



## Global Biodiversity Is Falling Fast, Imperiling Humanity. Can Better Policy Avert a Collapse?

**T**he South China tiger, the passenger pigeon, and chestnut ermine moth are extinct. The Florida yew, Sumatran rhinoceros, and North American right whales are critically endangered. And it is not just a few scattered species. Stunningly, at least half the global insect and phytoplankton biomass is now gone. Remarkably, about 96 percent of the total mammalian biomass on Earth is now humans and domestic mammals, and roughly 75 percent of the total bird biomass is domestic fowl. It is truly the age of the Anthropocene.

The tropical rainforests of South America, Southeast Asia, and equatorial Africa — the three main hotspots of terrestrial biodiversity, together treasuring a storehouse of genetic information and serving as key components of the terrestrial biosphere — have been decimated. Much of the natural habitat that remains is cut through with roads, dwellings, and larger buildings, and every imaginable sort of resource extraction activity.

Meanwhile, the challenges mount as the seas rise, invading coastal ecosystems; ocean waters become more acidic and inhospitable to many

marine denizens; and terrestrial climate zones migrate toward the poles faster than their established ecosystems can keep up.

In apparent contradiction to the dire condition of biodiversity on the ground, there appears to be a robust legal regime to protect biodiversity, including the U.S. Endangered Species Act and similar legislation in many other countries. The world community has established the international CITES accord to limit trade of endangered organisms and formed the Convention on Biological Diversity. Beyond the statutory and treaty regime, one can point to substantial parks and other means of protecting natural habitats. Efforts to protect biodiversity include work by governments, businesses, and NGOs and are themselves quite diverse — debt-for-nature swaps being a prime example.

Yet somehow, that legal regime and protection efforts have been grossly ineffective. Upgrading these measures to meet the extent of the threat is in order. Our expert panel looks at the difficult issues involved in saving the global environment from biodiversity collapse.



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**Rodolfo Dirzo**

*Bing Professor of Environmental Science*  
STANFORD UNIVERSITY



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**Patrick Parenteau**

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## Saving the Services to Humanity of Biology's Richness

By Rodolfo Dirzo

The Earth's majestic terrestrial and marine ecosystems, together with their climatic envelopes, geological substrates, and the processes and products resulting from their functioning, represent humanity's life-support systems. Their precious roles include capturing carbon dioxide, releasing oxygen, supplying food and drinkable water, controlling soil erosion, regulating pests, recycling wastes, and providing inspiration through the wonders of our natural home.

These services are, essentially, the result of about 4 billion years of relentless organic evolution — so relentless, in fact, that it has overwhelmed the occurrence of five major pulses of biological extinction that occurred over the last 550 million years. Extraordinarily, never in the history of life has the planet accumulated more biological diversity than in the present times — when we humans are also present.

Ironically, despite the current pinnacle of biodiversity, humanity since the industrial revolution, but most notably in the last few decades, has become a formidable force of environmental change and a formidable threat to the life forms and life-support systems upon which all depend.

The global community of scientists who study the interaction of humanity with the rest of the biosphere has helped us understand the trajectory of key impacts on the planet. We now have clear evidence that *Homo sapiens* is causing the strongest, fastest climatic disruption since modern people evolved. At the same time, we have driven a massive deterioration of terrestrial and marine habitats, while maintaining a steep overexploitation of their resources. Furthermore, sci-

ence has also documented increasing levels of toxic pollution correlated with human activity, which further poison species.

We now see increasing evidence of the most critical, truly irreversible global environmental change: massive biological extinctions of local populations and species, preluded by steep declines of the abundance of plants and animals. Not only the large and charismatic animal species are dying off, but invertebrates too, including many beneficial insects. The most significant drivers of these affronts to nature are the unprecedented growth of the human population and excessive resource consumption in the richer countries.

Each one of these anthropogenic impacts has profound consequences when analyzed separately, yet it is their compounded, synergistic effects that place humanity's life support systems on the verge of a critical tipping point — an abrupt shift in biodiversity, ecological structure, and ecosystem functioning that would imperil all life. The effects result in an acceleration of the chances of crossing critical thresholds, leading to irreversible change within a few decades while fueling mounting international conflict.

When multiple global pressures combine, ecosystem changes occur more unexpectedly, faster, and more intensely than what would be predicted from considering each impact separately. The crossing of tipping points leading to different ecological settings has been documented at a variety of temporal and spatial scales. Some tipping points in the past have been of profound and global impact and, yet, life recuperated afterward — in a manner of speaking.

Let us consider the case of the massive extinction of 250 million years ago, when natural global changes brought about the demise of the majority of species. Although one might say the flora and fauna were able to recover, it took tens of million years for ecosystems to reach

comparable levels of diversity, and for life-support systems to reach a new, relatively stable ecological state.

The last massive global extinction permitted the demise of the dinosaurs, some 65 million years ago, along with most other species then living on the planet. While biological recovery did in fact ensue, once more it took millions of years — and the resulting diversity was very different from that of the pre-extinction global ecosystem.

While post-tipping point recoveries can and do occur, this is of no consolation from the perspective of today's interdependent global civilization. There is no way society could wait even ten years for nature's depleted services to be restored, let alone ten million.

If action is not immediately undertaken to change the current path, we can conclude that humanity's quality of life will suffer substantial degradation within a few decades. Therefore, it is essential that, beyond the scientific community, society at large — the general public and governments at all levels — gains a deeper understanding and develops a recognition of the urgency of the predicament we all face.

Policymakers will need to implement solutions that drive social change. Scientific knowledge and technological capacity are not the limiting factors; we are limited, rather, by personal attitudes and priorities. We need systematic education explaining how human wellbeing depends on environmental life-support systems, emphasizing the pressing need to cease the abuse of these systems and resources. Should we commit to curve the trajectory of the Anthropocene Era, it is our youth who will be safer when they reach maturity and find a planet with the same biological treasures we have enjoyed ourselves.

**Rodolfo Dirzo** is Bing Professor in environmental science at Stanford University and senior fellow at the Woods Institute for the Environment.

# Making Species Worth More Alive Than Dead

By Frank Hawkins

Looking at global biodiversity collapse from where I started, in western Madagascar, and from where I am now, in Washington, D.C., the reasons for the loss of species are the same. People convert biodiversity to cash, knowingly or unknowingly, directly or indirectly.

Poor people in Madagascar have no other option but to cut forest for land to plant subsistence or cash crops, using the trees as a nutrient burst for the crop. In the western world, people unknowingly pay companies money for goods that are produced on land cleared of primary rainforest. Both cases are leading to the loss of fabulously rich and complex ecological systems. The end result is the same: we are facing a mass extinction event the equal of anything since the end of the Cretaceous, when a comet or meteor slammed into our planet, wiping out the dinosaurs and the majority of other species.

The solution to the present crisis is that the Earth's great examples of ecology need to be worth more as ecosystems than as cash — and by *worth* I mean of both financial and spiritual character. For the Malagasy farmers of Madagascar, that means the opportunity to participate in an economic system that brings them much better long-term prospects than the gut-wrenching insecurity of moving from patch to patch every year to cultivate subsistence or local-market goods. For the American consumer, it means knowing that the palm oil in her bag of Chips Ahoy was produced without the loss of orangutans and their habitat, or any other form of Bornean biology.

So how can we make that happen? It's a matter of managing risk.

The Malagasy farmer is faced with huge risks, most of them caused by governance issues — over land tenure and over the ability to negotiate fair deals in contracts. The cookie manufacturer needs to be acutely aware of the risk to biodiversity it is causing by supporting the destruction of rainforests.

For companies, most of this risk is currently reputational— they suffer if they can be portrayed as badly behaved by consumer groups. This can have generally short-term impacts on company behavior, since they quietly find ways to manage this very adeptly. So in order to be effective in reducing biodiversity loss, the downside to companies of destroying biodiversity needs to be backed with teeth— legal and financial teeth.

A big opportunity to produce this kind of behavior— one that lies a little way in the future — is to associate the impacts of producers on biodiversity with the behavior of consumers through something that bears the weighty name of Environmentally Extended Input-Output Analysis. This way, the impact of the coffee produced in Ghana can be traced all the way to all the countries that buy and consume it, thus enabling us to pass some of the costs of mitigating ecosystem impacts directly to consumers, perhaps in the form of a tax. The politics of how these cost transfers can happen still needs working through, but at least producers and consumers won't be able to say they don't know what the impacts of the production are any more, at least in financial terms.

The opportunity side of the equation is starting to take off. Around \$300–400 billion is needed globally on an annual basis to sustain biodiversity. Only about a tenth of this can be expected to come from public finance. The rest has to come from private investment. However, investing in conservation is tricky — risks of failure are high, returns are unpredictable, deals are currently rather small.

So here's a great opportunity for some policy gain. If governments were to use their public money to create conditions for private finance to flow to conservation deals that make money, we'd be solving the Malagasy farmer's problem and able to create economic opportunity driven by demand from informed consumers. The conditions that are needed include capacity building to improve governance and knowledge of deal development in the countries that need it most — and as I can swear, Madagascar is a really good example — and lots of risk finance that can draw in private investors.

Investment in nature can come in many forms. Examples include support to sustainable agriculture like palm oil that protects orangutans, investments in coral reefs and mangroves that provide carbon sequestration, food, and storm surge protection, deploying upstream green infrastructure to deliver water to downstream users, and many others.

It's largely a matter of seeing a revenue stream — reduced insurance payments? eco-certification? avoided deforestation credits? reduced sedimentation risk for farmers? ecotourism revenue? — and bundling these streams into investable vehicles that the rather indolent and risk-averse finance world will buy. Indeed, the non-indolent and non-risk averse members of that group are already doing this, and successful models are being standardized, replicated, and aggregated in these sectors.

There are already dozens of these kinds of deals. But we need tens of thousands of deals, of an immensely greater value, in order to deliver the scale of investment in nature that will be needed to sustain the planet while lifting the lot of the Malagasy and the billion or more poor people to participate in sustainable local, regional, and global economies.

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## Dealing With Our Own Species to Stop Genetic Loss

By William Magnusson

I do not believe that the biodiversity crisis, or for that matter climate change, is an existential threat to humanity. And I say that as someone who loves biodiversity, has spent much of his life studying it and engages in hot battles to conserve what is left of it. There is likely to be some level of biodiversity below which humans cannot survive, but we have no idea what that is, and attempts to say we do just puts us into the realm of fake news.

This brings us back to the question of why we value biodiversity. Saying that it is because we are in imminent danger of extinction, as well as being human centric, makes us vulnerable to those who can present contrary arguments. In 1500, any thoughtful person armed with the facts would have come to the conclusion that humans could not withstand the loss of over 90 percent of the large terrestrial wild vertebrates, but we did. Obviously, something was lost, but it was not the potential for human life or civilization.

Survival in an extremely bio-uniform world is obviously possible, but the question is whether that is what we want. Most conservationists value biodiversity for spiritual or aesthetic reasons, and only a handful are engaged in the fight because they are trying to save humanity, though that is the argument that most present to the general public. If we want to participate in the debate, let's be honest.

There are lots of reasons to value biodiversity, but the one that appeals most to me is that it enhances the potential for evolution and we are a product of evolution. Sometimes we say that human progress is likely to depend on products or processes we can extract from biodiversity, but we

are generally talking about domesticating micro-organisms and not borrowing genes from whales. Micro-organisms hold the greatest amount of biomass and genetic material on the planet, and contrary to mammals and birds, most of that biomass is not domesticated.

For whatever the reason, humans value biodiversity and have enacted laws or adopted practices to conserve it throughout the world. These have obviously been resoundingly ineffective and, rather than imagine that some new law based on a general fear of the extinction of humans due to biodiversity loss will be more effective, it would be better to investigate why the present laws have not worked.

*Homo sapiens* is a colonizing species. This is an almost direct consequence of the capacity of members of the species to contemplate new opportunities. At first we colonized new lands, but as they became exhausted we started to colonize new dimensions. Each new specialization that developed opened new frontiers for those who were better endowed intellectually and had sufficient courage.

Many of those that had the sensibility to conquer new frontiers also had the perspicacity to see that resources were dwindling and to propose rules of law to protect those resources. The law of supply and demand ensures that the value of a resource increases with its rarity, but protection by the law moves the resource from the private to the public sector and the tragedy of the commons means a common resource is difficult to protect.

Why should some sectors want to exploit a resource to extinction? The simple answer is that those sectors can see no alternative. People with the ingenuity to exploit new frontiers can often see the value in protecting a dwindling resource. Entrepreneurs such as Bill Gates often spend much time and money to protect biodiversity. But not everyone can recognize the new frontiers that are opening up, or have the courage to colonize them.

Up until the last couple of centuries, most of the frontiers were related to biodiversity exploitation, and much of the world's population became rich exploiting them. They successfully enacted laws to protect what was left, but two groups were left behind. In the process of colonization, the local people were often not respected and not provided with adequate education, and the only frontier they can see is that which was colonized by their oppressors. The route to conservation is to provide them with the education to see the opportunities that reside in biodiversity that are not related to its reduction.

The other group that got left behind is composed of the populist politicians that lack the educational or intellectual capacity to see the new frontiers. Some of these are rich and powerful by heredity or luck. As they cannot see the potential in the new frontiers, they continue to try to exploit the resources that made their ancestors rich, and sell that route to riches to an uneducated electorate.

Some of those politicians become richer, but none of their voters do. Laws cannot contain the destruction when the perpetrators are among the lawmakers.

Law enforcement is important, but cannot be the whole story. In Brazil, where I work, a positive development is the Program for Biodiversity Research (PPBio), which I help coordinate in western Amazonia. It was created by the federal government to fill the gap between local needs and national obligations. The first phase created regional hubs with committees constituted by representatives of all local stakeholders. The hubs are linked in a multidisciplinary network that defines priorities for capacity building. This ensures that research and management is not divorced from the needs and aspirations of the local people. PPBio is a good first step.

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## A Bug's-Eye View of the Sixth Extinction

By Patrick Parenteau

Imagine a world without bugs. Sounds appealing at first. No more mosquitoes spreading disease. No more ticks hiding in your socks. No more ants ruining your picnic.

But what if there were no insects to pollinate your food? Up to 75 percent of our cultivated plants and up to 90 percent of all wild plants are dependent on insects to propagate. What if there were no insects to decompose waste and recycle organic substances essential to maintaining soil fertility? What if there were no good bugs to eat the bad bugs?

Insects are the most abundant form of life on Earth. 1.5 million varieties have been catalogued. In terms of biomass, insects outweigh humanity by 17 times. But more than 40 percent of insect species are declining and a third are endangered. The rate of extinction is eight times faster than that of mammals, birds, and reptiles. The total mass of insects is falling by a precipitous 2.5 percent a year. At that rate, insects could be functionally extinct within a century. The main drivers of this decline appear to be habitat loss through conversion to intensive agriculture and urbanization, pesticides and fertilizers, invasive species, and climate change.

Even if the predictions of an “insect apocalypse” prove hyperbolic, there is no doubt that we are in the throes of the Sixth Extinction. Only this time it is not meteors raining death and destruction on global biodiversity. It's humans. According to distinguished conservation biologists like E. O. Wilson, the rate of human-caused extinctions is hundreds or thousands of times the

natural rate. And it would take millions of years for nature to replace the biodiversity being lost, according to a study by Danish researchers.

The legal and policy responses to this impoverishment of the natural world have been woefully inadequate. The Convention on Biological Diversity was signed by 150 nations at the 1992 Earth Summit, with the United States abstaining. It begins with the lofty objectives of “the conservation of biological diversity, the sustainable use of its components, and the fair and equitable sharing of the benefits arising out of the utilization of genetic resources.” But the results have been disappointing. None of the 196 nations that have ratified the treaty met their 2010 targets for reducing biodiversity loss.

In 2010, the CBD announced a strategic plan that includes 20 global biodiversity goals, known as the Aichi Targets, to be achieved by 2020. The goals include conserving 17 percent of total terrestrial and inland water on Earth and cutting in half the current rate of loss of all natural habitats. Fully funding the Global Environment Facility created at the Earth Summit, which is the CBD's principal mechanism for financing projects, is the biggest challenge. The Trump administration's cancellation of the U.S. contribution hasn't helped.

In the United States, the Endangered Species Act, which the Supreme Court once called “the most comprehensive legislation for the preservation of endangered species ever enacted by any nation,” has not been re-authorized since 1992, a victim of the gridlock in Congress.

Even when it is allowed to function properly — that is, when imperiled species are promptly listed, critical habitat is designated, recovery plans are adopted, federal agencies obey the command to avoid jeopardizing species, and non-federal parties obtain permits to mitigate the “take” of species through habitat

conservation plans and other mechanisms — there is widespread agreement that the pace of recovery is too slow. The law has too few tools to deal with the backlog of species that are candidates for listing, let alone deal with the surpassing threats posed by climate change.

Critics of the ESA claim that it has a poor record of recovering species. In fact it has saved some very high-profile animals from almost certain extinction, including the whooping crane, California condor, black footed ferret, and Santa Catalina fox. The reintroduction of the gray wolf to the Yellowstone ecosystem is one of the most dramatic conservation achievements in history. The fact that 99 percent of the listed species are still alive with a chance to survive is remarkable given the massive loss of habitat most have suffered.

The rap on the ESA is that it is all stick and no carrot. In truth there are dozens of landowner-friendly policies under the act — safe harbors, no-surprises agreements, habitat conservation plans, conservation banks, candidate conservation agreements, and tax credits, just to name a few. More incentives would certainly be welcome, and there is no shortage of ideas, but that requires a dedicated funding source, which is not part of the current debate in Congress. Draft legislation to “modernize” the ESA is but the latest attempt to weaken the law by handing over responsibility to states, shielding delisting decisions from judicial review, and burdening the already underfunded and beleaguered federal wildlife agencies with new deadlines, paperwork, and other requirements.

We need fresh approaches, informed by science, inspired by the successes to date, and grounded in the reality that the fate of humanity is tied to the fate of our fellow travelers on Spaceship Earth.

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