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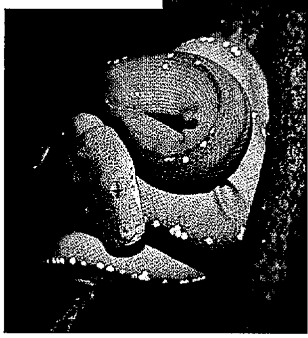

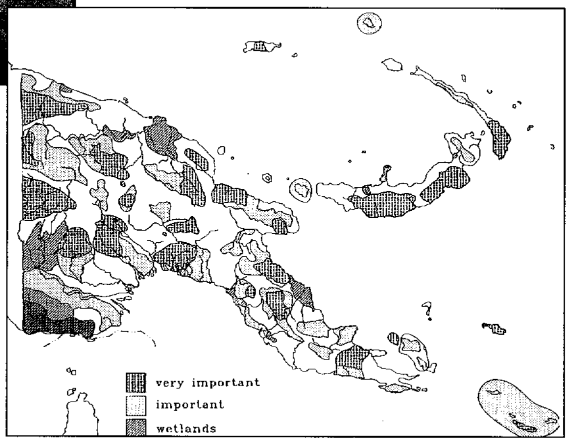

Biodiversity in the Balance: Approaches to Setting Geographic Conservation Priorities

By Nels Johnson

The Biodiversity Support Program is a USAID-funded consortium of World Wildlife Fund, The Nature Conservancy, and World Resources Institute

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ISBN 1-887531-23-8

The Biodiversity Support Program (BSP) was established in 1988 with funding from the Research and Development Bureau of the U.S. Agency for International Development (USAID), under cooperative agreement number DHR-5554-A-00-8044. BSP is implemented by a consortium of World Wildlife Fund, The Nature Conservancy and World Resources Institute. BSP works to conserve biodiversity in developing countries by supporting innovative, on-the-ground projects that integrate conservation with social and economic development; research and analysis of conservation and development techniques; and information exchange and outreach.

Cover design by Mimi Hutchins, World Wildlife Fund, Washington, D.C. Layout by Mimi Hutchins, WWF, and Leslie Murray, Leslie Murray Art & Design.

Cover photographs show various components of biodiversity (from left to right): 1) the species is *Chundropython uiridis,* a python native to the island of New Guinea, 2) the ecosystem is a tropical forest on St. Lucia, the Caribbean, and 3) the genetic diversity shown is a wealth of indigenous foods on display at a marketplace in Mexico. A map of Papua New Guinea shows priority areas for the conservation of biodiversity.

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For more information and/or copies of this publication contact: The Biodiversity Support Program, c/o World Wildlife Fund, 1250 24th St., NW, Washington, D.C. 20037, USA. Tel. 202-861-8313, Fax 202-861-8324.

Printed by Corporate Press, Inc., Landover, Maryland.

Printed on recycled paper

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FOREWORD

Growing awareness during the last fifteen years of the unprecedented elimination of the earth's biological diversity has stimulated new national and international conservation programs and policies. The geographic areas receiving the greatest conservation funding and attention from national governments, nongovernmental organizations, and international donors have been selected for many reasons, including biology (e.g., how rich in species an area is), politics (e.g., a foreign aid program operates in a certain country and elects biodiversity as its area of focus), and economics (e.g., people depend on an area's biological resources for their economic development). Conservation investment decisions have rarely been made in a systematic, analytical, and transparent manner.

Setting conservation priorities is not an easy or comfortable undertaking. We believe that biological diversity and biological resources should be conserved **everywhere** because of their critical role in meeting human needs (from the physical to the spiritual) and in maintaining local and global ecological processes. Some people reject the concept of priority setting because they fear that the very act of setting priorities will result in supposedly "low priority" areas never getting attention. Yet either explicitly or implicitly, every conservation investment decision is a statement of priorities, with the funding organization or government investing in areas it considers to be a high priority.

The realization that the magnitude of the biodiversity crisis far exceeds the financial resources available has led to numerous efforts over the last decade to determine geographic conservation priorities. At the same time, the information available to assist in determining priorities has been increasing due to new remote-sensing technologies and research results in many fields. We are gaining a better understanding of the distribution of biodiversity, of biodiversity's importance for meeting human needs and for maintaining ecological processes, and of the threats that human endeavors pose to the maintenance of biodiversity. All this information can play a role in determining where biodiversity conservation actions are needed with the greatest urgency.

The Biodiversity Support Program supported the production of *Biodiversity in the Balance: Approaches To Setting Geographic Conservation Priorities* because we believed it was important to review the various approaches to priority setting in order to encourage all those individuals, organizations, and agencies investing in conservation to analyze the assumptions behind their decisions and to clarify, and perhaps revise, the reasons for their investments.

Much of the literature on conservation priorities in the 1970s focused on identifying those highly visible species most at risk of extinction. Legislation such as the U.S. Endangered Species Act and the Convention on International Trade in Endangered Species (CITES) focused on conserving species vulnerable to extinction.

As the complexity of biodiversity received more attention during the 1980s, scientists and conservationists began to focus on other dimensions of biodiversity in setting priorities. They began to concern themselves with issues such as economically important plants and animals, marine biodiversity, and the importance of representative ecosystems and biogeographic regions. By the late 1980s, international agencies, national governments, and private foundations increasingly sought advice on how to clearly define conservation priorities in order to spend limited financial resources effectively. Even as a global perspective was added to priority setting, however, most methods continued to emphasize the evaluation of biological information. The establishment of the Global Environmental Facility (GEF) in 1990 and the initiation of the Convention on Biological Diversity in 1993 further increased recognition of the need for priority setting in determining how best to support conservation. Most of the methods described by this book are based primarily on biological criteria. Yet, we know the success of conservation efforts depends on the influence of social, economic and institutional factors. For this reason, we believe newer approaches that integrate biological with non-biological criteria in the priority-setting process hold particular promise.

Biodiversity in the Balance clearly outlines why setting conservation priorities is important, what methods and approaches have been used to date, and how setting biodiversity priorities can be more effective for a range of conservation objectives. We believe that everyone concerned about the conservation of biodiversity—nongovernmental organizations, national governments, and international donors—will benefit from this synthesis of priority-setting issues and approaches. We welcome your thoughts and reactions.

—Kathryn A. Saterson
Executive Director
Biodiversity Support Program

ACKNOWLEDGEMENTS

Many people have contributed to this publication in a variety of ways. None has contributed more than Kathy Saterson. The author wishes to thank her for the intellectual contributions, constructive reviews, and steadfast support she has provided throughout the research and writing of this publication. Ron Miller also deserves special thanks for his collaboration during the critical early stages of planning and research for the project. The report has benefited tremendously from the comments and suggestions of reviewers. In particular, the author wishes to express his appreciation to Janis Alcorn, Walter Arensberg, Dirk Bryant, Eric Dinerstein, Gary Hartshorn, Malcolm Hunter, Richard Margoluis, Jeff McNeely, Kenton Miller, Kate Newman, Silvio Olivieri, Richard Primack, Kent Redford, Walt Reid, Bruce Stein, Meg Symington, Steve Taswell, and Michael Wright. Also recognized are Doug Baker, Ian Bowles, Roberto Cavalcanti, Marea Hatziolos, Vernon Heywood, Chris Rodstrom, and Simon Stuart for providing valuable information.

Thanks also go to Lea Borkenhagen, Steven Lanou, Anu Sud, and Sue Terry who tracked down literature, compiled data, and otherwise provided indispensable research support. Rosemarie Philips did an outstanding editing job to help the document convey complex issues in clear, readable prose. Robbie Nichols deserves credit for working with the author to craft the executive summary. The production skills and patience of Mimi Hutchins and Leslie Murray and the efforts of James-Christopher Miller were critical to producing the final publication.

Finally, the U.S. Agency for International Development deserves recognition for its support of innovative efforts around the world to assess biodiversity conservation priorities. Without USAID's financial support, this publication would not have been possible.

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EXECUTIVE SUMMARY

Government agencies, donor institutions, and nongovernmental organizations (NGOs) around the world face hard choices about where to conserve biodiversity with limited financial resources. One response to this problem has been to define conservation priorities geographically by identifying the ecosystems, habitats, or species most important to conservation goals. Efforts to implement the Convention on Biological Diversity will spur interest in setting such geographic priorities to help institutions choose among conservation actions in coming years.

Done well, this kind of priority-setting exercise can boost conservation efforts in several ways. Not only does priority setting save time, money, and personnel, but it often generates new knowledge about the distribution and status of biological resources in the geographic areas evaluated. A deliberate and well-documented priority-setting process can make conservation planning and decision-making more transparent, giving the public a sense of how priorities were selected and enhancing the scientific credibility of conservation decisions. Just as important, this process will appeal to conservation funders since they want to see their resources targeted on strategic and well-justified priorities.

Priorities reflect value judgments, so it follows that they flow from prior decisions about what matters most. Establishing biodiversity conservation priorities demands a conscious effort to assign values to genes, species, and/or ecosystems and to then evaluate risks and opportunities in light of those value judgments in order to decide which conservation efforts should get the highest priority. Biodiversity can be valued from so many different perspectives—utilitarian, cultural, aesthetic, moral, political, and scientific—that there cannot be a universal scheme for establishing priorities.

Any deliberate priority-setting effort uses criteria to narrow the elements of biodiversity considered for priority status. The complexity of biodiversity and the number of ways to value it make a host of criteria theoretically possible, but only a handful of them are commonly used. Among the biological criteria are *richness* (the number of species—or ecosystems—in a given

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area), *rarity, threat* (degree of harm or danger), *distinctiveness* (how much a species differs from its nearest relative), *representativeness* (how closely an area represents a defined ecosystem), and *function* (the degree to which a species or ecosystem affects the ability of other species or ecosystems to persist).

Some priority-setting approaches use social, policy, and institutional criteria as well. *Utility*, the most common non-biological criterion, points to biodiversity elements of known or potential use to humankind. Utility may be narrowly defined as economic value, but in a broader sense it can signify scientific, social, cultural, or religious significance as well. *Feasibility*, often paramount in deciding how to allocate conservation resources, may be defined in political, economic, logistical, or institutional terms. Considering feasibility along with biological criteria helps identify areas where conservation actions are most likely to succeed. These criteria are newer entries to the field than biological criteria, but their use will increase alongside growing recognition that social, policy, and institutional factors are crucial to conserving biodiversity.

Many methods of setting geographic priorities for a wide range of conservation objectives have emerged over the last decade. Some are based on *genetic* analysis, some on *species* analysis (including systematic analysis of evolutionary relationships at taxonomic levels higher than species), and some on *ecosystem* analysis. These three categories of methods rely mainly on biological information, but may use any of the biological or social and institutional criteria. A fourth category comprises *integrative* methods that include significant consideration of economic, social, and cultural factors in addition to biological factors.

No one priority-setting method fits all conservation objectives. For example, if the objective is to conserve a representative array of a country's natural ecosystems, a priority-setting approach that relies on species richness may neglect to represent important ecosystems that are relatively species-poor.

Global geographic priority-setting approaches have included identifying "megadiversity" countries that are unusually rich in biodiversity, "hotspots" where species-rich ecosystems are imminently threatened, and "major wilderness areas" where limited conservation efforts may avoid the intensive efforts needed in more threatened areas. Smaller-scale efforts—including the "centres of plant diversity" project initiated by the IUCN and the "endemic bird areas" project of Birdlife International—identify specific sites where many species belonging to a major taxonomic group are found. Finally, the World Conservation Union's Commission on National Parks and Protected Areas (IUCN/CNPPA) and others are working to identify a series of sites that could form the basis of a network of marine protected areas representing all of the world's major coastal and marine bioregions.

Global priority-setting efforts are driven by several considerations. First, biodiversity is unevenly distributed, with some nations having more diversity than others, just as some ecosystems have more species than others. An area's biological resources may be valuable to the world at large, not just to its community or nation, especially if the genetic material found therein holds the promise of agricultural or pharmaceutical advances. And conserving biodiversity will require international investments to share the cost of maintaining biological resources whose benefits often flow beyond national borders.

Some of the most innovative priority-setting is taking place at the regional level, an intermediate plane between national and global that avoids both the imprecision of global priorities and the arbitrariness of national borders. Regional approaches can form the basis of multinational networks and alliances to promote biodiversity conservation, share experiences, and develop cross-border conservation projects. For example, in South and Southeast Asia, sub-Saharan Africa, and Oceania, systematic reviews have been carried out to identify gaps in protected areas coverage. Conservation International and other groups have been using "expert workshops" to rapidly identify important conservation areas by using existing data and the consensus of experienced scientists and conservationists. Conservation biologists at World Wildlife Fund/U.S. and other organizations are developing dynamic models to categorize regional ecosystems by their conservation needs. A consortium effort led by the Biodiversity Support Program has developed an integrative framework that considers regional priorities from biological, conservation potential, and policy/institutional perspectives. While such approaches can only be as effective as the conservation strategies used to implement their recommendations by the region's nations, they are probably more promising than global approaches.

The priority-setting that takes place at national and local levels will have the most impact. Priorities set at these levels are indispensable because they are more likely to focus on specific conservation objectives; specify species, ecosystems, or sites; reflect national and local values and needs; mesh with policy and planning processes; engage a wider spectrum—from government agencies to NGOs and local communities—in the process; and fit their plans to the available financial and human resources. In addition, priorities set at this level indicate to international donor agencies and conservation organizations which ecosystems, habitats, and species are considered most important from a national perspective.

Relatively few countries have established clearly defined conservation priorities. Even fewer have consensus priorities that are actively used to guide conservation activities or to direct government and donor resources. As a result, biodiversity gets short shrift in many planning and policy processes (e.g., Tropical Forestry Action Plans and National Environmental Action Plans) that determine how resources are used or where development takes place. In the absence of good conservation priorities, these processes may actually speed the loss of biodiversity rather than strengthen its conservation. At the very least, the absence of geographic priorities in such processes represents lost opportunities for focusing conservation efforts.

However, a growing number of priority-setting efforts have been applied in such countries as Brazil, Papua New Guinea, Bulgaria, the United States, Australia, and Mexico, and some of them have influenced the allocation of conservation resources. The wide range of approaches used at the national level illustrate an important point. There is no one "right" way to set priorities—each approach reflects a unique set of objectives, underlying values or assumptions, and circumstances.

There are nonetheless principles that can make any such priority-setting exercise more effective:

1. **Link Biodiversity Priorities with Clear Conservation Goals and Objectives.**
   All priorities are determined with some objective in mind—the key is to ensure that the objective is explicit and can be understood by others. Whether the objective is to maintain the broad diversity of life associated with natural habitats, or to maintain the diversity of agricultural and semi-domesticated species and varieties, no set of priorities makes much sense without a link to clearly defined objectives.
2. **Use a Replicable, Transparent Process to Develop Credible Priorities.**
   Using a transparent, replicable approach is important because it lends credibility to the priorities selected, minimizes the role of prejudice, clarifies assumptions and value judgments, and reveals what information was or was not evaluated. Explicitness is always a virtue in setting priorities, and it will save time, effort, and mistaken speculation when priorities are subsequently revised or reviewed by others.

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3. **Clarify Local, National, and Global Biodiversity Conservation Priorities.**
   Conserving biodiversity is a common concern of all humanity, but this shared concern does not translate into shared priorities or perceptions—which vary depending on whether the point of view is global, regional, national, or local. Enduring solutions demand that a partnership be reached among all interested parties and that the legitimacy of their perceptions and interests be recognized at whatever scale priorities are identified.
4. **Evaluate the Advantages and Disadvantages of Relevant Priority-Setting Schemes.**
   Biodiversity can be thought of as a vast collection of many elements—genes, species, and ecosystems—differentially distributed in space. Any priority-setting scheme will only identify some subset of these elements and will usually consider only some portion of the biosphere's total space. For any given objective, some approaches will be more suitable than others and decisions about what methodology to use should be informed by consideration of the strengths and limitations of the chosen scheme with respect to the subset of biodiversity being considered.
5. **Make Full Use of Relevant and Available Information.**
   Priorities are only as good as the information they are based on. Knowing where the data came from, when and how they were collected, and whether they were subject to expert review and ground-truthing is essential to any credible scientific effort. However, a dearth of data should seldom be used as an excuse not to set priorities—all available information should be fully utilized. For example, local communities can provide indispensable information on species distribution patterns and conservation status and identify social and economic issues which may be relevant to the priority-setting process.
6. **Involve Those Responsible for Implementing Conservation Actions.**
   Who will be responsible for taking action once the biodiversity conservation priorities have been identified? For any particular subset of biodiversity in any particular place, certain institutions (e.g., government agencies, local communities, NGOs, or universities) will have responsibilities, interests, and capacities for taking actions to conserve priority species or ecosystems. It may be possible to identify sound priorities without involving these institutions, but it is unlikely that the actions given priority will be effectively carried out without their cooperation.
7. **Involve Communities and Other Stakeholders.**
   People will be living in most areas identified as conservation priorities, and conservation efforts can have significant impacts on them. Bringing local people into the process offers opportunities to build respect, trust, and collaborative relationships between them and outside conservationists from the beginning. While it may be impractical to involve local people in large-scale (e.g., global or regional) priority-setting efforts, local involvement should be considered whenever possible.
8. **Consider How Priorities Fit in a Policy and Institutional Context.**
   Once a basic set of conservation priorities has been determined, it will usually be impossible to undertake actions in all areas simultaneously. Decision-makers who must allocate resources inevitably confront this issue, but too often they must make decisions in a vacuum—without knowing why a particular set of priorities was selected or which ones are most urgent. For this reason, priority-setters should be prepared to be involved in the policy process that transforms a set of systematically chosen and scientifically credible priorities into a series of decisions about where to spend money,

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what type of activities to support, how to allocate personnel, and what policies to revise.

9. **Link Conservation Priorities to Other Planning and Policy Processes.**
   Conservation usually depends on the allocation of money, personnel, policy reforms, and land-use changes, and not simply on knowing which species and ecosystems are most important for a particular conservation objective. At all levels—local, national, and global—there are institutions, mechanisms, and planning processes that can significantly influence or directly take actions needed for the conservation of biodiversity priorities. Conservation priorities will be effective only when they are linked to economic and sectoral policy and planning processes that affect resource allocation, land use, and the consumption of natural resources. National biodiversity strategies and action plans, as called for under Article 6 of the Convention on Biological Diversity, provide an excellent opportunity to link geographic priorities with an important national planning and policy process.

10. **Establish a Process to Revise or Reassess Priorities at Regular Intervals.**
    New information on species and ecosystems is constantly being generated, and the threats to those resources also change with time—even very short periods of time. The values that humans attach to species and ecosystems change as well. Change is inevitable with conservation priorities, and conservation planners should be flexible enough to accommodate new information and to revise existing priorities on a periodic basis.

As efforts to implement the Convention on Biological Diversity increase, national and international institutions are seeking frameworks to help them allocate resources for biodiversity conservation. Several issues are vital to using priority-setting efforts to bolster biodiversity conservation policies and strategies. First, explicit objectives are essential, both to provide guidance to the selection process and to clarify what elements of biodiversity are included in the priorities. Second, biodiversity is important everywhere, so biogeographic representation should be an objective of initial efforts to set priorities. Third, the conservation of biodiversity is less a question of biology than of social, economic, and political factors. Therefore, while priorities must be scientifically sound, the social and institutional context in which conservation decisions are made should also be considered. Fourth, priority-setting must become an integral part of national biodiversity strategies, action plans, and related policy and planning processes. This will require investing in national capacities to develop and implement comprehensive conservation priorities. Finally, at the international level, priority-setting should complement but not supersede nationally and locally determined biodiversity conservation priorities.

If conservation priorities set during the next decade or so actually guide investment, they will influence conservation activities in many places for decades and perhaps centuries into the future. Biodiversity priorities set in the 1990s will not be the last, but they could well be the most important.

There is no single formula for developing effective biodiversity conservation priorities: the process will vary according to available information, local perceptions, and development objectives. Priority-setting will become more sophisticated in coming years, as more effective approaches and processes emerge, but priorities will have to be revised again and again as circumstances change. Therefore investments in building the information base, making appropriate technologies available (e.g., computer mapping and databases), defining participatory mechanisms, and providing training will be a valuable long-term contribution to the conservation of biodiversity. There will never be a better time to invest in developing the capacity to set priorities at all levels—local, national, and global.

CHAPTER ONE

INTRODUCTION

The one process ongoing in the 1990s that will take millions of years to correct is the loss of genetic and species diversity by the destruction of natural habitats. This is the folly that our descendants are least likely to forgive us.

E.O. WILSON (1992)

The earth's biological foundation is eroding at a rate unequaled in at least 65 million years. Rapidly escalating human demands for narural resources are causing genes, species, and natural ecosystems to disappear at an unprecedented rate. Conservation is becoming a crisis discipline. Deciding what to conserve and where is an essential first step in managing the crisis.

In an ideal world, all biodiversity conservation needs would be addressed without jeopardizing human aspirations for social and economic development. Despite evidence of modest growth in conservation funding support (Abramovitz, 1994), it is clear that biodiversity conservation needs around the world will continue to vastly exceed the financial resources available. This publication examines the scientific basis for setting biodiversity conservation priorities, reviews practical experience from around the world, and recommends principles for making priority-setting an effective conservation tool at local, national, and international levels.

WHAT ARE WE LOSING AND WHY SHOULD WE CARE?

Extinction is a fact of life. Sooner or later, every species meets its fate; it may be overwhelmed by environmental change or by the debut of a new species. The fossil record indicates that, during the more than 3.5 billion year history of life, the average longevity of a species has ranged from less than a million years for some groups of mammals to about 10 million years for certain groups of invertebrates and flowering plants (Wilson, 1992). Whatever the circumstances of the species' demise, other species, perhaps new ones, have always found ways to use the resources previously consumed by those that have departed. Through the broad sweep of geological time, for each species that

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has disappeared, more than one species has replaced it. Gradually the world has become more, not less, biologically diverse in spite of the extinction that each species inevitably faces.

Although estimates vary widely, there may now be 30 million or more species on earth. Living organisms are found everywhere on the surface of the planet, including such inhospitable places as the polar icecaps and deep within sulphur springs thousands of meters below the surface of the Pacific Ocean. The interaction of species with each other and their environments has multiplied with the growing diversity of life, giving rise to new evolutionary pathways that eventually contribute to the formation of new species and ecosystems. One of these pathways produced the species *Homo sapiens* roughly one million years ago. Other evolutionary pathways have produced a vast array of species and productive ecosystems that have helped humans to succeed as a species.

The increase in *biological diversity* (see Box 1.1) has not been without its setbacks. Occasionally, changes in climate brought on by continental drift, massive volcanic eruptions, or asteroid impacts have caused mass extinction events that actually reduced the planet's biodiversity. The fossil record indicates that life has been impoverished by five massive extinction events during the past 450 million years, each of them wiping out between 25 and 50 percent of all biological families (Raup, 1988). At the end of the Paleozoic period 245 million years ago, as many as 96 percent of all species may have been eliminated, and the most recent mass extinction episode abruptly ended the dinosaur era at the end of the Cretaceous period 66 million years ago. After each of these major biological catastrophes, life has recovered its diversity—but only after tens of millions of years

A sixth major extinction event is now underway as large-scale rapid environmental change affects much of the earth's surface. This time the agent of environmental change is not astronomical or geological, but biological. Humans are the most powerful agent of environmental change driving the latest wave of extinctions. Human activities have already caused the destruction of over a third of the world's forests, and a majority of the world's native grasslands have been lost to either the plow or to desertification caused by overgrazing. The human species now appropriates 40 percent of the solar energy captured in the photosynthetic process of plants (Vitousek et al., 1986). Through the transformation of natural habitats into domesticated land uses (cropland, plantations, permanent pasture, and human settlements) and the direct consumption of wild flora and fauna, human uses of natural resources are exacting a heavy toll on other species. In the few plant and animal groups that are well known, extinction is taking place at far faster rates than before humans inhabited the earth. Conservative estimates indicate human activity has increased extinction rates of plants and vertebrates to between 10 and 100 times the normal "background" rate—a figure that may be much higher for invertebrates. According to Wilson (1992), "we are in the midst of one of the great extinction spasms of geological history."

In the vast majority of extinctions, we will never know what we are missing. Only a fraction (about 1.6 million species) of the world's total number of species—estimated to be between 10 million and as many as 30 million—have been identified and described by science. But even if human society does not notice the passage of these anonymous species, it is clear that biological resources in their myriad forms are essential to human welfare.

From the earliest days of recorded history, the fundamental social, ethical, cultural, and economic values of biological resources have been reflected in religion, art, and literature. Diversity in genes, species, and ecosystems has contributed immensely to the productivity of agriculture, forestry, fisheries, and industry. In many parts of the world, especially in predominantly agrarian and preindustrial societies, the daily lives of people and the biodiversity that surrounds them are closely intertwined. Wild

Box 1.1 The Diversity of Life

Biodiversity refers to the variety and variability among living organisms, the ecological complexes in which they occur, and the ways in which they interact with each other and their environment. Biodiversity is usually divided into three hierarchical categories—genes, species, and ecosystems. A more comprehensive definition, based on Sanderson and Redford (1994), is used here to better represent the components of biodiversity and how they are measured.

Genetic diversity refers to the variability within a species. This diversity can be measured by the variation in genes within an individual species, population, variety, subspecies, or breed. Until recently, measurements of genetic diversity were applied mainly to domesticated species and populations held in zoos or botanic gardens. These techniques are increasingly being applied to wild species.

Species diversity refers to the variety of species within a local area, region, or at the global scale. Such diversity can be measured in many ways, and scientists have not settled on a single best method. The number of species in a region—its species "richness"—is the most often-used measure, but population biologists sometimes use a more precise measurement that weighs the presence of species versus their frequency at a given locality. Since the species is the unit best understood by lay people, and because of the work of taxonomists, much of the attention to biodiversity, including priority-setting, has been focused at the species level.

Taxonomic diversity refers to the variety of organisms within a region at a taxonomic level higher than the species level (e.g., genera, families, order, etc.). When the objective is to preserve the greatest genetic variation, species from different higher taxa should be selected. For example, an island with two species of birds and one species of lizard has greater taxonomic diversity than an island with three species of birds but no lizards. Similarly, more species live on land than in the sea, but terrestrial species are more closely related to each other than ocean species are, so diversity is higher in marine ecosystems than a strict count of species would suggest.

Diversity of communities and *biotic processes* refers to groups of different species that co-occur in the same habitat or area and interact through trophic (e.g., foodwebs) and spatial relationships. Pollination, predation, and mutualism are examples of biotic processes. Diversity is harder to measure at this level because the "boundaries" of communities are elusive. While there is no consensus approach to measuring diversity at this level—mathematical relationships of species co-occurrence and vegetation cover are two of the approaches used—the number and distribution of communities can be measured as long as a consistent set of criteria is used.

Diversity of ecosystems refers to a community of organisms and their physical environment interacting as an ecological unit. Ecosystem processes differentiate this level from the community level and include abiotic factors such as fire, climate, and nutrient cycling that influence the composition, structure, and interaction of biotic communities. The difficulties of measuring diversity at this level are similar to those at the community level. This is also the level at which many evolutionary processes operate. Biodiversity conservation at the ecosystem level seeks to preserve the basic trophic structure (i.e., the food web of plants, herbivores, predators, and decomposers that transforms energy into life) and patterns of energy flow and nutrient cycling. At this level, conservation should seek to preserve properties and processes, not just species or assemblages of species.

Sources: Sanderson and Redford (1994); WRI/IUCN/UNEP (1992)

species provide people with food, dyes, fibers, building materials, and medicinal plants, while home gardens and agricultural plots are planted with distinct domesticated crop varieties produced through many generations of breeding to balance productivity with adaptation to environmental conditions and human tastes. The livelihood of forest dwellers, farmers, trappers, fishermen, and others depend on their ability to manage the diversity of life to meet their perceived needs without necessarily diminishing the environment's capacity to meet their needs on the next day.

In modern society, biodiversity contributes enormously to human welfare as well. For example, a quarter of the prescription drugs dispensed in the United States, and a substantially higher figure for all drugs worldwide, owe their existence to compounds first derived from plants. Two of the more well known examples of such drugs include vinblastine, an effective treatment for childhood leukemia derived from the rosy periwinkle of Madagascar, and taxol, a promising new treatment for breast, ovarian, and other cancers derived from the Pacific yew tree of the Pacific Northwest in the United States and Canada. The thousands of other drugs derived from plants include a variety of widely prescribed sedatives, stimulants, analgesics, antitumor agents, cardiovascular drugs, antimalarial agents, and birth control pills. The over-the-counter value of plant-derived pharmaceuticals alone exceeds $40 billion per year worldwide (Miller and Tangley, 1991). Yet only 5,000 plant species (most of them from temperate zones) have been comprehensively screened for their medicinal properties, leaving the vast pharmaceutical potential of plants (especially tropical plants) unknown (Kapoor-Vijay, 1992). Our understanding of the link between biodiversity and human welfare will continue to expand as, for example, researchers learn more about the role of soil microfauna—one of the least known parts of the biological world—in maintaining crop and tree productivity.

In a world faced with the potential for rapid environmental change caused by climate change and pollution, biodiversity offers options for agriculture, forestry, and other human activities to adapt to changing conditions. Advances in breeding, biotechnology, and genetic engineering have enhanced the value of wild species because their genes can now be used to confer new properties such as disease resistance or tolerance for a wider variety of environmental conditions to domesticated species. The loss of biodiversity reduces the options for nature and people to respond to changing conditions. As Noss (1993) observes, it is sustainability that depends on biodiversity, not the other way around.

Yet thousands of species and even entire communities of species around the world face premature extinction each year.[1] National-level biodiversity assessments are depressingly similar in their long lists of endangered species, unprotected ecosystems, threats to biodiversity, and inadequate conservation resources.[2] Deciding which species, habitats, and ecosystems have precedence in the allocation of conservation resources is a difficult, but inevitable aspect of conservation planning in the 1990s. Scientists, conservation agencies, nongovernmental organizations, and donors have begun to set explicit biodiversity conservation priorities in a variety of ways.

PRIORITY-SETTING

For many people, setting conservation priorities is an uncomfortable task, akin to playing god. To others, it may seem a redundant activity that merely confirms what knowledgeable folks already know. Moreover, setting priorities may seem a poor use of resources since conservation priorities are not always influential and are sometimes overlooked entirely. However, every decision to spend time, money, and effort in a particular place and in a particular way means that those conservation resources cannot be used somewhere else. In short, priorities are continually being established for biodiversity conservation—even if there is no deliberate process for doing so. This volume assumes that it is better to set priorities in an informed, transparent, and deliberate way than to leave them to chance and opportunity.

Biodiversity in the Balance was written with several audiences in mind. *Policymakers* with responsibility for defining conservation policy

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and implementing conservation strategies at the national and provincial/state levels will find the discussion of the policy context for setting priorities, and the range of available approaches, useful for planning, especially as countries move to implement the Convention on Biological Diversity. *Donor agencies* faced with increasing demands to support conservation efforts with limited financial resources are already increasingly involved with priority-setting efforts, and this volume should assist agency professionals involved in this valuable and complex task. Both policymakers and managers should benefit from the use of straightforward, non-technical language to discuss what can be complicated and technical concepts. Finally, this publication is written for *scientists* and *conservation management professionals* who have already done much to advance the cause of identifying efficient means for conserving biodiversity. It is hoped that they will benefit from seeing the range of approaches that have been developed and stand resolved to push the evolution of priority-setting further.

Chapter II stresses that any set of conservation priorities reflects human values. In order to distinguish between the almost infinite variety of genes, species, and ecosystems, priority-setters assign values to elements of biodiversity. Two major value systems are applied to biodiversity: 1) its use value, and 2) its existence value. Use values may represent economic, scientific, ecological, or social and cultural benefits from biodiversity that people and institutions consider most important. The value of biodiversity can also be considered entirely separate from its use to humans or the biosphere. Valuing biodiversity simply because it exists is important to many people in cultures around the world. Given the range of values that people associate with biodiversity, it is not surprising that there is no generally accepted universal scheme for establishing biodiversity conservation priorities. Chapter II also explores biological and social factors used in setting priorities and examines the general types of approaches that have been developed to establish biodiversity conservation priorities. Literally hundreds of approaches have been developed during the past two decades. This chapter categorizes and analyzes priority-setting approaches by the types of conservation objectives they are designed to support. These categories include genetically-based, species-based, ecosystem-based, and "integrative" (combining social and economic criteria with biological factors) approaches to setting biodiversity conservation priorities.

Chapter III reviews conservation priority-setting in practice. Specific examples of priority-setting at international, regional, and national scales are presented. These range from well-known schemes for setting global priorities such as the "hotspots" (Myers, 1988) and "megadiversity" approaches (Mittermeier and Werner, 1990) to regional (e.g., Amazonia) and national level efforts (e.g., Papua New Guinea). While these approaches are strongly influenced by the issues discussed in Chapter II, they are each unique, reflecting the enormous variation in bio-physical conditions, institutional values and objectives, and available resources.

Chapter IV presents a set of ten principles to strengthen the effectiveness of any process to set biodiversity conservation priorities. These principles were developed to build on the strengths and limitations of the approaches reviewed in Chapter III. They are based on the premise that an effective priority-setting process should provide a critical link between conservation goals and objectives and on-the-ground actions that make conservation a reality. These principles stress the importance of process and participation in priority-setting efforts, especially at local levels.

Finally, Chapter V concludes with a summary of issues most vital to using priority setting effectively to support conservation policies and objectives. These issues include the importance of using clear objectives to guide priority setting, the role of biogeographic representation in first-cut priorities, recognizing that non-biological factors will ultimately determine the fate

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of priorities, making priorities an integral part of national biodiversity strategies and action plans, and defining a complementary role for setting priorities at international levels.

Endnotes

1. Assuming there are 10 million species, current annual losses could range from 8,000 based on the most conservative estimates of Reid (1992a) to 85,000 based on Raven's (1988) estimates on extinctions due to tropical deforestation. Most of these estimated extinctions are of invertebrates in the tropics.
2. National level biodiversity assessments have been carried out by the World Conservation Monitoring Centre, and by government agencies and national and international nongovernmental agencies. Support for these assessments has generally come from various multilateral development agencies (e.g, World Bank, United Nations Environment Program, Global Environment Facility), and bilateral agencies, especially the U.S. Agency for International Development (see WRI, 1992a). More recently, countries have begun to develop national country studies, strategies and action plans as called for under the Convention on Biological Diversity (see Miller and Lanou, 1995).

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CHAPTER TWO

BIODIVERSITY CONSERVATION PRIORITIES: VALUES AND APPROACHES

Establishing biodiversity conservation priorities should be a conscious effort to assign values to genes, species, and/or ecosystems, and then to evaluate other criteria (such as risks and opportunities for their conservation) in relation to those values in order to arrive at a set of geographic priorities. Priority-setting is a complex process around which achieving consensus would be difficult if only one scheme existed. However, hundreds of approaches have been developed to support a range of conservation objectives, each with its own strengths and weaknesses.

In many ways, the benefits of establishing credible conservation priorities are self-evident. Efficiency in the use of limited conservation resources is the most obvious. Efforts spent deciding where and what to do first may be repaid in savings of time, finances, and personnel. The data and analysis required to establish priorities help give a more complete understanding of the distribution and status of biological resources in the geographic area evaluated. Many potential funders of biodiversity conservation efforts are likely to be more supportive if their resources are directed to strategic and well-justified priorities. A deliberate and well-documented priority-setting process can also provide transparency in conservation planning and decision-making. Transparency provides interested institutions and the public with a sense of what information was important in the selection of priorities and enhances the scientific credibility of conservation decisions.[1] Given the complexity of biodiversity, and the range of values, perspectives, and goals that influence how biodiversity is viewed, it is not surprising that there is no generally accepted universal scheme for establishing conservation priorities. Different criteria and conservation objectives characterize various approaches. This chapter, therefore, seeks 1) to examine the role human values and perspectives play in determining biodiversity conservation priorities; 2) to review criteria most frequently used to assign value to elements of biodiversity, and; 3) to categorize various priority-setting approaches by the type of conservation objective they are designed to support.

Priorities are Value Statements

Just weeks before the United Nations Conference on Environment and Development (UNCED) was convened in Rio de Janeiro in June 1992, 98 nations gathered in Nairobi to conclude negotiations on a biodiversity convention after three years of complex and sometimes divisive debate. Although an international agreement was reached in the final hours of the Nairobi negotiations, and the Convention on Biological Diversity was forwarded to Rio for signature at the UNCED meeting, a number of countries expressed reservations almost immediately. Although most countries signed the convention in Rio, with the United States a notable exception,[2] a number did so with serious reservations. To some, the disagreements that arose in the late rounds of negotiation weakened the treaty by not specifying formulas or payment mechanisms for the use of genetic materials and for conservation financing in general. Other countries indicated that the failure to include a list of the most important ecosystems, habitats, and species for international conservation rendered the treaty hollow.

The disagreements over whether to include a list of biodiversity conservation priorities raised serious issues of sovereignty, responsibility, compensation, and values that limited progress in other areas of the convention as well. In many respects, the debate reflected fundamental differences in how various interests see biodiversity. *Industrialized countries*, most of them relatively poor in species diversity and natural habitats, argue that the global importance of biodiversity makes it part of the common heritage of mankind, for which all nations share some responsibility, regardless of where the biodiversity is found. These arguments, reflecting both ethical and utilitarian values, are motivated by many factors, including a desire to protect rights that allow developed countries to explore and exploit the commercial value of biodiversity found in the tropics. In *developing countries*, many of them relatively well-endowed in biodiversity, governments often view the species, habitats, and ecosystems found within their borders as sovereign resources valued primarily for the direct economic development benefits they may provide. For *local peoples throughout the world*, biodiversity often represents cultural, spiritual, and basic subsistence values that were left out of the formal discussions on the Biodiversity Convention.

In short, the debate on the Convention on Biological Diversity was motivated by concerns about whose priorities were being singled out, who would bear most of the burden to protect species and ecosystems, and who would benefit from their conservation. The inability of treaty negotiators to agree on a single set of global conservation priorities was perhaps inevitable given the differing views, values, and definitions associated with biodiversity.

The etymology of *priority* begins, not surprisingly, with the Latin word "prior" meaning first. The Medieval Latin "prioritas" and subsequent Middle English "priorite" established a noun with much the same meaning that priority has today, or "that which has the most importance." In its most common modern English usage, priority is defined as something which has precedence or is established by order of importance or urgency. Importance, of course, is crucial to the meaning of priority and implies that whatever is a priority is something having great value or significance. Moreover, calling something a priority implies that its value or significance is greater than other things with which it is being compared. There are no self-evident priorities: priorities cannot be chosen before the set of things being considered are assigned relative values. Valuation is, itself, relative and depends on the valuer and his or her objectives.

Conscious consideration of biodiversity values in the priority-setting process provides benefits beyond the more obvious benefits described above. For example, the deliberate choice of values to be emphasized can help to

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clarify what values are not protected under a given conservation objective—values that may have to be considered under additional conservation objectives and protected by separate sets of priorities. Discussions about why, where, and how to conserve biodiversity when framed in terms of value considerations are likely to be more specific and tangible to the public. In short, value considerations that assess the many roles biological diversity plays in nature and in human societies can help us to disaggregate the immense complexity embodied in the term "biodiversity." Considering biodiversity values will in most cases reveal how little we know about the life around us and where we should look to learn more.

Unfortunately, the values which inform the establishment of biodiversity conservation priorities are usually left unstated by those making the determination. This leaves others with the task of identifying what underlying values are implied by priority-setting exercises as they try to decide whether the values assigned coincide with their own views on what is most important for conservation action. The most obvious area where values are revealed is in the criteria used by various schemes to narrow the elements of biodiversity considered for priority status.

Criteria for Assigning Conservation Value

Criteria provide standards to judge whether a thing or a process has certain desired properties, characteristics, or values. Any deliberate effort to establish biodiversity conservation priorities uses criteria, although they are not explicitly defined in all cases. Given the complexity of biodiversity and the many ways in which it is valued, the number of criteria that could be used to identify genes, species, or ecosystems as conservation priorities is enormous. In practice, however, a handful of criteria are most commonly used.

Biologically defined criteria are used in virtually all priority-setting schemes; some approaches use additional social, economic, institutional, and other criteria. The most commonly used biological criteria and several examples of economic, social and institutional criteria are summarized below. These criteria, in principle, can be used at any level of biodiversity (e.g., genes, species, ecosystems).

Biological Criteria

Ethical, historical, cultural, and political values are key determinants in shaping peoples' conservation priorities. Yet conservation biologists and international organizations typically seek to establish conservation priorities based on the biological and physical characteristics of biota. Under these criteria, biodiversity measurements (e.g., species richness and endemism levels) are a key determinant of biodiversity priorities (see Box 1.1). Most conservation priority schemes use one or more of the following biological criteria: richness, distinctiveness, rarity, representativeness, threat, and function. Often several criteria are combined to evaluate tradeoffs and make value judgments before a set of priorities is reached.

Richness. Species richness refers to the number of species in a given area; the more species, the greater the species richness. Use of this criterion alone (without additional criteria) implies that all species are of equivalent value, and that areas with more species are of greater value to conservation than areas with fewer species. Species richness is very important in most schemes to identify biodiversity conservation priorities and is the simplest and most quantitative criterion available to identify priorities. For example, a habitat containing 800 species would be of greater conservation importance than a nearby habitat with only 500 species.

Although richness is usually applied at the species level, it can also be considered at the genetic and ecosystem levels. For example, a species population with relatively high genetic variation would be more important for conservation than a population of the same species where inbreeding has led to relatively little genetic variability. Or, a region with numerous ecosystem types (e.g., eastern slopes of the Andes) would be of higher conservation priority than a region with fewer ecosystem types (e.g., the cerrado).

Rarity. This criterion is used to assign higher conservation value to the least common genotypes, species, or ecosystems. This criterion also relies on quantitative information—in other words, the number of occurrences of a genotype, species, or ecosystem is the relevant measure for rarity. Nearly every approach to establishing conservation priorities employs this criterion, sometimes combined with one or more other criteria. For example, a genotype of a wild relative of an agriculturally-important species found in only one reproductively isolated small population would have higher conservation value than a widely distributed genotype found in a number of interbreeding populations of the same species.

Using the rarity criterion, the peregrine falcon (*Falco peregrinus*) would be accorded greater conservation value than the closely related, but much more common American kestrel (*Falco spaverius*).[3] Likewise, ecosystems that are widespread and found in a number of locations (e.g., boreal spruce-fir forests) are less important to biodiversity conservation than are rare ecosystems of limited area (e.g., wetlands in arid regions). In other words, rarity constrains conservation options by leaving only one small location or population for conservation efforts. Conservation of widespread ecosystems and common species is less urgent because there are many more options.

Distinctiveness. In contrast to rarity, which simply measures the relative quantity of something, distinctiveness is a criterion used to assess the degree of separation of a population, species, or ecosystem from its nearest comparable analog. A species, for example, may be numerically common (and thus not rare) but could be exceedingly distinct in the sense that it has few if any closely related species — the duck-billed platypus (*Ornithorhyncus anatinus*) in Australia is an example.

The following dichotomies show how this criterion influences priority assessments. For example, conserving a plant community with many endemic species (i.e., species found nowhere else in the world) makes a greater contribution to the conservation of biodiversity than conserving a community containing many widespread but few endemic species. A species that is monotypic (the only species in the genus), or a species that is the only representative of its family or order is more deserving of conservation than is a species that belongs to a genus with many species.

In many parts of the world, however, our knowledge about the distinctiveness of species is limited. Many tropical species are not described by science and little is known about their genetic relationships.[4] For example, in the South Pacific, The Nature Conservancy's efforts to identify conservation priorities is starting out simply by trying to identify major ecosystems and assess their rarity.

Representativeness. This criterion is used to ensure that conservation efforts in a given area include examples of all species or ecosystems (or genotypes of a particular species), depending on the level of interest. For example, this criterion is often used to design reserve systems containing different ecosystems typical of a region's variety of ecosystems. Alternatively, this criterion might be used to decide which of two sites within the same ecosystem has the most representative sample of species and ecosystem processes that characterize the ecosystem. At the genetic level, representativeness is an important criterion in selecting samples for ex-situ preservation in seed banks and captive breeding programs.

Threat. Under this criterion, elements of biodiversity facing the greatest imminent danger or harm (usually from human activities) are considered most worthy of conservation. In the case of a species, danger or harm usually means a decline in numbers that puts a species at risk of not being able to maintain a viable breeding population. Causal relationships between potential threats and their effect on elements of biodiversity are frequently difficult to establish, and therefore this criterion usually adds a more subjective element into priority considerations. This criterion is widely used, usually in conjunction with "rarity" and "distinctiveness." In fact, "threat" tends to merge with "rarity" since as a species or ecosystem becomes more threatened, it is, by definition, becoming more uncommon. However, "rarity" tends to be a physical factor while "threat" adds a greater sense of time or urgency (i.e., some species are naturally rare but not threatened with extinction). The practical issue, once again, is that fewer options and less time are available to protect endangered species than other species. This criterion is often motivated by a sense of moral responsibility on the part of humans to avoid causing the loss of a species or habitat.

The use of the threat criterion in setting priorities might lead to the following results. For example, among African antelopes, a species listed by the World Conservation Union as "endangered" (e.g., Addax) would receive higher priority than one that is listed as "vulnerable" (e.g., Giant Eland) which in turn would receive higher consideration than one that is listed as "rare" (e.g., Yellow-backed Duiker) (IUCN, 1988).[5] An unprotected natural habitat surrounded by intensive agricultural development would receive more priority than a similar habitat with less intensive agricultural development on only one side. When species are evaluated, a major weakness with this criterion is that our information on what is threatened is often simply a reflection of the state of knowledge about the species. We simply do not know enough about most species to know for sure whether, and to what degree, they and their habitat may be threatened. Obviously, our knowledge of threatened genotypes is even more limited. And while the World Conservation Union (IUCN) and many national and even state and provincial governments have developed classification systems for threatened and endangered species, no classification has been developed to categorize ecosystems by degree of threat.

Function. This criterion emphasizes the role that certain species, communities or ecosystems have in determining the ability of other species, communities or ecosystems to persist. The "keystone" concept is nearly synonymous with function in this context. Within biological communities, a *keystone species* is one (or sometimes a group of closely related species) that makes a disproportionately large contribution to community structure, composition, or processes. For example, fig trees and vines (*Ficus* spp.) provide a reliable source of fruit to primates, birds, and other fruit-eating vertebrates during periods of drought when other preferred sources of food are unavailable (Terborgh, 1986). Fig trees in turn depend on highly specialized wasps, which mature inside the developing fig fruit, for pollination. Thus the health of the *Ficus* spp. depends on the health of the wasp populations, while many species in the vertebrate community depend for survival on the continued productivity of the figs. In the islands of the Indian Ocean and the South Pacific, the seed dispersal and pollination relationships between pteropid bats ("flying foxes") and many plant species are so close that the rapid decline or extinction of these bats could have disastrous consequences for hundreds of species of tropical plants[6] (Cox et al., 1991).

The keystone concept also applies to certain habitats and physical resources, which Primack (1993) calls "keystone resources." For example, mangrove forests growing in the intertidal zone of many tropical and subtropical coastlines are vital to the survival of many coastal and marine species. First, they provide

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breeding grounds and nurseries for juveniles of many marine fish species which later move into other coastal and marine habitats. Second, through the build-up of detritus from leaf litter, the periodic release of larvae from a tremendous diversity of species, and the abundance of their invertebrate life, mangrove habitats contribute much of the organic matter that makes its way into marine waters that are otherwise nutrient-poor, including coral reef ecosystems. In addition, mangrove forests protect beaches and shorelines and their biological communities from erosion and can protect low-lying coastal lands from saltwater inundation by lessening the impact of ocean surges associated with typhoons. At the same time, mangrove ecosystems trap sediments resulting from upland soil erosion and thereby protect fragile coral ecosystems and other sensitive marine environments from destructive siltation. Clearly, mangrove forests are keystone ecosystems.

Physical resources can also play keystone roles. Salt licks and other mineral deposits provide essential mineral nutrients for many vertebrate species, especially in inland areas with heavy rainfall and mineral leaching. Dead standing trees and woody debris on forest floors support many vertebrate and invertebrate species in the Pacific Northwest of North America; their removal through intensive forest management can have damaging impacts on local levels of biodiversity (Hansen et al., 1991).

Where keystone relationships can be established, the strategic value of using this criterion to set biodiversity conservation priorities is obvious. Once again, limited knowledge constrains use of this criterion. As a result, relatively few priority-setting schemes have used it explicitly. However, as food webs, biogeochemical cycles and other ecological processes become better known, the use of the function criterion will undoubtedly grow in importance.

Social and Institutional Criteria

Some priority-setting schemes address non-biological criteria such as economic, cultural, or existence value to humans. Most of these schemes combine one or more of the biological criteria above with non-biological criteria, usually some aspect of human utility. In general, social and institutional criteria have been used less often than biological criteria in priority-setting mechanisms. Social and institutional criteria, however, have become more important in priority-setting as the contribution of social and institutional factors to successful conservation efforts has become more widely appreciated.

Utility. The utility criterion emphasizes the importance of biodiversity elements that have known or potential utilitarian value to humans. Utility may be defined as economic value but it can also be used to identify elements of biodiversity that have scientific, social, cultural, or religious significance as well. Since the same species or communities can have different utility values to various groups of people, this criterion introduces perhaps the most subjective considerations into the priority-setting process. For example, "degraded" forest areas may retain substantial biodiversity with utility to local people who depend on the local biota for food and other products but may be viewed as having relatively little utility to a government that is more interested in wildlife habitats that attract tourists. This is especially true when potential or future utility values are being considered, since human premonitions of what might have future value are usually little more than speculation.

Decidedly anthropocentric, the utility criterion is more likely to produce conservation priorities that can draw widespread political support than biologically-defined criteria. Although the utility criterion has been increasingly used by conservationists in the last few years, it has not often been employed in published priority-setting schemes despite the emphasis human societies place on utilitarian values. Local traditional systems of conservation and management, on the other hand, often do focus on species of utilitarian value (e.g., Adisewojo et al., 1984; Alcorn, 1984; Johannes, 1984; Weinstock, 1985).

Elements of biodiversity that will be more highly valued using a utility criterion include wild plant species related to domestic food crops, wild relatives of domesticated animals, medicinal plants, fodder plant species for domestic animals, plant and animal species harvested by people, and animal species useful as research models. Likewise, an ecosystem that plays a critical role as the watershed for irrigation or drinking water, or that provides habitat for fish species important to local diets, will be accorded more value than an ecosystem that provides limited indirect ecosystem services to humanity. The concept of utility can, of course, change with time and geographic scale. For example, indirect ecosystem services, such as carbon sequestration in tundra ecosystems, may be viewed as having tremendous utilitarian value on a global scale as knowledge of climate change factors increases.

Feasibility. When decisions are made to allocate conservation resources, feasibility (something that is practical or easy to do) is often the most important factor. Feasibility may be defined in political, economic, logistical, or institutional terms. For example, a conservation project may be located in a particular place where political support is strong rather than in a more biologically diverse area where influential politicians or economic interests are opposed to the project. Many conservationists fear that this is the principal or only factor considered by policymakers and that it is usually done without explicit justification. Feasibility, unlike biological criteria, can change rapidly and dramatically as policies and institutions shift. Perhaps for these reasons, feasibility is not widely used in priority-setting schemes.

Feasibility has its strengths, however, and is the most important criterion for assessing the likelihood that actions to conserve a particular species or ecosystem will succeed. Moreover, if feasibility is not explicitly considered as a criterion for selecting priorities, priority setters virtually guarantee it will be considered behind closed doors when government decision makers or funding agencies divide up the conservation pie.

The feasibility criterion could be used in the following way. Land ownership and resource tenure are vital aspects of conservation and sustainable natural resource management in many parts of the world (Lynch and Alcorn, 1994). Particularly in developing-country communities where people have lost tenure to land and resources, they have often also lost their incentive or ability to use local environments (e.g., forests, coastal areas, coral reefs, grasslands) or species (e.g., valuable trees, medicinal plants, or wildlife) in a sustainable way. This loss of tenure by local communities may create "open access" situations where resource depletion and degradation are rapid, even if the area is now under the ownership or stewardship of the government. In such situations, the feasibility criterion could be used to select an area with a stable tenurial system over one where tenurial systems are poorly defined or routinely ignored. In developed countries, the feasibility criterion applied to land ownership would probably have a different result; it is usually easier to create a protected area on publicly-owned land than by purchasing many small, privately-owned properties.

Other Social and Institutional Criteria. It is important to recognize that many people have other criteria that influence their decisions about assigning conservation values. These criteria include ethical/religious, historical/heritage, and social/cultural points of view (and there are likely to be others as well). Such criteria are often found in the informal knowledge systems of local peoples, not just in developing countries but in Western societies as well. While few published methodologies for evaluating conservation priorities

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include these criteria,[7] such issues are extremely important in many areas. They should be identified and included in assessments of biodiversity conservation priorities whenever possible.

Not all people or institutions value biodiversity in the same way. Priorities depend on objectives that are rooted in how individuals, institutions, and other collective groupings of people (even nations) value biodiversity. The criteria people use are shaped by their cultural and historical experiences—which may have developed over hundreds or even thousands of years—as well as by social, economic, geographic, and scientific factors that prevail today.

There are, of course, numerous variations under all criteria—biological and social/institutional. For example, under the utility criterion, biodiversity elements can be evaluated in terms of their current utility or their future utility, for their local utility or their global utility. Value considerations are evident in conservation strategies around the world.

Criteria as a Reflection of Societal Values

Two brief examples are presented here to illustrate how societal values influence the choice of criteria for setting biodiversity conservation priorities. One is from a developed country, the other from a developing country. These examples oversimplify the complex roles values play in choosing criteria and setting priorities in any society, but they do suggest that economic circumstances, development needs, and history are important influences in setting priorities at national levels.

The simple fact that a species (or a gene or an ecosystem) exists is reason enough for many people, especially in developed countries, to support conservation efforts. Existence value is defined by McNeely (1988) as the importance people attach "to the existence of a species or habitat that they have no intention of ever visiting or using; they might hope their descendants may derive some benefit from the existence of these species, or may just find satisfaction knowing that the oceans hold whales, the Himalayas have snow leopards, and the Serengeti has antelope." Existence value is not a priority-setting criterion at all, but it does fuel many priority-setting efforts that use biological-defined criteria such as "rare" or "threat." In the United States, the Endangered Species Act (ESA) is implicitly based on the existence value of species.

The ESA was designed to protect all species that meet scientific criteria for being "threatened" or "endangered." When a species is judged by the U.S. Fish and Wildlife Service to be vulnerable to extinction (i.e., when population levels or geographic ranges are severely reduced), human activities are restricted in critical parts of its natural habitat. Only scientific evidence, not social or economic considerations, are considered in granting a species protection under the Act. In other words, the ESA is based on the assumption that species are of value in themselves, not just because individual human beings or societal institutions have preferences for them. In reality, of course, social, economic, and political considerations do affect the priority under which species are accorded protection under the ESA (see for example, Mann and Plummer, 1995).

In Costa Rica, on the other hand, the National Biodiversity Institute (INBio) was established in 1989 to promote the conservation of biodiversity based on the premise "that tropical biodiversity will survive only to the extent that societies use it for intellectual and economic development" (Gamez et al., 1993). Although INBio seeks to develop a complete inventory of the country's biodiversity, it is concentrating initially on insects and plants—a choice guided in no small part by the chance to find chemical substances of potential interest to biotechnology concerns. In October 1991, Merck Pharmaceutical signed a $1 million contract with INBio in exchange for the opportunity to screen the samples that INBio is collecting. INBio essentially brokers Costa Rica's wild biotic wealth to orga-

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nizations interested in using that wealth for profit. The "utility" criterion in the form of known or potential economic values is thus prominent in Costa Rica's strategies for conserving biodiversity. Similar strategies are being considered by other tropical countries.

Most approaches to setting priorities use more than one criterion. Taken together, the criteria used in a given scheme reveal a considerable amount about the values and concerns of the people or institutions proposing or using the approach. Countries having priorities (not necessarily a single set of priorities) chosen by using criteria that reflect a wide range of biological and social values will stand a better chance of maintaining the widest diversity of life and its benefits.

Approaches to Priority-Setting

A biodiversity conservation goal is usually expressed in broad terms. The overall goal expressed in the Convention on Biological Diversity, which most of the world's countries have now signed, is "...to conserve and sustainably use biological diversity for the benefit of present and future generations."[8] Conservation objectives to support that goal, however, are usually defined—often implicitly—in terms of protecting a subset of an area's (or a country's, region's, or the world's) biodiversity. For example, conserving a country's economically important plant species, and conserving a representative array of a country's natural ecosystems, might be two objectives under a broader national conservation goal. The criteria described in the previous section help to narrow the subset. However, approaches to identifying conservation priorities under an objective are usually oriented toward one of the hierarchical levels of biodiversity—genetic, species, or ecosystem.

A simple typology of priority-setting approaches contains several broad categories: 1) methods based on *genetic* analysis; 2) methods based on *species* analysis (including the use of systematics[9] to analyze evolutionary relationships at taxonomic levels higher than species); and 3) methods based on the analysis of *ecosystems*. The priority-setting approaches in these three categories rely principally on biological information, but may use any of the biological or social/institutional criteria previously discussed. A fourth category of priority-setting approaches consists of *integrative* methods that include significant consideration of economic, social, and cultural factors in addition to biological information. Some approaches in each category may have characteristics that define another category. Nevertheless, the typology is essential to understanding the basic elements of the hundreds of priority-setting approaches that have been developed.

Genetically-Based Approaches

Genetic variation underlies the more visible diversity of life that we see expressed in individuals and populations of a particular species, the different species themselves, and the higher taxonomic orders that species belong to. With the rise of biotechnology and the perception that genes are the grist for the next (or the current) technological revolution, genetic diversity has become the focus of increased research—and controversies over who "owns" genetic resources and who benefits from their conservation.

Biological depletion occurs not only at the more visible species and higher levels of biological organization, but also at the genetic level. As Meffe and Carroll (1994) point out, "Many species are far from threatened, but their gene pools have been sorely reduced through the elimination of most of their populations." This is particularly true for most important agricultural crops and breeds of livestock. For example, trillions of individuals of wheat (*Triticum turgida*) flourish with each growing season, yet the great bulk of genetic diversity has disappeared with the loss of wild relatives (through

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habitat conversion) and primitive cultivars (replaced by more modern and genetically uniform cultivars).

Traditionally, efforts to characterize and conserve genetic diversity have been dominated by an emphasis on domesticated plants, particularly a few dozen agriculturally important species. A growing number of agricultural research institutions have sought ways to limit genetic vulnerability—a uniformity of genotypes that leaves crops vulnerable to new environmental stresses, pests, and disease—by preserving the range of genetic diversity found in crop species and their wild relatives. During the past twenty years, endangered species recovery programs have stimulated considerable research on the genetic variability of remaining individuals and populations to find ways to ensure that populations do not succumb to a combination of inbreeding and a narrowed genetic base. Others are interested in conserving genetic diversity within populations because of their potential future utility (see Ledig, 1988), or because a decline in diversity represents interference in the evolutionary process and the loss of evolutionary potential (see for example, Hamilton, 1993; Mlot, 1989).

Genetic resources can be conserved in-situ in reserves or special management areas or in ex-situ facilities such as seed banks, zoos, botanical gardens, aquaria, etc. As collectors take plant cuttings or shake seeds of a specimen into an envelope for ex-situ preservation, or as conservation biologists protect the habitat of an animal population for in-situ conservation, they are deciding which genes of a species are most likely to persist, especially if the species is rare or highly endangered. This is where genetically-based approaches to identifying conservation priorities are needed.

Genetically-based approaches to setting priorities are used to support three general objectives. The first objective is to ensure that individuals representative of genetic variability within a species are included in conservation programs. The second objective is to help determine which population(s) contain the greatest genetic variation. And the third objective is to conserve populations across their geographic range and the ecotypes in which they are found to ensure that co-adapted gene complexes, not just a representative sample of alleles, are conserved.[10]

Tools used for identifying genetically-based conservation priorities range from simple surrogate measures of underlying genetic variation (e.g., variation in plant or animal morphology) to highly sophisticated molecular genetic techniques. In most cases, analysis of enzyme variants (allozymes) is used to gauge the overall genetic variability within a species, population, or a number of populations. Sampling strategies can be complex and considerable debate about the advantages and disadvantages of different sampling techniques is seen in the literature. These issues are beyond the scope of this publication and are discussed in detail elsewhere (see Falk and Holsinger, 1991; Hartl and Clark, 1990; and Schonewald-Cox et al., 1983).

Advantages and disadvantages of genetically-based approaches are summarized in Box 2.1. In most areas of the world, where information is scarce, species are numerous, and threats to diversity at all levels are acute, genetically-based approaches should probably be viewed as a secondary strategy for identifying conservation priorities. Genetically based approaches should be used to "fine-tune" priorities once the "coarse filter" provided by ecosystem-based approaches (complemented by species-based approaches) has been applied. Woodruff (1992) suggests that ecological management is the cheapest and most effective way of conserving genetic diversity:

> "Genetic factors do not figure among the four major causes of extinction: overkill, habitat destruction and fragmentation, impact of introduced species, and secondary or cascade effects (Diamond, 1989). Thus, although genetic factors are major determinants of a population's long-

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term viability, conservationists can do more for a threatened population in the short-term by managing its ecology."

Nevertheless, genetically-based approaches to identifying conservation priorities are pivotal in some circumstances. These include setting priorities for small isolated populations, genetically vulnerable species of high economic or other value, and to identify individuals or populations for which there is no conservation alternative to ex-situ preservation in the short-term.

SPECIES-BASED APPROACHES

A species is the unit or element of the biodiversity spectrum—from genes to large-scale ecosystems—most commonly used by scientists and the public to represent biological variation. On the one hand, species are the most recognizable expression of genetic diversity. At the same time, species are the building blocks of ecosystems (McNeely et al., 1990). In other words, species are viewed as the "common currency" of biodiversity. Not surprisingly, more biodiversity conservation efforts focus on species than any other element of life systems, including genes, populations, ecosystems, or ecosystem processes. Likewise, most approaches to setting biodiversity conservation priorities have relied heavily on the species as the basic unit for analysis.

Although biologists have been arguing over the details of species definitions since before Darwin, modern biology (not necessarily botanists) has settled on a general definition first formulated by Ernst Mayr in the 1940s

BOX 2.1 ADVANTAGES AND LIMITATIONS OF GENETICALLY-BASED APPROACHES

Advantages

- Genetically-based approaches may provide information critical to the successful conservation of extremely rare or highly endangered species or populations.
- Genetically-based approaches are especially useful in identifying conservation priorities for domesticated species and their wild relatives, especially agricultural crop and livestock species, and other economically important species where genetic vulnerability is an issue.
- Priorities identified using genetically-based approaches are very specific and actions needed to conserve targeted individuals or populations are usually easy to define and limited in scope.

Limitations

- Many techniques relevant to genetically-based approaches are expensive, require considerable experience and sophisticated lab equipment, and deciding which sampling strategies to use is important to the results but can be confusing—mistakes will reduce confidence in the results.
- Plant or animal tissues collected for genetic analysis must be carefully collected, transported, and stored under demanding requirements (e.g, kept fresh or frozen in a hot humid environment) and maintained in appropriate storage facilities—sampling is often difficult or expensive and sometimes simply impractical.
- Genetically-based approaches may do little or nothing to help conserve ecosystems and dynamic ecological and evolutionary processes without which the value of genetic diversity preserved in isolation will be increasingly diminished over time.

(Mayr, 1942). Wilson's (1988) formulation of the concept is as follows: "...species are regarded as a population or series of populations within which free gene flow occurs under natural conditions. This means that all the normal, physiologically competent individuals at a given time are capable of breeding with all the other individuals of the opposite sex belonging to the same species... By definition they do not breed freely with members of other species."[11]

The biological species concept is not perfect. As Wilson (1992) notes, the concept "has been corroded by exceptions and ambiguities." The major weakness is that a species (or at least populations of a species) at some point in its evolutionary history may not be reproductively isolated. Hybridization between species does occur, and in some cases (especially plants), populations may partially interbreed enough to produce a good many hybrids on a persistent basis. These *semi-species*, for example, are very common among the white oaks of eastern North America (Whittemore and Schaal, 1991). Nevertheless, the white oaks (*Quercus alba, Q. stellata, Q. macrocarpa, Q. muehlenbergii*, and other *Quercus spp.*) do remain distinct since breeding within the species continues to be much more common than hybridization and the gene pool remains at least partially closed. Whatever the limitations of the concept, Wilson (1992) states that, "the biological species is likely to remain central to the explanation of global diversity."

Even without such rational explanations, the species concept provides an intuitive appeal to peoples around the world. As Wilson (1992) relates, the prominent biologist Ernst Mayr discovered the nearly universal recognition of the species concept during the late 1920s when he was a young researcher in the Arfak Mountains on the island of New Guinea:

> "Once settled in camp, Mayr hired native hunters to help him collect all the birds of the region. As the hunters brought in each specimen, he recorded the name they used in their own classification. In the end he found that the Arfak people recognized 136 bird species, no more, no less, and that their species matched almost perfectly those distinguished by the European museum biologists. The only exception was a pair of closely similar species that Mayr, a trained biologist, was able to separate but that the Arfak mountain people, although practiced hunters, lumped together."

Wilson (1992) maintains that the species classifications are more than cultural artifacts borne of convention about anatomy and more than scientific names that arose from intuition and historical accident. They are, he believes, natural units that widely separated peoples with no previous contact have developed to facilitate their survival. Wild birds were the Arfak peoples' principal source of meat. Similarly, Amerindian peoples in the Amazon and Orinoco Basins have put names on a thousand or more plants used for food, medicinal purposes, and fibers. If Wilson is right, it should not be surprising that the species concept plays such a prominent role in conservation efforts.

The key feature of species-based approaches is their emphasis on analyzing population sizes and geographic distributions of individual species to identify conservation priorities. The species-based approach to setting conservation priorities does not generally include analysis of biodiversity at higher levels of organization such as genera, families, communities, ecosystems, ecosystem processes, or biogeographic features. However, the analysis of evolutionary relationships at taxonomic levels higher than species is rapidly emerging as a tool for assessing biodiversity conservation priorities (Box 2.2).

A species-based approach may express priorities in terms of specific sites or habitats, but the habitat is not necessarily chosen because it is threatened or rare. For example, the Kirtlands warbler (*Dendroica kirtlandii*) is one of the world's most endangered songbirds, and its nesting sites are a conservation priority for the species. These nesting sites are found in jack pine (*Pinus banksiana*) forests in lower Michigan, which are common elsewhere (e.g., upper Michigan, Minnesota, and Canada) and would not necessarily be considered conservation priorities were it not for the presence of a highly endangered bird species. Species-based approaches emphasize biological individualism (i.e., stressing the value of individual species), whereas ecosystem-based approaches emphasize the importance of interactions between genes, species, and biophysical processes.

Species-based approaches to setting conservation priorities are usually expressed in terms of two general objectives. The first is to conserve rare or threatened individual species. Species conservation priorities, and programs to protect them, often generate considerable response from the general public and political authorities. Save the tiger, save the panda, save the redwoods, elephants, whooping cranes, or the California condor, are frequently heard examples of such individual species conservation priorities. Priorities in these cases may be identified simply as the species (wherever they are found), or specific habitats critical to the survival of the species of concern. For example, conserving the whooping crane *(Grus americana)* has been a conservation priority for the U.S. Fish and Wildlife Service for nearly 50 years. With a population reduced to only 15 individuals in 1942 (Johnsgard, 1991), efforts to save the species from extinction have included designating the cranes' winter habitat in Texas as a national wildlife refuge, artificially re-establishing a second flock, and closely monitoring the original flock.

BOX 2.2 THE USE OF SYSTEMATICS TO ASSESS PRIORITIES

Most species-based approaches to conservation assume that all species are taxonomically equivalent. For example, when species richness is used to identify priorities, each species is given equal weight in making decisions about where to focus conservation efforts. This assumption is troubling for many biologists and conservationists who believe that some species are more important to conserve than others. In particular, conserving species that are the only representatives of a genus, family, or higher taxonomic group will do more to conserve biodiversity than saving species with many close relatives at the genus or family level. Using cladistic analysis[12] and quantitative weighting techniques, systematists are becoming actively involved in developing new approaches for identifying conservation priorities (see Daugherty et al., 1990; Faith, 1992; Forey et al., 1994; May, 1990; Vane-Wright et al., 1991).

The use of systematics in priority-setting efforts is appealing because it provides a firm biological and evolutionary basis for conservation. Such approaches have the potential to maximize the conservation of evolutionary pathways that more traditional species-based approaches do not. Robert May (1990) believes the combination of quantitative measures of taxonomic distinctness with more familiar ecological considerations of abundance and geographic distribution are vital to future conservation efforts.

While there is considerable appeal to using quantitative measures of species relationships to identify priorities, there are also serious limitations as well. First, such approaches are even more limited by a lack of information than species-based approaches—the cladistic relationships of the vast majority of organisms are simply unknown. For the time being, cladistic analysis is possible only for limited number of plant and animal groups. Second, cladistic approaches are mainly concerned with conserving a representative genetic legacy of evolutionary history. While this is an important conservation objective, biodiversity has many values that are independent of evolutionary history and taxonomic distinctiveness. Advances in systematics and the growing interest of systematists in conservation, however, suggest the use of systematic tools to determine conservation priorities—in combination with other types of species and ecosystem-based analysis—will expand in coming years.

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Species-based conservation priorities are sometimes driven by factors other than endangerment, such as species importance. Species importance may be defined in economic terms (e.g., wild relatives of maize or coffee) or in ecological terms (e.g., "keystone" species). It could be argued, for example, that it is more important to conserve a keystone species whose loss could trigger the greatest number of secondary extinctions than to conserve a more endangered non-keystone species. Symbolism can also be important in identifying species conservation priorities, as in the case of efforts to protect "national" birds such as the bald eagle in the United States or the Saint Lucian parrot in St. Lucia.

The second type of species conservation objective is to conserve habitats characterized by a high degree of species richness or endemism. Usually such objectives are further narrowed to protect habitats critical to a taxonomic grouping of species, birds, or plants, for example. Priorities are usually expressed in the form of specific sites or habitats important to the taxonomic grouping. For example, Birdlife International[13] has identified 221 localities around the world with unusual concentrations of endemic bird species and labeled them as high priority sites for conservation (Bibby et al., 1992).

A species-based approach to biodiversity protection usually begins with several assumptions. The first is that species are discrete genetic groupings that best represent taxonomic distinctiveness. The second assumption is that species are optimal indicators of biodiversity since they package genetic diversity on the one hand, and form the building blocks of ecosystems on the other. Species richness is thus assumed to be relatively indicative of other biodiversity values—e.g., areas of concentrated species richness are likely to also represent considerable ecological heterogeneity or diversity.[14] Species-based approaches often—but not always—implicitly assume that some species are more important than others.

Some of the advantages and disadvantages to using species-based approaches to setting biodiversity conservation priorities are summarized in Box 2.3.

Ecosystem-Based Approaches

Ecosystem-based approaches to setting conservation priorities have been increasingly favored both because knowledge of variation at the species and genetic levels is so poor, and because entire ecosystems, not merely isolated species, are under threat. Conservation of communities or ecosystems can preserve large numbers of species in a self-sustaining unit, while rescuing individual species has proven to be difficult, often ineffective, and extraordinarily expensive (Reid, 1992a). In the long run, spending $1 million on habitat conservation might conserve more species than the same amount of money spent to conserve a handful of threatened species. For these and other reasons, some approaches to setting conservation priorities are based on ecosystem or biogeographic classifications. Scott et al. (1991) make the following case for ecosystem-based approaches to identifying biodiversity priorities:

> "Clearly, it is inefficient to save selected species while allowing the natural communities and ecosystems that support them (along with myriad inconspicuous species) to deteriorate. It would be wiser, surely, to identify and manage functioning representatives of each ecosystem type for the maintenance of native biodiversity. While very localized species, likely to be missed by a network of biodiversity management areas, would still require individual protection programs, such an integrated conservation strategy would ensure that the vast majority of species never become endangered."

Ecosystem approaches to setting biodiversity conservation priorities seek to conserve biodi-

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versity by protecting most species within conservation areas that are representative of the array of more or less well-defined ecosystems or natural communities. A major challenge facing ecologists in many areas is how to classify ecosystems and at what scales. In any case, ecosystem approaches for identifying conservation priorities use multiple criteria such as species richness, endemism, and abundance, as well as considerations of the physical environment, ecological processes, and disturbance regimes (e.g., fire, storms, floods, drought, etc.) that help to define ecosystems.

The basic objective of most ecosystem-based approaches is to conserve the range of habitats (including their constituent species) and ecological processes found within the geographic scale of interest. Ecosystem-based approaches are sometimes favored because they can be used as a surrogate for detailed species

BOX 2.3 Advantages and Limitations of Species-Based Approaches

Advantages

- Species-based approaches give the ability to selectively focus on those species that are most threatened, or those that are most valued from a particular perspective.[15]
- In some cases, species-based approaches can be used as an efficient proxy for protecting natural communities or habitats in place of more complicated ecosystem approaches (e.g., using the "function" criterion to identify priority "keystone species" whose conservation would safeguard many dependent species).[16]
- Species-based priorities are more likely to be understood and supported by the public than ecosystem-based approaches—people are fascinated by large mammals, but many have a difficult time recognizing or understanding ecosystems and ecological diversity.[17]
- Species-based approaches may be preferable in many areas where "natural" ecosystems no longer exist or have been heavily modified.

Limitations

- Species definitions can vary—one biologist's species is another biologist's subspecies, or a different species altogether.[18]
- For many parts of the world, the breeding patterns and other basic life history traits are unknown for the vast majority of species, and most species have yet to be "discovered" or even named by science.[19].
- Monitoring and evaluating the success of species-based approaches can be difficult—it is easier, for example, to measure the loss of a hectare of forest or other natural habitat than it is to monitor changes in species numbers.
- "Hotspots" (concentrations of species richness and endemism) for one taxonomic group are not necessarily "hotspots" for another taxonomic group.[20]
- Relying on species-based approaches, especially those that emphasize "threat" criteria, to identify priorities may leave decision makers with limited and restrictive conservation options. Actions to protect the species may preclude any sustainable use of the species (or its habitat)—uses which may have been possible at an earlier time.[21]

knowledge. But ecosystem-based approaches also have value in their own right since they can protect habitats that might never be considered by species-based approaches. For example, ecological approaches may identify sites such as migration habitats, or important areas for the exchange of energy and nutrients, such as mangrove forests, that species-based approaches overlook. In the view of many ecologists, ecosystems are the most complex biological systems and include interactions and processes that represent a vital aspect of biodiversity not captured in priority analysis based on a species approach. In short, conserving the whole (i.e., a healthy ecosystem) is worth more than conserving the sum of its parts (the species that are found in an ecosystem).

Protected areas are the most commonly used measure to conserve ecosystems. Not surprisingly, most ecosystem-based approaches to setting biodiversity priorities are designed to identify new protected areas or to strengthen existing areas. The 1982 IUCN Bali Action Plan (IUCN, 1984), for example, called for the establishment of a worldwide network of national parks and protected areas covering all terrestrial ecological regions. As part of the Action Plan, IUCN sponsored several efforts to evaluate regions around the world to determine the proportion of major biogeographic regions and habitat types included in protected areas, as well as the threats that face them, the need for action, and their conservation importance. Reviews were published for the Indo-Malayan Realm (MacKinnon and MacKinnon, 1986a), the Afrotropical Realm (MacKinnon and MacKinnon, 1986b), and Oceania (Dahl, 1986). During the past decade, similar efforts have been carried out at the national level in countries around the world (see McNeely et al., 1994).

Other measures besides protected areas can be used to conserve ecosystems (see UNEP, 1995). These include land management practices that avoid threatening species and disrupting ecological processes, and a wide range of legal and economic incentives to encourage habitat protection outside of protected areas. Ecosystem-based approaches could be used to identify areas where land management practices may need to be changed through the use of various legal and economic policies, including incentives to landowners.

Grumbine (1992) suggests ecosystem management should be practiced over a broad area including, but not confined to, protected areas. To conserve biodiversity, he suggests ecosystem management should pursue four goals:

1) protecting enough habitat for viable populations of all native species in a region;
2) managing at regional scales large enough to accommodate natural disturbances (fires, wind, climate change, etc.);
3) planning over a period of centuries so that species and ecosystems may continue to evolve; and
4) allowing for human use at levels that do not result in significant ecological degradation.

Some of the advantages and limitations of ecosystems approaches are summarized in Box 2.4.

Integrative Approaches

Since Aristotle, science has had a tendency to break complex phenomena down into component parts and treat them as if they had little relationship to each other. Biodiversity thus becomes genes, species, populations, communities, and ecosystems, each with its separate constituent biological disciplines. And to this day, the natural world is usually viewed as standing quite apart from the human world—uncorrupted in the view of some, unharnessed in the view of others. Conservation priorities have frequently reflected these views—endangered species are to be protected in pristine natural habitats, protected areas sanitized of human influence.

However, during the past decade, many ecologists have begun to challenge these ways of viewing nature and its biological composition.

In other words, biodiversity cannot be understood without looking at all of the hierarchical levels and their interactions. At the same time, advances in ecology, paleobiology, and conservation biology are calling into question the very meaning of a "natural" ecosystem. This has prompted some to go so far as to state that the overarching goal of ecological management should be to maximize human capacity to adapt to changing ecological conditions (Reid, 1994), not some romantic notion of maintaining natural "biological integrity."

The more holistic views of biology, together with the realization that humans are almost everywhere a vital part of the ecological landscape, have begun to influence the way in which biodiversity conservation priorities are set. These views emphasize that non-biological factors have a role to play in setting conservation priorities and that diversified strategies are needed to adapt to the myriad cultures and value systems around the world.

They emphasize the use of multiple biological and non-biological criteria. To accommodate the dynamic nature of ecosystems, holistic approaches to identifying biodiversity conservation priorities emphasize looking across the entire landscape—protected and unprotected,

BOX 2.4 Advantages and Limitations of Ecosystem-Based Approaches

Advantages

- Once some meaningful classification of ecosystems or habitats is developed, their size and distribution, unlike species populations, is relatively easy to determine. If representative ecosystems are conserved in large enough areas, the vast majority of species and much of their genetic diversity will be protected as well.
- Ecological processes (e.g., nutrient cycling, hydrological regulation, micro- and meso-climatic regulation, the maintenance of disturbance regimes upon which many species depend, etc.) are essential to the survival of many species. Only ecosystem-based approaches are likely to ensure the protection of these vital links to biodiversity.
- Ecosystem-based approaches are the most cost-effective way to identify conservation priorities that include a wide spectrum of biodiversity.
- If little is known about species distributions and conservation status, and time and financial resources are limited, habitat or ecosystem-based approaches are the only realistic option for analysis.

Limitations

- What constitutes a "natural" ecosystem? Many ecosystem-based approaches attach priority to natural habitats (e.g., MacKinnon and MacKinnon, 1986a). In reality, nearly all ecosystems have been influenced to varying degrees by human activities.[22]
- Despite many attempts to classify ecosystems, there is still no internationally recognized standard and most countries, including the United States,[23] are still without a consensus classification scheme.[24]
- Ecosystem-based approaches to identifying conservation priorities fail to include all rare or potentially endangered species. Localized species will sometimes be left out of priorities determined by ecosystem analysis, especially in the tropics where species ranges are typically quite small.[25]

natural and heavily modified. The objectives of such approaches are not necessarily the preservation of biodiversity for its own sake, but maximizing life's capacity to adapt to changing conditions. In a sense, it is not biology but social issues—the desire to have an environment that supports human welfare—that are the unifying force of integrative approaches to identify biodiversity conservation priorities.

Simply stated, the objective of integrative approaches to setting biodiversity priorities is to conserve biodiversity in the presence, not the absence, of humans. This means setting priorities in the human-dominated landscapes that are found over two-thirds of the earth's land surface. Integrative approaches have also evolved because people realized that: 1) more than biological criteria are needed to select successful conservation projects, and; 2) conservation is a social and political process where feasibility is often defined in social, economic, and political terms.

Few methods, however, have been developed to identify conservation priorities outside of strictly "natural" landscapes. What does exist are not so much methodologies for setting conservation priorities as criteria for assessing the social value of biodiversity in the landscape. Several approaches have been proposed or developed (McNeely et al., 1990) to give more

Box 2.5 Advantages and Limitations of Integrative Approaches

Advantages

- Integrative approaches can recommend priority areas for conservation that have a greater feasibility of actually being conserved because policy and institutional factors have been considered.
- Integrative approaches can help link biodiversity to other natural resources valued by humans for other reasons. This means that selected priorities will often have non-biological values that could strengthen political support for conservation actions.[26]
- Integrative approaches can make the evaluation of economic, social, or political factors more explicit and transparent. These factors are usually applied by policymakers in a much less transparent way when priorities defined strictly on biological criteria are presented to them.

Limitations

- Integrative approaches may de-emphasize biodiversity values to balance other social, economic, and political values. The consideration of non-biological factors as co-variables with biological factors could make it difficult to say whether a chosen priority is important mainly because of its biological values or because of the contribution of other variables.[27]
- In many situations, it may be unclear which social, economic, or other non-biological factors are most important to conservation.[28]
- Integrative approaches are largely experimental, and frameworks for evaluating non-biological factors in setting priorities are not as well developed or tested as many biologically-based frameworks.
- Social, economic, and other non-biological data are often not available at the appropriate scale (i.e., these data are usually at the aggregate national level) and some factors (e.g., institutional) can change rapidly and limit the useful life of the priorities.

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prominence to social factors in the establishment of biodiversity conservation priorities. Other approaches driven principally by biological information are also making more use of social factors, such as the evolving experts workshop process pioneered by Conservation International (Olivieri, et al., 1995).

Some of the advantages and disadvantages to integrative approaches are summarized in Box 2.5.

Endnotes

1. Since information about biodiversity, threats to its conservation, and how it is valued will continue to change, conservation priorities should be revisited on a periodic basis. Knowing what information was used to determine priorities and guide decisions in earlier efforts is therefore vital to an informed reassessment of conservation strategies.
2. On June 4, 1993, President Clinton signed the convention. However, as of October 1, 1995, the U.S. Senate had not yet ratified the convention. As of June 21, 1995, 118 countries had ratified the convention.
3. This is in terms of a global perspective. It might be noted that the kestrel is less common than the peregrine falcon in some areas (e.g., possibly in Alaska).
4. One method to compensate for this limited knowledge is to rely on patterns in a few well-known species that can serve as indicators of where endemicity might be concentrated.
5. The World Conservation Union (IUCN) has revised the IUCN categories of threat so that they are listed as follows: Extinct, Extinct in the Wild, Critical, Endangered, Vulnerable, Rare, Not at Risk, Not Evaluated, and Insufficiently Known.
6. Many plant species are entirely dependent on "flying foxes" for pollination and seed dispersal. On Guam, where the two native species of *Pteropus* have become extinct and virtually extinct, researchers have documented plant species that are no longer fruiting and others that are declining in abundance, signaling the effects of absent pollinators and seed dispersers (Meffee and Carroll, 1994).
7. The World Heritage Program of the United Nations (UNESCO) does explicitly consider these perspectives in its designation of World Heritage sites. The Papua New Guinea Conservation Needs Assessment (Alcorn, 1994) also explicitly considered social, legal, and cultural factors in its assessment of priorities.
8. See last paragraph of preamble to the Convention on Biological Diversity (UNEP, 1992).
9. Systematics is the study of biological classification (species, genus, family, order, etc.).
10. Co-adapted gene complexes are groups of alleles on one or more genes that adapt to the same selective pressures experienced in a particular environment.
11. Some plants and invertebrates, however, are physiologically bisexual; they can breed with themselves and do not breed with other individuals.
12. Cladistics is a taxonomic system used to classify organisms on the basis of evolutionary relationships. It uses a dichotomous branching scheme to develop ancestral "trees" or cladograms that can be used to quantitatively assess how closely related species are. This is done by tracing the shared possession of derived characters (e.g., morphological features such as beak structure in birds) back to a common parent taxon.
13. Formerly known as the International Council for Bird Preservation (ICBP).
14. This is not always a reliable indicator, however, since species richness in many areas is poorly known.
15. For example, those concerned with the conservation of agricultural diversity will find a species-based approach more suitable since ecosystem-based approaches use a broad net

(or a coarse filter) that does not pinpoint agriculturally important species.

16. Similarly, using the "feasibility" criterion to identify priority "charismatic megavertebrates" with large habitat requirements may lead to conservation efforts that protect many other species, various natural communities, and even large samples of several major ecosystems. For example, the habitat requirements of the grizzly bear in North America, or the elephant in Africa, are likely to encompass the habitat requirements of hundreds or thousands of other species in a wide range of taxonomic groups.
17. In some cases, such as "tropical rainforests" in general or old-growth forests in the U.S. Pacific Northwest, ecosystem conservation has the potential to generate considerable public support.
18. Among the criteria for making species determinations are morphological discontinuity (i.e., large difference in size and appearance), interbreeding ability (physiological factors that prevent breeding), reproductive isolation (i.e., organisms cannot interbreed because of physical geographic barriers such as mountain ranges that separate two similar populations), relationships of ancestry and descent, ecological adaptation, and genetic cohesion (Rojas, 1992). The problem is that the various criteria can cause a non-congruence between species classifications. This is especially true in plants where breeding (e.g., natural hybridization), genetics (e.g., polyploidy or multiple sets of genes), and evolutionary histories (e.g., reticulate evolution or reversion to earlier forms) can further complicate taxonomic determinations. In other words, how does one determine biodiversity conservation priorities when it is not entirely clear what a species is in the first place? Even with some of the better known vertebrate species, different taxonomies can be used to obtain different priority rankings.
19. Even in countries such as the United States, the inventory of invertebrates species, for example, is far from complete. Moreover, vital data on population sizes, geographic distribution, and basic life history traits and habitat requirements are poorly known for the overwhelming majority of the world's species.
20. See, for example, Prendergast et al. (1993).
21. These considerations have generated a debate in the United States over the need to supplement or revise the Endangered Species Act so that ecosystem/habitat protection is emphasized rather than last-minute efforts to conserve an individual species (Reid, 1992b).
22. In some parts of the world (e.g., Europe, the Mediterranean region, Japan), virtually all ecosystems are heavily modified after centuries or several millennia of human culture. See Reid (1994) for an interesting discussion on the limits of using "natural" as a modifier for the definition of conservation objectives.
23. The most widely used classification scheme in the United States is the Bailey's Ecoregions system (Bailey and Hogg, 1989). Although widely used, other systems are used as well and The Nature Conservancy is developing a new classification system for the United States that it hopes will become the standard. Bailey (1989) also has developed a global ecoregion system.
24. Ecosystems, like species, vary greatly and are poorly understood. Ecosystems are difficult to define since their size, composition, complexity, and distribution change with scale in both time and space. Not surprisingly, ecologists differ in their descriptions and definitions of ecosystems.
25. There will always be some need for individual species protection programs, even if comprehensive ecosystem protection programs are implemented.

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26. For example, a priority area that has significant watershed value or tourism potential (in addition to biodiversity value) may be more socially and politically viable than an area selected solely for its biodiversity values.
27. This limitation could be overcome by making it clear exactly what factors (biological and non-biological) were considered, and how much weight was given to each. Biological and non-biological factors should be kept separate until the final integration stage.
28. This, of course, is also a problem for biological criteria, but the uncertainties with respect to non-biological factors will generally be greater.

CHAPTER THREE

PRIORITY-SETTING IN PRACTICE

This chapter reviews a variety of priority-setting methods representative, but not inclusive, of the many approaches developed or used around the world in recent years. Taken together, these examples illustrate various ways in which biodiversity priorities can be defined at the species and ecosystem levels and at different geographic scales (e.g, global, regional, national, or local). These methods reflect a tremendous amount of analysis, innovation, and dedication to the conservation of biodiversity on the part of their creators.

None of the examples discussed in this chapter should be applied wholesale to a new setting. Each reflects a unique set of objectives, underlying values or assumptions, and circumstances. However, readers should be able to identify specific approaches, or elements from several approaches, that can be adapted to form the basis for new priority-setting efforts. Rather than being viewed as a set of competing methodologies, the examples presented here should be seen as a rich resource for informing future priority-setting efforts.

The examples are grouped according to the geographic levels for which they were developed—global, regional, and national or local. This is an arbitrary division in some ways. Most of the examples could (with modification) be used at any geographic scale. Any alternative grouping (by method of analysis, for example) would risk being arbitrary as well. Therefore, the reader is urged to consider the concepts behind different methods rather than focus on the geographic scale categories used here to organize the chapter.

The examples profiled in this chapter are categorized in Table 3.1 by the criteria (rarity, distinctiveness, threat, utility, etc.) and approach categories (genetically-based, species-based, ecosystem-based, and integrative) that best characterizes each methodology.

SETTING GLOBAL AND REGIONAL PRIORITIES

The most visible efforts to establish conservation priorities in recent years have centered on identifying those parts of the world with the greatest biodiversity. These efforts are driven by

TABLE 3.1 Typology of Priority-Setting Approaches

Priority-Setting Approaches	Criteria for Assigning Conservation Value									Type of Analysis			
	Biological						Social & Institutional			Genetically-Based	Species-Based	Ecosystem-Based	Integrated
	Richness	Distinctiveness	Rarity	Representativeness	Threat	Function	Utility	Feasibility	Other				
Global Priorities													
Biodiversity Hotspot Areas	*				*						*		
Megadiversity Countries	*										*		
Major Wilderness Areas				*	*			*				*	
Centers of Plant Diversity	*						*				*		
Endemic Bird Areas	*		*		*						*		
Large Marine Ecosystems	*			*	*	*						*	
Regional Priorities													
IUCN Regional Protected Areas Reviews	*			*	*							*	
CPTI for Indo-Pacific and Latin America Regions				*	*		*					*	
Priority-Setting Workshops in South America	*		*		*						*		
IUCN Species Survival Action Plans		*	*	*	*					*	*		
BSP Priority-Setting Framework	*			*	*		*	*					*

TABLE 3.1 Typology of Priority-Setting Approaches (continued)

Priority-Setting Approaches	Criteria for Assigning Conservation Value									Type of Analysis			
	Biological						Social & Institutional			Genetically-Based	Species-Based	Ecosystem-Based	Integrated
	Richness	Distinctiveness	Rarity	Representativeness	Threat	Function	Utility	Feasibility	Other				
National & Local Priorities													
Natural Heritage Programs	*	*	*	*	*	*					*	*	
Papua New Guinea	*			*	*				*		*	*	
Conservation Needs Assessment/Gap Analysis in the U.S.	*			*				*				*	
Iterative Approaches to Reserve Selection in Australia		*		*								*	
Identification of Useful Plants for Conservation and Development		*	*			*	*		*		*		
Priorities for Conserving Genetic Diversity in Forest Trees	*	*	*	*	*	*				*			
Ecologically Sensitive Areas	*		*		*	*	*	*	*		*	*	*

several considerations. First, biodiversity is unevenly distributed around the world, with some nations having greater diversity than others, just as within a nation some ecosystems have more species than others. Second, biological resources found in one area can have regional or global significance in addition to local and national value, especially in terms of genetic resources for agriculture and pharmaceuticals. Third, most of the world's species are found in the tropics, where countries with limited conservation resources (e.g., funding, training, etc.) face enormous pressures on their biological resources. Fourth, conserving biodiversity will require international investments to share the cost of maintaining biological resources, the benefits of which often flow beyond national borders.

Biodiversity, in other words, is often considered to be a global good with international value that exceeds the value that accrues to an individual country. Because its conservation is very likely to cost more than what an individual country can afford, particularly in the tropics, and because the benefits of conservation accrue to those outside individual countries, other countries will have to help. In recent years, donor agencies have been investing more resources in biodiversity conservation (Abramovitz, 1991; Abramovitz, 1994), and they have also been seeking ways to identify international biodiversity conservation priorities to guide their investments (e.g., Dinerstein and Wikramanayake, 1993; Braatz et al., 1992; WCMC, 1994; Dinerstein et al., 1995; BSP et al., 1995). Now that the Convention on Biological Diversity has entered into force, this will intensify.[1]

Although disagreements over the balance between biodiversity as a global good and as a national sovereign resource have often divided the international community, the Convention obligates member countries to protect biological resources for national and international benefits. Among other things, the Convention also starts a process to establish financial mechanisms that can assist members in carrying out their obligations. The resources available to do so are limited, meaning that donors (mostly countries in Europe and North America, and Japan) and international agencies with Convention-related responsibilities (e.g., the Global Environment Facility) will have to devise mechanisms for directing resources.

For the most part, international approaches to setting geographic priorities have assumed that using the number of species (and sometimes endemism rates) is the most effective way to broadly distinguish conservation priorities between countries or regions. Most approaches focus on species richness for the best understood taxonomic groups because they are the most easily measured (albeit incomplete in most areas) indicators of biodiversity.

Some international approaches add additional criteria to further narrow priorities. For example, the "hotspots" approach (Myers, 1988) examines various indicators (e.g., deforestation rates) to identify which of the areas richest in biodiversity are most imminently threatened by habitat loss and species extinctions (see Box 3.1).

International priorities have been set using different scales of analysis, which McNeely et al. (1990) have categorized as regional, national, and site. Regional analysis often distinguishes between major biogeographic units, irrespective of political boundaries. For example, the eastern Himalayas, encompassing parts of Nepal, India, Bhutan, Tibet, and China, are considered a priority region under one method (Myers, 1988). National analysis, on the other hand, distinguishes among individual countries, as in the "megadiversity" countries approach (Mittermeier, 1988), which identifies Indonesia, Colombia, and Zaire and several other countries as international conservation priorities because they have high species richness and endemism levels with their borders. Still, priorities determined under either of these levels of analysis are relatively broad, and will require further elaboration at the national, regional, or local level. Finally, the site approach to setting international priorities focuses on indi-

Box 3.1 Data Evaluated in Myers "Hotspot" Analysis

- Extent of original (pre-agricultural) habitat
- Extent of present habitat
- Geographic patterns of plant species diversity
- Geographic patterns of plant species endemism
- Estimated "total of plant species eliminated or on verge of extinction"
- Diversity in other taxonomic groups, if known
- Human population growth rates
- Deforestation rates

Source: Myers (1988)

vidual habitats or sites known to be important to certain taxonomic groups, such as birds (Bibby et al., 1992) or plants (WWF and IUCN, 1994). Site approaches are likely to be much more specific than regional and national approaches to setting international priorities.

Approaches for Setting Global Priorities

Six efforts to set priorities at the global scale are presented below. These examples, in principle, have no geographic limits to their analysis, although the first five ("biodiversity hotspot areas," "megadiversity countries," "major wilderness areas," "endemic bird areas," and "centers of plant diversity") focus on terrestrial areas. The sixth is an example of priority-setting for coastal and marine areas.

Biodiversity "Hotspot" Areas

In 1988, British ecologist Norman Myers published an article in which he identified international conservation priorities on the basis of species richness and endemism, combined with an assessment of threats to natural habitats. The results of his "hotspots" analysis have since become perhaps the most commonly cited list of conservation priorities of any kind. References to the Myers (1988) "hotspots" are frequently encountered in the conservation literature and occasionally in the media, usually in the context of international or tropical biodiversity conservation efforts. The Myers analysis has also had considerable influence on the funding decisions of a number of public and private donors that support international conservation efforts.

The methodology first used by Myers is relatively simple. He made several important initial assumptions: that species richness and endemism are the best indicators of biodiversity values, that floristic diversity patterns are broadly representative of other taxonomic groups, and that humid tropical forests are the most important ecosystems for biodiversity conservation and among the most threatened. The objective was then defined as identifying tropical forest areas that have exceptional concentrations of plant species numbers (i.e., species richness) and high levels of endemism and that also face exceptional degrees of threat from human activities. Myers termed these areas biodiversity "hotspots."

Table 3.2 Location of Biodiversity "Hotspots" and Number of Endemic Species

REGION	PLANTS[1]	MAMMALS[2]	REPTILES[2]	SWALLOWTAIL BUTTERFLIES[2]
Cape Region[b] (South Africa)	6,000	15	43	0
Upland Western Amazonia[a]	5,000	—	—	—
Atlantic Coastal Brazil[a]	5,000	40	92	7
Madagascar[a]	4,900	86	234	11
Philippines[a]	3,700	98	120	23
Northern Borneo[a] (Malaysia, Indonesia)	3,500	42	69	4
Eastern Himalayas[a] (Nepal, Bhutan, India)	3,500	—	20	—
S.W. Australia[b]	2,830	10	25	0
Western Ecuador[a]	2,500	9	—	2
Colombian Chaco[a]	2,500	8	137	0
Peninsular Malaysia[a]	2,400	4	25	0
Californian Floristic[b] Province (USA)	2,140	15	15	0
Western Ghats (India)[b]	1,600	7	91	5
Central Chile[b]	1,450	—	—	—
New Caledonia[a]	1,400	2	21	2
Eastern Arc Mountains[b] (Tanzania)	535	20	—	3
S.W. Sri Lanka[b]	500	4	—	2
S.W. Côte d'Ivoire[b]	200	3	—	0
TOTAL	49,955	375	892	59

Sources: [a] - Myers (1988); [b] - Myers (1990); [1] - plants from Myers (1988; 1990);
[2] - other taxonomic groups from WCMC (1992).

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To identify the "hotspots," Myers collected data (Box 3.1) on such factors as the extent of primary forest habitats, the biogeography of plant diversity and distribution patterns in the humid tropics, rates of plant species endemism, and estimates of endangered plant species. By looking at human population growth rates in combination with deforestation rates, Myers assessed the degree of threat to those forest areas with high levels of species richness and endemism among higher plants[2]. Although the analysis is based on the distribution of plant species richness, Myers found that such areas are also relatively species-rich for some vertebrate and invertebrate animals. However, he does not present comparable data between sites for these taxa.

Although the 10 "hotspots" identified in the original Myers (1988) analysis include only 3.5 percent of the remaining primary humid tropical forest (and only 0.2 percent of the earth's land surface area), these areas are home to at least 27 percent of the higher plant species found in the tropics, and nearly 14 percent of all of the world's plants (see Table 3.2).

Myers recognizes the limitations facing conservation biologists who attempt to compile data from which to assess conservation priorities. At their best, some figures can be taken as fairly accurate (perhaps within 5 percent), but others are little more than "best guesses" of specialists who have worked in a specific area for many years. Nevertheless, Myers concludes that the overall approach, uneven as it is, is justified as an analytical exercise that seeks to delineate the conservation challenge facing the humid tropical forests.

The original "hotspots" analysis was limited to tropical forest regions and therefore neglected a number of extremely important temperate and non-forest areas. For example, in the semi-arid grasslands and mountains south of the Tropic of Capricorn in southern Africa (South Africa, Lesotho, Swaziland, Namibia, and Botswana), the high plant species diversity (23,200 species) is also exceptionally high in endemism (18,560 or 80 percent). This gives the area the world's greatest plant species richness (calculated as species/area ratio), or 1.7 times greater than Brazil (Davis et al., 1986). The region also has the highest concentration of threatened plant species (2,373) of any temperate region (McNeely et al., 1990). Recognizing this limitation, Myers (1990) expanded his earlier analysis to identify eight additional terrestrial "hotspots," four in the humid tropics and four in Mediterranean-type habitats (Table 3.2).

The Myers analysis is widely recognized as a timely advance in determining where conservation needs are greatest and where the potential benefits of conservation might be maximized. It has limitations, however. Among the problems are the limited distribution data for many of the world's plant species, limited knowledge of endangered status, and the difficulty of quantifying threats to habitat areas. The "hotspots" approach does not address the number of species per unit area, which would provide a more accurate reflection of the relative levels of biodiversity between areas. And while the "hotspots" are geographically limited, they are not precise enough to allow conservationists, governments, or donor agencies to take action without a more detailed assessment of conservation priorities within the "hotspot" area. One response to this problem has been to develop techniques to rapidly assess biodiversity in areas where information on species and ecosystems is limited (Box 3.2).

In addition, it is not yet clear how indicative plant species distributions are for other taxonomic groups. For example, Daniels et al. (1991) show that centers of plant diversity in India are not necessarily centers of diversity for other taxonomic groups. In the United Kingdom, researchers empirically tested whether species-rich areas for different taxa coincide and whether species-rich areas contain substantial numbers of rare species (Prendergast et al., 1993). For Britain, at least, the findings indicate that "hotspots" for different taxa rarely coincide, and that most rare species do not occur in the most species-rich areas.

Megadiversity Countries

Another approach developed at the same time as the "hotspots" analysis has become widely cited in the context of international conservation priorities. Developed by Russell Mittermeier and others, the "megadiversity countries" concept is based on three premises (Mittermeier, 1988; Mittermeier and Werner, 1990):

- Although international conservation priorities should ideally be based on basic scientific information on biodiversity and endangered ecosystems, it is governments of sovereign nations that develop conservation policies and programs;
- Biodiversity is not evenly distributed among the world's more than 170 countries; and
- A very small number of countries, lying wholly or partly within the tropics, contain a high percentage of the world's species (including species from marine, freshwater, and terrestrial habitats), and most of them require special international conservation attention.

Several kinds of biological information are integrated in the "megadiversity" concept, although species numbers and levels of endemism (at the species level and higher taxonomic levels) are the main determinants of whether a country is considered to be a "megadiversity" country. Based on initial analysis, a dozen countries were included in the first list of megadiversity countries: Brazil, Colombia, Ecuador, Peru, Mexico, Madagascar, Zaire, Australia, China, India, Indonesia, and Malaysia (see Figure 3.1 and Table 3.3). Together, these countries contain as much as 60 to 70 percent (and perhaps more) of the world's species.

The list of megadiversity countries was prepared from published and unpublished species lists, as well as in-country literature and field research conducted by Conservation International. Although Table 3.3 presents a straightforward tally of species diversity, the megadiversity analysis also considers endemism levels (Mittermeier, 1988; Mittermeier and Werner, 1990; McNeely et al., 1990). For example, a number of countries would rank ahead of Madagascar solely on the basis of species diversity (e.g., the United States, Thailand, Venezuela). However, the extraordinary endemism among all taxonomic groups in Madagascar, despite lower overall species richness, led to its listing as a "megadiversity" country. On the other hand, the United States is left off the list, despite its high species diversity, presumably because endemism rates are generally low (i.e., many species in the United States are also found in Mexico and Canada).

The main advantage of the megadiversity approach is that it provides a straightforward, relatively quantitative analysis that results in conservation priorities defined by political boundaries (this is also a disadvantage; see below). This is appealing to donors, since they negotiate with individual governments and because their funding and development priorities are usually defined by political geography, not biogeography. In addition, most of the information needed for setting priorities is organized by countries, and not by biogeographic regions. Finally, most conservation programs and policies are developed by national governments—conservation agencies defined on the basis of biogeographic boundaries may be an ecologist's favorite daydream but they simply do not exist.

The megadiversity approach has a number of limitations, however. Species richness and endemism are only the simplest indicators of biodiversity. They do not convey other ecological dimensions of biodiversity, such as human dependency or serious threat. For example, centers of diversity for economically important wild plant species will not always coincide with the megadiversity countries. Like the Myers (1988) "hotspots" approach, conservation priorities determined by the megadiversity approach are heavily biased toward humid tropical forest areas. If conservation resources were directed primarily to megadiversity countries, many biomes and the vast majority of ecosystem types which are found elsewhere in the world would be neglected. Because tropical forest ecosystems are so disproportionately species rich, and the megadiversity and hotspots analysis so reliant on species richness, they put priority setters in the awkward position of favoring certain types of ecosystems and their inhabitants over others—even if that was not the intent.

Finally, the country-level analysis obscures the actual distribution of biodiversity. For example, if the island of New Guinea were a single country, there is little doubt—with its high endemism rates and limited species ranges—that it would be a megadiversity country. But the island is shared by two countries, Indonesia (the province of Irian Jaya) and Papua New Guinea. Indonesia is a megadiversity country but Papua

BOX 3.2 Rapid Ecological Inventory and Assessment in Belize

A lack of information is a major constraint to better biodiversity conservation planning and management, particularly in the tropics. One strategy pursued in a growing number of areas around the world is to quickly augment limited information on biodiversity with the use of rapid ecological assessments and inventories. Experienced field researchers using simple but standardized survey techniques are common elements of rapid biodiversity assessment programs.

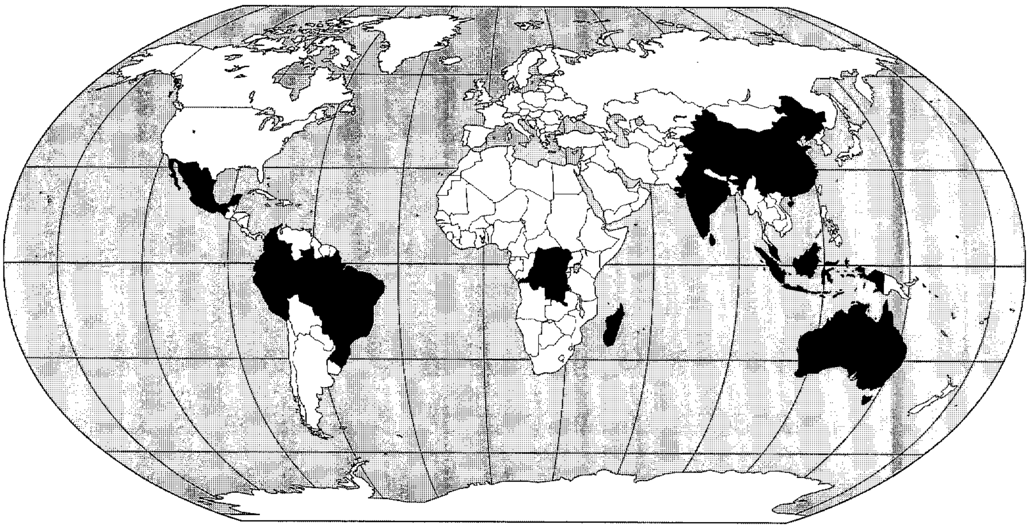
Two of the more prominent examples of these assessment programs have been used recently in the Maya Mountains of Belize, a country with the largest contiguous area of tropical forest remaining in Central America. The Rapid Assessment Program (RAP) developed by Conservation International uses experienced international and local biologists to survey—within a matter of weeks—the biota of an area thought to be of high conservation value. The Conservation International RAP team, including biologists from Belizan organizations, visited the Columbia Forest River Preserve to assess the conservation importance of this little-known area in the southeastern Maya Mountains on the border with Guatemala. Their findings suggest the reserve contains the most species-rich plant and animal communities in Belize (Parker et al., 1993).

The Rapid Ecological Assessment (REA) program developed by The Nature Conservancy is designed to quickly identify management actions needed in areas already known to be of significant conservation value. Joined by the Belize Audubon Society, and the Program for Belize, The Nature Conservancy organized a Rapid Ecological Assessment (REA) of the Bladen Nature Reserve, which happens to be adjacent to the Columbia River Forest Reserve. Interdisciplinary teams of Belizan and international scientists (including social scientists) surveyed species distributions, plant communities, and human uses of the area to identify the most important management actions for the reserve (Iremonger and Sayre, 1994).

Strictly speaking, neither the RAP nor the REA approaches are priority-setting methods in themselves. Neither approach ranks sites on a comparative basis and then selects among them. Their proponents, however, clearly see them as complementary tools to priority-setting processes.[3]

Critics of programs such as RAP and REA fear that such approaches undermine support for long-term scientific field research (Abate, 1992). The results of such surveys have not been published in peer-reviewed journals, they charge, because the methods would not stand up to scientific scrutiny. Proponents of rapid biodiversity assessments respond that scientific rigor is not their goal. In a recent article on the controversy, Ted Parker[4]—a prominent participant in CI's RAP missions—concluded, "Ten or fifteen years from now our scientific contributions won't be important, but there may be some places that still exist because of what we've done." (Abate, 1992). In the meantime, RAPs, REAs, and similar approaches have proliferated in many parts of the world.

FIGURE 3.1 GEOGRAPHIC DISTRIBUTION OF "MEGADIVERSITY" COUNTRIES



Source: Mittermeier (1988)

New Guinea is not. There is, however, no guarantee that conservation resources allocated to Indonesia would go to the province of Irian Jaya. When ranked on a species/area basis, six of the top dozen countries (Costa Rica, Panama, South Africa, Venezuela, Guatemala, and Haiti) are not on the megadiversity list (see WRI 1994). In other words, megadiversity countries are rankings of countries determined largely by their area (large) and location (tropical); their species richness and endemism[5] simply reflect these two important biogeographical factors.

MAJOR WILDERNESS AREAS

A considerably different approach is embodied in the identification of major wilderness areas (McCloskey and Spalding, 1989; CI, 1990). Whereas the "hotspots" analysis considers the urgency of human threats to a limited subset of natural habitats, in combination with species diversity, the wilderness approach emphasizes the identification of large relatively undisturbed natural areas with low human population densities and does not explicitly evaluate species diversity or endemism. It can be assumed that wilderness areas in the humid tropical forest biome are relatively rich in biodiversity, although some areas will be more important than others, and some areas within a particular wilderness area will be more diverse than others. Globally, relatively undisturbed habitats cover approximately one third of the earth's land surface (McCloskey and Spalding, 1989)—much of it composed of desert, boreal, and arctic/antarctic ecosystems (see Tables 3.4 and 3.5). As relatively undisturbed habitats shrink in the temperate, tropical, and even boreal zones, these wilderness areas will become increasingly important for the conservation of biodiversity.

The objective of the McCloskey and Spalding (1989) inventory was to identify only large blocks of wilderness with over 400,000 hectares. They defined wilderness as it appears in the U.S. Wilderness Act, i.e., land that "generally appears to have been affected primarily by the forces of nature, with the imprint of man's work substantially unnoticeable." As McCloskey and Spalding (1989) point out, this does not mean that such areas are pristine or absolutely

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Table 3.3 Species Diversity in Selected Countries

	Mammals	Birds	Reptiles	Angiosperms	Swallowtail Butterflies
			Megadiversity Countries[1]		
Brazil	428	1,622	467	55,000	74
Colombia	359	1,721	383	45,000	59
China	394	1,195	265	27,000	99-104
Mexico	449	1,010	717	25,000	52
Australia	255	—	686	23,000	—
Indonesia	515	1,519	>600	20,000	121
Peru	361	1,701	297	20,000	58-59
Ecuador	280	1,447	358	15,000	64
Malaysia	293	1,200	171	15,000	54-56
India	350	1,200	182	14,500	77
Zaire	409	1,086	280	11,000	48
Madagascar	—	250	269	10,000	—
			Other Countries for Comparison[2]		
United States	466	1,090	368	20,000	30-31
France	113	342	36	4,500	—
Costa Rica	203	796	218	8,000	—

Sources: [1] Adapted from McNeely et al. (1990); [2] WRI (1992).

untouched. It does mean that wilderness is land without settlements or roads and is not regularly cultivated or heavily and continuously grazed. Most of this land has been lightly used and occupied by indigenous peoples at various times, and seasonal pastoralism, particularly in arid and upland areas, will have been common.

From a global biodiversity perspective, wilderness areas in the tropics, particularly the humid tropics, are most important. Large wilderness areas in most of the temperate world have disappeared, and major wilderness areas in the tropics are becoming increasingly rare. There are, however, a few major tropical wilderness areas where very large tracts of primary forest are likely to persist well into the next century. Although more threatened habitats, such as those identified by Myers (1988; 1991), will require more urgent attention and higher levels of funding for conservation, major wilderness areas should not be overlooked in the assessment of conservation priorities. These areas will be increasingly important, as McNeely et al. (1990) indicate, because:

- They will be the last areas where major evolutionary processes can continue to take place with only limited impacts by humans (although the influence of climate change

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and pollution are becoming increasingly pervasive);

- They can serve as "controls" against which the effects of human activities in managed ecosystems can be measured;
- They are major storehouses of biodiversity, where large numbers of individuals of many species will continue to exist;
- They play a key role in maintaining local, regional, and, in some cases because of their large size, global climate patterns;
- They will be the last areas where aboriginal peoples can choose to continue to live their traditional lifestyles; and
- They will represent increasingly rare aesthetic, spiritual, and scientific values in an increasingly crowded, urbanized world.

Using Jet Navigation Charts and Operational Navigation Charts published by the U.S. Defense Mapping Agency at a scale of 1:2,000,000 and 1:1,000,000, McCloskey and Spalding (1989) eliminated all areas showing roads, settlements, buildings, airports, railroads, pipelines, power lines, canals, causeways, aqueducts, major mines, dams and reservoirs, and oil wells. Although the maps did not show agricultural development or logging, these activities usually depend on proximity to roads and settlements. Most of the charts were last updated in the early-to mid-1980s, but in many areas more recent map sources were consulted for verification. McCloskey and Spalding (1989) concede that the inventory has weaknesses (e.g., varying levels of map detail on human artifacts on the landscape), but argue that in aggregate, the findings are reasonably accurate.

The inventory produced an area of approximately 48 million square kilometers of wilderness in 1,039 separate areas in 77 countries, covering 32.3 percent of the earth's land surface area (see Table 3.5). Using the Udvardy biogeographical system,[6] McCloskey and Spalding show that 41 percent of large wilderness areas are found in the high arctic or antarctic, 20 percent in warm desert areas, 20 percent in temperate regions (mostly in the boreal or taiga province), 11 percent in the tropics, 4 percent in mixed mountain systems, 3 percent in cold

TABLE 3.4 DISTRIBUTION OF LARGE WILDERNESS AREAS BY CONTINENT

Continent	km^2	Wilderness % of Total	# of Areas[1]
Antarctica	13,208,983	100.0	2
North America	9,077,418	37.5	85
Africa	8,232,382	27.5	434
Former Soviet Union	7,520,219	33.6	182
Asia[2]	3,775,858	13.6	144
South America	3,745,971	20.8	90
Australia	2,370,567	27.9	91
Europe[2]	138,553	2.8	11
TOTAL	48,069,951	32.3	1,039

[1] - Only contiguous areas of at least 4,000 km^2 are included.
[2] - Does not include former Soviet Republics.

Source: McCloskey and Spalding (1989).

TABLE 3.5 WILDERNESS DISTRIBUTION BY BIOME

Biome	km^2	% of Total	# of Areas
Tundra Communities	20,047,533	41.7	100
Warm Deserts/Semi-Deserts	9,329,531	19.4	389
Temperate Needleleaf Forests	8,799,312	18.3	120
Tropical Humid Forests	3,006,855	6.3	77
Mixed Mountain Systems	1,973,391	4.1	76
Cold-Winter Deserts	1,478,494	3.1	51
Tropical Dry Forests	1,424,099	3.0	120
Tropical Grasslands/Savannas	735,331	1.5	33
Temperate Rainforests	450,215	0.9	15
Temperate Broadleaf Forests	290,646	0.6	20
Temperate Grasslands	272,016	0.6	24
Evergreen Sclerophyllous Forests	170,885	0.4	7
Mixed Island Systems	91,647	0.2	7
TOTAL	48,069,951	100.0	1,039

Source: McCloskey and Spalding (1989).

desert regions, and a small fragment is found in island regions.

The McCloskey and Spalding (1989) wilderness inventory does not identify biodiversity conservation priorities *per se.* Conservation International (1990), a nongovernmental organization based in the United States, has modified the wilderness inventory approach to assess humid tropical forest conservation opportunities as part of its Rainforest Imperative program. The major tropical forest wilderness areas identified as conservation priorities include the island of New Guinea; the humid tropical forests of the Zaire Basin (Zaire, Congo Republic, and Gabon); and a major arc of forest wilderness from southern Guyana and Suriname, across southern Venezuela, the northern Brazilian Amazonia, and down through the western Amazonian lowlands of Brazil, Colombia, Ecuador, Peru, and Bolivia.

The advantages of identifying major wilderness areas as priority sites for biodiversity conservation include: lower management and maintenance requirements; large habitat areas for a wide range of species, especially large predators, encompassing most if not all species for the ecosystems within the wilderness; and relatively few of the social and economic pressures that afflict most smaller habitat "islands" surrounded by intensive land uses.

Perhaps the greatest disadvantage to this approach is that wilderness is viewed as a western concept with little value or desirability in many developing countries. In addition, wilderness does not lack owners. What appears as "wilderness" in a satellite image or to the casual outside observer is often someone's home. There are other disadvantages as well: a) there may be little information on how much biodiversity is actually included in the wilderness area, b) other areas with higher concentrations of biodiversity may be missed because they are not classified as "wilderness," and c) attention focused primarily on large wilderness areas with few imminent threats may divert resources from areas facing more urgent problems.

Finally, the relatively "undisturbed" wilderness area, as defined by McCloskey and Spalding (1989), may be overrepresented for some biomes. For example, relatively low human population densities (and grazing animal densities) can have significant adverse impacts on grassland ecosystems, especially in semi-arid regions. Transhument pastoralism in some grassland and other semi-arid regions represents a seasonal or prolonged period of human and livestock presence that will not be registered by identifying settlements and other infrastructure on jet navigation charts.

In any case, identifying wilderness areas should be viewed as a first step in defining more detailed priorities and should not be viewed as a comprehensive approach to setting biodiversity priorities. Nevertheless, knowing where wilderness areas are can help to focus biodiversity assessments in areas where conservation prospects are less complicated by human activities.

The three previous examples identify large areas (i.e., countries or regions) as global conservation priorities. The two following examples, centres of plant diversity and endemic bird areas, involve identifying individual sites or habitats critical to threatened or endemic species, or an unusual concentration of species. Site approaches identify priorities without specific reference to country or biogeographic boundaries. Priorities identified in this way have the advantage of being relatively precise in geographic terms. At the same time, they are often limited to a narrow subset of species or habitats. For example, an approach may identify well-defined habitats that are important to endemic birds, but such habitats may do little for the conservation of many other elements of biodiversity. However, sites of concentrated diversity or endemism for some groups of organisms may be indicative of biodiversity concentrations more generally. In any case, sites identified in this way may be used to add specificity to more general country (e.g., megadiversity) or regional (e.g., hotspots) priorities.

Centres of Plant Diversity

Plants are vital constituents of any ecosystem and are usually the most visible indicators of habitat types and condition. Moreover, it is estimated that as many as 60,000 of the world's approximately 250,000 vascular plant species may become extinct before the middle of the next century (IUCN, 1987). These reasons, plus the fact that plants as a taxonomic group are generally well known, provide a good basis for using plants to identify conservation priorities.

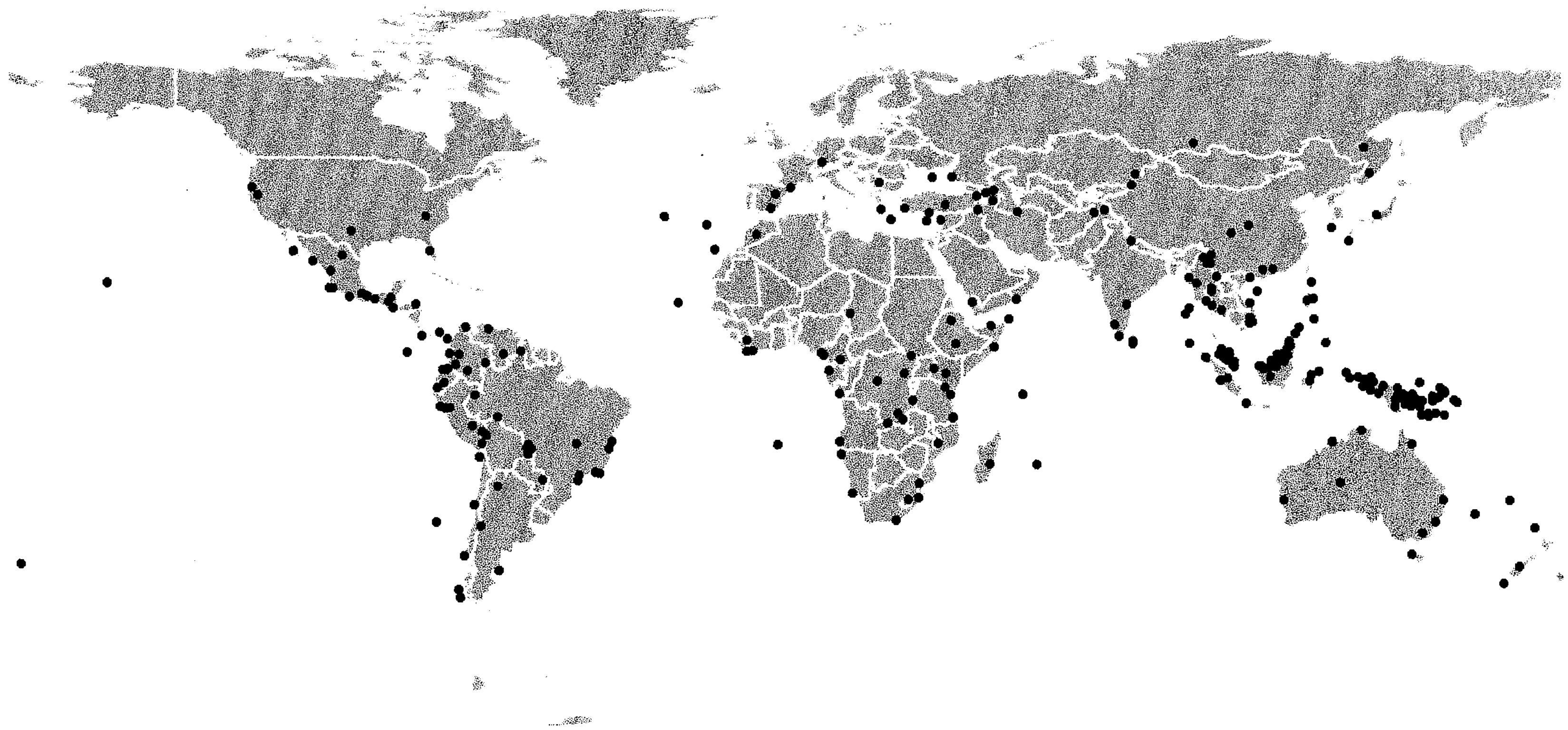
In 1986, the IUCN and the World Wide Fund for Nature (WWF) initiated a project to identify major centres of plant species diversity (IUCN, 1987). The goal of the project was to identify places with unusual concentrations of plant diversity and endemism that, collectively, represent a majority of the world's plant species. The final list of sites for the "Centres of Plant Diversity" project is 234, most of them in the tropics (see Figure 3.2 and Tables 3.6 and 3.7).

The project is intended to identify "first order" sites of global significance. The sites were chosen without reference to political boundaries. Some countries have numerous sites (e.g., Indonesia), while others (e.g., Egypt) have none. The ultimate goal is to confer some form of protected area status to all vulnerable sites—many of which already are included in protected areas and nevertheless remain vulnerable.

Working with botanists and other collaborators from around the world, the Centres of Plant Diversity Project identified three basic types of sites (WWF and IUCN, 1994):

1) botanically rich sites that are well-defined geographically (e.g., Mt. Kinabalu in Sabah, Malaysia on the island of Borneo, or Darien National Park in Panama);
2) less well-defined geographic regions with high species diversity and/or endemism (such as the High Atlas Mountains of

Figure 3.2 Geographic Distribution of Centres of Plant Diversity



Source: WCMC (1992)

TABLE 3.6 REGIONAL DISTRIBUTION OF CENTRES OF PLANT DIVERSITY AND ENDEMIC BIRD AREAS

Region	Centres of Plant Diversity # of Sites	Endemic Bird Areas # of Sites
Africa	33	32
Asia	83	63
Australia/South Pacific	22	33
South America	46	42
Central America/Caribbean	23	31
North America	6	14
Europe and Middle East	21	6
TOTAL	234	221

Source: adapted from WCMC (1992) and WWF and IUCN (1994).

Morocco or the Klamath-Siskiyou Mountains of Oregon and California); and

3) vegetation types and floristic provinces that are exceptionally rich in plant species (such as the Cape Floristic Province in South Africa, or the Atlantic Forests in southeastern Brazil).

Selected sites must have one or both of the following characteristics: the area must clearly be species-rich, even if the number of species present is not yet accurately known, and/or it must be known to contain a large number of endemic species.

In addition, the evaluation process considers such other characteristics as whether the site a) contains diverse habitat types, b) contains plant genetic resources of economic importance, c) contains an unusual number of species adapted to special edaphic (soil) conditions, and d) is threatened or imminently threatened with extensive degradation (WWF and IUCN, 1994). In practice, the site selection process has emphasized botanical importance rather than threat, and distinctiveness rather than utility.

While a simple set of criteria and characteristics was used to help select initial sites for consideration, a deliberative and consultative process with regional botanical experts was used for the final selection rather than a quantitative ranking process. This helps to ensure that important areas for which data are not available are considered for the final list, as well as to update and strengthen the data collected for each site. Regional workshops in Africa, China, India, and North and South America reviewed and revised data on sites proposed by IUCN.

ENDEMIC BIRD AREAS

Not long after the IUCN initiated the Centers of Plant Diversity project, the International Council for Bird Preservation (now known as Birdlife International) launched a similar effort to identify critical areas for the conservation of bird species around the world. It collected information on the geographic ranges of bird species, then mapped them to identify Endemic Bird Areas (EBAs), that is, areas having large numbers of endemic birds with restricted ranges. It also reviewed the endemism of other taxonomic groups within the Endemic Bird Areas to assess the value of birds as biodiver-

Table 3.7 Countries with the Most Centres of Plant Diversity Sites

Country	# of Sites
INDONESIA	18
MALAYSIA	13
BRAZIL	12
MEXICO	12
AUSTRALIA	10
CHINA	8
UNITED STATES	8
PERU	8
COLOMBIA	8
INDIA	6
PHILIPPINES	6
TURKEY	6

Source: adapted from WWF and IUCN (1994)

sity indicators. The great advantage of using birds as an indicator for biodiversity—assuming there is correlation with species richness and endemism for other groups—is the abundant data collected by ornithologists and amateur bird watchers during the past century; these are useful for preparing distribution maps and other analysis.

To identify Endemic Bird Areas, locality records were gathered from ornithologists, museums, universities, and conservation agencies to identify species with breeding ranges of 50,000 km^2 or less. Over 55,000 separate locality records were accurately geo-referenced and mapped using a computer-based Geographic Information System (GIS). The mapping yielded the surprising result that 27 percent of the world's approximately 9,600 bird species have breeding ranges restricted to less than 50,000 km^2 (Bibby, et al., 1992). Not unexpectedly, species of restricted range tend to occur together, for instance on islands or in isolated mountain habitats. Using multi-variate analysis, Birdlife International researchers developed boundaries around the groupings of the restricted-range endemic birds, designating these areas as Endemic Bird Areas. In all, 221 EBAs have been identified which contain the habitats of 2,484 restricted range endemic birds—or 95 percent of all known restricted-range species (see Figure 3.3 and Table 3.8).

Most Endemic Bird Areas are found in the tropics (76 percent), with very few found in the northern temperate areas. Although the southern hemisphere has only about 25 percent of the world's land area (excluding Antarctica), it has more than half of the EBAs (119). Most of the EBAs are found either on islands (46 percent) or in mountainous habitats in continental areas.

The Endemic Bird Areas are not uniform in size—the smallest (5km^2) is found in the northwestern Hawaiian Islands, and the largest (174,000 km^2) is in northern South America in French Guiana, Surinam, Guyana, and Brazil (Bibby et al., 1992). Although there is considerable variation in size, some patterns are evident. For example, all EBAs smaller than 1,000 km^2

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TABLE 3.8 COUNTRIES WITH GREATEST NUMBER OF ENDEMIC BIRD AREAS

Country	# of Endemic Bird Areas	# of Restricted-Range Bird Species[1]
INDONESIA	24	410
PERU	18	215
BRAZIL	17	200
COLOMBIA	14	185
MEXICO	14	105
CHINA	12	60
PAPUA NEW GUINEA	12	170
ECUADOR	11	190
PHILIPPINES	9	115
ARGENTINA	9	100

1 - Numbers are approximate

Source: Adapted from Bibby et al. (1992)

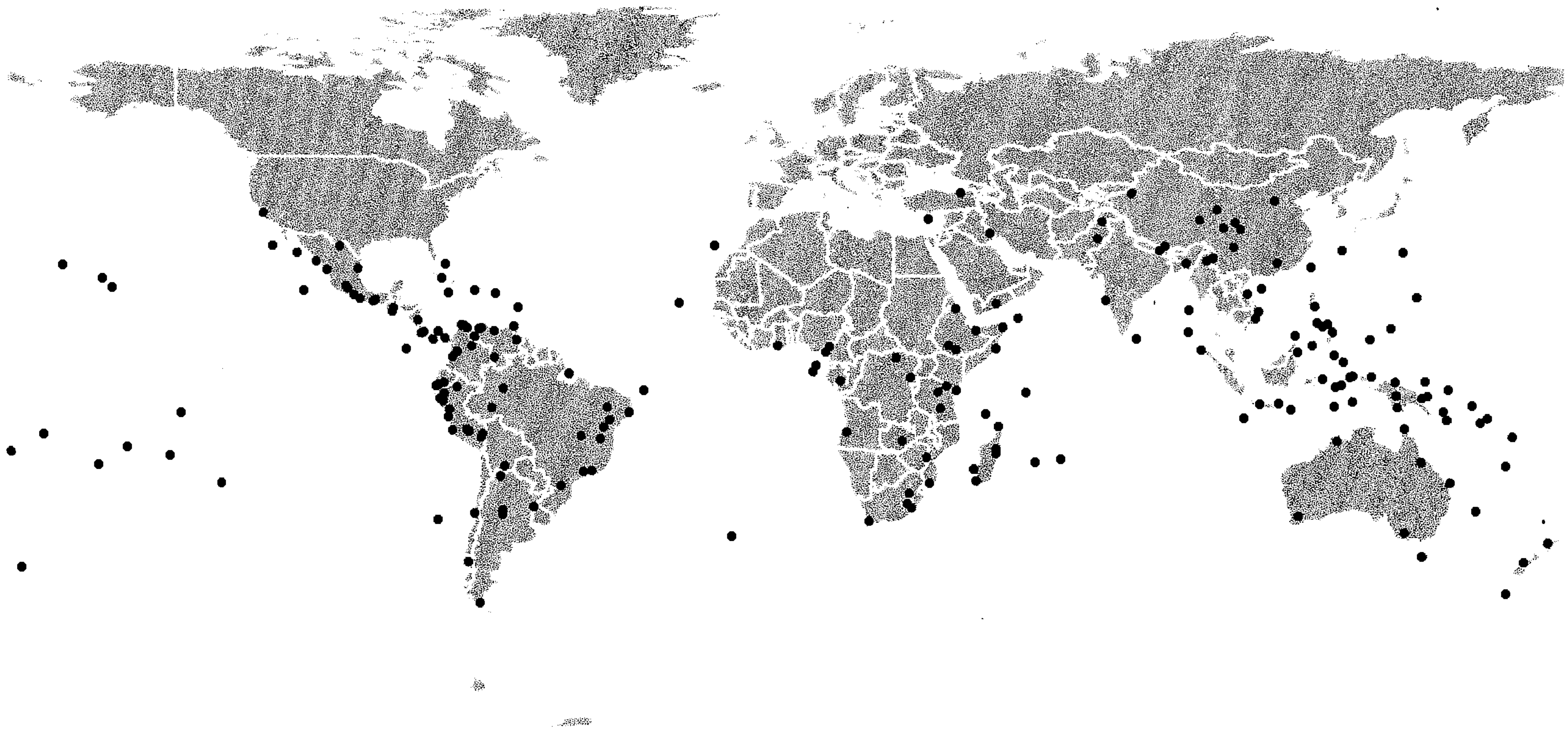
are found on islands and the larger EBAs tend to be continental. Only 16 percent of EBAs are larger than 50,000 km^2, which is the maximum range size allowed for any one restricted-range endemic species.

Like size, the number of species contained in Endemic Bird Areas varies considerably beyond the two species minimum. There are an average of 11.2 restricted range species per EBA, but the numbers range from 2 in a number of locations (e.g., on Australia's Lord Howe Island) to 67 in the Solomon Islands. Most EBAs are found in predominantly forest habitats (70 percent), while fewer EBAs are found in predominantly scrub habitats (11 percent), or mixed habitats (11 percent). Grasslands and wetlands are poorly represented, most likely because species in these habitats are more widespread (WCMC, 1992).

Regardless of their location, restricted range-endemic bird species are frequently listed as threatened (29 percent), and most EBAs (85 percent) are known to contain threatened endemic species (Bibby et al., 1992).[7] Only 8 percent of the land area found in EBAs is under any form of protection. Nearly one third of the individual EBAs have no protected areas coverage whatsoever, and 35 percent have less than 5 percent of their area legally protected (although not necessarily in practice).

Bibby et al. (1992) also evaluated endemicity patterns for other groups of animals and plants to determine the level of congruence with bird species endemicity. In some parts of the world, there are striking similarities in patterns of endemicity—for example in Amazonia, there is a high degree of overlap between centers of endemism for birds, some lizards, butterflies, and trees. Overall, there appear to be some general patterns of congruence in endemism between birds and other taxonomic groups, but the overlap varies considerably from region to region, and distribution patterns for groups other than birds are poorly documented in most parts of the world.

FIGURE 3.3 GEOGRAPHIC DISTRIBUTION OF ENDEMIC BIRD AREAS



Source: Bibby et al. (1992)

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Having identified the 221 Endemic Bird Areas, Bibby et al. (1992) took their analysis one step further. They classified the EBAs on the basis of their biological importance (species richness and endemism levels) and the immediacy of the threats they face. The EBAs were classified into three groups to indicate increasing level of biological importance (determined by the species to area relationship), and classified separately into another three groups by the degree of threat to the area.

Although the classifications are based on quantitative information, Bibby et al. (1992) were reluctant to use numerical ranking alone since it "gives an air of greater objectivity and finality than is appropriate." Rather, they evaluated the EBAs in each of the areas, giving scores of 1 to 3 on biological importance[8], and 1 to 3 on degree of threat.[9] These two classification systems are then combined into a conservation priority classification.

These two classification systems are then combined into a conservation priority classification. Those EBAs with a combined score of 5 or 6 are classified as "critical," those with a combined score of 4 are "urgent," and those with a combined score of 2 or 3 are "high" conservation priority. The final classification has 79 "critical" priority EBAs, 87 "urgent" EBAs, and 55 "high" priority EBAs.

The Bibby et al. (1992) analysis is one of the most comprehensive assessments of biodiversity conservation priorities ever made at a global scale. One hopes that similar efforts will be mounted for other taxonomic groups as more information becomes available.

The site selection approaches—centers of plant diversity and endemic bird areas—have the advantages of being relatively specific geographically, quantitatively based, and amenable to straightforward analysis. They also have their limitations. For example, restricting the analysis to birds with less than 50,000 km^2 of range means that larger areas of avian endemism such as the Mediterranean Basin or Amazonia are not included. Similarly, wide-ranging migratory or sea birds that depend on a very confined breeding or wintering habitat are not included, even though such birds may be the most vulnerable of all. But, as Bibby et al. (1992) note, "the thrust of this report is not intended to deny that conservation action is needed in all the world's biomes. It is suggested that the smaller centers of endemism are the more pressing for conservation action because they are more susceptible to sufficient destruction to cause extinctions."

Global Priorities for Marine Biodiversity Conservation

In many parts of the world, marine ecosystems have been relatively neglected in conservation efforts. With human populations in coastal areas expected to swell in coming decades, marine biodiversity conservation is getting more attention, but efforts to identify conservation priorities for marine species and ecosystems are just beginning.

Oceans cover more than two thirds of the earth's surface and host a diversity of life rivaling that found on land. Although species diversity is less than in terrestrial ecosystems, diversity at the phyla level is greater: 32 of the world's 33 animal phyla[10] are found in the ocean—and 15 of them are found only there (Norse, 1993). Marine diversity is so little known that there is no published list of the world's fish species (McAllister et al., 1994), and many new marine species, genera and even families of marine life are discovered every year. Like terrestrial biodiversity, marine diversity at all levels—genetic, species, and ecosystem—is under increasing threat from human activities. Well over half of the world's population lives within two hundred kilometers of a coastline. Coral reefs, mangrove forests, estuaries, coastal marshes and other coastal habitats have been rapidly degraded by pollution and sedimentation or converted to other uses and overfishing has depleted many of the world's major fisheries to a point of collapse (WRI, 1992b).

Marine biologists are quick to point out the ways that marine environments and their biota differ fundamentally from terrestrial ecosystems (Grassle et al., 1991). The fluid medium of oceans, their role as biogeochemical sinks, the more complicated structure of marine food webs, and the relative inaccessibility of ocean environments to humans all have important implications for conservation (Norse, 1993). However, as with terrestrial ecosystems, some coastal and marine areas are especially important for the conservation of biodiversity.

Norse (1993) identifies six biological criteria (several of which are commonly used in terrestrial priority-setting efforts) for deciding what marine areas to protect. Species diversity and areas of high endemism are cited, with the proviso that they should be used only in conjunction with other criteria since species richness and endemism do not necessarily include economic importance, ecological importance, evolutionary significance or endangerment.

The other criteria are more specific to coastal and marine ecosystems and focus on ecological processes. Areas of high primary productivity sustain many of the world's populations of seabirds and marine mammals—as well as dense concentrations of fishes—and therefore merit special attention in marine conservation efforts. Shallow estuaries and coral reefs are examples of highly productive coastal areas, while upwelling areas where cold nutrient-rich subsurface waters come to the surface are examples of unusually productive marine areas.[11] Reproductive areas and nursery grounds should also get priority. Many marine organisms—including fishes, birds, mammals, and reptiles—depend on very localized breeding grounds, even though they live their adult lives within broad geographic ranges. Many fish and invertebrate species need specialized habitats during their juvenile stages. Estuaries, coral reefs, seagrass beds, and other habitats often serve as nurseries for species that inhabit much larger surrounding areas as adults.

Finally, many marine species, particularly shorebirds and marine mammals, are highly migratory. For species with well-defined migration routes, certain stopover points or narrow passages are vital to making a successful journey. For example, certain beaches and coastal wetlands that are rapidly disappearing are essential migratory stops for shorebirds. Even migratory species with large populations are therefore vulnerable to oil spills, hunting, or other events that destroy or degrade migratory habitats.

Until recently, priority-setting efforts in marine ecosystems have lagged considerably behind efforts on land. Recognizing the increasing threats to marine ecosystems, the IUCN's Commission on National Parks and Protected Areas (CNPPA), the Great Barrier Reef Marine Park Authority (GBRMPA), and the World Bank launched an ambitious project in 1991 to identify priority areas for the conservation of marine biodiversity (Kelleher et al., 1995). The ultimate goal of the project—consistent with resolutions passed at major conservation forums[12]—is to establish a global network of protected areas that includes all of the world's distinct marine ecosystems.

One of the first major challenges confronting the project was the lack of consensus on a marine biogeographical classification. The CNPPA project divided the world's marine areas, based on biogeographical considerations and political boundaries, into 18 regions, such as the wider Caribbean, Mediterranean, southeast Pacific, and northeast Pacific. Existing biogeographic classifications were then used or adapted to identify priorities within each of these regions. In the future, a better system based, for example, on the Large Marine Ecosystem (LME) concept (see Sherman and Laughlin, 1992) may become available.

Working groups composed principally of marine resource managers and marine scientists were established in each of the 18 regions (Kelleher et al., 1995). These regional working

BOX 3.3 RESPONSIBILITIES OF CNPPA REGIONAL MARINE WORKING GROUPS

- Summarize main physical and biological characteristics of regional marine environment.
- Divide marine region into constituent biogeographic zones.
- Inventory existing marine protected areas (MPAs).
- Identify gaps in representation of biogeographic zones in MPAs.
- Identify national priority areas for strengthening management of existing MPAs and establishment of new MPAs.
- Identify areas of regional priority for strengthening management of existing MPAs and establishment of new MPAs.
- Prepare other recommendations to promote the establishment and strengthen the management of MPAs in the region.

Source: Kelleher et al. (1995)

groups were charged with subdividing their region into constituent biogeographic zones or "realms" and then identifying areas of national and regional priority for strengthening existing marine protected areas (MPAs) and establishing new MPAs (see Box 3.3).

Within guidelines developed by Kelleher and Kenchington (1992), each working group used a two-step process to apply biogeographical, ecological, social, and feasibility criteria to identify priority MPAs in their region (Box 3.4). First, biogeographical and ecological criteria (using existing data) were applied to generate a list of candidate areas. These candidate areas were then screened by economic, social, scientific, and feasibility criteria to select priority areas. In other words, all priority areas had to be assessed as having a reasonable chance for being successfully managed as a marine protected area.

National priority areas were identified principally on the basis of recommendations by national representatives on the CNPPA regional working groups, so they are usually consistent with priorities previously identified in National Environmental Action Plans or National Conservation Strategies or other plans. Regional priority areas were produced through a three-year consultative process led by the regional working group leader. The consultative process—based on consensus—was designed to give marine scientists and resource managers in each country an opportunity to help shape the final list of national and regional priority MPAs.

The CNPPA regional priorities for establishing or strengthening marine protected areas are limited to the dozen or so actions needed to conserve a representative sample of all biogeographic zones within a regional network of MPAs. National priorities for new and strengthened MPAs are generally more numerous, depending on how comprehensive existing national MPA systems are. These areas have been mapped on a GIS database of the 18 marine regions by the World Conservation Monitoring Centre and will be available to any interested users.

The World Bank, which supported the CNPPA project, hopes to begin collaborating with governments, other bilateral and multilateral donor agencies, and NGOs to implement regional and national MPA projects. Eventually, these efforts may lead to the development of a globally representative network of MPAs as envisioned in the CNPPA report.

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BOX 3.4 CRITERIA USED BY CNPPA WORKING GROUPS TO SELECT PRIORITY MARINE PROTECTED AREAS

Biogeographic Importance:

- contains rare biogeographic qualities or is representative of a biogeographic "type"
- contains unique or unusual geological features

Ecological Importance:

- contributes to essential ecological processes or life-support systems (e.g., source of larvae for downstream areas)
- encompasses a complete ecosystem by itself or in association with other MPAs
- contains a variety of habitats
- contains habitats for rare or endangered species
- contains nursery or juvenile habitats
- contains feeding, breeding, or migratory rest areas
- contains rare or unique habitats
- preserves genetic diversity (i.e., high species diversity)

Naturalness:

- degree to which area has not been subject to human change

Economic Importance:

- degree to which protection will maintain or enhance economic value (e.g., recreation, tourism, subsistence use, refugia for economically important species)

Social Importance:

- degree to which protection will maintain or enhance heritage, historical, cultural, aesthetic, or educational values for local, national, and international communities

Scientific Importance:

- value for research and monitoring

National and International Significance:

- potential for listing as World or National Heritage Area or Biosphere Reserve; alternatively, extent to which area already figures in international or national conservation agreements

Feasibility of Management:

- degree of insulation from destructive activities
- social and political acceptability and degree of community support
- accessibility for education, tourism, and recreation
- compatibility with existing local uses
- compatibility with existing management regimes

Source: Kelleher et al. (1995)

Regional Approaches to Setting Priorities

Regional approaches to setting priorities have the advantage of working at intermediate scales that can (to some extent) avoid the imprecision of global priorities and the arbitrary limits of political boundaries that may bias nationally based conservation priorities. In coming years, regional organizations, such as the Central American Commission on Environment and Development (CCAD),[13] are likely to play a larger role in coordinating conservation policies and actions. Donor organizations are often structured regionally and frequently set policies and priorities in a regional context. And regional approaches can serve to develop multi-national networks and alliances to promote biodiversity conservation, share experiences, and develop cross-border conservation projects.

Regional approaches to priority setting will often have to rely on nationally based analysis and databases to assess priorities at a regional scale. Moreover, they can only be as effective as the national strategies used to implement conservation actions. Nevertheless, regional approaches are a promising area for future work on assessing conservation priorities—probably much more so than global approaches.

Five examples of efforts to set regional priorities are presented here. The first example, IUCN Species Survival Action Plans, is focused on distinct groupings of wild species rather than on a particular region, but since species are often found in several countries, and the action plans often include recommendations that are regional in scope, they are included here. The other examples include the IUCN Regional Protected Area Reviews; conservation potential and threat assessments for Asia and Latin America developed by World Wildlife Fund-U.S.; the expert workshop approach developed by Conservation International; and a framework for setting biodiversity conservation priorities in Latin America developed by the Biodiversity Support Program and five other NGOs for the U.S. Agency for International Development (USAID).

Species Survival Commission Action Plans

In the mid-1960s, the World Conservation Union (IUCN) established the Species Survival Commission to focus expert attention on the status and conservation needs of distinct groupings of wild species. There are now over 100 Specialist Groups covering mammals, birds, invertebrates, reptiles, fish, and to a lesser degree plants. Each of these Specialist Groups is a volunteer network of scientists (nearly 5,000 are involved) that seeks to generate and update information on the species covered by the group, and to devise and implement programs to conserve the most threatened of those species in collaboration with IUCN members. The most important responsibility of the Specialist Groups is to develop an Action Plan that provides a comprehensive overview of all the species within their brief, establishes or applies a system for setting research and conservation priorities, and proposes projects to address those priorities (Stuart, 1987). The overwhelming focus, thus far, has been on animals.

By the late 1980s, the first comprehensive Action Plans were being completed. As of 1993, twenty-five Action Plans had been produced. Not surprisingly, the Action Plans use various priority-ranking schemes reflecting differences in data quantity and quality, the number of species covered by the Specialist Group, and other factors perhaps best known to members of the particular group. The Action Plans rank conservation priorities for several objectives.[14]

While it is difficult to generalize about the characteristics of priority-ranking schemes, the Action Plan for Asian Primates (Eudey, 1987) provides a good example of the priority-setting process used by an IUCN Specialist Group. First, the Action Plan generates an overall conservation priority ranking for the 64 species

BOX 3.5 IUCN CONSERVATION PRIORITY RANKING CRITERIA FOR ASIAN PRIMATES

A) Degree of Threat

1) **Not known to be rare or threatened.**

2) **Rare or at risk.** Populations exist at low density and/or in limited geographic areas, or are widely distributed in diverse habitats but some populations subject to extreme selection pressures due to habitat alteration and hunting/trapping.

3) **Vulnerable.** Populations have limited distribution and/or ecological tolerance and habitat destruction and hunting/trapping are slowly but steadily reducing population. Likely to move to category 4 by 2000 without conservation action.

4) **Highly vulnerable.** Surviving populations small or fragmented, and threatened by human activities. Likely to move to category 5 by 2000 without conservation action.

5) **Endangered.** Less than 25,000 individuals remain and threatened by human activities. Populations found in very limited areas, or in highly fragmented ranges. Likely to move to category 6 by 2000 without conservation action.

6) **Highly endangered.** Less than 10,000 individuals remain and no subpopulation is considered secure.

B) Taxonomic Uniqueness

1) A member of a large species group (one of several closely related species).

2) A very distinct species, or member of small distinct taxonomic group.

3) Only member of genus or family (monotypic genus or family).

C) **Association with Other Threatened Primates**

1) A wide-ranging species, and/or most of range does not overlap with any highly threatened species.

2) Major part of species' range overlaps with highly threatened species.

Source: Eudey (1987)

found in Asia. This is a composite score combining ratings for each species on the basis of three criteria: degree of threat, taxonomic uniqueness, and association with other threatened primates (see Box 3.5). Those species with scores above 7 (11 is the maximum score possible) are judged in need of conservation action—37 species or 59 percent of all Asian primates received a 7 or above.

Second, the Action Plan prioritizes recommended conservation actions in each of four areas: small-scale surveys, large-scale surveys at the regional or country level, protected area development and management, and special projects (e.g, captive breeding). The project priority rankings are based on the evaluation of four criteria—number of species in the project area, imminence of threat to the project area, primate species diversity in the area, and number of endemic primates in the area (see Box 3.6). A total project rating is produced by summing the scores for each of the criteria.

The rating systems used in the Action Plans typically mix quantitative and qualitative information, and use somewhat arbitrary weightings for scores that combine more than one criteria. These are not really weaknesses—qualitative information may be the most important of all and arbitrary judgments are almost inevitable in any priority-setting process. However, the more reliant a priority-ranking scheme is on qualitative data and relatively arbitrary

BOX 3.6 IUCN PRIMATE SPECIALISTS GROUPS CRITERIA FOR ASSESSING PROJECT PRIORITIES

A) **Number of species in project area with high conservation priority rating** (priority ranking of 7-11), or vulnerable (priority ranking of 5-7), or at risk (priority ranking of 4), scored on the following scale of 1-5:

1. 1 or more vulnerable or at risk species
2. 1-2 high priority species
3. 3-4 high priority species
4. 5-6 high priority species
5. 7 or more high priority species

B) **Imminence of threat to the ecosystem under consideration**, scored on scale of 1-4:

1. Low degree of threat
2. Moderately threatened
3. Highly threatened (under serious threat from increasing human activities although undisturbed area is still relatively large)
4. Very highly threatened (ecosystem is small in size and/or highly fragmented and subject to intense pressures from human activities)

C) **Overall primate diversity in project area**, rated on a scale of 1-3:

1. 3 or fewer species
2. 4-7 species
3. 8 or more species

D) **Number of endemic primate species and subspecies in project** area, rated on scale of 1-4:

1. 1 or more populations living under marginal conditions
2. 1 or 2 endemic subspecies in the area
3. 1 endemic species, or more than 2 endemic subspecies
4. 2 or more endemic species in the area

Source: Eudey (1987)

weightings, the more likely that experts will disagree on the results. This is less likely to be the case with the IUCN Species Survival Commission Action Plans since many of the most knowledgeable experts are involved in the Specialist Groups. The Action Plans are widely viewed as fairly authoritative statements on the conservation status and needs of species covered by the groups. One of their strengths is that they are often quite specific with respect to geographic conservation priorities and the types of conservation actions that are needed.

But the Action Plans also have limitations. Since the conservation priority rating systems vary from one animal or plant group to the next, it is not possible to rank conservation needs across groups. It is also often impossible to determine whether high priority rankings for protected areas management, for example, are more important than an equivalent ranking for surveys or captive breeding. In many regions, the geographical conservation priorities of one Action Plan have not been correlated with overlapping priority areas identified in other Action Plans. However, as more Actions Plans are completed, IUCN is working to prepare regional and country overviews of priorities identified by various Specialist Groups. The first of these overviews (Stuart et al., 1990) includes countries in sub-Saharan Africa. Finally, there is the danger of obscuring elements of subjectivity behind the impression of numerical precision. "However," as Cumming et al. (1990) point out, "the purposes of calculating and using such indices is to produce rational, dispassionate thinking into the process of setting priorities and to reduce arbitrary, subjective elements as much as possible. A primary function of such exercises is to make the rationale for choices explicit and so aid in reaching consensus about priorities for conservation action."

The Action Plans developed by the IUCN Species Survival Commission Specialist Groups can be an important reference for nearly anyone involved in setting conservation priorities. With continued refinement of the priority-ranking process by the Specialist Groups and the IUCN, these documents are likely to become better guides for establishing priorities in the future.

Regional Protected Area Reviews

In 1982, following the Third World National Parks Congress in Bali, the IUCN prepared the Bali Action Plan for protected areas. The first objective of the Bali Action Plan was to establish a worldwide network of national parks and protected areas, exemplifying all terrestrial ecological regions, by 1992. To do this, the Congress agreed that a biogeographical approach would be used to identify areas for a variety of conservation objectives, particularly the protection of unique ecosystems and rare and valuable species (MacKinnon and MacKinnon, 1986a).

Over the next several years, the IUCN Commission on National Parks and Protected Areas (CNPPA) authorized a series of systematic regional reviews to identify gaps in protected areas coverage, including weaknesses in existing parks, and recommendations for new protected areas. Since then, reviews have been completed for three regions including the Indo-Malayan Realm (MacKinnon and MacKinnon, 1986a), the Afrotropical Realm (MacKinnon and MacKinnon, 1986b), and Oceania (Dahl, 1986). A fourth review covering the neotropics was planned but never completed.

The basic approach used in these reviews was to divide the regions (or biogeographic realms) into distinct biogeographical subdivisions based on the Udvardy (1975) system. For example, the first subdivision of the Indo-Malayan Realm (tropical Asia) is into four separate subregions: Indian, Indochinese, Sundaic (peninsular Malaysia and western Indonesia), and Wallacean (eastern Indonesia and Philippines). This is followed by further subdivision into biogeographic units (biounits).[15] The Indo-Malayan Realm, for example, has 43 biounits stretching from the mountains of Baluchistan (in Pakistan) in the west, across the Indian subcontinent south of the Himalayan crest, through southern China and Indochina, and south through insular southeast Asia (Philippines and Indonesia). Finally, each biounit is characterized by the major habitat types—based on vegetation cover—within it. Typically, a biounit is divided into between 4 and 10 habitat types.

Two main objectives of the protected areas reviews are to 1) characterize threat levels to biounits and habitat types, and 2) provide an index of the effectiveness of protection afforded each habitat type (MacKinnon and MacKinnon, 1986a). Estimates were made for the "original" and current extent of each habitat type within each biounit, although the basis for these estimates is not provided. The percentage of remaining habitat is used as a simple index of the threat faced by each habitat type. Next, the boundaries of existing and proposed protected areas are plotted over the maps showing remaining natural habitat. This provides an index of current and proposed protection for each habitat type.

MacKinnon and MacKinnon (1986a) used

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a simple scoring system to evaluate conservation needs in three areas: the conservation importance of existing protected areas, the amount of protection provided in different biogeographical units, and help identify priorities for further protected areas action in each biogeographic unit. Individual protected areas were scored with respect to protection objective and management effectiveness (see Table 3.9). The individual protected area scores were then summed for the biogeographic unit, and the protected areas evaluated with respect to habitat coverage (i.e., are all major habitats included in the protected area system?) and altitudinal range.[16]

A maximum score can occur only if a protected areas system offers total protection to 10 percent of the biogeographic unit, is under effective management, and includes adequate areas of all habitat types and the complete elevational range of the biogeographic unit.

To determine conservation priorities, MacKinnon and MacKinnon (1986a) use a two-component system. The first part, called "urgency for improvement," is based on a model which reflects a decreasing need for conservation as more land is set aside, and as protected areas management improves (see Figure 3.4). The need for protection increases as the remaining area of natural habitat decreases, but decreases if the scope or potential for additional protection decreases. According to MacKinnon and MacKinnon (1986a), such scope for added protection includes improving the objectives and effectiveness of management as well as increasing the area protected. Looking at Figure 3.4, the highest urgency goes to highly underprotected areas where there is still adequate opportunity to improve protection. The lowest urgency is given to unthreatened units already adequately protected or to biogeographic units so fully developed or degraded that there is little opportunity for additional protection.

TABLE 3.9 SCORING MATRIX FOR EFFECTIVE CONTRIBUTION OF PROTECTED AREAS

Protection Objective	Effective Management	Moderate Management	Poor Control	No Effective Control
Total protection	1.0	0.8	0.5	0.3
Nonconsumptive uses only	0.9	0.7	0.5	0.3
Managed for visitor uses	0.8	0.6	0.4	0.2
Managed for protection and production	0.7	0.5	0.4	0.2
Resource reserved for future use	0.6	0.5	0.3	0.2
Multiple use, no habitation	0.4	0.3	0.2	0.1
Multiple use, with habitation	0.2	0.2	0.1	0.1

Source: MacKinnon and MacKinnon (1986a)

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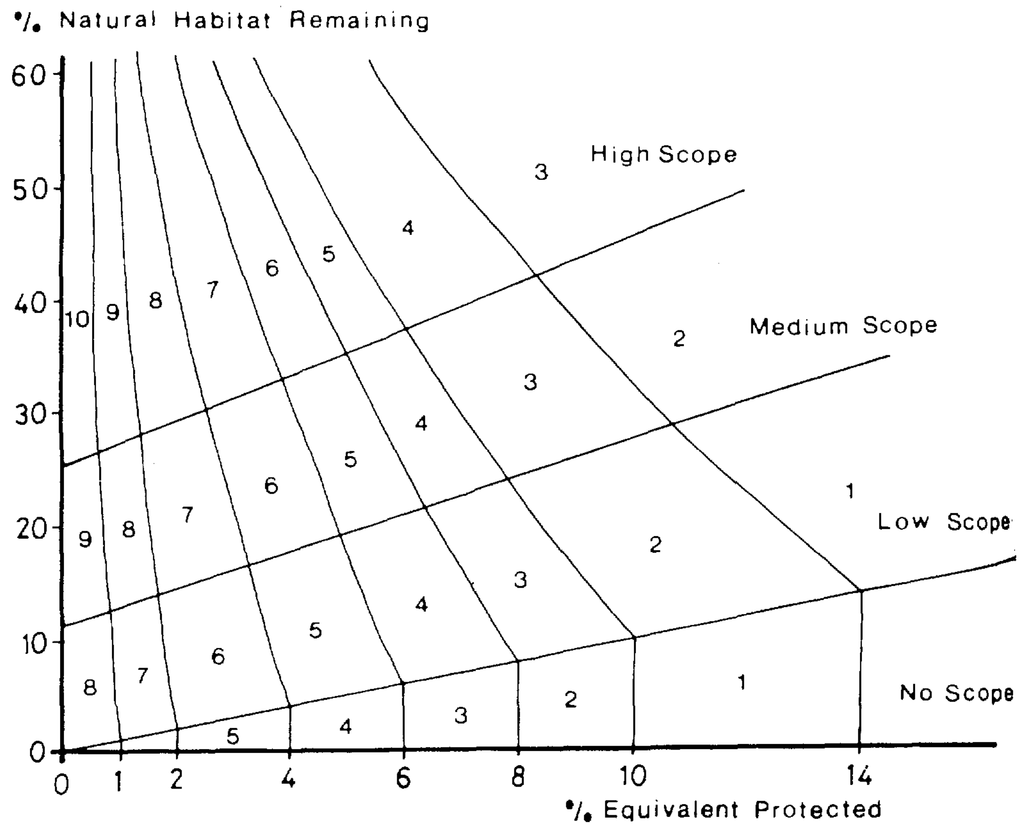
FIGURE 3.4 MACKINNON AND MACKINNON MODEL FOR SCORING CONSERVATION "URGENCY"



Source: MacKinnon and MacKinnon (1986a)[17]

The second part of the priority score, called "conservation importance," is based on species richness and levels of endemism for selected plants and animals. For the Indo-Malayan Realm, the scores are determined for passerine birds, ungulates, and diurnal primates, in addition to plants.[18]

The combined importance score for the biogeographic unit is simply multiplied by the urgency score to produce a final priority score for action within the biogeographic unit.

The strengths of the MacKinnon and MacKinnon (1986a) system include its biogeographic classification, its specificity in locating biodiversity conservation priorities, and its recognition that institutional factors (i.e., the effectiveness of protected areas management) are critical in determining conservation priorities.

But the approach is not without weaknesses. For example, the scoring matrix for determining the effective contribution of protected areas seems arbitrary. Is it reasonable to assume that a protected area managed for "total protection" but with "no effective control" is better for conserving biodiversity than a multiple-use area, with habitation, that is under "effective management"? MacKinnon and MacKinnon's (1986a) methodologies are difficult to replicate both because of the subjective assessments used (e.g., management effectiveness) and because the methodology was not detailed. This illustrates the need for transparency and explanation of what factors were critical to subjective judgements. Finally, since conservation data in many

Box 3.7 Data for Construction of Conservation Potential/Threat Index (CPTI)

Basic Data

- Country area (km^2)
- Remaining forest area (km^2)
- Rate of deforestation (%/year)
- Protected area (km^2)

Secondary Data

- Number of protected areas
- Number of protected areas >300 km^2
- Number of protected areas >1,000 km^2
- Species richness (mammals, birds, reptiles, amphibians, freshwater fishes, swallowtail butterflies, vascular plants)
- Species endemism (mammals, birds, vascular plants)
- Human population density (#/km^2)
- Conservation funding (dollars/km^2/yr)

Source: Dinerstein and Wikramanayake, 1993.

areas are limited and often questionable, is it prudent to assign conservation priorities across the whole of tropical Asia? Despite the weaknesses of this ambitious attempt to set conservation priorities, the strengths have influenced subsequent approaches to priority setting (e.g., Dinerstein and Wikramanayake, 1993; Dinerstein et al., 1995).

Conservation Potential and Threat Assessments in the Indo-Pacific and Latin America Regions

Tropical Asia and the island nations of the South Pacific (or the Indo-Pacific region) have some of the world's highest human population densities, most rapidly growing economies, and still contain some of the richest and most varied habitats on earth. Remaining forests and other natural habitats, however, are shrinking fast in most parts of the region as demands for timber, agricultural lands, water development, and coastal resources escalate. Seeking to develop a "paradigm" to establish conservation priorities at regional, national, and subnational levels, Dinerstein and Wikramanayake (1993) developed a model to quantify conservation potential and threats to biodiversity in the region.

The model produces a conservation index—called the conservation potential/threat index—based upon the interaction of the size of terrestrial protected areas, remaining forest habitat, deforestation rates, and biological richness. This index forecasts how deforestation during the next decade will affect conservation opportunities, which are largely defined as establishing protected areas. The goal of the approach is to identify where reserves are most needed and therefore suggest how funding can be most effectively invested to conserve biodiversity.

The approach has a number of distinctive features. First, the scheme is a simple model based on assumptions about future trends (i.e., deforestation); nearly all other approaches are based on the static analysis of contemporary

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BOX 3.8 CONSERVATION POTENTIAL/THREAT INDEX CATEGORIES

Category I: Countries with a relatively large percentage (>4 percent) of forests under formal protection and that will have a high proportion (>20 percent) of unprotected forest areas remaining after ten years.

Category II: Countries with a relatively large percentage (>4 percent) of forests under formal protection, but that will have little (<20 percent) unprotected forests left after ten years.

Category III: Countries with a relatively low percentage (<4 percent) of forests under formal protection, but that will still have a relatively large proportion (>20 percent) of their unprotected forests left after ten years.

Category IV: Countries with a relatively low proportion (<4 percent) of forests under formal protection, and that will have little unprotected forest area remaining under current deforestation rates in 10 years.

data. Second, the approach is designed to be broadly useful at several geographic scales—regional, national, and subnational, or within and between biogeographical units. Third, the approach considers the size and location of existing protected areas to identify and roughly quantify gaps in the reserve network. Fourth, because the conservation potential/threat index (CPTI) is designed to be a model, the assumptions upon which it is premised are clearly stated; this valuable feature is missing from most approaches to setting conservation priorities.

Data for constructing the CPTI are, relatively speaking, easy to collect, although the availability and quality of data will vary from location to location, especially at subnational levels. The basic information needed includes data on forest cover, deforestation rates, protected areas (location and size), species richness and endemism, as well as population density and conservation funding (see Box 3.7).

The CPTI is constructed with two axes: the percentage of the country (or province or biogeographic unit) in protected areas is plotted along the y-axis; and the percentage of unprotected forest assumed to be remaining in 10 years is plotted along the x-axis. Deforestation rates and protected area coverage rates are assumed to remain constant during the next 10 years. Thus data points for the y-axis are the current percent of land area currently in IUCN-recognized protected area status. The projection of forest area remaining at the end of 10 years is calculated by subtracting the amount of forest lost during the next 10 years from the existing forested area given a constant rate of deforestation.

Two threshold lines are added to the graph which, in effect, divides the graph into four rectangles. A horizontal line along the y-axis delineates the global average for protected areas (4 percent). Countries falling below this threshold line have less than average protected areas coverage while those above have more. If one were to use the optimum protected area of 10 percent (as advocated by IUCN), the threshold line would of course move up the y-axis. The other threshold is a vertical line along the x-axis set at 20 percent of unprotected forest remaining in 10 years. This threshold was chosen as an estimate of the minimum amount of multiple-use forest area that would be required to maintain minimal ecosystem functioning.[19]

Countries (or provinces or biogeographic units) plotted against the two axes will thus fall into one of four categories (see Box 3.8).

Dinerstein and Wikramanayake (1993) applied the model to 23 countries in the Indo-Pacific region (see Figure 3.5). The countries vary widely in terms of conservation threat and potential. Only three countries—Indonesia and

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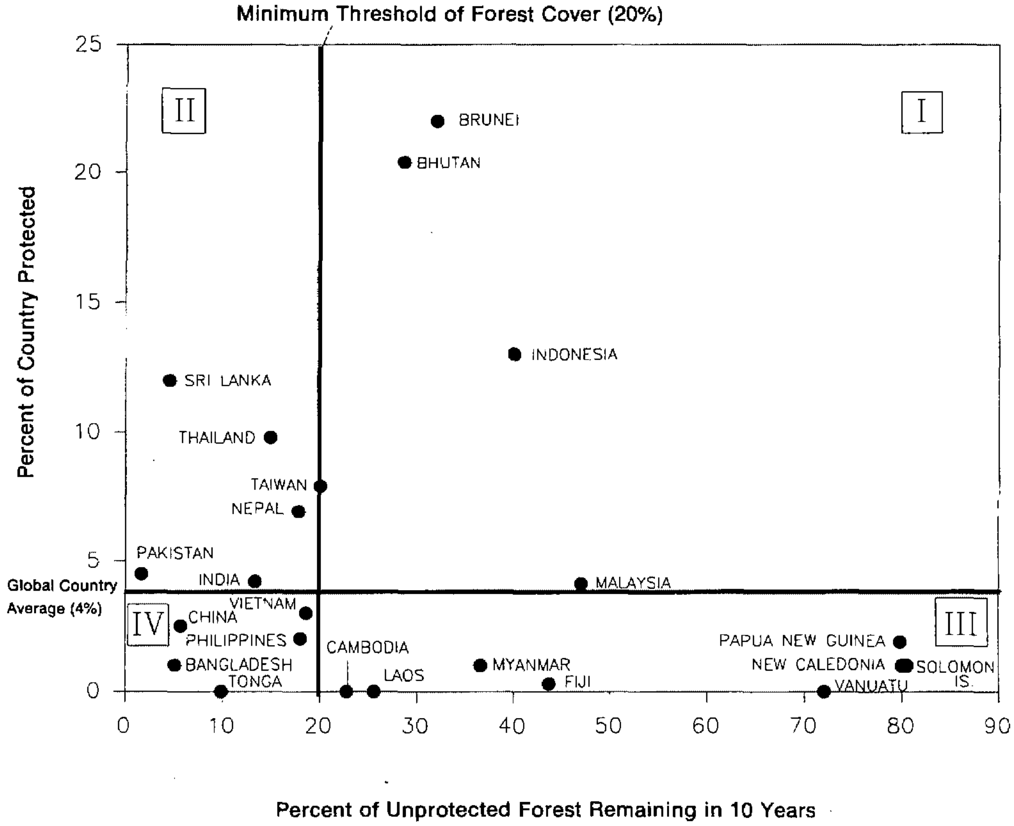
FIGURE 3.5 DISTRIBUTION OF INDO-PACIFIC COUNTRIES IN CONSERVATION POTENTIAL/THREAT INDEX CATEGORIES



Source: Dinerstein and Wikramanayake (1993)

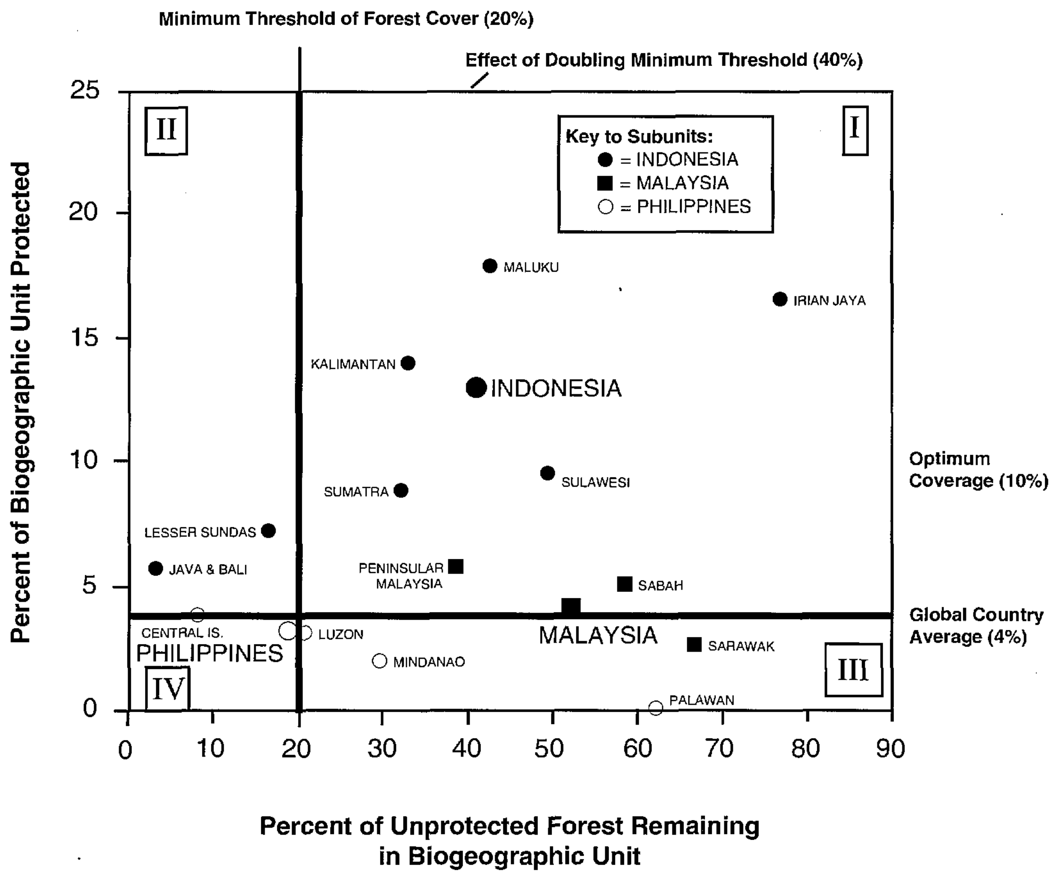
tiny Brunei and Bhutan—fall in Category I (highest potential, lowest threat). On the other hand, six countries—Bangladesh, Cambodia, China, the Philippines, Tonga, and Vietnam—are placed in Category IV (lowest potential, greatest threat). The South Asia nations are clustered in or near Category II, while southeast Asian and South Pacific nations are clustered in Category III.

Finally, Dinerstein and Wikramanayake (1993) compare investments in biodiversity conservation in Indo-Pacific countries. Using data from Abramovitz (1991) and UNDP/World Bank/UNEP (1991), conservation investments from U.S.-based institutions and the Global Environment Facility were calculated in dollars per square kilometers for remaining habitat. This information, while only partial, provided a sense of how funds are distributed compared with the distribution of countries in the CPTI categories.

According to the Dinerstein and Wikramanayake analysis, the CPTI index yields the following useful (if rather general) recommendations for conservation investments in the Indo-Pacific region. First, while countries in Category I (Bhutan, Brunei, and Indonesia) are the conservation ideal, protecting already established reserves remains problematic. Therefore, conservation financing should be directed to ensuring that those reserves that are essentially "paper parks" (especially large reserves) become operational as soon as possible. In Category II, where countries have a relatively large proportion of their territory in protected areas but have rapidly diminishing unprotected natural habitats, countries with high species richness (such as India and Thailand) and high endemicity (India, Sri Lanka, Taiwan, and Thailand) qualify as high priorities for conservation investments. Countries in Category III (relatively small area protected, but large areas of remaining habitat) have the greatest potential for conservation before habitat areas become highly fragmented. They represent important opportunities for establishing networks of large protected areas most suited to maintaining biodiversity. While all countries in Category III (Cambodia, Fiji, Laos, Malaysia, Myanmar, New Caledonia, Papua New Guinea, Solomon Islands, and Vanuatu) represent good investments in biodiversity conservation, those where external financing has been minimal (e.g., countries in Indochina and the South Pacific) should be given the highest priority for investments. Finally, although countries in Category IV have relatively little protected area and are expected to have little forest outside of protected areas in ten years, biodiversity considerations (i.e., high species richness and endemism) indicate that China, the Philippines, and Vietnam are key countries for conservation investments.

Dinerstein and Wikramanayake (1993) suggest the goals for conservation investments in the Indo-Pacific region over the next decade should be to move countries from Categories II

FIGURE 3.6 CONSERVATION POTENTIAL/THREAT INDEX APPLIED TO INDONESIA, MALAYSIA, AND THE PHILIPPINES



Source: Dinerstein and Wikramanayake (1993) and III into Category I, while immediate actions are taken to halt the erosion of biodiversity in Category IV countries. To do this, they suggest that trust funds be used wherever possible to finance ongoing management, expansion of existing protected areas, and the creation of new areas. Such trust funds in countries with low absorptive capacity for conservation programs and funds (e.g., Bhutan, Laos, and Papua New Guinea) could be used initially to support training, professional development, and institutional strengthening, with support gradually being shifted to protected areas management.

Within countries, however, there is considerable variation in the distribution of remaining habitat and protected areas. Dinerstein and Wikramanayake (1993) applied the CPTI to three countries—Indonesia, Malaysia, and the Philippines—to assess conservation potential and threat in their constituent biogeographic units (as defined in MacKinnon and MacKinnon, 1986a) or administrative units. Within Indonesia, most of the biogeographic units (5 out of 7) have high potential for conservation (Category I), while in Malaysia all 3 administrative units have intermediate potential, and in the Philippines 3 of 4 biogeographic units are under great threat (see Figure 3.6).

The advantages of the CPTI—its simplicity, quantitative basis, clear assumptions, and its design as a model with interacting factors—are also limitations. For a part of the world as varied in natural habitat and human societies as the Indo-Pacific region, protected area percentages can only serve as a rough proxy for biodiversity conservation potential and deforestation rates can only serve as an even rougher proxy for biodiversity threats.

The World Wildlife Fund-U.S. has undertaken an ambitious project to increase the sophistication of the concepts first outlined by Dinerstein and Wikramanayake (1993). Using a series of criteria to quantify conservation potential and threat, the study was designed to assess the conservation status of ecoregions within five broad terrestrial ecosystem categories found in Latin America and the Caribbean (from Mexico to Tierra del Fuego). Funded by the World Bank, the study was intended to provide guidance to the Global Environment Facility (GEF) as it expands its portfolio of biodiversity projects in the region. The authors stress that the results of the study are not intended to set priorities *per se*, but will serve as the first of several important filters to guide conservation planning (Dinerstein et al., 1995).[20] Additional information on species distribution patterns, and social, economic, and institutional factors would be critical to the final determination of priorities.

The Dinerstein et al. (1995) approach differs from earlier applications of the CPTI (Dinerstein and Wikramanayake, 1993; Dinerstein et al., 1993; Krever et al., 1994) in several important respects. The two most important are a) the use of a detailed ecosystem and habitat classification scheme and b) the use of a series of quantifiable and weighted criteria to assess both potential and threat. Other important differences include methodology, and the use of more refined levels of biological and social and economic information.[21] These differences are briefly summarized below.

Dinerstein et al. (1995) created a hierarchical classification scheme based on level of ecological organization and interaction, with the ecoregion as the basic unit of analysis (see Figure 3.7). An ecoregion is defined as "a geographically distinct assemblage of communities that share a large majority of their species and similar environmental conditions, and whose ecological interactions are critical for their long-term persistence." To benefit from substantial previous research experience, the authors based ecoregion boundaries wherever possible on classification systems used by regional biologists and conservationists. In their first attempt to classify ecoregions in Latin America and the Caribbean, Dinerstein et al. (1995) identified 178 ecoregions.

A set of ecoregions with comparable climatic regimes, similar physiognomic structure, and whose flora and fauna show similar guild structures and life histories are grouped in

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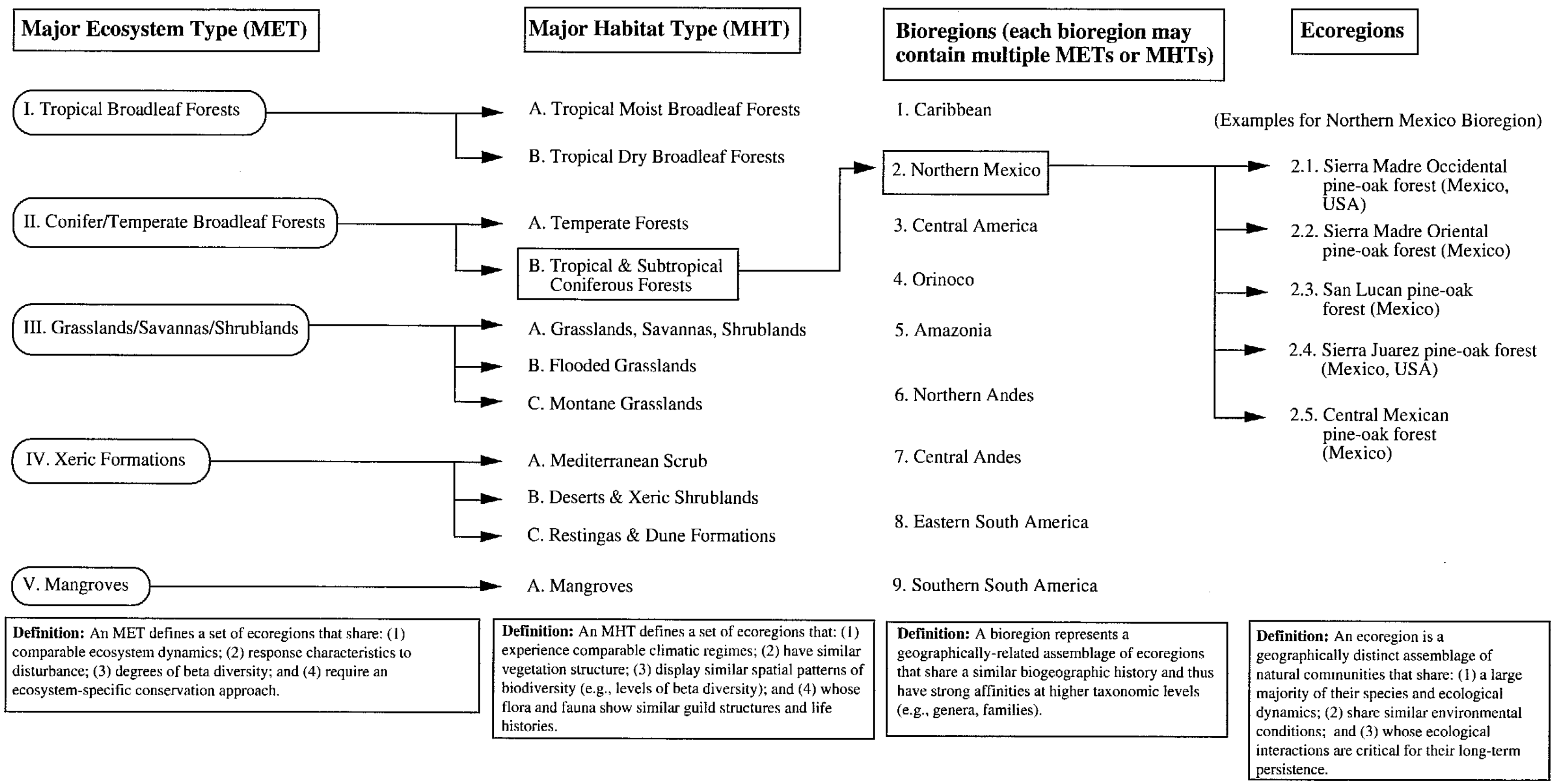
FIGURE 3.7 ECOSYSTEM CLASSIFICATION SCHEME USED BY DINERSTEIN ET AL.



Source: Dinerstein et al. (1995)

Major Habitat Types (MHTs). The broadest level category is *Major Ecosystem Types* (METs). These are defined as a set of structurally similar habitats and their constituent ecoregions that "(1) share comparable ecosystem dynamics in terms of both function and scale, (2) display similar ecological responses to habitat loss, fragmentation, and degradation, and (3) all require a similar suite set of conservation activities appropriate to that ecosystem type."

Dinerstein et al. (1995) then classified ecoregions on the basis of their *conservation status* and *biological distinctiveness.* Conservation status categories for ecoregions were adapted from the IUCN categories for species: Extinct (completely converted), Critical, Endangered, Vulnerable, Relatively Stable, or Relatively Intact. Five indicators, including loss of original habitat, number and size of habitat blocks, rate of habitat conversion, degree of habitat fragmentation, and degree of protection, were used—together with a weighting system based on indicator values—to assign ecoregions to one of the categories. This initial classification was modified by consideration of potential future threats over the next twenty years. Out of 178 ecoregions, 31 were identified as Critical, 51 as Endangered, 55 as Vulnerable, 27 as Relatively Stable, 8 as Relatively Intact, and 6 were unclassified. While the highest number of Critical and Endangered ecoregions were in the tropical moist forest and tropical dry forest MHTs, the tropical dry forest ecoregions were on average more threatened and most xeric ecoregions were either Critical, Endangered, or Vulnerable.

Biological distinctiveness was determined on the basis of such variables as beta diversity (species diversity between habitats), species richness and endemism for selected taxa, unique biological communities or ecological processes, and rarity or distinctiveness of habitat types at varying biogeographic scales. With help and reviews from over 150 regional biodiversity specialists and conservation planners, Dinerstein et al. (1995) classified ecoregions—using weighted values—as Globally Outstanding (34 ecoregions), Regionally Outstanding (32), Bioregionally Outstanding (59), or Locally Important (47). Montane grasslands had the highest proportion of ecoregions classified as Globally or Regionally Outstanding, followed by tropical moist forests (concentrated in western Amazonia, tropical northern Andes, and Atlantic forests of Brazil). However, all MHTs were represented by at least one ecoregion classified as Globally or Regionally Outstanding.

Using a matrix of conservation status and biological distinctiveness and "decision rules" to achieve bioregional representation, 74 ecoregions were designated as of Highest Priority at the Regional Scale. While Dinerstein et al. (1995) believe the matrix should be used as a guide by governments and donors to prevent the complete conversion or degradation of the most threatened ecoregions, they stress that specific investment decisions also require assessment of social, economic, and political factors. Concerns by conservationists in Latin America that such admonitions may be ignored by donors has fueled criticisms of broad geographic priority-setting efforts at continental scales, such as the Dinerstein et al. (1995) and BSP et al. (1995) projects.

At a time when the Global Environment Facility (and other donors) are directing increasing amounts of biodiversity conservation financing in an ad-hoc manner, it is encouraging to see approaches such as the CPTI used to make investments more systematic and effective. Such an approach cannot, of course, substitute for participatory priority setting at the local level, where the success of conservation investments will ultimately be determined. Nevertheless, the evolving CPTI could provide a clearly evaluated basis from which more locally based and consultative efforts could depart to determine effective conservation priorities on the ground.

Priority-Setting Workshops in South America

While national-level priority-setting projects often benefit from a somewhat coherent information base, and sometimes benefit from previously identified conservation priorities, conservation planners in the Amazon Basin have had to start from the ground up. The Amazon region's extraordinary endowment of biodiversity is poorly documented—estimates of its overall species richness have varied dramatically during the past decade. Until recently, no effort had been made to develop an overview of the distribution of Amazonia's immense array of species and ecosystems. Without this information, conservation investments in the region have amounted to little more than shots in the dark.

In January 1990, a workshop held in Manaus, Brazil, made the first attempt to consolidate a full spectrum of ecological information about Amazonia. The workshop was jointly sponsored by IBAMA (Brazilian Institute for the Environment and Natural Resources), INPA (National Institute for Amazon Research), Conservation International, the New York Botanical Garden, the Royal Botanical Garden (Kew), and the Smithsonian Institution. It brought together over one hundred of the most knowledgeable scientists working in the seven countries of the Amazon Basin. The goal of the workshop was to decide which areas should receive highest priority for conserving biodiversity. This was accomplished through mapping species distributions and consolidating hydrological, geological, and ecological research on the Amazon (IBAMA/INPA/CI, 1991).[f] Before the workshop was over, the participants had identified nearly 100 discrete geographic areas with high conservation value and classified them by conservation importance.

The approach pioneered by Conservation International and its partners in Manaus differs from the previous examples of regional priority setting by using a workshop to develop priorities through consensus. Workshop participants were local and regional experts, most with several decades of field research experience within the region. The approach stresses the use of species-level information (not to the exclusion of other factors, however), and assumes that using expert knowledge within a well-designed workshop process is the most rapid and informed way to set priorities when published data are nonexistent, spotty, or suspect.

The workshop consisted of specialists in plant systematics, plant ecology, mammals, ornithology, herpetology, ichthyology, entomology, geomorphology, and protected areas, many with experience across the vast geographic expanse of Amazonia. They pursued a three-step process to develop a set of conservation priorities.

During the first step, each of the specialist groups was convened separately. Each group's task was to define, just for that taxonomic group, what areas of the Amazon Basin should be classified as areas of high conservation value. Thus each group prepared—through discussion and consensus—a map showing areas they selected. These maps were drawn by hand on a transparent base map of existing protected areas provided at a scale of 1:1.5 million. A ranking system was devised in which areas were classified by importance from 1 to 5, with 5 the most important. The criteria used by the groups for their classification included diversity (richness), endemism, and rarity of species. The groups gave names to classified areas based on existing physiographic names (rivers, mountain ranges, etc.). Each group prepared a standard justification sheet for each area they selected, describing it by country(s), location, diversity or endemism, and the rank of relative importance.

The next stage of the process consisted of intensive synthesizing of information. All the information from the zoological groups was merged together, as was that from the systematic botany and vegetation ecology groups. Separate botany and zoology maps were then prepared by these combined groups, with the design and boundaries of the areas reached by consensus within the larger groups. The same ranking system was used as in the first groups, and boundaries were redrawn by hand on a fresh workshop base map.

During the final stage of the process, the botany and zoology specialists convened in one large group. The two synthesis maps prepared in the previous stage were overlayed and compared, both on a geographic basis and by ranks. Again, through a process of consensus, information was merged, boundaries were redrawn on a new map sheet, and rank priorities were reassigned, using the same ranking system as in the two earlier stages.[22] The final map ranked priorities from 5 (highest) to 1 (lowest).

In the final synthesis map, over 150 individual areas throughout Amazonia are identified as conservation priorities. They cover nearly 55 percent of the Amazon Basin. The highest priority areas (rated from 3 to 5) are so rich in species and high in endemism that participants in the workshop indicated they should be protected from any development. Areas not identified as priorities are not necessarily unimportant for conservation; in many cases, there simply was not enough information to make an informed judgement. This raises the obvious question of how much the identified priorities merely reflect intense research and site visits by a handful of scientists.

The participants and organizers of the Manaus workshop saw it as the beginning of an ongoing effort to continually revise and narrow conservation priorities in Amazonia, and publication of the map was intended to be part of an evolving conservation strategy. The Peruvian government used the map to help identify the location of a new conservation area. Other governments and funding agencies, including the World Bank, have used the map as a guide to conservation efforts. Few processes have started with so little previously synthesized information and analysis to develop a conservation overview of such a vast area.

The Manaus workshop process was an experiment in priority setting for a large area in the absence of detailed information. In several respects it was a success—it synthesized a large body of information and experience into a form that governments and donor agencies could use as a rough guide to conservation planning. And whatever its limitations, it brought together a multinational team of scientists and conservationists to establish a foundation for future priority-setting.

A number of lessons emerged from the workshop. For example, the priority-setting process was limited to a handful of individuals from government agencies, universities, and large national and international NGOs. "Grassroots" groups and local experts with valuable information on biodiversity resources and distribution as well as experience with land-use/conservation problems were not involved. Another problem was replicability—the priorities were determined by a group of experts but the information they used in making their decisions was not recorded. Each expert brought his or her own knowledge and experience. Workshop participants did not have a common base of information to build upon and shape according to their knowledge. And the Manaus workshop produced many priorities, but little or no practical guidance on how to implement actions to protect them.

Like other approaches, including the Species Survival Commission Action Plans and the conservation potential/threat assessments, the expert workshop approach is being refined with each application. In December 1993, Conservation International together with the Foundation for Biodiversity, a national level Brazilian NGO, and the Northeastern Ecological Society, held a workshop in Recife to identify priority conservation areas in the northern half of the Atlantic coastal forest region of Brazil (a second workshop for the southern half of the region is planned for 1996). Several improvements were introduced by Conservation International at this Atlantic Coastal Forest Workshop (Olivieri et al., 1995).

First, nearly a year was spent preparing for the workshop. Data were collected and assembled in advance to provide each of the seven working groups with a basic database to build upon and modify. For example, information on 144 species representing species addressed by the six taxonomic working groups[23] was collected, mapped, and assessed with respect to quality and geographic coverage. The working groups were also smaller than the working groups in Manaus, ranging from 4 to 12 in size.

Second, the Recife workshop considered

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disturbance levels and human development pressures. The seventh working group used demographic data (population growth and density) and land-use data to identify areas most threatened and least threatened by human activities. The results of this group's findings were used to finalize the list of priority areas once the results of the taxonomic working groups were integrated.

Third, detailed records of information used by experts in reaching decisions were compiled during the workshop process. Written explanations of what information was used and how (e.g, whether weighted factors were used, etc.) were recorded on standardized forms.

Fourth, to enhance the role of local expertise and to minimize the possibility of a geographically biased final selection, subregional groups were organized to integrate the findings of the seven topical working groups relevant to their geographic subregion.

Fifth, a concerted effort to communicate the results of the workshop to policymakers, conservationists, and the public is planned. In addition to a map (similar to the widely disseminated Manaus map), a detailed technical report will be published for scientists and conservationists. An executive summary or policymaker's guide will be widely distributed. The maps and databases used in the project are available for anyone's use; they are likely to be particularly useful to planners and Environmental Impact Assessment specialists. Finally, information from the project will be packaged in a flexible interactive CD ROM format to allow educators, students, and the public to consider the values and conservation options of the Atlantic Coastal Forest.

The improvements in the Recife workshop addressed a number of the limitations encountered in Manaus. Still, the process, like all methodologies, could be improved. Since no working group addressed ecosystem classification and distribution, the reliance on taxonomically-based working groups raises concerns about the representation of ecotypes and habitats in the final priorities. An aquatic working group, however, ensured that river systems and wetlands were not overlooked. The relatively small geographic area covered and the objective of identifying conservation priorities for one threatened ecosystem type (Atlantic coastal forests in northeastern Brazil) perhaps obviated the need for ecosystem-based analysis. Still, the question of sampling bias remains (i.e., are species occurrences and expert knowledge a reflection of concentrated research in some areas and little or no investigation elsewhere?). For both the Manaus and Recife workshops, the principal goal was conserving the species richness of the most visible taxonomic groups. Is that enough to capture large-scale ecological processes upon which species diversity ultimately depends?

The expert workshop model has influenced other efforts to set priorities. For example, the BSP priority-setting framework described below uses an expert workshop as a key step in its process, and the Papua New Guinea Conservation Needs Assessment (described under national-level efforts) also used an expert workshop approach. Together with local organizations, Conservation International plans to co-organize future expert workshop events to identify priorities in a number of regions including the southeastern Atlantic coastal forest, and the cerrado in Brazil, the entire length of the Andean mountain complex, the Maya region (Guatemala, Mexico, Belize), Madagascar and Irian Jaya (Olivieri, personal communication).

An Integrative Framework for Setting Regional Biodiversity Conservation Priorities

Under a new strategy designed to focus resources on supporting sustainable development, the U.S. Agency for International Development (USAID) identified biodiversity loss as a problem that could widely affect development options and the global environment (USAID, 1994). USAID requested the Biodiversity Support Program (BSP)[24] to lead an effort to develop a framework for setting geographic conservation priorities that would guide the agency's biodiversity conservation investments in Latin America and the Caribbean. BSP invited representatives of five major international NGOs to form a collaborative NGO working group to assist in this effort. The working group included representatives of Conservation International (CI), The Nature Conservancy (TNC), World Resources Institute (WRI), the Wildlife Conservation Society (WCS), and the World Wildlife Fund/U.S (WWF).

Over a nine month period, beginning in January 1994, the working group developed a framework and collected and synthesized data to identify priority areas for conservation in Latin America and the Caribbean. In September 1994, a workshop with the participation of regional experts was held in Miami, Florida to review and revise the framework methodology and data and apply the framework to identify preliminary geographic priorities for USAID investment in the region.[25]

The goal of the project was to identify areas of outstanding regional importance for biodiversity conservation. The collaborative working group concluded that the framework should address three sets of criteria: a) biological importance, b) conservation status, and c) institutional and policy feasibility (defined as institutional and policy characteristics that could lead to successful conservation investments (BSP et al., 1995). All members of the working group held the common view that a logical, transparent, and integrative priority-setting framework would represent a significant advance over analytical approaches limited to species richness or other easily measured biological factors commonly used by funding institutions, government agencies, and NGOs.

Underlying the approach were several principles including recognition that:

- Biodiversity is important for every nation's development; the framework is intended to identify biodiversity conservation priorities at a regional scale;
- Effective biodiversity conservation requires maintaining representation of all major habitat types found in the region. Since major habitat types cut across national boundaries, the priority-setting analysis should be based on biogeographic units, not country units;
- Biological importance alone is not a sufficient criterion for determining biodiversity conservation priorities at a regional level since natural habitats have been degraded to varying extents and because national commitment to conservation varies. Biodiversity conservation priorities should integrate biological importance, conservation threat and opportunity, policy/institutional feasibility and utility factors.

The framework builds upon the approach developed by Conservation International to assess biological importance and the analytical approach to determine conservation threat and potential used by WWF-U.S. and the World Bank. For example, a hierarchical ecological classification scheme based on the Dinerstein et al. (1995) system is used to organize information on biological value (e.g., ecosystem, phyletic, and species diversity), conservation opportunity and threat (e.g., presence/absence of large blocks of original habitat, protected area coverage, degree of habitat degradation and/or fragmentation), and institutional and policy feasibility (e.g, national commitment and capacities of government and NGOs to implement conservation projects). However, recognizing that the best information often resides with local and regional experts, the data collected under the BSP framework used a workshop process to refine data. The role of workshop participants was to revise criteria and indicators, provide additional information, and determine weighting factors.

Before the Miami workshop, the working group collected existing data from a variety of sources for each set of criteria. Biological importance data was compiled by CI and WCS. Information on species richness, endemism and distribution were entered into tabular databases and mapped using computer-based geographic information systems (GIS).

The WWF Conservation Science Program provided an analytical framework within which conservation threat and opportunity at the landscape level could be quantified. WRI compiled data on policy and institutional factors and worked with the WWF Policy Program to develop a methodology for assessing those factors. An analysis of potential utility factors related to biodiversity was prepared by the Institute for Sustainable Development.

Once the NGO working group had collected basic data in the three areas, it was critiqued, revised and supplemented at the Miami workshop by biologists and social scientists with regional expertise.

Since a major premise of the approach was that USAID should support the conservation of priority ecosystems representative of the region's rich diversity of ecosystems, a biogeographic classification scheme was a critical consideration. Based on work by Dinerstein et al. (1995), the Latin American and Caribbean region was divided into 148 ecoregions. These were clustered into 35 biogeographically similar ecoregions (Regional Habitat Units or RHUs) which in turn were aggregated into 7 major habitat types (Table 3.10). Biological importance, conservation status, and utility values of regional habitat units were compared only *within* the same major habitat type (e.g., tropical dry forests in Mexico were compared with tropical dry forests in Central America but not with Mexican pine/oak forest which is part of the temperate forest major habitat type).

Over 50 scientists and conservationists from throughout the region came to the Miami workshop. They were invited on the basis of their regional experience and their knowledge about issues critical to either biological importance (e.g., taxonomists), conservation status (e.g., protected area planners), or feasibility/utility (e.g., social scientists). At the workshop, participants were organized into a series of working groups to review, refine, and apply the draft framework and data assembled by the NGO working group.

To identify areas based on their biological importance, six taxonomic expert groups—plants, insects, birds, fish, reptiles/amphibians, and mammals—identified "taxonomic biodiversity priority areas" (TBPs). Each TBP was characterized using a standard form, and rated as being of high, medium or low biological value based on a variety of criteria that differed slightly for each taxonomic group but included species richness, phyletic diversity, number of endemic species, beta diversity and presence of rare/endangered species. The data from the six taxonomic analysis were then integrated to determine the overall biological importance of each Regional Habitat Unit.

An innovative approach was used at the workshop to assess the current and estimated future conservation status of the 148 ecoregions in Latin America and the Caribbean. The method determined current conservation status by considering a series of landscape-level features for each ecoregion including: presence/absence of large blocks of original habitat; percent of remaining original habitat; rate of conversion; degree of degradation and/or fragmentation; and, degree of protection. Each variable was assigned a numerical value that, when summed and weighted, provided a snapshot status assessment.

Ecoregions were then grouped by categories inspired by the IUCN categories for threatened and endangered species: Extinct (completely converted); Critical; Endangered; Vulnerable; Stable; and Relatively Intact. The presence of large blocks of original habitat, a high percentage of remaining habitat, and some degree of formal protection highlight opportunities for conservation within the ecoregion. Combined with degree of fragmentation and degradation, these variables also help predict the maintenance of ecological processes (e.g., predation, pollination and seed dispersal systems, nutrient cycling, migration, dispersal, and gene flow) that, ultimately, will determine how much

Table 3.10 Hierarchical Classification of Major Habitat Types and Regional Habitat Units in Latin America and the Caribbean

Major Habitat Type	Regional Habitat Unit (RHU)
1. Tropical Lowland Moist Forests	1. Atlantic Lowland Moist Forest 2. Upper Amazonian Lowland Moist Forest 3. NE Amazonian Lowland Moist Forest 4. SE Amazonian Lowland Moist Forest 5. Choco/Darien Lowland Moist Forest 6. Central American Lowland Moist Forests
2. Tropical Montane Moist Forests	1. Tropical E Andes Montane Forest 2. Central American Montane Forest 3. Caribbean Montane Forest 4. Venezuelan Coastal Montane Forest 5. Guayanan Montane Forest
3. Tropical Dry Forests	1. N South America Dry Forest 2. W Andean Dry Forest 3. Chaco 4. Central American Dry Forest 5. Mexican Dry Forest 6. Cerrado/Pantanal
4. Xeric Formations	1. Mexican Xerics 2. Caribbean Xerics 3. Caatinga 4. Peruvian/Chilean Deserts 5. Chilean Winter Rainfall Xerics 6. Argentinian Monte
5. Herbaceous Lowland Grasslands	1. Central American Pine Savanna 2. Llanos/Grande Savanna 3. Pampas 4. Patagonian Steppe 5. Amazonian Savannas
6. Herbaceous Montane	1. Paramo 2. Puna 3. Southern Andean Alpine 4. Pantepui
7. Temperate Forests	1. Southern Cone Temperate Forest 2. Brazilian Araucaria Forest 3. Mexican Pine/Oak Forest

Source: BSP et al. (1995)

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biodiversity will persist over the long-term. Future trajectories of conservation status were assessed by considering the type, intensity, and timeframe of severe threats to the biota and landscapes of an ecoregion to produce a modified conservation status. The ecoregion assessments were then aggregated to determine the conservation status for each of the 35 RHUs.[26]

Participants in the policy and institutional working group at the Miami workshop focused much of their discussion on the fact that the relevance of policy and institutional analysis to geographic priority setting depends on the types of potential conservation investment. In other words, in order to answer the "where" question, one must specify the "what".

As a partial resolution of this issue, workshop participants developed an "investment portfolio" model that balances short and long-term conservation benefits with levels of risk associated with conservation investments. The group defined two different policy and institutional vectors relevant to priority-setting:

1) Existing policy and institutional capacity conducive to effective on-the-ground conservation interventions in the short-term; and
2) Policy and institutional environments conducive to productive long-term investments in the development of such capacity (i.e., currently weak but improving institutional capacity combined with strong political will).

The group also considered whether high human utility value could be used to discriminate among otherwise equal regional habitat units. Workshop participants agreed that human utility values were important in setting priorities and could potentially capture ecosystem function values of biodiversity not captured by biological importance. They stressed the need to consider local as well as global utility values. They recommended assigning the highest value to genetic resources, followed by productive and protective biological resources, and carbon sequestration, in that order. For example, "unique" utility values in an ecoregion, such as wild relatives of important food grains, are more important than the ecoregion's incremental contribution to a "non-unique" value, such as carbon sequestration.

Because of the project's emphasis on representation, and weighting of biological value and conservation threat criteria, the final list of priority regional habitat units contains a number of areas that have not received significant conservation attention in the past. For example, temperate forest ecosystems (e.g., pine-oak forests in Mexico), xeric formations (e.g., the Caatinga in Brazil), and grasslands (e.g., the Patagonian steppe) were recognized by workshop experts as having high levels of biological importance (see Table 3.11).

Workshop participants provided creative and constructive suggestions for improving policy/institutional analysis in relation to setting geographic conservation priorities. In particular, policy and institutional analysis should emphasize greater use of data to assess feasibility rather than emphasizing expert input. Many participants also suggested that policy and institutional factors are most important for determining what types of conservation investments to make in priority areas identified on the basis of biological importance and conservation status. Other participants believed that policy and institutional factors could be used to decide between areas ranked equally on the basis of conservation importance and conservation status.

A major limitation to the framework was the absence of analysis for aquatic and marine ecosystems—a problem recognized by the NGO working group. Other lessons learned, particularly for policy and institutional analysis, include the need to involve local counterparts earlier in the process and to collect and disseminate data to workshop participants further in advance of the workshop. These lessons and others will be applied by the Biodiversity Support Program as it plans work in 1995 with conservation groups and regional experts to improve and apply the framework in the Asia and Pacific region.

The usefulness of the integrated framework

Table 3.11 Regional Habitat Units with Regionally Outstanding Biological Value

Regional Habitat Units (within Major Habitat Types (MHTs))

1. TROPICAL MOIST LOWLAND FORESTS
1-1 Atlantic
1-2 Upper Amazon

2. TROPICAL MOIST MONTANE FORESTS
2-1 Tropical Andes

3. TROPICAL DRY FORESTS
3-3 Chaco
3-6 Cerrado-Pantanal

4. XERIC FORMATIONS
4-1 Mexican Xerics
4-3 Caatinga

5. HERBACEOUS LOWLAND GRASSLANDS
5-4 Patagonian Steppe

6. HERBACEOUS MONTANE GRASSLANDS
6-1 Paramo
6-2 Puna

7. TEMPERATE FORESTS
7-1 Southern Temperate Forest
7-3 Mexican Pine-Oak

Source: BSP et al. (1995)

approach, however, was widely recognized by workshop participants. One indicator of success was the interest expressed by participants in using similar frameworks to assess priorities in their home countries. The integrative approach using multiple criteria, the consideration of biodiversity at species and ecosystem levels, and stressing the representation of all major ecosystems across a broad and diverse region represents a significant step forward in priority-setting efforts.

Setting Priorities at National and Local Levels

The most effective actions to conserve biodiversity will take place at national and especially local levels. National and local capacities and resources for conservation are limited everywhere, especially in developing countries. Ultimately, setting priorities at these levels will have the greatest effect—and should help influence and strengthen priorities set from an international perspective, thereby strengthening the effectiveness of international resources. Priorities set at these levels are indispensable because they are more likely to:

- focus on specific conservation objectives;
- specify species, ecosystems, or sites;
- reflect national and local values and needs;
- afford the opportunity to mesh with policy and planning processes;
- provide the opportunity to involve a wider spectrum of participants—from government agencies to NGOs and local communities—in the priority-setting process;

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- reflect the resources and capacities available to implement priorities; and
- indicate to international donor agencies and conservation organizations which ecosystems, habitats, and species are considered most important from a national perspective.

In short, the links between nationally and locally set priorities and actions on the ground are usually more direct than such links between international priorities and implementation.[27] In any case, most internationally set priorities will depend on further elaboration at national and, even more, local levels.

The conservation literature describes a wide range of available approaches for setting priorities at national and local levels; these approaches employ an array of techniques, tools, and data. In addition, approaches originally used to identify priorities from an international perspective may be adapted to priority considerations at more local levels. Many of these approaches are directed at similar conservation objectives—most commonly establishing and maintaining protected areas representative of ecosystems and species found in the country or a region within it. Much less attention has been directed at identifying priorities for protecting biodiversity in managed agricultural and forest ecosystems and human settlements (although crop genetic conservation priorities have received some attention by national and international research institutions). Some of the methods described in this section are flexible enough to identify priorities for a range of conservation objectives, but much more work is needed to develop approaches for identifying priorities consistent with national and local values and objectives.

Although many methods suitable for use at the national and subnational levels have been described in the literature, relatively few countries have established clearly defined conservation priorities. Even fewer countries have consensus priorities that are actively used to guide conservation activities or direct government and donor resources. As a result, many planning and policy processes that in effect determine how resources are used or where development takes place do not adequately consider biodiversity. For example, geographic conservation priorities have rarely been specified or considered in such relevant activities as the development of Tropical Forestry Action Plans, National Environmental Action Plans, National Conservation Strategies, or donor-funded natural resources assessments and profiles. In the absence of good conservation priorities, these processes may actually threaten the conservation of biodiversity rather than strengthen it. At the very least, their absence in such processes represents lost opportunities for focusing on conservation efforts.

However, there are a growing number of examples of priority-setting efforts applied at the national or subnational level, some of which have been used specifically to influence the allocation of conservation resources. These include efforts in Argentina (Ruben-Vila and Bertonatti, 1993), Brazil (Olivieri et al., 1995), Mexico (Peterson et al., 1993), Papua New Guinea (Swartzendruber, 1993), Bulgaria (BSP, 1994), the United States (Scott et al., 1991), Russia (Krever et al., 1993), Australia (Margules et al., 1994; Pressey et al., 1994), New Zealand (Atkinson, 1994), and India (Rodgers and Panawar, 1988; Daniels et al., 1991).

Seven examples of efforts to establish biodiversity priorities at national and local levels are profiled in the remainder of this chapter. They include the Natural Heritage Programs used at the state/provincial level in over a dozen countries in the Western Hemisphere; the Papua New Guinea Conservation Needs Assessment; gap analysis in the United States; iterative approaches to reserve selection in Australia; the use of rapid ecological assessment and inventory techniques in Belize; a system proposed by IUCN and WWF to identify economically important plant species; strategies for identifying genetic resource conservation priorities; and the identification of Ecologically Sensitive Areas proposed by McNeely et al. (1990).

Natural Heritage Programs

In 1974, The Nature Conservancy (TNC)—a U.S.-based private, nonprofit membership organization—took the first steps to develop a methodology for ranking natural areas based on their respective wealth of rare species. TNC already had nearly 25 years of experience in protecting natural areas throughout the United States, but until 1974, remained "sheepishly ambivalent about what made an area worth saving" (Stolzenburg, 1992). The solution to the problem came when TNC decided to use computer technology to log information on the known occurrences (or locations of subpopulations) of rare or endangered species. This approach was further refined over the next several years to include other geographically referenced information on species and habitats. In partnership with a number of state governments, the program was named the "Natural Heritage Program," and became a tool for land-use planning and setting habitat protection priorities. Today, the Natural Heritage Program has been established in all 50 U.S. states. Conservation Data Centers in 5 Canadian provinces and 13 Latin American countries use the same biodiversity ranking system developed in the Natural Heritage Program model.

The system works by assigning conservation priority ranks to "elements of natural diversity," which are plant and animal species, subspecies, and natural communities or habitats. In practice, the ranking scheme has been used primarily with species of vertebrates and plants since a compatible classification of ecological communities at national and international levels has yet to be accomplished and data are sparse for invertebrates (Master, 1991). However, a standardized natural community classification system has been completed for the western United States and soon will be for the eastern part of the country. Thus the Natural Heritage Programs in the United States will increasingly focus on community and habitat elements of diversity.

The species ranks are based on information about each species for a series of criteria, including the known or estimated number, quality, and condition of element "occurrences" (i.e., subpopulations of the species); the estimated number of individuals; narrowness of range and habitat; trends in population and habitat; threats to the element; the element's fragility; and other factors (TNC, 1988). This information is then used to assign a rank of 1 to 5 (with 1 representing extreme vulnerability) to the species at three separate scales—global, national, and state or province (see Table 3.12 for an example of what the ranks might mean at a global level).

When the global, national, and subnational ranks are combined, the system allows for a rapid assessment of the species' known or probable threat of extinction or extirpation in a particular jurisdiction. For example, a species ranked G5/N2/S1 is extremely vulnerable to extirpation in the state or province (S), vulnerable (but not critically) at the national level (N), and widespread and abundant globally with no threat of extinction (G).

In practice, TNC and its partners do not use the ranking system alone to set priorities. With each species or element record, recommendations are included for protection, inventory, research, and management. These recommendations are frequently based on a number of site-specific facts and qualitative assessments of the species' conservation needs; they are crucial determinants of follow-up actions. In most cases, conservation actions are not directed at an individual species but instead tend to focus on sites that are home for more than one priority species. To choose among such sites, TNC uses another 1 to 5 scale to assess "site biodiversity significance" and "site protection urgency." The former focuses on the overall number and ranking of element occurrences at the site, while the latter assesses the relative threat of destruction to the site.

The element ranking system developed by TNC has been highly successful in many respects. It has served as the organizing principle for building a huge database on species and

Table 3.12 Global Ranks Used by Natural Heritage Programs and Conservation Data Centers

G1	critically imperiled globally (typically fewer than 5 occurrences);
G2	imperiled globally (typically 6 to 20 occurrences);
G3	rare or uncommon but not imperiled (typically 21 to 100 occurrences);
G4	not rare and apparently secure, but with cause for long-term concern (usually more than 100 occurrences);
G5	demonstrably widespread, abundant and secure;
GH	of historical importance (possibly extinct; still searching with the expectation that it may be rediscovered);
GX	assumed to be extinct throughout its range;
G?	not yet ranked
G#T#	for infraspecific taxa (subspecies); the G rank applies to the full species and the T rank applies to the infraspecific taxon;
G#Q	taxonomic status is questionable.

Source: Master (1991)

habitats throughout the United States and to a more limited extent in Latin America and Canada. This database has helped TNC and various government agencies pinpoint where habitat protection programs are needed. In addition, the Biodiversity Conservation Network (as the combined Natural Heritage and Conservation Data Center programs are called) has been used extensively in land-use planning decisions to avoid destroying critical habitats. For nearly two decades, it has helped to specify biodiversity conservation priorities in a relatively systematic way over a large area. Over a third of the G1 (critically imperiled) and G2 (imperiled) species in the United States have never been formally considered as candidates for federal protection under the Endangered Species Act. Aquatic habitats and species are disproportionately threatened. Only a small fraction of aquatic groups (amphibians, fishes, crayfishes, and unioid mussels) have been federally listed. In contrast, nearly all mammal and bird species classified as G1 or G2 have been protected under the Endangered Species Act (Natural Heritage Center Network, 1993).

Like any scheme, the ranking system has limitations for some conservation objectives. For example, the system does not distinguish between species on the basis of economic, ecological, or taxonomic value. Another limitation is that the system has been used primarily to identify and purchase or otherwise conserve[28] small "ecologically unique" habitats rather than conserve large diverse landscapes.[29] The Nature Conservancy, however, has focused more on large-scale ecosystem conservation in recent years through its Last Great Places program which works with a variety of private and public land owners to conserve vital elements of large ecosystems. Nevertheless, the Natural Heritage ranking system is the most institutionalized system for ranking conservation priorities anywhere.

Papua New Guinea Conservation Needs Assessment

In 1990, the government of Papua New Guinea embarked on the development of a National Forestry and Conservation Action

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Plan. The country, which occupies the eastern half of the island of New Guinea and includes several large island groups off its east coast, has a tremendous range of terrestrial and marine habitats and exceptionally high levels of species richness and endemism. Its 700 languages reflect its cultural diversity. Clan groups own 97 percent of the land under traditional tenure systems that are recognized in law and the constitution (Alcorn, 1994). With 85 percent of its natural forests intact, the country probably retains more of its biological heritage than any other country in the Asia/Pacific region. At the same time the country's people and its government have a strong desire for the benefits of a modern economy—benefits which they realize are often being gained at the expense of its environmental quality and biological wealth (Taylor, 1993).

As part of the National Forestry and Conservation Action Plan,[30] the government requested assistance in 1991 from USAID to assess the country's conservation needs. The Papua New Guinea Conservation Needs Assessment (CNA) was organized by the Biodiversity Support Program and carried out collaboratively by Papua New Guineans and representatives from international conservation and scientific organizations. It was designed to compile and analyze the country's existing base of scientific information on its biodiversity and to develop research and conservation priorities.

The process that evolved was unusual in several respects. First, the CNA attempted to involve the full range of stakeholders—from government agencies to landowner groups—in the process of evaluating conservation priorities. Second, the project made use of social scientists and legal experts to define the dynamic social context in which conservation actions take place. And third, the CNA developed consensus recommendations on the actions and policies needed to conserve biodiversity, identified issues still to be resolved, and suggested processes to expand consensus on conservation priorities and actions where it did not exist. In other words, process was as important as product—the maps and recommendations represented not the end, but the starting point of a participatory approach to conservation.

A key part of the CNA was the use of a workshop process to define goals and integrate information before identifying potential priorities. Influenced by the Manaus workshop, the CNA used several teams composed of experts with lengthy field experience in the country. While the CNA workshop lasted only one week, over six months of intensive preparation—involving biological reports, assessments of related social and legal issues, and surveys of landowner views—preceded it.

The *biology team* consisted of seven groups writing reports synthesizing existing information on the biodiversity and conservation of flora; warm-blooded vertebrates; fishes, amphibians, and reptiles; invertebrate fauna; freshwater wetlands; coastal and marine ecosystems; and humid forest environments. Each report was prepared in accordance with guidelines provided by the biology team leader and the BSP project manager to ensure that results generated by the different focal groups would be comparable (see Box 3.9 for guidelines). Each of the seven biology groups contained, in addition to the topic leader, four to six correspondent experts, who provided information, advice, and criticism on the draft report before it was submitted to the workshop. These 42 internationally recognized experts—many of them Papua New Guineans —had a combined total of several hundred years of field experience in the country as well as intimate knowledge of its ecosystems, the distribution of unique biological communities and rare species, and threats to biodiversity.

Topic leaders used computerized base maps at scales of 1:2,500,000 and 1:4,000,000 to delineate relevant geographic parameters. The maps were prepared by Conservation International, based on its previous information management and GIS experience. At the workshop itself, the various teams each added their relevant information; together workshop participants discussed overlaps and decided on a set of biologically determined priority areas for terrestrial and marine areas. Areas little-known to science were also identified.

In addition to the biology team, four additional teams of experts contributed to the advance preparations by collecting and analyzing social and legal information. The four-member *social science team* described general relationships between people and nature in Papua New Guinea; identified various stakeholder's interests in biodiversity and their conflicts with conservation; and assessed institutional capacity for implementing integrated conservation and social development projects (see Box 3.10).

The three-member *legal team* prepared reports on the legal basis for conservation in Papua New Guinea. An *NGO/landowners team* in collaboration with the National Alliance of NGOs (NANGOs) surveyed landowner knowledge and views of conservation issues. An *information management team* prepared computerized base maps for use by the specialist teams and at the workshop. They also assessed options for establishing a biodiversity data center in the Department of Environment and Conservation (DEC), trained a technician at DEC to digitize data onto computerized maps, and, after the workshop, installed the map database at DEC and the University of Technology at Lae.

At the workshop in April 1992, members of the five technical teams were joined by landowner, NGO, government, and donor representatives in the town of Madang to identify priority areas for conservation and research, consider constraints and opportunities for conservation, and propose culturally appropriate processes and options to conserve biodiversity (Alcorn, 1994). A series of plenary sessions, presentations by the different teams, and small-group discussions produced occasionally sharp debate, which ultimately helped to shape the project's recommendations as well as identify unresolved issues for continued dialogue.

BOX 3.9 Papua New Guinea Conservation Needs Assessment Biology Assessment Guidelines

Each topic report should include:

1) a brief survey of the discipline's history in Papua New Guinea;
2) major gaps in knowledge;
3) a current assessment;
4) representative biologically important areas for Papua New Guinea;
5) conservation recommendations;
6) a bibliography of papers and publications most important to future studies of biodiversity.

In addition, each topic report should use a standardized basemap to identify (where relevant):

1) biologically unknown areas;
2) species richness;
3) distribution of rare and endemic forms;
4) ecologically critical areas;
5) ecologically fragile areas;
6) distribution of economically important species;
7) known threats;
8) disposition of major wilderness areas.

Source: Beehler (1993)

Important centers of species richness and endemism, unusual ecosystems facing imminent threat, and areas for which there is a lack of scientific information were represented in the various biological working group maps. Through considerable discussion and consideration of alternatives, these maps were synthesized (see Figure 3.8), with the caveat that the maps represented areas selected through human judgment based on incomplete information. The final maps produced by the CNA workshop represented a consensus of most participants (Swartzendruber, 1993). The three synthesis maps included:

1) A map of 42 terrestrial areas of high biodiversity and 13 important wetland areas;
2) A map of 30 marine and coastal areas of high biodiversity and 5 watersheds critical to the health of those ecosystems, and;
3) A map of 16 areas where biological information is nearly nonexistent that merit immediate survey and study.[31]

Despite the general consensus on the areas represented in the maps, concerns were raised by

BOX 3.10 Issues Addressed in Social/Legal Reports in Advance of Papua New Guinea Conservation Needs Assessment Workshop

Social Science Team

1) general relationships between people and nature in Papua New Guinea;
2) identification of stakeholders in conservation and description of their interests and assumptions;
3) conflicts between stakeholders and conservation issues arising from the conflicts;
4) institutional capacities and potential for collaborative conservation action;
5) guidance for socio-cultural feasibility assessments to be conducted at site of proposed conservation actions.

Legal Team

1) detailed information on laws relevant to conservation;
2) assessment of implications of strong landowners' rights to achieve national conservation objectives;
3) proposed strategies for developing conservation partnerships between customary landowners, the government of Papua New Guinea, and supportive international organizations.

NGO/Landowners' Team

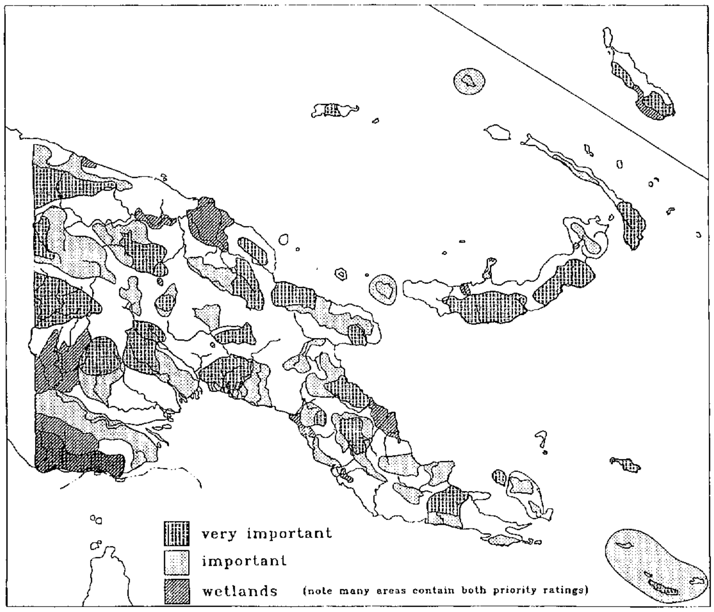
1) survey of customary landowner views on biodiversity conservation and its attendant benefits and costs;
2) recommendations based on survey responses for improving landowner awareness of conservation options and support for conservation activities.

Information Management Team

1) digitization of maps used by biologist teams and workshop participants and revision of maps in response to workshop deliberations;
2) assessment of issues and options for establishing a Biodiversity Information Center in the Department of Environment and Conservation.

Source: Alcorn, 1993

FIGURE 3.8 PRIORITY AREAS IDENTIFIED IN PAPUA NEW GUINEA CONSERVATION NEEDS ASSESSMENT



CNA Map produced by Conservation International (CI), the Papua New Guinea Department of Environment and Conservation (DEC), and the Biodiversity Support Program (BSP), with funding from the United States Agency for International Development. Report and full-color large format (approximately 24" 36") map available from CI, DEC, or BSP.

Source: Swartzendruber (1993)

a number of participants about their interpretation by people unaware of the complex socio-political realities in Papua New Guinea. As a result, a map legend was negotiated among participants to alert future readers that the information should be considered in the social context of Papua New Guinea (see Box 3.11).

The debate over the social map legend illustrated the different perspectives and values brought to the workshop by the participants. Not all differences were resolved at the workshop; a number of issues were left for future dialogue. Alcorn (1994) identifies several such issues: 1) many participants felt that the CNA should develop a "landowner interest" map to compare areas where local people want to take conservation actions with the high biodiversity area maps in order to determine priorities; 2) the appropriate mix between the landowners' and the central government's rights and authority to take conservation actions was hotly debated; and 3) many expressed concern that the government must demonstrate more political will to support conservation actions. In addition, Papua New Guinean participants believed that relations between NGOs and government conservation agencies needed to be improved, and that the interest of expatriate scientists in conserving biodiversity should not overwhelm local interests in human welfare and development.

These issues will continue to surface in conservation policy and action in Papua New Guinea in coming years. Nevertheless, the CNA was an innovative approach to priority-setting because it combined a knowledge base generated by national and international biologists, conservation planners, and social scientists with hundreds of years of experience in the country, considered the social feasibility of conservation options, and provided an opportunity for public

BOX 3.11 Social Legend on CNA Consensus Maps of High Biodiversity Areas

1) The Constitution of Papua New Guinea promotes equality and participation, the wise use of natural resources, and Papua New Guinean forms of development;
2) Ninety-seven percent of Papua New Guinea is owned according to customary tenure;
3) This map was prepared by biological scientists and, based on available knowledge, identifies areas richest in biodiversity;
4) This map is not intended to, nor should it be used to, exclude any areas or any landowners from conservation programs and initiatives; and
5) When identifying appropriate conservation strategies and areas, local initiative is as important a criterion as biodiversity.

Source: Swartzendruber (1993)

participation that built "ownership" and commitment to the results.

Gap Analysis in the United States

For years, conservation biologists have used a process to identify short-term and longer-term priorities called "gap analysis." This generic concept for setting priorities, as Burley (1988) noted, is "deceptively simple." First, within a particular region or country, various elements of biodiversity (e.g., ecosystems, habitats, vegetation types, and species) are identified and classified on a "base map." With this base map, maps of existing and proposed systems of protected areas and other land-management units that could function to conserve biodiversity are superimposed. Finally, "biodiversity elements" (e.g., endangered species, ecosystem types, rare habitats, etc.) that are poorly represented in the protected areas system or conservation areas are identified. Then, using whatever biological criteria are deemed to be most relevant for the conservation objective(s) being pursued, priorities for the next set of conservation actions are established.

One of the most systematic applications of the gap analysis process has been carried out by a group of researchers in the Pacific Northwest region of the United States (see Scott et al., 1991). Similar approaches are being developed and used in several Latin American countries and Australia, among others places. This section briefly reviews the process developed by Scott et al. (1991).

Gap analysis relies on the association of species with habitat types. Habitat is a powerful predictor of the distribution of many mammals and birds, as well as reptiles and some amphibians. However, large-scale documentation of the distribution of an entire fauna has rarely been attempted, even in such well-studied areas as the United States. To be practical, gap analysis relies on indirect indicators of biodiversity, based on relatively well-known groups such as vegetation, vertebrates, and butterflies.

The first stage in gap analysis is to generate maps of actual vegetation (as opposed to potential natural vegetation), vertebrate species distributions, protected areas (known as biodiversity management areas), and land ownership classifications. Vegetation maps at a 1:500,000 scale are derived from whatever sources are most up-to-date and accurate (e.g., maps of public lands, soil surveys related to agricultural production, etc.) and then adjusted on the basis of remote imagery. Species distribution maps are more problematic, and Scott et al. (1991) suggest using whatever data can be found on species-habitat relationships in a specific area, including

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museum records of species distributions on a county-by-county level (or similar political subdivisions), Natural Heritage databases, and other sources. Using a computer Geographic Information System, the data sets for species distributions are superimposed on the vegetation maps to generate predicted species distributions.

The area in question is then divided into biodiversity management areas (BMAs) and "cultural" land-cover types. BMAs are defined as areas that can be managed for the maintenance of native species and vegetation. They are categorized according to a scale used by The Nature Conservancy:

Level 1: total protection of native communities (e.g., national parks, strictly protected nature reserves);

Level 2: partial protection of native communities (legally protected wilderness areas, designated areas of special environmental concern);

Level 3: no protection (mostly private lands and nondesignated public lands).

Cultural land-cover types—agricultural land, urban areas, intensively used rangelands, and logged forest areas—are mapped on the basis of Landsat imagery. In addition, corridors of natural vegetation between BMAs are mapped.

Once these maps have been completed, gap analysis can begin. The first step in the analysis is elementary: Which species and vegetation types are represented in BMAs? For example, how many vegetation types occur in BMAs, and how much of that area is protected? How extensive are BMAs, and what is their average size? The database can also provide answers to more complex questions: for example, are BMAs large enough to form a "minimum dynamic area" that is required for the expression of normal disturbance regimes (e.g., fire, storms, etc.) necessary to maintain a landscape in a mosaic of characteristic successional stages? This, of course, assumes that one has enough information to know what a "minimum dynamic area" (see Pickett and Thompson, 1978) is for a given vegetation type.

Gap analysis in and of itself does not yield conservation priorities. It does, however, provide a powerful tool for analyzing the distribution and status of natural resources and identifying gaps in protection; it can be used to apply virtually any priority scheme or criteria for selecting new conservation areas. Gap analysis was first used to identify conservation priorities in the U.S. Pacific Northwest (Idaho, Oregon, and California) and is now being used nationwide and in several other countries as well. Gap analysis is an important feature of the U.S. Department of Interior's National Biological Service and is already being used in various parts of the country to help federal, state, and local agencies, and nongovernmental conservation groups to conserve inadequately protected ecosystems and habitats. With GIS technology and remote sensing images increasingly available, gap analysis could be applied in many parts of the world.

Iterative Approaches to Reserve Selection in Australia

As an isolated continent with diverse environmental conditions, Australia is richly endowed with species and ecosystems found nowhere else. Perhaps because of this, Australia has been a hotbed of research and experimentation in setting biodiversity conservation priorities. At the species level, for example, methods have been proposed to rapidly survey invertebrates and mosses as indicators of overall patterns of biotic diversity (Oliver and Beattie, 1993). Faith (1994) uses phylogenetic diversity (diversity at taxonomic levels higher than species—genus, family, etc.) to propose alternative conservation priorities for Australian orchids and Tasmanian invertebrates. In the case of orchids, the Faith (1994) priorities differ from those determined by their endangered species status, while for Tasmanian invertebrates, Faith (1994) shows that the distribution of protected areas in Tasmania does not adequately protect the taxonomic diversity of invertebrates.

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Considerable work has also been invested in developing systematic approaches to selecting protected areas that conserve the greatest amount of biodiversity in the least amount of area. These "iterative" approaches to reserve selection are summarized here.

As Pressey et al. (1994) note, most protected areas have been selected as if biodiversity conservation were a secondary objective (secondary to scenery, recreation, political opportunism, etc.). An ad-hoc or opportunistic process to enlarging a reserve network is risky in that conservationists may use up their protected area options before many biodiversity elements—even entire ecosystems—are included. To address this problem, Australian researchers (e.g., Kirkpatrick, 1983; Margules et al., 1994; Pressey et al., 1994) have designed procedures that select each additional protected area on the basis that it protects biodiversity features not adequately protected in existing areas.

A good overview of the basic approach to iterative reserve selection is provided by Margules et al. (1994). They make the assumption that the reserve network should encompass the region's known subset of species, communities, or ecosystems. Once the first protected area or set of protected areas is in place, the challenge is to identify which sites should be added next. "The conservation value of a site in a region," Margules et al. (1994) state, "is the contribution it makes to sampling regional biological diversity." In other words, each site should complement the subset of biodiversity protected in other reserves. One of the important implications of this approach is that sites do not necessarily have to be exceptionally diverse or species-rich to have high conservation value. Any site, even a species-poor site, has high conservation value if it contributes a sample to the overall regional diversity that cannot be provided anywhere else.

To select the most efficient set of reserves, two things are required: a) a database with appropriate information on species, habitat types, communities, or environments, and b) a procedure for using the data to identify complementary sites.

For most places, the enumeration and distribution of all species would be impossible. Therefore, the database ideally would contain information on the distribution patterns of a number of species that serve as indicators of a broader range of species. In the absence of proven correlations between "indicator" species and other species, however, Margules et al. (1994) suggest that the database should be built around maps of habitat types or ecosystem classifications, since they "...may stand a higher chance of sampling biodiversity than a sample of some species." They use a process of "environmental regionalization" that employs computers and numerical classification using grid cells to cluster components of landscape, climate, soils, landform, and vegetation into broad scale patterns of co-occurring variables (Margules et al., 1988). On this base, habitat types, forest communities, species distributions, and other relevant data (e.g., protected area boundaries, units of tenure, existing habitat patches, etc.) can be arrayed.

The second step uses iterative algorithms to search for a set of objects within the region that, taken together, sample all attributes (e.g., species, habitats, natural communities, etc.) of the grid cells in the region. The algorithm is set to identify the minimum number of grid cells needed to sample a given percentage (e.g., 10 percent) of a community or a species distribution, or whatever the attribute of interest is.

As part of a project to resolve conflicts over the use of coastal hardwood forests in southeastern Australia, a database using a previously generated environmental regionalization with 9 km^2 grid cells and the distribution of 31 tree communities was constructed and a search algorithm developed (see Box 3.12). The algorithm was defined to run until at least 10 percent of each forest community was represented.

In this case, 37 grid cells (out of a total of 382) in the state of New South Wales was the minimum number needed to represent 10 percent of each tree community in the coast hardwood forest region of New South Wales. The result, according to Margules et al. (1994), is a nominal core reserve network which could serve as a base upon which to build a regional conservation plan.

This type of "coarse filter" approach is not without limitations. The use of land classes will miss some taxa, and other problems include taxa that vary temporally and spatially in distribution and abundance (e.g., migration); taxa are often patchily distributed so protecting one representative sample of a land class might miss many taxa; land classes do not recognize areas that may provide critical resources that some populations may need in times of scarcity; and many taxa require a combination of habitats not recognized by land classification. Pressey et al. (1994), therefore, stress the importance of including information on endangered species in the database.[32]

Another potential problem is that some of the areas identified using the most efficient selection algorithm, such as the Margules et al. (1994) example described above, will already be committed to other land uses. Recognizing this problem, Bedward et al. (1992) developed a procedure to build flexibility into iterative reserve selection approaches. This procedure, or the Conservation Options and Decisions Analysis (CODA), is designed to give the user complete control over the configuration and content of the reserve system by selecting or de-selecting individual sites until the representation goal is accomplished. In other words, if an area is too costly to acquire or is unsuitable for some other reason, the procedure takes this into account and calculates the next most efficient outcome to achieve desired conservation goals. The CODA procedure is summarized briefly in Box 3.13.

The CODA procedure was used to identify an expanded reserve system in the Eden region

BOX 3.12 Algorithm Steps for Iterative Reserve Selection

1) Include existing reserves or grid cells known to have rare species;
2) Select all grid cells with unique occurrences of forest communities;
3) Find the next rarest forest community and select the grid cell that, when added to those already selected, will represent that forest community plus the greatest number of other forest communities, at or above the 10 percent level;
4) If there is a choice, select the grid cell nearest to one already selected;
5) If there is still a choice, select the grid cell that also contributes the largest number of forest communities not yet represented at the 10 percent level;
6) If there is still a choice, select the grid cell that will enable the 10 percent level to be achieved for the rarest group of forest communities remaining under- or unrepresented;
7) If there is still a choice, select the grid cell that will contribute most to achieving the 10 percent level of representation of the rarest group of forest communities remaining under- or unrepresented;
8) If there is still a choice, select the grid cell which either a) contains the smallest percentage area necessary to achieve the 10 percent level of representation or b) contributes the largest percentage of that forest community if no grid cell can enable the 10 percent level of representation to be achieved. If b) is invoked, the algorithm returns to step 3 and the process continues until the 10 percent sampling is accomplished.

Source: Adapted from Margules et al. (1994)

BOX 3.13 Basic Stages in the CODA Procedure

Stage 1: Identify biodiversity features (e.g., habitat types, species ranges, etc.) of interest and set targets for representation. The extent of representation is stated explicitly as a fixed area of each feature or a fixed percentage of the total extent of each feature.

Stage 2: Identify focal areas—these are the core elements of a reserve system that are fixed or "non-negotiable" because of their known importance for biodiversity conservation. Focal areas may include existing protected areas and other sites known to have endangered species or threatened communities. The procedure (detailed in Bedward et al., 1992) calculates the extent to which representation targets are met within focal areas.

Stage 3: Select a preliminary extended reserve network to fully achieve representation targets. A minimum set algorithm (see Box 3.12) selects a set of additional sites to bring all features up to full desired representation.

Stage 4: Modify the preliminary network to address other conservation objectives or concerns. For example, while some sites selected in Stage 3 will be contiguous with focal areas, in good condition, and likely candidates for reservation, others may be too disturbed, too small or isolated, or too costly to acquire. CODA allows the user to find replacements for unsuitable sites and still achieve representation targets—each time a site is added or deleted, CODA calculates the implications for representation targets.

Source: Adapted from Pressey et al. (1994)

of New South Wales, where conservation reserves make up 9 percent of the area but do not represent many of the region's natural communities. The expanded network is more than twice the size of the existing network, with many new proposed areas adjacent to existing reserves or located on state forest lands.

Iterative analysis for protected area selection have much to recommend them. If used well, they can provide explicit, replicable, flexible, and efficient strategies for setting biodiversity conservation priorities (see Margules et al., 1994), especially if used in conjunction with expert knowledge and "fine filter analysis" (e.g., distribution of rare and endangered species). In some areas, especially in the tropics, suitable databases to use an iterative approach to identifying geographic priorities do not exist. In such cases, the time and expense of developing an adequate information base must be weighed against the urgency of the situation and the use of alternatives (e.g., an expert workshop approach).

The biggest challenge facing the use of iterative systems is the translation of the results into a real system of reserves on the ground. This, of course, is a difficult task in the face of social, economic, and political constraints. Pressey et al. (1994) recognize that this will inevitably require compromises in the integrity of the reserve system. The CODA procedure, however, is an example of the kind of innovation that can be used in technically driven priority-setting efforts to allow greater anticipation of demands from policymakers and the public, or even their direct participation.

Identification of Useful Plants for Conservation and Development

In the mid-1980s, the IUCN/WWF Plants Conservation Program determined that there was a large gap between the very detailed work of the International Board on Plant Genetic Resources for major food crops and the much

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more general work of the conservation community to conserve all species, irrespective of utility (Hawkes, 1988). The program decided that there was an urgent need to develop a list of economically important plants and a framework for assigning conservation priorities. A broad interpretation of "economically valuable" was developed that required a plant species to meet at least one of three criteria: 1) they must be cultivated as field and garden crops, forage, or as medicinals and pharmaceuticals; 2) they must be systematically gathered from the wild; or 3) they must be relatives capable of breeding with plants in the first two categories.

The system proposed by Hawkes (1988) uses five basic criteria to evaluate each species: 1) the extent of utilization based on how widely and intensively it is used; 2) the frequency with which the plant is used during the year; 3) the importance the plant has for the communities that use it; 4) the extent to which the plant is used in trade; and 5) how many uses the plant has (see Table 3.13).

For species that are not in current economic use, but are relatives of economically important species, Hawkes (1988) adds an additional criterion. Since the wild relative is likely to have little or no current use, its score is determined by taking the score of the economically important plant to which it is related and factoring by one of three percentages. The highest factor (.80) is for a wild relative that is in the same gene pool (or biological species). A wild relative that can transfer genes with some difficulty gets a medium factor (.60), and one that cannot currently transfer genes, or only with great difficulty, is assigned the lowest factor (.40).

Finally, each plant is assigned a factor reflecting the type of use it falls into. Plants used for human food get the highest factor (8), while those used as ornamentals or as textile dyes get the lowest factor (1). These factors are meant to reflect the "basic value of each plant for the survival and well-being of those who use them." To get the final score for the plant, its raw score—based on the sum of its ratings for the five criteria—is multiplied by the category of use factor.

The system is arbitrary in many respects. How do we know that plants in the industrial chemical uses category are twice as valuable to people as fiber plants used for textiles, ropes, twine, and nets? We cannot be precise about many of these assumptions, as Synge and Heywood (1988) point out, because the ranking system measures human uses that often have no discrete measures. The cash value of plants distorts the true value of many plants, especially those that never enter the cash economy. Despite these shortcomings, the explicit ranking of species proposed by Hawkes (1988) shows clearly on what basis plants are scored, although the "importance to community" category is ambiguous.[33] Anyone who disagrees with the assumptions made, can readjust the system to reflect different assumptions, or at least consider the difference in judgment when considering the scores.

Nevertheless, it seems likely that different scorers will come up with a range of rating values for the same plants. To examine this possibility, Hawkes (1988) had several experienced botanists score a variety of species. The discrepancies in raw scores assigned by different scorers typically ranged between 10 and 20 percent—surprisingly good given the imprecise criteria in several of the ranking categories. The discrepancies might have been higher, however, if ethnobotanists, with more detailed knowledge of the human uses and values of plants, had been involved in the test.

Priorities for Conserving Genetic Diversity in Forest Trees

Like modern agriculture has done to many crop species, forestry practices can narrow the genetic diversity of trees. This increases the vulnerability of managed forests and plantations to pests, disease, and climatic extremes, and

Table 3.13 Hawkes Scoring System for Economically Important Plant Species

		SCORE
I.	**Extent of Utilization Based on Area**	
A)	**Area**	
1.	Pan-tropical	200
2.	New world tropics (Mexico, Caribbean, South America)	60
3.	Old world tropics	140
a)	Africa only	50
b)	Indo-Malaysia only	50
c)	Australia-Pacific only	40
4.	Pan-temperate	200
5.	Old world temperate - Eurasia	140
6.	New world temperate (north of Rio Grande)	60
B)	**Use** (multiplication factor)	
1.	Commonly used within its area	x 1.0
2.	Not very commonly used within its area	x 0.75
3.	Rarely used within its area	x 0.5
II.	**Extent of Utilization Based on Time**	
1.	Used all year round; articles of daily use	100
2.	Used periodically throughout the year	75
3.	Seasonally used during the year	50
4.	Occasionally used throughout the year	30
5.	Rarely used throughout the year	20
6.	Used less than once a year (e.g., for house construction)	10
III.	**Importance to Community (national or local)**	
1.	Very important (community could survive without it but only with difficulty)	100
2.	Important (superior plant but substitutes exist)	75
3.	Moderately important	50
4.	Minimally important (could get on well without it)	25
5.	Not important	10
IV.	**Use in Commerce**	
1.	Widely sold internationally	100
2.	Sold to some extent internationally	80
3.	Widely sold or exchanged nationally	60
4.	Sold or exchanged in certain area	40
5.	Occasionally sold or exchanged	20
6.	Very rarely sold or exchanged	10

Source: Hawkes (1988)

reduces future options for breeding improvements. Generations of "high grading" have left degraded natural populations of economically valuable tree species in some areas around the world.[34] Ledig (1986) cites pitch pine (*Pinus rigida*) and loblolly pine (*Pinus taeda*) in the eastern United States, various pine species in Mexico, and mahogany (*Switenia mahogoni*) in parts of Central America and the Caribbean as examples where poor silvicultural practices have depleted valuable genetic resources.

Strategies to counter such genetic losses start with good silvicultural practices that avoid high-grading or leave relatively undisturbed genetic reserves in production forest areas. Other strategies include collecting seeds and pollen for *ex-situ* preservation in seed banks, establishing seed orchards, and increasing the genetic diversity of plantations. Ultimately, the most effective strategy is *in-situ* preservation of natural forest stands large enough to maintain themselves through natural regeneration and to encompass natural disturbance events (e.g., fire) as well as other ecological processes and biotic interactions (i.e., evolutionary forces).

Both *ex-situ* and *in-situ* preservation will benefit from identifying priority populations to sample or save. Priorities for *ex-situ* preservation strategies need to identify which populations and what number and distribution of populations need to be sampled. Effective *in-situ* genetic conservation strategies must determine which populations to maintain and what size, distribution, and number of populations are required to meet a number of objectives. These objectives include 1) preserving a representative sample of among- and within-population variation; 2) protecting the genetic integrity of individual populations from genetic contamination (e.g., cross-breeding with genetically uniform plantation stands); and 3) maintaining a dynamic equilibrium between inter- and intraspecific competition, including adequate range of age distribution, habitat availability for pollinating and seed disseminating species, and the breeding system that shapes the species' genetic structure (Ledig, 1986).

Similar approaches can be used to identify priority populations for both *ex-situ* and *in-situ* conservation. Genetic patterns in tree species are often completely unknown or known for only an unrepresentative fraction of a species' population. A common strategy in the absence of genetic information is to preserve or sample populations in representative habitats since they will probably include a maximum range of the species' genetic variability. Ledig (1986) stresses the importance of sampling marginal habitats since selection may have favored novel variants in these areas.

The ideal strategy is to map geographic patterns of genetic variation over a species range and measure the extent of variability within populations. This, of course, requires good information on population distributions and considerable expense and effort to characterize genetic variability within populations. Technological innovations during the past decade have made surveying genetic variation much more practical—especially for species with small ranges or few populations. Once collected, samples can be characterized by using electrophoretic gel separation of enzymes which provide markers of genetic composition (allozymes).

Genetic analysis can provide information critical to identifying priorities for the conservation of rare or endangered species limited to a handful of populations. For example, only two populations of Torrey pine (*Pinus torreyana*) remain, both of them located in southern California. Although both populations are believed to have lost much of their natural genetic variation, allozyme analysis revealed significant differences in the genetic makeup of the two populations (alleles differed at 8.5 percent of their gene loci). Therefore, conserving both populations is probably critical to their long-term persistence, especially because of the low level of genetic variability to begin with.

Recognizing that biodiversity is found in a range of landscapes—some natural and others significantly altered by human activities—and that it is not just the biological components of an ecosystem that are important to human welfare, McNeely et al. (1990) have proposed the concept of "ecologically sensitive areas" as a way to determine geographic priorities for conservation. Ecologically sensitive areas (ESAs) are areas of outstanding natural value for hydrological, geological, scenic, and biological resources that should be carefully managed to maintain those values. Although the difference between ESAs and traditional protected areas may seem semantic, the philosophical difference is that ESAs are selected and maintained for the contributions they make to society including ecosystem services and habitat maintenance.

The difference can be seen in the criteria McNeely et al. (1990) use to define ecologically sensitive areas. Habitats can be considered as ESAs if they:

- provide protection of steep slopes, especially in watershed areas, against erosion;
- support natural vegetation on soils of inherently low productivity that would yield little value to human communities if transformed;
- regulate and purify water flow (as forest and wetlands often do);
- provide conditions essential for perpetuation of species with medicinal and agricultural genetic value;
- maintain conditions vital for perpetuation of species that enhance the attractiveness of the landscape or the viability of protected areas; or
- provide critical habitat that threatened species use for breeding, feeding, or migration.

The first four characteristics are solidly utilitarian and not typical of most schemes to identify conservation priorities—only the last two characteristics are commonly evaluated in conservation priority-setting schemes. Although not all criteria will be found in all ESAs, the point is that their maintenance usually has very direct human benefits. They are parts of the landscape that are best left in their current condition because of the functions they provide, and the limited productivity they would exhibit if they were substantially altered.

Developing criteria to select priority areas would be one of the first tasks in planning a system of ESAs to support national development goals. McNeely et al. (1990) provide a list of model criteria by which priority ESAs could be identified, although they recognize the importance that local social, economic, and political factors will play in selecting and managing ESAs. The criteria presented are ideals against which any given site could be measured, perhaps with the use of numerical scores. McNeely et al. (1990) describe three kinds of criteria that can be used in evaluating potential ESAs.

I) Criteria to Determine the Importance of the Site to Human Society

Economic benefit. The site provides obvious long-term economic benefits, such as watershed protection or tourism, and does not involve great opportunity costs.

Diversity. The site has a great variety of species and ecosystems and is sufficiently large to contain viable populations of most species. It also contains a variety of geomorphological features, soils, water regimes, and microhabitats.

Internationally Critical Habitat. The site is essential to the survival of one or more globally threatened species, contains the only example of certain types of ecosystems, or contains landscapes of outstanding value.

Nationally Critical Habitat. The site is essential to the survival of one or more nationally threatened species, or contains the nation's only example of certain types of ecosystems. The ecological functions of the area are vital to the health of ecosystems beyond its boundaries (e.g., habitat for migratory species, an important catchment area for lowland irrigation systems, protection of the coast against typhoons, etc.).

Cultural Diversity. The site supports populations of indigenous people who have developed mechanisms for living in a sustainable balance with natural ecosystems, and whose continued presence in the area would help to ensure that its diversity is maintained.

Urgency. Action is required in order to avert an immediate threat.

II) Criteria to Determine What Additional Elements Enhance the Value of the Site

Demonstration. The site demonstrates the benefits, values, or methods of protection, and can show how to resolve conflicts between natural resource values and human activities.

Representativeness. The site is representative of a habitat type, ecological process, biological community, physiographic feature, or other natural characteristic.

Tourism. The site lends itself to forms of tourism compatible with the aims of conservation.

Landscape. The site has features of outstanding natural beauty that any alteration would significantly reduce the area's amenity value.

Recreation. The site provides local communities with opportunities to use, enjoy, and learn about their natural environment.

Research and Monitoring. The site can serve as a non-manipulated area against which to measure changes occurring elsewhere—i.e., to assess ecological change. Research conducted over an extended period and major field studies on the site provide a strong foundation on which new research can build.

Awareness. Education and training within the site can contribute knowledge and appreciation of regional values.

III) Criteria to Help Determine the Management Feasibility of the Site

Social Acceptance. The site is already protected by local people, or official protection by the government—particularly against outside exploitation—would be welcomed.

Opportunism. Existing conditions or actions at the site lend themselves to further actions (e.g., the extension of a protected area, or the establishment of a buffer zone around a protected area).

Availability. The site can be acquired easily, through inter-departmental transfer, easements, or other legal forms of control.

Convenience. The site is accessible to researchers or students for scientific and educational purposes.

Unlike the vast majority of priority-setting schemes, the process outlined by McNeely et al. (1990) does not rely exclusively or principally on biological information. In a sense, the process folds in social and economic considerations that usually are only considered after biologically determined priorities have been identified. The advantage to this approach is that biodiversity can be explicitly linked to other natural resources and the values society attributes to them. The disadvantage is that many important elements of biodiversity may get lost in the process of selecting priority ESAs if non-biological factors are heavily weighted; there is no guarantee that biodiversity will be broadly represented in the final network of ESAs.

Although the ESA approach described in McNeely et al. (1990) is a conceptual one, the suggested criteria could be used by conservationists who struggle to reconcile biodiversity maintenance goals with human needs in an increasingly crowded world.

Endnotes

1. Over 150 countries had signed the Convention on Biological Diversity by the June 30, 1993 deadline. By June 21, 1995, 118 countries had both signed and ratified the Convention.
2. Higher plants include flowering plants (angiosperms), and conifers, cycads and tree ferns (gymnosperms). Ferns are sometimes included, but mosses (bryophytes), lichens, and algae are not.
3. Conservation International (CI), for example, considers the RAP program to be part of its hierarchical approach to setting conservation priorities. CI's global priorities are based on "hotspots," "megadiversity countries" and major tropical wilderness areas, while expert workshops are used to identify priorities at the regional level. However, since only limited sites within Conservation International's global priority areas have been inventoried, RAP was devised to provide a "first-cut" assessment of biological value in little-known areas. This information can then be used to provide a more informed basis for conducting expert workshops to identify specific priorities within a "hotspot" region.
4. Ted Parker (an ornithologist), Al Gentry (a botanist at the Missouri Botanical Gardens), and several others were killed in a plane crash while conducting a RAP in Ecuador in August 1993.
5. Endemism is usually defined according to political rather than biological boundaries. For example, species listed as endemic to large countries such as Brazil or Russia may have geographic ranges of several hundred thousand square kilometers. They may be endemic to those countries, but they do not necessarily have highly restricted geographic ranges, which Bibby et al. (1992) and others have used to define endemic species.
6. The Udvardy (1975) system classifies the world's ecosystems into a hierarchical set of realms and provinces that are defined on the basis of shared groups of species.
7. Bibby et al. (1992) base this percentage on the occurrence of species classified as "threatened" or "near-threatened" by Collar and Andrew (1988).
8. The biological importance classification is determined by the species to area relationship (# species/1,000 km^2) of the EBAs (see Reid and Miller, 1989 for discussion on using species-area curves for ranking richness). Thus, those areas with twice as many birds as expected are classified as very important (3), those with less than the expected number are classified as least important (1), and those with approximately the expected number are classified as of importance (2). Bibby et al. (1992) adjusted this basic classification to account for taxonomic uniqueness of bird species found in an area—the classification was raised by one class for an EBA if it had an unusual taxonomic score (only 17 areas benefited from this analysis). Finally, a tentative scoring system was used to classify the EBAs by the level of endemism found in other taxonomic groups—an EBA's level is revised upward if the score for endemism in other taxonomic groups is high. In the final analysis, 89 EBAs are ranked high (3) for their biological importance, 68 are ranked moderate (2), and 64 areas are ranked low (1).
9. In terms of threat, the basic score is determined by the prevalence of "threatened" species in an endemic bird area. A score range of one to three is used. Then, the EBAs are scored on the basis of their protected areas coverage ranging from those with less than 5 percent protected (3) to those that are more than 20 percent protected (1). The overall threat classification of an EBA is lowered by one class if it has more than 20 percent of its area protected. This results in 61 EBAs classified as highly threatened, 99 as moderately threatened, and 61 as facing a low threat level.

10. In taxonomy, a phylum comes just below kingdom, but above class, order, family, genus, and species.
11. Upwelling areas support one third of the world's fish catch despite covering only 0.1 percent of the ocean's surface area (Norse, 1993).
12. These include the 17th General Assembly of the IUCN (1988) and the 4th World Wilderness Congress (1987).
13. The Central American Commission on Environment and Development (CCAD) was established in 1991 by the presidents of five Central American countries (Guatemala, Honduras, El Salvador, Nicaragua, and Costa Rica). CCAD has become a focal point for coordinating resource conservation and sustainable development policies and regional conservation projects. For example, the CCAD is now in the process of developing a regional "biodiversity conservation corridor" connecting protected areas in the region with a north-south natural habitat corridor from Mexico to Colombia. And one of the most promising Tropical Forestry Action Plan initiatives has been developed by the CCAD (Sizer, 1994).
14. For example, the Mustelid and Viverrid Action Plan (for weasels, civets, mongooses, and their relatives) starts with ranking the overall conservation needs within the 123 known species (Schreiber et al., 1989). It then generates conservation priority ranks for those species that are most in need of surveys and field studies, identifies geographic areas of the world important for mustelid and viverrid diversity, and determines which existing or proposed protected areas are most important for endangered species within the two families.
15. MacKinnon and MacKinnon (1986a) divided the four subregions into biounits on the basis of levels of similarity and distinctiveness for plants, mammals, birds, and reptiles. The resulting "biounits" are basically a modified set of the units defined by Udvardy (1975). See MacKinnon and MacKinnon (1986a), pp. 31-39, for an explanation of how biounits were derived.
16. The score (P) is expressed as a percentage of the total area of the unit:

$$P = \frac{(\text{sum of } c)}{S} \times \frac{h}{H} \times \frac{a}{A} \times 100$$

where c = the conservation contribution of individual protected areas, S = total size of the unit, h = the number of distinct habitat types included in the protected areas system, H = the total number of distinct habitat types recognized in the whole unit, a = the altitudinal range covered by the protected areas system, and A = the total altitudinal range of the biogeographic unit.
17. This score is based on the amount of natural habitat remaining, the current extent of protected areas as a percent of land area, and the potential "scope" or opportunities for establishing new protected areas.
18. This score is determined by the formula:

$$\frac{\text{Total species of unit } e(2)}{\text{mean no. of units per species} + e(1) + 2}$$

where e(1) = the number of endemics to a unit and e(2) = the number of near endemics shared with only one other unit.
19. Dinerstein and Wikramanayake (1993) state that benefits provided at this level might include adequate protection of watersheds, agricultural productivity, stability of local climate, fuelwood supplies, a sustainably harvested local timber industry, and conservation of some fraction of biodiversity falling outside of protected areas.
20. This provides little comfort, however, to many conservationists in Latin America who fear that the results of such a study will amount to *de facto* priorities that have not been adequately informed by regional and local expert knowledge and data. In response to this criticism, the Dinerstein et al. (1995) report was circulated within the region for review and comment.

21. More refined biological information might include zones of endemism, species richness, beta diversity gradients, migration corridors, critical resource or breeding habitats and other information that resides in national conservation strategies, regional analysis, and species-based studies. Dinerstein et al. (1995) suggest that although social, economic, and institutional factors (e.g., macroeconomic policies, debt burdens, land tenure, demographic patterns, capacity of local non-governmental and governmental institutions, etc.) are critical to the success of conservation efforts, the analysis of these factors is best done after landscape-level biological assessments. Population density and development plans, however, are used as modifiers for rates of habitat loss and the long-term effectiveness of protected areas.
22. However, this step added a sixth category for areas ranked as "5" by more than one specialist group. At the same time, the two lowest rankings were combined so that the final map priorities were again on a 1 to 5 scale.
23. The taxonomic groups included plants, birds, mammals, reptiles/amphibians, insects, and aquatic biota.
24. The Biodiversity Support Program is a consortium of World Wildlife Fund, World Resources Institute, and The Nature Conservancy. BSP is funded by USAID through a cooperative agreement with the World Wildlife Fund.
25. An important assumption of the exercise was that the list of priority areas will be used to guide some but not all of the agency's biodiversity conservation funds. USAID acknowledges that biodiversity conservation will be important to sustainable development in all countries and it will support conservation efforts requested by host country governments as part of its individual country mission programs.
26. Because many of the RHUs cover large areas, it proved essential to conduct the conservation status assessment at the ecoregion level first to ensure transparency of results and greater objectivity. Conservationists interested in how a RHU's conservation status was determined can refer to the status assigned to the ecoregions that compose that RHU and the values assigned to the landscape-level variables and threat indicators for each ecoregion.
27. This is not always true. Some international conservation NGOs set priorities on a global or regional basis, usually informed by field staff, to determine where they will develop or fund projects on the ground.
28. Other than outright purchase, TNC may negotiate with private land owners to purchase conservation easements, or work with natural resource management agencies to designate special management areas on public lands where rare or endangered species are found.
29. Even The Nature Conservancy, with a 1994 annual budget of over $250 million, has limits on how much real estate it can purchase, especially in such ecologically diverse states (with high land values) as Florida and California.
30. Supported by the World Bank and other multilateral and bilateral donors.
31. Together with several Papua New Guinean institutions, Conservation International is planning a Rapid Assessment Program expedition to survey several of these unknown areas.
32. Modifying the results based on expert knowledge and experience may be an even more useful complementary strategy.
33. It is not entirely clear what "importance to the community" means. Plants can be important for a wide range of uses or beliefs (e.g., food, medicine, livestock forage, spiritual beliefs, aesthetic reasons, building materials, etc.).
34. *High grading* refers to the selective logging of the straightest defect-free trees on a short rotation interval.

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CHAPTER FOUR

PRINCIPLES FOR SETTING BIODIVERSITY CONSERVATION PRIORITIES

Priorities provide the critical link between conservation goals and objectives and on-the-ground actions that make biodiversity conservation a reality, not merely an abstract idea. Therefore, a set of geographic priorities should be viewed as a means, or a tool, for effective implementation of conservation objectives, not as an end in itself. Relationships between objectives, priorities, and the implementation of conservation actions must be considered. This chapter presents ten principles to be considered in choosing a method for setting conservation priorities (see Box 4.1). They were developed to build on the strengths and limitations of the approaches reviewed in Chapter III. These principles can help make any process to set biodiversity conservation priorities more effective.

Setting geographic conservation priorities is usually thought of as a quantitative, largely objective, and mostly biologically based technical activity. Indeed, it is difficult to envision arriving at a set of priorities that did not emphasize biological characteristics. At the same time, experience shows social, political, and economic considerations often are combined with quantitatively based and objectively derived conservation priorities when it comes to directing investments. Holistic approaches, therefore, call for making the non-biological criteria more explicit.

Ecologists and other biologists typically involved in setting conservation priorities often fail to realize a simple fact of life that helps to explain why conservation priorities are so often ignored. In most circumstances, effective conservation is ultimately, for better or worse, a political process whose chances of success are improved through wider participation. Broader participation (e.g., policy makers, representatives of local communities and land owners) can strengthen the linkage between priorities and on-the-ground actions, without distorting the technical integrity of a process to establish biodiversity conservation priorities.

Several of the principles discussed in this chapter, therefore, address the political need for participation and consultation in the priority-setting process. Others address largely technical considerations, and one or two might simply go under the heading of "common sense."

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Box 4.1 Principles for Setting Biodiversity Conservation Priorities

1. Link biodiversity priorities with clear conservation goals and objectives.
2. Use a replicable, transparent process to develop credible priorities.
3. Clarify local, national, and global biodiversity conservation priorities.
4. Evaluate the advantages and disadvantages of relevant priority-setting schemes.
5. Make full use of relevant and available information.
6. Involve those responsible for implementing conservation actions.
7. Involve communities and other stakeholders.
8. Consider how priorities fit in a policy and institutional context.
9. Link conservation priorities to other planning and policy processes.
10. Establish a process to revise or reassess priorities at regular intervals.

1. Link Biodiversity Priorities with Clear Conservation Goals and Objectives

A strategy that defines basic biodiversity conservation problems and sets out a range of appropriate conservation objectives should be linked to identifying conservation priorities for ecosystems, habitats, and species. This step, however, is often overlooked or left unstated. Yet without this step, conservation priorities are likely to have little meaning for anyone but those who made the determination. All priorities are determined with some objective in mind—the key is to ensure that the objective is explicit and can be understood by others. Moreover, the strategy and objectives that priorities are intended to support will help to determine which priority-setting schemes are most appropriate.

Is the goal of conservation efforts to conserve representative examples of all habitat types within a country? Or is it to conserve the biodiversity found only in forest or marine ecosystems? Other typical conservation objectives might be to conserve biodiversity associated with agricultural landscapes, or to protect wild relatives of agricultural and other economically important plants. Perhaps the objective is to protect rare and endangered species wherever they are found, or maybe it is to protect vital migratory bird habitats. In many cases, conservation objectives are broadly defined as the protection of all species and ecosystems found within a given region or country. Ideally, the objective should indicate whether the intent is to maintain current levels of biodiversity, to increase biodiversity, or to minimize the loss of biodiversity (and thus protect evolutionary processes that maintain biodiversity), and it should specify what areas or taxonomic groups are involved.

The Indonesia Biodiversity Action Plan outlines several major objectives for which it seeks to develop or refine conservation priorities (Indonesia Ministry for Population and Environment, 1991). For example, one of these objectives is to "establish an integrated protected areas system covering all major terrestrial habitats covering at least 10 percent of the country's land area." Another is to ensure that biodiversity losses are minimized in unprotected production forests. In terms of marine conservation, the action plan identifies the expansion of the marine protected area system to 20 million hectares adequately representing all seven major biogeographic regions in the country.[1]

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Once conservation objectives have been established, the next step is to identify which ecosystems, habitats, and species must be protected/conserved if the objective(s) is to be met. Whether the objective is to maintain the broad diversity of life associated with natural habitats, or to maintain the diversity of agricultural and semi-domesticated species and varieties, no set of priorities makes much sense without a link to clearly defined objectives.

2. Use a Replicable, Transparent Process to Develop Credible Priorities

Using a transparent, replicable approach is important because it lends credibility to the priorities selected, minimizes the role of prejudice, clarifies assumptions and value judgments, and reveals what was and what was not evaluated. Too often, governments, donors, and the public are confronted with lists of conservation priorities that are accompanied by little or no description of the criteria, methods, and information used in their identification. Without this information, it is quite possible to conclude that the priorities reflect nothing more than the personal predilections or intuitions of those who identified them.

Although setting conservation priorities is a political process, clear justifications for proposed priorities can help to keep discussion focused on the merits of the identified priorities—and lessen subjective and political interpretations of them. Explicitness is always a virtue in setting priorities, and will save time, effort, and mistaken speculation when priorities are subsequently revised or reviewed by others.

3. Clarify Local, National and Global Biodiversity Conservation Priorities

The conservation of biodiversity is a common concern of all humanity, but this shared concern does not translate into shared priorities or opportunities. Within nations, local needs for food, fuel, and shelter may conflict with the national government's plans to use biodiversity to fuel national development priorities. Among nations, the threats to biodiversity differ, as does the technological or economic capacity needed to respond to them. The nature lover in the United States or Europe generally holds a very different view of the elephant than does the African farmer or the Sumatran palm oil entrepreneur. And, of course, the European nature lover's view of elephants would probably be similar to the African's perspective—perhaps even less tolerant—if elephants were trampling their garden.

Perceptions of biodiversity can vary substantially when viewed from global, national, or local perspectives. As a result, conservation priorities influenced by one perspective may not coincide with those selected from another perspective, and they may actually conflict. Viewing biodiversity through global, national, and local "lenses" can help to sort out differing perspectives and priorities. The matrix in Table 4.1 provides examples of how perspectives and priorities might look from each of these vantage points.

Globally, the first priority for many conservationists is to maintain the greatest global diversity of species and ecosystems; they focus their attention on species-rich countries or regions where extinction threats are high. Attempts to identify "hotspots," "megadiversity countries," and Vavilov centers of agricultural diversity[2] are examples of biodiversity priorities viewed through a global lens (McNeely et al., 1990).

Nationally, choices and priorities in conserving biodiversity reflect each country's development needs. A nation in northern Europe may rank low on a list of international biodiversity conservation priorities because it has relatively few species and ecosystems, but from a national perspective conserving them should be a top priority. By the same token, conserving wheat varieties may be the global concern for genetic

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TABLE 4.1 THREE VIEWS OF BIODIVERSITY CONSERVATION

	GLOBAL	NATIONAL	LOCAL
PRIORITY	Save all ecosystems, species and genes	Save ecosystems, species and genes useful nationally	Save species and habitats that meet local resource needs
GUIDING CONCERN	Intergenerational equity Ethics	Sustainable development Ethics/utilitarian	Direct benefits Utilitarian/cultural
OWNERSHIP	Common heritage	Sovereign resources	Local resources
PRIORITY SITES	Endemic Bird Areas Hotspots Representation of all major ecosystems in global network of protected areas	National hotspots and regions serving multiple needs.	Sources of cultural/ material benefits
STRATEGIES FOR ACTION	Debt leverage Development assistance Conditionality	Debt forgiveness Technology transfer Biotechnology National planning	Regaining resource control Participation in planning

resource conservation in Ethiopia, but conserving sorghum is likely to be a higher Ethiopian priority because sorghum is an important staple food in that country (WRI, 1992b).

Locally, conservation priorities shift to species and habitats that directly meet material, cultural, and aesthetic needs. The people who are today most directly concerned with conserving biodiversity are the forest dwellers, farmers, trappers, fishermen, and others who rely directly on biological resources for their livelihood. Each day, they manage the diversity of life to meet their perceived needs without unnecessarily diminishing the environment's capacity to meet their needs on the next day. Reflecting their own livelihood, their priorities may sometimes differ from those of others concerned with biodiversity conservation. From a local standpoint, it may be entirely rational to remove certain species or modify habitats that directly threaten human welfare. Local people may attempt to eliminate what to them are threatening aspects of biodiversity—such as lions, wolves, or other predators—just as society at large tries to eliminate smallpox or AIDS.[3] Similarly, crops of little national significance may be vital to local communities or serve important cultural roles. From an ethical standpoint, each individual in the global human community has the right to try to meet his or her own daily needs.

Efforts to influence national and local action based on globally perceived conservation needs are destined to fail if they run counter to local needs. They will fail because national and local perceptions are treated as obstacles instead of legitimate points of view. Enduring solutions demand that a partnership be reached among all interested parties. Cooperation among countries is needed to lead and orient biodiversity conservation and to set international priorities for action. But these priorities should not be requirements for national and local action, but rather one component of a global partnership. To achieve conservation objectives that have higher international than national or local priority, international institutions should provide acceptable incentives through funding or technical assistance, or should help broker debt relief and technology transfer. Alternatively, international institutions might agree to support a country's national biodiversity priorities in exchange for national support of international priorities found within its borders.

4. Evaluate the Advantages and Disadvantages of Relevant Priority-Setting Schemes

Governments, donors, and conservation agencies are frequently interested in priorities because they seem to simplify difficult choices about which they may know little. However, they should be wary of claims that any single scheme can optimally protect everything that is important about biodiversity. Such a scheme does not exist and never will.

Biodiversity can be thought of as a vast collection of many elements—genes, species, and ecosystems—differentially distributed in space. Any priority-setting scheme will only identify some subset of these biodiversity elements and will usually consider only some portion of the biosphere's total space. How large or how small that subset is, and what space it covers, depends primarily on how the conservation objective is defined. For example, the approach developed by Birdlife International (Bibby et al., 1992) identifies priority areas for bird conservation by analyzing the geographic ranges of endemic bird species. It does not identify conservation priorities for migratory birds, nor does it include domesticated fowl. Likewise, a priority-setting scheme for identifying the most important forest elephant habitats will not cover grasslands and savannas, and may or may not protect gorillas. Trade-offs should be consciously made and decisions should be informed by consideration of the costs and benefits of the chosen scheme.

5. Make Full Use of Relevant and Available Information

Priorities are only as good as the information evaluated in the priority-setting process. Lack of information should seldom be used as an excuse not to set priorities—all available information should be fully utilized. Moreover, because of the rapidity with which natural habitats are being destroyed and species endangered, it is important to seek the most recent data.

Often, information relevant to setting priorities is widely dispersed and unpublished. Surveys of existing government institutions can lead to a basic information base for priority-setting at the national level (forest inventories; land-use, ownership, and trade statistics; natural resources consumption patterns, population growth rates, etc.). Especially for local-level assessments, nongovernmental organizations will sometimes be the best sources of information. Governments rarely maintain detailed and current information at the subnational level, but local groups might. At the international level, the World Conservation Monitoring Center, UNEP's Global Environmental Monitoring Service, the U.N. Food and Agriculture Organization, and internationally recognized scientific institutions (such as the New York Botanical Garden, the Missouri Botanical Garden, the Royal Botanic Garden/Kew, Leiden, etc.) can provide a useful entry point. A more detailed discussion on information useful to priority-setting can found in Reid et al. (1993).

A balanced picture of conservation priorities depends on information concerning a number of subjects. In addition to the obvious information on species and habitats, information on local human communities can be very useful for integrating relevant social and economic issues into the priority-setting process. This information might include knowledge about institutions and their decision-making processes, their expressed interest in conservation, natural resource and land-use patterns, population trends, employment and livelihood patterns, land and resource tenure, and local development projects. Even more useful is to identify the stakeholders that influence the factors that could determine the success of conservation efforts. For example, who depends on wood from certain types of biologically valuable woodlands—

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are they urban charcoal buyers or international corporations with timber concessions? Such information may not be readily apparent, since many stakeholders may not be visible in, or even part of, local communities. The kind of information needed will depend on the choice of priority-setting methodology or scheme, as well as an assessment of which are most critical to the success of the stated conservation objective.

Finally, it is important to be aware of the quality and limitations of data used in the priority-setting process. An effort to assess data quality is time well spent. Knowing where the data came from, when and how they were collected, and whether they were subject to expert review and ground-truthing is essential to any credible scientific effort. Such information helps priority setters and users to know where weak or incomplete data may affect results and how results should be interpreted in the light of data quality; it also indicates where better data are needed.

6. Involve Those Responsible for Implementing Conservation Actions

Biodiversity is often thought of as a common heritage resource.[4] Who will be responsible for taking action once the biodiversity conservation priorities have been identified? For any particular subset of biodiversity in any particular place, certain institutions will have responsibilities, interests, and capacities for taking actions required to conserve priority species or ecosystems. For example, marine ecosystem conservation priorities may require the involvement of one or more agencies that are not typically involved in conservation efforts but have responsibilities over the use and management of the resource; in addition, the participation of organizations representing coastal communities in both planning and implementation may be critical for success.

As soon as possible, those involved in the priority-setting process should identify other groups and organizations (stakeholders) with an interest in the outcome of the effort, and identify which organizations will play a decisive role in implementing conservation actions within the priority area. Such organizations might include government agencies (such as the national parks and protected areas agency or the ministry of forestry or fisheries), communities, and private land owners in the affected areas. It is possible that sound, technically derived priorities can be identified without the involvement of these institutions, but it is unlikely that priority conservation actions will be effectively implemented without their cooperation. Moreover, in many cases, these institutions will have valuable information and experience for the priority-setting effort. When, and to what extent, to involve these institutions will depend on the situation, but at a minimum, they should be informed early on that the priority-setting effort is taking place.

7. Involve Communities and Other Stakeholders

With few exceptions, the areas identified as conservation priorities will contain people and communities. Actions to conserve biodiversity can have significant impacts on those who live in the affected communities. For both biodiversity and the people who live with it, local participation in the priority-setting process can have benefits that endure long after the priorities are identified. Ideally, those coordinating the priority-setting process should consult with communities, landowners, and local residents because they have a tremendous influence over and knowledge of land-use activities. They also often have considerable knowledge about species and ecosystems found in their vicinity. The conflict between local needs and sentiments and outsiders' conservation objectives is a universal problem that should be addressed from the earliest stages of conservation planning. Setting priorities offers outside conservationists and local people and interests (including local conservationists) one of the first opportunities to build respect, trust, and collaboration. Imposing conservation actions in priority areas without local participation is a virtual guarantee that conflicts will develop, perhaps fatally weakening local support for biodiversity conservation efforts.

Like the previous principle, the timing and degree of local involvement will vary with the circumstances of the project. It is never too early to consider how local peoples whose lives depend on natural resources—including biodiversity—can be effectively involved in conservation planning and priority-setting.

8. Consider How Priorities Fit in a Policy and Institutional Context

Once a basic set of conservation priorities has been determined, it will usually be impossible to undertake actions in all areas simultaneously. Some priorities might be more important than others for a variety of reasons, including strictly biological/ecological considerations. Decisionmakers responsible for allocating resources must inevitably confront this issue. For this reason, priority-setters should be prepared to be involved in the policy process that transforms a set of systematically chosen and scientifically credible priorities into a series of decisions about where to spend money, how to allocate personnel, and what policies to revise. In most cases, these decisions are made by policymakers in the absence of scientifically-credible priorities. When this happens, proponents of a particular set of priorities have wasted their time and other's money by not working to keep biodiversity conservation priorities on the policy agenda.

The ability of decisionmakers to take action is usually constrained by some factors, motivated by others. For example, uppermost in the minds of decisionmakers might be factors related to the existing capacity to take action, or perhaps the ability of a priority action to attract political support or to generate economic returns. Decisionmakers may well want to "overlay" social, economic, or political factors that the priority-setting process did not consider. While many scientists may be adverse to being accomplices in the political process, they should consider the likely results if they do not remain involved. Whatever criteria are used to rank or reshuffle conservation priorities, it should be clearly explained why and how the basic set of conservation priorities has been ranked.

9. Link Conservation Priorities to Economic and Sectoral Planning and Policy Processes

Conservation priorities will be effective only when they are linked to economic and sectoral policy and planning processes that affect resource allocation, land use, and the consumption of natural resources. Conservation usually depends on the allocation of money, personnel, policy reforms, and land-use changes, and not simply on knowing which species and ecosystems are most important for a particular conservation objective. At all levels—local, national, and global—there are institutions, mechanisms, and planning processes that can significantly influence or directly take actions needed for the conservation of biodiversity priorities.

At the international level, the Global Environmental Facility administered by the World Bank, UNDP, and UNEP, and the recurrent policy revisions and program planning efforts at international conservation organizations and bilateral and multilateral development institutions provide opportunities for linking the assessment of conservation priorities to major policy processes and funding mechanisms.

At the national level, the development of National Conservation Strategies (NCS), National Environmental Action Plans (NEAPs), National Biodiversity Strategies, Tropical Forestry Action Plans (TFAPs), etc., provide opportunities to link conservation priorities with policy processes and funding mechanisms that could have significant impacts on biodiversity. National Biodiversity Strategies, as required of all countries that are party to the Convention on Biological Diversity, provide a timely opportunity to link biodiversity conservation priorities with an important national policy process in many countries.

Finally, at the provincial and local level, land-use planning, economic development strategies, and the preparation of zoning legislation and local regulations could be important ways to increase the influence of conservation priorities.

10. Establish a Process to Revise or Reassess Priorities at Regular Intervals

New information on species and ecosystems is constantly being generated, and the threats to those resources also change with time—even very short periods of time. The values that humans attach to species and ecosystems change as well. With this in mind, conservation planners should establish a process for revising priorities on the basis of new information, new threats, or new or revised values. Priorities should never be viewed as static. Change is inevitable with conservation priorities, and conservation planners should be flexible enough to keep track of new information and to revise existing priorities on that basis. Any changes to the priorities should involve stakeholders in the decision-making process, and changes should be documented so that it is clear how and why the priorities changed.

One implication of revising and reassessing priorities is the universal need for better monitoring of biodiversity status and trends at all levels (genes to ecosystems) and scales (local to global). At the regional and global scales, and in most countries, no biodiversity monitoring exists, with the minor exception of monitoring some endangered species populations and trade levels under CITES (Convention on International Trade in Endangered Species).

Endnotes

1. The seven biogeographic regions include terrestrial areas and adjacent offshore areas.
2. "Vavilov centers" refer to restricted geographic areas where an unusually high diversity of crop species and their wild relatives are found. They are named after Nikolai Vavilov, a prominent Russian plant geneticist, who believed these centers are where crop species originated. Vavilov identified a number of these centers in Central Asia, China, and South and Central America.
3. Some might argue that in some places society at large is still preoccupied with eliminating predators. For example, the U.S. government still has a predator control program in parts of the western United States that is often criticized as unneccesary and out of touch with current knowledge about the role of predators (e.g., coyotes) in controlling species that are destructive for agriculture (e.g., various rodents).
4. As the debates over the Convention on Biological Diversity illustrated, however, this view is being replaced by a more proprietary view as biodiversity is increasingly seen to have significant economic value. But this proprietary view is held mainly between national governments, not at the level of subnational or local institutions. This could change as the benefits from "biodiversity prospecting" grow and institutions (and individuals) seek to claim that value as their own.

Chapter Five

CONCLUSIONS

Conservation priorities set during the next decade or so, if they are actually used to guide investment, will influence conservation activities in many places for decades and perhaps centuries into the future. There are two reasons for this. First, habitat loss and genetic erosion are likely to continue at rates at least as high as they were during the 1980s. Already, a growing number of countries have less than 10 percent of their original natural habitat remaining, and some biomes—most of them in the temperate zones—have been reduced to only a few fragmented remnants of relatively undisturbed habitat (WRI, 1994). Second, a combination of factors and events, including the establishment of the Global Environmental Facility and the signing of the Convention on Biological Diversity, will inevitably drive governments and intergovernmental agencies (e.g., GEF, UNDP, UNEP, FAO, etc.) to focus on setting conservation priorities during much of the rest of this decade. Biodiversity priorities set in the 1990s will not be the last, but they very well could be the most important.

Despite the growing literature and experience concerning biodiversity priorities, very little attention has been focused on policies and actions required to build institutional capacities to set effective priorities that—taken together—will help to conserve the world's variety of genetic resources, species, habitats, and ecosystem functions. As efforts to implement the Convention on Biological Diversity increase, institutions at national and international levels are groping for frameworks to help them allocate resources for biodiversity conservation.

Several issues, in particular, are vital to using priority-setting effectively to support biodiversity conservation policies and strategies. First, explicit objectives are essential both to provide guidance to the priority-setting process and to make clear what elements of biodiversity are included in the priorities and which are not. Second, biodiversity is important everywhere, and biogeographic representation should be an objective of initial efforts to set priorities. Third, the conservation of biodiversity is less a question of biology than of social, economic, and political factors. Therefore, while priorities must be scientifically sound, their proponents should

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consider how priorities can have an impact in the social context in which conservation decisions are made. Fourth, priority-setting must become an integral part of national biodiversity strategies, action plans, and related policy and planning processes. This will require investing in national capacities to develop and implement comprehensive conservation priorities. Finally, at the international level, priority-setting should complement but not supersede nationally and locally determined biodiversity conservation priorities.

Clear Objectives a Prerequisite to Effective Priorities

One of the perils in establishing biodiversity priorities is setting them in isolation from clearly defined conservation goals. Indeed, the goals of biodiversity conservation set out in the Convention on Biological Diversity, Agenda 21 (the consensus document passed at UNCED), and documents establishing the GEF, are so broad that working definitions are left by default to various institutions carrying out actions pursuant to the larger framework. Ironically, the danger is that biodiversity conservation goals, priorities, and actions will be defined too narrowly to adequately protect the broad array of economic, scientific, moral, and cultural values that biodiversity represents.

For example, the GEF is the funding mechanism through which multilateral financial resources will flow to help developing countries meet their obligations under the Biological Diversity Convention. The rationale for intervention by the GEF is to capture the global values of biodiversity conservation, while individual countries are expected to take conservation actions that are in the country's self-interest. Incremental costs—costs which exceed national benefits from conservation investments but are less than global benefits—are, in principle, the basis for grant financing at the GEF (Mittermeier and Bowles, 1995). As Pearce et al. (1993) note, the GEF is concerned primarily with financing projects that will yield net global economic benefits.

Although those most familiar with incremental cost concepts (e.g., Pearce et al., 1993; King, 1993) take pains to note the broad nature of economic benefits and costs, it is clear that priority-setting efforts driven by the quantification of economic values will not encompass many dimensions of biodiversity. This is because little is known about the economic value of the overwhelming majority of genetic resources, species, ecosystems and ecological processes. The risk is that conservation actions (in countries, biomes, or habitats, or for species and genetic resources) which do not meet 1990s definitions of "cost-effectiveness" will not be included in priority lists at one of the most critical junctures in the history of life on earth.

What is needed—under a broad conservation goal—is a series of specific objectives to conserve biodiversity; these objectives should encompass the range of biodiversity values (e.g., scientific, economic, cultural, moral, etc.) that society wants to sustain (see Box 5.1). In all likelihood, supporting these objectives will

BOX 5.1 An Illustrative Biodiversity Conservation Goal Statement

The overall goal of biodiversity conservation—at global, national, and local scales—must be broadly defined. The broad overall goal of biodiversity conservation, upon which to base conservation objectives and supporting priorities, could be defined as follows: The goal of biodiversity conservation is protecting and using biological resources in ways that do not diminish the world's or a nation's variety of genes, species, habitats, and ecosystems.

BOX 5.2 ILLUSTRATIVE EXAMPLES OF NATIONAL BIODIVERSITY CONSERVATION OBJECTIVES

The Convention on Biological Diversity calls on member countries to undertake a wide range of actions to conserve biodiversity. Article 7, for example, requires each party to "identify components of biological diversity important for its conservation and sustainable use," and Article 8 sets out a series of in-situ management objectives. To meet these requirements, a country might set objectives to maintain or recover:

a) Biodiversity in representative natural ecosystems and habitats (terrestrial and marine);

b) Biodiversity in landscapes where agriculture, forestry, fisheries, and grazing are dominant land-uses;

c) Threatened and endangered populations of wild species;

d) Agricultural and other economically important species and their wild relatives;

e) Species or habitats of significant social or cultural importance (e.g., "sacred" forest groves)

f) Habitats or ecosystems associated with key evolutionary (e.g., "refugia" during times of climatic change) or biological processes (e.g., migratory habitats or corridors).

Under each of these objectives, a different priority-setting approach or set of approaches might be employed—some of which are likely to be adapted from the examples discussed in Chapter III. The sum of these objectives and their supporting priorities should encompass the national biodiversity conservation goal (see Box 5.1).

require different sets of priorities determined by using more than one approach. Examples of conservation objectives can be seen in Box 5.2.

THE IMPORTANCE OF BIOGEOGRAPHIC REPRESENTATION

Biodiversity is important everywhere. Ecosystems and people in desert, grassland, and even tundra biomes depend on their biotic diversity just as ecosystems and people do in humid tropical forests. In practice, priorities for funding, research, and conservation programming have focused on a limited number of biomes and bioregions, in part, because priority-setting approaches have emphasized the use of a few easily measured indicators (e.g., species richness, species endemism, tropical deforestation rates, etc.). Too often, biodiversity priority-setting is reduced to counting species and assuming that threats to biodiversity are synonymous with tropical deforestation rates; this results in many biomes not being considered at all.

The folly of this is vividly illustrated by Mares (1992). In comparing the mammalian diversity of lowland Amazonia with that of drier South American ecosystems, Mares found that deserts, scrublands, and grasslands have 53 percent more endemic species and 440 percent more endemic genera than the humid tropical forests of the Amazon basin. Marine ecosystems, desert and grassland biomes, and temperate and boreal forests are virtually absent from the list of priorities generated by "hotspots," "megadiversity," and other approaches that rely on species numbers and endemism levels. There is no doubt about the importance of humid tropical forests as immensely rich and threatened repositories of biodiversity, but their importance should not blind scientists, donor agencies, and governments to the many biodiversity values of other threatened ecosystems around the world or in a particular country.

Noting the bias toward humid tropical forest conservation and the relative neglect of marine ecosystems and arid and semi-arid biomes (e.g., deserts, grasslands, and scrublands), Redford et al. (1990) argue that "a pluralistic view towards the conservation of biodiversity is imperative."[1] The gaps in our knowledge of global biodiversity should prompt more humility on the part of international biodiversity conservation policymakers and priority setters. This is explicitly recognized in the *Global Biodiversity Strategy* (WRI/IUCN/UNEP, 1992).[2] The Strategy offers ten principles for conserving biodiversity; one of them suggests how priorities should be addressed in the context of a comprehensive biodiversity conservation goal:

> "Priorities for biodiversity conservation differ when viewed from local, national, and global perspectives; all are legitimate, and should be taken into account. All countries and communities also have a vested interest in conserving their biodiversity; the focus should not be exclusively on a few species-rich ecosystems or countries."

This principle should be the starting point of efforts to set conservation priorities. Representation of all species and ecosystem types in conservation programs, therefore, should be a conservation objective around which priorities are initially set.

The Social Context for Setting Biodiversity Conservation Priorities

The issues raised above are concerned principally with ensuring that priority-setting overall is not biased toward a particular subset of the diversity of life forms and processes. It is equally important to stress that biodiversity conservation priority-setting should not take place in a socioeconomic vacuum. Successful implementation of conservation priorities ultimately depends on the support of important biodiversity stakeholders, the public, and various government agencies—all of whom have social, economic, and political needs they consider at least as important as conserving biodiversity.[3]

The best way to ensure that priority-setting both informs and is informed by the range of actors who influence the fate of biodiversity is to develop an effective *process* for setting priorities. An effective priority-setting process, notwithstanding its technical integrity, is one that starts with clearly defined conservation goal(s) and objectives, is guided by the widest possible array of relevant information, and links priorities to discrete institutions, actions, and constituencies. In practice, this means involving potentially affected stakeholders in the priority-setting process.[4] This is especially important at the beginning of the process when goals and objectives are defined and toward the conclusion of the process when follow-up actions to conserve priorities are defined.

As priorities are identified with increasing geographic specificity, participation will become more important. Specific communities, institutions, and individuals have important information, local priorities, land and resource tenure regimes, and a variety of socioeconomic needs and constraints that will determine the ultimate disposition of the identified priorities. The experience of a number of priority-setting projects (see, for example, the profile of the Papua New Guinea Conservation Needs Assessment in Chapter III) shows the importance of local involvement in the priority-setting process. Without such involvement, distrust and even antagonism toward the process can result.

It should, however, be noted that the relationship of many social factors (and institutional, economic, and political factors) to biodiversity and its conservation are not well known and they can change rapidly. Much more work is needed to develop appropriate frameworks for the consideration of social factors in biodiversity priority-setting approaches.[5]

With rare exceptions, the biodiversity priority-setting process is left to the "usual suspects"—government natural resource management agencies, academics in the biological sciences, and large national and international conservation NGOs. Those who think of priorities in terms of economic or agricultural development might be involved as well—if only to see where overlaps and conflicts are likely to be. Setting biodiversity conservation priorities is an enormously educational experience for everyone involved. Including such interests as social scientists, development-oriented NGOs, finance and agriculture agencies, and farmer and rancher groups, for example, could develop support for biodiversity conservation in important institutions outside the usual conservation circles.

Although biodiversity conservation priorities are most often intended to lead to the establishment of new protected areas, endangered species programs, or *ex-situ* conservation programs, geographically defined priorities could have tremendous policy implications in other ways. For example, information on species and ecosystem distribution and trends, habitat quality, and human land-use and demographic patterns, could be correlated to land tenure and other policies (e.g., tax, agricultural subsidies, etc.) that contribute to ecological degradation. This would allow priority-setters to identify specific policy reforms that could help conserve biodiversity outside of traditional protected areas.

Similarly, cultural/demographic/land-use data (in conjunction with species and ecosystem information) could be used to identify biologically important areas where people use natural resources in ways that are relatively compatible with biodiversity conservation. Strategies could then be developed to encourage the preservation of such land uses and protect them from rapid and ecologically destructive change.

Finally, what follow-up will take place after the priorities have first been established? Conservation priorities have been developed in hundreds of places—some of them very solid and well-evaluated—but most have never amounted to anything more than a list in a study. Who will be responsible for translating the priorities into actions, how will progress be monitored, and what strategies can be used to ensure that all those who should know about the priorities understand their significance? In other words, how will the priorities be used to influence land-use policy, development decisions, conservation policy, etc.? One way to address these concerns is to link biodiversity priority-setting to the development of national biodiversity strategies and action plans as called for under Article 6 of the Convention on Biological Diversity (see below).

Priorities Should be Integral to National Biodiversity Strategies and Action Plans

The Convention on Biological Diversity calls on countries to use a wide range of measures to conserve and sustainably use their biodiversity. Each country, however, must determine what steps it should take to implement the Convention. The first substantive article of the Convention, Article 6 (UNEP, 1992), calls on countries to:

> "(a) Develop national strategies, action plans or programs for the conservation and sustainable use of biological diversity or adapt for this purpose existing strategies, plans of programs which shall reflect, *inter alia*, the measures set out in this Convention relevant to the Contracting Party concerned; and
>
> (b) Integrate, as far as possible and as appropriate, the conservation and sustainable use of biological diversity into relevant sectoral or cross-sectoral plans, programs and policies."

Setting biodiversity conservation priorities, or using existing priorities, can help define what specific steps should be emphasized in such strategies and plans.

Few countries have approached biodiversity planning in the comprehensive manner required by the Convention (Miller and Lanou, 1995). Fewer still have comprehensively assessed priorities for biodiversity conservation. Nevertheless, planning efforts pursuant to Article 6 provide a great opportunity to define an influential role for the establishment and implementation of conservation priorities. Priority-setting can take place either as an integral part of the national strategy or action plan process, or as a result of key strategy elements or action points that put priority-setting efforts in motion.

In any country, a range of institutions and interests can be called upon for information and knowledge and for the financial, technical, and human resources needed to set priorities to address national biodiversity conservation goals. Universities, NGOs, museums, botanical gardens, zoos, professional societies, and local communities, as well as various government agencies, all have legitimate roles to play in setting effective conservation priorities. National resources and, where needed, international donor resources and technical assistance, should be invested in priority-setting as an integral or complementary process to the development of national biodiversity strategies and action plans. These national level priorities can then guide implementation and provide donors with clear indications of where they can best support national conservation programs.

International Priorities Should Support National Priorities

The biodiversity of any ecosystem—from the tropics to the poles—has values that benefit people beyond the watershed, province, and country in which the ecosystem is located. Priorities based on the premise that biodiversity around the world is important to all peoples have an important role to play. However, the role of international priorities should be defined in ways that avoid unnecessary conflicts between national/local and international perspectives on biodiversity. As a matter of principle, international priority-setting should identify gaps that exist after national level priorities have been identified—and the international community should be prepared to fund conservation in areas that are clearly not national priorities. In reality, of course, this may not be possible for some time, since most countries have not yet comprehensively assessed biodiversity conservation priorities.

The case for establishing *de novo* global or international priorities to allocate donor resources can be compelling—every year more species and habitats become endangered, conservation options narrow, and budgets decline—but it should not become a habit. A *bottom-up approach* to identifying international priorities will take more time, money, and dialogue, but it will yield more durable and achievable results, for participation will always result in priorities having wider ownership and political support. Yet participation is increasingly difficult as the geographic scale increases. A *top-down approach* to identifying international priorities, on the other hand, sacrifices participation and ownership of priorities in order to save time and improve the technical or conceptual approach. This presumably increases the "objectivity" of the priority-setting process.

In the future, international priority-setting will require a synthesis of priorities developed through bottom-up and top-down processes[6]. Local perspectives will not always include elements of biodiversity that are important when viewed from larger scales. International perspectives will not always encompass biodiversity elements that are of vital importance to local peoples or national economies. Top-down approaches are relatively easy to undertake. Meshing those priorities with priorities selected from local and national perspectives is often not possible today, because so few countries have had the human, technical, and financial resources to systematically evaluate priorities.

Donors, therefore, should view national and local-level priority-setting as an important and long-term investment in conservation plan-

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ning capacity and commit themselves to using the results to help guide their programming and funding decisions. Donors can start by working with recipient countries to build priority-setting into the National Biodiversity Strategy and Action Plan process.

There is no single formula for developing effective biodiversity conservation priorities. The process of setting priorities will vary between countries according to available information, local perceptions, and development objectives. Priority-setting will increase in sophistication and more effective approaches and processes will emerge in coming years. However, as WCMC (1994) notes, "For most countries and the world as a whole...there is sufficient information on species richness and endemism to allow realistic decisions to be made on where these attributes are likely to be most pronounced, and where investment in safeguarding them would be most effective." Priority-setting and revising earlier priorities will be a recurrent activity, not a one-time event. Therefore investments in building the information base, making appropriate technologies available (e.g., computer mapping and databases), defining participatory mechanisms, and training, will have long-term value and contribute significantly to the conservation of biodiversity, particularly if policymakers and donors pay attention.

There will never be a better time to invest in developing the capacity to set priorities at all levels—local, national, and global.

Endnotes

1. The point expressed by Redford et al. (1990), Ray (1988), and others is that tropical rainforests are not synonymous with biological diversity. They are a subset (albeit, a very important one) of the diversity of life forms and ecological processes.
2. The Global Biodiversity Strategy defines the goal of biodiversity conservation as "...supporting sustainable development by protecting and using biological resources in ways that do not diminish the world's variety of genes and species or destroy important habitats and ecosystems."
3. Usually they consider these factors more important than, and often separate from, conserving biodiversity.
4. Biodiversity stakeholders will range from local communities living in or depending on natural habitats, government agencies with responsibilities over natural resources and economic development, private sector businesses with control or access to significant biological resources, and the interested public and the independent institutions (e.g., nongovernmental organizations) that represent them.
5. One possibility, for example, is to use two separate frameworks. The first would consist of biological, environmental, threat (e.g., rate of habitat loss) and certain social factors (population density, demographic trends) that are quantifiable and generally agreed to be of importance to selecting biodiversity priorities—a "stable framework." A second framework would consist of social, institutional, and economic factors that are important for determining feasibility, but which change rapidly, are difficult to quantify, and the relationship of which to biodiversity conservation is not always clear. This "feasibility" framework would then be overlaid on the preliminary priorities identified using the "stable framework" to select priorities for implementation (Olivieri, personal communication).
6. In an ideal world, it would be useful to have a framework that would lead to the identification of global priorities to conserve the variety of genetic resources, species, habitats, and ecological processes in each of the world's major biomes or biogeographic zones. The framework would be "filled-in" as individual countries reported their progress in implementing obligations of the Biodiversity Convention. The framework

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could then be used to guide the allocation of limited international financial and technical resources to "global" conservation priorities not addressed by individual countries. In other words, the international framework should be designed to both assist individual countries in developing or refining national priorities, and to identify "gaps" in biodiversity conservation from a global perspective.

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