# EVALUATION OF BIODIVERSITY PROJECTS

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# Evaluation of Biodiversity Projects

Committee on Criteria and Guidelines for the
Evaluation of Projects Designed to
Protect or Enhance Biodiversity

Board on Biology
Commission on Life Sciences
National Research Council

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1989

NOTICE: The project that is the subject of this report was approved by the Governing Board of the National Research Council, whose members are drawn from the councils of the National Academy of Sciences, the National Academy of Engineering, and the Institute of Medicine. The members of the committee responsible for the report were chosen for their special competence and with regard for appropriate balance.

This report has been reviewed by a group other than the authors according to procedures approved by a Report Review Committee consisting of members of the National Academy of Sciences, the National Academy of Engineering, and the Institute of Medicine.

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# Preface

It is regrettable that this document is needed. It is regrettable that the survival of biological diversity requires extraordinary initiatives such as "biodiversity reserves." Only a world on the brink of ecological suicide would resort to such artificial means. To the citizens of a balanced world, the phrase "biodiversity reserve" would sound just as ridiculous as does the concept of "developer reserve" to us.

In denaturalizing most of the planet's tropical and temperate surface, in usurping virtually all unfrozen land and water, in polluting the highest reaches of the stratosphere, and in altering the heat balance of the atmosphere, we are fast approaching a new global, ecological threshold—our carrying capacity. As we cross this invisible barrier, less pushy species will be crowded out.

Now "experts" are being summoned to help slow and eventually reverse the human machine of population and denaturalization. This document was written by such experts—in the fields of appropriate development and conservation biology—in response to a request for guidance on the selection, monitoring, and evaluation of biodiversity-related projects in developing countries. Although our specific charge was to provide such guidance to the U.S. Agency for International Development, the Committee was mindful of the needs of other organizations. It was our objective, therefore, to provide organizations, private and governmental, with a flexible tool, if not a precision instrument, for improving the quality and efficiency of biodiversity projects. At the very least, we hope that users will be led to ask a few questions that might not otherwise have occurred to them.

In the process of producing the following report, Donna Gerardi, Norman Grossblatt, and Linda Jones provided excellent technical assistance. Walter Rosen performed his usual magical midwifery.

Michael E. Soulé
Chairman

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# Executive Summary

This report is based in part on recommendations generated at a workshop attended by 14 experts in various aspects of conservation biology, ecology, systematics, and economic development. It presents guidelines for evaluation of proposed, current, and completed projects designed to protect and enhance biological diversity (biodiversity). The guidelines cover four kinds of projects that the U.S. Agency for International Development might be expected to evaluate: ecosystems and habitats, species, habitat classification and inventory, and genetic resources.

For each kind of project, four categories of evaluation criteria are offered: biological, social and economic, institutional capability, and linkage. Guidelines are primarily in the form of checklist questions, with questions in each category preceded by general guidance. Not all questions will apply to all projects, and the appropriate answers to the questions will vary with the category and the specific project. The guidance suggested here must therefore be applied flexibly in the evaluation process. The report also stresses the importance of linkages—to other local and national programs and to international organizations—in the evaluation process.

Although it does not include education and training as a specific category, the report stresses the importance of education and training and recommends support for education and training projects.

The report includes appendixes that provide sources of further guidance in project evaluation.

# 1
# Introduction

In 1985, an Interagency Task Force, with the U.S. Agency for International Development (A.I.D.) as the lead agency, issued a report that reviewed the evidence concerning the loss of biological and genetic diversity in the developing world, outlined current federal activities and programs for dealing with conservation of natural resources, and developed a strategy for building on those activities and programs to assist developing countries (U.S.A.I.D., 1985). Later, Congress charged A.I.D. with the preservation of biodiversity in all its development activities and earmarked $2.5 million in the FY 1987 A.I.D. budget for biodiversity-related projects (U.S.A.I.D., 1988). Reasons for concern about biodiversity include (OTA, 1986):

- Recognition of the substantial existing and potential benefits of diversity among plants, animals, and microorganisms.
- Evidence that degradation of ecosystems undermines economic development projects.
- Esthetic and ethical motivations for avoiding irreversible loss of unique life forms.

In 1987, the A.I.D. Bureau for Program and Policy Coordination invited the Board on Biology of the National Research Council's Commission on Life Sciences to conduct a study to identify criteria and procedures for evaluating proposed, active, and completed biodiversity projects. The Board appointed a committee of seven experts in relevant disciplines, including ecology, conservation biology, systematics, social sciences, and development. The Committee's specific charge was to prepare a report on the conditions and procedures necessary for the proper monitoring and evaluation of A.I.D. interventions designed to conserve biodiversity and to provide guidance to project managers and other persons involved in biodiversity projects on how to monitor and evaluate their projects.

The Committee was *not* charged to examine, review, or propose specific biodiversity projects or development objectives. Nor was it charged to

prepare a research agenda for tropical biology or conservation biology or a critique of development projects.

Unless otherwise stated, "conservation" in this report means the protection and management of biodiversity as defined by the Office of Technology Assessment (OTA) in 1987.

## APPROACH TO THE CHARGE

At its first meeting, the Committee identified four kinds of projects that A.I.D. might be expected to evaluate:

- *Ecosystems and habitats.* Projects intended to protect biodiversity and natural resources by establishing and managing protected areas.
- *Species.* Projects that focus on one or a few species.
- *Habitat classification and inventory.* Projects intended to describe or refine the descriptions of the ecosystems (communities, habitats, biocenoses, biomes, etc.) of a particular region or nation and the species composition of the ecosystems.
- *Genetic resources.* Projects that aim to protect genetic materials with current or potential economic value.

For each kind of project, the Committee identified four categories of criteria for evaluation:

- *Biological criteria.* Criteria (questions) to determine whether a project has attained (or might attain) its immediate conservation-protection objectives.
- *Social and economic criteria.* Criteria (questions) to determine whether a project is integrated into the social, political, and economic life of the country or region and to elicit analysis of the long-term benefits of the project and its potential for the protection of diversity.
- *Institutional capability criteria.* Criteria (questions) to determine whether a project improves the regional or national institutional capability, self-sufficiency, and potential for maintenance of the project's objectives far into the future.
- *Linkage criteria.* Criteria (questions) to determine whether a project's leaders are sensitive to the need for, and effective in, coordinating the project with regional and international programs for the protection of biodiversity, natural resources, and the environment.

By constructing a matrix of kinds of projects and categories of evaluation (see Figure 1), we were able to identify critical elements for the development of system guidelines and criteria for evaluating biodiversity projects. On the basis of the matrix, the Committee identified persons with expertise in

biology, economics, social sciences, and development to assist in creating the guidelines and criteria requested by A.I.D. The experts then participated with the Committee members in a 2-day workshop, "Criteria and Procedures for Evaluating Programs to Conserve Biological Diversity," which was held on June 1-2, 1988, at the National Zoological Park in Washington, D.C. (see Appendix A). At the workshop, participants were deployed in four teams, one for each type of project. Each team was asked to generate criteria for each of the four categories of evaluation, as defined above and shown in Figure 1.

After the workshop, the Committee drafted this report, using the output of the workshop. This report itself, although reflecting the materials produced in the workshop, is entirely the responsibility of the Committee.

As stated above, the charge was to develop criteria for evaluation and monitoring of projects. There is, however, a great deal of overlap of procedures used to monitor projects in progress, to evaluate project proposals, and to evaluate completed projects. For example, a project in Africa might be intended to measure the impact of poaching on elephant populations. Such a project clearly would require the monitoring of the populations. Reviewers of the original proposal should ask whether the authors of the proposal have considered how they will monitor the elephant populations. Those evaluating the project after its completion should ask whether all elephants in the populations were counted and, if not, whether the sampling procedures were appropriate.

Acknowledging these kinds of overlap, the Committee agreed that the drafting of three lists of criteria (checklists or questions)—for reviewing proposed projects, monitoring active projects, and evaluating completed

| KINDS OF PROJECTS | BIOLOGICAL CRITERIA | SOCIAL & ECONOMIC CRITERIA | INSTITUTIONAL CAPABILITY CRITERIA | LINKAGE CRITERIA |
|---|---|---|---|---|
| ECOSYSTEMS AND HABITATS | | | | |
| SPECIES | | | | |
| HABITAT CLASSIFICATION AND INVENTORY | | | | |
| GENETIC RESOURCES | | | | |

FIGURE 1 The conceptual matrix used by the Committee to organize the workshop and to generate the checklists to be used for monitoring and evaluation of biodiversity-related projects. The Committee members and workshop participants were asked to produce questions that are appropriate for each cell of the matrix. The chapters of this report follow the order of the "Kinds of Projects."

projects—would be redundant. Instead, the Committee decided to produce only one set of criteria and to point to the existence of elements common to the three activities. For example, an A.I.D. officer using the checklists to evaluate a particular project might discover that the project had failed to take into account some aspect of linkage with conservation organizations. He or she might be reluctant to approve future projects, unless they addressed the appropriate linkages explicitly.

The approach, therefore, has been to produce multipurpose checklists of questions that can be used to:

- Review potential projects.
- Guide the monitoring of projects.
- Evaluate completed projects.

Checklists are necessary but not sufficient for the evaluation of specific projects. Checklists constitute only the first step, and they will have to be adapted and fitted to the particular conditions and objectives of each specific project. For example, if one were asked to provide evaluation criteria for a conservation project in a deep tropical lake, one would need a detailed protocol outlining specific kinds of sampling regimes (water chemistry, physical measures, plankton, macrobiota, etc.) and statistical analyses of the data. Clearly, it was impossible for the Committee to develop such a protocol for each of the projects that A.I.D. might sponsor. Experts might have to be called on for that purpose, if the scope and conservation importance of a project justified the expense.

Notwithstanding those caveats, the Committee feels that the checklist approach, as a first step in review or evaluation, has the virtue of comprehensiveness even if it lacks specificity. In the design of a project, omission of a major component of evaluation (e.g., involvement of local institutions) could be more dangerous than failure to include a particular procedure. In any case, it would be inappropriate for the Committee to attempt to produce a comprehensive manual for evaluation, given the variety of ecosystems and projects in which A.I.D. is involved.

As a general rule, evaluation should be simple and inexpensive, and it should not require a large investment of time. Even if expert consultants are recruited, an evaluation based on a few indicator species or on some simple bioassay is likely to be preferable to an exhaustive accounting. Evaluation procedures developed during or after a project are no substitute for advance planning. It is important that procedures for evaluation be written into the proposal itself and thereby be subject to review.

Finally, the Committee emphasizes that not all the questions in the checklists will apply to every project. Some judgment on the part of the evaluators in using a checklist approach is always necessary.

## ORGANIZATION OF THE REPORT

Chapters 1 through 4 are in order of the subject-matter headings in Figure 1. The checklists in each chapter include questions designed to address all four kinds of evaluation criteria. In adopting this structure, the Committee has explicitly acknowledged the social and political matrix in which all conservation programs are imbedded. The Committee has taken the position that project evaluation, to be useful, must consider all four kinds of criteria.

For each project type, evaluation criteria are provided in the form of questions. With the exception of Chapter 5, the questions are grouped to reflect the four categories indicated in Figure 1: biological, social and economic, institutional capability, and linkage.

It must be stressed that there is no "correct" answer to each question. Not all questions will be appropriate to all projects. Because responses to the questions will always be contextual, the rejection or termination of a project because of a "wrong" answer is an unsound practice. Each project should be assessed individually, within its own biological and social context.

## EDUCATION AND TRAINING

The Committee did not specifically address projects in education, of either professionals or the general public. Nevertheless, it is the Committee's view that the appropriate education of those constituencies is essential to the success of projects in the listed categories. Appropriate education should be a part of every project intended to protect or enhance biodiversity.

The conservation of biodiversity in tropical countries and the effectiveness of development assistance depend on the availability of a cadre of professionals and managers with adequate training and technical experience. Many countries (e.g., island nations in the Caribbean and small mainland nations in the Caribbean Basin) have few if any people qualified to do the work of inventory and conservation and to staff the institutions charged with conservation and resource management. Often, positions are occupied by persons who lack training and experience.

The problem is severe. Time after time, development assistance efforts have failed solely because no trained persons were available to carry on the tasks set by development projects and to ensure their continuity. In many cases, no permanent full-time staff positions are available. In fields related to conservation, these positions are often the first to be cut back or permanently eliminated. Job security for persons trained in conservation of biodiversity is often ephemeral at best.

Development assistance will always have to emphasize training and professional development as prerequisites for natural resource management

and conservation of biodiversity. Biodiversity conservation projects must include more than token efforts to train local persons and to ensure that in-country career-track positions are maintained or created for them. This requires institutional support. Such emphasis is essential if there is to be any success in conserving natural resources and biodiversity in developing countries.

For each of the project categories that follow, evaluators should determine whether appropriate educational and training components have been included. In addition, projects designed exclusively to provide education about the importance of biodiversity to human well-being should be encouraged and supported at all levels and in all countries.

# 2
# Ecosystems and Habitats

## THE GENERAL PROBLEM

Habitat and ecosystem degradation and, ultimately, destruction result from at least five forms of human activities:

- Outright destruction or fragmentation—in the case of terrestrial communities, the process usually involves the removal or radical modification of vegetative cover, such as clearing for farms, plantations, ranches, or housing.
- Overexploitation of plant or animal species, such as cutting for timber and fuel, and poaching of wildlife.
- Introduction of exotic substances or species that adversely affect the system, e.g., sediments and pollutants in coastal marine systems and weed or predator species that are difficult to control in terrestrial systems.
- Loss of indigenous knowledge, management techniques, and practices developed over millennia.
- Discharge of greenhouse gases and other air pollutants, deforestation, and other activities that cause regional or global climatic, oceanic, and atmospheric changes.

In developing criteria for ecosystem and habitat conservation, social, political, and environmental issues must be considered in the context of a comprehensive system, not as individual or isolated issues (Agee and Johnson, 1988). Over the long term, ecosystem and habitat conservation often must be integrated with other programs and objectives on a regional scale. A.I.D.'s current strategy emphasizes the incorporation of conservation into mainstream agricultural and rural development activities and the assistance of host countries in developing the ability to sustain important natural resources. Therefore, criteria for evaluating a project designed to protect ecosystems should consider explicitly the effects of development activities. Unless the primary concerns of people and governments—e.g.,

food, water, energy, development, health, and housing—are somehow linked to the project, the modestly funded conservation activities in the developing countries might themselves be unsustainable (M. Kux, 1986, unpublished manuscript; World Commission on Environment and Development, 1987).

## AN INTEGRATED APPROACH TO THE EVALUATION OF BIODIVERSITY PROJECTS

The evaluation of proposals should consider the sensitive status of tropical biomes. Not only are they the depository of most of the world's biodiversity, but it is generally conceded that continued deforestation in the tropics will contribute to unwanted changes in the world's climate. The matter is exacerbated by our lack of knowledge of tropical community ecology.

Traditionally, threatened or endangered habitats are sustained through some form of protection, as in national parks or similar reserves, usually established without regard to the welfare and concerns of the burgeoning human populations that surround them. The traditional approach can be improved through the use of scientific knowledge and experience to anticipate the destructive results of policies and practices and to encourage policies and actions that rationalize land use, sustain natural resources, and improve human living conditions.

An international program that promotes an integrated approach is the Man and the Biosphere (MAB) Program of the United Nations Educational, Scientific and Cultural Organization (UNESCO). It includes an international network of "biosphere reserves." A.I.D should encourage host countries, as appropriate, to participate in international biosphere reserve programs.

Ideally, the reserve managers, local officials, scientists, and persons who live in or near the protected habitats work together to find ways to sustain their natural resources. A useful mechanism for outlining or defining an integrated approach, in a broad sense, is the formal Country Environmental Profile now required by A.I.D. for all target countries.

Another useful tool is the National Conservation Strategy (of the International Union for the Conservation of Nature and Natural Resources (IUCN)), which involves government agencies, private interests, and the community at large in analysis of natural resources issues and assessment of priority actions (Agee and Johnson, 1988; M. Kux, 1986, unpublished manuscript; World Commission on Environment and Development, 1987). A.I.D.'s Country Environmental Profile and IUCN's National Conservation Strategy, when done sequentially, are especially effective in this regard. Such an open and holistic approach by itself, however, is not enough.

What is needed now is a global monitoring system and a worldwide network of research sites for early detection of problems related to habitats and ecosystems. That is a goal of the Man and the Biosphere Program and of the International Geosphere-Biosphere Program (IGBP) (Dyer et al., 1988).

Global monitoring, however, will still not be sufficient; monitoring must also be carried out at the regional, national, and local levels. The choice of a monitoring system will depend on the habitat in question—e.g., fresh water, estuarine, marine, or terrestrial—but most terrestrial and some aquatic habitats can be monitored with an appropriate combination of remote sensing and ecological observation and studies. Monitoring should not be thought of as an end in itself; it must be followed by analysis and, where indicated, by corrective action.

## SOME ECOSYSTEM CATEGORIES

Criteria for evaluation and monitoring must be appropriate for the ecosystem of concern. The more narrowly defined the ecosystem, the more specific the criteria can be, in part because different systems are subject to different threats and hazards. This section summarizes the most important problems associated with certain kinds of ecosystems.

### Freshwater Systems

Freshwater systems—rivers, streams, lakes, marshes, swamps, and other related wetlands—are extremely vulnerable to pollution and to modification through damming, draining, or irrigation schemes. Tropical freshwater systems are also vulnerable to the effects of introduced fish.

### Coastal and Marine Systems

Coastal and marine systems such as mangroves, seagrass beds, and coral reefs contain critical habitats for fish, shellfish, and other marine life. Many coastal ecosystems are highly vulnerable to physical disruption, siltation, pollution, and overexploitation.

The main problem associated with mangroves is clearing. The most useful criterion for evaluation of protection measures is the number of trees of a given height or diameter left standing in specific, permanent plots.

The problems for coral reefs include siltation, dynamiting and poisoning for fish, spearfishing, collection of shells and corals, and destruction of the reefs by divers and waders. The criteria for effective protection should reflect those problems. Fish censuses of conspicuous indicator species might be used as criteria for the overall health of a reef. Censuses should be conducted both in protected areas and on adjacent public portions of the

reef. Coral and mollusk abundances are less easily ascertained, because of difficulties in identification and cryptic habits, and will therefore require greater effort, expense, and training for census-taking. To see whether populations of keystone species are stable or increasing in protected areas, evaluation should probably take place once a year, beginning with a baseline census when protective measures begin. Censuses should also be conducted in control areas—where protective measures have not been taken and which are at some distance from protected plots.

For other shallow-water environments, overfishing is a chronic problem in many areas, as is overcollection of shells and of invertebrate food organisms. If a project is of sufficiently large scope, censuses of conspicuous indicator species should be carried out annually in protected and nonadjacent, unprotected control sites. Some guidelines for the selection of marine systems are provided in Appendix B.

## Terrestrial Systems

Terrestrial systems are broadly divided into tropical and temperate systems and subdivided into such categories as arid and semiarid lands and subhumid and humid tropical forests. These can be further subdivided into a great variety of biomes or ecosystems on the basis of plant assemblages, reflecting unique species compositions, and then into functional ecosystems or biotic regions that reflect adaptations to regional climatic, hydrological, and soil conditions. Generally speaking, we can identify several tropical terrestrial habitats on the basis of mean annual rainfall: multilayered closed-canopy tropical evergreen forest, open-canopy semideciduous dry forest, savanna, and xeric to desert habitats.

Census efforts should be designed to assess the current status of ecosystems and the effects of management interventions. Census techniques have been worked out for both forest and savanna habitats, and manuals for instruction of students are available (Avery, 1975; Davis, 1956; National Research Council, 1981; Salm and Clark, 1984). Suitable control areas will have to be developed in conjunction with experimental plots. Aerial censuses are required in open habitats, whereas line transects are often used in forest habitats. Vegetation can be assessed with variations of the quadrant technique, and instruction in this technique can be found in readily available manuals (Daubenmire, 1947; Pandeya et al., 1968; Schemnitz, 1980).

Although this discussion has emphasized the tropics, temperate and montane systems should not be ignored. Many developing countries have temperate habitats. In addition, biologically diverse sensitive montane habitats occur in many tropical countries. Many such regions are subject to extreme deforestation and to the erosion, siltation, desertification, and flooding that inevitably accompany it. Furthermore, many temperate or

montane regions contain valuable genetic resources, such as wild relatives of potatoes, maize, tomatoes, wheat, coffee and barley. And they often have especially high concentrations of species that occur nowhere else (i.e., they are locally or regionally endemic).

The replacement of natural forests with village silviculture or with single species forest plantations, such as teak, eucalyptus, and Monterey pine, frequently provides little or no habitat for native plants and animals.

### Oceanic Islands

Perhaps no habitats are at higher risk than oceanic islands that have been visited or colonized by humans. The floras and faunas of those islands are unique and constitute living laboratories for scientists. Native flora and fauna have been broadly eliminated from many oceanic islands (for example, Hawaii) and replaced with exotic species. Island habitats should be subjects of special concern.

## CRITERIA FOR PROJECT EVALUATION

### Biological Criteria

Regardless of the main objectives of a project, some general kinds of information are almost universally needed. An important first step for every project manager is to identify both international and host country institutions and specialists that can provide information.

Basic ecological data are essential, although the detail needed will vary with management objectives and problems and with available manpower. However, it is essential to know what ecosystems are present, where they are, and the direction and rate of their change (Franklin, 1978).

To monitor changes, initial inventories of major ecosystems should be supplemented and repeated. The intervals for monitoring should be based on such considerations as the rate at which an ecosystem is likely to change and its importance in maintaining biodiversity in its area. A few good observations and records made annually in selected areas that are most likely to change might reveal important trends in the structure or function of an ecosystem, and in its ability to maintain biodiversity.

Managers may need detailed information on the conditions in some locations, particularly where human activities are concentrated and where rapid biological changes occur, owing to either human or natural causes. Often, simple photographic records of monitoring sites or along observation routes can show important changes. Aerial photography should also be considered for problem areas or areas of special interest. For large areas, remote sensing should also be used regularly to observe changes in ecosys-

tems. Remote sensing offers flexibility, wide range of application, and low cost, compared with ground surveys.

The following questions are relevant:

- What kinds of ecosystems are present (classification)? Have the ecosystems and habitats in the area been identified and described? If the information is inadequate, how is new information to be acquired?
- Has the distribution of the ecosystems been mapped? Where are they? Do maps show the locations of the vegetation types and important habitats?
- What are the biological and physical characteristics (e.g., characterizations of biotic composition and climate) of the ecosystems?
- What are their dynamic properties (rates and direction of change)? Periodic monitoring of changes in ecosystems, and at the transitions between important ecosystems, is essential.
- Have major influences that can affect the ecosystem or its habitats been identified outside the project area?
- Have neighboring habitats that can be used by valuable species as feeding areas been identified? Have other critical habitats that could be linked with the project area been identified? Can cooperative arrangements be made to achieve common objectives of management?
- Have areas that can serve as buffer zones with respect to the core project habitats been identified or planned? How can buffer and multiuse zones be established that will help to protect the core habitats while the needs of local people are accommodated?
- Have regional strategies been developed, especially where habitats and natural resources are intimately linked and shared, such as coastal and marine habitats?

The questions in the following checklists should be applicable to most wildlands and natural systems. They should be useful at any stage in the development of a project, from initial review to final evaluation. As stated elsewhere, it is virtually impossible to develop a comprehensive list of such questions; natural systems are too heterogeneous. Experts on particular systems could add specific questions that are relevant to particular countries, regions, habitats, or protected areas.

### Adequacy of the Information Base

- Is the information base up to date? Components of the information base might include:

—Satellite imagery and aerial photos.
—Pre-existing surveys of fauna and flora.
—Locations of human communities.
—Knowledge of encroachment rates, pressures.
—Degree of threat to ecosystem.
—Locations of populations of endangered species.

- Has the project been evaluated according to the following criteria?
  —Habitat variety.
  —Level of endemicity.
  —Unique habitats.
  — Species richness.
  —Unique genetic stocks that will be lost if not protected.

**Projects Related to Designation of Particular Areas for Protection**

- Is the project representative of an important or threatened ecosystem?
- Is it of adequate size to maintain existing diversity? What criteria were used to make this decision?
- Are proposed boundaries defensible? Do they take into account present or future patterns of encroachment?
- Is the area exposed to effects of upstream disturbance and pollution and downwind transport of aerial contaminants?
- Are key species, such as top predators, missing or depleted? If so, should they be reintroduced or restocked?
- Is the ecosystem self-contained? Are introduced or migratory species, etc., important to its integrity?

**Projects Related to Management and Protection of Established Conservation Units**

- Is there adequate baseline information for monitoring (e.g., aerial photographs of the habitat, fauna surveys, counts of flagship or endangered species, censuses of human communities, assessments of water quality, data on poaching and other encroachments)?
- Has management resulted in reduction in encroachment, poaching and illegal extraction of natural resources?
- Are populations of key species (e.g., endangered mega-fauna and top predators) stable or increasing?
- Is the quality of the habitat stable or improving?
- Is the desired balance of habitats (e.g., forest vs. savanna) being maintained (e.g., via controlled burning)?
- Are exotic and pest species under control?

- Is the monitoring program adequate for continued assessment of environmental change?

## Social and Economic Criteria

The long-term maintenance of ecosystems and biodiversity can be accomplished only with the participation, support and cooperation of the host country and local populations. To stimulate participation and support of local populations, educational programs and national policies and development plans for the maintenance of natural ecosystems and biodiversity must be encouraged. Land-use planning and resource allocation policies are essential in devising conservation strategies that are compatible with development. However, the pressures on natural ecosystems and habitats will continue to increase as human populations increase, so particular attention should be given to integrating conservation projects with development assistance projects to meet the needs of people.

The establishment of a protected area does not necessarily imply the total prohibition of commercial activity in the area. Properly designed projects that include carefully limited development should be supported. Examples of controlled resource exploitation include agroforestry, limited tourism, controlled harvest of wild plant and animal species, and other practices designed to provide a sustained yield with minimal negative impact on ecosystems and their constituent species.

In some cases, the maintenance of biodiversity will require that abusive activities of the human population be curtailed. That might be accomplished through incentives for cooperation and some form of regulation. If the problem is overexploitation, demonstrations with experimental and control plots can often be an effective way to show benefits of the project and enlist cooperation. These are some important questions:

- Is the biodiversity of the project area placed at risk by the extraction of goods and services (e.g., water, fuel, building materials, and food and medicinal plants)?
- What alternatives have been developed to meet the needs of people if the natural resources of the project area are strictly protected?
- If the project site has religious, historical, artistic, or other cultural values, how are these values protected? Is the area zoned and managed to minimize conflicts in uses?
- How are local people involved in the project planning and implementation?
- How will local or indigenous people benefit from the project?
- Do local people receive a substantial fraction of user fees or other income derived from the protected area? Do existing institutional

and social structures provide for effective use and distribution of such fees?

- Will the survival of indigenous people and their cultures be compromised by the project?
- On a regional scale, are the "victims" of a project compensated by the beneficiaries?

## Institutional Capability Criteria

We have already indicated that a national policy aimed at maintaining biodiversity is essential. The objectives of a project should be clearly defined in a site-specific management plan; the best ecological information can be of little use without clear management objectives. Ecological information can show what is present in an area, how it is changing, and possibly why. Such information can also indicate biologically feasible options, constraints and dangers, and alternative strategies to achieve the objectives once they are clearly defined.

Beyond that, the principles of maintaining biodiversity and the benefits of sustained yields must be transferred to the indigenous peoples who exploit the land directly via some "grass roots" program. Education programs should ideally begin at the primary-school level and continue throughout the various life stages. Equally or more important, however, is training of teachers and agricultural extension workers. Finally, the training of students from the host country is essential for the continuity of environmentally sensitive efforts in conservation and development.

The following questions are designed to assist in the evaluation of research proposals and projects:

- Will the results of the research be of benefit to conservation efforts and to host-country institutions?
- Does the research hold promise for implementation of the following?
  - —New conservation strategies and policies.
  - —New technologies for sustainable use of natural resources.
  - —Improved methods for environmental monitoring.
- Does the research involve host-country students and institutions?
- Do host-country students benefit directly through opportunities to conduct research leading to theses or professional certification?
- Does the research lead to increased information flow or transfer of technologies?
- Were the results published in appropriate technical journals?
- Were the results and conclusions disseminated in the host country, including the popular media and schools?

## Linkage Criteria

National agencies—such as the ministry of education, ministry of agriculture (especially the departments of forestry, fisheries, and wildlife), development planning units—will have to be encouraged to form liaisons that transcend traditional bureaucratic boundaries; that could be a formidable task.

Whenever possible, biodiversity projects in ecosystem or habitat protection that involve a monitoring component should relate to or be linked with local, national, and international programs (see Appendixes C and D).

Whenever possible, biodiversity projects should be compatible with projects of other development sectors, e.g., agriculture, rural development, nutrition, health services, family planning.

The following questions are intended to aid in the evaluation of projects related to conservation planning:

- Is the project consistent with the country's environmental profile?
- Is the project consistent with the IUCN master plan or the National Conservation Strategy?
- Are the host-country government organizations and nongovernment organizations (NGOs) involved?

# 3
# Species

It is critically important for efforts in conservation of biodiversity to include projects focused on individual species. Much of the relevant conservation legislation and many international agreements are based on the conservation of individual species. Moreover, species—especially "flagship" (popular) species—are in many ways the best vehicles for conveying the issue of conservation to the general public. They are also important symbols in awareness and education programs in both the developing and the developed world. Finally, it is essential to recognize that conservation of biodiversity consists of the conservation of species and the genetic resources they represent. That is not meant to detract from the great importance of habitats and ecosystems and of the ecological processes they maintain.

It is widely acknowledged that limited resources will often require the abandonment of an endangered species project in favor of projects that will produce greater overall benefits. On the other hand, species cannot be protected in situ without attention to habitat, so it is imperative to link species and ecosystem conservation.

Given the wide variety and scope of species-focused projects that might usefully be supported, it is extremely difficult, if not impossible, to suggest detailed recommendations on the types of data that will be required for project evaluation. Consequently, project review guidelines should be developed specifically for species-focused proposals. Specific issues—including types of data to be gathered and reported, analytical procedures, etc.—should be recommended or reviewed by independent experts. For the same reasons, project evaluations might often require the involvement of independent experts. Numerous sources of expertise are available both within U.S. government agencies (e.g., Fish and Wildlife Service, Fisheries Service, Smithsonian Institution, Forest Service, Agricultural Research Service, and National Park Service) and in the professional conservation community [e.g., IUCN Species Survival Commission (IUCN/SSC), Society for Conservation Biology, World Wildlife Fund, International Board for

Plant Genetic Resources (IBPGR), and International Council for Bird Preservation]. (See Appendix C.) The involvement of appropriate expertise in proposal and project evaluation need not entail a substantial administrative or financial burden.

## BIOLOGICAL CRITERIA

### Choice of Species to be Protected

- Is the species recognized as endangered, threatened, or vulnerable, either locally or throughout its range, as noted in the Fish and Wildlife Service's "Endangered Species List," IUCN/SSC action plans, or other relevant plans?
- Is the species rare or locally endemic?
- Is the species critical to the long-term viability of other species? (I.e., is it a *keystone* species?)
- Will protection of the species provide for the survival of many other species through protection of their habitat? (I.e., is it an *umbrella* species?)
- Does the species have high value for public awareness and political and financial support? (I.e., is it a *flagship* species?)
- Is the species representative of a community or ecosystem that is of high conservation concern, as recognized in IUCN systems reviews or other studies?

### Project Effectiveness

- Has any attempt been made to determine the long-term population viability of the focal species in the park, reserve, region, or country with modern approaches that incorporate demographic, environmental, and genetic considerations?
- Is the project activity identified in an IUCN/SSC species action plan or other global conservation action plan?
- Did the project maintain or restore the natural distribution of the species?
- Did the project reduce fragmentation of the habitat or populations?
- Did the project maintain or expand population sizes in the remaining habitat?
- Are the census differences (before project vs. after project) statistically significant?
- Has the population reached or surpassed local carrying capacity?

- Have factors placing the species at risk been identified and addressed? These factors might include:
  - — Habitat destruction.
  - — Habitat fragmentation.
  - — Poaching.
  - — Pollution.
  - — Trade.
  - — Disease.
  - — Predation or other interspecies interactions.
  - — Other.
- During the project, was overall status of the species improved? If not, why not? If not, could anything be done about it?

## SOCIAL AND ECONOMIC CRITERIA

- Is conservation of the focal species considered important in the host country by:
  - — Local communities?
  - — National government?
  - — General public?
- Were surveys conducted on local and national levels before and after the project to determine human attitudes toward the species and its habitat?
- Has the actual or potential economic importance of the species been investigated, e.g., for food, medicines, fibers, other consumer products, industrial materials, recreation and tourism, or genetic engineering?
- Has the project increased the economic contribution of the species to the national economy, e.g., through tourism, exports, or local cottage industries?
- Did the project increase net income, employment, and availability of goods and services for the local population? Did it ensure sustainability of these values?
- Did the project increase or maintain sustainable harvest of the species?
- Did the project maintain the option for traditional life styles or traditional uses of the species?
- Did the project meet human needs, as defined by local communities or at regional or national levels?

## INSTITUTIONAL CRITERIA

- Was the project adequately coordinated with host-country institutions and communities, e.g., the wildlife ministry, other ministries, local nongovernment organizations?
- Has the project improved the ability of local institutions (public and private) to carry out similar projects in the future?
  — What percentage of the project budget involved training personnel? How many people? How many person-days at what levels? What skills do they have now that they lacked before? How has this helped the host country?
  —Did it provide needed equipment?
  —Did it improve local fund-raising capacity or long-term financial support?
  —Did it improve international cooperation for species conservation? If so, how?
- Has the project contributed to effective host-country participation in relevant international conservation programs and conventions, e.g., RAMSAR Wetlands Convention, Man and the Biosphere Program, International Union for the Conservation for Nature and Natural Resources, Convention on International Trade in Endangered Species, and World Heritage Convention? (See Appendix C.)
- Will host-country institutions be able to maintain the success of the project without outside financial and technical assistance? What continuing assistance (technical, financial) might be needed?
- Does the project contribute to the establishment or implementation of a national policy, program, or strategy for the conservation of biodiversity?
- Was the project constrained by lack of support from government agencies or authorities?

# 4
# Habitat Classification and Inventory

Most developing countries do not have adequate information and biological data for planning effective conservation action, setting conservation priorities, or avoiding conflicts between development and conservation. It should be a primary task in many developing countries to gather and analyze information on diversity, systematics, geographic distribution, and ecological relations of the biota as quickly as possible. Assistance in such inventory activities properly falls within the A.I.D. mission.

The great majority of species and ecosystems can be conserved only in place (in situ) and through land management systems that allow the retention of major natural or seminatural areas. The identification of critical ecosystems and the country-wide analysis of ecosystem coverage (gap analysis) aimed at conserving the full array of biodiversity in tropical countries are two specific activities that A.I.D. can support within the framework of development assistance (see U.S.A.I.D., 1985, recommendations 37 and 32).

The participation of nongovernment organizations (NGOs) in inventory projects is highly desirable. The benefits include quality control, performance monitoring, and linkages with and support of the private sector.

Several reports with specific recommendations about data collection and inventories have been produced in recent years. They are *U.S. Strategy on the Conservation of Biological Diversity* (U.S.A.I.D., 1985), *Recommendations for a U.S. Strategy To Conserve Biological Diversity in Developing Countries* (World Resources Institute, 1984), *Conserving International Wildlife Resources: The United States Response* (U.S. Department of State and U.S. Department of the Interior, 1984), *Technologies to Maintain Biological Diversity* (OTA, 1987), and *Research Priorities in Conservation Biology,* (Soulé and Kohm, in press).

Preliminary inventories are needed in many developing countries to locate and describe regions with unusually high species richness or endemism. The level of detail in such inventories will depend on the quality and geographic resolution of available ecological information on those

countries. Most urgently needed are permanently operating biodiversity centers in each country (or multiple centers in larger countries) which can cumulatively amass and analyze the needed information and put it into use in conservation and development decision-making. Resource centers should operate at several levels or scales of analysis, with an inverse relationship between geographic scale of coverage and degree of detail. An entire country or region should be examined superficially at first, and later investigations should be more thorough as time, resources, staffing, and available information allow.

Broad-scale analysis of ecosystem coverage and vegetation, with adequate ground-truthing (verification, by direct observation, of data obtained by remote sensing), is the first step. This should be followed by in-depth inventory and monitoring to provide the data sets necessary for choosing conservation actions. Levels of inventory include major ecosystem analysis and ground-truthing, species inventories of major ecosystems, and establishment and monitoring of permanent plots. The latter provide increasingly detailed information that can be used in conservation and development planning and is essential for managing protected areas. The "long-term memory" of the process must be vested in national and regional institutions such as conservation data centers, natural-resources agencies, and botanical gardens.

Currently, there are attempts to develop some universal standards and protocols for inventorying and monitoring. To facilitate comparability it is essential that future projects follow such guidelines. It is also essential that data be accessible. Standardization of data formats and of database management systems must be components of universal standards and protocols.

Preliminary inventories should be made and presented in the context of global, regional and national conservation priorities. Inventories should be part of a broader conservation strategy and not be developed for their own sake. Similarly, steps need to be taken from the beginning to link the inventory process and data-center outputs to the broader process of national planning and economic development and to the management of protected areas.

Projects in biological inventorying can be more easily evaluated if properly designed. The project description must state what is intended to be accomplished, as well as the importance of specific project activities to biodiversity conservation, their relationship to other development work, and the institutions through which they are to occur. Project proposals should address the following questions:

- Will inventories and data collection be cumulative, iterative, and self-correcting?
- How will universal standards and protocols of data collection, formatting, storage, and retrieval be implemented?

- How can results at all stages be applied to decision-making?
- How can results be incorporated into existing institutional structures and procedures (i.e., so that results will not be lost over time or buried in distant libraries)?

If the objectives and methods are clearly stated, self-evaluation should be an integral part of the project. Interim and final reports can state the degree to which the expected results are being or have been attained. In addition, reports should describe design failures and changes and describe unexpected results. Further evaluation can be limited to spot-checking by staff (or outside contractors if necessary) of the accuracy and veracity of claims made in project reports. However, in reviewing projects for effectiveness and the degree to which stated objectives are achieved, specific questions can be considered, as outlined below.

## BIOLOGICAL CRITERIA

- Does the project build on previous inventories, so that the base of information can be continually refined and applied in conservation programs? Is there a narrative overview of all prior inventory activities?
- Do the results of the project contribute to the setting of broad conservation priorities and help to identify further specific conservation actions in the country or region? For example, do the results help in identification and planning of new localities for conservation management or sustainable use of natural resources?
- Has the inventorying effort included species and ecosystems that are considered to have high priority (indicator species, critical ecosystems, etc.)?
- Do the results of the project contribute to an analysis of national and regional ecosystem conservation priorities? If not, can the project be modified so that its results will do that?
- What collection procedures are being used? Are biological specimens being deposited in local repositories, in addition to foreign institutions? Can local institutions handle the acquisitions and manage them properly? What assistance do they need? Have the necessary collection and research permits been obtained, and has the project forwarded full progress reports and data to the host-country institutions involved?
- Are the research results available in the local language? If not, have summaries of the results been produced in that language and widely disseminated?

- Does the project include mechanisms for transferring relevant information to managers of protected areas?

## SOCIOECONOMIC, INSTITUTIONAL, AND LINKAGE CRITERIA

- Has the project included training of local persons in inventory methods, data collection, filing, archiving, ecosystem gap analysis and conservation decision-making?
- Has the project assisted local efforts in conservation education? If not, can it be modified to assist such local efforts and build local support for conserving biodiversity?
- Does the project help in the building of local institutions, particularly natural-resources agencies, forestry and conservation departments, conservation data centers, and nongovernment organizations? Have efforts been made to ensure that those institutions benefit directly from the output and activities of the project? Do local institutions benefit by receiving tangible goods (vehicles, field and laboratory equipment, computers, publications, etc.)?
- Are the project results relevant to development planning, to the welfare of people in the region, and to local economic development? Do the inventory results have applications locally, beyond being a general contribution to the body of ecological knowledge of the region?
- Does the project enhance continuity of the inventory process and other similar efforts in the region? Is there provision for ensuring that the results are disseminated and used, especially locally and nationally?
- What direct links are there between the project and other inventory efforts, especially those of local and national institutions? Does the project enhance or compete with those efforts? How can they be made mutually supportive?

# 5
# Genetic Resources

"Genetic resources" refers to plants and animals that are likely to harbor valuable germplasm (i.e., elements of biodiversity that have known or potential economic value). In the case of plants, such resources can be found in wild species, including wild ancestors of domesticated species and weedy or semidomesticated relatives in both ancient and modern lines, cultures, and stocks (e.g., landraces of traditional crops).

The following guidelines are intended to direct the evaluation and monitoring of projects aimed at conserving genetic resources of useful or potentially useful plants and animals. Among the projects that might be included in this category are surveys of genetic resources, support of collections and of facilities, maintenance and replenishment of the collections, and conservation of the resources on site. The criteria elaborated here are intended for preproject evaluation, project monitoring, and postproject evaluation. Three general types of criteria are important at each step: the value of the resources, the degree of threat, and the likelihood of success in bringing about genetic resource conservation.

## VALUE OF GENETIC RESOURCES

Genetic resources can be valuable because of their present or potential use. It is easier to establish the economic value of resources that are already being exploited, but much genetic resource conservation is aimed at potential use, so value cannot be estimated precisely. The estimation of economic value is especially important in deciding whether to support a particular project for the conservation of genetic resources. The time frame for using genetic resources is very long. It might require 2 or 3 decades to incorporate particular genes from wild plants into domesticated ones. Moreover, the existence of particular useful genes cannot be established a priori. Their discovery is often fortuitous, although it occurs with sufficient frequency and impact to make conservation worthwhile. Therefore, a genetic resource

project cannot be realistically monitored or its results evaluated merely by measuring the added economic value of the resources.

Several guidelines might be useful in estimating value. They are related to the taxonomic and ecological uniqueness of the resources, their known importance, and their potential importance.

The uniqueness of a resource can be estimated by reference to its place in the taxonomy of a particular species or family of species. For instance, one species might be known as ancestral to others. Other unique characteristics are the ability to serve as a genetic link between cultivated and noncultivated relatives and the presence of polyploidy (changes in chromosome number).

Ecological uniqueness, a more general characteristic, is based on the relation of a particular species or family to particular environmental conditions, e.g., the ability of a subspecies to thrive in a particular habitat where the other members of the species do not, overall ecological diversity, or the success of a particular group of organisms in an area of known pathogenic or environmental stress.

The current importance of genetic resources can be established by the degree of use of the plant or animal species in question. Current use can be measured either locally or in distant areas where the species is used. It can be estimated in absolute economic or nutritional terms according to the amount of production or according to the number of people who depend on it. Utility can also be judged in relation to other products and their production; a minor resource might be critical to a larger production system.

Potential importance cannot be established with certainty or precision, but several guidelines can be applied. They include the known importance of related organisms and specific phenotypic characteristics: quantitative traits (such as yield), disease and insect resistance, drought tolerance, and broad adaptability. Nevertheless, it is impossible to anticipate exactly what traits will be considered desirable by the next generation of breeders.

## THREATS TO GENETIC RESOURCES

Genetic resource conservation is necessary in part so that the resources can be used in breeding programs to improve crops and livestock or to introduce new plants or animals into production. Conservation can take place either on-site or off-site. Decisions on whether to survey, collect, replenish, or maintain resources depend in part on the degree of threat. In assessing threat, three factors should be considered: the degree of endemism of a particular species or population, the extent and urgency of threat associated with human activity, and the minimal habitat, density, or population size for a species to be viable.

"Endemism" refers to a restricted geographic distribution of a popula-

tion. Degree of endemism is similar to the idea of uniqueness. The degree of endemism is an expression of how widely or narrowly dispersed a species is. Endemic species that are confined to very specific limited habitats are more threatened than more widely distributed endemic species. In estimating degree of endemism, it is necessary to establish the presence or absence of similar populations in different areas. Species without similar populations in other areas are inherently vulnerable.

Habitat disturbance and destruction constitute the most important threats to genetic resources. Examples are the clearing or modification of natural areas that contain wild or semidomesticated relatives of crops and domesticated animals and the introduction of exotic species or varieties that replace local species.

Those direct environmental changes are the result of underlying changes in human populations: population growth, incorporation of local markets into larger regional and national markets, changing consumption patterns, and the development of new technology. The pattern of environmental change should be understood as an expression of human and technological changes, and the degree of threat to genetic resources can be estimated in relation to them. This correlation of population and technological changes with past environmental change is important because it allows for the estimation of future environmental change. Several typical human and technological changes might be relevant to estimating the degree of threat to genetic resources:

- Rapid population growth and increasing population density.
- Rapid or anticipated economic expansion resulting from road-building, settlement, and new irrigation.
- Introduction of new technologies that are expected to replace existing local technology, including the introduction of new varieties or new crop species, which often lead to the displacement of older varieties.

The data sources necessary to document such changes and the ability to estimate their impact on genetic resources might not be developed, but project evaluation at all stages should seek some form of reference to the underlying causes of environmental change as a way to establish the degree of threat. Quantitative measures are preferable, but qualitative estimates suggested by local experts are also useful.

In determining the threats to genetic resources posed by population growth, habitat destruction, and technology, one cannot ignore such factors as the minimal habitat size, population density, and population size necessary to maintain viability of a local population. The estimation of these minimums is quite technical, and the methods are developing rapidly.

## LIKELIHOOD OF EFFECTIVE CONSERVATION

Criteria to evaluate the probability of success of projects in genetic resource conservation should be built into all the stages of such programs. There is no absolute human or biological means to ensure conservation, but four categories of criteria are helpful: institutional capability, linkage to other programs, economic and biological potential, and quality control. These categories differ somewhat from those in the previous chapters, because genetic resources are inherently economic resources and because their conservation depends on the maintenance of ex situ germplasm collections.

The institutional capability to accomplish genetic resource conservation cannot be absolutely or definitively established, especially because the time frame of the conservation effort is long. Four institutional characteristics are relevant in judging capability: extent of technical skills and expertise, longevity of the institution, quality of records, and stability of personnel.

Technical skills can be a matter of either training or experience, and they fall into a wide range of categories. Previous experience in survey, collection, replenishment, and maintenance is important. Some important skills are implied in the discussion of the assessment of value and threat. Skills and subjects that are particularly relevant include taxonomy, genetics, population biology, agronomy, reserve design, reserve management, collection management, reproductive biology, and data management.

Institutions and their records must persist for long periods if they are to be effective in genetic resource conservation. The expected persistence of an institution can be judged by its age, by its roots in the broader institutional structure of a country or region, and by the number of professional persons engaged in its activities. The longevity of an institution depends on its financial base. That base might be national or international sponsorship, but this is indefinite and often vulnerable. Long-range local support is preferable to short-term nonlocal support.

The stability of productive scientific personnel in an institution is a particularly useful way to estimate its capability. Rapid turnover suggests potential problems in managing the task of biological conservation. Stability is important because of the highly idiosyncratic nature of data and of the long time involved in evaluating genetic resources for use.

Linkage between institutions can be used to assess both the potential technical skills and longevity of an institution and its ability to be effective in conservation of genetic resources. Affiliations between local institutions and national and international institutions engaged in genetic resource conservation should be defined in both directions. Local institutions might depend especially heavily on linkage with larger agencies for technical skills training and funding support. Reciprocity is essential; national and inter-

national institutions might require linkage to local institutions to ensure access to information and to survey and collection sites.

A project evaluation should consider the potential benefits of the project for successful conservation of genetic resources. That is, benefit-risk studies are recommended. Efforts should be directed at species for which there is the greatest potential for gains in productivity or other values. It might be virtually impossible to avert the loss of genetic resources in some threatened species. For example, the seeds of some species are "recalcitrant" and cannot be stored with existing off-site maintenance technologies. Much tropical flora is of that nature.

Quality control should be specified in surveys and collecting for biological conservation. This quality control has to do with the information gathered and the method of recording for surveys and for the storage of material being conserved.

Before a survey (including preliminary sampling) of a set of genetic resources is attempted, the extent to which the resources are unique or threatened should be demonstrated. The justification of the survey should include any prior survey information available. On completion, the justification should be reviewed and if necessary modified by the investigators. The time frame for the survey should correspond with the period of the year when the resource to be surveyed is most abundant (e.g., at harvest). The same reasoning applies to surveys as applies to collections: it is more important to survey more distinct sites than to survey additional habitats at each site (Marshall and Brown, 1975).

Data collected must be adequate for the assessor to be able to answer the questions posed earlier in the report; excessive or irrelevant data will only complicate the process of evaluation. At a minimum, geographic data [altitude, latitude, longitude, universal transverse mercator (UTM) grid coordinates, and locality] and preferably climatic and ecological data should be recorded. For plants, slope, aspect (compass direction), and soil types should be included where appropriate. Recommendations for such basic descriptor data are published by IBPGR for many species of cultivated crops.

If the genetic resources being surveyed are subpopulations within a species, they should be characterized as to site-to-site differences. Those characterizations can be based on differences in ecological adaptation (as measured by climatic or ecological descriptors), in proposed transplantation sites, in electrophoretic properties, or in other biochemical properties. In most cases, even for plants or animals of economic importance, information on ecogeographic variation (on or near the site) is probably the most that can be expected. Local names and uses should be recorded whenever available.

If genetic surveys are to be conducted, adequate voucher specimens or

photographic records should be deposited or retained in appropriate repositories. Reports should be filed with the appropriate international centers or agencies. There should be plans for survey data to be published or deposited with appropriate scientific organizations in easily reproducible formats. The data should be of adequate quality to enable future or immediate decisions about needs to collect, preserve, or restore the species, populations, or habitats in question.

It is axiomatic that genetic resource collections should not be made unless they can be properly maintained. It follows that adequate facilities should be available and be staffed by properly trained personnel. In the case of flowering plants, for example, the requirements for successful seed storage of most species (low temperature and low humidity) are well known, as well as the need for periodic monitoring of seed viability. As a precaution, storage of duplicate samples is imperative. World storage facilities are available for many crops (Plucknett et al., 1987). Other aspects of proper maintenance include the following:

- *Rapid deposition of accessions after collection.* In the experience of plant collectors, seeds harvested in the wild can lose viability rapidly, particularly in the humid tropics. They should therefore be sealed with desiccants in small airtight containers during collecting expeditions and regenerated as soon as possible thereafter. Remnants and newly increased seed lots should promptly be placed in long-term storage.
- *Proper mating systems.* An understanding of genetic makeup of a species is essential to its proper maintenance. Strictly self-pollinating species are simply regenerated—if monomorphic (genetically homogeneous), from relatively few individuals. At the other extreme, obligatory out-crossing species must be increased by random mating in large populations to avoid loss of genetic variability and to prevent inbreeding (Crossa, in press). Partially outcrossed species constitute an intermediate situation. The probability of success of projects in this regard will hinge largely on the existence of necessary facilities and trained personnel and on the observance of the aforementioned guidelines. Proposals should be judged by the degree to which they meet these criteria.
- *Maintenance of genetic variation.* The primary goal of management of genetic resources should be the maintenance of the existing genetic variation within a species. Genetic variation must be considered at two levels: within local populations and between local populations. Two measures of genetic variation, average heterozygosity and amount of allelic diversity, are commonly used (see Frankel and Soulé, 1981, for definitions of these terms). Both must be considered in developing and evaluating a management

plan, and both can be used to assess the genetic variation within local populations. The more alleles present and the higher the degree of heterozygosity, the more variation is present within populations. Measures of genetic differences among populations can be expressed as qualitative differences (differences in alleles present) or quantitative differences (differences in allele frequencies).

Population sizes should be large enough for maintaining the existing amounts of heterozygosity and allelic diversity within local populations. Maintenance of small populations over one or more generations will have a much more serious effect on the loss of relatively rare alleles than on the loss of heterozygosity. Many other aspects of population management must be considered, because they can also affect the rate of loss of genetic variation (e.g., sex ratio and relative reproductive success of individuals). When feasible (e.g., with large mammals), pedigrees should be maintained so as to balance the contribution of individuals to a population and to minimize inbreeding.

Management plans should be based on the distribution of genetic variation, as determined by surveys. As many genetically different local populations as possible should be included. Those local populations that are genetically most distinct should receive high priority for inclusion in a management scheme.

In situ (on-site) conservation of genetic resources might be a useful complement to or substitute for ex situ (off-site) conservation in gene banks. In situ methods are less expensive for conservation purposes, assuming that just a few populations are involved, because they might require a lower level of management. However, they can be less desirable than ex situ methods if utilization is the immediate goal or if large numbers of populations must be separately preserved . For genetic resources contained in wild relatives, in situ conservation is essentially the same as the conservation of biodiversity in natural preserves. The objectives are to define areas of maximal diversity of wild relatives of economically useful plants and animals and to ensure the maintenance of viable populations of these relatives by protecting habitats.

The genetic resources in semidomesticated relatives and ancestral stocks are the product of the modification and management of ecosystems. Maintenance might coexist with technological changes that threaten genetic resources. That could come about through policies that encourage farmers to maintain traditional practices. Ordinarily, policies to maintain genetic resources in situ should not result in loss of production or income potential for farmers. In some instances, however, the value of genetic resources might have to be weighed against short-term interests of farmers. Long-term conservation goals might best be achieved through investment in public information and education about traditional crops and animals,

through research on ways to improve the productive performance of traditional crops and animals without decreasing diversity, through policies to stimulate marketing of traditional crops and animals, and through reconsideration of subsidies for products that compete directly with traditional crops and animals.

## EVALUATION OF PROJECTS AND PROPOSALS

- Do the genetic resources in question have substantial current or potential cultural or economic value?
- Are the targeted genetic resources vulnerable to extinction or significant disturbances?
- Does the institutional and technical capability exist to maintain the genetic resources?
- Will the genetic resources be adequately maintained?
- Will population samples of adequate size be collected without endangering the populations from which the samples are taken?
- Will duplicate samples be deposited with national and international agencies for backup?
- Will adequate voucher specimens (or their equivalents) be appropriately deposited? If so, where?
- Will adequate site data be recorded and made available?
- Do the genetic resources in question have features unavailable or scarcely available elsewhere?
- Are institutions available to maintain, evaluate, and preserve the newly collected materials?
- Do institutions have the necessary linkage to national and international programs and funding for genetic resources?
- Will information from previous surveys be used?
- Will farmers or other experts on the ecogeographic variation of the genetic resource be consulted?
- Will the results of the projects be documented by publication or international data banking?

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# Appendix A
# Participants,
# A.I.D. Biodiversity Criteria Workshop

**National Zoological Park**
**Washington, D.C.**
**June 1-2, 1988**

Fred Allendorf, Department of Zoology, University of Montana, Missoula, Montana

Peter Ashton, Arnold Arboretum, Harvard University, Cambridge, Massachusetts

Terry Erwin, Department of Entomology, National Museum of Natural History, Smithsonian Institution, Washington, D.C.

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# Appendix B
# Criteria for the Selection of Marine Systems for Biodiversity Protection

## BIOLOGICAL CRITERIA

The values of ecosystems and their species may be measured in the following terms:

- *Diversity.* The variety of richness of ecosystems, habitats, communities, and species. In selecting sites for protection, one should give areas with the greatest variety higher ratings. However, this criterion might not apply to simplified ecosystems, such as some pioneer and climax communities, or to areas subject to disruptive forces, such as shores exposed to high-energy waves.
- *Naturalness.* The lack of disturbance and degradation. Degraded systems have little value as fisheries or for tourism and little biological productivity. A high degree of naturalness scores highly in site selection. If restoring degraded habitats is important, however, a high degree of degradation might confer high priority.
- *Dependence.* The degree to which a species depends on an area or the degree to which an ecosystem depends on ecological processes in the area. If an area is critical to more than one species or process or to a valuable species or ecosystem, it should have a higher rating.
- *Representativeness.* The degree to which an area represents a habitat type, ecological process, biological community, physiographic feature, or other natural characteristic. If a habitat of a particular type has not been protected, it should have a high rating. (A classification scheme for coastal and marine areas is desirable in applying this criterion.)
- *Uniqueness.* Whether an area is one of a kind. The occurrence of habitat of an endangered species in only one area is an example. Interest in uniqueness might extend beyond country borders and assume regional or international significance. To keep visitor impact low, tourism may be prohibited, but limited research and education permitted. Unique sites should always have high ratings.

- *Integrity.* The degree to which the area is a functional unit—an effective, self-sustaining ecological entity. The more ecologically self-contained the area is, the more likely its values can be effectively protected, and the higher the rating given to it should be.
- *Productivity.* The degree to which productive processes within the area contribute benefits to species or to humans. Productive areas that contribute most to sustaining an ecosystem should receive high ratings. Exceptions are eutrophic areas, where high productivity could have a deleterious effect.
- *Vulnerability.* The area's susceptibility to degradation by natural events or the activities of people. Biotic communities associated with coastal habitats might have a low tolerance to changes in environmental conditions, or they might exist close to the limits of their tolerance (defined by water temperature, salinity, turbidity, or depth). They might suffer natural stresses that inhibit development, such as storms or prolonged immersion. Additional stress (such as domestic or industrial pollution, excessive reduction or increase in salinity, and increase in turbidity from watershed mismanagement) might determine whether there is total or partial recovery from natural stress or whether the area is totally destroyed.

## SOCIAL CRITERIA

Social benefits are measured in the following terms:

- *Social acceptance.* The degree to which the support of local people is ensured. When an area is already protected by local tradition or practice, protection should be encouraged, and the area should receive a higher rating. If local support is high, an "official" protected-area designation might be unnecessary.
- *Cultural attributes.* The religious, historical, artistic, or other cultural value of the site. Natural areas that contain important cultural features should be given high ratings, because their protection might help to maintain the integrity of adjacent ecosystems.
- *Conflicts of interest.* The degree to which area protection would affect the activities of local residents. For example, if an area is to be used for recreational purposes, the site should not be a major commercial fishing area and should have few dependent fisherman. In some instances, careful zoning can minimize such conflicts.
- *Benchmark potential.* The degree to which the area might serve as a "control group" in the scientific sense—an unmanipulated area

used to measure changes elsewhere. Benchmark areas are essential to an ecological monitoring program and should receive high ratings.

- *Educational potential.* The degree to which the area represents various ecological characteristics and can be useful for research and demonstration of scientific methods. Areas that clearly demonstrate different habitat types and ecological relationships and are large enough both to serve conservation objectives and to accommodate teaching (e.g., field trips and on-site learning centers) should receive high ratings.

## ECONOMIC CRITERIA

Economic benefits are measured in the following terms:

- *Importance to species.* The degree to which commercially important species depend on the area. Reefs or wetlands, for example, might be critical habitats for species that breed, rest, shelter, or feed there and that support local fisheries in adjacent areas. Such habitats need management to support the stocks.
- *Importance to fisheries.* The number of dependent fishermen and the size of the fishery yield. The greater the dependence of fishermen on an area and the greater its yield of fish, the more important it becomes to manage the area correctly and to ensure sustainable harvest.
- *Magnitude of threats.* The extent to which changes in use patterns threaten the overall value to people. Habitats might be threatened directly by destructive practices, such as fishing with explosives and use of bottom trawls, or by overexploitation of resources. Areas traditionally harvested by local fishermen are important to manage. The numbers of fishermen in such areas might increase, causing extra pressure on stocks and habitats. Even if the numbers do not change, the traditional capture methods might be replaced by others that yield more per unit effort (an extreme example is the use of explosives). The stocks of some species might not be capable of withstanding such increased drains on their breeding populations. Species have disappeared from fishing grounds or have become exceedingly rare in that way.
- *Economic benefits.* The degree to which protection will benefit the local economy in the long term. Restricting uses of an area might have a short-lived disruptive economic effect. Restrictions with obvious positive effects should have high ratings (for example, for protecting feeding areas of commercial fish or areas of recreational value).

## PRAGMATIC CRITERIA

The feasibility and appropriate timing of protection may be measured in the following terms:

- *Effectiveness.* The feasibility of implementing a management program. A site that satisfies many criteria, but cannot be adequately managed (i.e., monitored, patrolled, and defended), is not a good candidate for protection. Higher ratings should go to sites that are manageable.
- *Opportunism.* The degree to which existing conditions or actions already under way justify further action. A proposed extension of an established protected area should generally receive a high rating.
- *Availability.* The degree to which an area is available for acquisition or can be managed satisfactorily by agreement with the owners. The problem of tenure rarely applies to the sea; beaches often belong to the central or provincial government. Thus, acquisition of aquatic areas, wetlands, and seashores from private owners might not be necessary. However, adjacent lands and islands might be privately owned or leased. Generally, to secure long-term control over these areas, titles or leases will need to be obtained. Higher ratings should go to areas owned by state or national governments.

# Appendix C
# Major International Programs in Biodiversity Conservation

The *International Union for Conservation of Nature and Natural Resources* (IUCN) is an international network of governments, nongovernment organizations, scientists, and other conservation experts joined to promote the protection and sustainable use of living resources. IUCN has more than 450 nongovernment and government members in over 100 countries. Its Conservation Monitoring Center (CMC) gathers and organizes data on the status of ecosystems and endangered plant and animal species and maintains the United Nations lists of national parks, biosphere reserves, and other protected areas. Its Species Survival Commission (SSC), Commission on Ecology, and Commission on National Parks and Protected Areas have memberships composed of recognized authorities in their fields. The SSC has specialist groups on a number of plant and animal species.

The *United Nations Education, Scientific, and Cultural Organization* (UNESCO) deals with research, training, and development aspects of biological resource conservation, especially through its Man and the Biosphere (MAB) Program and the World Heritage Convention. UNESCO's Scientific Advisory Panel on Biosphere Reserves and the MAB General Scientific Advisory Panel examine worldwide coverage of representative samples of ecosystems suitable for conservation in biosphere reserves and make recommendations for action needed. Those reserves, which are now designated in more than 70 countries, are mostly large multipurpose protected areas established to conserve natural communities and the species they contain and for long-term ecological research and monitoring. One of the MAB research themes is "ecosystem functioning under different types or intensities of human impact." A number of MAB international pilot projects of regional and international significance that focus on sustainable natural resource conservation and human development have been developed. The World Heritage Convention identifies, on the basis of nominations by member states, cultural and natural areas of outstanding value protection; decides which areas included in the World Heritage List are to be inscribed on the "List of World Heritage in Danger"; and deter-

mines ways in which the World Heritage Fund can be used to protect these areas.

The *Food and Agriculture Organization of the United Nations* (FAO) has an international secretariat in agriculture, forestry, and fisheries. In its Agriculture Department, the Plant Genetic Resources Group assists member governments in developing policies and infrastructures to support work on plant genetic resources and in strengthening their activities in conservation and use of these resources. Through the Seed Laboratory, the Seed and Plant Genetic Resources Service facilitates the exchange of seeds and collects, stores, and distributes information on seed procurement and handling. In the Forestry Department, the Forestry Resources Development Branch (FORB) provides technical assistance in conservation of forest genetic resources specifically and in questions related to in situ conservation of plant genetic resources. FORB is the focal point for the assessment, monitoring, and management of forests and woodlands in developing countries and for plantation forestry and protection, fields closely related to conservation. The Forest, Wildlife and Wildlands Conservation Branch (FORW) deals with protected areas, ecosystem conservation, and the conservation and management of wildlife and with the related fields of watershed protection and management, conservation of mountain ecosystems, and arid zone forestry (with respect to fuelwood, shelterbelts and windbreaks, forest grazing, land rehabilitation, etc.). The coordinating unit for the Tropical Forestry Action Plan, a global framework for action in conservation of forest ecosystems, is in FAO's Forestry Department.

The *United Nations Environment Program* (UNEP), established after the UN Conference on the Human Environment in Stockholm, Sweden, in 1972, has a mandate to help to develop suitable environmental protection programs for implementation by the international community and to heighten global awareness of environmental issues. One of its programs, the Global Environment Monitoring System (GEMS), is concerned with coordinating worldwide monitoring efforts in pollution, climate, and renewable natural resources. Although global in scope, the data collected by GEMS might be usable in assessments for environmental management and land-use planning, even at the local scale.

FAO, UNESCO, UNEP, AND IUCN coordinate their work in environmental matters through the *Ecosystem Conservation Group* (ECG). A Working Group on In Situ Conservation of Plant Genetic Resources was established within the framework of the ECG in 1984 and includes representatives of the International Board for Plant Genetic Resources and of member organizations of the ECG. The working group's purpose is to identify ways to strengthen cooperation and action related to in situ conservation. It also promotes development of pilot demonstration conservation areas.

The *World Wildlife Fund* (WWF) is a leading international fund-raising organization to save endangered wildlife and habitats around the world. It includes national organizations in 23 countries.

The *Consultative Group on International Agriculture Research* (CGIAR) is an independent, international consortium sponsored by FAO, the World Bank, and the United Nations Development Program. Under the aegis of the CGIAR, 13 international agricultural research centers (IARCs) have been established, including the *International Board for Plant Genetic Resources* (IBPGR) and seven crop-specific centers, to focus on plant genetic resources. The mandate of the IBPGR is "to further the study, collection, preservation, documentation, and evaluation and utilization of genetic diversity of useful plants for the benefit of people throughout the world." Its work is concentrated on a number of crop species and their relatives. It has also developed criteria and guidelines for "ecogeographical surveying for purposes of in situ conservation of plant genetic resources" (IBPGR, 1985).

The *International Union of Forestry Research Organizations* (IUFRO) is an international nongovernment organization consisting of a secretariat and a worldwide network of research institutes and scientists. It has promoted forestry research, conservation, and development in developing countries; and in cooperation with FAO's Forestry Department, it has organized research planning workshops in all major regions.

The *International Council of Scientific Unions* (ICSU) is an international, nongovernment organization that, through its Scientific Committee on Problems of Environment (SCOPE), seeks to identify environmental problems of regional or global concern and make useful contributions through specific projects. A Global Change Program (also referred to as the International Geosphere-Biosphere Program) is being planned to establish an internationally sponsored Earth-observing system of remote sensing from satellites. With a network of sites on Earth, it will help to describe and understand the interactive physical, chemical, and biological processes that regulate the total Earth system.

The *International Association for Ecology* (INTECOL), the general ecology section of the International Union of Biological Sciences, is dedicated to promoting, developing, and communicating the science of ecology and to applying ecological principles through international cooperation.

The *Society for Conservation Biology* (SCB) is an international organization of scientists and managers dedicated to improving the theoretical and technical bases for the protection of biodiversity.

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# Appendix D
# Background Documents and Published Guidelines

The publications listed below have been prepared under the A.I.D.-National Park Service Project for Managing Natural Resources on a Sustainable Basis in Lesser Developed Countries.

Useful publications for A.I.D. biodiversity proposals and projects include A.I.D. and National Park Service project review papers, case studies, and design aids that are intended to enable A.I.D. mission and host-country personnel to integrate natural resource concerns with social, economic, and institutional factors in development strategies and in project planning, design, and assessment. If such documents are unavailable now, they should be reprinted, because they are directly relevant to A.I.D.'s mission to assist countries to conserve biodiversity. The publications were prepared for major ecosystem types—islands and coastal zones, arid and semiarid range lands, and humid tropical forests (ICSU, 1986).

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## BACKGROUND DOCUMENTS

The A.I.D document number follows each citation in the following list.

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## ARID AND SEMIARID RANGE LANDS

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## HUMID TROPICS ZONE

Lugo, A.E., J.R. Clark, R.D. Child, Eds. 1988. Ecological Development in the Humid Tropics: Guidelines for Planners. Morrilton, Ark.: Winrock International Institute for Agricultural Development. Washington, D.C.: U.S. Department of the Interior. National Park Service. Washington, D.C.: U.S.A.I.D Bureau for Science and Technology. Office of Forestry, Environment and Natural Resources.

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