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The world that became ruined

Our cognitive incapacity to perceive large-scale and long-term changes is a major obstacle to rational environmental policies

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As humans, we are only able to perceive a small region of space and a short length of time. These limits to our sensual and cognitive capacities are the result of our biological evolution. Both our senses and our cognitive apparatus evolved in response to challenges in our immediate neighbourhood—such as a predator hiding in tall grass or an upcoming thunderstorm—and they have served us well throughout most of our history. Today, we have vastly improved our knowledge in terms of both time and space: an educated human knows about scales as different as the age of the universe, the size of our solar system and the size of a cell. Yet, humans are not capable of coping with the global environmental deterioration that we are inflicting upon ourselves. I therefore argue that the most prevalent threats to our societies and our environment are caused by the mismatch between the vastly expanded range of human influence and our limited perception of the world, which is still no more advanced than that of our African ancestors living more than 100,000 years ago.

Most of the time, we only perceive and worry about what is going on around us, although we occasionally spare a thought for the relatively near future. Of course, modern communication provides us with up-to-date news about what is happening in other parts of the world, but such events seem remote and not a reason to worry. These limits to our sensual and cognitive capacities make it difficult to appreciate that planet Earth is a finite sphere in a vast space that is almost devoid of matter, and that our activities have an impact that extends far beyond our immediate environment—in both space and time.

Occasionally, there are drastic events that demonstrate—at a scale that every human

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would notice—the facts that the Earth is finite and that life is vulnerable. However, the last such event took place a long time before *Homo sapiens* evolved: 65 million years ago, an asteroid with a 10-km radius hit our planet and the impact released an enormous amount of energy, comparable with 10 billion Hiroshima-sized nuclear bombs—more than 50 bombs for every square kilometre of the land surface of the Earth. Given these figures, it is not surprising that the impact had catastrophic consequences for life and meant the end for the dinosaurs, which had been the dominant life form on Earth for tens of millions of years.

From the cosmological perspective, it does not matter whether an event takes place over one day, one year, or a few hundred years; however, from the human perspective, these are huge differences. We are good at assessing the current state of our immediate environment, but we are not able to recognize and react to environmental changes that take decades or even longer. Although humanity has a record of the environmental changes of the past few hundred years, we fail to appreciate fully the meaning of these data; the apparent stability of the current state of the world is deceiving our senses. We fail to understand how enormous our impact on the Earth has been or how quickly things have changed and are changing.

I have made a rough calculation of the amount of energy that humankind has been releasing by burning fossil fuels throughout human history: in comparable units, it amounts to around 0.5 billion Hiroshima bombs—a couple of bombs for every square kilometre of the land surface of the Earth (Hanski, 2007). This is less than the energy released by the asteroid impact 65 million years ago, but not by orders of magnitude; the human impact on the Earth is therefore comparable with the catastrophe that led to the demise of the dinosaurs. The simultaneous detonation of several nuclear bombs on every square kilometre of land would concern everyone; yet, we fail to see that our own species has caused global environmental changes that in many ways are equally drastic over just a few hundred years.

Three major environmental changes that have resulted from human activities are the transformation of natural ecosystems, the loss of biodiversity and climate change. At the dawn of agriculture, about 10,000 years ago, around 50% of the land surface was covered by forests. Since that time, the forests have shrunk to less than 20% of the land surface and only about 5% is covered by larger expanses of relatively natural forests (World Resources Institute, 2000). Open habitats have expanded, while various man-made ecosystems—with the primary function of producing food and other resources—now cover nearly one-third of the

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land surface. Equally staggering, although more difficult to document and appreciate, is the transformation of marine ecosystems, including the collapse of the megafauna of the ocean, and the demise of coral reefs and coastal ecosystems. Google Earth has made it possible to visualize the scale of our impact on the Earth; it allows us to see, for instance, the sediment trails that follow deep-sea trawlers, which cause massive havoc in deep-sea ecosystems that would otherwise remain invisible (www.skytruth.org).

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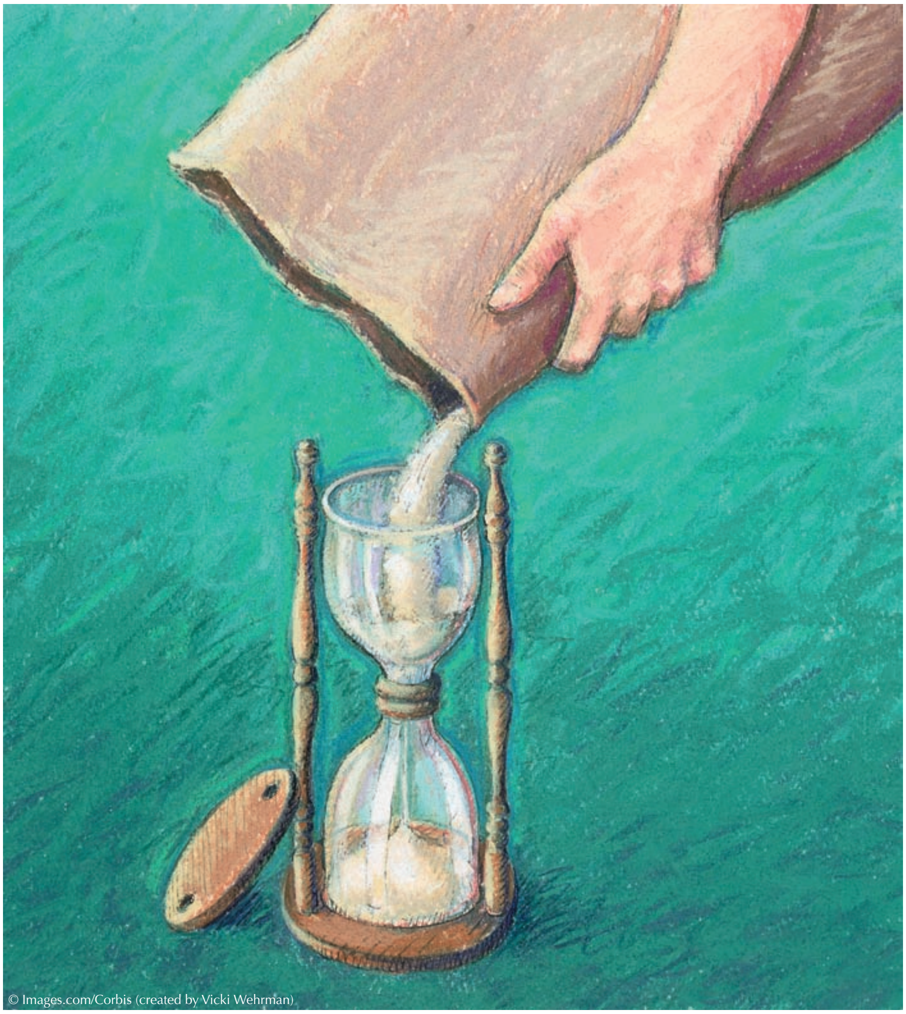
The transformation of ecosystems has taken place extremely fast on the timescale of ecological processes, which are measured, for example, in generations of trees—that provide the structure for forests—or in the lifespans of deep-sea corals that might be thousands of years old (Roark *et al*, 2006). Again, we fail to perceive these timescales: our perception remains focused on the current state and tricks us into the false impression of long-term stability. We fail to comprehend the natural speed of biodiversity dynamics, which is set by the rates of speciation and natural extinction.

Starting in the 1970s, the World Conservation Union (IUCN; Gland, Switzerland), together with other organizations and with the help of many interested specialist groups, began compiling a 'red list'of animals and plants threatened by extinction, or that have gone extinct during human history (www.iucn.org). Almost all of the mammalian and bird species known to science—numbering some 15,000—have been assessed for their conservation status: 1–2% of these species have gone extinct in the past 400 years, and another 12% of birds and 23% of mammals are now classified as threatened. Among the other vertebrates, only 5% of the species are sufficiently well known to allow for classification; among those, 1–5% have gone extinct and a staggering 40–70% are threatened.

The current rate of species extinction that can be calculated using these figures is about 50 extinctions per species per one million years (Hanski, 2005). The pre-human extinction rate of mammals, which is known from the fossil record, is about 0.5 per species per million years. The current



> **Technology can help us to deal with environmental deterioration, but will it ultimately lead to a dead end once we have reached the limits of the planet?**

rate is therefore roughly 100 times higher than the background rate. As high as this estimate is, it is certainly an underestimate, as the extinction rate has been increasing (Groombridge, 1992). If the rate of loss of tropical forests remains at its current level of 1% per year, the projected losses of species have been estimated to be at 1–5% per decade (Reid, 1992).

Some might argue that the loss of threatened species, most of which are rare or have restricted geographical ranges, is not likely to have major consequences, simply because ecosystems are most dependent on the presence, population sizes and dynamics of common species. This is true to the extent that many currently rare species have a limited impact. However, there are also other factors to take into account.

First, some species have a disproportionate influence on other species and thereby on whole ecosystems, even if their numbers are small. Carnivores that occupy the top of the food chain are one obvious example—in particular, *Homo sapiens*. Even before the dawn of civilization, the human impact on some parts of the globe had already been massive. Humans most likely played a decisive role in the demise of the megafauna in Australia and North America 45,000 and 13,000 years ago, respectively, and most certainly in Madagascar during the past 2,000 years. Another demonstration of the influence of top carnivores on ecosystem function is the recent return of wolves to the Yellowstone National Park in the USA;

this had notable consequences for the tree-species composition owing to reduced browsing by large herbivorous mammals, particularly moose, which are preyed on by wolves (Morell, 2007).

Second, many currently threatened species are 'insignificant' in their ecosystems only because humans have caused them to be rare—either because the impact of human activities has been exceptionally severe or because they are especially sensitive to human interference. A notable example is the now extinct passenger pigeon, which might once have been the most numerous bird on Earth. It disappeared during the early 1900s, before there was a chance for researchers to document the consequences of its loss for ecosystems (Sekercioglu, 2006). Sharks and other large predatory fish have been hunted down to low numbers in the oceans (Myers & Worm, 2003), which has led to cascading effects down the food chains, including the termination of a century-long scallop fishery in the northwest of the USA (Myers *et al*, 2007).

Even if our main concerns are the narrow human interest and the role of common species in ecological processes, we should nonetheless worry about threatened species because they represent the tip of the iceberg: there is a correlation between the well-being of rare and common species because they are influenced by similar environmental factors. A recent meta-analysis of small-scale experiments, long-term regional time series of ecological changes, and fisheries data indicated several adverse effects of biodiversity loss in marine ecosystems: a higher rate of resource collapses, a reduced potential to recover, a reduced numerical stability and reduced water quality owing to the loss of organisms, such as mussels, that filter water (Worm *et al*, 2006).

The good news is that, regardless of human impacts on the Earth—intensive land use, warming climate, persecution, excessive harvesting and introduction of non-native species into new regions—life on Earth itself is not threatened. However, apart from the rich microbial life, severely human-dominated landscapes retain only a set of ubiquitous species: those with ecological requirements that are compatible with the conditions in these transformed landscapes. These species include widely distributed invaders in many parts of the world, exemplifying the ongoing globalization of nature. Animal and plant communities in the future will include fewer species and will be more vulnerable to perturbations.

Some biologists seek to deal with this problem by introducing synthetic life forms—man-made organisms that are released into the wild. The fact that scientists are even thinking along these lines provides the best example for my thesis: the tragedy of the limits to human awareness of time and space, and the delusions to which such limits might lead.

> **…by pretending that the Earth is only 70% of its real size we would gain a sustainable planet for our species**

The American biologist Jared Diamond has carefully documented the environmental context of past human societies and the environmental causes of their collapse (Diamond, 2005). Yet, there are two main differences between these past events and our present situation: our far superior technology and the global reach of our impact. Technology can help us to deal with environmental deterioration, but will it ultimately lead to a dead end once we have reached the limits of the planet?

The loss of natural ecosystems and biodiversity must therefore be contemplated in the context of the finite size of the Earth. It would be better to pretend that the Earth is 30% smaller than it really is and only to exploit 70% of its resources. In the long term, human enterprise would adapt to a 'smaller' world and fewer resources—there is nothing magic about the exact size of our planet. Yet, by pretending that the Earth is only 70% of its real size we would gain a sustainable planet for our species. In the long term, we must raise ourselves beyond the limits of our perception and our personal focus, and save something for our descendants to inherit.

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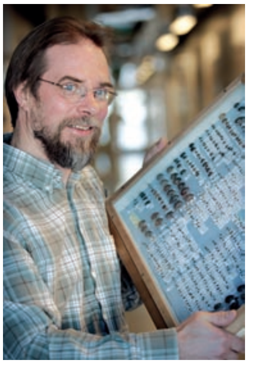

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