs became extinct — environmental change is probably the most plausible (e.g. different plants grew—loss of food to many creatures and they overgrazed themselves; most popular reason is that there was a massive meteor shower and the debris or dust in the air reflected so much sunlight that the earth's temperature cooled and the environment changed drastically). Q. What happened to the dinosaurs when their environment changed? A. They became extinct. Q. Did all the dinosaurs die? A. (Probably be yes but in reality it's no — some dinosaurs, or rather relatives of the dinosaurs still remain today e.g. dragonflies, some lizards, crocodiles and tortoises) Q. Where did these relatives come from? Why did some dinosaur relatives survive? A. They evolved, or adapted to the change in their environment and new species were created.

Bring your audience back to a time in the present park setting. Tell them that they are going to discover how evolution actually works by assuming the role of a park species — the elk. Ask your audience if they have seen any elk. Ask for some descriptions both habitat-wise and physical. Explain that there is just as much difference within a group of elk as there is within the audience. Just like humans, some elk are different sizes, different colors, etc. The differences in elk occur the same way they do in people. Each elk has a genetic 'fingerprint 'that determines itscharacteristics— these genetic fingerprints are a combination of the 'fingerprints' of their parents, grandparents, great-grandparents etc. Select about one-third of the audience to be bull elk. Explain that the male elk have large antlers— these antlers are used in the rutting season when the males battle for females. Usually, dominant males have the largest antlers. Explain that the group is going to participate in the evolution of the elk on the basis of this one characteristic, for simplicity. Give each of the bull elk a cut-out of an antler (you can simply use different length sticks if you want) and a recipe card. Measure the length of the antler and write it on the recipe card, i.e. 20 inches. Have the group compute the average length of antlers in the population, who has the largest set of antlers and the range (i.e. smallest number to largest number).

Now tell your population that something is going to happen to their environment. Humans are encroaching on the meadowlands that elk use for browsing and thus the elk are being forced into the forest. Additionally, the only forests that remain are those that have been aerially seeded and not thinned so that the trees are growing very closely together (you can probably make up a more realistic scenario than this!!). Have six or so non-bull elk people stand up very close together—say within one foot of each other. Tell your elk that in order to get to the rutting grounds —they must go through the forest. Have them try to get there. (You should have your antler measurements worked out so that only about 50% of the elk can get through - those with the smaller antlers, some elk may break off one antler to get through - this is all right) Have your audience compute the average number and range of the elk that manage to get through the forest. They will find that it is significantly smaller - and only those elk that make it to the rutting grounds to battle for a female can have offspring. Explain that if this happens over and over again, the genetic trait that will become dominant in the population will be small antlers. Eventually the elk may adapt behaviorally to this physical evolution - perhaps dominance will be expressed by something other than large antler size. Explain that this exercise was hypothetical and cite a real case if you can think of one. Darwin used the example of giraffes that may once have looked like horses. Because of environmental change, the trees browsed on by the giraffes gradually became taller (the trees of course were evolving to meet an environmental change of their own), as the trees became taller, those giraffes in the population with longer necks were more successful; they were strong enough to reproduce and eventually long-neck giraffes were dominant in the population and short neck giraffes could not survive.

Explain to the audience that what they have just participated in is a linear change within a species. Ask them what might happen if a population of elk in one park suddenly separated - perhaps a river was dammed and they couldn't swim across or perhaps a road went through the park that had a high fence alongside it. Explain that what sometimes happens is that a species is divided and forced to live in different environments. Each population adapts to their own environment. Since no interbreeding can occur, the populations may become sufficiently different over time that they can no longer interbreed—thus there are now two distinct species. This process is called speciation.

Extension and Evaluation:

After you have conducted the activity using your audience as the resource, ask them to apply what they have learned to what may happen if certain species in the park system were separated. Introduce the concept of Parks as genetic islands. Have the audience help you discover how isolation such that it may cause eventual speciation, may happen. Discuss whether the experts think that isolation, within the park setting, will result in a new species (probably not because the genetic stock is limited and coupled with inbreeding, there may be less genetic variability within the population and thus the species is less able to adapt to change). Discuss what can or does the NPS do to help — the transfer of genetic stock from park to park to ensure healthy animals.

Carlsbad Caverns National Park

John Roth

This program, *What The Fossils Tell Us*, was developed as a part of a workshop held at the Harper's Ferry Training Center in 1988. The program consists primarily of a 45-minute walk through the Scenic Room portion of Carlsbad Cavern. The objective of this program was to answer the question, "What causes biodiversity seen in the fossil record and how does this relate to the global mass extinctions presently occurring?" Excerpts from this program are included below.

A — Speciation

Isolation is the most important mechanism for creating new species. Small, isolated populations are most likely to undergo rapid change as new mutations are not as likely to be diluted as they would be in large populations. Divide the audience into two unequal size groups and use colored water to illustrate the dilution effect.

Explain about continental drift and relate the layers of the earth to the layers visible from within the cave. Talk about how continental drift was one of the first and definitely the most important causes for isolation of species and subsequently, speciation.

B — Extinction

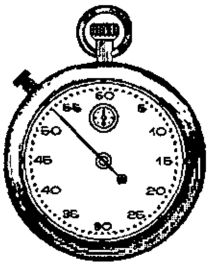
Global mass extinctions occur as isolated events perhaps every 31 or 33 million years.

The main causes of extinction are increasing and unpredictable environmental extremes (low or high temperature, nutrients, rainfall, carbon dioxide, etc.) may possibly be caused by:

- Increased period of mantle upwelling and carbon dioxide degassing. This causes frictional heat and effects the Earth's core and mantle. (Explain)
- Extraterrestrial impacts causing build-up of dust, blocking sunlight - theory of meteor showers and how they might have caused the end of the age of the dinosaurs (Explain.)

Current Mass Extinction

The average recovery time from past extinctions is ten million years but the present extinction rate is ten to a hundred times faster than past mass extinctions. Therefore, the world's biodiversity may never recover. National parks and other reserves of biodiversity need continued support because of natural and human-caused climate changes. For example, parks should have north-south and elevation variations so that organisms can migrate in response to climate change. Otherwise, extinctions will continue. It is ironic that at a geological time of great biodiversity, it is most endangered.



Impact of Consumer Behavior

Buyer Beware

By Pamela A. Wright — The Ohio State University

Audience: Family Groups
Duration: 20 minutes (part of a larger program)
Interpretive Technique: Activity and discussion; involves audience participation.
Park's Primary Resource: natural or recreational
Materials Needed: copies of inspector badges, safety pins, note pads and pencils, copies of brochures from Natural Resources Defense Council on plant trade and a brochure entitled "Entry Refused" from Traffic U.S.A. - World Wildlife Fund, samples of products made from endangered or threatened species - or slides of them
Program Objectives:

- Participants will be able to list at least two objects that are made from endangered or threatened species.
- Participants will be able to explain the concepts of supply and demand and how this effects endangered species.
- Participants will be able to answer questions about the different laws and conventions that govern the endangered species trade.
- Participants will be able to list what they can do to help stop the impact of consumer behavior on endangered species.

Program Description:

This program involves audience participation, particularly from children in the audience. Some parts of the program could be potentially embarrassing if you single out individuals; plan ahead and structure the activity so that the activity involves the entire group. Introduce your program by telling the audience that "in tonight's program we are going to examine the role that we as consumers play in maintaining our biological diversity." Ask for a few children to volunteer to be Wildlife Inspectors [kids between the ages of 8 -12 will probably be best]. Deputize your wildlife inspectors—by pinning on their badges. Ask your audience to help the wildlife inspectors *carry out their investigation.*

The first task will be to determine what things in the room - or surrounding environment, come from plants or animals. Have your investigators help discover these items. Make labels for these items (i.e. Wood) and have your deputies tape them on the objects when they find them. Try to get a diversity of items for example: wood chairs and tables - various trees, cotton clothing - cotton plants, paper - trees, wool clothing - sheep, rubber - rubber tree, etc. Talk about not only the range of diversity of the plants or animals from which these objects come, but also the sheer numbers of objects that we trace back to animals or plants.

Often in a park situation, your room and audience may be fairly homogeneous and your list be relatively small —if so, ask them to think about things that they might find back at their campsite or, at home.

Ask your young inspectors what happens if? — you run out of facial tissues at home, your jeans get too small, etc. The hopeful answer of course will be: we buy more, or another pair. Explain that this process is called demand. The more boxes of facial tissues or the jeans we buy, the more the company has to supply us with. For every x number of boxes of facial tissues or jeans, someone has to harvest another tree or grow another bale of cotton. As demand increases, supply normally increases.

Now, have your audience and inspectors think back to all those things that are around the home or park that come from plants or animals and see how many of them come from a species that is endangered (explain) or threatened (explain). Keep a list and see how many you get. For example: pearls from oysters, coats from endangered cats, medicines from plants, coral or ivory objects or jewelry, reptile products, i.e. shoes or briefcases, some liquors, tortoiseshell jewelry, combs, some food products, cosmetics made with turtle oil, feathers, etc. You probably won't get too many suggestions so have a list (or slides) prepared ahead of time. Thank your inspectors for their participation.

Tie the discussion together by relating back to the facial tissues example. Explain that the rarer something is (little supply), the more we want it (big demand) - use an example of gold - how rare it is, how valuable it is. Talk about the effect of this on an endangered species.

Spend some time talking about how the different laws and conventions are used to help control the fate of these species. Mention that these laws don't solve all the problems because people find ways around them.

- Endangered Species Act — prohibits the import and export of species listed as endangered and most species listed as threatened.
- The Lacey Act — prohibits the import of species that have been taken, possessed, transported, or sold in violation of foreign law. Many countries now completely ban or strictly limit wildlife trade.
- CITES — a comprehensive wildlife treaty signed by nearly 100 countries, including the United States, that regulates and in many cases prohibits commercial imports and exports of wild animal and plant species that are threatened or endangered by trade.
- The Marine Mammal Protection Act — prohibits the import of marine mammals and their parts and products. These species include whales, walruses, narwhals, seals, sea lions, sea otters, and polar bears.

Bring the discussion back to a park level and talk about endangered or threatened species (or possible candidates) in your park. You might want to use the wildflower and domestic plant brochures for this portion. National Parks have laws similar to those listed above to protect biological diversity, for example, collecting laws for wildflowers and other objects, no hunting laws etc.

Conclude this activity by discussing the importance of changing consumer behavior and demand for these products in order to preserve global biological diversity. Give an example such as the following: Until recently, marine mammals such as harp seals were killed to provide people all over the world with fur coats, boots, etc. As people became aware of the impact that the seal kills were having on the species, and the cruel way in which the harvest was conducted, they stopped demanding the products.

[Use this as a program in itself or use it as a portion of a larger program — a program on your parks endangered or threatened species. If you want another resource, the WWF Wildlife Trade Education Kit comes complete with a slide tape show and a variety of other resources]

Cuyahoga Valley National Recreation Area

Carol J. Spears

Cuyahoga Valley National Recreation Area (CUVA) has proposed a visitor center display designed to interpret illegal trade in wildlife and plants. This display is aimed at a mixed group of adults and children with little prior knowledge of the subject. The display's goal is *to educate visitors about the* critical problem of illegal trade in wildlife and plants, and its effects on natural populations. The display will encourage people to take responsibility for their own practices as resource consumers.

This display is proposed to be constructed at the park and will be composed primarily of text and accompanying specimens of wildlife or wildlife products confiscated by Port of Entry authorities, U.S. Fish and Wildlife Service. At CUVA, emphasis will be placed on confiscated migratory birds and endangered species. Facts will be presented objectively with a clear answer to the visitor's question of "What can I do about it?"

Brochures

Natural Resource Defense Council and Traffic (U.S.A.) World Wildlife Fund

The NRDC, in conjunction with World Wildlife Fund has developed two excellent brochures that can be used as supplementary resources for displays or programs on consumer impact on biological diversity. See the references section for listings on how to obtain these brochures.

"*Your House Plants Are . .. Part of the Plant Trade,*" is an eight-panel brochure designed to help people understand their impact on biological diversity. Topics addressed in this brochure include:

- a description and extent of the problem
- information on governing regulations such as the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES)
- technical information on how CITES works and problems encountered enforcing these regulations
- a "what you can do" section.

"*Wildflowers in the Garden*" is also an eight-panel brochure addressing topics such as;

- traditional sources of wildflowers
- hazards of wildflower collection
- impact of the trade and-problems encountered with wildflower transplants
- the status of legal protection
- a "what you can do" section.

Both brochures are printed on non-glossy paper and include attractive line drawings. In an interpretive sense, both are text heavy. However, they are excellent sources of additional information both for your use and for your visitor's education.

Integrated Development

Biological Diversity Trivia Game

By Kimberly Tassier — The Ohio State University

Audience: Family Groups
Duration: 30 minutes
Interpretive Technique: Game
Park's Primary Resource: All
Materials Needed: Large wooden block (6" dimensions) with dice markings painted on it. One copy of the game cards printed on heavy cardstock and laminated if possible. Large plant or animal markers - perhaps magazine cutouts that are backed on cardboard and also laminated. Masking tape. Game board—see directions at the end of the program.
Program Objectives:
- participants will be able to describe the concept of the Biosphere Reserve
- participants will be able to state at least one preservation and restoration activity that the park currently has underway

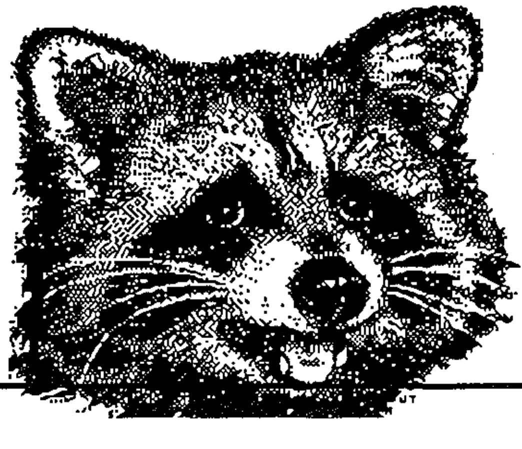
Program Description:

Adapted from: The Southern Appalachian Biosphere Reserve Game

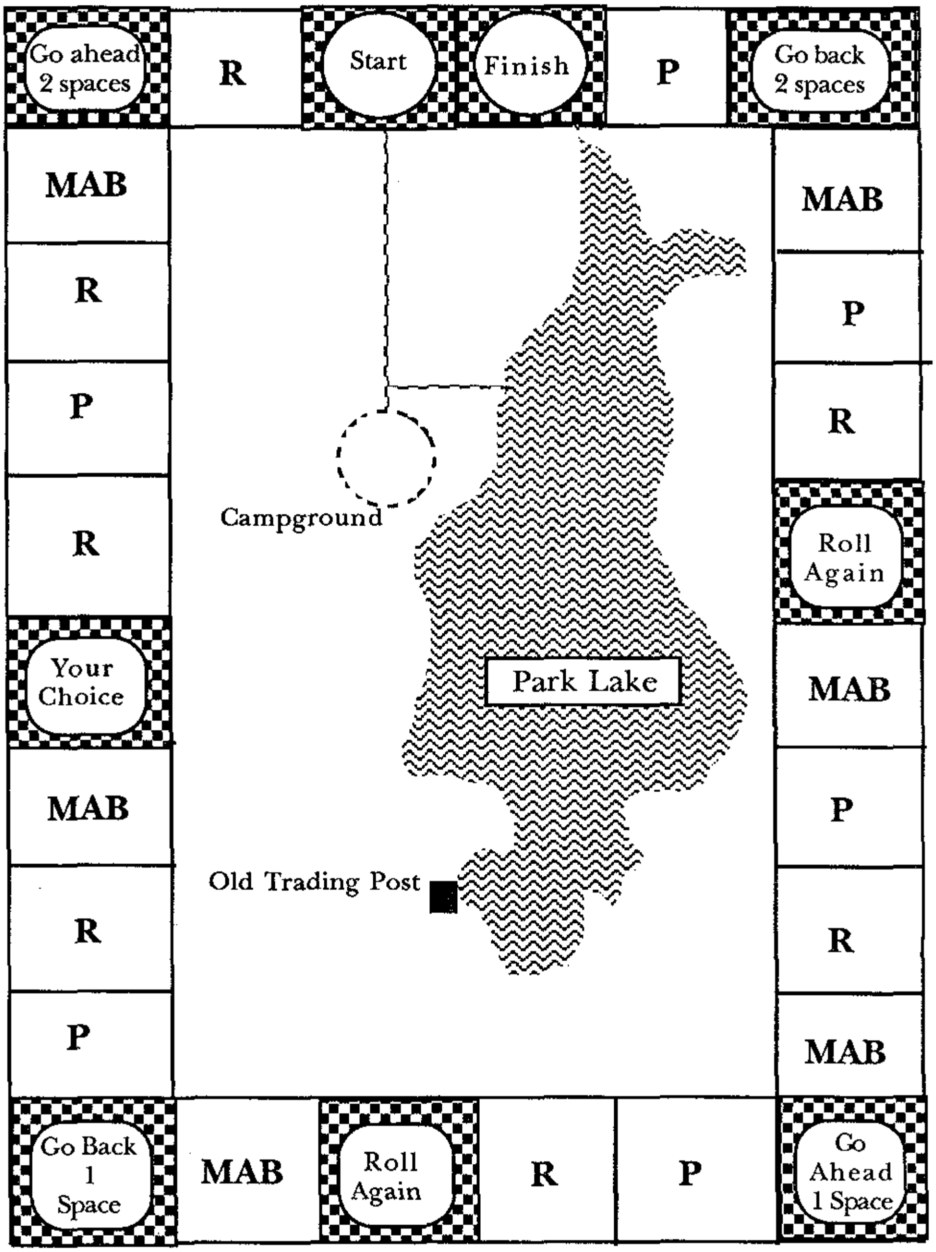
Use this program as an activity after a talk or slide presention on a related topic.

Divide your audience into two to four groups. For example, split the audience down the aisle. Each group should choose a gamepiece marker that you will move around the board. A small piece of rolled masking tape on the back of the playing pieces will allow you to easily move their them around the board.

Simply develop your own questions and answers (see examples provided) and glue the card sheets to construction paper. *Participants, or teams, should answer a* question from the category indicated by the square on which they land. When a player lands on a question square, the player from the opposite team should take a card from the top of the stack, and read the appropriate question. If the first team answers the question correctly, the team may take another turn. The question card should be placed at the bottom of the stack after one question has been read. Play continues until the first team reaches the FINISH square.



Game Board Directions:



Use a 1/4 inch, 4' by 4' piece of plywood or chipboard and draw your park boundary and any other significant features on it. For example, draw particular trails, camp-sites, historic sites, etc. Draw a second park boundary line, one inch away from the first one. Paint the area outside of the park boundary green. By using swirlwing brush strokes on a marine paint, you can make the area look like vegetation. Use large vinyl or letra-set letters and stenciled letters to make the playing area of the game as in the example shown. Have a start square —perhaps located near the park entrance and a finish square. In each of the other squares put one of the following letters: P for preservation, MAB for Man and the Biosphere and, R for restoration. Also designate a few squares with either spin again, go ahead or, go back 1 space. Use paints, photographs or drawings to decorate the inside of your game board. You may want to place small photographs or line drawings of specific features approximately near where they belong. When you are finished designing the board you may want to laminate or shellac it in order to protect it. When using the board— prop it up against a chair at the front of the group and make sure that it is at a height that everyone can see.

Example Cards

Restoration — Q. What kind of bird has been reintroduced in the Smokies BR? A. Peregrine falcon
Preservation — Q. What is an exclosure? A. An area surrounded by a fence to keep certain animals out. This is to show how the land and plants would look if certain animals were not there.
MAB — Q. What is the goal of MAB? A. To show that people and the environment can live in harmony with one another.

Restoration — Q. What killed the American chestnut trees? A. Chestnut blight.
Preservation — Q. What is the name of the ecosystem at the highest elevations in the Smokies BR? A. The spruce-fir ecosystem.
MAB — Q. What is the area of a biosphere reserve called where no changes can be made in the ecosystem? A. The core area.

Restoration — Q. What does "reintroduced" mean? A. Replanting animals or plants in areas where they had become extinct.
Preservation — Q. What is killing the Fraser fir trees? A. The balsam woolly aphid (or adelgid) an alien species.
MAB — Q. What has been one of the two major accomplishments of MAB? A. Setting up biogeographical regions and/or setting up biosphere reserves in the biogeographical regions.

Restoration — Q. What caused the most damage to natural lands in the Smokies biosphere reserve in the last century? A. Lumbering . . . over 60% of the forests in the area that is now the Smokies biosphere reserve was clear-cut.
Preservation — Q. What is species of trout that is native to the Smokies BR? A. Brook trout.
MAB — Q. MAB is a part of what organization? A. UNESCO (United National Educational, Scientific, and Cultural Organization)

Biological Diversity

Intensive Management of Select Species

Meet a Celebrity — Behind The Scenes

By Pamela A. Wright — The Ohio State University

Audience: Family Groups
Duration: 30 minutes
Interpretive Technique: Evening program with inter-active slide show and activity
Park's Primary Resource: Natural
Materials Needed: Slides or video footage, telemetry equipment and other appropriate tools, tape recorder.
Program Objectives: Program participants will be able to:

- site two reasons why certain species in National Parks are undergoing intensive management
- tell two things that the NPS is doing to manage species
- name one other species in another national park that is also the subject of intensive management.

Program Description:

This program centers around the recurring message element of a behind the scene interview with a celebrity. You can carry this celebrity analogy as far as you like for this program — you may even want to keep the identity of the guest species a complete mystery in the program advertisement and not reveal the celebrities name until after the program introduction.

Introduce your program by telling your audience that you were very fortunate in managing to get an exclusive, behind-the-scenes interview with a very important celebrity. This celebrity has been receiving a lot of attention lately and is very hard to find. Tell your audience that you are now going to show them some of the footage you took in your recent interview or/ perhaps you will actually interview the celebrity live. (The best way to do this interview is to have a previously written script that corresponds with slides or video footage. If you have a second interpreter available, they can respond to your question. If you do not have a second interpreter, pre-tape your guest's responses and press the play back button to hear the response once you have completed answering the question. Make sure you practice doing this so the breaks between the questions are smooth and in the correct order. Have someone record the responses for you in a voice that we might associate with the species i.e. a Gila Trout might have a bubbly voice while a bison might have a slow , deep voice. If you have the advantage of a second interpreter —you can make time for a question and answer period directly from the audience.

Use slides or video footage to illustrate the interview and try to cover the following points:

1. An introduction of the mystery guest. (Peregrine falcon)

2. Ask the guest to tell the audience a little bit about themselves (physical, behavioral and territorial description).

3. Ask the guest why they are such a celebrity (perhaps because they are an endangered species).

4. Have the guest tell the audience why they became endangered.

5. Ask the guest to tell who is giving them so much attention and what specifically they (resource managers) are doing.

6. Ask the guest why they are doing this (value of species, role in ecosystem, etc.)

7. Ask the guest what they see in their future (prognosis).

8. Have the guest tell the audience what they can do to help (activities, further programs they can participate in, reporting sightings, etc.).

9. Thank the guest and conclude the interview.

After the slide portion of the program, have the audience examine some of the tools of the intensive management of this species e.g., telemetry or hack boxes. Perhaps you can invite your park scientist or resource manager to come in and tell more about the management process.

Conclude the program by reminding the audience of why the NPS is involved in this management project and what they (the audience) can do. Explain that programs like this are happening all over the country in different parks. Use some examples from the fact sheet.

Adaptation for Children:

The following activity was adapted from an activity (Activity 8) designed as part of the environmental education curricula on biological diversity that was developed by the Minnesota Environmental Education Board through NPS Mid-West Region.

"Their Day"

Plan a program in honor of a species undergoing intensive management, e.g. reintroduction into the wild. The children must decide the following things and then have the celebration.

- what event is being celebrated
- what species is being honored
- how can this be made into a special occasion for the species in question
- how can this occasion be celebrated by people in an environmentally safe way
- what "present" might the children give to honor the species
- what could the children do to help others learn about and celebrate the day

Extension and Evaluation:

Develop a follow-up activity such as a hike and see how many people also participate in this activity. Use a Who Am I quiz, such as the one here to help people learn about other species in your park or in other parks that are also subject to intensive management. Perhaps you could provide resource information or a display where people could look up the correct answers or you could provide the correct answer as illustrated.

Quiz One

- This species eats prairie dogs
- Attempts to eradicate prairie dogs reduced the food source for this species.
- This species was thought to be extinct by the mid 1970s.
- Hope was renewed when one was found dead in 1981 in Wyoming.
- Intensive searching revealed 22 remaining.
- Telemetry, observation and captive breeding are now being used in the management of this species.
- Cooperation of ranchers is vital to success
- Wanted Alive posters for this species can be found in many wildlife magazines

Who Am I?

Black-footed Ferret

Quiz Two

- This is the state bird of Hawaii.
- All Hawaiian relatives to this bird are extinct.
- In 1950 there were 50 birds believed alive.
- Two captive breeding programs established in Hawaii and England have raised over 2,400 of the birds.
- About one-third of all birds released live due to habitat loss, alien competition and predation.
- Hawaii Volcanoes National Park is intensively managed for these birds by trapping predators and fencing the boundaries.

Who Am I?

Nene [Hawaiian Goose]

Great Smoky Mountains National Park

Kim Tassier

This program was designed for children and utilizes children's creativity in making simple masks and then acting out a play on the intensive management of select species: the peregrine falcon and the river otter.

Mask-Making: Using paper grocery bags, have each child make a mask (or hand puppet from lunch bags) representing one of the plants or animals in the food chains of the otter and falcon. Make sure that someone makes a ranger (representing a park resource manager), a hunter, a trapper and DDT. You will need bags, scissors, construction paper, glue, paste, and pipecleaners. Wearing these masks, the children will enact the following skit.

Script — The Story of the Peregrine Falcon and the River Otter in the Smokies.

(The children should act out their parts as the script is being read. This may take some doing at first! Use a large room with chairs and desks pushed aside, or use a large outdoor area. They should make themselves known when their character type is read by some appropriate movement or sound: growl, move wings, bubble, quack, jump, etc. Words in CAPITAL LETTERS denote these characters in the script.)

Narrator/Interpreter: A long time ago, before the pioneers came to our country, there were many more animals and plant here than there are now. (Enter plants and all animals.) Back then, they lived in nature as they were meant to live. The PLANTS grew green in the clean air and sunshine. The INSECTS hummed in the sunshine. The FISH swam happily in the streams. FROGS jumped in and out of the waters. The CRAYFISH moved slowly along the river and lake bottoms. DUCKS quacked from the sky. BLUE JAYS called from the trees. RIVER OTTERS played happily in the streams. PEREGRINE FALCONS flew quickly through the sky.

All of nature was healthy then — the ANIMALS could find enough to eat and there was plenty of land on which to live. There are not as many ANIMALS today as there were then. They do not have as much room to run, with all the cities and towns there are now. But nature still goes on. As they did long ago, PLANTS are still eaten by the INSECTS. FISH, FROGS, and CRAYFISH eat INSECTS. RIVER OTTERS eat FISH, FROGS and CRAYFISH. And, DUCKS eat PLANTS. BLUE JAYS eat INSECTS, and the PEREGRINE FALCONS eat DUCKS, BLUE JAYS and other birds. So these food chains work today as they did long ago. (Have the students line up as their food chain is read, with the plants at one end and the otters and falcons at the other end.)

Sometimes people can hurt all of nature — and the ANIMALS and PLANTS — without knowing it. FUR TRAPPERS caught too many OTTERS. There were no RIVER OTTERS left in the Great Smoky Mountains National Park Biosphere Reserve for 50 years.

Some HUNTERS killed too many PEREGRINE FALCONS and some took their eggs. There were fewer and fewer left in the Smokies. Then, a chemical called DDT was used to kill insects that hurt farmer's crops. But when the birds, like the BLUE JAYS, ate the INSECTS, they got DDT in them. Then the PEREGRINE FALCONS ate the BLUE JAYS, and they got the DDT in them! They did not die, but the DDT in them made their egg shells too soft, and the FALCON chicks died. So there were very few PEREGRINE FALCONS left in our country. And none left in the Smokies, ever since your grandparents were your age.

RIVER OTTERS and PEREGRINE FALCONS are endangered animals. They are in danger of becoming extinct — of all dying, all over the country. But some people are trying to save them from becoming extinct. And some people are helping them to come back to the Smokies!

The people in the Great Smoky Mountains National Park Biosphere Reserve — the RANGERS — have brought in OTTERS and PEREGRINE FALCONS from other places. Now they are protected in our park. There are lots of FISH and CRAYFISH and FROGS and DUCKS and BLUE JAYS and other birds for them to eat. And lots of streams for RIVER OTTERS to play in and lots of mountains for the PEREGRINE FALCONS to fly over.

HUNTING and TRAPPING are not allowed in the park (ranger tells hunter and trapper to leave) so that all the PLANTS and ANIMALS there are safe. And nature can be healthy once more in the Smokies.

Medically Important Species

Nature's Medicine Cabinet

By Kim A. Palmer — The Ohio State University

Audience: Adult and family groups
Duration: 25-30 minutes
Materials Needed: One piece of moldy bread and one blindfold
Interpretive Technique: Guided Walk
Program Objectives:

- The audience will be able to list at least three medically important species.
- The audience will be able to cite at least two threats to biological diversity.
- The audience will be able to list at least two ways they can help promote the preservation of biological diversity.

Program Description:

Carry the moldy piece of bread in a plastic bag in your backpack and at the appropriate time, after your introduction if using this as a complete program or at another appropriate point if using this as a program input, explain to the visitors that in your backpack is something that could save millions of lives. Have them gather around closer as you continue to drop subtle clues about this lifesaving item in you backpack, e.g., it's often taken for granted and is often thrown away by people everyday.

When everyone is within viewing distance, pull out the moldy bread. Comment that while this particular mold may not be Penicillin producing mold, it signifies the fact that things in the natural world that we often disregard can offer tremendous benefits to the medical world.

For example, the mold that was *Penicillium notatum* was found growing on bread. However, it didn't offer a very high yield so its true potential as an antibiotic wasn't realized until World War II. At that time, in a grocery store in Peoria, Illinois, growing on a cantaloupe, was the species *Penicillium chrysogenum* that has since saved millions of lives.

℞

Now ask the audience if anyone there has ever had a tooth pulled or been in a situation where they had to get a prescription for a pain killer. Tell them they can thank a poppy. A flower made it possible for them to be more comfortable through tooth extractions and other painful experiences. The opium poppy is the source codeine and morphine.

A third example is that over 3 million sufferers from heart disease depend upon a flower for their cardiovascular drugs. Digoxin, a cardiovascular drug, is made from Wooly Foxglove (*Digitalis lanata*). Without this plant, 3 million people would be out of luck and maybe out of life.

At one time or another, most of us have used some type of drug for an illness. Over half of all the prescription drugs in the United States contain substances from natural materials. That amounts to an $8 billion market domestically and a $40 billion dollar trade worldwide!! Even if drugs are made synthetically, they frequently use natural materials as "blue prints," making the number of drugs derived directly or indirectly from a natural material overwhelming.

Every day, new medical products are being developed from sources that are totally unexpected: who would have expected a treatment for children with acute leukemia would have come from a flower? Point to a flower on the trail or hold up a picture of a flower if no natural model is available. Flowers are saving lives.

The rosy periwinkle, a flower originally from Madagascar, contains valuable alkaloids and two of these alkaloids are vital in treating Hodgkin's disease and leukemia. Species we take for granted or never give a second thought may hold the key to valuable information. Now, this (point to common plant in park) that we are all standing on/ near may lead to a breakthrough in treating cancer, heart disease or even AIDS. We just don't know enough about the richness of our planet.

Sounds great, right? However, nature's medicine cabinet is disappearing before we can even know what is inside. The diversity of Earth's resources are being threatened. Every hour, two to three species become extinct. That's 48-72 species a day. As large tracts of tropical rainforest are cleared for development, grazing, etc., species that have not even been named yet, let alone studied for potential medical values, are lost... lost forever.

To demonstrate this, have a volunteer step near the center or front of the audience. Explain that he/she is going to be a medical researcher searching for a treatment for a disease that is devastating the population.

However, due to our current superficial knowledge of the Earth's biological diversity, the researcher has very limited capabilities. This can be represented by blindfolding the volunteer. (NOTE: obviously pick a volunteer who will be able to handle being blindfolded and stay near the blindfolded person at all times to assure his and her safety).

The remainder of the audience becomes species. Each person represents a species that could yield tremendous medical values, but they have not been discovered yet. Pick a small percentage of people to represent the species that would yield information for the disease the researcher is trying to cure. Indicate this by giving these people something to hold or wear (a pine cone or construction paper star). These valuable species should be randomly scattered throughout the group.

Slowly guide your blindfolded volunteer towards the mass of "undiscovered species" and point out that with this great amount of species, even being blindfolded, the researcher will have a relatively good chance of "discovering" a species.

But, now designate a large section of the audience as being decimated by some anthropogenic source, e.g., ozone damage, acid deposition, cleared for road building, etc. Instruct that group of people to move away a bit. Have a second group also be affected by an anthropogenic source, and then point out the probability of the researcher now finding a valuable species when the amount of available species has declined drastically. (Repeat the removal of species as many times as you feel necessary to get the point across).

Take the blindfold off the volunteer and reiterate the rate at which species are disappearing. Mention that the cure for Aunt Sophie's cancer or Uncle Jack's heart problem could be "getting the ax" right now. The penicillin that saved millions in WWII and continues to help people, was just sitting there, growing on a cantaloupe in Peoria, Illinois. So, any species anywhere may be medically valuable.

Biological diversity means much more than just penicillin and pain killers. It is the key to the stability of the Earth's ecological systems.

What does this all mean? Obviously we can not paralyze development with the fear of destroying a potentially medically valuable species. We can, however take a more responsible and sensible approach. One such approach is happening right now with the Man and the Biosphere Program (MAB).

The MAB program was initiated in 1971 to provide the knowledge, skills, and human values to support harmonious relationships between people and their environments throughout the world. A Biosphere Reserve is an international designation made by the United Nations Educational, Scientific and Cultural Organization (UNESCO) .

These reserves act as a keystone of MAB by providing a global network of sites for cooperative research and demonstrate the sustainable use goals of the United Nation's World Conservation Strategy. There are over 40 Biosphere reserves in the United States and 22 of these are managed by the National Park Service.

By participating in education programs such as this, everyone present is contributing to the preservation of biological diversity. The more aware they become of issues surrounding our natural resources, the better able they are to make appropriate and responsible decisions concerning their management and use.

We can all begin to make certain changes in our lifestyles as well. (Examples of actions: become involved in conservation groups such as Audubon Society, World Wildlife Fund or The Nature Conservancy; learn more about and get involved with the legislation concerning natural areas; conserve energy, recycle and learn more about corporations or products that contribute to habitat destruction or overharvesting and avoid their products.)

Reemphasize the interdependence of everyone of us with the earth's resources and remind the audience that along with that interdependence comes a responsibility from preserving biological diversity.

Evaluation:

Ask the audience to show examples of how biological diversity is threatened.

Ask the audience to list some ways in which they can contribute to preserving biological diversity.

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Durrel,L. 1986. State of the Ark. Doubleday.

Meyers, N. 1983. A Wealth of Wild Species, Storehouse for Human Welfare. Colorado: Westview Press

Oldfield, M.L. 1984. The Value of Conserving Genetic Resources. USDI/NPS.

Great Smoky Mountains National Park

Kimberly Tassier

Tell Me A Biodiversity Story

The following activity was designed as part of an environmental education series for classroom use. You could easily adapt this for any kind of interpretive audience.

Divide the class into pairs of students. Let each pair draw five (5) cards from the card deck. These cards contain descriptions of the past and present uses of plants and animals in the Southern Appalachians. After they have drawn the cards, they should brainstorm together to develop a story or scenario that includes all of the plants and animals listed on their cards. Have them work on their stories and then present them.

An example of a biodiversity story would be: A family lives in a PINE-wood house. For breakfast, they eat BLUEBERRY muffins on an OAK table. The youngest child becomes ill and is given tea made from SASSAFRAS roots. They wear clothes made from DEER skins.

Example Cards

Black walnut trees: beautiful dark brown wood that is used for furniture, fence rails and paneling.

Wild Gooseberry (shrub): reddish striped prickly berries used in jams, jellies and pies.

Sumac: Used as a medicine. Tea is made from the berries (or sumac lemonade —sumacade) to relieve tiredness and reduce fever.

Pennyroyal: used to rub on your face to keep insects away.

Wild Roses: the rose hips, are very rich in vitamin C and are made into rose hip tea, juice or soup.

Red Clover: tea is made from the flower to use as a "spring bracer" to relax a patient.

Catnip: tea made from the leaves is used to make people relax and go to sleep.

Yarrow: an all purpose medicine. Leaves on the brow cured headaches, and in the shoe would heal blisters.

Mayapple: roots are ground to make poultices to help heal sores.

Biological Diversity

Native vs Alien Species

Alien Invaders

By Pamela A. Wright — The Ohio State University

Audience: 1) Children 2) General Park Visitor Group

Duration: 1) One hour 2) Five minutes

Interpretive Techniques: A two part program involving 1) the development of a display or exhibit at a childrens program, and 2) the subsequent viewing of that exhibit by visitors to a display board in the park —i.e. in the visitor center or at an outside kiosk.

Park's Primary Resource: all types

Materials Needed: Construction paper, white drawing paper, crayons, pencils and watercolors, scissors, tape, thick markers, large light colored poster board, field guides and picture books, old newspapers, newspaper clippings from magazines like National Inquirer (optional).

Objectives:

- Designers and viewers of this exhibit will be able to distinguish the differences between a native and an alien species.
- Designers and viewers of this exhibit will be able to list at least two reasons why alien species may harm park environments.
- Designers and viewers will be able to describe at least one alien species in your park.
- Designers and viewers will learn what they can do to help control the spread of alien species.

Program Description:

This two-part program is designed as a technique to help interpret the biological diversity story of native versus alien species to both children and adults. By using the artwork of children, which is an acceptable casual display, you can enhance your park's communication of the biodiversity story. Run a children's program (say ages 8 to 12), on alien invaders. Using a combination of storytelling and artwork, the children will develop the bulk of the exhibit. You can put the remainder of the exhibit together after the program and display it on a bulletin board or in a kiosk. Remember that although it will be casual, it will be acceptable because it is the work of children.

Once the children are gathered at the program, read them a short children's story about aliens— the usual ones such as E.T. You may find a children's story at your local library or you may be able to create a brief one. Ask the children to help you describe what aliens look like: What kind of vehicles they travel in, etc. Now ask — how many of you have seen aliens in X National Park?

Tell them that about the alien invaders we find in our national parks; provide them with a photograph or picture of these and tell a little story about what an alien is, and what damage it causes in your park. Provide them with drawing paper and crayons or paints and have half of them draw a picture of an alien or an alien spaceship while the other half draw a picture of an alien species in your park.

For the children drawing aliens in our National Parks, give them some directions or ideas about what might go in a picture for example a pig, trampling on some plants or digging up a mud hole. Have prepared on poster board titles that say, in marker or another medium, 'What Is An Alien," 'Alien Problems, ' and 'What Can We Do?' Have the children help you think of ideas for each of these categories and then have some of the older children write them on the posters. When the children are done their drawings and have helped you fill in the text on the poster board, let them know that what they have done is help you make a display to teach adults about alien invaders in our national parks.

Let them know where the display will be and when it will be put up (this will also help you make sure you get the display completed if you know you have all these eager eyes waiting to see the finished product). Conclude the program by going on a walk to look for alien invaders or playing a game.

To complete the exhibit - follow these ideas. You may decide to have as many of these as possible completed prior to the children's program and add on their drawings and comments as soon as they have finished them.

Make a title, perhaps cut out of colored construction paper letters that says "Alien Invaders - Sighted in [Your] National Park."

Mount the children's artwork on different colors of construction paper— to frame it.

Make captions, either handwritten on the bottom of pictures or typed and enlarged, for the bottom of the pictures drawn by the second group of kids. An example caption might say, "Feral pigs tramp native grasses and the Nene (Hawaiian geese) go hungry."

Make sure you include a credit page somewhere in the exhibit. For example: "completed by the children of Yellowstone," and include all their names.

You may want other captions and other graphics - see those suggested in the example layout.

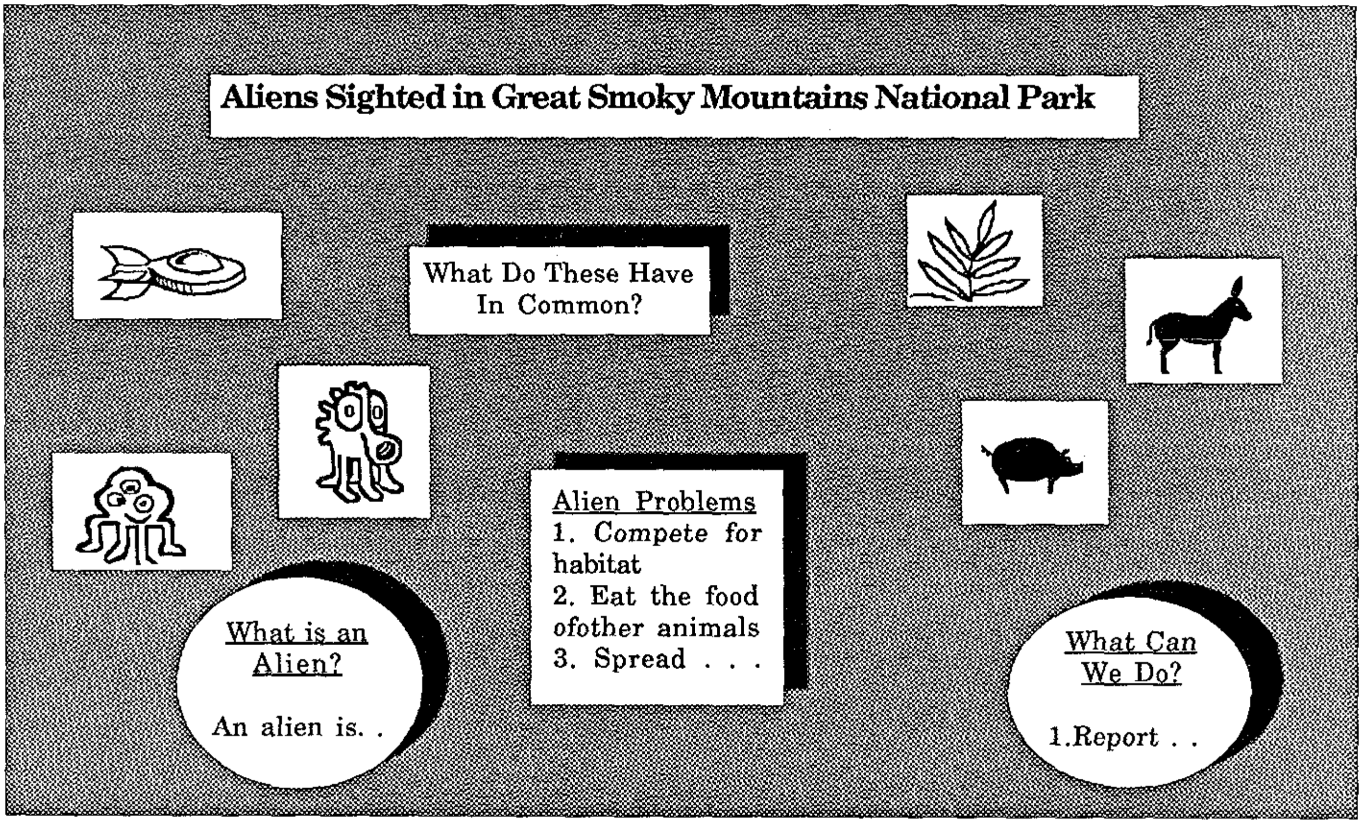
Finally, don't forget to include a space for advertising-related programs about natives versus alien species, or post a copy of a supplementary brochure that your park may have available with directions on how to get copies.

Suggested Evaluation:

Evaluate the success of the display by recording the number of people who spend time at the exhibit, and the amount of time spent at the exhibit, the number of people who ask about advertised programs or supplementary brochures listed on the exhibit. Evaluate the success of the exhibit design portion of the program by determining how effectively the children (relative to their age) portray in their drawings the information that you have told them.

References:

Fact Sheet: Alien Invaders
Field Guides
Studies of alien or exotic plants in your park or region
Children's books on outer space or aliens from your local library



Cuyahoga Valley National Recreation Area

Carol J. Spears

Cuyahoga has suggested a program entitled "The Aliens Among Us" that combines both guided hike and storytelling in a program for mixed adults and young people. The theme of the program is natural biodiversity is threatened by alien species."

Use your storytelling talents to weave a tale of stability in a community of naturally competing plants and animals and the non-living components of the ecosystem. Then introduce the alien(s) — plants or animals. Your story can then follow several scenarios of what may happen when a natural ecosystem is disturbed by the introduction of a species. Unfold the story at appropriate stops. Try and finish at an area where the visitors can witness the effects of alien species. Bring field guides or photos to help visitors. Discuss NPS policy on alien species management and discuss the park's resource management plan of action for alien species.

At Cuyahoga Valley, this program focuses on the gypsy moth. The gypsy moth traps set out by interpreters are used as a stop on the hike.

Restoration of Ecosystems

X Marks The Plot — Prairie Restoration

By Pamela A. Wright — The Ohio State University

Audience: Primarily adults
Duration: 2 hours
Interpretive Technique: Guided Walk and Activity
Park's Primary Resource: Cultural or Historical
Materials Needed: Knapsack with field guides, yard-sticks, sets of 4 stakes (tent pegs will do), ball of string, clipboards, pencils and paper
Program Objectives:
- participants will be able to describe at least two factors that may have led to the disruption of the natural ecosystem
- participants will be able to explain why the restoration of these ecosystems is important to the local environment, the park, and global biological diversity
- participants will be able to list three things that resource managers need to consider prior to undertaking a restoration project
- participants will be able to demonstrate how to establish a plot
- participants will be able to list three techniques used in prairie restoration

Program Description:

This program can be adapted for any ecosystem. For this example, a cultural/ historical resource site with a prairie environment has been used.

This program is activity-oriented. It need not involve any particular physical labor however, so most audience members could participate. Although it was designed as an 'adult' centered program, children could easily participate if given some guidance. The program has three components, and is designed to take place at least partially in the out-of-doors. If you plan ahead it could be easily adapted to an indoor program. Either of the last two components could be dropped if you are faced with time or resource limitations; in this case you may want to have a follow-up program another day.

Component One — The first section of the program is designed to equip your participants with the knowledge and skills necessary to participate in the remainder of the program. You may choose to conduct this program in an indoor auditorium or in a comfortable outdoor setting. Introduce your audience to your program and to the park and prairie resource. Using a United States map, slides, photographs or drawings explain the differences between short grass, mixed and tall grass prairies and highlight your park's prairie type. Explain the relationship between the cultural and historical resource of your site and the prairie environment and discuss how, through time, the prairie environment has changed. Highlight some of the reasons for this change (e.g., over grazing, introduced species, over harvesting, differing land management techniques, loss of keystone species). Introduce the concept of biological diversity and using questioning, have the audience help you determine why the restoration of the park's ecosystem is desirable.

Component Two — Select a nearby area that has yet to be restored. If this is not possible on park land, ask the permission of a nearby landowner or construct a simulated area in an open space or large room. Survey your site in advance and collect information on the species, soils and possible management activities necessary for restoration prior to the program. You will need to provide resources for the answers to these questions. If the answers are already identified in books or plans, bring them in and mark the pages. If not, obtain the answers and provide them on a typewritten sheet of paper. If you want to stress the research component of this activity, provide the answers for each question (or a clue) on single sheets of paper. Let your teams know that you have the answers in your backpack research library but before you give all the information to them, they have to formulate the correct questions. Depending on the size of your group, you may need to divide into several teams; make sure you have plenty of equipment.

Explain to your group that before a restoration project is undertaken, the resource manager needs to have the answers to some questions. For example, what is the present situation, what species were actually native to the area (and what varieties of those species), is there adequate habitat and food still present for the restored species, what management activities are needed to restore the ecosystem and to maintain it, and will permission need to be obtained from anyone outside the park system, i.e. if the plan calls for the reintroduction of a keystone species such as a wolf, is the political climate favorable to this, what about surrounding land owners attitudes? Explain that the group's task will be to identify a number of assessment plots and to carry out an evaluation of each plot to obtain answers to the questions above. Let them know that you have all the equipment and the literature necessary to help out and that you will be the resource librarian. Each team should construct their plot and work through the work sheet. When they need an answer they should come to the resource librarian and they will get help in finding the answer. If there is information that you need but you can't obtain, use a best-guess answer. Clearly identify that this answer is just a "Guess" but that it can be used for the purposes of the exercise. After your groups have worked through their plot sheets (you should place a time limit on this part), bring them back together and compare the two or more plots. If there are significant differences between them, ask your audience how the resource managers might determine how much of each kind of different mini-biome there is. Managers may choose to treat each environment individually, or they may use aerial photographs or topographical maps to estimate how much of each type of environment there is. Help your participants work through a discussion of the management activities that are necessary to restore their plot or a larger similar environment. Proceed to step three.

Component Three — If your park has a managed restoration plot take a short guided walk through this area. If the area is not accessible, or your park does not yet have a restoration area, use a restoration plan for your park and help your audience visualize what it may look like someday. As you take your real, or imaginary, walk through your restoration plot, have the participants help you identify the particular processes that occurred in the plot's development or subsequently occured in its management. If your park has a volunteer or cooperating association that helps in plot restoration or management, indicate how your audience might become involved in these activities. Conclude by reiterating the importance of restoration to the ecosystem, the park and global biological diversity.

Plots - Explain the principle of a plot. In most cases it is not possible to carry out a complete inventory of the entire park ecosystem, so the resource managers and scientists, using a variety of techniques (including plots) sample a variety of different environments. Try and select two different plot sites; these sites should be close enough to each other so that you can be easily accessible to both groups. Plots are constructed by measuring off a one-yard area — place a stake in each corner of the plot and tie a string boundary around the stakes. You may wish to further break down your plot by putting string grids across it but this is not necessary.

Suggested Evaluation:

After demonstrating the skills that are needed to assess the plot, have each team use the work sheets, plotting materials, field guides and other support materials you have provided for them to determine the fate of their plot. After they have finished, and the entire group has tallied their results, they are to prepare a management plan. By observing their behavior, and assisting them with their decisions, you will be able to determine the degree to which they achieved the desired objectives.

References:

Fact Sheet — Restoration of Ecosystems

Tallgrass Prairie Brochure — Pipestone National Monument, Pipestone, Minnesota

Manasek, Robert (letter and photo) Scotts Bluff National Monument — Gering, Nebraska

X MARKS THE PLOT - PRAIRIE RESTORATION
DATA SHEET (example)

Plot Location_______________________
General Description____________________

	1	2	3	4	5	6	7	8	9	10
Species										
Frequency										
Introduced Sp.										
Native Sp.										
Habitat										
Restoration										
Management										

(This example data sheet asks participants to identify what species now occur in the plot, the frequency with which they occur, e.g., they cover 20% of the plot, whether they are an introduced or native species. If the plant is an introduced species have the participants identify what native species would normally have filled that niche, and whether there is adequate habitat still,i.e., has the soil type changed or management of the land, how could the proper species be restored, what management process will be need to maintain it, prescribed burns, control of non-native plants, etc. This form is only an example, you will be in a better position to design one that suits your environment and the kind of information you think is appropriate to gather.)

Yosemite National Park

Vicki Jo Lawson

A series of interpretive elements were designed to interpret the restoration of meadows in Yosemite National Park. These meadows have been subjected to a great deal of human manipulation and impact during the last century. As a result, meadow size and species diversity have been reduced. Two biodiversity connections are recognized: ecosystem diversity is threatened because meadows provide the basis of many food chains, and species diversity is threatened because Yosemite meadows contain 36% of the park's total plant species on just 3.5% of the park's land. The strategy to interpret this restoration includes signage, a park newspaper article and a prepared slide show. Drafts of one sign and the newspaper article are included.

Press Release — Meadow Restoration

This October you are likely to see more than pocket gophers digging in Yosemite Valley's meadows. As part of a major meadow restoration project, the Yosemite Fund, backed by Chevron USA, Inc., will begin to restore acres of trampled vegetation and miles of "volunteer trails" to healthy meadow land.

The donation will fund two, eleven-person crews from the San Francisco Conservation Corps to work in Stoneman and Ahwahnee Meadows. The crews will be eliminating all but essential trails in and around these meadows. Restoration techniques will be experimental, including: loosening of compacted soils on "volunteer trails" to encourage receptivity to natural seeding; transplanting of sod and bushes; removal of exotic species such as thistle, mullein, and Klamath weed; removal of encroaching small pine and cedar trees; and redefining of retained trails to channel hikers.

In 1866, the California Geologic Survey mapped 745 acres of meadows in Yosemite Valley. Today we are left with only 390 acres. Due to natural successional changes, as well as human manipulation of the environment, these meadows are becoming drier and smaller. Human-induced changes include removal of a portion of a glacial moraine dam near Bridalveil Fall, long-time suppression of natural fires, grazing of domestic animals, planting of exotic species, and unrestricted camping and traveling. Although these types of human influences are no longer permitted, their impacts are long-term.

To restore natural meadow processes in an area visited by three million people annually is no small task. Visitors to Yosemite can help restore healthy meadows by using only established trails, avoiding wet meadow areas, respecting imposed barriers, and biking only on paved surfaces. With the help of the Yosemite Fund, Chevron USA, Inc., the San Francisco Conservation Corps, and each park visitor, these meadows will be reminiscent of the healthy meadows first mapped in 1866.

Photo caption: Maze of volunteer trails to be revegetated in Stoneman Meadow, Yosemite Valley.

Yosemite National Park

Meadow Restoration Area

Due to human impact, this area has been included in Yosemit National Park's revegetation program. You can help th restoration process:

- Stay on maintained trails
- Avoid fragile wet areas
- Keep bicycles on paved surfaces

Careless people trample vegetation and destroy wildlif habitat.

Watch your step.

This project is made possible through the Yosemite Fund and a grant from Chevron USA, Inc. in cooperation with the Nation Park Service and the San Francisco Conservation Corps.

Additional Biological Diversity Programs

Participants at the NPS training workshop, Critical Resource Issues for Interpreters, worked on developing park specific interpretive programs. The following information is provided for those of you who may wish to follow up on some of these biodiversity ideas that are being worked on by fellow communicators.

Endangered Species "Th..Th..Th..That's All Folks" [Activity] Big Thicket National Preserve — Sardie Hand

Sandspits Here today, gone tomorrow? [Site Bulletin] Apostle Islands — Diane M. Chalfant

Native & Alien Species A Panther's Tale [Story Telling] Everglades National Park — Isobel Kalafarski

Threatened Ecosystem Coastal Sage Scrub of California [Audio Visual Program] Cabrillo National Monument — Edmond Roberts

Restoration [Slide Presentation] Jamaica Bay Wildlife Refuge, Gateway National Recreation Area — Cathy Cika

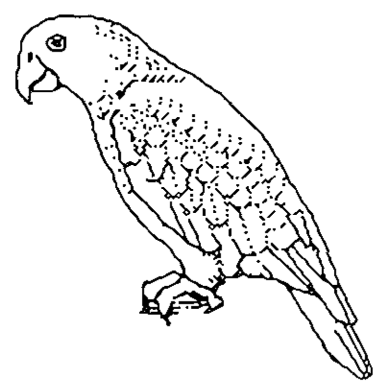
Praire Restoration [Slide Presentation] George Washington Carver National Monument — Bill Norton

Preservation of Native Hawaiian Plants Love The Land (Aloha 'Aina) [Slide Presentation] Puukohola Heiau National Historic Site — Daniel Kawaiaea.

Habitat Loss and Global Ecosystems No Place to Land [Video Tape] Guly Islands — G. Isishgs

Grazing Impact Grazing at Fossil Butte Monument [Display Panels] Fossil Butte Monument — Andrew E. Banta

Alien Species Mangrove Menace [Sign] Kaloko Honokohau National Historical Park — Francis Kuailani



Habitat for Endangered Species [Signs] Golden Gate National Recreation Area — Dan Sealy

Loss of Habitat [Video Tape] Gateway NRA, Sandy Hook Unit — Randy Turner

Prairie Dogs & Ferret Restoration [Portable Exhibit] Badlands National Park — Valerie J. Naylor

Exotic Pest Plants [Poster/Flyer] Rock Creek Park — Clark A. Dixon, Jr.

Restoration Behind the Scenery at Floyd Bennett Field [Slide Program] Jamaica Bay District Gateway National Recreation Area — Christopher Stein

Biological Diversity General [Slide Program] Golden Gate National Recreation Area — Colleen Collins

Exotic Species [Training Videotape] Virgin Islands — Chuck Weikert

Wetlands and Island Biodiversity [Slide Presentation] Cumberland Island NS — Karen Taylor-Goodrich

Isle Royale National Park

Barbara Nelson-Jameson

Using technology and expertise available within park staff, Isle Royale is attempting a video production on "The Effects of Acid Precipitation on Biological Diversity." This program is designed for the general park visitor and it is aimed not only at interpreting biological diversity, but also at the research and monitoring programs going on within national parks and the entire MAB program.

The proposed video begins with a general introduction of biological diversity and acid deposition. Background music is integrated with a combination of slides transferred to video and actual video footage taken within the park. The bulk of the program includes exerpts from an interview conducted with a park researcher, Dr. Robert Stottlemyer. The interpreter designing the video has structured this part of the program by providing a brief introduction to a topic or point and then splicing in quoted text and video footage from the researcher.

Although many of us may feel challenged in producing such a piece of work, it is probably a lot easier than you think. Find someone on your staff who is an experienced home videographer or practice yourself. Consult your local film developer about slide to video transfer. Map out your program plan just like with any other program and follow your shooting schedule. The nice thing about video is that you can see instant results of the footage you just shot and if home-done, it can be incredibly inexpensive.

While you can do your own splicing of footage simply by using two VCR machines, you may want to get a professional to help you with this part. First order all the segments that you want to be spliced, noting the recording numbers of the start and finish of each segment. Then do a rough splicing job to iron out all the glitches and to provide a road map for the final product. Inquire about the best way to add in background music and voice overs.

Biological Diversity: It Makes All The Difference In The World

Sample text and suggested slides

By Carol J. Spears

SLIDES

City neighborhood with people
Farm scene— people, farm animals
Cabin in mountains
Close-up, city wildlife/plants
Close-up, farm animals/plants
Close-up, mountain animals/ plants
Artsy shot of a scene from Yellowstone

Lake with multi-species of waterfowl — people on shore

Person with monarch on hand

Graphic: BioDiversity
- Species
- Genetic
- Ecosystem

Spring scene from Smoky's lush greenery

Algae - covered rock in stream

Redwood tree

bird munching insect

people in produce department of grocery store
insect eating leaves of tree

shot filled with different kinds of insects

house cat
bullfrog in pond
robin in city lawn in rain
grizzly in Denali
timber wolves
douglas fir from Crater Lake
lilac in bloom
foggy scene at Olympic looking out into ocean

MUSIC: suggest one clear wind instrument, e.g. flute. 5 SECONDS CONTINUE MUSIC 10 SECONDS FADE OUT AS NARRATION BEGINS

Whether you live in the city, country, or mountain wilderness, you share the world with an incredible variety of different life forms. This array of living things and the communities in which it survives is called biological diversity. The very existence of our world depends on biological diversity. Even though many people feel this variety of life is the greatest natural resource of our earth, it is in great peril of disappearing.

Does it really make any difference whether the human species is alone or one of many species on the planet? Answer that question for yourself, after taking a glimpse into: Biological Diversity: It Makes All The Difference In The World... .

Biological diversity is a scientific term for the most elegantly common phenomenon around us—life, in all its many forms. The astounding variety of life can be categorized into three levels of diversity: species, genetic, and ecosystem. Let's first explore the most obvious kind of biological diversity—species diversity, which means different kinds of plants, animals, and microbial life.

Wherever you are in the out-of-doors, whether it's in your own backyard or in a national park, what color overwhelms all others? Green. The many different shades of green found in vegetation make our planet a living one, for it is the green pigment that allows plants to be the cornerstone of all other life forms. Thousands of different kinds of green plants, from one-celled algae to the towering majesty of the largest living things, the redwood trees, use sunlight and the green pigment chlorophyll to manufacture food for themselves. This dizzying array of plants, in turn, is the source of food for all other life on the planet, from shiny, tiny insects to swift-flying birds, to grocery-shopping humans.

And what an assortment of wildlife is busily changing plant fiber into animal tissue. There may be millions of different kinds of insects alone. The number of species of all plants and animals living on earth now is a puzzle, though the estimates are mind-boggling. Scientists think there may be up to 30 million. Think about how many you can name. There are cats, dogs, horses, bullfrogs, black widow spiders, houseflies, robins, bald eagles, grizzly bears, timber wolves, sugar maples, Douglas firs, roses, lilacs.... You could name quite a few—but can you imagine 30 million different kinds of living things? And about ninety percent of these 30 million beings sharing our planet have never even been studied or identified by scientists or given an official name. This great treasury of unknown species is one of the greatest mysteries of science.

underwater scene with multi-species of marine fish Bald eagle perched close-up of Bald eagle bill	Where on earth did all this variety come from? Over the hundreds of millions of years that life has graced this planet, animals and plants have been competing for energy, food, and secure space. This competition for survival has led to increased specialization in natural life forms, with every species slightly different from the next. For example, let's look at two kinds of birds that make their living in very different ways: the bald eagle and the smaller, but flashier, northern cardinal.
Bald eagle soaring Cardinal perched close-up cardinal bill cardinal flying	The bald eagle eats other animals, either by catching them or by feeding on a carcass. It possesses an extremely strong bill that is curved at the tip which helps to tear flesh into bite-sized morsels. Bald eagles are large birds. Their size enables them to attack and carry away food. Long, broad wings allow them to soar high in the air to scout large territories. Now for the cardinal. The cardinal feeds mostly on nuts and seeds. Take a look at its bill. How thick and stout it is–perfect for cracking open shells to get into the nutritious seeds. Cardinals are birds of the forest and fields. Short wings enable them to move easily amongst crowds of trees.
	These differences enable each of these species to survive, and they show us the importance of the species component of biological diversity. But outward differences in species are just hints of an even greater variety inside. And it's what's inside that counts in the long run.
Drawing: horse with cell, nucleus, chromosomes superimposed Drawing: chromosome enlarged showing gene segments Drawing: Illustration of evolutionary line	Deep within the cells of living beings are the microscopic genes. It is these tiny genetic storehouses of information that make red birds with thick bills a different species from soaring birds with strong, curved bills. In the genes are the cumulative products of all the evolutionary adaptations of the ancestors of that life form to the variety of changes that have taken place over millions of years on Earth. And those genes are what guarantee life in the future, for they will enable species to react to changes yet to come.
two horses, each with cell, nucleus, chromosomes superimposed as above same as above, each horse's gene segments shown in different colors	Genes are like the blueprints of life. Some plants and animals have up to 400,000 different genes. All individuals of a species have the same number and types of genes that define them as members of that species. But gene types also occur in tremendous variety within a species. If imagining 30 million different species was hard, think about thousands of individuals of each of those 30 million species, each individual with thousands, maybe hundreds of thousands, of different genes. This staggering genetic diversity represents an irreplaceable biological wealth beyond our imagination.
marsh habitat rain hitting vegetation storm clouds earth cut away to expose soil marsh habitat with great-blue heron great blue heron eating a fish tropical forest of Hawaii Volcanoes	Let's leave the tiny insides of life and move into the larger picture of ecosystems. In ecosystem diversity we step from the world of only the living to include the non-living components of the Earth–air, water, weather, climate, sunlight, minerals, and temperature and moisture of soil. Ecosystems gain their identity from the unique combination of living and non-living. A natural ecosystem is a study of exquisite equilibrium at any moment in time, but also one that is dynamic, changing with time. Within an ecosystem lives a community of animals and plants, each with fascinating adaptations thousands, sometimes millions, of years in the making and each fitting into intricately balanced relationships with its fellow organisms.

coral reef community
array of marine fish
Acadia coast
Shenandoah forest
Olympic old-growth forest
wetland
prairie
Saguaro cactus

Every region of our planet sports a different complex of ecosystems. Some examples include: tropical forests, least known and may hold more than fifty percent of all the Earth's species; coral reefs, some of the most productive areas on the planet; oceans, with creatures that dazzle the mind; coastal zones, where land and sea meet; temperate deciduous forests; old-growth forests; wetlands; prairies, flowing in broad sweeps of grasses and wildflowers; and deserts, whose plants and animals boast amazing adaptations for survival in spite of a scarcity of the planet's most precious commodity—water.

four-image slide: tropical, forest, prairie, desert, coast

The more diverse our earth's ecosystems, the more diverse are the animals and plants that populate the planet. Whereas genes are the blueprints of species, ecosystems are the architects, for it is here that events and conditions occur that eventually result in new species.

Series of 4 image slides

- Marsh in upper left, rest blank

- add water flowing into marsh in upper right

- add heron in lower left

-add heron eating fish in lower right

- all same, black over lower right

-all four images in slide

But is it so essential that there be birds with different bills and wings, with different feeding strategies? What good is this diversity? Each species lives in a specific type of ecosystem. An ecosystem is the particular medley of the living and non-living things in an area. You could think of an ecosystem as a theatrical stage. The non-living components are the scenery and props, the living beings are the actors, and the essence of each actor's character is its genetic makeup. The interaction of actors with one another and the scenery compose the play. If one character drops out of a performance, the other actors' lines and the overall story of the play do not make sense, and may even totally break down. The same is true in a natural system. Each species is an actor who plays out a unique role in its ecosystem, the stage, with help from the non-living components, the props and scenery. Each functional role supports the other, and together they make up the entire complex system. Even if an animal or plant is rare, it carries out a vital function in its ecosystem. Remember the old theatre adage, "There's no such thing as a small part." Many scientists believe that ecosystems with more diversity of plants and animals are actually more stable, and more likely to withstand changes that may occur in the future.

people in suburban environment
- T.V.'s in department shore
- aisles in grocery store
- clothing sotre
- stockpiles of coal
- cars on freeway
- people listening to radios
- medicines on pharmacy shelf
- cats sitting in window

person eating cereal

What does all this mean to you? What does it mean to human society? How do we fit into the explosive variety of life on earth? Certainly we are a part of the biological diversity of the planet. But we are not only a part of it, we are also the primary consumers of biological diversity. Modern society is built on the resources and knowledge gained from sharing the earth: products for human use; food to sustain us; fibers to clothe us; energy sources for manufacture, transportation, and living pleasure; irreplaceable medicines to heal and comfort us; even the pets that add such joy to our lives.

large cornfields

drought-impacted cornfield

What did you have for breakfast today? Chances are, you enjoyed a wholesome bowl of cereal made from one of a handful of grain crops cultivated in our modern world, such as, wheat, corn, rye, or oats. The natural ancestors of the grain you ate this morning once grew wild in the great grassland ecosystems of ancient earth. For thousands of years, people have been domesticating these few grains. The human cultures that first tamed the growth of corn have passed into history, but their food stuffs live on in our society. Now, the majority of the world's human population survives on these specialized grains and the few other cultivated foods passed on to us. But what would happen to our food supplies if

Aerial view of African grasslands

environmental changes or disease bring about conditions that our current crops cannot survive? Years of drought or global warming from the greenhouse effect, disease, or insects could mean serious disruptions in how we obtain our food. If, instead, we cultivate a diversity of natural crops in mixed fields, our nation's farms will stand a better chance of producing the needed food, even in times of adverse conditions.

Person shaking empty cereal box into empty bowl

two aspirins in palm of someone's hand

But where will the diversity of crops come from? Growing uncultivated in the fragmented grasslands stretching across the earth are plants that may help us survive such changes in the future. They'll help because of the genetic diversity found in the natural crops. Are these plants even now being threatened by human-caused destruction? The generations that follow us may depend on the storehouse of wild food crops we leave to them. What will that storehouse contain? Will there be a reliable source of cereal grains 36,000 mornings--a mere 100 years--from now?

person paying pharmacist

experiment set up in shuttle — from NASA

Forest ecosystem

Have you taken an aspirin lately? Perhaps you have had surgery with anesthesia, or taken anti-cancer drugs. Fifty percent of all the medicines taken in the United States, including aspirin, anesthesia, and many anti-cancer drugs, are made from substances originating in our natural world. Americans spend billions of dollars each year to purchase cures found in medicines whose active ingredients come from plants. Many of these medicines have been used by humans for thousands of years. Now these ancient remedies are accompanying us into the space age. Natural substances have been taken aboard the space shuttles for experimenting with how to make them even better suited to heal our ills. Yet, with so many areas of the earth unexplored for sources of medicinal drugs, and many of these areas fast disappearing, what are we losing? Substances to help us fight AIDS? New treatments for crippling diseases of the mind and body?

And possibly most important, functioning ecosystems, the great associations of plants and animals that comprise the natural diversity of the world, hold within them the precious secrets of survival on our Earth.

Children holding their breaths

From the combined workings of each species in the complex ecosystems come clean air, fertile soil, nutrient recycling, stable global weather patterns, and replenished water sources. These are services and benefits that we cannot duplicate. Without them, our quality of life cannot be sustained and options for future generations would be limited.

Close-up of surface of tree leaves

Everglades with lots of bird life

For example, take a deep breath. As you inhale, your lungs fill with a mixture of mostly oxygen and nitrogen. The wild forests that garnish our continents in patches and girdle the tropical earth do more than shimmer green and silver in the wind. As a consequence of their own life processes, they cleanse the air, remove substances poisonous to animals, and shower the biosphere with life-giving oxygen.

drawing of glacial age

If we are surrounded with all these bountiful life forms, too numerous for us to even count, what is the problem? The peril is, in the last two hundred years, the living diversity of our planet has been dying away at a rate seldom experienced since life first began its tenuous existence four billion years ago. A quick trip back in time will give us an idea of why.

drawing of dinosaurs dying birds and mammals in same habitat as background for above	Many times over the past hundreds of millions of years, the living, breathing profusion of life has experienced great natural environmental changes and shifts that have resulted in occasional mass extinctions, or losses, of species. In the past, the changes that caused extinctions have usually taken millions of years to happen, though there have been events of catastrophic, sudden extinctions of animals. While some species slowly died out, others slowly took their functional roles in the ecosystem. As if an understudy moved in to take on the part of an ousted actor. Scientists think that an average of one or two species was lost each year through extinction in the long millions of years of history of our planet.
listing of species known to have become extinct in the last 200 years: to five a feeling of numbers, not to be read in detail	But in the last two hundred years, the rate of extinction has increased sharply. By the year 2000, the extinction rate is expected to be about four hundred times the normal rate. That means we are losing species much faster than normal evolution can replace them. There just is not enough time for the understudies waiting in the wings to learn new parts. And, for the first time, it is not just animals that are undergoing mass extinctions. Plants are disappearing, also. And whole communities–ecosystems–are being irrevocably changed or lost. With the disappearance of all these unique life forms of animals and plants and ecosystems, goes the depletion of our precious treasury of biological diversity and all its benefits, without our ever even knowing some of these species and assemblages.
Drawing of readily recognizable extinct species e.g. dodo, dinosaur - Black background, white outline of above with drawing of chromosomes on it - same as above without chromosomes -stack of books of Shakespeare's poems/plays on desk -same scene no books	What is it that cannot be reproduced once it steps into the oblivion of extinction? It is the unique identity of genes that dictates what makes a cardinal a cardinal and a bald eagle a bald eagle. When the last combination of the particular genes that define a species vanishes, it will never exist again. There remain animals or plants that are similar, but not the same. It is like losing all of the masterworks of the gifted playwright and poet, William Shakespeare. The words of which they were crafted still exist, but the particular arrangement that had created such beauty and perfect form is lost forever.
Ghandi, outdoor scene if possible -dense housing -highway system -large city -large expanse of farm fields -smokestack emission -effluent into river -landfill -large clearcut -sheep or cows in overgrazed field -coal strip mine -confiscated illegal trade in wildlife items	What has caused such a dramatic increase in diversity loss? For the answer we must take a hard look at ourselves. As the great philosopher of India, Mahatma Gandhi, said, "Earth provides enough to satisfy every man's need, but not for every man's greed." Our modern human societies have slipped away from living with the other creatures of the Earth, like an actor in a play who constantly is trying to upstage all the other players. Accelerated destruction of natural habitats to make room for houses, roads, and cities for human societies steadily increasing in numbers; conversion of natural, diverse ecosystems into vast agricultural fields; pollution of the planet's air, water and land; irresponsible logging, overgrazing, mining, and exploitation of wildlife and other natural resources have made life on Earth unliveable for many wild animals and plants.
- natural scene including wildlife - people birdwatching - Chief Seattle portrait -horses running through meadow	All of the life-sustaining current and future benefits of biological diversity eventually will be lost to humans and the Earth's other remaining residents if these trends continue. Many people feel that sharing the Earth with other life forms is a tremendous benefit by itself. These animals and plants are a part of the Earth community, just as we are, and have a right to exist, just as we do. We humans gain a richness of wonder and excitement from living among them. Can you imagine what kind of

-children playing with dogs

NPS/DOI symbols

green forests of Isle Royale

green forests at Congaree

mountain shot of Smokys

Wildlflowers at Smoky

long-shot of Mt. Rainier

Crater Lake — old growth forest

Redwood grove

I'iwi in Ohi'a tree in
Hawaii Volcanoes

Glacier — mountains and
alpine meadows

-Yellowstone — Falls at
Grand Canyon of Yellowstone
-Elk browsing in burned area
-woodpecker on tree in burned
area
- regrowth beginning in
burned area

-Mt. McKinley, moose
in foreground
- Glacier Bay, with whales
- tundra, mountains
-Big Bend, with javelina
-Organ pipe cactus
-Joshua Tree
-Everglades, coastal zone
-Padre Island, Ridley sea turtle
on beach
-Channel Islands
-Wind Cave, prairie
-New River
-Mammoth Cave
-Lake Mead

-collage of agency signs
(FS, F&W, Nature
Conservancy, private arboretum)
-researchers at a park; e.g.
air quality at Isle Royale

Earth we would have without its incredible diversity of life? Over a hundred years ago Chief Seattle, from the Dwamish tribe of native Americans, spoke these words that seem fit for today's world, "If all the beasts were gone, we would die from a great loneliness of spirit...All things are connected. Whatever befalls the earth befalls the children of the earth." For all these benefits, do you think saving the natural diversity of our planet is worth it?

Preserving land and wilderness areas and a variety of ecosystems within the many sites of the National Park System helps to save a small portion of the natural diversity of our country. Within the national parks are examples of our biological diversity heritage. Journeying through the parks, you can experience the spectrum of life across our country.

Explore the cool, green forests of the east and midwest, with their noisy, chattering wildlife, at parks such as Isle Royale and Congaree Swamp. Great Smoky Mountains National Park sprawls across the Appalachian highlands and is perhaps the world's finest example of a temperate deciduous forest. Its diversity is best seen in the over 1400 different kinds of flowering plants that help to give the park its fabled beauty. On the other side of the continent, in the Pacific Northwest, visit Mt Rainier, Olympic, and Crater Lake National Parks, and step into stately old-growth forests, with patchy sunlight silvering the understory. Move southward and discover Redwood, Sequoia-Kings Canyon and Yosemite National Parks, which will captivate you with their ancient, massive trees. How can any living thing be so big? The endangered tropical forests of Hawaii Volcanoes and Haleakala National Parks are the last refuge for rare, startlingly beautiful bird life.

Along the country's midsection, visit the Rocky Mountain wilderness at Glacier, Rocky Mountain, and Yellowstone National Parks. Yellowstone is the largest intact wild ecosystem remaining in the temperate zone of the Earth, and will thrill you with its variety. The forest fires of 1988 will increase the natural diversity of Yellowstone. The fires helped to open new areas for grazing and browsing wildlife, cleared the forest floor of dead-wood fuel that had piled up from years of fire suppression, hastened the recycling of essential nutrients through the system, and provided heat needed to open seed cones of certain conifer tree species.

In the great land of Alaska, discover the enormous heaving of the Earth that gave rise to Mt. McKinley at Denali, the world of blue ice and gray seas at Glacier Bay, and sweeping expanses of mountainous, windswept tundra at Gates of the Arctic. In the Southwest are a variety of delightful deserts in Big Bend, Organ Pipe Cactus, and Joshua Tree. The deserts may surprise you with their enchanting nature. Add to this collection the coastal wetlands, marine areas, islands, prairies, rivers, caves, and lakes in the National Park System, and you have a representation of the differences of life that combine to make such beauty on the planet.

National parks are preserved and protected from development, though pollution and other environmental threats from outside the parks can have an effect on the life within them. But the lands of the National Park System represent only a small fraction of our natural heritage. The Forest Service, U. S. Fish and Wildlife Service, and many other state, private,

wolf with wolf biologist	public, and international agencies also preserve examples of our natural diversity across our country and around the world. The National Park Service and other agencies are actively involved in intensive research on biological diversity and in attempts to restore damaged ecosystems and restore wild species to natural areas where they once thrived.
Capitol building in Washington car pooling several products, e.g. fur coats, rare species as pets, hamburgers, styrofoam products	What may you do to help protect the essential variety of your world? It will take a willingness to think along the lines of long-term benefits. In addition to encouraging the preservation of lands, you may support state and federal legislation for clean air and water, support sustainable use of natural resources, practice energy conservation, and learn which products you buy result in species exploitation and ecosystem destruction. You may also share with friends and family your understanding of the importance of biological diversity.
- night with stars - earth from space - mushroom - fish and underwater plants - damselfly on vegetation - salamander - human picnicing - sun sparkling on water in city park	It is wonderfully fanciful to turn our eyes into the black and silver night sky and wonder, "Can there be living things across the galaxy?" The only planet known to have life, Earth, is a vision of stunning beauty, though we often take for granted the life that abounds around us. A variety of glorious life, that, for all its differences, shares the identical, basic life-giving elements, the same genetic code systems, even the same percentage of salt water in our veins. Our world, Earth, is one of the rarest and most precious in the Universe, because it has life.
-misty shot of thick, green forest, perhaps from Olympic — aura of mystery -family enjoying picnic in a national park — wildlife in the shot	The Earth has shaped us, sustained us, extracted from our evolutionary ancestors what we are today. And our entire existence is intricately dependent on the plants and animals that live here with us: thirty million plant and animal species and their genetic wonders sharing the resources of our planet and forming the delicate, ecosystem networks that keep life functioning.
close up of a toddler in a meadow reaching for flowers	And what about the original question? Does it matter if the human species is alone on the earth or one of many? Can the planet's biological diversity be preserved? The answer is up to all of us.
Series of six slides from the park site at which the program is being shown - 5 seconds each to illustrate its biological diversity (generic servicewide shots may be provided to some parks upon request)	MUSIC FADE UP UNDER NARRATION MUSIC UP TO FULL VOLUME

6.0 Park Plan

Planning Your Biological Diversity Program

By Gary W. Mullins — The Ohio State University

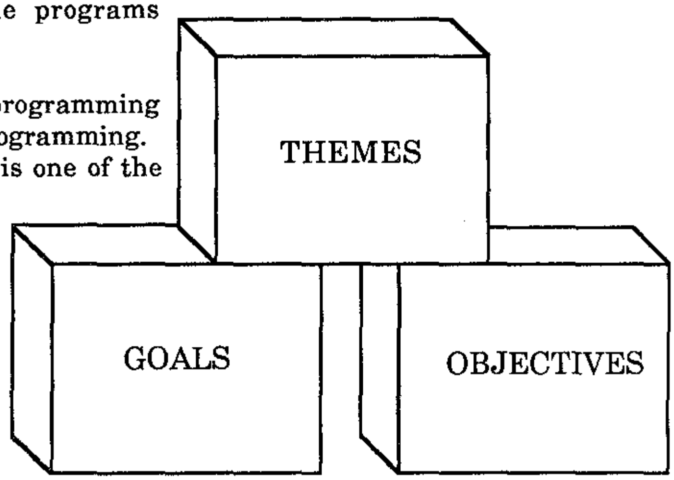
Introduction

Biological Diversity, the interpretive initiative beginning in 1989, has perhaps as many meanings as there are National Parks Service areas. A broad national program has been established by the Biological Diversity Interpretative Initiative Task Group. Different regions are actively pursing their individual programs. Overall though it is what will occur on-site at individual parks that will determine the effectiveness of the National Park Service in contributing to the maintenance of biological diversity through educational, interpretive and public awareness programming.

Each park is unique and the Service's resources are diverse; therein lies the value of the National Park System. Each park, using its own themes, goals and objectives as a guide, can address the biological diversity interpretive initiative in a manner deemed most appropriate by that park's staff. No one prescription can be offered to set forth the program each park should follow.

On the other hand, there are commonalities that each park should draw upon. Perhaps foremost is a training plan that ensures all communicators have a sound grasp of the topic, understand the problems associated with misinformation or incomplete information and have an action plan that encourages the protection and maintenance of biological diversity without sounding as an alarmist. Next is the communication plan. The plan begins with a clear understanding of the park's themes, goals, and objectives. Specific biological diversity interpretive objectives are then constructed as subsets of overall programming objectives. These objectives serve to both direct the programming and provide a basis for evaluation of the programs.

Objectives are then translated into messages, which are matched with the various media that are in turn matched to target audiences. This matching forms an action plan. In the action plan are listings of allocation of personnel, resources, money and time. Last but not least is an evaluation strategy for the programs themselves.



The inclusion of biological diversity interpretive programming should complement, not compete with, existing programming. Given that the maintenance of biological diversity is one of the management strategies for maintaining healthy ecosystems, all National Park Service areas can and should become involved.

Excerpts from two park plans are provided as examples of individual park efforts. One is from Golden Gate National Recreation Area and the other from Shenandoah National Park. Following the parks' action plans is a summary of the Pacific

Northwest Region's proposed action plan for interpreting biological diversity.

Golden Gate National Recreation Area Biological Diversity Program

The Golden Gate National Recreation Area (GGNRA) plan is an action oriented plan. The following materials were excepted from that plan:

Objectives:

- Increase the public knowledge about biological diversity as a whole, and of the biological diversity of GGNRA in specific.
- Communicate the National Park Service history and role in preserving biological diversity issues.
- Gain public support for natural resource projects.

Communications Points and Objectives:

1. To inform the public that there are native ecosystems
When Portola and other early explorers arrived in 1742 they saw an assemblage of plants and animals that are considered native to this area. Many explorers were botanists and biologists who documented these organisms in the mid-1700s.

2. To explain what biological diversity is
When you sit by a stream with lush of vegetation and insects purring and birds singing you are in a biologically diverse community. It consists of the number of different native species in a habitat or the variety of different habitats in an area.

3. To teach the value native biological diversity
It took thousands of years of evolution to create a balance between the native plants and the wildlife that depend on them. Biological diversity currently contributes many direct and indirect benefits to humanity including material resources, ecological services, scientific values and intrinsic values.

4. To communicate that biological diversity losses are occurring
Urbanization, hunting, fire suppression, introduction of plants and animals from other areas, grazing, and over use by visitors have drastically changed the natural biological diversity.

5. To alert the public to the ramifications of this change
Landscapes, plants and animal species are becoming extinct at an alarming rate throughout the world.

6. To give examples of these problems
   - The grizzly bear on our state flag is extinct in the state; it once roamed the Bay area.
   - Extinct species once found in the GGNRA include: San Francisco popcorn flower, *Xerxes* blue butterfly, laurel hill manzanita.
   - Pampas grass is, at this moment, invading habitat for two butterflies found only several places in the world.
   - Muir Woods is now threatened with an extreme fire hazard due to a 100-year build up of fuels surrounding the woods.

• Due to our urbanization, os serpentine slopes, the Raven's manzanita is reduced to only one plant left in the world.
• The California coastal prairie is reduced to small patches due to grazing impacts and the introduction of exotic grasses.

7. To state that a natural balance can be restored
Successful restoration projects have occurred in GGNRA and throughout the Bay area. In GGNRA, Peregrine falcons are released, a Raven's manzanita propagation program has a successful beginning and habitat is being increased for two endangered butterflies.

8. To communicate NPS history and role in preserving diversity
National Park Service policy clearly states our mission as one of preservation. Exceptions must be legislated by Congress.

9. What we need from the public
• Support the park in programs of exotic plant removal, prescribed fire, restoration of native plant and animal communities.
• Tell a friend about the importance of biological diversity.
• Volunteer to help in the "Habitat Renewal" program.

10. What we need to do
• Build a campaign around national action plan for biological diversity.
• Write articles for local magazines.
• Provide training for all park interpreters and all park partner interpreters.
• Incorporate the biological diversity program into all interpretive activities.
• Create a traveling exhibit to promote natural diversity.
• Create a site bulletin for the whole park.
• Create a slide program and have an active outreach program. Our interpretive rangers will deliver at least two programs to the community during the year using the prepared slide and video programs.
• Complete a poster promoting habitat conservation.
• Produce a public service announcement for local use.
• Develop a volunteer group with "Habitat Renewal" as a focus.
• Hold a press conference to announce the biosphere reserve designation and the effort promoting biological diversity.

Timeline for the 1989 Biological Diversity Program

Date	Action
August 15 1988	Decided on additional Park's Association interpretive efforts.
September 1988	Choose designer for habitat poster. Approach Headlands Institute about hosting a public seminar on Bio-diversity.
October 1988	Send memo regarding the program and the responsibilities for "Fact Sheet" development.Begin detail for the program.Begin planning training program.
November, 1988	Purchase Smithsonian poster display or research other

	exhibit. Begin "Habitat Renewal" Volunteer program. Solicit articles for January. Make decision on Biological Diversity poster.
December, 1988	Contact Ames Research.
February, 1989	Staff Training. Biosphere Reserve designation celebration and kick off press conference. Integrate biological diversity into interpretive programs. Begin facts sheets.
February, 1989	Site Bulletin completed and distributed. Distribute national brochure.
March, 1989	Slide program completed. Distribute national interpreters manual.
April, 1989	Begin outreach program. Begin special emphasis activities. Public Service Announcement released. National slide repository available.

Action Plan

Biological Diversity Campaign: All the program ideas fit into the context of the national emphasis on biological diversity. Many of the following ideas are recommended in the initiative plan entitle "Interpreting Biological Diversity In The National Parks" (1988). Additional items are marked with an "*." These are parts of the program that are specific to GGNRA.

<u>I. National Park Service Staff Training</u>

* A. The Branch of Interpretation together with the Natural Resources staff and the Marine Sanctuary will develop a one day staff training to be given twice so that all staff members who want to participate will be able to attend.

* • Experts in the Bay Area that are not directly associated with the park will be requested to speak. This will give the program the spark needed to attract all staff members.
* • All park partners will be requested to attend the training. It is imperative that we incorporate them into the program even if a special training session is required.
* • The program will begin in early February 1989. February will be the kick off for the program in this park. It permits us the time necessary to develop teaching materials and plan programs.
* • The program taught includes the goal of having every interpretive program that occurs in this park to include the message of biologic diversity.

* B. "Fact Sheets" will go to all park staff each month. Each month a different aspect of the natural diversity of the park will be emphasized. A tentative list of ideas follow:

- Greenhouse and plant restoration
- Pig: an alien species problem
- Predators in the park
- Alien plants
- Raptors
- Streams and water
- Rare and endangered plants
- Erosion effects on biological diversity

- Butterflies
- Fire and Biological Diversity
- Birds other than raptors
- Reptiles
- Marine mammals

II. Interpretive Materials In Development

A. An NPS Communicator's Handbook for Biological Diver sity is being developed for the national program. It will be distributed throughout the park and used in program development.

B. A foldout brochure is being prepared for national distribution. More brochures should be ordered by the park if at all available.

C. A slide repository will be available.

D. Purchase and distribute a set of the Smithsonian Institution "Diversity Endangered" poster exhibit is proposed.

*E. A poster will be created to promote natural diversity through native habitats with an emphasis on plants.

*F. Traveling exhibit researched and developed.

III. Interpretive Materials For Development

*A. A detail will be created for FY89 for an interpretive specialist to assist with the program. Duties will include:

*1. The development of a site bulletin to be created for use by the park. The subject, of course, will be the biological diversity of GGNRA.

*2. Creation of a synchronized slide program which will be applicable to the whole park. This program will be duplicated for each district and an outreach program will be initiated.

*3. Coordination of other aspects noted in this program.

*4. Interpretation of natural diversity and outreach.

*5. Research and develop traveling exhibit.

*B. Production a public service announcement for local use.

C. Develop any additional interpretive materials for GGNPA.

IV. Park Interpretive Activities

A. Interpreters will integrate activities into their standard operations that interpret natural diversity. Guided walks and talks will include the topic.

B. The possibility of a seminar will be discussed with the Headlands Institute.

C. Any environmental education curricula and activities develo ped by the national committee will be given to our environmental education permittees.

D. Our Volunteer in Parks program will be included in the interpretive effort (staff coordinating volunteers). A new group of volunteers will form in order to begin "Habitat Renewal".

E. Community outreach program will be planned by the park staff. Each staff member with interpretive responsibilities will present two outreach programs to the community.

V. External Educational Activities
A. Newspapers, magazines, radio and television writers and producers will beassisted in producing articles and presenta tions on biological diversity issues in the park. The idea of a press conference will be explored.
B. Contact Ames Research Center, Moffett Field, to inquire if they would participate in the effort.
C. Special emphasis activities in local schools and community groups will be explored. These could include essay contests on biological diversity issues or artwork to be displayed in the visitor centers.
E. Biosphere designation celebration with kick off press conference for the first year of the "Interpreting Biological Diversity" focus.
(Developed by the staff of Golden Gate National Recreation Area.)

Shenandoah National Park Biological Diversity Plan

This proposed plan was excerpted from Napier Shelton's proposed plan for Shenandoah National Park.

This sourcebook defines biological diversity, provides background on the biological diversity initiative, discusses messages to convey to the public and presents a number of ideas for interpreting biological diversity. This plan also lists information sources and slides available in NPS. Because loss of biological diversity is a major concern that will be with us indefinitely, it is recommended that the park equip itself with slides and other materials necessary to interpret this subject indefinitely.

Definition of Biological Diversity:

Biological diversity refers to the variety among and within living organisms and the ecological systems in which they occur. It encompasses biomes, ecosystems, communities, species, populations, genetics, and supportive life processes.

Background of the Biological Diversity Initiative:

Because of the concern about the loss of global and North American biological diversity, National Park Service (NPS) Director Mott instructed the Service to initiate an intensive research and public awareness campaign regarding this issue.

Steps Taken To Date Include:

- Convening of an Interpretive Task Group on Biological Diversity in September 1986 to review the NPS role in protecting biological diversity.
- A symposium on this subject in May 1988 out of which an NPS plan, including research and other activities, will be developed.
- Development of an NPS interpretive initiative plan in April 1988.

Messages To Get Across To The Public:

- What is biological diversity?
- Why visitors should be concerned about biological diversity.
- Importance and value of biological diversity; the great losses now occurring.
- The role of national parks in general, and Shenandoah NP in particular, in conserving biological diversity.

Interpreting The Subject:

Three special characteristics of this subject that affect its interpretation come to mind. One is its relative abstractness. You cannot see biological diversity; you can only see plants and animals. Therefore it might be a good idea to start with individual plants and animals and relate them to biological diversity issues; e.g., through endangered, rare, or economically valuable species in the park.

Another characteristic is the global nature of this issue. We are not losing much if anything in Shenandoah National Park, and the loss of biological diversity nationwide is small compared with losses in the tropics. Furthermore, there are certain links of Shenandoah, such as migrant birds, with what is happening elsewhere in the world. Therefore the global aspects of biological diversity issues should be brought in whenever they can be related to the park.

A third aspect of the subject is that diversity is the ultimate resource we are concerned about: the earth's total gene pool. If genes are lost, presumably the genetic engineers cannot recreate them. I have barely mentioned genetic diversity in the talks and walks I have suggested, probably because you can see plants and animals and natural communities, but you can't see genes (in the field). Thought should be given, however, to ways of talking about genetic diversity to the visiting public.

Various ideas for interpreting biological diversity in Shenandoah follow, along with suggested slides for evening programs and information sources available in the park. (Lack of time prevented me from addressing exhibits, site bulletins, and other media.) These ideas are meant only to stimulate thought. Every interpreter will of course have his/her own ideas about these things and ways of expressing them.

Materials Developed:

As part of the Shenandoah National Park Biological Diversity Plan the following items were developed:

- "Shenandoah—A Reservoir of Life" (a slide program message)
- "Gypsy Moth & Chestnuts" (a slide program message)
- "What is a Tree Worth?" (a slide program message)
- "Guarding the Lite of Shenandoah" (a slide program message)
- "Protecting Endangered Species" (a slide program message)
- "Shenandoah's Tropical Connection" (a slide program message)
- "National Park—Preserving the World's Biological Diversity" (a slide program)
- The plan offers interpreters seven other program ideas with a brief explanation.
- "Values of Plants" (a guided walk)
- "Gypsy Moths & Chestnuts" (a guided walk)

- "What is a Tree Worth?" (a guided walk)
- A list of 22 various topics & their relationship to biological diversity is outlined in the plan.
- A check list of Shenandoah summer birds, & their wintering grounds. (Developed by Napier Shelton August 1988)

Pacific Northwest Regional Plan

The Pacific Northwest Regional Office (PNRO) has prepared a Draft Action Plan (Scott Shane, Jan. 1989), which outlines that region's biological diversity initiative. Shane, as regional initiative coordinator, participating in the Mather Training Center course, "Critical Resource Issues for Interpreters" (Jan. 9-13, 1989), and as part of that course outlined a series of proposed activities to ensure that the initiative is coordinated between the regional office and regional parks. Included in the plan are descriptions of:

- objectives
- key people involved
- distribution of interpretive materials
- methods of region-wide implementation —(workshops, regional task group, discussion groups, field seminars, prototype programs, review/audit time schedules, distribution of materials, newsletter, media presentation, coordination with state curriculum people and volunteer program)

This plan establishes a realistic agenda for action.

Conclusions

The two sets of park plans and the regional summary shared here are only examples. Many other parks and regions are actively planning for the implementation of the biological diversity initiative. Each unit should choose its own course of action, taking into consideration the service-wide goals of the NPS initiative and world-wide problems associated with protecting biological diversity.

Preparation of fact sheets and development of program sheets for your individual park are easy steps in getting involved. Clipping articles from newspapers and magazines relating to park specific issues is another method. By binding these into the handbook, future park staff as well as the current staff will have a ready reference on biological diversity as it relates to your park.

These plans summarized herein and the suggestions made are not cast in concrete but are targets to work towards. If the loss of biological diversity can be accepted as a real critical resource issue, and if plans are followed by commitment, our biological diversity efforts may yield results. The challenge is before us.

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This book is a comprehensive reference of objective information and data on the state of the environment and the earth's natural resources. Numerous figures and tables are included.

II. Curriculum Materials

Biological Sciences Curriculum Study (BSCS)

BSCS is an educational research and development institution whose goal is the advancement of science literacy and education in the life sciences. The organization develops a variety of materials for teachers and students of all grade levels including textbooks, laboratory manuals, subject modules, and films. The following selected list represents available teachers' guides and activities:

Biological Science: An Ecological Approach

This updated edition uses articles by prominent naturalists and scientists to examine the impact of human life on ecosystems. For high school and adult students.

Camouflaged Critters

This exercise is designed for grades K-3. Camouflage is important for the survival of animals in their natural habitat. In this exercise, students define and create camouflage and develop an understanding of animals' interaction with their environment and the need to protect nature.

BSCS is developing a new high school module with activities and case studies on genetic technology that may be an appropriate reference for teachers interested in biological and genetic diversity.

For more information, contact Biological Sciences Curriculum Study (BSCS), The Colorado College, Colorado Springs, Colorado 80903, telephone (303) 473-2233

Biologues

Biologues is a series of fact sheets on endangered species from the U.S. Fish and Wildlife Service. They are free to teachers and club leaders.

For more information, write U.S. Fish and Wildlife Service, Attn: Publications Dept., 18th & C Streets, NW, Washington, DC 20240.

Carolina Biological Supply Company

Environmental preservation and ecological concepts can be taught with kits. The kits from Carolina Biological Supply Company deal with air and water pollution and acid rain and include materials and teachers' manuals. For high school students.

Carolina Biological Supply Co. has a board game called Endangered Species (Advanced), as well as endangered species rummy cards.

For more information, write Carolina Biological Supply Co., 2700 York Rd., Burlington, NC 27215.

Center for Environmental Education
"A Nation of Oceans." (1980) Describes marine ecosystems and conservation efforts for secondary grades.
"Sea Turtles & Shrimp Trawlers." (1986) Background facts about the effect of fishing on sea turtles.
"The Ocean-Consider the Connection." (1985) Activities for elementary school-age students include word games, art projects, experiments, and information.

Center for Environmental Education, 624 9th St., Washington D.C. 20001.

Conservation Learning Activities in Science and Social Studies (The CLASS Project)
This series of environmental education investigations is designed for grades 6-9. The exercises help students develop the knowledge and basic skills needed to carry out a community environmental preservation project. The goals of the activities are to protect and enhance the natural environment. Background information for teachers, a list of community action projects, and instructions for getting started are provided.

For more information, contact Jack Greene, Director, Education Programs, Laural Ridge Education Center, 8925 Leesburg Pike, Vienna, Virginia 22180.

Defenders of Wildlife
Defenders of Wildlife has sets of 10 endangered species fact sheets and posters of endangered animals. Each poster features a different animal on each side.

For more information, write Defenders of Wildlife, 1244 19th St., NW, Washington, DC 20036.

Delta Education, Inc.
This set of 100 activities for grades 3-9, the Outdoor Biology Instructional Strategy (OBIS) offers a wide variety of hands-on experiences in outdoor biology. The exercises are designed for an urban environment and reveal that nature can be discovered in a black-topped schoolyard or in weedy vacant lots. The OBIS program is intended for groups and leaders without extensive training in biology and has been appreciated by scout troops and biology classes alike. Activities are available in modules according to age level and group size and are packaged in easy-to-carry folders. An OBIS sampler module is available as is a catalog of other Delta publications.

For more information, contact Delta Education, Inc., Box M, Nashua, NH 03061

Dial Books for Young Readers
The Living World of Jungles. (1984) A picture book for elementary students about the tropical forests.

For more information, contact Dial Books for Young Readers, 2 Park Ave., New York, N.Y. 10016.

Endangered Species
Endangered Species (Advanced) is an issue pac containing a poster, background information, lesson plans, and activity pages.

For more information, write National Institute for Urban Wildlife, 10921 Trotting Ridge Way, Columbia, MD 21044.

Endangered Species
(Vol. 10, No. 1) is a back issue of Environmental Education Report containing background information and activity ideas for various ages.

For a price list of this and other materials, write American Society for Environmental Education, P.O. Box 800, Hanover, NH 03755-0800.

Estuary: What a Crazy Place
This is a booklet by the National Wildlife Federation.

For more information, write National Wildlife Federation, 1412 Sixteenth St., NW, Washington, DC 20036-2266.

GEM
Our Endangered Atmosphere. (1987) A book for secondary students presenting views on warming and ozone depletion.

For more information, contact GEM, 411 Mallalieu Drive, Hudson, WI 54016.

Global Tomorrow Coalition (GTC)
GTC is a national alliance of organizations and individuals that is committed to improving public understanding of worldwide trends in population, resources, environment, and development to ensure a more sustainable future. GTC has compiled education packets that include an essay "Citizens Guide to Global Issues", activities, and a thorough glossary for students K-12. Packets are available on biological diversity, tropical rainforests, populations, marine and coastal resources, and a unit entitled "Consider the Connections" that illustrates the interrelationships among populations and environment and resource issues.

For more information, contact Global Tomorrow Coalition, 1325 G Street N.W., Suite 1003, Washington, D.C. 20005.

International Institute for Environment & Development
"Antarctica: A Continent in Transition". Resources about international interest in areas concerning legal, environmental, and economic issues. (1984)

International Institute for Environment & Development, 1319 F Street, N.W. Suite 800, Washington D.C. 20004.

Investigating the Human Environment: Land Use

This unit for high school, college, and adult students provides sources of information about land use. Decisions about land development and management, the authors argue, will be made more effectively if those involved have accurate information about proposed solutions. Understanding the impact of projects on the natural environment is also stressed. The unit discusses the variety of natural and constructed geographies of the United States. A Teacher's Guide is also available.

Izaak Walton League of America

Wetlands Adoption Kit contains background information and tips on how to help preserve wetlands.

For more information, write Izaak Walton League of America, Suite 1100, 1701 N. Fort Myer Dr., Arlington, VA 22209.

National Geographic Society

Mammals and How They Grow (Preschool and Primary) and Learning About Animals: Mammals (Intermediate and Advanced) are Wonders of Learning Kits. Each kit contains a cassette and read-along booklets of 25, ready-to-copy activity sheets, and teacher's guide.

For catalog write National Geographic Society, Educationl Services Dept. 85, Washington, DC 20036.

Massachusetts Audubon Society

A publication with reprints from The Curious Naturalist as well as other educational publications. Mammal-related publications include An Introduction to Massachusetts Mammals, The Art of Mammal Watching, and Skullduggery. Curious Naturalist reprints include "Reproduction in Mammals." These publications are available at very low cost.

To receive a list of publications and available issues of The Curious Naturalist write Massachusetts Audubon Society, Public Information Office, Lincoln, MA 01773.

National Wildlife Federation

A catalog of National Wildlife Federation publications, the Conservation Education Catalog lists books, curriculum and research materials, kits, educational programs, and periodicals. A variety of topics are addressed in NWF publications including: wildlife study and preservation, conservation and public policy, pollution, energy (non-renewable and renewable), natural history, and the protection of endangered species. The section, "Conservation Education

Publications" lists pamphlets with ideas for public action and involvement in conservation issues.

For copies, contact The National Wildlife Federation, 1412 16th Street, N.W., Washington, D.C. 20036-2266

Population Reference Bureau, Inc.

"Human Needs and Nature's Balance: Population, Resources, and the Environment". (1987) A module containing reading, additional resources, and exercises for secondary students.

For more information, contact Population Reference Bureau, Inc., 777 14th St., N.W. Washington D.C. 20005

Project Jonah

A teaching packet for upper elementary students about whales and the intracicies of the oceans. (1981)

For more information, contact Project Jonah, P.O. Box 476, Bolinas, CA 94924.

Project Wize, New York Zoological Society

For copies, contact NY Zoological Society, 185th Street and Southern Blvd.,Bronx, NY 10460.

Salt Marshes

Food for the Sea is a booklet on food chains.

For more information, write to the Massachusetts Audubon Society, Public Information Office, Lincoln, MA 01773.

Sea Grant Communications

Wavelets are free fact sheets with background information on marine topics. Wetlands sheets include salt marshes, brackish marshes, and freshwater wetlands.

For more information, write Sea Grant Communications, Virginia Institute of Marine Science, Gloucester Point, VA 23062.

Sierra Book Club

Islands in a Far Sea (1988) A book with the history of human impact on the ecology of Hawaii.

For more information write: Serria Book Club, San Franscio California.

The International Crane Foundation

The International Crane Foundation has six different activity packets about cranes for various age levels. The packets contain background information, activity sheets, and puzzles. The ICF also has films and videos available for rent.

For more information, write International Crane Foundation, E-11376 Shady Lane Rd., Baraboo, WI 53913-9778.

U.S. Fish and Wildlife Service

U.S. Fish and Wildlife Service has lists of endangered species, pamphlets, brochures, and other free materials.

For more information, write U.S. Dept. of the Interior, Fish and Wildlife Service, Patuxent Wildlife Research Center, Laurel, MD 20708.

III. AUDIO-VISUAL MATERIALS

Films or Videos

Benchmark Films, Inc.
Film entitled, "I'm a Mammal and So Are You"
This film is a short musical film on mammal characteristics.

For more information, contact Benchmark Films, Inc., P.O. Box 315, Franklin Lakes, NJ 07417.

Bullfrog Films Inc.
Films entitled, "The Last Chance" and "The Northern Elephant Seal"
Running Time (both) 15 minutes
The Last Chance (Advanced) is a film on endangered species from the National Zoo. This film comes in 16mm or VHS. It is directed to 7 yrs to adult. The cost for 16mm is $515.00 - VHS $100.00.
The Northern Elephant Seal (Primary and Intermediate) explains in simple terms how genetic similarity may cause species such as the elephant seal to be endangered despite their large numbers. This film comes in 16mm or VHS. It is directed to 7 yrs to adult. The cost for 16mm is $315.00 - VHS $245.00.

For more information, write Bullfrog Films Inc., Oley, PA 19547.

Canadian Broadcast Corporation
Film entitled, "Return of the Sea Otter"
Running time 30 minutes, color, 1986
During the 19th century the sea otters of the Northern Pacific coast of the United States were almost driven to extinction by excessive hunting. Today their survival depends on whether the threats from human-made pollution and hunting can be offset by intensive legal and scientific efforts to protect them.

For more information, contact Canadian Broadcast Corporation, P.O. Box 500, Terminal A, Toronto, Ontario M5W 1E6, (416) 925-3311 ext. 222.

Coronet/LCA/MTI/Chedd-Angier Production Company for NOVA/WGBH
Film entitled, "Seeds of Tomorrow"
Running time 60 minutes, color, 1985
With visits to Ethiopia, Greece, and Peru, the filmmakers examine current wordwide efforts to save the seeds that feed the world. Most of the food consumed in the United States has genetic roots in "centers of diversity" located in Third World countries. Because of new agricultural development, these centers are losing the ancient crop variaties. The film follows Dr. Noel Vietmeyer to Peru where he rediscovers an ancient Incan plant—amaranth—part of a highly nutritious but relatively unknown crop.

For more information, contact Coronet/LCA/MT 108 Wilmont Road, Deerfield, Illinois 60015 (800) 621-2133.

Coronet/MTI Film & Video

Film entitled, "Prairie Slough"

Running time 30 minutes, documentary

Prairie Slough (Intermediate and Advanced) is available in 16mm film or video cassette. It covers the importance of preserving our national wetlands. The cost is $250.

For more information, write Coronet/MTI Film & Video, 108 Wilmot Rd., Deerfield, IL 60015, or call Tricia (312) 940-1260.

Encyclopaedia Britannica Educational Corp.

Films entitled, "The Marsh Community"
"Our Vanishing Marshland"

"The Marsh Community" (Primary and Intermediate) and "Our Vanishing Marshland" (Advanced) are available in film or video. The film, "Marsh Community," comes in 16mm or VHS and the cost is $190.00 for 16mm. The running time of this film is 11 minutes. The film is directed to elementry and high school students. The film, "Our Vanishing Marshland," comes in 16mm or VHS. The length is 22 minutes. It is directed to elementary and high school students.

For more information, write Encyclopaedia Britannica Educational Corp., 425 N. Michigan Ave., Chicago, Il 60611.

Films Incorporated

Film entitled, "Return of the Osprey"

Running time 60 minutes, color, 1985

Ospreys nested in great numbers along the East coast of the United States until the pesticide DDT caused their near-extinction. This film is the story of the people who fought to ban DDT, and the amazing comeback of these magnificent birds of prey. The film comes in 16mm for $720.00 or VHS for $198.00. It is directed to college level students.

Video cassette entitled, "The Frozen Ocean"

Running time 58 minutes, color, 1986

The Arctic—the largest untouched wilderness left on earth--is a vast, pristine area of frozen land and sea that crowns the northern boundaries of Alaska, Canada, Greenland Scandinavia, and the Soviet Union. Often characterized as a lifeless desert of ice and snow, the Arctic is in fact a unique area of rare subtle beauty and ecological richness. This film is part of the series "Kingdom of the Ice Bear", a BBC Television Production. The film comes in color VHS for $129.00. It is directed to college students.

International Film Bureau, Inc

Film or Video entitled, Adaption for Survival: Mammals and The Living Mammals

Running Time 17 minutes

Both films come in 16mm or VHS, and are directed to all ages. The cost for each film is different: Adaption for Survival: Mammals is $275 for 16mm and $225 for VHS, and The Living Mammal is $295 for 16mm and $275 for VHS.

For more information contact, International Film Bureau, Inc., 332 S. Michigan Ave., Chicago, Il 60604-4382, (312-427-4545).

Karol Media

Film entitled, "Protecting Endangered Animals"

Running Time: 15 minutes

Protecting Endangered Animals (all ages) is available in film or video.

This film comes in 16mm and color VHS. The price for 16mm is $240 and for VHS $147. It is directed to grades 4-9.

For more information, write Karol Media, 22 Riverview Dr., Wayne, NJ 07470-3191, (201-628-9111).

Maryland Sea Grant College

Film entitled, "Chesapeake: The Twilight Estuary"

Running time 39 minutes, color, 1985

This film is a scientific detective story about the solving of a major environmental mystery--the disappearance of seagrasses throughout the rivers and mainstem of the Chesapeake Bay. The film explains the mysterious decline of the seagrasses. Unexpected research findings identify the seagrass killers and point the way for a major environmental cleanup of the Chesapeake Bay. This film comes in 16mm or color VHS. The price is $500 for 16mm and $75 for VHS.

For more information, contact The Maryland Sea Grant College, 1222 H.J. Patterson Hall, University of Maryland, College Park, MD 20742, telephone (301) 454-6058

National Academy of Sciences/Films Incorporated

Video cassette entitled, "Fate of the Earth"

Running time 58 minutes, color, 1985

As the concluding program of the Planet Earth series, this film explores new theories about life's begining—and perhaps its end. New discoveries indicate that life may be a billion years older than previously thought. Are humans a threat to the earth's future or a force for good? How is the Amazon rainforest a critical piece in the puzzle of the health of our planet? The film, through special effects, looks closely at "nuclear winter" and "ultraviolet spring."

For more information, contact Films Incorporated, 5547 N. Ravenswood Ave., Chicago, Illinois 60740 (800) 323-4222

National Audubon Society
VHS video tape entitled, "What is the Limit?"
Running time 23 minutes
Accompanied by discussion guide, "Where Do We Go From Here?" Cost $25.00
The video discusses the interrelationships between human population growth, environmental degradation, resource depletion, habitat destruction and the ethical considerations for the future.

For more information, contact National Audubon Society, Population Program, 801 Pennsylvania Avenue SE, Washington D.C. 20003.

National Geographic Society
Film entitled, "Creatures of the Mangrove"
Running time 59 minutes, color, 1986
Teeming life thrives and extraordinary creatures battle to survive in a tropical mangrove forest that is the setting for this film. The coastal island of Siarau and its tidal forest of mangroves are the offspring of Borneo's steamy interior rainforest, built up by silt washed down from the mountains and deposited in the sea. Using close-up photography, the filmmakers examine the mangrove forest's unusual creatures.

For more information, contact National Geographic Society Television Section, 17th and M Street N.W., Washington, D.C. 20036, telephone (202) 857-7671.

National Geographic Society
Films entitled, "Vanishing Animals of North America",
"Vanishing from the Earth"
"Vanishing Animals of North America" (Advanced) and "Vanishing from the Earth" (Advanced) are filmstrips with cassettes available from National Geographic Society.

For more information, write National Geographic Society, Educational Services, Dept. 85, Washington, DC 20036.

National Park Service/National Audiovisual Center
Film entitled, "Denali Park"
Running time 30 minutes, color, 1983
Photographed over the course of a year, the animals of Denali National Park in Alaska are shown in their daily struggle as members of a diverse and integrated ecosystem.
For more information, contact National Audiovisual Center, GSA, Reference Section CH, Washington, D.C. 20409

The Nature Conservancy/Direct Video

Film entitled, "Garden of Eden"

Running time 28 minutes, color, 1983

The planned development of a portion of Florida's Apalachicola Bluffs region--"the Garden of Eden"--is used as a case study to illustrate the possible conflict between unknown, but potential benefits of an untouched area and the demand for regional growth. The film shows that access to accurate ecological information and cooperation among conservationists, government, and industry are essential to making balanced decisions. The film shows clearly that we, in making these choices, are the single species with the most to gain and the most to lose.

For more information, contact Direct Cinema, P.O. Box 69589, Los Angeles, CA 90069 (213) 656-4700

National Wildlife Federation

Video entitled, "Our Threatened Heritage"

Running time 18:50 minutes, full color

One copy $20.00, two or more, $15.00 each

"Our Threatened Heritage" addresses the complex issues associated with habitat destruction in the tropical forest. It focuses on the links between environment and development in the tropics. Because the tropical forest touches our lives every day in countless unrealized ways, it is of concern to all of us.

For more information, contact National Wildlife Federation, 1400 Sixteenth St., N.W., Washington, D.C. 20036-2266.

Partridge Films/AML International

Film entitled, "Korup"

Running time 54 minutes, color, 1982

The portrait of a Cameroon rainforest, "Korup" describes elaborate relationships that have evolved between plants and animals. Sequences show monkeys and bats pollinating flowers, ants defending their tree nest, and a fungus that alters ant behavior. The film stresses the importance of conserving tropical rainforests, among the richest habitats on earth for plants and animals. Sixty percent of this documentary was filmed on platforms 120 feet high.

For more information, contact AML International, #6 Goodwins Court, St. Martin's Lane, London, WC2 N4LL, England

Phoenix Films and Video

Film entitled, "Ethiopia"

Running time 28 minutes, color, 1985

Without narration, this film is an impressionistic collage of primal landscapes and beautiful images in Ethiopia. It is a visual poem of life and a depiction of the forgotten and unexpected beauty in the country.

For more information, contact Phoenix Films and video, 468 Park Avenue South, New York, New York 10016, telephone (212) 684-5910

Sandra Nichols Productions, LTD.
Film entitled, "The Fragile Mountain"
Running time 55 minutes, color, 1982
The film describes the lives of the mountain people of Nepal, vividly portraying the links among the environment, population, and development.

For more information, contact Sandra Nichols Film Library, P.O.Box 315, Franklin Lakes, New Jersey 07417, telephone (201) 891-8240

Smithsonian Institution Traveling Exhibition Service (SITES)
VHS videocassette entitled, "Diversity Endangered"
Running time 9.5 minutes

For more information, contact Smithsonian Institution Traveling Exhibition Service, Washington, D.C. 20560, telephone (202) 357-3168

Society for Visual Education, Inc.
Film entitled, "Swamp Survival Ecosystem"
Swamp Survival Ecosystem (Intermediate and Advanced) is a filmstrip with cassette.

For more information, write Society for Visual Education, Inc., Dept. BJ, 1345 Diversey Pkwy., Chicago, IL 60614-1299, or call 1-800-621-1900.

Stanton Films
Film entitled, "Pupfish of the Desert"
Running time 18 minutes
The film tells the story of a tiny fish that exists in the extreme environment of a desert. This film is designed for all ages. It comes in 16 mm or 1/2in. film. The cost for 16mm is $300, and for half inch $250.

For more information, write Stanton Films, 2417 Artesia Blvd., Redondo Beach, CA 90278, or call Georgina at 213-542-6573.

Slides

The following list was compiled from a report by Dr. Peter White, University of North Carolina, who is planning a systemwide repository of slides on biodiversity, and from Napier Shelton, National Park Service.

American Fisheries Society
5410 Grosvenor Lane
Bethesda, MD 20814
301-897-8616

Kind of organization--professional society. With 660 slides of North American fishes, freshwater and marine. Most are museum specimen photographs, but some are underwater or aquarium pictures of living fish. The objective is to have a picture or pictures of all species of fish on the continent. The collection is arranged taxonomically. Specific slide sets for particular geographic areas are also available. Slides are sold through a catalogue. They are $1.00 to $1.50 per slide. Purchased slides may only be used for educational purposes. No reproduction is permitted as the Society or the photographer holds copyrights. Reproduction must be negotiated on a case-by-case basis.

American Museum of Natural History
Central Park West at 79th St.
New York, NY 10024
212-769-5400
Contact: Ann LaSala

Kind of organization: private institution or business. Large (1000s) catalogue of slides, about one-half of which are now available for sale. Topics include aquatic life, astronomy, birds, earth science (this includes a subheading for national parks and monuments of the U.S. and Canada),insects, mammals, mineral resources, paleontology, reptiles and amphibians, and miscellaneous subjects (e.g. protective coloration in nature). Taxonomic and discipline oriented. Not specifically on biological diversity. Many of these slides are based on museum exhibit halls. Slides are for sale: $1.00 per slide ($0.85 per slide if more than 25 are purchased). Slides may not be reproduced.

American Rivers Conservation Council
801 Pennsylvania Avenue, S.E., Suite 303
Washington, D.C. 20003
202-547-6900

Kind of organization--conservation
Pictures of 110 rivers with slides of threats to rivers (including dams). 1300 slides in

all. In alphabetical order by river system. Honor system utilized—just call and ask for slides. Give credit to organization when used.

Bird Photographers, Inc.
254 Sapsucker Woods Road
Ithaca, NY 14850

1600 color slides of birds, mammals, amphibians. Some slides are in sets and come with scripts. A catalog of offerings exists. Slides are for sale. May not be duplicated.

Carolina Biological Supply
2700 York Road
Burlington, North Carolina 27215
919-226-6000
Contact: Cindy Bright

Kind of organization--private institution or business. Over 60,000 slides including everything from species (bacteria to vertebrates and vascular plants), scenic vistas, and communities to wind surfers and nuclear power plants. While photos are primarily from the Southeast, they also include Alaska, the Galapagos, Antarctica, South America, and the Western U.S. If needed slide does not exist in collection, they will take it for you. For species, organized taxonomically. Access is easier via sending a list of needed slides. Either they will select slides from the collection or they welcome representatives to come to Burlington to select slides for themselves. $25 for one-time use. No duplication permitted.

Educational Images
P.O. Box 3456,
West Side, Elmira,
NY 14905
Marie 607-732-1090.

Slide sets entitled: Endangered and Extinct Animals
Rare and Endangered Animals 1&2
25 slides per set, with text

The slides in this set show rare, endangered, and extinct species of the world. It is directed to all audiences. The cost per set is $39.95.

Mammal Slide Library
Division of Biological Sciences, Box 50
Emporia State University
Emporia, Kansas 66801
316-343-1200
contact: Dr. Dwight W. Moore

Has 970 slides of 600 mammal species. About one-third North American. Many ungulates, neotropical bats. Sells slides for $1 apiece. A catalog ($2.00) describes slides. List of species is free. Projection rights only, no printing.

National Geographic Society
17th and M Streets, N. W.
Washington, D.C. 20036
202-857-7195
Contact: Barbara Shattuck

Slide collection of all photographs used in National Geographic publications. Slides indexed by page and volume number of publication. Request must include this information. Send letter requesting identified photographs, also including purpose of use. National Geographic will determine rates, if any apply.

National Marine Fisheries Service
Northwest & Alaska Fisheries Center,
7600 Sand Point Way,
N.E. Bin C 15700
Seattle, WA 98115

Slide presentation entitled "Marine Debris" 81 slides and script.

National Zoological Park
Rock Creek Park
Washington D.C. 20009
202-673-4862
Contact: Jesse Cohen

200,000+ slides of everything to do with zoo from staff to animals to research. Collection not indexed. Slide requests would have to be made to photographer who will attempt to find them, if they exist. No originals will be loaned. Instead, send list of needed slides to Ms. Cohen, who will find and duplicate them. No cost for slides, except for reimbursement for duplication charges.

New York Zoological Park
The Zoological Park
Bronx, New York 10460
212-220-5100

Kind of organization--private institution or business
Photographs of all animals (present and past) housed in the zoo, plus captive breeding in Georgia. By common name of species. Send list of animals wanted, plus kind of shot (close-up, etc.). Requested slides will be sent, and duplicates can then be made. A $30 service charge exists.

Rainforest Action Network
300 Broadway, Suite 28
San Francisco, CA 94133
415-398-4404

Kind of organization--conservation. Slides on the tropical rainforest, its plight and conservation. Slides range from the beauty of the forest to slides of habitat, individual species, deforestation, and conservation groups in action. By subject. No catalogue exists, but there is a computer printout of slides available. Slides are sold or rented.

Robert Simpson
Route 1, Box 154b
Stephens City, VA 22655
703-869-2051

100,000 slides of North American and Mexican vertebrates, butterflies, fungi, higher plants. Many of rare species. Scenics, including parks. Tropical forest cutting in Mexico. Other habitat destruction. Shopping malls, pollution, etc. Some research, recreation. Zoos around the world. Sells right to duplicate slides--$3 to $5 per slide depending on quantity. No right to print duplicate slides. Can send you a general inventory, but no list of individual slides.

U.S. Department of Commerce-NOAA
Public Affairs Office
Rockville, MD
301-443-8470
Contact: JoAnne David

Some marine mammals and other marine animals are contained in this slide collection. Indexed by taxon. Probably OK to copy the slides; permission would have to be requested to use the slides in publication.

USDA-Forest Service-Public Affairs Office
P.O. Box 2417
Washington, D.C. 20013
202-447-3760
Contact: Jill Bauermeister

Kind of organization--Federal government. Jill Bauermeister is the librarian. There is a color slide collection (1000) in the library of the Public Affairs Office. It is not specifically indexed for biological diversity, but it does contain some slides that might be useful. National forests, activities within forests, etc. Some Forest Service regional offices have much larger collections. Case-by-case negotiations. Be specific about subjects requested.

USDI-Fish and Wildlife Service-Audiovisual Office
Washington, D.C. 20240
202-343-5612
Contact: Craig Koppie

A very limited number of slides. Endangered species and other species. Work of Fish and Wildlife Service. Scenics. Indexed by species. Case by case basis. Cannot handle large volume. Be specific about slide subjects requested.

USDI-National Park Service-Office of International Affairs (023)
Box 31727
Washington, D.C. 20013-7127
202-343-7063
Contact: Ron Cooksy

Slides of 57 U.S. National Parks, plus parks in 46 other countries in office file. Individuals also have slides taken in South America and other regions. Will send duplicates.

USDI-National Park Service-Office of Public Affairs (040)
Box 37127
Washington, D.C. 20013-7127
202-343-7394
Contact: Rick Lewis

8000 slides, mostly of U.S. National Park areas. Scenics, recreation, some plants and animals, not necessarily identified. Sends duplicates.

USDI-National Park Service - Wildlife and Vegetation Division (490)
Box 37127
Washington, D.C. 20013-7127
202-343-8122
Contact: Bill Gregg

A small collection of slides of biosphere reserves, United States and foreign. Can send duplicates.

VIREO
The Academy of Natural Sciences of Philadelphia
19th and The Parkway
Philadelphia, PA 19103
215-299-1069

4000+ slides of birds. Strongest in North and South American birds. Some habitat photos, mainly North and South America. Bird research. North American slides - $2.00. Other countries - $3.00. Will send free catalogue.

Ward's Scientific
5100 West Henrietta Road
P.O. Box 92912
Rochester, NY 14692
716-359-2502

Kind of organization--private institution or business. Sells many slide sets, including topics of physical geology (including erosional and disturbance processes, rivers, groundwater, etc.), features of coasts and shorelines, alpine glaciation, continental glaciation, surface landforms, diastrophism, rocks and rock structures, paleontology, Grand Canyon geology, use of remote sensing, oceanography, meteorolgy, astronomy and space science, and others. The index to this collection may be found within the Ward's Scientific Catalogue. Ward's will sell slides only as sets, not individually. Prices for programs listed within catalog. Typically run between $25-$35 per 20 slides.

Miscellaneous

Carolina Biological Supply

Records of mammal calls. Audible Audubon Living Sound System Kits include player and two sets of recordings. Mammal recordings include "Nature's Magnificent Wildlife," "Largest Animals of the Wild," and other sets. Callings is a two-record set by Paul Winter. Set includes calls of 15 sea mammals blended with music. "Songs of the Humpback Whale,"Deep Voices: The Second Whale Record," and "Ocean of Song: Whale Voices" are recordings of humpback, right, and killer whales.

For ordering infirmation write Carolina Biological Supply Company, Burlington, NC 27215 (919-584-0381).

Do Dreams Music

Record entitled, "Romp in the Swamp"

Romp in the Swamp is a record (or cassette) of 14 upbeat kids' songs by Bill Brennan.

For more information, write Do Dreams Music, P.O. Box 5623, Takoma Park, MD 20912.

Focus Media, Inc.

Software entitled, "The Balance in Nature" (Intermediate and Advanced)

Using imaginary animals in a marine environment, along with colorful graphics and questions, this program introduces the concepts of food chains, adaptation, survival, and extinction. Available for Apple and Commodore 64.

For a catalog of this and other programs write Focus Media, Inc., 839 Stewart Ave., P.O. Box 865, Garden City, NY 11530.

Global Tommorrow Coalition

Cassette Recording "A Tropical Forest Walk"

Running Time 15 minutes, cost: $9.95.

A musical cassette with sound and script containing sounds of the tropical forest. This tape is directed for all audiences.

For more information contact, Global Tomorrow Coalition, 708 S.W. Third Avenue, Suite 227, Portland, Oregon 97204. Phone number: (503) 295-0382.

National Park Service,
Uplands Field Research Center
Great Smoky Mountains National Park,
Rural Route 2 Box 260,
Gatlinburg, Tennessee 37738

Poster entited, "Preserving Biodiversity in the Great Smokies: Preserving What We Have and Replacing What's Been Lost". The poster shows species of plants and animals that are unique and rare in the Smokies.

Yaker Environmental Systems, Inc.

Software entitled, "Biomes 2: Wilderness Webs"

Wilderness Webs (Advanced) allows children to build food webs in eight different biomes including the Everglades. After building the webs, they learn how people's involvement affects the biomes and how to help preserve the habitats. Available for

Apple II and IIE.

Software entitled, "Endangered Species"
Endangered Species (Advanced) is a four-part program featuring extensive lists of endangered animals, maps pointing out the locations of different species, explanations of why they became endangered, a simulation in which children make decisions regarding the futures of endangered species, and a game that reinforces concepts from the program. Available for Apple.

For a catalog of this and other programs write Yaker Environmental Systems, Inc., P.O. Box 18, Stanton, NJ 08885.

The Smithsonian Institution

Diversity Endangered. A Poster Exhibition (15 posters)
Posters cover the following topics: title poster, magnificent diversity of life, tropical rain forests, watery nurseries, the web of life, systems that sustain life, the dollars and cents of diversity, diversity in danger, deforesting the tropics, pollution, what happens to wildlife, the new conservation, alternatives to destruction of Noah's ark, a modern approach, what you can do.
For more information contact:
SITES, Department 0564
Smithsonian Institute
Washington, DC. 20073 - 0564
Poster Price (1 set of 15 posters): $300.00
10 minute video: $25.00 per copy
Posters Mounted on Kiosk: +$125.00

Biological Diversity Curriculum Project

Supplementary curriculum materials for students grade 4 - 6 and park visitors. The curriculum is designated to facilitate NPS outreach efforts to schools and to further citizen support and understanding of the significant roles parks play in the preservation of ecosystems and genetic diversity. Units stress a hands-on, self-discovery teaching approach to the topic, and are interdisciplinary in nature. Modules have been field tested and evaluated by teachers and students.
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Glossary

Abiotic Nonliving; referring to the nonliving components of ecosystems (water, light, etc.) (ReVelle and ReVelle, 1988).

Adaptation A characteristic that helps an organism survive in a particular environment (ReVelle and ReVelle, 1988).

Agro-ecosystem A human-modified ecosystem consisting primarily of domesticates cultivated or hubanded and managed by humans, and a physical environment suitable for the propagation of individuals of such species. In most cases, they are partly supported by nearby natural ecosystems which contribute nutrients, water, biological control agents, or other essential elements (Oldfield, 1984).

Allele One of two or more alternative forms of a gene. Mutations give rise to different alleles at the same gene locus (Oldfield, 1984).

Alkaloid Any of a large group of nitrogen-comtaining, organic compounds most commonly found in seed-producing plants and in herbivorous animals that feed on such plants. Alkaloids are typically biologically or pharmacologically active. (Oldfield, 1984).

Angiosperm A "higher" or flowering plant that produces seeds enclosed within an ovary; a plant or species belonging to the class Angiospermae of the vascular or land-dwelling plants (division Tracheophyta) (Oldfield, 1984).

Artificial Selection Selection applied according to a specified set of environmental conditions. In contrast to natural selection, it is a purposeful process directed by humans (usually a plant or animal breeder) in order to meet certain socioeconomic goals or standards; see selection (Oldfield, 1984).

Biodegradable Able to be broken down by living organisms. (ReVelle and ReVelle, 1988).

Biology The science of life; the study of the principles applied to the origin, structure, function, development, and ecology of living organisms as represented by plants, animals, and microbes. (Oldfield,1984).

Biological Controls Pest-control methods that use natural predators, parasites, or diseases or that rely on the use of naturally produced chemicals such as insect pheromones. (ReVelle and ReVelle, 1988).

Biological Diversity The sum of diversity within and between species, between communties and between higher taxonomic levels (family, class, phylum, kingdom); includes genetic diversity. Biological diversity is not necessarily equal to species diversity. Some groups may house more biological (including genetic) diversity than others. (Schonewald-Cox, 1987).

Biological Magnification The process by which certain, often toxic, materials become more concentrated as they move up food chains. That is, organisms at the top of the food chain contain more of the substance than do organisms on the bottom of the food chain, or than does the environment itself. (ReVelle and ReVelle, 1988).

Biomass The total weight of living material, usually expressed in terms of dry weight of an organism, a population, or a community. (Oldfield,1984).

Biomes Climax communities characteristic of given regions of the world. (ReVelle and ReVelle, 1988).

Biota Flora and fauna, considered together. (Oldfield,1984).

Breed A group of domesticated animals genetically related by descent from common ancestors and which share similar phenotypic characteristics. (Oldfield,1984).

Carnivores Meat-eaters. (ReVelle and ReVelle, 1988).

Carrying Capacity The largest population a particular environment can support indefinitely. (ReVelle and ReVelle, 1988).

Cell The fundamental structural and functional unit of all living matter. (Oldfield,1984).

Charismatic Species A species that is culturally popular. By virtue of receiving legal protection, such a species can offer protection to less conspicuous and potentially biologically more important species. (Schonewald-Cox, 1987).

Chromosome Self-duplicating units of genetic material that are species-specific in number and complexity (and often organism-specific in cases of chromosomal aberrations). (Oldfield,1984).

Climate A complex of atmospheric factors affecting the environment. Climate includes temperature, humidity, amount of precipitation, rate of evaporation, amount of sunlight, and winds. (ReVelle and ReVelle, 1988).

Climax Community The characteristic and relatively stable community for a particular area. (ReVelle and ReVelle, 1988).

Coadaptation Genetically, the evolutionary process of selection for harmoniously collaborating genes within the gene pool of a population; genes are coadapted if the specific interactions between them confer high fitness to the individual inheriting them. Ecologically, the evolution of mutually advantageous heritable characteristics within two or more species as a consequence of their ecological interactions over time. (Oldfield,1984).

Coadapted Gene Complex A mutually concordant set of alleles (genes) that, when inherited intact, confers fitness to the individual; although they need not be closely linked on the same chromosome, the alleles that comprise such a complex have been most often demonstrated to exist in tightly linked systems inherited as a unit. (Oldfield,1984).

Coevolution The joint evolution of two (or more) taxa resulting in the mutual development of genetically determined traits, advantageous to each other, that facilitate their ecological interactions; even though coevolved species have close ecological relationships, they do not exchange genetic material with one another. (Oldfield,1984).

Community A group of populations that are ecologically and geographically interconnected, and represent a few to several species. Such a group constitutes an assemblage of plants and animals living in a common home, under similar conditions of environment, or with some apparent association of interest. (Schonewald-Cox, 1987).

Community All of the living creatures, plant and animal, interacting in a particular environment. (ReVelle and ReVelle, 1988).

Community The biotic components (all organisms considered together) in an ecosystem; an association of interacting populations. (Oldfield,1984).

Competition In ecological terms, the struggle between individuals or populations for a limited resource. (ReVelle and ReVelle, 1988).

Competitor A species (population) that uses or defends a resource, thus reducing its availability for use by another species (population). (Oldfield,1984).

Conservation The wise use of natural resources; the planned management of a natural resource to deter or prevent overexploitation, irreversible destruction, or neglect. (Oldfield,1984).

Conservation Compromise between protection and multiple land, species and/or resource use. Visitation, concessions, recreation, logging, hunting, and mining are various forms of compromise with protection. (Schonewald-Cox, 1987).

Consumers Organisms that eat other organisms. Primary consumers eat producers, secondary consumers eat primary consumers, and so on. (ReVelle and ReVelle, 1988).

Crop Gene Center A region or center of pronounced genetic diversity for a crop species that arose in association with traditional agro-ecosystems and ancient farming practices; primary equals a site where crop species were first domesticated and became genetically diversified, and secondary equals an area of pronounced genetic diversity of a crop which did not originate there. (Oldfield,1984).

Diversity A measure of the number of species in a given area. The more species per square meter, the higher the diversity. (ReVelle and ReVelle, 1988).

Ecology The study of the interaction between organisms and their environment. (ReVelle and ReVelle, 1988).

Ecological Processes Interactions within and between communities (at all levels), including interactions with abiotic environments and short as well as long-term interactions; or, processes affecting mutual relations between organisms and their environment. (Schonewald-Cox, 1987).

Ecologically Important Species A keystone species is one that supports the stability or existence of several to many other species or is biologically important. It is not necessarily a charismatic species but can be. (Schonewald-Cox, 1987).

Ecosystem All of the living organisms in a particular environment plus the non-living factors in that environment. The non-living factors include such things as soil type, rainfall, and the amount of sunlight. (ReVelle and ReVelle, 1988).

Emigration The movement of organisms out of a population. (ReVelle and ReVelle, 1988).

Endangered species A species with so few living members that it will soon become extinct unless measures are begun to slow its loss. (ReVelle and ReVelle, 1988).

Erosion The loss of soil due to wind or as a result of washing away by water. (ReVelle and ReVelle, 1988).

Eutrophic Water that has a high concentration of plant nutrients. (ReVelle and ReVelle, 1988).

Evolution Change in the frequency of occurrence of various genes in a population. (ReVelle and ReVelle, 1988).

Evolutionary Processes Changes in gene frequencies owing to natural selection or stochastic processes. Or, more simply, temporal (short and long-term) changes in diversity at all levels. In nature, speciation and extinction are both characteristic of the evolutionary processes. Anthropgenic (humanly derived) extinctions or anthropogenically accelerated extinction rates may be undesireable, but a basal extinction rate is natural (i.e. one that must be specified and studied). Evolutionary processes are those by which (by means of a series of continious changes or step changes) any living organism or group of organisms has acquired the morphological or physiological characters that distinguish it, a process that shows a continuous change over time, as do the processes of nature. It suggests continued forward movement, procedure, and progress, but not necessarily advance in the sense of human values. Processes occur in a series of actions or events (being slow, gradual, rapid, and/or step-wise). (Schonewald-Cox, 1987).

Extinction The cessation of existence for a given form, or a previous loss of a given form.(Schonewald-Cox, 1987).

Extirpation Local extinction (not necessarily by mortality) can include the driving out of an organism from its habitat by various means, such as by newly introduced competitors or human disturbance.(Schonewald-Cox, 1987).

Food Chain A picture of the relationship between the predators in an area and their prey (i.e. who is eating whom). This term is applied when the relationships are simple and few creatures are involved. (ReVelle and ReVelle, 1988).

Food Web Interconnected food chains made up of many organisms, with many interrelationships. (ReVelle and ReVelle, 1988).

Gene Pool A group or aggregation of interbreeding individuals (not usually a reflection of total diversity within a species). Within each gene pool there is a certain amount of genetic diversity, and for each gene pool the nature and amount of genetic diversity characterizes the pool. Diversity can be stored between gene pools as well as within them. The gene pool (a genetic term) is also used frequently in the zoo and botanical garden community when referring to the captive groups of a species. In the wild, scientists and managers more frequently use the demographic term, population, to denote a group of interbreeding individuals. (Schonewald-Cox, 1987).

Genetic Diversity Diversity within the individual, among genes to produce the phenotype (or outward manifestations of the individual); diversity between individuals of a gend pool; and diversity between gene pools or individuals of a species (thus, inherited (structural) diversity at or below the species level). Also important are functional diversitees, such as behavioral, physiological, etc. (Schonewald-Cox, 1987).

Greenhouse Effect Atmospheric heating that occurs when outward heat radiation is blocked by carbon dioxide molecules that absorb the energy. The greenhouse effect suggests the earth will undergo a warming trend as carbon dioxide from fossil fuel combustion accumulates in the atmosphere. (ReVelle and ReVelle, 1988).

Green Revolution The term given to the new developments in farming, including the use of high-yielding grains, that promise to enable farmers to grow much more food on the same number of acres than with conventional techniques and older crop varieties. (ReVelle and ReVelle, 1988).

Habitat The physical surroundings in which an organism lives. (ReVelle and ReVelle, 1988).

Herbicides Chemicals used to kill weeds. (ReVelle and ReVelle, 1988).

Herbivores Plant-eaters. (ReVelle and ReVelle, 1988).

Immigration The movement of individuals into a population. (ReVelle and ReVelle, 1988).

Intensive Mangement Cases in which exceptional technologies are incorporated into overall management procedure, such as "captive population management" by zoos. This is a strained or extreme degree of management; manifested in the nearly "domesticated" treatment, extreme effort and strong and sustained stimulation of the population resource; such management is profoundly earnest or intent. (Some examples include restoration programs for peregrine falcons, condors, nene, tule elk, and desert bighorn sheep.) (Schonewald-Cox, 1987).

Management Human involvement in the protection of biological diversity (for purposes of this report). Management, taken alone, suggests administrative management or all forms of management combined, depending on context, whereas resources management suggests management of resources. Management can be either passive (non-interfering) or active (manipulative or interventionist), the distinction at times being vague. Management implies the manner of treating, for a purpose or out of a desire to control, and the use for a purpose (or, more important, in this context, the judicious use) of means to accomplish an end.(Schonewald-Cox, 1987).

Migration The periodic movement of organisms into or out of an area. (ReVelle and ReVelle, 1988).

Monoculture The cultivation of a single species of plant as opposed to mixtures of species, as is usually found in nature. (ReVelle and ReVelle, 1988).

Mutation An inheritable change in the genetic material of an organism. (ReVelle and ReVelle, 1988).

Natural Unhampered or unmodified by recent humans of the American continent. No fixed time frame should be set with reference to the word "recent," since characteristics that were adaptive or communities that were natural at an earlier time may no longer be adapted to 20th-21st century conditions. The term "natural" should be used with care, and one's points of reference and values should be specified as one goes along. A more conventional definition (from Webster) might be "in accordance with, or determined by, nature; characteristic of the operations of the physical world; normal. Of, pertaining to, or concerned with nature, or the physical universe." (Schonewald-Cox, 1987).

Natural Selection A difference in reproduction whereby organisms having more advantageous genetic characteristics reproduce more successfully than other organisms. This leads to an increased frequency of those favorable genes or gene combinations in the population. (ReVelle and ReVelle, 1988).

Niche Where an organism lives and how it functions in this environment (i.e. what it eats, who its predators are, what activities it carries out). (ReVelle and ReVelle, 1988).

Population The organisms, collectively, inhabiting an area or region; as, the frog population of a pond. For our purposes, the terms "gene pool" and "population" (of a given species) are synonymous; "population" will be used unless specific reference must be made to the genetic properties of a group of interbreeding individuals. (Schonewald-Cox, 1987).

Predator A creature that eats another. (ReVelle and ReVelle, 1988).

Preservation Protection of biological diversity (in the context of this report) without intentional compromises; it includes protection of parts and processes. Preservation suggests the act of preventing injury, destruction, or decay; maintaining a state of preservation; or assuring the existence or intactness of biological diversity. (Schonewald-Cox, 1987).

Prey A creature that is eaten by another. (ReVelle and ReVelle, 1988).

Primitive Cultivar or Breed A crop cultivar or livestock breed that has been genetically improved by traditional agriculturalists and that no longer resembles its wild progenitor(s), yet usually retains many of the beneficial genetic traits of its wild ancestors. (Oldfield, 1984).

Producers Organisms who produce organic materials by photosynthesis. (ReVelle and ReVelle, 1988).

Productivity Amount of living tissue (plant or animal) produced by a population in a given period of time. (ReVelle and ReVelle, 1988).

Selective Force Any biotic (human, other organism) or abiotic (temperature, rainfall) factor that directs or influences the process of selection. (Oldfield, 1984).

Short-Term/Long-Term Based upon current knowledge of ecosystem and evolutionary processes:

Short-Term

• 25 years administratively. Biologically it depends upon the species or processes one focuses upon, and is measured in generation times or recurrent population cycles.

Long-Term

•100 years administratively. Biologically it depends upon the species or processes one focuses upon, and is measured in generation times or recurrent population cycles.

Of course, politics require that yet smaller time intervals be used for short-term and long-term definitions, and it is these shortest definitions that predominate in current use by the NPS. These conceptual and administrative constraints placed on "time" are in direct conflict with requirements for study and documentation (biological, physical, and anthropogenic processes) and for protection of biological diversity. (Unfortunately, ecological and evolutionary processes and time do not change for human convenience.) (Schonewald-Cox, 1987).

Species All those organisms that are able to interbreed successfully (if they are given the opportunity to do so), that share ties of common parentage, and that share a common pool of hereditary material. (ReVelle and ReVelle, 1988).

Species One or more populations of individuals that are reproductively compatible and comprise a distinct form of animal or plant. Noteworthy exceptions are not the object of discussion here. This simpler definition is thought to be sufficient for this report, although for reference purposes, Webster defines "species" as "a category of classification lower than a genus or subgenus and above a subspecies or variety; or as a group of animals or plants that possess one or more characters distinguishing them from other similar groups, and do or may interbreed and reproduce their characters in their offspring, exhibiting between each other only minor differences bridged over by intermediate forms and differences ascribable to age, sex, polymorphism, individual peculiarity or accident, or selective breeding by man." (Schonewald-Cox, 1987).

Succession A natural process in which the species found in a given area change conditions to make the area less suitable for themselves and more suitable for other species. This continues until the climax vegetation for the area grows up. (ReVelle and ReVelle, 1988).

Threatened Species A species that is not yet endangered but whose populations are heading in that direction. (ReVelle and ReVelle, 1988).

Weed (species) A species that has colonizing (reproductive) capabilities in a disturbed environment, and can usually outcompete a wild species therein; it cannot outcompete wild species in natural environments, and since it thrives in human-disturbed habitats, it is typically considered as an unwanted, economically useless, or "pest" species. (Oldfield, 1984).

Wild (species) A species that usually exists in and often requires an undisturbed natural habitat, and which has not been influenced by the artificial selection pressures of human. Although it can sometimes be cultivated, a wild species remains such only so long as its natural habitat is maintained. (Oldfield, 1984).

References

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