Biodiversity Hotspots and Major Tropical Wilderness Areas: Approaches to Setting Conservation Priorities

The accelerating and potentially catastrophic loss of biotic diversity is unlike other environmental threats because it is irreversible. Given the rapid loss of biodiversity and limited resources available to address environmental issues, we must set priorities for our efforts to conserve biological resources. Because biodiversity is by no means evenly distributed, some areas are far richer than others in overall diversity and endemism. Furthermore, many of the richest areas also happen to be under the most severe threat.

Over the next few decades, focusing conservation efforts on areas with the greatest concentrations of biodiversity and the highest likelihood of losing significant portions of that biodiversity will achieve maximum impact for conservation investment. By focusing on these high-priority areas we are not suggesting that other less diverse, less threatened areas should be written off, only that the high-biodiversity areas receive priority attention.

Of the three different priority setting approaches we have used, we will discuss two in some detail: biodiversity hotspots and major tropical wilderness areas. A third approach, megadiversity countries, represents a country-based method intended mainly to better market biodiversity conservation in the world's top 17 countries for species diversity and endemism (Mittermeier et al. 1997). All three of these approaches are based on five fundamental premises:

(1) the biodiversity of each and every nation is critically important to that nation's survival and must be a fundamental component of any national or regional development strategy;
(2) some areas simply harbor far greater concentrations of biodiversity than others;
(3) many high-biodversity areas exhibit very high levels of endemism;
(4) many high-biodiversity areas are under the most severe threat; and
(5) to achieve maximum impacts with limited resources, we must concentrate heavily (but not exclusively) on those areas highest in diversity and endemism and most severely threatened.

In the first paper on biodiversity hotspots, Myers (1988) used plants as indicators for biodiversity and identified 10 tropical rain-forest hotspots containing an estimated 13% of all plant diversity in just 0.2% of the total land area of the planet. In a subsequent analysis (1990), he added several other rain-forest areas and four mediterranean-type ecosystems resulting in a total of 18 areas that accounted for 20% of global plant diversity in just 0.5% of the land area. In 1989 Conservation International (CI 1990*a*) and the MacArthur Foundation were the first organizations to adopt Myers' hotspots as the guiding principle for their conservation investment, with CI slightly modifying and expanding Myers' list to include areas overlooked in the original analyses (CI 1990*b*).

The major tropical wilderness area approach was developed simultaneously by Myers (1988, 1990) and Mittermeier (see CI 1990*a*). This approach again emphasizes high-biodiversity tropical ecosystems, but focuses on the opposite end of the threat spectrum. Whereas the hotspots consist mainly of heavily exploited and often highly fragmented ecosystems greatly reduced in extent (usually $<25\%$ of original pristine vegetation remaining), the major tropical wilderness areas are still largely intact ($>75\%$ of original pristine vegetation remaining) and have low human population density (<5 people/km^2).

The major tropical wilderness areas represent important storehouses of biodiversity and major watersheds, are controls against which we can measure the management of the more devastated hotspots, and play a vital role in climate stability. They are often the last places where indigenous peoples have any hope of maintaining their traditional lifestyles. These areas are likely to assume increasing recreational, aesthetic, and spiritual values on an increasingly overcrowded planet. The recently published *Forest Frontiers* analysis by The World Resources Institute (Bryant et al. 1997) highlights a number of these areas, but our wilderness area approach is somewhat different in scope. The latter focuses particularly on those areas that still harbor "pristine" wilderness, collectively representing less than 5% of the original extent of high-biodiversity terrestrial ecosystems in the tropics. Most are found in the southern Guianas, southern Venezuela and adjacent parts of extreme northern Brazilian Amazonia, parts of upper Amazonian Brazil, Colombia, Ecuador, Peru, and Bolivia, parts of the Congo Basin, and much of the island of New Guinea.

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The present reassessment of the biodiversity hotspots approach began in 1996 and is still underway. Therefore, what we present here are some initial conclusions; a more detailed presentation will be available in the near future. Our analysis is based first and foremost on species numbers, using plants as the principal indicator of biological diversity ("plants" here means the members of the Plant Kingdom, represented worldwide by some 270,000 species [Raven & Johnson 1991]). Hotspots were identified by two main criteria: first *plant endemism* and then *degree of threat*. In our analysis, we first identified phytogeographic regions with 0.5% or more of total global plant diversity represented as endemic species—a minimum of 1350 plant species. Second, to analyze the remaining vegetation cover within the selected areas, we used a combination of digitized forest cover data provided by the World Conservation Monitoring Centre and reference material on past and present trends in the distribution of original pristine vegetation. The areas selected for this analysis have lost an estimated 75% or more of their original, pristine vegetation; most of the areas on the final hotspots list have already lost 90–98%.

We also examined patterns of diversity and endemism for mammals, birds, reptiles, and amphibians in the target ecosystems. Not surprisingly, the tropical rain forest hotspots generally have high vertebrate diversity and endemism, following their global trends of plant diversity. In contrast, temperate hotspots like the Mediterranean-type ecosystems and drier tropical hotspots, although very high in plant diversity and endemism, tend to exhibit much lower vertebrate diversity and endemism. Comparative data on invertebrates were included in the analysis when available, but were usually more difficult to obtain than those for vertebrates and plants.

We placed strong emphasis on endemism as the principal criterion for hotspot status because endemics are entirely dependent on a single area for survival, bringing into play the "doctrine of ultimate responsibility" (McNeely et al. 1990). Additionally, endemic species, by virtue of their more restricted ranges, are often among the most vulnerable components of any particular community (Balmford & Long 1994). These restricted range species confined to highly threatened ecosystems will almost certainly be the first hit by extinction episodes (Pimm et al. 1995) and are most in need of rapid and effective conservation action.

Thus far, our analysis has focused only on the terrestrial realm. Although some freshwater ecosystems obviously are covered in the regions under discussion, we do not claim that these hotspots adequately cover freshwater priorities. Separate hotspot analyses on freshwater and marine ecosystems are currently underway.

We believe that biodiversity priority setting exercises must focus first and foremost on *biological parameters.* Threat analysis should come secondarily, highlighting the urgency of conservation action. Other approaches have attempted to incorporate threat criteria, in addition to social and political feasibility indicators, in the first steps of the priority setting analysis with mixed results. If such procedure is adopted at an early stage, it may result in certain high-priority areas for biodiversity conservation being under-funded or unfunded because of considerations such as social factors and political will of the nation in question (e.g., parts of Andean Colombia, Madagascar, and New Caledonia). This is not a trivial consideration. New Caledonia, for example, has been grossly under-funded relative to its global importance because of its political status as part of a G-7 country (France). Costa Rica, on the other hand, has received proportionately much more support than other comparably important countries because it has, to its credit, created a very receptive, positive environment for international conservation investment. If we are to have a real impact on biodiversity conservation worldwide, it is essential that we place great emphasis on the biologically most important regions regardless of their political or social situation and do whatever possible to overcome social and political obstacles.

Based on our method, the first 24 high–priority, terrestrial biodiversity hotspots have been identified (Table 1, Fig. 1). Of these, 9 are entirely tropical rain forest areas; 5 include tropical rain forest and tropical dry forest components; 3 include tropical rain forest, dry forest, and arid systems; 5 are temperate mediterranean-type ecosystems; 1 is a mosaic of dry forests and savannas; and 1 is an arid region. Compared to the earliest version of hotspot analysis, this new analysis includes a wider variety of terrestrial biomes, with exclusively tropical rain forest systems accounting for only 37.5% of the total. The remaining natural vegetation in these 24 hotspots covers only about 2% of the land surface of the planet, and yet have within them a phenomenal total of 124,035 plant species, or 45.9% of all plant diversity represented *as endemics*. Of course, these areas also harbor many non-endemics. Although the analysis of the vertebrate data is not yet complete, we estimate that these same areas will encompass between 30–40% of all terrestrial vertebrates as endemics. Considering total diversity, we conservatively estimate that these 24 hotspots will contain no less than 50% of all terrestrial biodiversity in only about 2% of the land surface of the planet. Furthermore, our data provide clear indications that at least 75% of terrestrial animal species in the critically endangered, endangered, and vulnerable categories, defined by IUCN for globally threatened species (Groombridge & Baillie 1996), are found within this extremely reduced extent of land. Without minimizing the importance of other, less diverse regions and other approaches to priority setting, it should be clear that these hotspots should be an investment priority for any institution seriously inter-

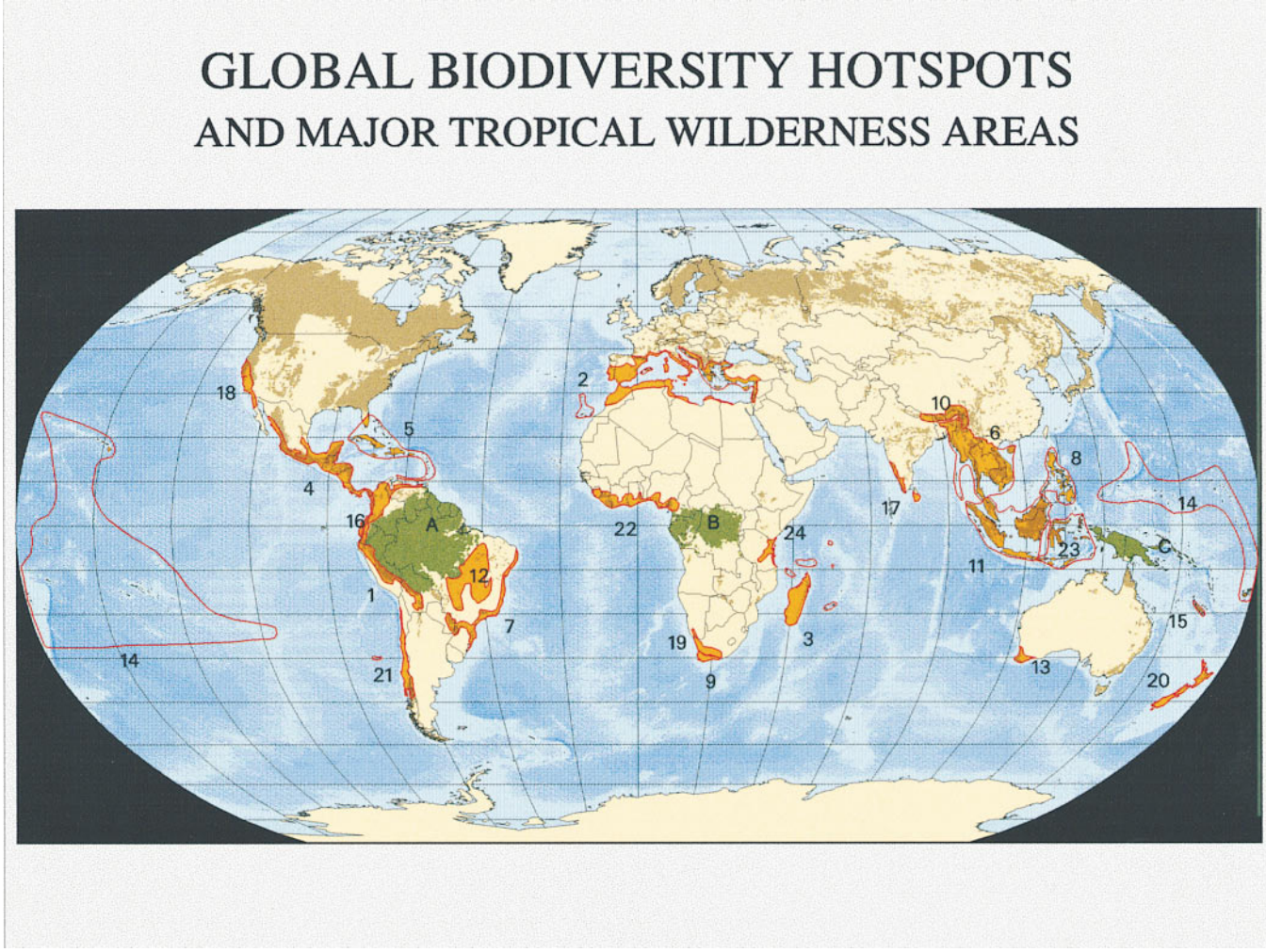

Figure 1. Global distribution of biodiversity hotspots (for key to numbers, see Table 1) and Major Tropical Wilderness Areas (A, Amazon Basin; B, Congo Basin; C, island of New Guinea and adjacent archipelago).

ested in conserving biodiversity in the terrestrial realm.

Looking in more detail at the hotspots list, it becomes obvious that there are top priorities within the list that can sharpen our focus still further. For example, the Tropical Andes hotspot by itself has 20,000 plant species, or 7.4% of the global total, endemic to it, whereas the Mediterranean Basin, a non-tropical hotspot, accounts for 13,000 plant species, or 4.8% of total global diversity, as endemics. The top 11 hotspots for plant endemism, harboring 5,000 or more plant species as endemics, account for 93,214 plant species, or 34.5% of total global plant diversity, *as endemics*. Again, total diversity in such areas is much higher than that represented by the endemics alone.

Furthermore, once we have determined the globally most important hotspots and wilderness areas, we can proceed with the next steps in what we refer to as the *hierarchy of priority setting* (global → regional → national → local → specific priority sites). Fortunately, a great deal of this more specific priority setting has taken place simultaneously with (and has been heavily stimulated by) global priority setting processes over the past decade and has included efforts such as CI's Regional Priority Setting Workshops (e.g., CI 1991; CI et al. 1993; CI et al. 1994; CI et al. 1996; Ganzhorn et al. 1997) and expeditions of the Rapid Assessment Program (e.g., Parker & Bailey 1991; Parker & Carr 1992; Parker et al. 1993*a*; Parker et al. 1993*b*; Parker et al. 1993*c*; Foster et al. 1994; Schulenberg & Awbrey 1997*a*, 1997*b*), BirdLife International's Endemic Bird Areas (Bibby et al. 1992; Stattersfield et al. 1998), and WWF and IUCN's analysis of Centres of Plant Diversity (1994–1997).

The original message of Myers' hotspots analysis echoes loud and clear: a very high percentage of global terrestrial biodiversity can be protected in a very small portion of Earth's land surface, and international efforts to conserve terrestrial biodiversity should focus heavily, but not exclusively, on these areas.

Table 1. Biodiversity hotspots organized in descending order according to plant endemism within them.

Biodiversity hotspot	*Endemic plant species*
1. Tropical Andes	20,000
2. Mediterranean Basin	13,000
3. Madagascar and Indian Ocean Islands	9,700
4. Mesoamerican Forests	9,000
5. Caribbean Islands	7,000
6. Indo-Burma	7,000
7. Atlantic Forest Region	6,000
8. Philippines	5,832
9. Cape Floristic Region of South Africa	5,682
10. Eastern Himalayas	5,000
11. Sundaland	5,000
12. Brazilian Cerrado	4,400
13. Southwestern Australia	3,724
14. Polynesia/Micronesia	3,334
15. New Caledonia	2,551
16. Choco/Darien/W. Ecuador	2,500
17. Western Ghats/Sri Lanka	2,182
18. California Floristic Province	2,125
19. Succulent Karoo	1,940
20. New Zealand	1,865
21. Central Chile	1,800
22. Guinean Forests of West Africa	1,500
23. Wallacea	1,500
24. Eastern Arc Mountains and Coastal Forests	1,400
Total plant species endemic to hotspots	124,035
Total global plant diversity endemic to hotspots	124,035/270,000 = 45.94%

Fortunately, although there has been considerable positioning and rhetoric in priority setting over the past decade (because its role in securing funding has become more and more evident), there is actually considerable agreement among the different approaches currently in use. For instance, if one compares the most critical of WWF's Global 200 ecoregions (Olson & Dinerstein 1997), the most important Endemic Bird Areas of BirdLife International (Stattersfield et al. 1998), and the WWF/IUCN Centres of Plant Diversity (WWF/IUCN 1994, 1995, 1997) with our biodiversity hotspots, the same regions usually rise to the top, among them the Tropical Andes, Madagascar, the Atlantic forest region of eastern Brazil, the Mesoamerican forests, the Philippines, most of Indonesia (regardless of how it is divided), the Cape Floristic Region of South Africa, and New Caledonia. What is really needed now is not further unproductive debate on whose method is the best, but agreement on what is most important and collaborative action to ensure that as much as possible is conserved.

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