# *Why Biodiversity Matters*

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Of the many dramatic changes underway in the world today, none is more stunning than the loss of biodiversity. Until the next big asteroid hits Earth, the future of all known life will depend much more on humanity than on any other force. We have the power to wipe out most macroscopic species and to change radically the future course of evolution of many of the rest. Humanity came into being when biodiversity - the amazing variety of life - was at an all-time high. Now, human activities influence virtually every cubic centimeter of the biosphere, the thin layer of life in the water, land, and air at Earth's surface. Our collective, day-to-day activities are causing a mass extinction as dramatic as that which ended the age of the dinosaurs.

These circumstances raise vexing questions, from both ethical and practical perspectives. Yet, from a science viewpoint, three points are salient. The first is that ecosystems and the biodiversity they comprise are capital assets. Ecosystem capital supplies society with a stream of vital benefits, or "services", without which human life would cease to exist. Second, traditional approaches to conservation, alone, are doomed to fail. Reserve networks are unlikely to protect more than a tiny fraction of Earth's biodiversity and ecosystem services over the long run. This means, third, that a new and complementary approach to conservation is required, one that makes conservation economically attractive and routine in places managed largely for human enterprise.

Some devoted conservationists raise objections to integrating economic considerations into conservation decisions, arguing that putting a price tag on the priceless is crass, at best, or outright immoral. There certainly are dangers inherent in attempting to harness selfish drives, such as the profit motive, in conservation. Yet, accepting the realities of the less "noble" dimensions of human nature is not giving in to them. Indeed, a rapidly growing partnership of leaders in environmental science, business, and government see the integration and harmonization of day-to-day economic activities with protection of ecosystem capital - the ultimate source of all wealth - as both an elegant and urgent mission. And there is cause for optimism. Numerous inspiring and innovative efforts to incorporate the value of ecosystem capital into decision-making are presently emerging in diverse societies worldwide. The challenge now is to explore these systematically, and develop a robust scientific basis for informing decisions, in order to replicate and scale up these promising models of conservation success.

## Ecosystems as Capital Assets

If properly managed, ecosystems yield a flow of vital services that sustain and fulfill human life. They supply ecosystem goods, such as seafood and timber, the harvest and trade of which represent an important and familiar part of the human economy. In addition, ecosystems produce life support processes (e.g., water purification, flood control, pollination), life fulfilling conditions (beauty, serenity, inspiration), and options (genetic diversity for future use).

One way to appreciate the nature and value of ecosystem services is to imagine trying to set up a happy, day-to-day life on the moon. Assume for the sake of argument that the moon miraculously already had some of the basic conditions for supporting human life, such as an atmosphere, abundant freshwater, and climate similar to those on Earth. After coaxing your family and friends into coming along, and packing prized possessions, the big question would be, Which of Earth's millions of species would you need to make the sterile moonscape habitable? You could first choose from among all

the species used directly (for food, drink, spices, timber, pharmaceuticals, etc.); even being selective, this list could amount to hundreds or even thousands of species. And you wouldn't have begun considering the species needed to support those used directly: the bacteria, fungi, and invertebrates that recycle wastes and maintain soil fertility; the insects, bats and birds that pollinate flowers; and the herbs, shrubs, and trees that hold soil in place, nourish animals, and help control the gaseous composition of the atmosphere that influences Earth's climate. As the collapse of the Biosphere II experiment showed, no one knows which - nor even approximately how many - species are required to sustain human life. So, rather than listing individual species, you would have to list instead the life-support services required by the lunar colony; then you could guess at the types and numbers of species required to perform each.

This is no simple task! There is no Yellow Pages to the planet's non-human inhabitants. Let's take soil fertility as an example. Soil organisms play important and often unique roles in the circulation of matter in every ecosystem on Earth; they are crucial to the chemical conversion and physical transfer of essential nutrients to higher plants and all larger organisms, including people, depend on them. The abundance of soil organisms is absolutely staggering: under a square meter of pasture in Denmark, for instance, the soil was found to be inhabited by roughly 50,000 small earthworms and their relatives, 50,000 insects and mites, and nearly 12 million roundworms. And that is not all. A single gram (a pinch) of soil has yielded an estimated 30,000 protozoa, 50,000 algae, 400,000 fungi, and billions of individual bacteria. Which to bring to the moon? Most of these species have never been subjected to even cursory inspection. Yet the sobering fact of the matter is, as Ed Wilson put it: they don't need us, but we need them.

Generation of soil fertility and all other ecosystem services derive from a complex of natural cycles, driven by solar energy. These cycles are ancient, the product of billions of years of evolution, and have existed in forms very similar to those seen today for at least hundreds of millions of years. They are absolutely pervasive, but unnoticed by most human beings. Who, for example, gives a

thought to the part of the carbon cycle that connects her to the plants in the garden outside, to whales in the Indian Ocean, to Julius Caesar, or to the global climate?

Noticed or not, human beings depend utterly on the continuation of natural cycles for their very existence. And for millennia, humanity has drawn benefits from these cycles without causing global disruption. Yet, today, virtually no place remains untouched - chemically, physically, or biologically - by the curious and determined hand of humanity. Although much more by accident than by design, humanity now controls conditions over the entire biosphere.

Unfortunately, relative to other forms of capital, the capital embodied in ecosystems is poorly understood, scarcely monitored, and - in many important cases - undergoing rapid degradation and depletion. Often the importance of ecosystem services is widely appreciated only upon their loss. As a result, the depreciation of ecosystem capital is typically undervalued, to the extent that it is considered at all. Protection of ecosystem services is still not even a focus of most conservation efforts!

## Conservation in Countryside

Traditional conservation is guided by the notion that the world comprises two types of places: natural habitat and human-created non-habitat. Remnants of natural habitat are seen as Noah's Arks of biodiversity, floating in a hostile sea of development. The logic is that organisms evolved tightly tuned to their native habitats; that few, therefore, are able to exploit areas devoted to human enterprise; and that those few - the rats and roaches of the world - do not merit attention, certainly not from a conservation standpoint. Traditional conservation strategy is to secure as nature reserves the biggest and most (bio)diverse a fleet of Arks possible.

But, as ecologist Michael Rosenzweig asks in his recent book, "What kind of environmental insult is Homo sapiens? A 40-day quickie?". He offers a blunt answer: "Not likely. Unlike the flood-

waters, we will not recede. We have no plans to vacate what we have taken - not in the next 40 days, not in the next 40 years. Not ever."

So, what proportion of the species existing at the time of Christ might the fleet of Arks sustain? Maybe 5 percent. Nature reserves are - and are likely to remain - simply too few, too small, too isolated, and too subject to change to protect more over the long run. Thus, Rosenzweig continues, "We must abandon any expectation that reserves by themselves, whether pristine or restored, will do much more than collect crumbs. They are the 5 percent. We need to work on the 95 percent." Equally important is the number of populations reserves can protect, since it is populations that deliver ecosystem services. A species of bee preserved only in Yellowstone National Park will not help pollinate fruit trees in California.

Abandon reserves? Absolutely not (many species will survive nowhere else) - just our false expectations of them. While reserves are, and will remain, a critical element of conservation strategy, they alone will never be sufficient. Save biodiversity in the hostile sea of development? You bet. However absurd or offensive this idea might seem, it is the only option left for preserving a level of biodiversity and ecosystem services that can sustain civilization.

The future of biodiversity, and the benefits it supplies society, will thus be dictated largely by what happens in human-dominated areas, whether on land or in the oceans. At the same time, the leading proximate drivers of biodiversity loss - agricultural, pastoral, fishing, and sylvicultural activities - are projected to expand greatly over coming decades. On land, the threat embodied in this expansion could be mitigated, in part, through efforts to conserve in human-dominated "countryside" species whose native habitats are rapidly disappearing. (See the next chapter on marine conservation).

Countryside refers to the growing fraction of Earth's unbuilt land surface whose ecosystem qualities are strongly influenced by humanity, and countryside biogeography is the discipline that investigates the functioning and fates of elements of biodiversity in countryside. Countryside includes active and fallow agricultural plots,

gardens and pasture; plantation or managed forest; and remnants of native vegetation in landscapes otherwise devoted primarily to human activities. It is critical not only to the future of biodiversity, but also to the future supply of ecosystem services. Many services are supplied on local and regional scales, and their delivery hinges on the capacity of countryside populations, species and ecosystems to generate them, in the midst of human residence and activity. Other services are important globally, such as carbon sequestration for climate stability; these also hinge on countryside because the global reserve system will never be large enough to ensure an adequate flow of benefits.

Thus the success of conservation efforts, and many aspects of human well-being, are intimately linked to the management of human-dominated countryside. Yet surprisingly little is known about the relative conservation value, for biodiversity and/or ecosystem services, of alternative production regimes and landscape configurations. Initial studies and conservation efforts understandably focused on natural ecosystems and, more recently, on their remaining fragments.

New work suggests that the conservation value of countryside can be high. In my decade of research on the conservation value of largely deforested Neotropical countryside, for instance, colleagues and I have found over half of the species in major vertebrate, arthropod, and plant groups occur commonly in deforested habitats. Adding to those the species that occur in small (0.1-100 ha) forest remnants still common in countryside, it appears that 75% or more of the native biota survives in densely populated, heavily farmed regions. Yet land-use intensification is ongoing and rapid throughout the Tropics. Our work suggest that there is an important window of opportunity to maintain and restore the diversity, abundance, and ecosystem services of the native biota in many human-dominated regions of the world.

## Making Conservation Profitable

The future of biodiversity also hinges on whether ways can be found for farmers and other landowners to capture the value of the ecosystem services it generates - that is, to align economic forces with conservation. Promising new efforts to achieve this alignment are presently underway worldwide. They include government mandated systems of payments for ecosystem services, such as those currently operating in Australia and Costa Rica; an ecological Value Added Tax operating in parts of Brazil; market-based approaches to paying for ecosystem services, such as the emerging international carbon market; mitigation banking approaches, such as those operating in the United States in the context of the Clean Water Act and the Endangered Species Act; conservation programs under the European Common Agricultural Policy and the U.S. Farm Bill; and various financial incentive schemes currently being designed and implemented internationally by the World Bank.

The year 2000 marked an especially formative time for this new paradigm, featuring diverse efforts to bring the abstract theory about ecosystem services down to Earth. These efforts differ greatly in the type of ecosystem capital focused on, in the geographic and cultural context of that capital, and in the motivation and incentives employed to protect it. Each offers insights to a prosperous, sustainable future:

- In Boston, the Hancock Natural Resource Group, a $3 billion division of John Hancock Financial Services, prepared a revolutionary investment fund with three types of returns. Institutional and corporate investors would be able to receive revenues from sustainable timber harvests and credits for the amount of carbon dioxide absorbed by the forests still standing. (Many firms believe such credits will be necessary if, as expected, laws are made to cap fossil fuel emissions. In that case, forest conservation projects could count as "offsets" mitigating their impact on the environment.) Other conservationists, meanwhile, could buy "biodiversity credits" to preserve flora and fauna in the timber areas.

- In Adelaide, Australia, environmentalist John Wamsley listed his conservation company on the national stock exchange, saying it was the first of its kind to go public. Wamsley's venture, Earth Sanctuaries Ltd., buys degraded farmland, restores it with native plants and restocks it with native animals threatened with decline or extinction, which attract ecotourists. Wamsley calls his approach "trading in biodiversity," and aims to use his business model to restore and protect vast regions - amounting to fully one percent - of Australia.

- In Napa, California, a town plagued for decades by floods, work began on an innovative effort to free the Napa River from its levees and dams to spill over onto its historic flood plain, providing natural flood protection. The Army Corps of Engineers, famous for pouring concrete, began tearing it out, removing the dams and levees along a seven-mile stretch. Residents, who had voted to raise their own taxes to pay for the plan, saw immediate paybacks, with property values soaring in expectation of a charming new waterfront district and a dry downtown.

- In Costa Rica, the government expanded its pioneering program of paying private land-owners to maintain functioning forests, giving individuals incentives to work for societal well-being. Property owners who conserve or regenerate forest on their land can receive compensation for the resulting flow of services, including carbon sequestration (for climate stability), watershed protection (for safe drinking and low-sediment hydropower supplies), biodiversity conservation (for pharmaceutical and other uses), and provision of scenic beauty (for ecotourism and other aesthetic enjoyment).

- In Bilthoven, The Netherlands, 95 of the world's top-ranking scientists met to launch the Millenium Ecosystem Assessment, the first comprehensive review of the state of the Earth's ecosystem assets, with a historically unique focus on the goods and services they render. The aim of this effort is to supply decision-makers worldwide with the information needed to incorporate ecosystem assets into business plans and policy development.

## CONCLUSIONS

Explicit recognition of ecosystem services and the conservation value of countryside provides two obvious benefits. The first is political. Understanding the role of ecosystem services powerfully justifies why habitat preservation and biodiversity conservation are vital, though often overlooked, policy objectives. While a wetland surely provides existence and option values to some people, the benefits provided by the wetland's nutrient retention and flood protection services are both universal and undeniable. Tastes may differ over beauty, but they are in firm accord over the high costs of polluted water and flooded homes.

The second benefit is instrumental. Efforts to capture the value of ecosystem services may spur innovative financial mechanisms and institutional designs that effectively capture service values and promote conservation at the local, regional, national, and international levels. If given the opportunity, natural systems can, in many cases, quite literally "pay their way." The key challenge is how to develop, replicate, and scale up models of success to make a difference globally.