



science applied

How Should We Prioritize the Protection of Species Diversity?

As a result of human activities, we have seen a widespread decline in biodiversity across the globe. Many people agree that we should try to slow or even stop this loss. But how do we proceed? Ideally, we might want to preserve all biodiversity. In reality, preserving biodiversity requires compromises. For example, in order to preserve the biodiversity of an area, we might have to set aside land that would otherwise be used for housing developments, shopping malls, or strip mines. If we cannot preserve all biodiversity, how do we decide which species receive our attention?

In 1988, Oxford University professor Norman Myers noted that much of the world's biodiversity is concentrated in areas that make up a relatively small fraction of the globe. Part of the reason for this uneven pattern of biodiversity is that so many species are *endemic species.* **Endemic species** are species that live in a very small area of the world and nowhere else, often in isolated locations such as the Hawaiian Islands. Because they are home to so many endemic species, these isolated areas end up containing a high proportion of all the species found on Earth. Myers called these areas **biodiversity hotspots.**

Scientists originally identified 10 biodiversity hotspots, including Madagascar, western Ecuador, and the Philippines. Myers argued that these 10 areas were in need of immediate conservation attention because human activities there could have disproportionately large negative effects on the world's biodiversity. A year later, the group Conservation International adopted Myers's concept of biodiversity hotspots to guide its conservation priorities. As of 2010, Conservation International had identified the 34 biodiversity hotspots shown in FIGURE SA2.1. Although these hotspots collectively represent only 2.3 percent of the world's land area, 50 percent of all plant species and 42 percent of all vertebrate species are confined to these areas. As a result of this categorization, major conservation organizations have adjusted their funding priorities and are spending hundreds of millions of dollars to conserve these areas. What does environmental science tell us about the hotspot approach to conserving biodiversity?

What makes a hotspot hot?

Since Norman Myers initiated the idea of biodiversity hotspots, scientists have debated which factors should be considered most important when deciding where to focus conservation efforts. For example, most scientists agree that species richness is an important factor. There are more than 1,300 bird species in the small nation of Ecuador—more than twice the number of bird species living in the United States and Canada. For this reason, protecting a habitat in Ecuador has the potential to save many more bird species than protecting the same amount of habitat in the United States. From this point of view, the choice to protect areas with a lot of species makes sense.

Identifying biodiversity hotspots is challenging, however, because scientists have not yet discovered and identified all the species on Earth. Because the distribution of plant diversity is typically much better known than that of animal diversity, the most practical way to

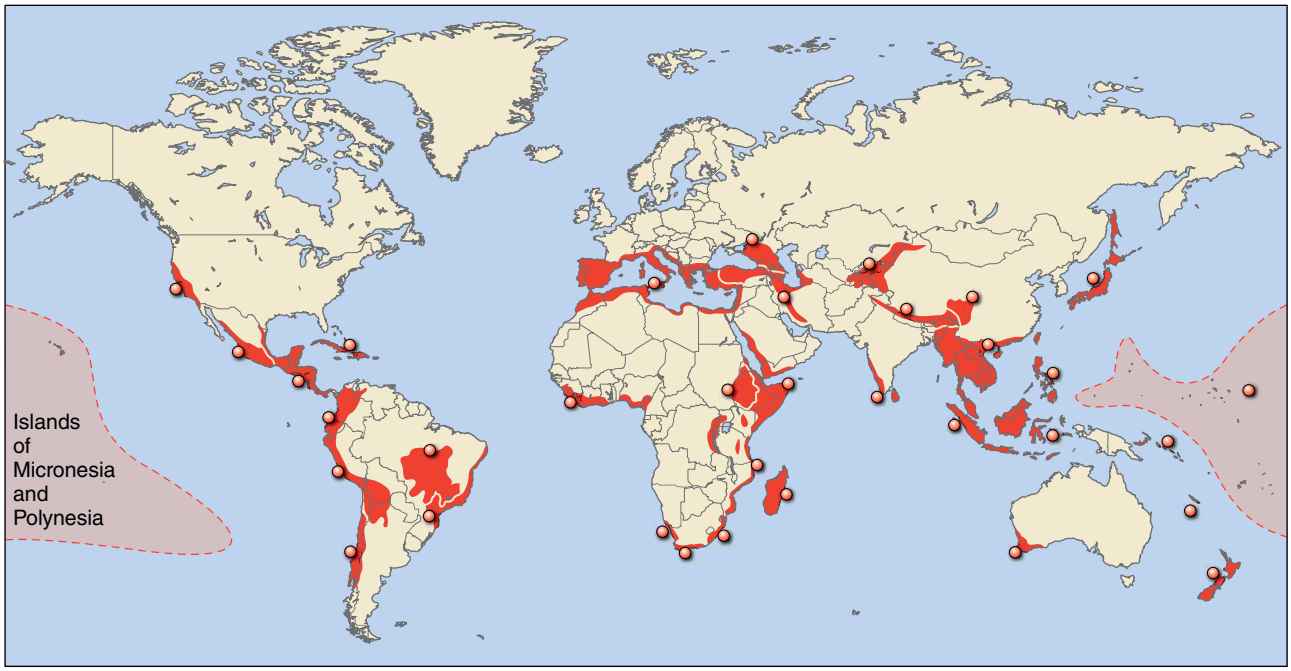

FIGURE SA2.1 Biodiversity hotspots. Conservation International has identified 34 biodiversity hotspots that have at least 1,500 endemic plant species and a loss of at least 70 percent of all vegetation.

identify hotspots has been to locate areas containing high numbers of endemic plant species. It is reasonable to expect that areas with high plant diversity will contain high animal diversity as well. Conservation International requires that areas it identifies as hotspots contain at least 1,500 endemic plant species. By conserving plant diversity, the hope is that we will simultaneously conserve animal diversity, especially for those groups, such as insects, that are poorly cataloged.

In addition to requiring high numbers of endemic plant species, Conservation International requires its hotspots to have lost more than 70 percent of the vegetation that contains those endemic plant species. In this way, high-diversity areas with a high level of habitat loss receive the highest conservation priority. High-diversity areas that are not being degraded receive lower conservation priority.

What else can make a hotspot hot?

The number of endemic species in an area is undoubtedly important in identifying biodiversity hotspots, but other scientists have argued that this criterion alone is not enough. They suggest that we also consider the total number of species in an area or the number of species currently threatened with extinction in an area. Would all three approaches identify similar regions of conservation priority? A recent analysis of birds suggests they would not. When scientists identified bird diversity hotspots using each of the three criteria—endemic species, total species richness, and threatened species—their results, shown in Table SA2.1, identified very different areas. Scientists using the three criteria to identify hotspots of mammal diversity reached the same conclusion.

As we can see in Table SA2.1, some areas of the world that have high species richness do not contain high numbers of endemic species. The Amazon, for example, has a high number of bird species, but not a particularly high number of endemic bird species compared with other more isolated regions of the world, such as the islands of the Caribbean. Similarly, areas with high numbers of threatened or endangered species do not always have high numbers of endemic species. These findings highlight the critical problem of deciding whether conservation efforts should be focused on areas containing the greatest number of species, areas containing the greatest number of threatened species, or areas containing the greatest number of endemic species. All three approaches are reasonable.

In addition to considering species diversity, some scientists have argued that we must also consider the size

Table SA2.1 Biodiversity hotspots for birds, identified by three criteria.

Rank	Total number of species	Number of endemic species	Number of threatened species
1	Andes	Andes	Andes
2	Amazon Basin	New Guinea and Bismarck Archipelago	Amazon Basin
3	Western Great Rift Valley	Panama and Costa Rica highlands	Guyana highlands
4	Eastern Great Rift Valley	Caribbean	Himalayas
5	Himalayas	Lesser Sunda Islands	Atlantic coastal forest, Brazil

Source: Data from C. D. Orme et al., Global hotspots of species richness are not congruent with endemism or threat, *Nature* 436 (2005): 1016–1019.

of the human population in diverse areas. For example, we might expect that natural areas containing more people face a greater probability of being affected by human activities. Furthermore, if we wish to project into the future, we must consider not only the size of the human population today, but also the expected size of the human population several decades from now. Scientists have found that many hotspots for endemic species have human population densities that are well above the world's average. Whereas the world has an average human population density of 42 people per square kilometer, the average hotspot has a human population of 73 people per square kilometer. Such places may be at a higher risk of degradation from human activities. This risk should be incorporated into our choices of priority areas for conservation, and it should motivate us to promote smarter development that does not come at the cost of species diversity.

What are the costs and benefits of conserving biodiversity hotspots?

A focus on regions containing large numbers of species places a clear priority on preserving the largest number of species within a given region. However, it does not explicitly consider the likelihood of succeeding in this goal, nor does it consider the costs associated with the effort. For example, there may be many ways of helping a species persist in an area, including buying habitat, entering into agreements with landowners not to develop their land, or removing threats such as invasive species. Each option will have a different impact on the number of species that will be helped, and each option will have different costs of implementation. Given the limited funds that are available for protecting species, it is certainly worth comparing the expected costs and benefits of different options, both within and among biodiversity hotspots. In this way, we have the potential to maximize the return on our conservation investment.

What about biodiversity coldspots?

The concept of biodiversity hotspots assumes that our primary goal is to protect the maximum number of species. That goal is an admirable one, but it could come at the cost of many important ecosystems that do not fall within hotspots. Yellowstone National Park, for example, has a relatively low diversity of species, yet it is one of the few places in the United States that contains remnant populations of large mammals, including wolves, grizzly bears, and bison. Does this mean that places such as Yellowstone National Park should receive decreased conservation attention?

Biodiversity coldspots also provide ecosystem services that humans value at least as much as species diversity. For example, wetlands in the United States are incredibly important for flood control, water purification, wildlife habitat, and recreation. Many wetlands, however, have relatively low plant diversity and, as a result, would not be identified as biodiversity hotspots. It is true that increased species richness leads to improved ecosystem services, but only as we move from very low species richness to moderate species richness. Moving from moderate species richness to high species richness generally does not further improve the functioning of an ecosystem. Since very high species diversity is not expected to provide any substantial improvement in ecosystem function, protecting more and more species produces diminishing returns in terms of protecting ecosystem services. Hence, if our primary goal is to preserve the functioning of the ecosystems that improve our lives, we do not necessarily need to preserve every species in those ecosystems.

How can we reach a resolution?

During the past two decades, it has become clear that scientists and policy makers need to set priorities for the conservation of biodiversity. No single criterion may be agreed upon by everyone. However, it is important to appreciate the bias of each approach and to consider the possible unintended consequences of favoring some geographic regions over others. Our investment in conservation cannot be viewed as an all-or-nothing choice of some areas over others. Instead, our decisions must take into account the costs and benefits of alternative conservation strategies and incorporate current and future threats to both species diversity and ecosystem function. In this way, we can strike a balance between our desire to preserve Earth's species diversity and our desire to protect the functioning of Earth's ecosystems.

References

Kareiva, P., and M. Marvier. 2003. Conserving biodiversity coldspots. *American Scientist* 91:344–351.

Myers, N., et al. 2000. Biodiversity hotspots for conservation priorities. *Nature* 403:853–858.

Orme, C. D., et al. 2005. Global hotspots of species richness are not congruent with endemism or threat. *Nature* 436:1016–1019.