

# Comprehensive Biodiversity Protection, Role of Hotspots: Geographical Overview

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## Abstract

This paper attempts to study **role of biodiversity hotspots in broad Biodiversity Protection** based on the conservation planning principles of irreplaceability and vulnerability. Biodiversity is a contraction of the term “biological diversity” that refers to variety among and between living organisms. The term biological diversity was used first by Arthur Harris (1916), an American botanist in his article "The Variable Desert" published in a science magazine called, *The Scientific Monthly* as part of a statement: “The bare statement that the region contains a flora rich in genera and species and of diverse geographic origin or affinity is entirely inadequate as a description of its real biological diversity”. The term, “biodiversity” was first coined by Walter G. Rosen in 1985. This widely used term biodiversity does not have a universally unified definition as it is often redefined according to the context and purpose of the each author (Swingland, 2001). However, biodiversity is usually defined by the biologists as the “totality of genes, species and ecosystem of a region”. Generally, biodiversity is divided into three fundamental categories namely genetic diversity, species diversity, and ecosystem diversity.

Biodiversity is very often regarded as a synonym of species diversity, and measured by the number of species in a particular area, species richness (Swingland, 2001). The distribution of biodiversity is neither random nor uniform on earth (Noss & al., 2015). The distribution of species is highly concentrated in specific geographical regions of the world. Over two-thirds of world’s biodiversity occur in tropical areas, especially in tropical forests (Raven, 1988; Pimm & Raven, 2000). The tropical zones with high level of species diversity have been identified as “Biodiversity Hotspots”. Biodiversity hotspots are ecologically unique regions that are exceptionally rich in species, and are thus priority targets for nature conservation. There are many definitions of biodiversity. All of them include the variation within and between species and of ecosystems and identify a set of priority areas that cover a small portion of the Earth, but house an exceptionally high proportion of its biodiversity. Because biodiversity underpins all life on Earth, these hotspots have significant global value as they contain species and habitats that are found nowhere else. Their loss would mean loss of species and habitats that provide wild and farmed food, medicine and other materials and services such as climate regulation, pollination and water purification, all of which maintain the health of the ecosystems we depend upon.

Keywords: Climate change, Coldspots, Species richness, Phylogenetic diversity, Ecosystem services

## Introduction

In an era of human activities, global environmental changes, habitat loss and species extinction, conservation strategies are a crucial step toward minimizing biodiversity loss. For instance, oceans acidification and land use are intensifying in many places with negative and often irreversible consequences for biodiversity. Biodiversity hotspots, despite some criticism, have become

a tool for setting conservation priorities and play an important role in decision-making for cost-effective strategies to preserve biodiversity in terrestrial and, to some extent, marine ecosystems. This area-based approach can be applied to any geographical scale and it is considered to be one of the best approaches for maintaining a large proportion of the world's biological diversity. However, delineating hotspots includes quantitative criteria along with subjective considerations and the risk is to neglect areas, such as coldspots, with other types of conservation value. Nowadays, it is widely acknowledged that biodiversity is much more than just the number of species in a region and a conservation strategy cannot be based merely on the number of taxa present in an ecosystem. Therefore, the idea that strongly emerges is the need to reconsider conservation priorities and to go toward an interdisciplinary approach through the creation of science-policy partnerships.

Healthy ecosystems, with flourishing biodiversity in natural conditions, are more resilient to disturbances, whether natural or human in origin. Environmentally sustainable development inside and outside hotspots could help reverse human impacts on biodiversity. The hotspots also capture and store carbon, thereby helping to mitigate climate change. Prioritization of protecting biodiversity in hotspots thus benefits nature conservation and helps mitigate climate change. A global network of protected areas and restoration initiatives inside biodiversity hotspots can also help increase resilience to the effects of climate change on biodiversity. As demonstrated by several researches, maintaining biodiversity is essential to the supply of ecosystem services and not less important to support their health and resilience (Pereira et al., 2013). However, despite there being an international interest to sustain and protect biodiversity, its loss does not seem to slow down (Butchart et al., 2010). Although there has been an extension of protected areas (Pimm et al., 2014), these provide a still low species coverage (Venter et al., 2014) and do not appear to optimally protect biodiversity (Pimm et al., 2014). For instance, a recent analysis (Selig et al., 2014) for conservation priorities in marine environments by combining spatial distribution data for nearly 12,500 species with human impacts information, identified new areas of high conservation value that are located in Arctic and Antarctic Oceans and beyond national jurisdictions.

Overall, habitat change and their over-exploitation, pollution, invasive species and in particular climate change are the major causes for biodiversity loss. The combined effect of these anthropogenic pressures may have already started a critical transition toward a tipping point (Barnosky et al., 2012). In particular, climate is modifying rapidly forcing biodiversity to adapt either through the change of habitat and life cycles or the development of new physical traits (Berteaux et al., 2010). For instance, rising temperatures can lead to potential biodiversity increases in northern regions (i.e. northern biodiversity paradox) where low temperatures usually are a limiting factor for the establishment of many species (Berteaux et al., 2010). Given the importance that biodiversity plays, the understanding of the main threats to biodiversity is today than ever before a central objective in conservation biology.

Nowadays there is serious concern about the effectiveness of existing strategies for biodiversity protection. A central issue in conservation is to identify biodiversity-rich areas to which conservation resources should be directed. Based on the observation that some parts of the world have far more species than others, the area-based approaches are widely advocated for species conservation planning. Areas with high concentrations of endemic species (species that are found nowhere else on Earth) and with high habitat loss are often referred to as "hotspots" (Myers, 1988). The hotspot approach can be applied at any geographical scale and both in terrestrial and marine environments. However, hotspots represent conservation priorities in terrestrial ecosystems but remain largely unexplored in marine habitats (Worm et al., 2003) where the amount of data is still poor (Mittermeier et al., 2011).

Despite this lack of homogeneity in data between terrestrial and aquatic ecosystems, the recent concerns over loss of biodiversity have led to calls for the preservation of hotspots as a priority. As reported by Myers (2003) at the end of his article, “Edward O. Wilson, one of the leading authorities on conservation, described the hotspot approach as ‘*the most important contribution to conservation biology of the last century*’”. Closely linked to the concept of biodiversity, the hotspot concept is used with increasing frequency in biology and conservation literature and often with different meanings. While in a strict sense, the meaning is based on an estimate of endemic species and habitat loss, in a broad sense it refers to any area or region with exceptionally high biodiversity at the ecosystem, species and genetic levels.

The aim of this work is to review the current literature on the general concept of hotspots. We first introduce the approach that lies behind the concept of hotspots, in both terrestrial and marine ecosystems. Next we discuss the main criticisms and controversies concerning this approach and we present the possibility of using different alternative metrics to identify hotspots. Then we bring to light the links between biodiversity hotspots and marine pelagic ecosystem processes and we briefly introduce the deep-sea, a realm for the most part unknown for which several key questions are still waiting for an answer. Finally, we briefly discuss additional approaches and criteria, such as costs, in order to highlight some challenges in assigning global conservation priorities.

### **Objective:**

This paper intends to explore and analyze **Biodiversity Protection through “Biodiversity hotspots”**; Coined by Norman Myers, the regions which are known for their high species richness and endemism. The region should have at least 1500 species of vascular plants i.e., it should have a high degree of endemism

### **A Historical Perspective on Biodiversity Loss**

About 99.9% of species that have ever lived on earth are now extinct, but at the same time, there are likely more species alive during the current era in geological history than at any previous time. Why is this?

Since the first cellular life appeared about 3.8 billion years ago, new life forms have been constantly evolving and some species have been going extinct. Since life on Earth is so old, most of the species that have ever lived are now gone, even if they persisted for millions of years. There have been periods of biodiversity explosions, as well as periods of mass extinctions, but generally, the trend has been toward an increase in the variety of life forms on this planet. *Speciation rates* (the rates of new species coming into existence) are high following mass extinction events and have been increased by the evolution of body types that allow animals to inhabit all types of habitats like deserts, soils, thermal ocean vents, and the sky. Also, the breaking up of Pangaea into separate continents has fostered an explosion in the number of species on Earth.

We should realize that humans are not responsible for most of the extinctions that have happened on Earth. At the same time, humans have been influencing biodiversity for a long time, and human-caused extinctions are not a new thing at all.

### **Early Anthropogenic Extinctions**

During the end of the last ice age (known as the Pleistocene), about 10,000 to 15,000 years ago, many of the large mammals, birds, and reptiles, collectively known as *megafauna*, went extinct in North and South America. Mastodons, mammoths, giant beavers, and saber-toothed tigers, along with many other species, disappeared in a fairly short period of geologic time.

While we do not have direct evidence of what caused their extinction, most researchers believe that overharvesting of wildlife by humans played a decisive role in many extinctions. The extinctions roughly coincide with the arrival of humans into the Americas, and a similar story is apparent in Australia, although human arrival there was much earlier.

It is important to note that during this period the climate was warming rapidly (due to natural, not human causes), and vegetation was changing as a result. Therefore, humans were not the only stress that may have damaged populations of these megafauna species. On the other hand, these species had persisted through significant climate fluctuations in the past, and the major new factor when they became extinct was the presence of humans.

Another striking example of human-caused biodiversity loss from before the modern era comes from Polynesia in the southern Pacific Ocean. Humans caused the extinction of over 2000 species of birds as they colonized these tropical islands between 1000 and 3000 years ago. Among the factors causing extinction were direct harvesting, habitat alteration, and the introduction of predators like pigs and rats. Flightless birds were particularly vulnerable to human and non-human hunters, and many of them went extinct.

One important lesson to draw from these two examples is that even people whom we identify as “native” or “indigenous” to a place can cause extinctions. It can be tempting to imagine that Western civilization, capitalism, or other “modern” ideas or technologies are the root cause of biodiversity loss, but that belief is not supported by this history. It is vital that we view indigenous peoples not as somehow “one with nature” or in perfect harmony with their ecosystems, but as dynamic and diverse human cultures that have long played important roles in shaping the landscapes that they inhabit. That said, there are valuable lessons that we can learn from indigenous cultures about how to maintain functioning ecosystems and biodiversity while providing for basic human needs.

## Biodiversity Hotspot

The term ‘biodiversity hotspot’ was coined by Norman Myers (1988). He recognized 10 tropical forests as “hotspots” on the basis of extraordinary level of plant endemism and high level of habitat loss, without any quantitative criteria for the designation of “hotspot” status. Two years later, he added eight more hotspots, and the number of hotspots in the world increased to 18 (Myers 1990).

Subsequently, the Conservation International in association with Myers made the first systematic update of the hotspots, and introduced the following two strict quantitative criteria, for a region to qualify as a hotspot:

- (i) It must contain at least 1,500 species of vascular plants ( $> 0.5\%$  of the world’s total) as endemics;
- (ii) It has to have lost  $\geq 70\%$  of its original native habitat.

The first systematic update of the hotspots, which involved an extensive global review, introduced seven new hotspots on the basis of the newly defined criteria and authentic new data, thus the number of hotspots has been increased to 25 (Mittermeier & al., 1999; Myers & al., 2000). The second systematic update revisited the hotspot regions and redefined several hotspots based on the distribution of species, threats, and changes in the threat status of these regions, which resulted in addition of nine more

hotspots thus the number of hotspots expanded to 34 (Mittermeier & al., 2004). The “Forests of East Australia” harbouring at least 2,144 endemic vascular plant species in an area with just 23% of its original vegetative cover remaining was identified as the 35th biodiversity hotspot (Williams & al., 2011; Mittermeier & al., 2011). In February 2016, the “North American Coastal Plain” meeting the criteria of hotspot, was recognized as the 36th global biodiversity hotspot.

Therefore, according to Conservation International (<https://www.conservation.org>), at present, there are 36 biodiversity rich areas in the world that have been qualified as hotspots, which represent just 2.5% of earth’s land surface, but support over 50% of the world’s endemic plant species, and nearly 43% of bird, mammal, reptile and amphibian species as endemics.

From lush rainforests to majestic mountains, some regions of Earth are simply irreplaceable. Many of these regions are biodiversity hotspots—areas that are both rich with life and at high risk for destruction.

Biodiversity hotspots make up about 2.3 percent of Earth’s land surface, but 44 percent of the world’s plants and 35 percent of land vertebrates live in these regions. Most plants in a biodiversity hotspot are endemic, meaning they are not found anywhere else on Earth. Yet biodiversity hotspots are, by definition, in a conservation crisis. To be classified as a biodiversity hotspot, a region must have lost at least 70 percent of its original natural vegetation, usually due to human activity.

There are over 30 recognized biodiversity hotspots in the world. The Andes Mountains Tropical Hotspot is the world’s most diverse hotspot. About one-sixth of all plant species in the world live in this region. The New Zealand archipelago is another hotspot. Life on New Zealand evolved in isolation, so the islands contain many species not found anywhere else. More than 90 percent of the insects and 80 percent of the vascular plants in New Zealand are endemic to the region. The Himalayan region contains the tallest mountains in the world, as well as incredible animals found only there, including the giant panda, the wild water buffalo, and the black-necked crane—the only alpine crane in the world. Deforestation and climate change have made the Himalaya a biodiversity hotspot.

In addition to land, the waters surrounding these tropical regions are just as important, and equally in danger. Tropical coral reefs are currently being threatened by climate change and habitat destruction. These areas are some of the most biodiverse ecosystems on our planet! Scientific studies of 3,235 marine species in these areas, including fishes, corals, snails, and lobsters, show that high percentages of these species are at serious risk of becoming extinct. Conservation of species living in fresh or seawater is especially difficult, because many bodies of water are interconnected. For example, all the oceans are connected through sea currents that allow the movement of species, minerals, and pollution across the entire globe.

Interestingly, the organisms that we know today represent only a very small portion of all the living creatures that have inhabited the planet since life began. All the species living today represent only 5% of all the species that have roamed the Earth during its history! This is a reminder that extinction is a constant force shaping Earth’s biodiversity.

However, many scientists would agree that, today, we are facing a rate of species extinction that is faster than has ever been seen before. Plant and animal species in biodiversity hotspots are currently suffering devastating losses. In fact, by definition, a biodiversity hotspot must have lost at least 70% of its habitat. Biodiversity hotspots now cover only 1.4% of the land on Earth, when they originally covered 12% of the land. Factors, such as pollution, exploitation of land, invasive species, and climate change are the leading causes of habitat loss and destruction. The fact that these factors are widespread creates challenges for

the species that manage to survive; and with an ever-changing climate and unpredictable circumstances, species that cannot resist the changing environment or move to a more suitable habitat will likely become extinct .

When we think about the future of biodiversity on Earth, we need to consider the role we play in climate change. Some scientists predict that up to 54% of species are at risk of extinction due to climate change. The consequences of climate change are extremely widespread, threatening even places untouched by humans . In order to protect our planet, we can start by making small changes in our daily lives. Taking action by recycling, picking up trash, being conservative with our water consumption, and limiting pollution by walking, biking, or taking public transportation are ways that we can help the environment. We can also come up with our own ideas, as we educate ourselves on biodiversity by reading about different places and living things.

Biodiversity hotspots are ecologically unique regions that are exceptionally rich in species, and are thus priority targets for nature conservation. There are many definitions of biodiversity. All of them include the variation within and between species and of ecosystems and identify a set of priority areas that cover a small portion of the Earth, but house an exceptionally high proportion of its biodiversity.

Because biodiversity underpins all life on Earth, these hotspots have significant global value as they contain species and habitats that are found nowhere else. Their loss would mean loss of species and habitats that provide wild and farmed food, medicine and other materials and services such as climate regulation, pollination and water purification, all of which maintain the health of the ecosystems we depend upon.

Healthy ecosystems, with flourishing biodiversity in natural conditions, are more resilient to disturbances, whether natural or human in origin. Environmentally sustainable development inside and outside hotspots could help reverse human impacts on biodiversity. The hotspots also capture and store carbon, thereby helping to mitigate climate change. Prioritization of protecting biodiversity in hotspots thus benefits nature conservation and helps mitigate climate change. A global network of protected areas and restoration initiatives inside biodiversity hotspots can also help increase resilience to the effects of climate change on biodiversity.

### **Criticism of biodiversity hotspots**

Since its introduction, the concept of hotspots was used as a key strategy for global conservation action. For this reason, it has become the principal global conservation-prioritization approach, attracting over \$1 billion in conservation investment (Sloan et al., 2014). The approach is thus partly economic and it is based on the fact that it is not possible to protect the full range of biodiversity since it would certainly not be a realistic target. Basically, biodiversity conservation requires prioritization to be effective, if only because funds are limited and must be allocated carefully (Myers, 2003). Therefore, among many others, entities like Conservation International, have explicitly adopted the hotspot concept as a central conservation-investment strategy (Sloan et al., 2014).

In a 2003 essay entitled “Conserving Biodiversity Coldspots”, conservation biologists Peter Kareiva and Michelle Marvier argued that non-governmental organizations, foundations and international agencies have been seduced by the simplicity of the hotspot idea, and significant financial resources (Dalton, 2000) have been directed toward them. In particular, the two conservation biologists argued that coldspots, despite begin poorer for number of species, play an important ecological role. By investing exclusively in hotspots and ignoring coldspots the risk is to lose large, natural and ecologically important areas that contribute to many ecosystem services (Kareiva and Marvier, 2003). On the same wavelength, Jepson and Canney (2001) have

warned that the biodiversity hotspots approach provides only a partial response for the conservation. The authors agree that promoting biodiversity hotspots, as a “silver bullet” strategy for conserving the most species for the least cost is a risk in complex areas of international policy, such as biodiversity conservation, because decision makers may view it as a cure-all. As a result, they conclude that spatial priorities and public policy cannot be determined on the basis of simple species counts, which is the foundation of the biodiversity hotspot approach. Furthermore, as pointed out by Smith et al. (2001) biodiversity hotspots entirely ignore regions of ecological transition. Hence, the authors promote a more comprehensive approach to include regions important to the generation and maintenance of biodiversity, regardless of whether they are “species-rich”. Recently, Stork et al. (2014) have emphasized the lack of consideration for the role of invertebrates (e.g. herbivorous insects, herbivorous fungi and nematodes) in decision-making about global biodiversity hotspots, suggesting a more detailed analysis of the role of plants as umbrella species for these herbivorous organisms. Furthermore, since data on species distributions are usually scarce the conservation of an entire global hotspot may be difficult and unsustainable. In this regard, Cañadas et al. (2014) pointed out the need to focus strategies on small areas that represent maximum diversity and/or endemism. Finally, for some of the same reasons that fueled disputes for terrestrial ecosystems, hotspots on coral reefs (Roberts et al., 2002) have also been the subject of controversy (Briggs, 2002, Hughes et al., 2002). In this respect, Parravicini et al. (2014) have recently identified tropical reef areas that are critical for preventing the loss of fish taxonomic and functional biodiversity. These areas, such as the Western Indian Ocean, differ in important ways from the fish richness hotspots previously identified close to the Indo-Australian Archipelago.

These criticisms highlight the problems associated with the idea of biodiversity hotspots, even though Myers (2003) (whose criteria include endemism and species richness) points out that other criteria are not ruled out by the theory itself. Essentially, the author affirms that the hotspot approach does not exclude other areas that need conservation, but nevertheless claims that a conservation strategy will always need a measure to determine priorities. In conclusion, although not completely free from criticism, the hotspot approach has become a key tool to guide conservation efforts and presently plays a leading role in decision-making regarding conservation cost-effective strategies (O'Donnell et al., 2012).

## Conclusion

There are 36 biodiversity hotspots on our planet, and these areas are dazzling, unique, and full of life. Plants, animals, and other living organisms that populate these places are rare and many of them are only found in these specific geographic areas. These biodiversity hotspots are currently at risk of being destroyed. Habitat destruction directly caused by humans, as well as destruction due to climate change, are the leading causes of the increasing extinction of Earth's species. Finally, it is becoming clear that the biodiversity hotspots approach represents a shortcut for a more complicated concept that is part of a bigger picture that includes consideration of ecosystem services, policies, costs, social preferences, and other factors, such as human activities and climate change. As mentioned by several authors, we need to go toward a common, modern and broader vision of biodiversity conservation. Scientific community, together with decision-makers in agencies, governments and non-governmental organizations, should thus carefully reconsider conservation priorities and, possibly, in order to avoid duplicating efforts (Mace, 2000), establish close partnerships (Berteaux et al., 2010, Maury et al., 2013) to develop successful conservation strategies for biodiversity management (Heller and Zavaleta, 2009). Because of the complexity of the topic and the unpredictability brought by climate change, there is no single definitive praxis to effective conservation, but rather an interdisciplinary approach. (Pohl and Hadorn, 2008) that is necessary today as never before.

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