

# Landscape fragmentation, biodiversity loss and the societal response

The longterm consequences of our use of natural resources may be surprising and unpleasant

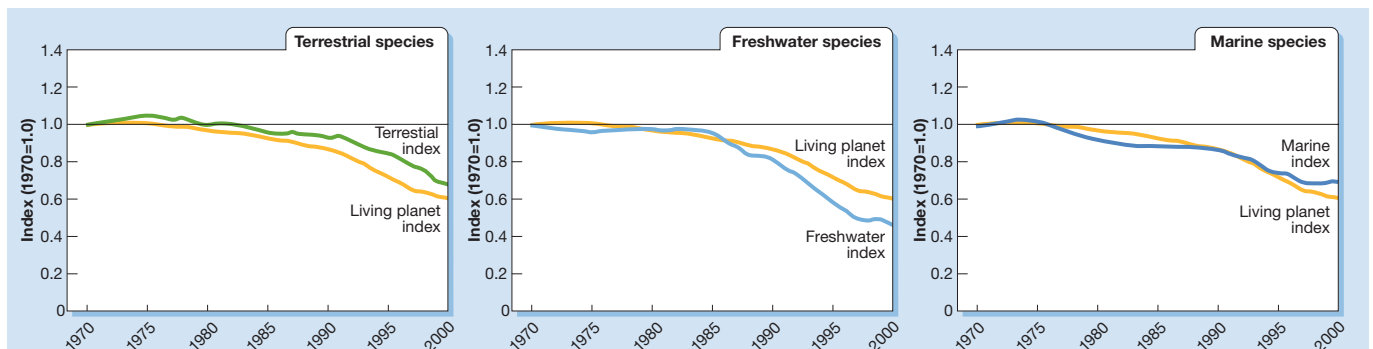
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Declining biodiversity is a major environmental problem everywhere on Earth, including developed regions such as Western Europe and the USA. European leaders have recognized this and set the target of halting biodiversity loss by 2010, under the EU Strategy for Sustainable Development that was adopted by the European Council in 2001. World leaders agreed upon a substantially less ambitious goal at the 2002 World Summit on Sustainable Development in Johannesburg, South Africa: to significantly reduce the current rate of biodiversity loss by 2010. The practical challenge for both goals is to measure the rate of change in biodiversity, to determine whether the decline is slowing or has stopped. This relates to the task of defining, in operational terms, what biodiversity is. The causes of biodiversity decline must be understood in order to devise effective countermeasures. None of this can take place without the participation of society at large, who have to be convinced about the importance of biodiversity if there is to be any real hope of implementing meaningful measures.

So what is biodiversity? The cynical answer is: everything that is good in nature. This captures the point that biodiversity is not a simple concept, has never been since its conception (Wilson & Peter, 1988), and never will be. The official definition is: "The variability among living organisms from all sources, including, *inter alia*, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems" (Convention on Biological Diversity, 1992). My personal interpretation is that there is no biodiversity loss in a particular landscape when there is no obvious decline in the abundances of large numbers of species living in that landscape. This is based on the observation that a range of species with diverse ecological requirements accurately reflects the state of the environment. It acknowledges that population sizes fluctuate for natural reasons, but in the absence of great environmental changes, entire communities of species would not be expected to exhibit a trend towards lower

abundances, ultimately leading to regional, national and global extinctions. This notion of biodiversity loss simplifies the issue by focusing on population sizes, but as every biologist knows, viable populations cannot be maintained without a sufficient habitat—and their habitat is not sufficient if habitat loss and fragmentation are the primary cause of biodiversity decline. On the other hand, an abundance of species in a certain landscape or habitat does not necessarily indicate that there is no threat to biodiversity; many of these species may already be threatened if their environment is insufficient to maintain their numbers and diversity in the long term.

Loss of biodiversity is real. Although there is no universal indicator that accurately reflects changes in biodiversity in different ecosystems at different spatial scales, the indicators that do exist deliver a clear message. One is the Living Planet Index (WWF, 2004), which is based on the population sizes of hundreds of vertebrate species in terrestrial, freshwater and marine ecosystems



**Fig 1** | Changes in the three components of the Living Planet Index in 1970–2000: the terrestrial species, freshwater species, and marine species indices (WWF, 2004).



around the world. In the 30-year period from 1970 to 2000, the LPI dropped by 37% (Fig 1). This decline has been particularly severe among freshwater species.

Declining biodiversity is also documented in national and global 'red lists' of threatened species. Loss of biodiversity is obvious in the densely populated parts of Europe, but it can also be a major problem in regions where human population density is low if natural resources are used so extensively as to affect large parts of the landscape. In Finland, which has well-known flora and fauna and exceptionally intensive forestry, nearly 20% of all species are extinct, threatened or near-threatened (Rassi *et al*, 2001). On the other side of Europe in Portugal, the corresponding figure is 33% for vertebrates, butterflies and bryophytes (EASAC, 2004). There are no sufficient data to assess the threat level for other species in Portugal, which reflects the embarrassing situation—not specific to Portugal—that we lack the knowledge of even very basic facts about our environment.

At the global level, the best-known groups of animals are mammals and birds, of which 24 and 12% are extinct, threatened, or near-

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threatened, respectively (IUCN, 2004). Much less is known about other groups of species, but they may be even more endangered. Among the species of reptiles, amphibians, fish and plants for which sufficient data are available to allow an assessment of threat—which amounts to less than 10% of all species in these taxa—40 to 70% have been classified as extinct, threatened or near-threatened (IUCN, 2004). The current rate of species extinctions on Earth is 100 to 1,000 times greater than the natural rate and is accelerating (May *et al*, 1995). The natural rate of extinctions can be calculated for mammals from comprehensive fossil data.

**T**he above figures suggest that biodiversity is being lost at local and global levels, and that the magnitude of threat is similar across different groups of species. The similarity across spatial scales

and different kinds of organisms also suggests similar causes. Indeed, there is one cause of declining biodiversity that operates locally, nationally and globally and which affects all groups of animals and plants: the loss and fragmentation of natural habitats, which is caused by agriculture, forestry, urbanization, construction of infrastructure and tourism (Delbaere, 1998).

Much attention has been given to forests, which have provided and continue to provide humanity with a wide range of products and services, but which have often been used wastefully. For instance, by 1950 only about 30% of the Mediterranean forest biome remained, and since then an additional 2.5% has been lost (Mace, 2005). Even higher rates of loss occur in the tropical biomes, where the current annual rate of forest loss is 0.6 to 0.8% (FAO, 2001). In the boreal forests in northern Europe, forest cover is high and not declining, but intensive forestry has turned natural forests into managed production areas with even-aged stands of single tree species. Such forests lose most of the ecologically specialized species of animals and plants (Hanski,



in the current level of biodiversity. Why is it so difficult to convince society of the need to halt biodiversity loss?

**Nature documentaries on television are popular, but they portray an exceedingly biased view of the natural world by focusing on the most impressive sceneries, habitats and animals on Earth**

One reason is related to the time lag with which populations react to changes in their environment. At large spatial scales, the time lag may be long—decades or even centuries—and the full impact of environmental changes will not become apparent until some time in the future. Given that much of the landscape transformation has occurred relatively recently—in the past 50 to 100 years—there is a substantial ‘extinction debt’, that is, large numbers of species that will not survive in the current landscapes, but have not yet had time to become extinct. Theoretical studies indicate that time to extinction is especially long in the case of threatened species that are close to their extinction threshold following environmental change (Hanski & Ovaskainen, 2002).

These time lags in species’ responses to habitat loss and fragmentation will easily lead us to underestimate the current threat to biodiversity. But there are other reasons why peoples’ perception of habitats may be severely biased: advances in information technology and media, transport technology, and changing perception of what constitutes natural habitats, which is moulded by lack of personal experience (Hanski, 2005).

With respect to information technology and media, people in developed countries know much more now about habitats and ecosystems across the world than did their ancestors. Improved public knowledge should be beneficial, and more so if the knowledge covers the entire globe. But when television beams spectacular films of natural history and wonderful places from all over the world, one evening after another, there is the danger that anything else may appear second-rate and mundane—the meadows behind the highway, the woodland close to the city. Nature documentaries on television are popular, but they portray an exceedingly

2000). The same is true of plantations—which have increased forest cover in some parts of Europe in recent decades—although plantations may still be ecologically preferable to deforested land. In addition to natural forests, the disappearance of wetlands has been dramatic over the last century, ranging from 60% in Denmark and Finland to 90% in Bulgaria (EEA, 2003). Another important landscape change is the replacement of low-intensity farming systems—which support a high level of biodiversity (Bignal & McCracken, 1996)—with industrial agroecosystems. In Finland, the loss of habitats that are associated with traditional low-intensity agriculture is the second most important threat to species after forestry (Rassi *et al*, 2001).

**Why is it so difficult to convince society of the need to halt biodiversity loss?**

Other causes of biodiversity loss include climate change, the impact of invasive species, harvesting and persecution. Climate change has already caused significant changes in the geographical distribution of species (Parmesan *et al*, 1999) and in their seasonal occurrence (Parmesan & Yohe, 2003; Root *et al*, 2003). The predicted rise in average global temperature by 2050 will cause such great changes in global habitats and ecosystems that an estimated 15 to 37% of species will become endangered (Thomas *et al*, 2004).

No similar analysis has been carried out for Europe alone, but a comparable level of threat can be expected, particularly for species that live in distinct habitats on mountains and at extreme latitudes from where they cannot move away. Climate change will have particularly harmful effects in regions where natural habitats are highly fragmented, which hinders the movement of species over geographical ranges (Warren *et al*, 2001).

The above predictions and the studies from which they originate should be convincing enough, yet—like with many other environmental issues, including climate change—the societal response has been underwhelming. Everybody presumably agrees that the dependence of humans on biodiversity is absolute—there is no possibility of our survival on Earth without a substantial fraction of today’s biodiversity. Taking into account future generations, the safest option is to maintain biodiversity at the current level, or even to restore it to some previous level if the present state is considered insufficient. Any rate of continuous decline will translate into a severely reduced amount of biodiversity in the future. We do not have the knowledge to predict what level of reduction is tolerable in the long run, and we do not know how difficult it will be to stop further decline if the current situation continues. But not everyone is convinced by these arguments; many people apparently believe that there is substantial redundancy



biased view of the natural world by focusing on the most impressive sceneries, habitats and animals on Earth. There is little chance that, by these standards, most natural habitats would score well in peoples' minds. They are bound to appear dull and insignificant, and hence of little value.

Nature documentaries increase our wish to see these spectacular places, and advanced transport technology has made it possible. A huge number of people in developed countries now have the means to take a vacation practically anywhere on Earth, but here lies another danger, apart from the environmental impact of air travel itself. Because it is so easy to visit a national park or see natural forests, this may create the illusion that such places are much more common than they actually are. Our everyday experiences in cities reinforce this: cafes, museums and cinemas only take up a small fraction of the total land in any city, but it is easy enough to find one whenever we want. Humans in developed countries increasingly perceive the entire world as their personal environment. The situation is, of course, very different for the vast majority of people in developing countries and for practically all other species.

**H**abitat loss occurs in our minds. Let me explain this with an example concerning forests in Finland. Finland is a country that is largely covered by forests and bogs, though most of the latter have already been drained to make more forests. Given the emphasis on measures to increase the growth of trees in forests, including massive government subsidies and organizations that have been established to ensure the forest owners' collaboration with the forest sector at large, it is no wonder that the concept of natural forest has undergone a massive transformation in peoples' minds. Most Finns are convinced that forests must be cared for to remain healthy and viable—just like cornfields. People have been led to believe that unattended forests will become fatally debilitated; not only will individual trees die, but the entire forest will succumb. A letter published in a Finnish national newspaper in 2002 vigorously attacked the concept of continuous forest harvesting, which results in forests with diverse age and size structure. The argument in the letter was that this is unnatural—as natural forests are supposed to consist of single cohorts of trees of the same age and size. This is an

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example of the extent to which the idea of a habitat—the natural forest—has been lost in our minds: not only do the characteristics of natural forests indicate an unhealthy state of the environment, but they are proclaimed unnatural. With no personal experience, it is too easy to be misled by fallacious arguments that are created for the sake of intensive forest management.

The message here is that we should recognize the biases that make us devalue 'ordinary' landscapes with some fragments of natural or semi-natural habitats. It will not be possible to maintain viable populations and life-supporting ecological processes only in existing national parks, because the biggest parks are located in the most unproductive and species-poor ecosystems. The world's largest protected area in northeast Greenland is nearly 1 million square kilometres in size—it alone represents 17% of the total area of protected areas, strict nature reserves and national parks in the world. We need these national parks and reserves, and we need more of them, but we also have to maintain a high level of ordinary biodiversity in everyday landscapes closer to home (Hanski, 2005).

**E**cologists are inevitably asked about the longterm consequences of landscape fragmentation and biodiversity loss. The short answer is that we do not know the big picture. There are no previous examples of comparable global environmental changes in human history, and any theoretical predictions are complicated by the possibility of drastic qualitative changes in the functioning of global ecosystems once critical threshold values in the state of the environment have been passed. We do not know what challenges a world with severely reduced biodiversity will pose to future human generations, though we can be sure that they will be much worse off than our own generation.

I conclude with a story about human history, which is based on Jared Diamond's 1997 book *Guns, Germs, and Steel*. It may have weaknesses as a description of actual events, but the story

alone is a compelling illustration of the value of the natural environment and lost opportunities.

The story begins 14,000 years ago with the migration of groups of hunter-gatherers from Siberia to North America. The immigrants encountered a truly new world, an unspoiled paradise in which big mammals were exceedingly easy to hunt. It took just 1,000 years for the immigrants to multiply and occupy all of the Americas, from north to south and east to west. In the process, most big mammals disappeared. Whether human 'overkill' was the primary cause of this megafaunal extinction is still the subject of debate. To me it seems probable that humans were indeed responsible, as they were in so many other places on so many other occasions. But did it really matter that most of the large native mammals disappeared when the vast majority of other species were not affected?

Having caused their extinction, the Siberian immigrants had no opportunity to domesticate large-bodied mammals, unlike their counterparts in the Old World who evolved and coexisted with large mammals for a long time. With no domesticated animals, agricultural and hence cultural development proceeded at a relatively slow pace compared to the Old World. Eventually the two civilizations collided in 1492 when Christopher Columbus sailed to America, an interaction that turned out to be highly asymmetric. The inhabitants of the New World perished because of their inferior technology, ultimately due to their lack of advanced agriculture. More importantly, they were vulnerable to infectious diseases that the inhabitants of the Old World brought with them—zoonoses they had acquired from domesticated mammals and to which they had evolved immune protection. Why did all this happen? Because the first humans in the Americas had exterminated much of the native megafauna thousands of years earlier.

This period of human history will not be repeated, but it should make us realize that the consequences of our use of natural resources may be much more far-reaching than expected. Massive habitat destruction and fragmentation is happening now and is causing biodiversity loss even greater than the megafaunal overkill in the Americas so long ago. Unfortunate perhaps, but not of immediate concern. But in our ultimately finite world, the longterm consequences may be surprising and unpleasant.

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