BIODIVERSITY INDICATORS FOR POLICY-MAKERS

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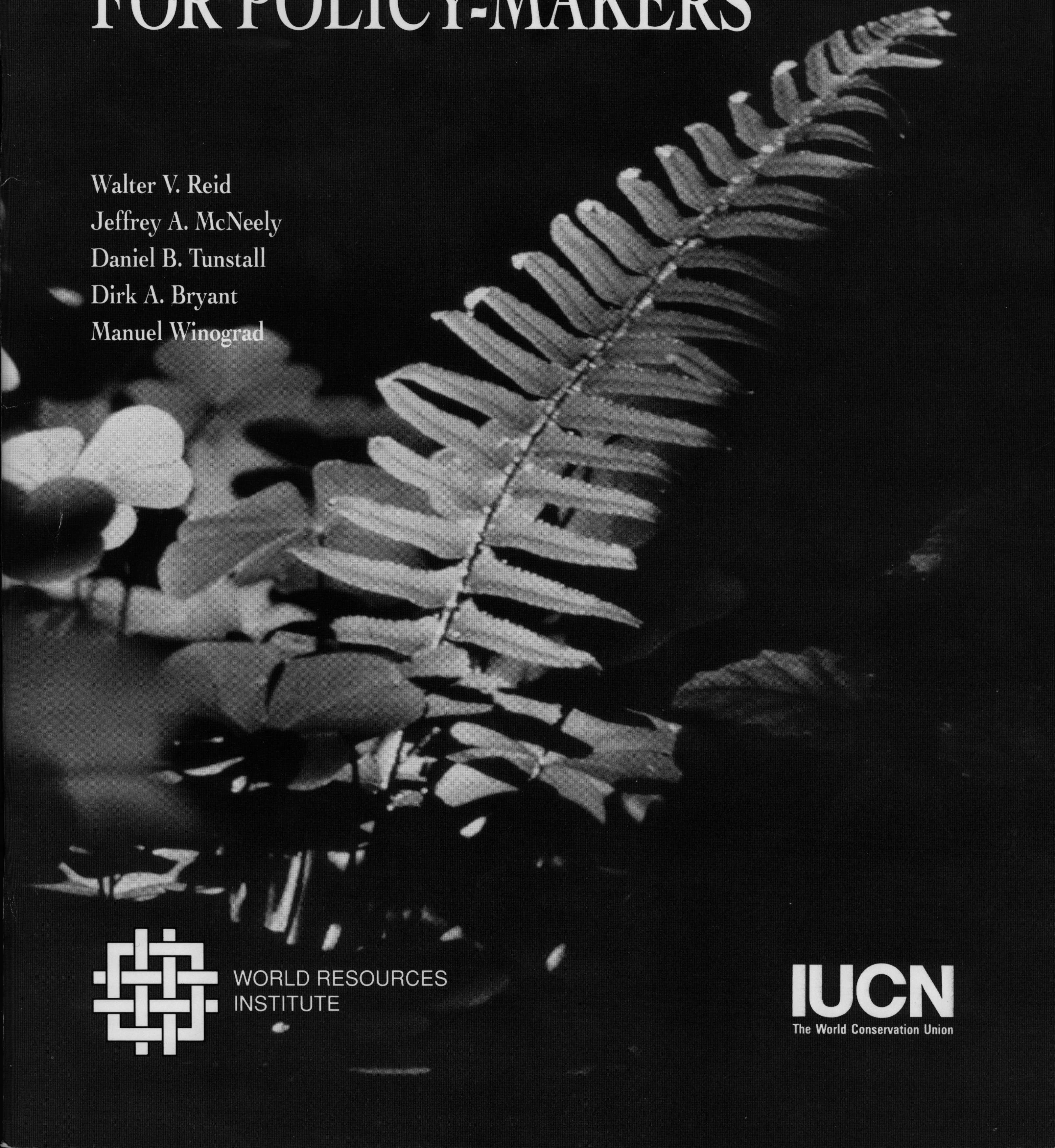

WORLD RESOURCES INSTITUTE

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The World Conservation Union

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This report represents a timely, scientific treatment of a subject of public concern. Its collaborating partners take responsibility for choosing the study topics and guaranteeing its authors and researchers freedom of inquiry. This report's authors have also solicited and responded to the guidance of advisory panels and expert reviewers. Unless otherwise stated, however, all the interpretation and findings set forth in WRI publications are those of the authors.

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ABSTRACT

This paper sets out a framework for assessing conditions and trends in biodiversity at local, national, regional, and global levels. The framework is used to identify a minimum set of indicators necessary to meet the needs of a diverse audience of policy-makers—those associated with international nongovernmental organizations, intergovernmental organizations, and local governments, for example—each with differing perspectives on and approaches to biodiversity conservation. These indicators can guide conservation decision-making by helping planners to set priorities, by influencing new policies, and by providing information to determine whether policy goals have been achieved.

The paper begins by reviewing the role that indicators can play in conservation and follows with a discussion of the approaches to measuring biodiversity. These include outlining what needs to be measured and some of the problems faced in attempting to measure individual biodiversity attributes. A set of 22 indicators is organized into three categories:

- indicators used to measure wild species' and genetic diversity
- indicators used to measure diversity at the community/habitat level
- indicators used to assess domesticated species (the diversity of crops and livestock).

The paper contains a review of the availability and the quality of the data needed to develop the indicators outlined in the text. It concludes with a discussion of how these indicators might be used for setting priorities for policy.

1.

INDICATORS AND THE CONSERVATION OF BIODIVERSITY

Biodiversity conservation has become an important concept in the thinking of government officials, conservationists, and even diplomats. A new convention on biodiversity has been signed by over 150 countries, and the topic was one of the main agenda items for the United Nations Conference on Environment and Development held in June 1992. In 1992, a Global Biodiversity Strategy was released by the World Resources Institute (WRI), The World Conservation Union (IUCN), and the United Nations Environment Programme (UNEP). It lays out a comprehensive plan of action to conserve diversity. Eighty-five proposals for action are outlined in the strategy, including several geared toward improving data collection and monitoring. The World Bank is working with other United Nations organizations to provide several hundred million dollars in grants and loans to support the efforts of developing countries to conserve biodiversity of global importance. Countries as dissimilar as Indonesia, Canada, and Costa Rica are developing national plans to conserve biodiversity.

The influential works of Soulé (1986), Wilson (1988), Juma (1989a), and others have helped to place biodiversity conservation on the sustainable development agenda. However, the push for action to conserve biodiversity has outpaced the development of an analytical framework for monitoring its status and trends and for establishing priorities and targets. Without such a framework, conservation actions may be ineffective and inefficient, and biodiversity conservation may change quickly to merely a rhetorical flourish on unaltered paths of resource exploitation. This paper provides a framework for developing a set of indicators that can be used to guide the establishment of conservation policies and to assess whether the plans and programs carried out to implement those policies actually achieve their stated objectives.

The Goal of Conserving Biodiversity

The fundamental goal of biodiversity conservation is to support 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 or ecosystems. Thus, biodiversity conservation encompasses three basic policy concerns:

- to minimize the loss of genetic diversity
- to minimize the loss of species diversity
- to manage biodiversity within and among biological communities so that human

> needs are met without reducing potential contributions to future generations.

The third concern, involving biodiversity at higher levels of organization than genes and species—namely, communities, ecosystems, and landscapes—is distinct from the first two for several reasons. First, many different "units" of diversity are involved at the supra-species level, among them the pattern of habitats in a community, the relative abundance of species, the age structure of populations, the pattern of communities on the landscape, trophic structure, and patch dynamics. Given the many components of biodiversity at this level of organization and their complex interactions, no simple normative statement comparable to those made for genes and species is possible. A strict focus on "minimizing" the loss of biodiversity at the level of a community, for example, might lead to the inappropriate goal of preventing a community from reaching a climax state in order to maintain the greater diversity of components and interactions present in earlier stages.

Second, at levels of organization higher than the species, unambiguous boundaries delimiting units of diversity do not exist. Biological communities are defined subjectively at a scale relevant to a specific research or management objective. Thus, the research or management question may relate to the "rocky intertidal community of Tatoosh Island," or adopt the larger spatial scale of the "intertidal community of Washington State," or the "Eastern Pacific coastal community."

Finally, communities are transient associations of species; communities do not possess temporal continuity like individual species. Paleoecological evidence for North America, for instance, indicates that most modern plant communities are less than 8,000 years old (Hunter *et al.*, 1988). Consequently, although communities can be defined based on their existing species composition and structure over shorter time periods of tens or hundreds of years, communities are too ephemeral to be considered important entities in their own right, particularly during periods of significant environmental change (Hunter *et al.*, 1988).

Therefore, a more appropriate statement of the concern for biodiversity conservation above the species level is stated in terms of the "management" of biodiversity. Consider the two basic reasons for maintaining diversity at the level of communities:

- ensuring the maintenance of the species comprising the community
- helping to maintain the benefits obtained from healthy ecosystems, such as pollutant filtration, nutrient cycling, climate control, and the maintenance of the productivity of resources harvested from the ecosystem, as well as nonconsumptive recreational, scientific, and aesthetic values.

In order to achieve the objective of species conservation, all of a community's attributes need not be preserved in their existing state (community attributes are bound to change through time). Rather, the diversity of community attributes and functions must not be altered in ways that would result in the loss of species. In some cases, certain aspects of the community (for example, ancient forests) may need to be preserved to achieve this end, while other changes in diversity may be entirely acceptable—the colonization of the western hemisphere by the African cattle egret (*Bubulcus ibis*) changed community-level diversity through a natural process. Similarly, to maintain the benefits that humanity obtains from healthy ecosystems, the concern is not the preservation of specific attributes of the community but, rather, the management of the system to meet human needs, support species and genetic diversity, and enable the system to adapt to changing conditions.

The Character and Usefulness of Indicators

Indicators are key statistical series that can be used to help policy-makers and the public assess conditions and trends and the achievement of specific goals. More specifically, indicators can be used to provide decision-makers with useful information on the status of and trends in biodiversity and to help determine if broad goals and targets for conservation are being attained. Indicators also enable policy-makers to ascertain whether existing policies are having the desired effects on biodiversity and to help clarify where problems exist in the current policy framework. Other uses include forecasting and projecting trends, negotiating and implementing regional and international treaties, and broad program planning. In these ways, indicators help determine priorities for action.

For maximum benefit, indicators should be based on data that are timely, accurate, of known quality, and available at both the level of decision-making (local, national, regional, global) and at biologically defined levels of observation, such as ecosystems or biogeographic regions. Traditionally, the highest quality and the most useful indicators are based on data from institutionalized monitoring programs, and their development and use involve solid scientific research, careful analysis, and effective reporting to the public.

Indicators are most valuable in the context of a specific policy concern or objective. Some of the ambiguity in the concept of biodiversity conservation results from disagreements over basic conservation objectives, which lead to the use of many different systems for measuring and monitoring biodiversity. If the objective is to minimize species extinctions, then a useful indicator would be changes in the number of species over time.

Alternatively, if the objective is to minimize the loss of species "diversity," where diversity encompasses both considerations of the number of species and their distinctiveness, then a measurement of the number of species would be insufficient. Using measures of species richness only, some would argue that the ocean has less biodiversity than the land because it has fewer species, while others—using a measure incorporating richness and distinctiveness—could argue that the ocean may be of comparable or greater diversity because of its diversity in higher taxonomic levels, both phyla and classes (Ray, 1988).

This paper presents a set of policy-relevant indicators of biodiversity conservation. Distinction is made between indicators needed to assess pursuit of the broadly stated biodiversity conservation concerns listed above and indicators that measure instrumental or management goals such as personnel, budgets, and the management of species and habitats. The numerous biodiversity indicators presented by Noss (1990), for example, are of greatest value at the level of the management of communities and species, while the indicators described in this paper are better used in provincial, national, regional, or global policy-making.

2.
MEASURING DIVERSITY

All three of the policy concerns listed at the beginning of Chapter 1 suffer from ambiguity associated with the term "diversity." Measurements of diversity and debates about their meaning filled a substantial fraction of the ecological literature for several decades, beginning in the 1950s, with no clear resolution emerging (Goodman, 1975). Thus, it is not surprising that there is no consensus yet on how "biodiversity" should be measured.

Defining Diversity

At the level of genes and species, two attributes are of primary concern: the number of elements (genes or species) and their distinctiveness. Measuring genetic diversity presents the least difficulty. Indirect measurements of diversity based on the relatedness of individuals have been used by population geneticists for decades, and these methods are complemented now by techniques ranging from electrophoresis to DNA sequencing (Falconer, 1981). So, techniques already available for measuring genetic diversity are able to provide the raw data needed for managing populations and making conservation decisions. However, such data have not been collected to any significant extent for wild populations, and their application is limited by an incomplete understanding of the relationship between genetic diversity, population dynamics, and species survival.

Measuring species diversity is more problematic. Often, species diversity is equated with species richness—the number of species in a given area or sample—but a more informative measure of diversity would incorporate the relatedness of the species involved. Using such a measure of "taxonomic richness," a region containing many closely related species would rank lower than one containing an equivalent number of distantly related species (May, 1990; Vane-Wright *et al.*, 1991; Williams *et al.*, unpublished manuscript).

For example, Vane-Wright *et al.* (1991) have developed measurements of taxonomic richness for various regions of the world based on the patterns of distribution and the relatedness of bumblebees in the *Bombus sibericus* group. They found that while a quadrant in Ecuador possesses the highest bumblebee species richness, a similar-sized area in China contains a much greater fraction of taxonomic richness and would be more important from the standpoint of conserving species diversity, all else being equal.

Effective methodologies for measuring

taxonomic richness are being developed only now (Cousins, 1991), and the data on species distributions needed to apply such methodologies to real conservation problems are still fragmentary. Moreover, the problem of developing a single measure of taxonomic richness that encompasses largely unrelated groups of species (say, primates, butterflies, and plants) promises to be challenging. Nevertheless, this type of measurement ultimately will improve our ability to set priorities and to monitor actions related to the conservation of species diversity.

In the absence of good measurements of taxonomic richness, the richness of genera or families may provide a somewhat more accurate reflection of species diversity than simple measurements of species richness. Measures of the richness of genera and families are commonly used when dealing with extinction at geological time scales. When complete information on species identity is unavailable (as in the fossil record or among many groups of invertebrates today) or when certain genera are particularly species-rich, measurements of richness at higher taxonomic levels may be a better reflection of the taxonomic diversity present. However, such measurements are not without their own problems; considerable subjectivity is involved in defining genera, and better studied taxa (such as plants and vertebrates) may be split into more genera than others.

Problems associated with measuring biodiversity at the community level are even greater. Any number of community attributes are components of biodiversity and may deserve monitoring for specific objectives. Nevertheless, given the importance of conserving communities and ecosystems, several "generic" measurements of community-level diversity can provide useful information to policy-makers.

Temporary though such patterns may be on a geological time scale, community classification schemes can be developed at many levels of resolution based on existing species distribution patterns. For example, biogeographic provinces have been defined for the world (Udvardy, 1975) and, at much more fine-grained scales, for specific countries, provinces, and regions. Community classifications provide a baseline for evaluating changes in the extent of natural communities. The fact that the baseline itself is shifting is not a major concern over time periods of decades; a bald-cypress swamp, for example, is a sufficiently distinct entity over time scales of a few hundred years to be useful in conservation planning.

Another approach is to establish classifications based primarily on the physical environment (soils, topography, and climate) and to monitor the extent to which relatively undisturbed communities exist across the range of diversity in the physical environment. Given the fundamental role of the physical environment in determining the composition of species in any region, this approach focuses on conserving the "arenas" of biological activity, rather than on the temporary occupants of those arenas (Hunter *et al.*, 1988). The existing worldwide classification scheme closest to this approach is the "ecoregion" map developed by Bailey (1989). To a much greater extent than biogeographic provinces, the definition of ecoregions relies heavily on physical attributes of the environment such as climate and soils.

For the development of indicators relevant for national and international policies, the approach of conserving arenas of biological activity has numerous advantages. Whether using biogeographic regions or ecoregions as the basic classification, the consistency of their definition and application at a global scale allows effective comparison of indicators among regions. The fine-grained community classification schemes developed for individual nations or regions cannot be compared easily at a global level. However, these fine-grained approaches are likely to be much more valuable for conservation planning at the subnational level.

The Issue of Scale

The issue of scale is implicit in the choice of indicators of community-level diversity, but it is also of major importance in developing indicators for species and genetic diversity. At a global scale, the loss of species diversity is equivalent to species extinction—the complete disappearance of the species. However, viewed from a national or local standpoint, the local disappearance of a species (extirpation) is of serious concern, even if the species has not become extinct globally.

Moreover, at the local level the rationale for biodiversity conservation is often somewhat different from the rationale globally, and some indicators may be more appropriate for local concerns than others. The rationale for biodiversity conservation can be divided into utilitarian values, such as economic, social, cultural, and scientific uses (both to meet current needs and to meet obligations to future generations), and the nonutilitarian or more strictly ethical values, such as knowing that society has conserved species for their own sake. From a global standpoint, both rationales are important. However, the rationale from a local standpoint often relates more directly to the utilitarian values. Moreover, considerations of the needs of future generations are likely to take a back seat to the urgent needs of today.

In developing indicators of biodiversity, two techniques to deal with the issue of scale were adopted: the use of indicators of both local extirpation and global extinction, and the presentation of measurements in both absolute numbers and percentages. Based on the absolute numbers of reptiles at risk, Madagascar, with 231 endemic reptiles and a massive loss of habitat, clearly represents a global concern, but based on the percentage of species at risk, a country like Germany, with only 12 reptile species, but 9 of which are threatened with extirpation (75 percent), is clearly in urgent need of action too. (OECD, 1991). (Of Madagascar's 256 total reptiles, only 12 are listed as threatened by the IUCN, although this probably understates the true level of threat because only a part of Madagascar's reptile taxa have been surveyed to determine their status.) Most species at risk of extinction today are found in tropical forests, but some islands have a much higher percentage of species at risk, and Mediterranean ecosystems may be a close second in terms of numbers of threatened species (Reid and Miller, 1989). The fact that a larger and growing proportion of freshwater fish are threatened with extinction, as compared to marine fish, may be helpful in promoting additional conservation action.

A second, scale-related problem in designing biodiversity indicators stems from the fact that politically defined regions are the sphere of decision-making, while biologically defined regions (such as biogeographic regions, life zones, or ecoregions) are the appropriate unit for analyzing the status of, and trends in, biodiversity. Ideally, planners and policy-makers should have access to data aggregated along both political and biophysical units. However, data are most readily obtained for political units, and this scale of measurement is likely to be the most useful one for policy-makers, even if it obscures important biological information. With the development of Geographic Information Systems (GIS) data bases over the next decade, it will become increasingly possible to present indicators that bear upon both political or biological regions. The unit of measurement is not specified in the following list of indicators. Most of them can be applied either to biologically or politically defined regions, depending on the availability of data.

A third issue is the time scale of the indicator. Some measurements change relatively slowly with time and thus may not provide the immediate information needed for policy and management decisions. For example, measurements of species extinction clearly indicate the success or failure of conservation actions, but they are obviously too late to help in preventing extinctions. Policy-makers need timely information that provides some sense of the relative seriousness and urgency of the actions needed. Such information may be a mix of "ultimate" indicators, such as species extinctions, and more time-sensitive (though often less definitive) ones, such as trends in population size.

3.

INDICATORS OF BIODIVERSITY

A minimum set of 22 indicators providing information useful for national and international policy makers is presented in Table 1 and discussed below. The table presents a matrix combining the major conservation concerns with a working set of indicators that can be used to assess long-term trends in the conservation of biodiversity. Thirteen of the indicators deal with wild species' and genetic diversity, four with community diversity, and five with domesticated species. Together, they comprise a basic set of indicators that can be used to understand better how well the goals of biodiversity conservation are being met, whether at local, national, regional, or global levels.

Indicators of Wild Species and Genetic Diversity

This section identifies and describes the thirteen indicators that have been developed to assess wild species' and genetic diversity.

1. Species richness (number of species, number of species per unit area, and number of species per habitat type)

Species richness is only a partial measure of species diversity, but it remains one of the most useful indicators of status and trends. Peru, for example, has approximately 1,705 species of birds, whereas the United States, a country seven times larger, has about 650 species (WCMC, 1992). Even so, measurements of species richness are hindered by the lack of data in much of the world: less than one out of five species—possibly as few as one out of a hundred—has been identified and named by scientists. As a result, species richness measurements generally focus on better-known taxa, particularly plants and vertebrates. Although this has the effect of weighting the indicators of diversity toward these groups, such weighting is sometimes appropriate because:

- plants and vertebrates tend to be of considerable direct importance to humanity
- areas with high species richness in these groups tend to have high species richness in other groups
- data on these taxa within a country are often available (estimates of population size have been made for some taxa)
- the diversity of plants in a region does not fluctuate significantly over short time intervals.

Table 1. Indicators of Biodiversity Conservation

Indicator	Biodiversity Conservation Concerns		
	Genetic Diversity	Species Diversity	Community Diversity
Wild Species' and Genetic Diversity			
1. Species richness (number, number per unit area, number per habitat type)	X	X	
2. Species threatened with extinction (number or percent)	X	X	
3. Species threatened with extirpation (number or percent)	X	X	
4. Endemic species (number or percent)	X	X	
5. Endemic species threatened with extinction (number or percent)	X	X	
6. Species risk index	X	X	
7. Species with stable or increasing populations (number or percent)	X	X	
8. Species with decreasing populations (number or percent)	X	X	
9. Threatened species in protected areas (number or percent)	X	X	
10. Endemic species in protected areas (number or percent)	X	X	
11. Threatened species in ex situ collections (number or percent)	X	X	
12. Threatened species with viable ex situ populations (number or percent)	X	X	
13. Species used by local residents (number or percent)	X	X	
Community Diversity			
14. Percentage of area dominated by nondomesticated species		X	X
15. Rate of change from dominance of nondomesticated species to domesticated species		X	X
16. Percentage of area dominated by nondomesticated species occurring in patches greater than 1,000 sq km		X	X
17. Percentage of area in strictly protected status		X	X
Domesticated Species Diversity			
18. Accessions of crops and livestock in ex-situ storage (number or percent)	X		
19. Accessions of crops regenerated in the past decade (percent)	X		
20. Crops (livestock) grown as a percentage of number 30 years before	X		
21. Varieties of crops/livestock grown as a percentage of number 30 years before	X		
22. Coefficient of kinship or parentage of crops	X		

Other methods for weighting species prior to measuring species richness may be useful in certain circumstances. For example, one indicator suggested by Duke (unpublished manuscript) scores the economic importance of biodiversity in given regions by tallying the genera present that are known to include economically important species. (*See Table 1.*) These "econgeners" of plants important for medicine, fiber, fodder, food, and chemicals are among the most likely to provide economically important products in the near future. For example, 22 percent of the genera of plants present at the Rio Palenque Science Center in Ecuador contain economically useful species (Duke, unpublished manuscript).

The number of species found in an area is, of course, related to the size of the area chosen for measurement. Larger areas may encompass many more community types and thus more species, even though the number of species per unit area may be the same or smaller. Therefore, for measurements of species richness to be useful in decision-making, sometimes they must be converted to standard areas of measurement (Reid and Miller, 1989). For example, the United States has a higher species richness of mammals (346) than Costa Rica (197). However, Costa Rica has far more mammal species per unit area than the United States (127 per 10,000 sq km, compared to 55 per 10,000 sq km). (The conversion of values to a common area should not be done with a simple (linear) scaling because of the exponential shape of the species area curve: see Reid and Miller, 1989). All else being equal, the protection of 100 sq km in Costa Rica likely would conserve more mammal species than in the United States, even though the United States has a greater number of mammal species overall.

Measurements of species richness also can be given for specific types of habitats (wetlands, savanna/grasslands, tropical forest, temperate forest, etc.). When used in conjunction with national maps of vegetation distribution, data on species per habitat type highlight areas of high diversity within countries. It should be noted that the sum of the number of species for all habitat types will exceed the total number of known species because of the double counting of species that use or are found in more than one habitat type.

2. Species (populations) threatened with extinction (number or percent)

3. Species (populations) threatened with extirpation (number or percent)

The number of species threatened with extinction is one of the most common indicators of the status of biodiversity, although in most developing countries such data are unavailable even for the best-known taxa. The threat of extinction, however, may be less important than the threat of local or national extirpation of a species from the standpoint of national or subnational policy-makers. For example, even though the bald eagle was not threatened with extinction globally, its near loss from the contiguous United States led to considerable political support for work to save and restore the species. As discussed earlier, for many purposes the *number* of species threatened with extinction or extirpation also must be supplemented by the *percentage* threatened. Representative data for the numbers of species known, endemic species, and globally threatened species are presented in Table 2.

Each of these indicators also can bear on genetic diversity if patterns of richness, extinction, and extirpation are examined at the level of genetically distinct populations. For example, 159 distinct populations of salmon in the Pacific Northwest of the United States are thought to be in danger of extirpation, but they comprise only 4 species, none of which is threatened with worldwide extinction (Knickerbocker, 1991).

4. Endemic species (number or percent)

5. Endemic species threatened with extinction (number or percent)

All species are endemic to a region, be that region a small island, a continent, or most of the world. Thus, information on levels of endemism can be somewhat misleading. For example, Cameroon, with only 156 of its 8,000 plant species (2 percent) endemic, has a much smaller proportion of endemic species than Zaire, with 3,200 out of 11,000 plant species (29 percent) endemic. But because the countries are very different in size (Zaire is five times larger), the difference in the percentage of endemism does not mean necessarily that species in Zaire are much more local in occurrence than those in Cameroon.

Table 2. Species Threatened With Extinction

	Mammals			Birds			Reptiles			Amphibians		
	Number of Species Known	Number of Endemics Known	Number of Globally Threatened Species (a)	Number of Species Known	Number of Endemics Known	Number of Globally Threatened Species (a)	Number of Species Known	Number of Endemics Known	Number of Globally Threatened Species (a)	Number of Species Known	Number of Endemics Known	Number of Globally Threatened Species (a)
Africa												
Algeria	92	1	12	192	1	15	X	3	0	X	0	0
Botswana	154	0	9	569	0	6	143	2	1	36	1	0
Kenya	309	10	17	1,067	7	18	187	15	2	88	10	0
Mali	137	0	16	647	0	4	16	2	2	X	1	0
Rwanda	151	0	11	669	0	7	X	1	2	X	0	0
Zaire	415	25	31	1,086	23	27	X	33	2	X	53	0
Americas												
Brazil	394	68	40	1,573	191	123	468	172	11	502	294	0
Chile	91	11	9	432	15	18	78	33	0	39	25	0
Costa Rica	205	8	10	848	6	14	214	17	2	162	34	0
Jamaica	22	3	5	159	25	2	X	25	3	X	18	0
Mexico	439	136	25	961	88	35	717	368	16	284	169	4
United States	346	93	27	650	69	43	X	X	25	X	122	22
Asia/Oceania												
Australia	282	210	38	571	351	39	700	616	9	180	169	3
China	394	62	40	1,100	63	83	282	X	7	190	131	1
India	317	38	39	969	69	72	389	156	17	206	110	3
Iraq	81	1	9	145	1	17	81	X	0	6	0	0
Papua New Guinea	242	49	5	578	54	25	249	X	1	183	100	0
Philippines	166	90	12	395	172	39	193	131	6	63	44	0
Europe												
France	93	0	6	267	9	21	32	0	2	32	3	1
Greece	95	2	4	244	0	19	51	4	3	15	1	0
Netherlands	55	0	2	187	0	13	7	0	0	16	0	0
Poland	85	0	4	224	0	16	9	0	0	18	0	0
U.S.S.R.	276	55	20	X	13	38	168	X	3	37	2	0

Source: World Conservation Monitoring Centre, 1992.

Notes: Countries were chosen to be generally representative of the world's major ecosystems.
Globally threatened species numbers do not include species that are threatened only in certain countries of their ranges.
a. Includes naturally rare species. X = Not available.
For additional information, see the Appendix - Sources and Technical Notes for Tables.

This pattern still would result even if all of the species in the two countries had ranges of identical size because proportionately fewer of the ranges of the species in the larger country would extend past its border (giving it a higher ratio of endemics to nonendemics). Nonetheless, levels of endemism are useful statistics because they reveal nations, ecosystems, or communities that are particularly distinctive biologically. As with species richness, however, it is often more appropriate to express levels of endemism on a per unit area basis. Myers (1988, 1990) uses such a measure in his analysis of potential biodiversity "hot spots" by examining the percentage of endemic species in relation to the percentage of land area involved. Conservation actions in sites with a high number of endemic species relative to the land area are likely to be most efficient in conserving species diversity. Vane-Wright *et al.* (1991) note that measures of taxonomic richness can provide an even more efficient means of making conservation decisions, but measurements of endemism are more readily available today.

6. Species Risk Index

A Species Risk Index combines information on endemic species within a community and on the status of that community in order to provide insights into the status of species, even in the absence of detailed threatened species lists. The index is calculated by multiplying the number of endemic species (per unit area) in a community by the percentage of the natural community that has been lost. Thus, an ecological community with many endemics and with a high proportion of its area lost would be ranked at high risk, while a community with few endemics or one that has experienced little conversion would be ranked at low risk.

The application of this index is demonstrated for seven biogeographic units for which MacKinnon and MacKinnon (1986a) provide data on the endemism of plants, birds, and mammals (*see Table 3*). To calculate the index, the number of endemic species was converted to a per-unit-area basis, using a species-area curve. The slope of the species-area curve, determined by the exponent z, varies from region to region because of differences in the number of habitats present. Empirical studies of the species-area relationship have found that the z value typically varies from 0.15 to 0.35. Therefore, a midpoint of 0.25 was chosen for calculations for the Species Risk Index (Connor and McCoy, 1979; Simberloff, 1986). The species-area curve is expressed as:

$$S = cA^z$$

where S is the number of endemic species as listed in MacKinnon and MacKinnon (1986a), A is the area of the biogeographic unit, c is a constant, and z is the exponent. Solving for c and then substituting this value into the same equation (but using a standard area) gives:

$$S_s = (S_1\ A_s^z)/A^z$$

where S_s is the number expected per standard area, and A_s is the standard area (100,000 sq km). Multiplying this by the percentage of the biogeographic unit that has been converted yields the Species Risk Index values shown in Table 3. The Philippines, because of its large number of endemic species and relatively high fraction of community lost, is at the highest risk. Borneo and Sulawesi also rank high because of their large number of endemics, even though they have lost less habitat than most of the other regions.

7. Species (populations) with stable or increasing populations (number or percent)

8. Species (populations) with decreasing populations (number or percent)

Some countries have developed "Red Lists of Threatened Species," documenting native species at risk of extirpation or extinction. Diamond (1988) has proposed the establishment of "Green Lists" to document species for which adequate information is available to know that populations are *not* in jeopardy. Such lists could be extremely

Table 3. Species Risk Index

Biogeographic Unit	Country Containing the Unit	Original Natural Area (sq km)	Percent of Original Area Lost	Number of Endemic Species in Original Area	Endemics per 100,000 sq km (a)	Species Risk Index
Philippines	Philippines	293,194	79	416	318	251
Borneo	Indonesia	735,148	31	392	238	74
Sulawesi	Indonesia	187,882	41	191	163	67
Lesser Sunda	Indonesia	84,092	77	83	87	67
Malay Peninsula	Malaysia	198,482	56	134	113	63
Java/Bali	Indonesia	127,152	91	73	69	63
Sumatra	Indonesia	470,941	59	126	86	50

Sources: MacKinnon and MacKinnon, 1986 and World Resources Institute, 1990.
Note: The Species Risk Index is calculated from percent community loss and the number of plant, mammal, and bird endemics per unit area (see the text for details).
a. Calculated using a species-area curve to determine the expected number of species in a given area (for details see the Appendix - Sources and Technical Notes for Tables).

valuable as an indicator of the status of species diversity. In addition, a timely "National Green List of Monitored Species" would indicate the state of knowledge of particular species and the need for expanded ecological research. (*See Table 3.*) Several industrialized countries have begun to report on the percentage of species (mammals, birds, reptiles, amphibians, fish, invertebrates, and vascular and other plants) with decreasing populations (OECD, 1991).

Population trends provide one means for analyzing the status of a species well before it is threatened with extinction. Unfortunately, the costs of obtaining population information on a large number of species are generally prohibitive, although exceptions do exist. For example, the U.S. Fish and Wildlife Service assembles population trends of many breeding bird species in the United States based on yearly sample surveys (Droege and Sauer, 1989). A similar program is under way in the United Kingdom.
The existence of such data sets allowed the discovery of significant declines in populations of temperate migratory songbirds wintering in tropical forests, apparently due in part to the loss of habitat in their winter range (Robbins et al., 1989; Terborgh, 1990). Such data sets also can provide information on rapidly increasing populations and expanding ranges of exotic species, such as the African cattle egret (CEQ, 1981; 1990).

Population monitoring is more affordable when only a few indicator species are tracked. Candidates may include keystone species, those of particular importance to ecosystem function; species with large range requirements, whose survival assures that the habitat requirements of smaller-ranging species are protected; and species particularly sensitive to ecological change. Because of differences between ecosystems, a good indicator species for one region is not necessarily suitable for another. Therefore, data on the population trends of indicator species generally are not comparable between ecoregions or countries.

9. Threatened species in protected areas (number or percent)

10. Endemic species in protected areas (number or percent)

11. Threatened species maintained in ex-situ collections (number or percent)

12. Threatened species with viable (reproducing) ex-situ populations (number or percent)

Protected areas and *ex-situ* conservation centers are key tools used in the conservation of biodiversity. The coverage of known threatened or endemic species in protected areas is a useful baseline indicator of the potential conservation role of these areas. Particularly for locally endemic species that are restricted naturally to small areas, their presence in a protected area may ensure their conservation, barring significant environmental changes. However, the presence of threatened species in a protected area does not indicate that they are safe from extinction.

Biodiversity conservation involves the close linkage of *ex-situ* and *in-situ* conservation. Ideally, species threatened with extinction in the wild would be maintained *ex-situ* as insurance until the wild population stabilized. For example, a breeding population of the golden lion tamarin, threatened in its native habitat in the Atlantic forest of Brazil, is being maintained in zoos, and offspring from the captive population are being reintroduced to supplement the wild population. This demonstrates how indicators of the coverage of *ex-situ* conservation are important complements to indicators bearing on *in-situ* conservation.

These few management indicators provide only the minimum set needed for monitoring the effectiveness of specific conservation tools. In particular, information on the status of the management of protected areas, zoos, and botanic gardens would be essential, as would be information on pollution, harvest, and species introductions. In addition, for those indicators ofthe status of species in protected areas (indicators 9 and 10), estimates of whether these populations are viable are also extremely valuable. However, such information is available at present for very few species only and is costly to obtain. Except for individual species of special concern, the acquisition of such data on a broad scale is unlikely.

13. Species used by local residents (number or percent)

The dependence of local residents on biodiversity is an important factor influencing opportunities for its conservation. Where people continue to utilize a variety of wild species for food, medicine, and building materials, the local benefits to be derived from maintaining that diversity are likely to be high. Where such use is low, both local knowledge of biodiversity and the incentive for its conservation will be low as well. An example of data on the percentage of tree species used locally in various regions of the Amazon basin is presented in Table 4. Such an indicator also could be used to compare dependence on biodiversity among gender or age groups.

Indicators of Community Diversity

Indicators of community diversity that can be used at international and global levels are fewer in number and in general are less developed than species indicators.

14. Percentage (extent) of area (province/nation/ecoregion) dominated structurally by nondomesticated species

15. Rate of change from structural dominance of nondomesticated species to domesticated species

16. Percentage (extent) of area (province/nation/ecoregion) dominated by nondomesticated species occurring in patches greater than 1,000 sq km

Traditionally, the status of communities or habitats has been evaluated by a measurement of the remaining natural area. Rarely, however, is "natural" defined. A natural community generally is assumed to be one undisturbed by humans. Arguably, however, all communities have been altered substantially by human activity over the past several thousand years, so the range of human

Table 4. Tree Species Used by Local Amazonian Residents

Country	Life Zone	Forest Type	Amazonian Community Name	Average Number of Tree Species per Hectare	Average Number of Tree Species Used per Hectare	Percent of Tree Species Used	Source
Brazil	Tropical dry forest	Managed	Kayapo	120 {a}	118 {a}	98	Anderson and Posey, 1989.
Brazil	Tropical moist forest	Managed	Ribereno Isla das Oncas {b}	28	25	89	Anderson and Posey, 1989.
Bolivia	Premountain tropical moist forest	Unmanaged	Chacobo	94	74	79	Prance et al., 1987.
Brazil	Tropical moist forest	Unmanaged	Ribereno Isla das Oncas {b}	53	42	79	Anderson and Posey, 1989.
Brazil	Tropical moist forest	Unmanaged	Ka'apor	99	76	77	Prance et al., 1987.
Brazil	Tropical moist forest	Managed	Tembe	119	73	61	Prance et al., 1987.
Peru	Tropical moist forest	Managed	Ribereno San Rafael {b}	158 {c}	95 {c}	60	Pinedo-Vasquez et al., 1990.
Venezuela	Tropical moist forest	Unmanaged	Panare	70	34	49	Prance et al., 1987.
Peru	Tropical moist forest	Unmanaged	Ribereno Mishana {b}	250	72	26	Peters et al., 1989.

Source: Manuel Winograd, World Resources Institute.

Notes: Average number of tree species and tree species used are based on surveys of trees over 10 cm diameter at breast height.

a. Includes shrubs, vines, and tree species under 10 cm diameter at breast height.
b. Heterogenous population of detribalized Indians and mestizos.
c. Data are for a 7.5 hectare parcel.

impacts on ecosystems prevents a clear distinction between "natural" and "disturbed" systems. For this reason, this traditional dichotomy is avoided herein. Instead, distinguishing land dominated structurally by domesticated species from that dominated by nondomesticated species is recommended. For example, if land is divided evenly into categories of agricultural land, timber plantations, secondary forest, and primary forest, the indicator would show that 50 percent of the region is dominated by nondomesticated species. For terrestrial ecosystems, the use of domesticated versus nondomesticated categories (croplands, improved pasture and range, forest plantations, and aquaculture) also lends itself to analysis from remote sensing. However, the categories would be of less use in either marine or freshwater environments. Representative community indicators based on the extent and loss of nondomesticated habitats, are presented in Table 5.

Appropriate baselines for such measurements differ, depending on the scale of analysis. For evaluating the status of community diversity at subnational levels, detailed community classification schemes are generally most useful. Such classifications allow the incorporation of ecologically relevant attributes into the classification of the community (such as the distinction between an old-growth redwood forest community and a second-growth community). But, as discussed earlier, in order to develop indicators relevant at national and international levels, it usually is more convenient to use coarse-grained but comprehensive systems such as ecoregions (or, less desirably, biogeographic provinces). Ideally, rates of change, rather than merely percentage of change should be analyzed over a long period of time. Only with this kind of indicator, which requires periodic monitoring, will it be possible to assess the effectiveness and efficiency of conservation practices and policies.

The fragmentation of a biological community has a significant influence on the numbers and types of species that can be supported. While the exact relationship between the number and size of natural areas and the number of species conserved depends strongly on local habitat and species distribution patterns, in general, larger areas are likely to contain viable populations of more species. But even extremely large nature reserves (10,000 sq km, for example) are thought to be too small to maintain populations of large mammals indefinitely (Frankel and Soulé, 1981; Shaffer, 1987). In the absence of a clear scientific understanding of the effects of patterns of fragmentation on species persistence, a relatively simple indicator of fragmentation based on the fraction of the remaining habitat dominated by nondomesticated species in "large" tracts (greater than 1,000 sq km) is proposed. Although this area is less than sufficient for the long-term survival of all of the species, the choice of a larger area would provide relatively little more information since few areas of such size remain. For example, only 10 percent of the protected areas in the Indo-Pacific region exceed 1,000 sq km in size (Dinerstein and Wikramanayake, 1993).

17. Percentage (extent) of area (province/nation/ecoregion/community type) in strictly protected status

A traditional objective of the establishment of protected areas has been to maintain representative samples of biological communities (McNeely and Miller, 1984). This goal has always been problematic, given both the subjectivity in defining communities and their ephemeral nature. Nevertheless, since communities can be defined and monitored meaningfully over periods of decades or even centuries, the conservation of representative samples of biologically defined communities is a reasonable target of conservation efforts. For longer-term conservation considerations, the representative sample approach might be better described as maintaining a representative arena of biological activity.

In either case, the coverage of protected areas is a useful indicator of the status of community conservation efforts. (*See Table 6.*) Protected areas

Table 5. Extent and Loss of Nondomesticated Habitat

	Forest		Savanna/ Grassland		Desert/ Scrub		Wetlands/Marsh		Mangroves	
	Current Extent (sq km)	Percent Lost	Current Extent (sq km)	Percent Lost	Current Extent (sq km)	Percent Lost	Current Extent (sq km)	Percent Lost	Current Extent (sq km)	Percent Lost
Africa										
Algeria	X	X	X	X	X	X	7,296	X	X	X
Botswana	112,926	62	122,470	53	0	0	23,310	10	X	X
Kenya	22,738	71	276,816	43	0	0	0	0	930	70
Mali	76,700	78	83,676	80	0	0	20,000	X	X	X
Rwanda	1,840	80	1,570	90	0	0	800	X	X	X
Zaire	832,548	57	54,050	30	0	0	2,150	50	1,250	50
Americas										
Brazil	X	X	X	X	X	X	296,903	X	25,000	X
Chile	X	X	X	X	X	X	88,267	X	X	X
Costa Rica	X	X	X	X	X	X	818	X	390	X
Jamaica	1,841	X	X	X	X	X	138	X	70	X
Mexico	384,608	66	X	X	1,000,000	X	32,640	X	6,600	X
United States	2,994,780	26	30,000	~100	X	X	870,000	54	X	X
Asia/Oceania										
Australia	420,000	X	4,100,000	X	5,500,000	X	17,000	~95	11,617	X
China	X	X	X	X	3,916,800	X	42,000	X	X	X
India	499,285	78	0	0	85,266	88	9,408	79	1,894	85
Iraq	X	X	X	X	X	X	19,205	X	X	X
Papua New Guinea	X	X	28,000	X	X	X	50,000	X	6,000	X
Philippines	63,429	79	0	0	0	0	13,220	X	777	61
Europe										
France	X	X	X	X	X	X	11,714	X	0	0
Greece	80,940	70	X	X	X	X	865	X	0	0
Netherlands	X	X	X	X	X	X	3,534	X	0	0
Poland	X	X	X	X	X	X	1,942	X	0	0
U.S.S.R.	X	X	X	X	X	X	28,372	X	X	X

Source: World Resources Institute (1990).

Notes: Habitat loss covers the period between preagricultural times and the present.
Countries were chosen to be generally representative of the world's major ecosystems.
X = Not available.
For additional information, see the Appendix: Sources and Technical Notes for Tables.

Table 6. Protected Areas

	National Protection Systems							International Protection Systems						
	Protected Areas (IUCN Categories I-V)			Strictly Protected Areas (IUCN Categories I-III)		Partially Protected Areas (IUCN Categories IV, V)		Biosphere Reserves		Wetlands of International Importance		Marine and Coastal Protected Areas		Number of Natural and Mixed Heritage Sites
	Total Area (000 ha)	Number of Sites	Percent of Land Area Protected	Total Area (000 ha)	Number of Sites	Total Area (000 ha)	Number of Sites	Total Area (000 ha)	Number of Sites	Total Area (000 ha)	Number of Sites	Total Area (000 ha)	Number of Sites	
Africa															
Algeria	11,898	19	5.0	11,787	12	110	7	7,200	1	5	2	2	1	1
Botswana	10,025	9	17.2	8,787	4	1,238	5	X	X	X	X	X	X	X
Kenya	3,347	36	5.8	3,277	30	70	6	851	4	19	1	7	3	0
Mali	889	7	0.7	350	1	539	6	771	1	162	3	X	X	1
Rwanda	327	2	12.4	327	2	0	0	15	1	X	X	X	X	X
Zaire	8,827	9	3.8	8,794	8	33	1	298	3	X	X	0	0	4
Americas														
Brazil	20,525	162	2.4	13,906	90	6,619	72	X	X	X	X	2,032	20	1
Chile	13,650	65	18.0	8,378	32	5,271	33	2,407	7	5	1	10,050	32	0
Costa Rica	606	28	11.9	476	17	130	11	729	2	X	X	194	7	1
Jamaica	0	0	0.0	0	0	0	0	X	X	X	X	0	0	0
Mexico	9,420	61	4.8	2,223	47	7,197	14	1,288	6	47	1	1,119	11	1
United States	98,342	968	10.5	38,471	304	59,871	664	19,108	43	1,116	8	54,317	107	9
Asia/Oceania														
Australia	45,654	728	5.9	29,575	355	16,079	373	4,743	12	4,478	39	13,035	184	8
China	21,947	289	2.3	101	4	21,846	285	1,819	7	X	X	1,184	20	2
India	13,481	359	4.1	3,525	59	9,956	300	X	X	193	6	474	14	5
Iraq	0	0	0.0	0	0	0	0	X	X	X	X	0	0	0
Papua New Guinea	29	5	0.1	7	3	22	2	X	X	X	X	0	0	X
Philippines	584	28	1.9	237	15	347	13	1,174	2	X	X	31	5	0
Europe														
France	4,779	81	8.7	278	9	4,501	72	503	5	85	1	849	27	1
Greece	104	20	0.8	71	10	33	10	9	2	107	11	84	13	2
Netherlands	355	68	9.5	230	26	125	42	X	X	306	11	54	10	X
Poland	2,230	78	7.1	135	13	2,095	65	26	4	7	5	73	4	1
U.S.S.R.	24,074	176	1.1	23,802	170	272	6	10,891	20	2,987	12	4,925	22	0

Sources: World Conservation Monitoring Centre and World Resources Institute, 1992.
Notes: Countries were chosen to be generally representative of the world's major ecosystems.
X = Not available or not applicable.
For additional information, see the Appendix: Sources and Technical Notes for Tables.

are divided into eight categories by The World Conservation Union (IUCN) in order to reflect different management objectives. Categories I through III are referred to as "totally protected areas": scientific reserves, national parks, and natural monuments. Categories IV through VIII focus on controlled resource exploitation: managed nature reserves, protected landscapes, resources reserves, anthropological reserves, and multiple-use areas. Coverage of totally protected areas is the most relevant measure of the status of biodiversity, although overall protected area coverage is useful too. Ideally, coverage should be expressed both as a fraction of a specific type of community, biogeographic region, or ecoregion and as a fraction of a nation (or other relevant political unit). Marine protected areas should be included in such indicators (and, at the global level, international protected areas such as that proposed for Antarctica as well), but they should be disaggregated from terrestrial and coastal areas.

The U.S. Fish and Wildlife Service's Gap analysis project offers one approach to calculating the extent of each community type under protected status. This analysis overlays state vegetation maps at the 1:100,000 or 1:250,000 scale with maps of protected areas and species distribution (Noss, 1992). Although the project's goals are management-oriented—identifying gaps in the protection of species and communities—the resulting data can serve as indicators of the area and the percentage of community types afforded protection, provide information on habitat fragmentation, and identify species-rich areas.

Indicators of Domesticated Species

Although clearly components of biodiversity, domesticated species are often overlooked in assessments of the status of, and trends in, biodiversity. Several of the most important indicators of biodiversity conservation among domesticated species are:

18. *Accessions of crops and livestock in ex-situ storage (number or percent)*

19. *Accessions of crops regenerated in the past decade (percent)*

The most common indicator of the status of *ex-situ* collections of domesticated species is the number and percentage of accessions for each crop or livestock species. Each accession represents a single collection from a population of the species; for example, from one farmer's field. Though valuable, the number of accessions is not a sufficient indicator of the diversity of land races or breeds that is maintained *ex-situ*. A much more useful statistic would be the number of accessions of distinct varieties as a percentage of the varieties in existence. At the present time, however, such data are not being collected, and estimates of the coverage of genetic diversity generally rely on the best guesses of experienced collectors (Lyman, 1984; Plucknett *et al.*, 1987).

The number of accessions held in a gene bank does not indicate the status of those accessions. In some cases, as much genetic diversity may be lost in gene banks as in the field (Keystone, 1991). The principal cause of the loss of diversity in gene banks is the failure to regenerate samples while they remain viable; this needs to be done every 10 years on average. Thus, a useful indicator of the status of collections in crop gene banks would be the percentage of accessions in a collection that has been grown out in the past decade. For example, the United States National Plant Germplasm System holds some 388,000 accessions; this number is projected to grow to 453,000 accessions by 2001. Over the past five years, 33,000 accessions have been grown out annually. At this pace, about 85 percent of the collection would have been regenerated in the previous decade.

20. *Crops (livestock) grown in an ecoregion or a nation as a percentage of the number grown 30 years previously*

21. *Varieties of each crop (livestock) grown in an ecoregion or a nation as a percentage of the number grown 30 years previously*

22. Coefficient of kinship or parentage of crops

At present, indicators for domesticated species bear only on the status of biodiversity *ex-situ*. This bias reflects the history of the global response to the loss of crop and livestock genetic diversity, which involved primarily an effort to preserve samples of germplasm *ex-situ* before they vanished. These indicators need to be supplemented by measurements of *in-situ* status. The status of diversity in fields has a direct bearing on the vulnerability of individual crops to disease and pests as well as on the vulnerability of regional economies and households to market or environmental changes.

One useful indicator is a comparison of the number of crops grown currently in a region with the number grown 30 years previously. Many traditional agricultural systems rely on a great diversity of crops. The Huastec Indians in Mexico, for example, manage some 300 species in their agricultural and forest plots and home gardens (Alcorn, 1984). Similarly, residents of the Bungoma district of Kenya use at least 100 different species of fruits and vegetables in their diets (Juma, 1989a). But these diverse cropping systems are often lost when cash crop economies are introduced. Too great a simplification of cropping systems may increase the vulnerability of local economies. Moreover, information on the loss of locally important crops is important to ensure that *ex-situ* conservation strategies can be implemented where needed.

Another important indicator is varietal diversity within individual crops. For example, the number of varieties of hard red winter wheat being grown in the United States increased from 5 in 1919 to 164 in 1984 (Cox *et al.*, 1986). From an agronomic standpoint, the number of varieties of a crop being grown in a region provides important information about the potential vulnerability of the crop to outbreaks of disease. In 1970, the U.S. corn crop suffered losses worth $1 billion when a leaf fungus spread through the genetically uniform crop (Tatum, 1971). In addition, a heterogeneous array of crop varieties allows their continuing evolution in response to predators and pests and thus helps to maintain the genetic diversity upon which future agricultural productivity depends.

However, the number of varieties being grown does not provide a complete assessment of the actual genetic diversity among the varieties. If all of the varieties descended recently from a common parent, then genetic diversity may be quite low. One means of incorporating information on the lineage of the varieties being grown is to calculate a coefficient of kinship or parentage for the various varieties. Coefficients of kinship and parentage—routine measurements in population genetics—indicate the probability that a pair of alleles drawn at random from the same locus in two individuals will be autozygous (identical by common descent) (Falconer, 1981). A high coefficient would be obtained if one variety were extremely common, or if all varieties grown shared a similar lineage. For example, Cox *et al.* (1986) calculated coefficients of parentage for soft red winter wheats and hard red winter wheats in the United States. For soft red winter wheat, they found that the uniformity of varieties increased significantly during the 1970s, but then dropped sharply in the 1980s. In hard red winter wheat, uniformity declined sharply from 1919 to 1949 and has decreased gradually since that time. Despite a 126 percent increase in the number of cultivars between 1959 and 1979, the genetic diversity increased only slightly during that period due to the close relatedness of the varieties released.

4.
Data Availability

Having established a framework for assessing biodiversity conservation goals and having identified indicators, the next question is: Are the data available? Do we know what species are being monitored and have been over time? Do countries maintain timely accurate statistics on their domesticated species, nondomesticated species, communities, and protected areas? On cropping patterns, varieties grown, and seed banks? Are these data available in time series, which can be used to calculate rates of change? How accurate are the data? Have species and community data been georeferenced to ecoregion, other biogeophysical delineations, and to local, national, and regional boundaries? And, finally, are the data accessible in standard reports, data tables, and electronic form for use by policy-makers and the public?

It is beyond the scope of this paper to provide detailed answers. For a review of existing data, readers are referred to *Global Biodiversity Status of the Earth's Living Resources* (WCMC, 1992), the first comprehensive sourcebook of information on this topic. Instead a simple ranking of the data available for wild species' and genetic diversity is provided in Table 7, for community diversity in Table 8, and for domesticated species in Table 9. Using the basic indicators associated with species, communities, and *ex-situ* facilities, Tables 7-9 indicate the degree of availability in terms of the completeness of the data (particularly taxonomic coverage), country coverage, time series, and quality. In the discussion below, some of the major sources for data at the global and national levels, including a few of the more accessible reports and data bases, are given.

Wild Species

Numbers of Species (Indicator 1). It is estimated that, at most, only one of five species has been named and described. However, the percentage of vertebrates and plants described is much higher than the overall average—between 80 percent and 90 percent. Based on its existing data base, the World Conservation Monitoring Centre (WCMC) is able to compile numbers of mammalian species for about two-thirds of all countries, bird species for about three-fourths of the countries, and reptiles and amphibians for 40 percent of the countries. For vascular plants, WCMC can tabulate numbers of taxa (species and subspecies) for about 145 countries (WCMC, cited in WRI, 1988). Very few data are available on invertebrate distribution. WCMC has assembled a complete data base on swallowtail butterflies. WCMC also has data on the numbers of land mollusks and several other invertebrate taxa found in European countries. Information on species richness at subnational levels is available only for

Table 7. Data Availability and Coverage for Biodiversity Conservation Indicators: Wild Species and Genetic Diversity

Indicator	Country Coverage		Time Series		Completeness of Data		Quality of Data (Rank)
	Rank	Notes	Rank	Notes	Rank	Notes	
1. Species richness (number)	2	Mammals: available for 2/3 of countries. Birds: available for 3/4 of countries. Reptiles & amphibians: available for 40% of countries. Invertebrates: selected taxa only. Vascular plants: available for approx. 145 countries.	4	Some information on extinctions for island nations and for some megafauna and bird species.	2-3	Incomplete for invertebrates and some aquatic vertebrate taxa.	3
2. Species threatened with extinction (global) and 3. Species threatened with extirpation (national)	3	Global status: data available for all countries. National status: data available for a limited number of OECD countries only. No data for invertebrates (global or national).	3	Limited to megafauna.	3	Global status: mammals: 50% of taxa assessed birds: 100% of taxa assessed reptiles: 15% of taxa assessed amphibians: 10% of taxa assessed vascular plants: 10% of taxa assessed	3
4. Endemic species and 5. Endemics threatened with extinction	2	Vascular plants: available for about 115 countries. Some country data for mammals, birds, reptiles, amphibians, and swallowtail butterflies.	N/A		2	Incomplete for invertebrates and aquatic vertebrate taxa.	2
6. Species Risk Index		(Composite index. See rankings and notes for relevant indicators.)					
7. Species with stable and increasing populations and 8. With decreasing populations	3	Limited to selected taxa in countries dominated by grassland and temperate forest habitats.	3	Limited to a few endangered megafauna, some game and bird species.	3	Limited to a few endangered megafauna, some game and bird species.	3
9. Threatened species in protected areas	3-4	Available for a few individual protected areas.	4		4		
10. Endemic species in protected areas	3-4	Available for a few individual protected areas.	4		4		
11. Threatened species in ex-situ collections and 12. threatened species with viable ex-situ populations	2		2		2	Major zoos/botanical gardens only.	2
13. Species used by local residents	3-4	Limited to special studies.	4		4		4

Sources: World Resources Institute and World Conservation Monitoring Centre staff.
Ranking Legend: 1 = good; 2 = moderate; 3 = poor; 4 = nonexistent or unavailable.

Table 8. Data Availability and Coverage for Biodiversity Conservation Indicators: Community Diversity

Indicator	Country Coverage		Time Series		Completeness of Data		Quality of Data (Rank)
	Rank	Notes	Rank	Notes	Rank	Notes	
14. Percentage of area dominated by nondomesticated species and 15. Rate of change							
i) Bailey, Udvardy, Holdridge, Olson and Watts maps	3	Best used at regional scale.	4		2	Indicates only expected vegetation cover.	2
ii) FAO land use data	1	Available for all countries.	1	Annual from 1950s.	3	Problems in adapting FAO land-use data to a habitat indicator.	3
iii) MacKinnon-based data	3	MacKinnon data only available for Neotropical and Malayan realms.	3	Original vs. current habitat extent only.	2	Comparability problems in combining MacKinnon data with separate country studies.	2
iv) Houghton et al. data	4	Regional only.	1	Ten-year estimates from 1850.	3	Composite from above sources. Limited land-use classes.	2
v) Matthews map	3	Regional only.	3	Preagricultural era to present extent only.	2	Limited by scale.	2
vi) IUCN/WCMC tropical forest atlases	2	Asian and African atlases have been published, Latin American atlas in preparation.	3	Original vs. current habitat extent for Asia and Africa.	3	Limited to tropical forest cover.	?
16. Percentage of area dominated by nondomesticated species occurring in patches	3	Available for 6 West African countries.	4		3	Forest area only.	3
17. Percentage of area in strictly protected status	1	Good coverage for extent of national protected areas.	2		3	Incomplete for local and provincial areas.	2

Sources: World Resources Institute and World Conservation Monitoring Centre staff.
Ranking Legend: 1 = good; 2 = moderate; 3 = poor; 4 = nonexistant or unavailable.

Table 9. Data Availability and Coverage for Biodiversity Conservation Indicators: Domesticated Species

Indicator	Country Coverage		Time Series (Rank)	Completeness of Data		Quality of Data (Rank)
	Rank	Notes		Rank	Notes	
18. Accessions of crops in ex-situ storage	1		2	1	Except for data on nongovernmental organization seedbanks.	1
19. Percentage of accessions regenerated	3		3	3		3
20. Number of crops grown	3	Indigenous use of crops not well documented.	4	4	Crops of widespread importance only.	4
21. Number of varieties grown	3	OECD countries only.	4	3-4	Some crops in OECD countries.	3-4
22. Coefficient of kinship or parentage of crop	4		4	4		4

Sources: World Resources Institute and World Conservation Monitoring Centre staff.
Ranking Legend: 1 = good; 2 = moderate; 3 = poor; 4 = nonexistent or unavailable.

certain countries and, in very few cases, such data have been georeferenced for use in a Geographic Information Systems (GIS). (The GIS, developed by the International Council for Bird Preservation in Cambridge, United Kingdom for its work on centers of avian endemism, is one notable exception.)

Habitat distribution has been defined for the known bird species of the world, which would allow a breakdown of threatened and endangered species by broad habitat type (Sibley and Munroe, 1990). Similar data for mammals are available for South America only. Mares (1992) classified mammal species by six habitat types: lowland Amazon forest, western montane forest, Atlantic rain forest, upland semideciduous forest, southern mesophytic forest, and drylands. WCMC's data fields on species generally do not include information on habitat distribution because of a lack of consensus on which habitat classification system to use.

Extinction (Indicator 2). Although more countries report on species status as compared to species numbers, these data are much less reliable. Approximately 50 percent of mammalian taxa have been surveyed for global endangered status, 100 percent of bird taxa, 15 percent of reptile taxa, 10 percent of amphibian taxa, and 10 percent of vascular plant taxa. At latest count, approximately 60 percent of countries and territories had compiled Red Data Books (lists of endangered and threatened species) for plants. These lists vary considerably in their completeness: WCMC estimates that about 45 countries have complete lists, 65 countries have completed a considerable amount of work for a number of selected families or groups, and 83 countries have preliminary data only. Species listed in Appendix 1 of CITES (an international treaty regulating trade in rare and threatened species) provide another indication of species at risk.

Extirpation (Indicator 3). Data for species threatened with extirpation within a given country are available for a number of industrialized countries, as reported in the OECD *Environmental Data Compendium* (OECD, 1991). Measures of threatened species are considered by most analysts to be very poor and usually understated because they are based on attempts by governments to identify and list threatened species that have to meet administrative as well as biological criteria. On the other hand, in a few cases naturally rare species may be included incorrectly in lists of endangered species.

Endemism and Species Risk Index (Indicators 4, 5, and 6). Data summarizing the numbers of plants endemic to specific countries are available for about 115 countries. *Global Biodiversity Status of the Earth's Living Resources* (WCMC, 1992) includes similar information for mammal, bird, reptile, and amphibian taxa. As with information on species richness, range information needed to permit the evaluation of patterns of endemism at a subnational level either does not exist or is not georeferenced adequately to specific locations within countries. Therefore, it is difficult to use at the level of ecoregions, states, or provinces. For the use of the Species Risk Index, information is needed on patterns of community coverage at a subnational level and patterns of endemism within community or ecosystem types. With the exception of the studies by MacKinnon and MacKinnon (1986a, 1986b), such data are not widely available yet.

Population Trends (Indicators 7 and 8). Data on population dynamics are available for selected species such as game, endangered megafauna (for example, rhinoceroses and whales), and data from bird counts. The data that have been compiled for industrialized countries are far more comprehensive than those available for developing countries.

Species Occurrence in Protected Areas (Indicators 9 and 10). WCMC text files on protected areas provide data (of variable quality) on species found in many national parks and reserves, including some information on endemism.

Communities

Area Dominated by Nondomesticated Species (Indicators 14, 15, and 16). This statistic is not readily available in a form comparable among countries. The Food and Agriculture Organization of the United Nations (FAO) land use data come closest to serving this need on a global scale, but a number of problems prevent their direct application, including considerable annual variation in the data and category definitions of little service for biodiversity indicators (for example, the "forest and woodland" category includes clear-cut areas, with many other habitats such as wetlands, parks, and coastal habitats classified as "other land").

Digitized vegetation maps are available for a number of countries through the WCMC map library. These maps provide information about the extent of the community, but tell nothing about the degree of degradation. WCMC is mapping the extent of tropical forest also (generally digitized at a 1:1,000,000 scale). These maps are being published in a series of regional atlases. The atlases of Asia and Africa are available. The final edition in this series, covering Latin America, should be completed by mid-1993.

Other options for calculating the area dominated by nondomesticated species include combining data on the Afrotropical and Indo-Malayan realms compiled in MacKinnon and MacKinnon (1986a, 1986b) with data reported in country environmental profiles and various natural resource inventories, such as the U.S. Agency for International Development studies of Mali, Mauritania, and Senegal. Matthews (1983) also provides regional-level information on global vegetation and land use, including agricultural and nonagricultural lands. Except in areas where land-use information is georeferenced, information on patterns of fragmentation is unavailable on a worldwide basis.

The global biogeographical maps of Bailey (1989), Holdridge (1967), Olson *et al.* (1983), and Udvardy (1975) are available in digital form through WCMC's map library. However, these data are estimates of the historical or potential coverage of nondomesticated species, rather than the current coverage. Also, they are too crude to be used at a scale finer than the regional level. A final approach uses infrastructure as a criterion. The Sierra Club and the World Bank have computed data for "wilderness" for countries based on the presence or absence of human settlements within 4,000 sq km units (McCloskey and Spalding, 1989). Conservation International, using some additional criteria, has mapped undisturbed, partially disturbed, and human-dominated areas of the world, at a base unit of 400 sq km (Hannah, unpublished manuscript).

Protected Area Coverage (Indicator 17). WCMC's Protected Area Data Unit maintains a relatively complete, country-by-country data base on protected areas. These data are organized according to several classifications, including by IUCN category. The WCMC map library contains polygon or point data for many of the IUCN category I-V protected areas over 1,000 hectares in size. The data are most complete for tropical forest countries where, in some cases, both protected areas under 1,000 hectares in size and forest reserves (generally, IUCN category VIII) have been mapped.

Information on species and habitats occurring in the protected areas is often available but not readily retrievable yet. The MacKinnons (1986a, 1986b) analyzed the percentage of each habitat type protected at the country level for the Afrotropical and the Indo-Malayan realms, using White's (1983) vegetation map of Africa and an Udvardy-based classification of Asia.

Biogeographical maps (Bailey, 1989; Udvardy, 1975; etc.) overlaid onto digitized maps can provide a surrogate measure of habitat coverage. IUCN (1990) published a regional analysis of protected area coverage by biome and province, using Udvardy's (1975) vegetation map of the world.

Domesticated Species

Gene Bank Coverage and Status (Indicators 18 and 19). Complete information on the numbers of crop accessions held by gene banks worldwide is maintained by the International Board for Plant Genetic Resources in Rome. Similar information for livestock genetic diversity is available through the Food and Agriculture Organization but is not as current or complete. Information on the extent to which accessions have been regenerated is available through each *ex-situ* facility only. In 1993, the FAO Commission on Plant Genetic Resources plans to publish a *Status Report on Genetic Resources*, which may contain data needed for some of these indicators.

In-Situ Species and Varietal Diversity (Indicators 20, 21, and 22). The numbers of species being grown in various subnational regions are available on an anecdotal basis only. The FAO does publish crop production statistics on a national basis, including many crops of solely national importance (Prescott-Allen and Prescott-Allen, 1990). Information on varietal diversity is kept for certain crops in certain countries only. For example, the United States kept close track of the varietal diversity of wheat beginning in 1919 but stopped monitoring this after 1984. Basic information on the numbers of varieties in use is available through patent offices in countries that require the registration of varieties and the issue of Plant Variety Certificates. In order to assess the coefficient of kinship or parentage, complete pedigree information is necessary for the varieties involved. Such data are held by breeders but are difficult to obtain because of proprietary considerations.

This cursory review of the availability of data suggests that a considerable amount of information is available with which to develop indicators that can be used to assess biodiversity conservation at national and global levels. There are major gaps in the data: in species, particularly marine, freshwater fish, and invertebrates; in species threatened, endangered and protected, which reflects a lack of good population data; and in communities, including baselines and rates of change. Significant limitations also prevent analysts at the local, national, regional, and global levels in getting access to and documenting the quality of data on species and habitats. Much biodiversity information is still treated as if it were of principally scientific interest, even though it has become relevant policy information and needs to be standardized and made available to policy-makers in and out of government in forms that are useful and usable.

5.

Using Biodiversity Indicators to Help Set Priorities

Indicators can help planners to set priorities for biodiversity conservation. The types of indicators used will vary depending on the scale of the decisionmaking: whether it is at the project level or for national or global planning. Because of data quality limitations, indicators listed here are most useful for planning. They would need to be supplemented with much more detailed, site-specific, management and economic information if used to set priorities or to make specific decisions for protection.

Decisions about resource allocation can range from choosing which conservation project to support, given limited funds, staff, and material, to land-use decisions, which entail trade-offs between preservation and development needs. Planners require measures of biodiversity for both types of decision: for relative comparison (different projects and sites) and to quantify what exists in a given locale.

The designation of new protected areas provides an example of how indicators can be used to set conservation priorities. One approach to conserving diversity is to identify "hot spots" and to protect those areas with the greatest diversity. The indicators required include: species richness (indicator 1), which serves as a good measure of diversity, and species endemism (indicator 5) which is important when choosing sites of global concern. The degree of threat that an area is under can be gauged indirectly by comparing the numbers of species threatened with extirpation (indicator 3) and species with stable, increasing, or decreasing populations (indicators 7 and 8). From a global perspective, policymakers would consider the numbers of species threatened with extinction (indicator 2).

A second example of indicator use entails protecting representative samples of habitat. The percent of each community type dominated by nondomesticated species (indicator 14) can guide planners in determining what is underrepresented in an existing protected areas system. This indicator can be analyzed along with the indicators used to determine "hot spots" and the measures of community types most threatened (indicators 14 and 15) which then can determine the remaining area and the rate of conversion to dominance by domesticated species. The Species Risk Index (indicator 6) can be used to take endemism into account. The planner also should consider whether new sites meet local needs in terms of the ecological services provided and whether local economies are dependent on the species present. The species used by local residents (indicator 13) would provide a measure of this. The planner also might modify boundaries to conserve "econgeners" better; that is, wild relatives of economically important species.

The criteria used in biodiversity planning, such as in the example above of establishing new protected areas, will differ depending on the perspective and the needs of the individual making policy decisions. From a national standpoint, the bottom line of a country's biodiversity policies should be to maintain the species of local importance and the integrity of national ecosystems. Nevertheless, numerous policy considerations could change the weight that a national government gives to the various indicators involved in setting priorities. Countries with important genetic resources related to existing domesticated varieties may wish to concentrate their investment in the conservation of these species and thus will place heavy weight on the "econgener" rating. Countries wishing to develop industries based on the exploration of their biodiversity for useful chemical compounds may focus more on species richness.

The criteria used by international nongovernmental organizations (NGOs) in setting biodiversity conservation priorities tend to differ from those of governments. For instance, many NGOs target their activities toward conserving the maximum number of species or, in some cases, the well-known birds, plants, or primates. Given the objective of conserving maximum species richness, countries are ranked in their order of importance from a conservation standpoint in terms of species richness and endemism. Then, investments are then allocated among countries to match roughly either the number of species in the country or the ranking of an index like the Species Risk Index described above.

On the other hand, if the NGOs are oriented more toward development, they likely would focus greater attention on conserving species and habitats that can be managed and conserved for sustained income generation by local residents. As a result, they probably would spend funds in accordance with the degree of local participation, the number of "econgeners," other measures of species richness, and other community-based social and economic goals.

An international assessment of conservation priorities by intergovernmental organizations, such as the United Nations, the multilateral development banks, bilateral development agencies, or the World Conservation Union (IUCN), might identify certain habitats in one country as being in need of added protection because of the high fraction of threatened species in those habitats that are of importance to the local people in the region. Such an international designation could be used by the country as leverage for obtaining bilateral or multilateral support to meet conservation needs in the designated area. Consequently, the country would be able to shift more of its own resources to the other sites within its borders that have been identified as priority conservation areas.

Clearly, priorities for biodiversity conservation have to be worked out at community, national, regional, and global levels. Indicators can play an important role in determining these priorities and in monitoring the impact and effectiveness of subsequent conservation policies.

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Appendix
Sources and Technical Notes for Tables

Table 2

Source: World Conservation Monitoring Centre (WCMC), *Global Biodiversity Status of the Earth's Living Resources* (Chapman & Hall, London, 1992).

The **number of species known** includes introductions. Data on mammals exclude cetaceans (whales and porpoises).

The **number of globally threatened species** consists of the following the World Conservation Union (IUCN) categories:

- Endangered. "Taxa in danger of extinction and whose survival is unlikely if the causal factors continue operating."
- Vulnerable. "Taxa believed likely to move into the Endangered category in the near future if the causal factors continue operating."
- Rare. "Taxa with world populations that are not at present Endangered or Vulnerable, but are at risk."
- Indeterminate. "Taxa known to be Endangered, Vulnerable, or Rare, but where there is not enough information to say which of the three categories is appropriate."
- Insufficiently Known. "Taxa that are suspected, but not definitely known, to belong to any of the above categories."

The number of threatened species listed for the countries shown excludes introduced or extinct species (in a few instances, species believed to be extinct, but whose present status is unconfirmed, are included). Threatened bird species are listed for countries in their breeding and/or wintering ranges.

Table 3

The number of endemics per 10,000 km^2 is a measure used in the species risk index to provide a relative estimate for comparing numbers of endemic species between countries of differing size. Because the relationship between area and number of endemics is nonlinear (as increasingly large areas are sampled, the number of new endemic species located decreases), a species-area curve has been used to standardize these numbers.

The curve predicts how many endemic species a country would have, given its current number of endemics, if it was a uniform 10,000 square kilometers. It is calculated using the formula: $\mathbf{S} = \mathbf{cA^z}$ where $\mathbf{S}$ = the number of endangered species, $\mathbf{A}$ = area, and **c** and **z** are constants. The slope of the species-area curve is determined by the constant **z**, which is approximately 0.33 for large areas containing many habitats. This constant is based on data from previous studies of species-area relationships. In reality, the constant **z** would differ among regions and countries, because of differences in species' range size (which tends to be smaller in the tropics) and differences in varieties of habitats present. A tropical country with a broad variety of habitats would be expected to have a steeper species-area curve than a temperate, homogenous country because one would predict a greater number of endemic species per unit area. Species-area curves are also steeper for islands than for mainland countries. At present, there are insufficient regional data to estimate separate slopes for each country.

For a more detailed explanation of the species-area relationship, refer to: W. Reid, "How Many Species Will There Be?" in *Tropical Deforestation and Species Extinction*, T. Whitmore and J. Sayer, eds. (Chapman and Hall, London, United Kingdom, 1992).

Table 5

Source: Data for Sub-Saharan Africa and Asia are based on a study by John T. and Kathy MacKinnon. This study and other sources are described in the technical notes to Table 20.4, Habitat Loss, 1980s in World Resources Institute (WRI), *World Resources 1990-91* (Oxford University Press, New York, 1990).

The MacKinnons relied on field investigations, interviews and other personal communications, and published sources to estimate the extent of current and past habitats. They followed the United Nations Educational, Scientific, and Cultural Organization/AETFAT/United Nations Sahelian Office vegetation map of Africa with classifications by F. White for the Afrotropical realm. For the Indo-Malayan Realm, they generally followed the classifications of Miklos Udvardy, the maps by T. C. Whitmore for the Malaysian section and Indochina, and the maps by H. G. Champion and H. K. Seth for the Indian subcontinent. Habitat types, as described below, are aggregated from the MacKinnons' data and other sources.

Forest includes both dry and moist forests.

Savanna/grassland consist of salt-pan vegetation, brushland/thicket, shrubland, grassland, halophytic, and (for Asian countries) savanna forest. This category excludes areas whose original vegetation is known to have been other than grassland (for example cut forests, irrigated desert, drained wetlands).

Desert/scrub includes Asian tropical thorn forest.

Wetlands/marsh include freshwater swamp, peat swamp, and seasonal marsh/seasonal salt marsh. Many estimates of the extent of wetlands are likely to be low. Totals for Poland exclude peatlands. Some wetland figures may include lakes, ponds, streams, and areas that are flooded periodically; others note only permanently inundated areas.

Mangroves consist generally of mangrove forests and swamp.

The determination of the extent of vegetation types in a country is difficult, and estimates vary significantly. Some data on the current extent of habitats may include restorations, although the vegetation may differ in a major way from the original. In addition, Table 5 does not distinguish pristine habitats from those that are significantly degraded. Although the information in this table is as complete as possible, much is missing; the data presented must be considered preliminary. For further details, consult the technical notes to Table 20.4, Habitat Loss, 1980s, in WRI, *World Resources 1990-91* (Oxford University Press, New York, 1990).

Table 6

Source: World Conservation Monitoring Centre (WCMC) data as published in Table 20.1, National and International Protection of Natural Areas, 1990 in World Resources Institute (WRI), *World Resources 1992-93* (Oxford University Press, WRI, Washington, DC, 1992).

National Protection Systems combine natural areas in five World Conservation Union (IUCN) management categories (the areas are at least 1,000 hectares). **Totally protected areas** are maintained in a natural state and are closed to extractive uses. They encompass the following three management categories:

- Category I. Scientific reserves and strict nature reserves possess outstanding representative ecosystems. A reserve's size is determined by the area required to ensure the integrity of the site. In many reserves, natural perturbations (for example insect epidemics and forest fires) are allowed. Generally, public access is limited, with only scientific research and educational use permitted.

- Category II. National parks and provincial parks are relatively large areas of national or international significance not materially altered by humans. Visitors may use them for recreation and study.

- Category III. Natural monuments and natural landmarks contain unique geological formations, special animals or plants, or unusual habitats.

Partially protected areas are areas that may be managed for specific uses, such as recreation or tourism, or that provide optimum conditions for certain species or communities of wildlife. Some extractive use within these areas is allowed. They encompass two management categories:

- Category IV. Managed nature reserves and wildlife sanctuaries are protected for specific purposes, such as the conservation of a significant plant or animal species. Manipulative management techniques are permitted to this end, such as predator control to protect an endangered species or livestock grazing to maintain grassland communities. Management for harvestable renewable resources is permitted.

- Category V. Protected landscapes and seascapes may be entirely natural or may include cultural landscapes (for example, scenically attractive agricultural areas). Examples would include coastlines, lakeshores, and hilly or mountainous terrain along scenic highways.

Biosphere reserves are representative of terrestrial and coastal environments that have been recognized internationally under the Man and the Biosphere Programme of the United Nations Educational, Scientific, and Cultural Organization. They have been selected for their value to conservation and are intended to foster the scientific knowledge, skills, and human values necessary to support sustainable development. Each reserve must contain a diverse natural ecosystem of a specific biogeographical province, large enough to be an effective conservation unit. These reserves also must include a minimally disturbed core area for conservation and research and may be surrounded by buffer zones where traditional land uses, experimental ecosystem research, and ecosystem rehabilitation may be permitted.

Any party to the Convention on Wetlands of International Importance Especially as Waterfowl Habitat (Ramsar, Iran, 1971) who agrees to respect the site's integrity and to establish wetland reserves can designate **wetlands of international importance**.

Marine and coastal protected areas refer to all protected areas with littoral, coral, island, marine, or estuarine components. The area given is the whole protected area. The figures in Table 6 do not include locally or provincially protected sites, privately owned areas, or areas managed primarily for the extraction of natural resources. National lists usually include sites that are listed under **international protection systems.**

World heritage sites are areas of "outstanding universal value" inscribed either for their natural features, for their cultural value, or for both natural and cultural values. Table 6 includes both **natural** and **mixed** natural and cultural sites. Any party to the World Heritage Convention may nominate natural sites that contain examples of a major stage in the earth's evolutionary history; a significant ongoing geological process; a unique or superlative natural phenomenon, formation, or feature; or a habitat for threatened species.

Because categories overlap, the total number of protected sites is less than the sum of all of the categories.

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Table 9. Data Availability and Coverage for Biodiversity Conservation Indicators: Domesticated Species

Indicator	Country Coverage		Time Series (Rank)	Completeness of Data		Quality of Data (Rank)
	Rank	Notes		Rank	Notes	
18. Accessions of crops in ex-situ storage	1		2	1	Except for data on nongovernmental organization seedbanks.	1
19. Percentage of accessions regenerated	3		3	3		3
20. Number of crops grown	3	Indigenous use of crops not well documented.	4	4	Crops of widespread importance only.	4
21. Number of varieties grown	3	OECD countries only.	4	3-4	Some crops in OECD countries.	3-4
22. Coefficient of kinship or parentage of crop	4		4	4		4

Sources: World Resources Institute and World Conservation Monitoring Centre staff.
Ranking Legend: 1 = good; 2 = moderate; 3 = poor; 4 = nonexistent or unavailable.