Ex-Situ Conservation of Biodiversity in the Context of Development

Report of an International Meeting

held at the

Smithsonian Institution, Washington, DC
February 16 - 19, 1993

Produced by
Leonard P. Hirsch
Office of International Relations
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Acknowledgements

This brief report summarizes much work, discussion, and collaboration. It sprang from a discussion with Dr. Seymour Sohmer, then of USAID in the Environment and Natural Resource section, about focussing attention on *ex situ* conservation as it fits into larger conservation and development programs. Sy took a wonderful next step by supporting an ensuing proposal for a small working conference on this topic and working closely with Dr. Joel Cohen, then of the Office of Agriculture of USAID, to jointly fund the project. Anyone with knowledge of how bureaucracies work, know that cross-divisional collaboration is all too rare, and cross-divisional funding of projects is rarer. But Sy and Joel knew that this topic was worth the effort and shepherded both proposal and the project through the system. Both were vital in insuring the intellectual clarity of the meeting.

This report distills information from the workshop discussions and from a much longer and more detailed review of the literature which undergirded the meeting. Damon Job did a yeoman job in pulling together the literature and developing, with me, the summary and analysis. His drafting of the background paper and the report were precise and detailed. Damon insured that the breadth of issues necessary to have on the table were well represented and organized. His contribution was vital for this and for the smooth functioning of the workshop.

Dr. Dianne Janczewski was with the project from its inception, first as a AAAS Fellow at USAID and then, when Joel and Sy both left USAID shortly after the workshop, as project manager. She has worked hard to make certain that this report reflects the needs of USAID and the broader donor community. Without her, this report would not be in the shape it is in.

The workshop participants came from disparate disciplines and many places, but they shared a humanity and thirst for knowledge that made the meeting one of the most enlightening and dynamic of any in which I have been involved. All are grappling with the large questions of protecting, exploring, and knowing the natural environment and how we, as humans, do and can interact with it. I hope that their ideas and needs are well represented in these pages, and that this report can do something to make their important work easier and stronger.

Finally, my colleagues and supervisors at the Smithsonian have provided me with intellectual resources that are unsurpassed. Dr. Robert Hoffmann lead the meeting with his usual lucidity and his comments strengthened this report greatly. Francine Berkowitz provided needed support and advice and I thank her for her continued mentorship. Drs. David Wildt and William Rall from the National Zoo were particularly generous with their time and knowledge to help frame these issues and discussions. And I thank Dr. Kristian Fauchald for providing an independent eye to the process and to this report.

All errors, of course, are mine, and I apologize in advance.

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I. Introduction

An international panel was convened at the Smithsonian Institution, February 16-19, 1993, to establish priorities on *ex situ* conservation to ensure the protection of biological and genetic diversity and ecological systems of developing countries. The following report includes a set of recommendations provided to the United States Agency for International Development (USAID) and other donor agencies on appropriate guidelines for enhancing the *ex situ* programs under their consideration to facilitate a comprehensive approach to conservation of biological diversity.

Ex situ conservation programs, programs maintaining biological organisms outside of their natural habitat, have been developed over the years by plant and animal breeders, museums, zoos, aquaria, botanical gardens, and more recently microbial culture centers. Program goals include the preservation, study, and use of living organisms, and their preserved tissues and germplasm. *Ex situ* conservation forms the basis of agricultural improvement programs and increasingly is used to preserve threatened or endangered wildlife and habitat. Techniques used for *ex situ* conservation target better short and long term storage of germplasm, as well as, methods of assisted reproduction. Programs range from those designed to maximize expression of specific alleles (as used by agricultural systems in market based economies for production of a uniform product) to those that maximize and maintain the genetic variability within a population (as needed in the preservation of endangered species).

The links between conservation and development are given great attention in the current international dialogue. However, it was clear to the panel that the dynamics between these sectors are not well understood and in fact are continually changing. While we seek to understand this changing landscape, the needs of people to make a living increase the pressure on natural resources and human institutions. This continues humanity's environmental gamble by destroying, altering, or fragmenting the remaining minimally disturbed tracts of habitat without understanding the long-term consequences. All panel members agreed that habitat protection (*in situ* conservation programs) is the number one **conservation** goal, but that in a world of rapidly expanding human populations, *ex situ* programs will play an integral role in preserving for future generations the rich and valuable genetic and ecological diversity needed for our survival and future health.

Donor supported *ex situ* conservation programs should focus on how to study and perpetuate the genetic base needed for development. The need of *ex situ* methods and techniques for *in situ* conservation of isolated, or minimally connected, or human bordered patches of "natural" habitat was a continuing theme in the panel discourse. *Ex situ* programs will be needed to ensure the sustainable part of sustainable development. From techniques of butterfly farming to chemical prospecting for future pharmaceuticals, *ex situ* conservation projects can bring the necessary higher returns from conservation needed to use market mechanisms to protect our global environment. But the market obviously does not automatically do this. It will take greater understanding, education, effective policy, and research into new techniques and methods to unleash this power.

Panel recommendations help fill programmatic needs generated by the obligations rising from the 1993 United Nations Conference on Environment and Development. In both **Agenda 21** and the Convention of Biological Diversity, the recognition of the role that *ex situ* conservation plays in the larger conservation and development process is evident. It is the hope of the panel that these recommendations will help guide the development of successful and integrated *ex situ* conservation projects. These projects could enhance the dual goals of bettering the standards of living for people around the world while preserving and protecting the health of the natural systems in which they live.

II. Proceedings

The objectives of this panel were to examine the role of *ex situ* conservation in the next decade and prioritize the activities to be targeted by USAID and other funding agencies in developing comprehensive and effective programs. Panel members were drawn from zoological and agricultural fields, academia, private sector and government, researchers and practitioners (Appendix 1). To help focus discussions, a technical background paper was developed reviewing the techniques and programs in *ex situ* conservation (Hirsch & Job, unpub). The meeting addressed general issues of the intersection between *ex situ* conservation, *in situ* conservation, and sustainable development. Three separate sessions were held in which animal, plant, and microbial research and conservation programs were examined. The panel also examined existing organizations and programs which explicitly fit into the larger framework of conservation and development needs. Each session surveyed the state of the art; examined the role of existing, new and future technologies on changing the way *ex situ* conservation is done and interacts with *in situ* conservation; and highlighted programs for *ex situ* conservation in the context of broader conservation and development concerns for the next decade.

In bringing together experts from diverse fields, the panel highlighted one of the major problems facing conservation practitioners around the world, namely the lack of coordination and understanding among the many disciplines involved in conservation programs. All panel members learned about the techniques, both scientific and organizational, which are being used to good effect in the other disciplines. The panel strongly recognizes the need for increased and better information sharing and networking of people and resources across the disciplines.

During the meeting the concept of utility to humans arose repeatedly. Many organisms which, on their own, are of no use to humans, are, however, very important for ecosystem maintenance. The commonly used, short-term market oriented, definition of usefulness or utility undervalues ecological, systemic, and long-term sustainabillity needs or uses. The delineation of economic utility and other aspects of utility (ecosystem, cultural, social) need to be clearly understood to avoid developing too narrowly constricted programs and to resolve the externality problemmatique in environmental economics.

The panel recommends the funding of *ex situ* biodiversity conservation programs in the following broadly defined categories: Organisms, Technology, Education, Information, Programs, and Institutions & Policy. Panel members emphasize that the discrete groupings provided above are an abstraction of convenience. Significant overlap exists among categories, and those programs or projects encompassing more than one category may warrant greater attention. Section VII: Recommendations elaborates on major foci for each of these groups.

There is much to be done, but the foundation has been laid by the many nations, organizations, networks and persons already doing vital conservation work. With ample funding of focal projects and integrative programs, the promise of *ex situ* conservation in the context of development can come to fruition.

III: Biological and Genetic Diversity

As we step into a new millennium, we find ourselves at, or perhaps over, the threshold of a period of mass species extinction. As long as life has been on this planet, extinctions have been an integral part of nature. What makes this current extinction period fundamentally different from previous episodes is the greatly accelerated rate at which extinctions are occurring. The background rate of extinction during the last 600 million years has been estimated at one species per year (Myers 1989). However, the rate today is believed to be hundreds of times greater and increasing steadily (Groombridge 1992). The other fundamentally different component of this extinction episode is the cause, namely human expansion. This expansion, both numerically and spatially, is affecting the biological and even the atmospheric processes necessary for a healthy environment. The impacts of this magnitude of global change on human development and potentials are only beginning to be understood.

The intermediate step between human population expansion and loss of biological and genetic diversity of plants and animals is the human-induced change, degradation, destruction, and fragmentation of habitat through human exploitation and pollution (Myers 1987; Groombridge 1992). Conversion of wild lands to farmland and urban uses, non-sustainable exploitation of resources, and pollution contribute to the decline of critical habitat for plants and animals (Swaminathan 1989). Modern commercial agricultural practices have led to the development of genetically homogeneous crops and animals that in many areas are replacing native breeds of livestock, land-races, and their wild relatives (Prescott-Allen 1985). The full complement of native species and strains is poorly documented and many species and cultivars are in danger of extinction, especially in tropical developing regions (Prescott-Allen 1985). Specific pressures on biological diversity include the disruption of sion, invasion of exotic species, suppression of fire, over-grazing and predation by feral and domesticated animals, alteration of hydrology, loss of pollinators, competitors, and symbionts, and illegal collection and vandalism (Myers 1989; Falk 1990; Seitre and Seitre 1992; Martin 1992; Groombridge 1992).

The areas of the planet with the greatest concentrations of biological diversity are in tropical regions, many of which are subject to rapid human population growth and increasing demands for resources. Many developing nations in these areas lack the economic resources, expertise, or time-frame considerations required to deal with preserving biodiveristy given these pressures. This irreversible loss of genetic information poses the dilemma facing the global community today: the short-term needs for increased exploitation of natural resources for today's income and economic growth decreases the potential for long-term, sustainable development. The many causes of diversity loss will require many different policy instruments to successfully match solution with problem.

We now know and acknowledge that biological diversity is important. However, because biological resources are so omnipresent, there has been a tendency for humans to take them for granted. Society has not asked the necessary questions about the impact of our use and destruction of biological diversity, habitat, and natural resources. These questions range from what are the implications of loss of particular species to what is the full economic benefit accruing to humans from the use of biological materials?

Estimates have been made of the economic, social, and aesthetic values of biodiversity (Ehrenfeld 1988; Hanemann 1988; Randall 1988; Reid and Miller 1989; Groombridge 1992). In the US, the economic benefit derived from wild species of plants and animals was estimated to represent 4.5% of the Gross Domestic product (GDP), some $87 billion per annum, in the late 1970s (Reid et al. 1992). These figures are imperfect, however, and difficult to accurately estimate. They can only deal with current uses and interest, with current knowledge, and with goods in the market economy. In Africa, Asia, and South America a large percentage of the population relies on non-market sources of food, fiber, and fuel. Traditional medicine, utilizing wild plants and animals, is the principal form of health care for 80% of people living in developing countries (Farnsworth 1988). The difficulty of assessing the value of common property (air, watersheds, the oceans, for example) and of developing policies for their protection is well known. Biological diversity fits clearly in this area of concern.

Our economic and development models place a high discount rate on the future. In other words, since there is uncertainty about the value of a product far in the future (a less expensive substitute may be developed or the product may be taken by someone else), the free market will, without intervention, place a higher value on use than on conservation. This will, in strict cost-benefit terms, make the costs of protecting biodiversity greater than the benefits (because the benefits will be strongly discounted). Current pricing and accounting mechanisms are geared to short run needs and expectations. This undervalues, in current terms, future uses and needs, creating what are known as externalities—issues external to the economic equation. Externalities generally have social, political, or common property economic implications, such as pollution, destruction of biodiversity, inadequate education and health care. Understanding the implications of our economic structures and moving toward a redefinition that factors in the externalities is central to the current debate on sustainable development and for biodiversity. It explains why government policies have to be developed in these areas.

The vast majority of organisms have yet to be described scientifically, much less evaluated economically. We cannot know which plant and animal species will in the future allow humanity to conquer disease, grow more food or adapt to local and global environmental change. In the US, over the last 25 years, 25% of all pharmaceuticals have contained compounds extracted from plants. Yet until recently, few pharmaceutical companies had active research programs to explore for new drugs from higher plants. Which organisms will be needed in the future cannot be answered given today's knowledge. Thus, one of the most important values of biological diversity to humans is its future benefits. Such benefits accrue from the presence of organisms in the collective (creating and sustaining the atmosphere, land, and clean water resources), and from particular ones through their potential for providing chemicals and/or genetic material needed for pharmaceuticals, crops, or unimagined uses.

IV: The Need For and Role of Ex Situ Conservation

The increasing global loss of plant and animal diversity, and the ecological and economic consequences, are being broadly addressed (Lovejoy 1991; Ehrlich 1988; Raven 1987; Wilson 1988; Atkinson 1989; Stebbins 1992). Environmental and conservation issues are rising in priority on the local, national and international political agendas. Many new programs and policies will have to be developed to cope with the massive anthropogenic changes to the environment. The range of policies dealing with the management and protection of biological diversity is broad and, as yet, ill defined.

It is almost universally accepted that the preservation of biological and genetic diversity within existing natural habitats and traditional pastoral agricultural ecosystems (*in situ* conservation) is the most logical, practical, and cost-effective approach. Investments in *in situ* conservation of biological diversity are significant and continue to increase every year. By 1985, the World Wildlife Fund had cumulative expenditures of more than $100,000,000 on 4,000 projects in 130 countries (Falk 1990). But given the increased demands on terrestrial and aquatic resources and the short-term distribution of benefits from their use, it is unlikely that *in situ* conservation alone will be sufficient to halt or reduce the extinction rate. *Ex situ* conservation is not a substitute for *in situ* conservation, but with continued and accelerated loss, modification, and fragmentation of natural habitats, it is necessary to consider more *ex situ* methods as a supplement to conserve biological and genetic diversity.

Ex situ conservation is an integral component that must be linked to larger environmental policies. It cannot be hermetically sealed from *in situ* conservation nor a substitute for it. The two kinds of programs must be more closely interwoven as the distinctions between them (though arbitrary to start with) become even more tenuous due to habitat fragmentation and elimination. There exists strong potential for links between *ex situ* and *in situ* conservation; links between domesticated and wild species conservation; links between the immediately economically useful resources and the potential future needs of the planet and its inhabitants. A critical question is, how can the new technologies of *ex situ* conservation (cryogenics, reproductive biology, and molecular biology) be used to develop cost-effective and, more importantly, environmentally effective conservation strategies?

Despite the growing importance of *ex situ* conservation, only 1% of $37.5 million expended for conservation in the US in 1987 was applied to *ex situ* conservation programs (Cohen 1991). There has been a call for widening the scope of conservation biology (Soulé 1989), greater and more equitable representation for lower organisms (Sohmer 1990; Groombridge 1992), and the need for a paradigm shift in conservation biology (Pickett et al. 1992). Neither traditional ecosystem protection, nor the preservation of organisms outside their natural environment will completely and adequately conserve global biodiversity. As natural environments become more fragmented and degraded, many once common species populations will be reduced to remnants, existing as small isolated populations in marginal habitat, separated by large expanses of unwelcoming land modified by humans (Conway 1983). As a result, more and more of the world's plants and animals will have to be maintained in areas subject to multiple use, within ranges smaller than optimal, and at suboptimal or nonviable population sizes. Such populations may be best sustained by an integration of *in situ* and *ex situ* methodologies, such as captive breeding, seed banking, or tissue culture propagation, for future reintroduction or translocation (Conway 1983). Balancing the needs of plants, and animals, including humans, will require active and integrated strategies and management (Jones 1992).

The capacity of either *in situ* or *ex situ* systems to fulfill management and conservation objectives will depend on a complex integration of biological, economic, and political factors. The biological considerations need to be of primary importance, though political and economic factors are often critical and should be considered where appropriate. For example, there has been a disproportionate devotion of resources in the U.S. to *ex situ* conservation of a unique sub-set of endangered organisms (black-footed ferret, California condor, peregrine falcon) to the exclusion of some plants and animals critical to maintenance of the habitat in which the focal organisms live, or to marine organisms where political jurisdiction is unclear or absent. Centering of a program around a "charismatic" organism is understandable in human terms, but does not always make the best conservation strategy. Even scientific considerations are not without ambiguity. As we learn more about biological diversity, new variables for consideration come to the fore. For example, during the last two decades, numerous indicators of biological diversity have been developed, giving a numerical count or representation of the number of species which make up the bulk of organisms in a particular area. Because of the difficulty of identification (and the limited impact they would have on a numerical indicator), organisms represented by few specimens in a sample are usually omitted from the survey. The irony is that as a species moves toward extinction, it would be increasingly left out of all synecological calculations using many present methodologies. These organisms may indeed be exactly the rare or unique species requiring study and protection. The technique may give us an indication of decreasing diversity, but may not be able to tell us what we are losing. The panel believed the research into techniques and the development of stronger, long-term datasets will assist decision makers in developing sound policies based on good information.

Ex situ conservation methods hold great promise. Technologies developed for the preservation and use of germplasm in domesticated species and advances in human reproductive research increasingly are being adapted to the maintenance and use of exotic plants and animals germplasm, particularly via captive breeding and cryopreservation. For example, artificial insemination and embryo transfer technology developed over the last two decades in domestic ungulates is being applied on a limited basis to the preservation of a few wildlife species held in zoos (Wildt et al 1992). Tissue culture, cloning, and germplasm cryopreservation are being applied to exotic plant preservation in botanical gardens and agricultural research centers (Bramwell 1990). In turn, research on organisms in captivity has been applied to maintaining animals and plants *in situ* (Benirschke 1983). However such technological linkage is limited, sporadic, and largely experimental and must be expanded to fully integrate the two conservation programs.

An expanded role and application of *ex situ* conservation technology can contribute to the maintenance of sufficient levels of genetic diversity. Most collections of plants and animals in zoos and parks do not contain sufficient numbers of individuals per species to retain sufficient genetic diversity. Use of *ex situ* methods such as cryopreservation will alleviate some of the problems of severe limitation of space and logistics necessary for maintaining genetically healthy populations. Systematic storage and use of germplasm from wild and captive plants and animals can maintain or even increase the genetic diversity represented in zoos, aquaria, and botanical gardens (Wildt et al 1992).

Greater application of *ex situ* conservation methods will enhance *in situ* conservation programs by reducing the costs and risks of moving living organisms, and providing a back-up source of stored, usable genetic variability of wild populations. Crop plant germplasm is exchanged among germ plasm storage facilities and the agricultural sector thereby contributing to the genetic diversity within crops. Similarly, the transfer of genetic material within and between *in situ* and *ex situ* sites can be used to maintain and enhance retention of genetic diversity of naturally occurring populations.

V: Ex situ Conservation & International Development

Growing concern over the loss of genetic and biological diversity is most acute for developing nations. In general, biodiversity is greatest in tropical regions comprised of mostly developing nations. The diversity in such regions is not well documented and the potential and actual degradation of ecosystems is greatest. Given the limited alternatives people have to make a living, unsustainably using natural resources becomes an understandable choice. Thus, the greatest threat to biodiversity in developing countries stems from a lack of development more than the effects of development programs.

The enormity, both qualitative and quantitative, of biodiversity concerns in developing countries means that conservation efforts need to be selective but effective. These efforts will depend upon the availability of the political will, financial and technical resources, and public support for *in situ* and *ex situ* conservation measures. Developing countries, in many cases, will have to depend upon practical application of reliable, low cost technologies. Direct financial and technical assistance from developed nations will be critical to the success of *ex situ* conservation of biological and genetic resources in tropical and developing regions.

Amendments to the U.S. Foreign Assistance Act have defined the maintenance of biodiversity as an important objective of international developmental assistance programs. The U.S. has a vested interest in maintaining biological and genetic diversity in developing nations. Much of this biodiversity is of great potential economic value for the production of biomaterials to meet the needs of future generations in an era of dwindling natural resources and increasing energy needs. Degradation of ecosystems and loss of biodiversity could also undermine the U.S. support of economic development efforts (OTA 1987). International development assistance can improve the capacity of developing countries to maintain genetic and biological diversity *ex situ* by providing funding and technical expertise. Donor support can catalyze the development and enhancement of institutional frameworks necessary for promoting sound, sustainable planning and management, augmenting technical capabilities, and the increasing of socio-economic benefits. The increased sensitivity of multi-national lending institutions, such as the World Bank, to the need for environmentally sound lending policies will enhance the ability of U.S. government agencies and non-governmental organizations (NGOs) to promote *ex situ* conservation measures.

Traditionally, development organizations, in providing international assistance, have focused upon enhancing the quality of life and concentrated upon agriculturally and economically important species. In contrast, conservation organizations have emphasized the protection of ecosystems and wild species from human exploitation and have focused little upon social and economic benefit to local human populations. More recently, international lending institutions and the federal agencies of developed nations involved in international developmental assistance have become more concerned with the preservation of biodiversity and the minimization of detrimental environmental effects of development policies and programs. These new strategies stem from increased awareness of the financial and economic costs of ignoring environmental costs.

In the 1970s, concerns grew about the effects of pollution and progressed in the 1980s, to issues of natural resource degradation and unsustainable extraction policies. Similarly, NGOs previously concerned solely with developing nature parks and conserving plants and animals are now addressing the social and economic needs of the local populace through linkage of conservation and development programs, including education and eco-tourism. Such policies stem from the realization that conservation programs, in isolation from social and economic considerations, cannot be maintained in the long-term. The development of the World Conservation Strategy, lead by the International Union for the Conservation of Nature and Natural Resources,directly linked conservation and development goals to ensure the maintenance of biological and genetic resources and sustainable use of natural resources (IUCN, 1980). However, conflicts still exist between developmental approaches, which emphasize economic factors, and traditional conservation approaches which tend to emphasize the preservation of flagship species and their habitats—the symptomatic approach. The first approach undervalues biological resources, the other human resources and welfare. Additionally, responsibility for natural resources often are split between agencies resulting in a lack of institutional overlap that hinders coordination of developmental and conservation programs (OTA 1987).

Development agencies should develop and fund *ex situ* conservation measures that not only effectively conserve critical biological and genetic resources, but also promote opportunities for local populations and enhance the immediate and long-term social and economic benefits from such actions. Biological and genetic resources can be preserved by their use; it is important to ensure that such use is economically, environmentally, and socially sustainable (OTA 1987). *Ex situ* programs, to be successful, must be supported locally, nationally, and regionally. For a comprehensive and effective conservation program, development assistance should be directed toward support for sound national inventory, planning, and management in addition to the enhancement of local technical expertise and facilities for *ex situ* conservation.

VI: Development Assistance

In the 1970s, U.S. foreign assistance programs included consideration of environmental concerns. The International Environment Protection Act (1983) included a Foreign Assistance Act (FAA) authorizing the addition of sound wildlife conservation measures to developmental assistance programs. In 1985, "The U.S. Strategy on the Conservation of Biological Diversity: An Interagency Task Force Report to Congress" defined 67 specific recommendations for the preservation of biological diversity in developmental assistance programs (OTA 1987). In 1987, Congress expressed dissatisfaction with the amount of funding directed to meet Section 119 provisions. Simply allocating new funds may not be an appropriate response (OTA 1989) and the Office of Forestry, Natural Resources and Environment (FNR) among others have had budgets reduced. The establishment of separate funding sources for FNR, or elevation of FNR to bureau status could speed implementation of many programs (OTA 1989), both *in situ* and *ex situ*. In addition, biological diversity concerns, and *ex situ* conservation programs in particular, should be made concerns in the form of general policy and at different levels within USAID, including regional bureau and mission levels (OTA 1989).

USAID and other donors should integrate the priorities listed here into their environmental strategies as part of a comprehensive program in biodiversity conservation. These initiatives should identify priorities and critical areas of *ex situ* conservation, especially where *in situ* measures are already established but limited in their effectiveness. Overlap and duplication by other agencies or NGOs should be avoided. Where other agencies or NGOs are active in *ex situ* conservation, cooperation will abet identification of areas where USAID can best help coordination or augment programs to ensure their long-term success. Increased inter-agency cooperation with agencies which have existing projects that relate to *ex situ* conservation, could further USAID's mandate.

Matching grants may help to fund cooperative joint ventures between public and private organizations (OTA 1989). USAID Country Profiles can help identify priority areas for *ex situ* conservation. Expertise that exists within other U.S. agencies, such as the Smithsonian Institution, the Department of Interior's Fish and Wildlife Service, the Environmental Protection Agency, and the Department of Agriculture, could enhance the ability of USAID to implement *ex situ* conservation programs. The Resource Service Support Agreement with the U.S. Department of Agriculture could be expanded beyond forestry to include exotic plant species.

VII: Recommendations

Based on the concerns and considerations described above, the panel recommends the funding of *ex situ* biodiversity conservation programs in the following broadly defined categories: Organisms, Technology, Education, Information, Programs, and Institutions & Policy. Initial, generalized recommendations provide a summary overview of funding needs in each category, while the more specific recommendations address particular projects, programs, policies, or proposals within each category that panel members considered worthy of further consideration.

Panel members emphasize that the discrete groupings provided above are an abstraction of convenience. These categories are not discrete areas for funding of *ex situ* conservation programs *per se*. Significant overlap exists among categories, and those programs or projects encompassing more than one category may warrant greater attention.

Ex situ conservation programs should be as closely linked with *in situ* conservation programs as possible. This will become increasingly important as habitats are increasingly fragmented and the techniques of *ex situ* conservation will be needed to maintain small free-living populations in nature.

Sustainable development can only be based on preserving and creating capital for future generations. Strongly linked *ex situ* and *in situ* conservation programs will create the information, systems, and understanding needed by the present and future generations to steward the resources of the globe and use them in a sustainable manner. Many existing programs were discussed during the meeting. One of the major points continually raised was the importance of documenting and networking the work already being done. There are "orphan" collections, data sets, taxa, and habitats that need particular attention to preserve vital and valuable information and diversity.

All projects should strive to strengthen local institutions. Programs that provide for the sharing of benefits with local communities will have greater potential for long-term success. The development and strengthening of property rights for habitats and genetic resources will additionally help foster interest in conservation.

Finally, all members counsel flexibility. Needs are enormous, but the potential for enhanced environmental policies is equally great. The differences in the needs of the various regions of the world, in the life span and scale of organisms, in our understanding of species richness, diversity, and ecosystem maintenance all preclude a rigid set of goals or priorities. But choices can be made. Projects with multiplier effects—those that inform other projects and help to strengthen overall conservation programs—should have priority.

1. ORGANISMS

The USAID Research Advisory Committee noted that there is significant funding directed toward popular, charismatic species (USAID 1991). There has also been attention given to documentation and *ex situ* conservation of some domesticated plants and animals of agricultural and economic importance, but a lack of support directed toward understanding and preserving local varieties and breeds. Marine organisms, non-charismatic wild organisms, and the wild progenitors of domesticated crops and breeds of animals are poorly represented in germplasm storage facilities and captive breeding programs.

We do not know which natural resources will be needed in the future. As one panel member stated: "After all, penicillin was once just a mold in a dish, without any apparent utility." The panel strongly believed that while funds must be channelled into saving organisms of known utility, a portion of the funds must be earmarked for species of unknown use or of ecosystems containing undiscovered species. If this is not done, the capacity of future generations is likely to be compromised.

Recommendations:

- Support documentation, inventory, and *ex situ* collection, storage, and use of novel, under-utilized, and previously unstudied plants, animals, and microorganisms and their germplasm resources, in both natural and agricultural systems.

- Contribute to the development, expansion, and coordination of local, national, regional and international programs for breeding and long-term conservation of whole organisms or their germplasm (cold-storage and cryopreservation) with emphasis upon locally or regionally known taxa with potential or actual economic (medical, industrial, agricultural etc.), cultural, or social significance, including rare varieties and breeds of domesticated plants and animals, keystone species, and exotic wildlife.

- Inventory and assess globally valuable microorganism culture, plant and animal germplasm collections that are in need of assistance, or are in danger of deterioration or loss to determine which require maintenance or assimilation into existing collections (see: Information section, page 27-8).

- Support the adoption of Conservation Assessment Management Planning (CAMP) procedures (developed by the World Conservation Union's Captive Breeding Specialist Group [CBSG]) to identify which wildlife species and taxa of organisms are most in need of *ex situ* conservation measures.

- Support the use of modified Population Habitat Viability Assessment (PHVA) process (also developed by the CBSG) to develop specific strategic plans for both *in situ* and *ex situ* conservation.

- Support the preservation, documentation, inventory, storage, use and marketing of lesser-known or under-utilized crops of cultural and social importance in partnership with indigenous tribal or ethnic groups. Ensure equitable arrangements that provide economic incentives to local people for supporting *ex situ* conservation programs.

- Seek to develop incentive programs for conservation of locally important breeds or varieties.

- Seek cooperative ties with agencies or institutions, such as the World Heritage Fund (WHF) (established by UNESCO and administered by the World Heritage Committee), to provide grants of financial assistance to protect existing local and national biological or cultural collections of outstanding value or uniqueness (i.e. microbial, plant or animal germplasm collections).

- Contribute to the development and application of sound, sustainable policies and programs for limited, regulated trading of biological resources (skins, shells, eggs, butterflies, etc.) to subsidize conservation beyond the 'ranching criteria' and species-based quotas defined by the Convention on International Trade in Endangered Species (CITES). Such projects should be developed under strictly monitored conditions, with regulated 'extraction', preferably where there are stable populations protected by existing local and national *in situ* conservation policies and programs.

- Collaborate with International Agriculture Research Centers (IARCs) to integrate conservation of land races and wild relatives of economically important crops and animals within and beyond their current crop mandates.

- Seek to enhance and develop programs which target conservation of globally important germplasm of agriculturally important plants and animals, agroforestry and aquaculture.

- Develop institutional arrangements for the documentation and conservation of aquatic genetic resource in fresh, brackish and marine waters.

2. TECHNOLOGY and METHODOLOGIES

Advances in reproductive and genetic technologies have been rapid and dramatic. Many techniques derived from agricultural breeding programs and human fertility research have significant, but untapped, potential for preserving biological and genetic diversity. There is great potential for strong and productive flow of technology among the agricultural, zoological, and botanical communities which is not being fully realized. Furthermore, there has been limited linkage between research institutions and insufficient transfer of technology and technical expertise, especially to developing regions. The potential for benefits from increased cooperative linkage and technology transfer is tremendous but has received minimal attention for organisms that are rare, endangered, or under-represented.

Recommendations:

- Contribute to the development, enhancement, and advancement of practical, cost-effective technologies for the medium and long-term storage and use of terrestrial and marine plant, animal, and microbial germplasm such as basic research in the understanding, development, advancement, and application of 'assisted' reproductive techniques in conjunction with ambient temperature, cold and ultra-cold (cryogenic) storage techniques (optimal cooling and thawing rates, ideal cryoprotectants, etc.).

- Contribute to increasing the transfer of plant and animal cryogenic and tissue culture technologies to zoos, aquaria, botanical gardens, germplasm banks, and other institutions in developing regions.

- Contribute to research advancing an understanding of cold-tolerance in invertebrates, especially insects, and the development of cryopreservation and vitrification techniques for whole organisms and their germplasm to augment techniques using continuous culture for agricultural bio-control, research, industrial, and nutritional applications.

- Develop model projects that integrate and link new knowledge and research in reproduction, genetics, disease, nutrition, animal husbandry and behavior to enhance both *ex situ* and *in situ* conservation.

3. EDUCATION

Education has a major role in the development of *ex situ* conservation programs, both for the practitioners of conservation and the beneficiaries of it. Throughout the world, too few people are trained in systematics, morphology, and ecology. More experts will make biodiversity surveys and conservation priority setting and action easier, more orderly, and most importantly, more effective. Additionally, too few persons are trained in the management fields necessary to keep *ex situ* conservation programs functioning properly.

Recommendations:

- Contribute to the training of students and scientists in graduate programs in plant and animal reproductive biology, systematics, taxonomy, genetics, cryopreservation technology, conservation biology, animal husbandry and behavior, veterinary medicine, and scientific business and information resources management to facilitate the practical management of *ex situ* biodiversity conservation programs within the U.S. and in developing countries, especially in the tropics.

- Provide assistance to students and facilitate research via internship programs in cooperating zoos, arboreta, wildlife parks, aquaria, private voluntary organizations (PVOs), nongovernmental organizations, and local, national government and international institutions.

- Cooperate with other donor agencies, NGOs, and PVOs to develop and implement short technical and managerial training courses for specialists in botanical, zoological, and microbial aspects of *ex situ* biodiversity conservation management and research.

- Fund educational and information programs providing the lay public and policymakers with information on biodiversity loss, and the need for *ex situ* conservation.

4. INFORMATION

Panel members recognize the critical need to develop, enhance, and maintain the collection, storage, retrieval, use, transfer, and sharing of information critical to the sustainable *ex situ* conservation of all organisms. Advances in computer science, including the development of powerful desk-top computers and computerized database systems, are aiding *ex situ* conservation programs. *Ex situ* conservation information available in developed nations must be shared with developing regions. Information transfer and networking can be facilitated by providing education, training, and cooperative assistance to existing institutions (See: Education). Independent researchers and specialists around the world have information that has not been documented and will be lost if time and resources are not expended in cataloging these lifetimes of work.

Recommendations:

- Provide support to develop computerized information databases, for local, national, regional, and global microbial culture collections, germplasm storage facilities, arboreta, botanical gardens, zoos, aquaria, and non-government organizations (NGOs) or institutions in most need of assistance.

- Enhance networking and sharing of *ex situ* conservation database information between public and private institutions and government and non-government agencies.

- Provide funding for data collection, retrieval, use, and dissemination within and among microbial culture collections, and plant and animal germplasm collections, and address recurrent costs including support to supply computer hardware and software, including networking and database software, computer training or professional advisors to conservation programs.

- Adapt the World Conservation Union's International Species Inventory System (ISIS) (used to maintain captive populations of wild animals) to the management of rare breeds of domesticated animals and their germplasm and contribute to the modernization of databases, or the adaptation of ISIS.

- Assist the 26-country network of Microbiological Resource Centers (MIRCENs) in the development of international standardization of technical information protocols to maximize the exchange of data and germplasm among network members and to enhance the existing network as a functional, useable germplasm resource.

- Provide assistance in making inventories and assessments of local, and national collections of living organisms or their germplasm, to determine which existing collections are most need of conservation measures.

5. PROGRAMS

The development and support of practical, small-scale *ex situ* conservation programs at the local and regional level, should be sustainable, and economically and socially beneficial. The linkage between *ex situ* and *in situ* programs should be improved and extended within and among conservation organizations to contribute to the cost-effectiveness of management systems and to achieve the objectives of maintaining biological and genetic diversity. Model projects should be developed for mammals, birds, fish, invertebrates, zoos, protected areas, etc. to help refine management and research protocols. These projects should be linked to provide recursive learning and the development of data and information that could be applied to conservation technology at the global level.

Recommendations:

- Assist the development of local, national and regional *ex situ* biodiversity conservation programs and continue to support existing local and national biological and agricultural conservation efforts. Help establish programs to address specifically the collection, documentation, maintenance and preservation of exotic, little known or underutilized plants and animals of future potential economic, genetic, cultural, or aesthetic value.

- Develop sustainable, economically productive, end-user techniques for programs with limited direct applicability such as tropical aquaculture programs and cryopreservation of marine and freshwater organismal germplasm.

- Contribute to *ex situ* conservation programs such as butterfly 'farming, orchid growing, and tropical fish rearing that can provide communities with income and relieve pressures upon wild plant and animal populations.

- Provide grants to assist grass-roots community-level based *ex situ* biodiversity conservation programs with links to education, training, technology transfer, and social policy.

6. INSTITUTIONS AND POLICY

Building and enhancing public and private support for *ex situ* conservation in developing nations is critically important to the success of development programs. Since the 1972 UN Conference on the Human Environment in Stockholm, Sweden, concern for ecosystem protection has grown considerably. Conservation of genetic resources of non-economic plants and animals is a relatively new concept in developed nations, and its value may not be appreciated fully. Nevertheless, institutions involved in seed banking or germplasm banking of agriculturally important species can expand facilities to take on staff with expertise in the conservation of exotic species germplasm. Upgrading, enhancement, modernization, and diversification of existing facilities is the most practical and cost-effective approach provided that training is made available for staff and recurrent costs are addressed. USAID could help such facilities find markets in Europe and North America for use of their stored germplasm.

Intellectual property rights need to be addressed to allay fears of loss of control of valuable resources. Existing *ex situ* programs could serve as models that could be adapted to suit each region such as the citrus and sugarcane program in India, the wild medical plant program in Sri Lanka, and teosinte program in Mexico (OTA 1987).

Panel members note that similar work is being done in disparate institutions in isolation or with little coordination and cooperation. Cooperation can help create an economy of scale enabling each to do more with fewer resources. However, some diversity and overlap in *ex situ* conservation program objectives is beneficial.

Recommendations:

- Develop institutional arrangements for the documentation and conservation of animal genetic resources, both wild and domesticated, learning from the current and emerging roles of international organizations with respect to genetic resources (such as the Consultative Group for

International Agricultural Research (CGIAR) and the Food and Agriculture Organization (FAO).

- Provide support for the institutional framework of local national and regional programs in *ex situ* biodiversity conservation.

- Grant funding so that organizations can move swiftly for crisis management (such as reaction to a natural disaster) so that funds could be available for a specific purpose on short notice.

- Review political and medical security needs for germplasm collection and transportation, and assist in developing safe and effective standards for handling and long-term storage of biological materials.

- Develop stronger cooperative linkage of disparate programs within and between zoos, aquaria, germplasm banks, arboreta, and private, government, and non-government institutions.

- Contribute to programs that provide the general public and policy makers with better access to information concerning *ex situ* biodiversity conservation policies and their long-term and short-term impact.

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