

Biodiversity and Globalization¹

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Abstract: Reduction of the earth's biodiversity as a result of human activities is a matter of great concern to prominent scientists. What are the economic aspects of this loss? In economic terms, what is biodiversity and why might it matter? And is the loss of biodiversity in any way connected with globalization of the economy.

Key words: biodiversity, public goods, globalization, bundling.

What is the issue?

There is a general scientific consensus that we are losing biodiversity at a rate greatly in excess of that which has been normal for much of human history. It is also agreed that this loss is largely attributable to human activities. Loss of biodiversity is driven largely by destruction of the habitats of the species that are becoming extinct, a product of the need to clear land for housing, growing food and providing firewood. Behind this increasing pressure on space is of course the great growth of the human population, from about one and a half billion in 1900 to six billion in 2000 and quite possibly to ten billion by 2050. Population growth, habitat loss and biodiversity loss are global problems, in the sense that they are occurring globally and have global consequences. But they are not problems of globalization: they are not driven by the expansion of international trade and capital movements, nor the possible cultural homogenization, which we associate as part of the phenomenon called globalization.

Another factor that may already be contributing to the loss of biodiversity, and will probably contribute much more in the future, is climate change. Again, this is a global

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problem but not really a problem of globalization. It is global in that it occurs at a global level and has to be solved at this level. But it is driven by economic growth and concomitant increases in energy use, which is a distinct issue from the expansion of trade and capital flows.

In the balance of this paper I set out briefly the economic consequences of biodiversity loss, and then argue that as a global problem it needs global solutions, and suggest that further globalization, in the sense of the development of global economic institutions, including markets, is a prerequisite for solving the problems posed by biodiversity loss. The central point here is that the willingness to pay for conservation and for the services that biodiversity provides is located largely in the rich countries, whereas the biodiversity itself is mainly in poor countries. Conservation requires institutions that turn this willingness to pay into cash flows from rich to poor countries, cash flows that are conditional on conservation and provide incentives for conservation. I review several mechanisms that could be important in achieving this.

Biodiversity as a commodity

I have set out elsewhere the characteristics of biodiversity as an economic commodity (Heal 2000). It provides human societies with a number of important services, which include enhancing the productivity and resilience of natural and agricultural ecosystems, providing insurance against attacks on agricultural crops by pathogens, and providing us with valuable knowledge of novel genetic and molecular forms.

The relationship between biodiversity and the productivity and resilience of natural ecosystems has been a topic of intense and sometimes controversial research amongst ecologists over the last decade (Tilman et al., Hooper and Vitousek, Grime). The controversy is associated mainly with the mechanisms through which increased diversity affects the resilience of natural ecosystems: there is general agreement that more diverse systems are more resilient in the face of natural and anthropogenic variations in their environment (Walker Kinzig and Langridge). Systems that are species poor relative to their natural state are vulnerable to collapse through predation, through introduced species and through climatic variations.

Biodiversity contributes to the productivity of agricultural ecosystems through a rather different mechanism. Access to the genetic diversity stored in wild races of plants and animals has been critical in raising the productivity of commercially valuable species. Indeed the US Office of Technology Assessment estimated that over \$1 billion has been added to the value of US agricultural output alone each year since the Second World War because of plant breeder's access to the biodiversity of wild races. This diversity operates as a source of characteristics that can be used to increase the productivity of commercial crops by cross breeding or genetic engineering. Historically these characteristics have included heat resistance, short stems (which reduce vulnerability to wind damage), and resistance to pathogens. Ultimately biodiversity is the source of all crops and domestic animals, through its role as the raw material in plant and animal breeding, and new and higher-yielding plant and animal varieties are generated from the natural variation in plants and animals. The great increases in grain yields of the "green revolution" of the 1960s and 1970s, which were responsible for keeping food output growing in parallel with population in developing countries, were largely achieved by use of the genetic diversity of plant populations. Specifically, in the last half century we have seen a doubling in yields of rice, barley, soybeans, wheat, cotton, and sugarcane, a threefold increase in tomato yields, and a quadrupling in yields of maize, sorghum and potato (National Research Council). All of this has been based on and derived from genetic variability in the underlying plant populations. In economic terms, this variability is an asset, and one that has yielded a great return at little cost.

Insurance against attack by pathogens has been one of the most important contributions of biodiversity. An example that illustrates well the issue here is the role of biodiversity in preserving the Asian rice crop in the face of a new virus, the grassy stunt virus, carried by the brown plant hopper. This appeared capable of destroying a large fraction of the crop and in some years destroyed as much as one quarter. Rice breeders developed a form of rice resistant to this with the help of the International Rice Research Institute (IRRI) in the Philippines, which conducts research on rice production, and holds a large seed bank of seeds of tens of thousands of different varieties of rice and the near-relatives of rice. In this case the IRRI located a strain of wild rice not used commercially but resistant to the grassy stunt virus. The gene conveying resistance was transferred to commercial rice

varieties, yielding commercial rice resistant to the threatening virus. This would not have been possible without genes from a strain of rice apparently of no commercial value. The same story was repeated later in the 1970s, and similar stories have occurred with other food crops, in particular corn in the United States (Myers). We have every reason to expect that events like these will recur regularly: planting large areas with genetically identical plants greatly increases the chances that once a disease starts it will spread with dangerous speed through the entire area and crop.

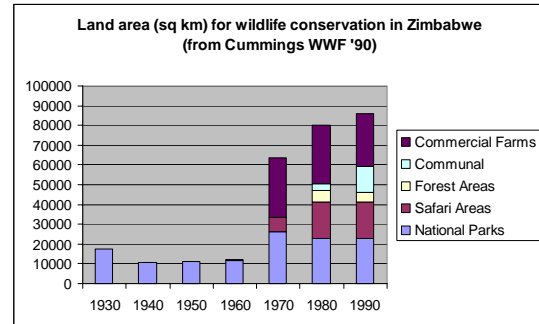
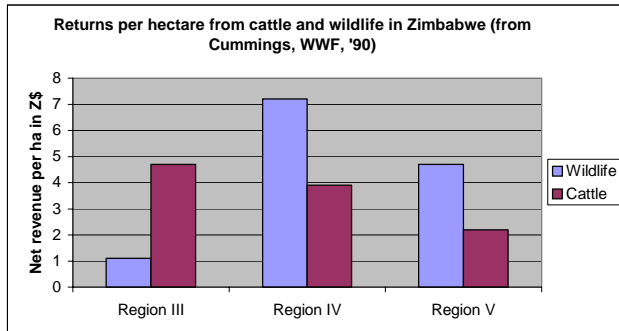
The third reason I gave above for the importance of biodiversity, is that it is a source of knowledge. We can learn from natural organisms how to make chemicals that have important and valuable properties. A good example is provided by the polymerase chain reaction (PCR). This reaction is central to the amplification of DNA specimens for analysis – as in forensic tests used in trials, and in many processes central to the biotechnology industry. Culturing requires an enzyme that is resistant to high temperatures. Enzymes with the right degree of temperature resistance were found in hot springs in Yellowstone National Park, and the heat resistance of these was then used to create an enzyme that could be used to culture DNA specimens. This enzyme is now central to the rapidly growing biotechnology industry. There are many less complex examples. In fact 37% by value of the pharmaceuticals sold in the United States are or were originally derived from plants or other living organisms (Carte). Aspirin comes from the bark of willow trees. The bark of Yew trees has been used to derive a drug that is effective against ovarian cancer. A derivative of the Rosy Periwinkle flower is being used to cure childhood leukemia. The key point is that certain plants and animals are known to produce substances that are highly active pharmacologically. Plants that live in insect-infested areas produce substances that are poisonous to insects, and these have been used as the basis for insecticides. Some snakes produce venom that paralyses parts of the nervous system, and others produce venom that reduces blood pressure. Other insects produce anti-coagulants. All of these have been adapted for medical use.

Markets and biodiversity

Given the undoubted economic value of biodiversity, it is natural to ask whether some of this value can be captured by markets. If it could, then this captured value would provide

a conservation incentive: some of the services of biodiversity could be sold by those who conserve it and would give a return on conservation. To some degree this is possible and is even happening, but the realization of its full potential requires further development of global markets – requires, that is, further globalization. Good examples of this point are provided by ecotourism, by emerging markets for carbon sequestration, and by the beginnings of a movement that merges conservation with development.

Ecotourism is emerging as a powerful force for combining economic development with environmental conservation in a number of poor countries, particularly in Africa and Latin America. Tourism is one of the world's largest industries, being according to several estimates the largest source of employment in the world and also the fastest-growing. Within this whole, one of the fastest-growing subsectors is ecotourism, tourism based on the desire to see and experience some of the world's most unique ecosystems. Within the industrial world there is a substantial willingness to pay for experiencing these ecosystems, and this translates into a high return to their conservation if this is accompanied by successful marketing in rich countries. Figure 1, based on data from Zimbabwe, illustrates this point. For three of the five ecological regions into which the country is divided (the three which cover the great majority of the country), it shows the returns to two different forms of land use, cattle ranching and game ranching. Cattle ranching is the traditional form of agriculture here, and destroys the native flora and fauna. Game ranching is the term used for reestablishing the original ecosystems and then charging tourists for viewing the animals that are a part of these. This usually involves some initial expenses, restocking the land with the native fauna and fencing it to prevent them from moving away. As the figure shows, for two of the three regions the revenue per hectare per year is greater from game ranching than from cattle ranching, and indeed for all three regions the return on capital is greater from game ranching. Environmental conservation or restoration is competitive with cattle ranching, and because of this we see in figure 2 that the land area devoted to wildlife conservation has increased dramatically over the last thirty years. Similar stories can be told for other African countries, and indeed for some regions in Central and South America. The growth of ecotourism in southern Africa has been so extensive that about eighteen percent of the land area is now given over to wildlife support.



The connection with globalization here is immediate: the great majority of the tourists whose spending supports game ranching are from the US and Western Europe. Only since the development of a truly global tourist industry has this business taken off. For tourism to both provide goods returns to the local population and be sufficiently low-impact to avoid adverse environmental impacts, it has to be low-density and high price, which means that most of the visitors must be from rich countries. So the existence of global markets is a prerequisite for tourism to support environmental conservation.

Markets for carbon sequestration have the potential to modify greatly the incentives for the conservation of forests, which are home to much of the planet's biodiversity. From an economic perspective the big problem with forest conservation is that the benefits of conservation accrue to people who do not pay the costs, and in particular very few of the benefits of conservation ever reach those who have to pay for it. This is a classic example of external effects and of course results in under-conservation relative to what is needed for efficiency. The benefits of forest conservation include biodiversity support, carbon sequestration and in many cases watershed conservation. In the first two cases – biodiversity and carbon sequestration – the benefits are global. Everyone on the planet benefits from the reduction of greenhouse gases and from the conservation of biodiversity. In the third case, watershed conservation, the benefits accrue to those who live downstream. In no case do the forest owners, who pay for conservation, receive the returns. The only returns that they can usually obtain are from logging, which in general

involves destroying the forest. To avoid this mismatch between costs and benefits we need to find ways of bringing returns from conservation home to the owners.

Bioprospecting is in principle one way of doing this, though there is some uncertainty about the yields from this (Simpson Sedjo and Reid; Rausser and Small). Another route lies via payment for carbon sequestration. This is possible under the Clean Development Mechanism (CDM) of the Kyoto Protocol, and rough calculations suggest that payments for carbon sequestration could be in excess of the returns from logging followed by cattle ranching (Heal 2000). If this were true, and this provision were implemented, then this would radically change the incentives for the conservation of forests, especially moist tropical forests. Again, a prerequisite for this is the development of global markets for carbon sequestration, through which willingness to pay for climate stabilization could be channeled to developing countries with forests.

Global markets and public goods

Many of the services provided by biodiversity are public goods. Its contributions to productivity, to insurance against pathogen attack and to the accumulation of knowledge are all essentially public in nature in that they are non-rival in consumption. It is counterintuitive that we should be seeking to use global markets, or indeed any markets, to ensure the adequate provision of public goods. After all, we know that markets will typically under provide public goods. In fact the examples discussed, tourism and carbon sequestration, illustrate situations where markets do have real potential for managing the provision of public goods. Incentives for carbon sequestration under the CDM of the Kyoto Protocol are a by-product of a cap and trade regime for greenhouse gases, which is central to the cost-minimization provisions of the Protocol. Cap and trade mechanisms are increasingly being used to manage the provision of public goods, particularly those that are privately produced (Heal and Lin). In this case a public bad, greenhouse gas, is produced by every individual and firm on the planet, and only decentralized mechanisms have the potential to provide incentives for reducing this production. This is where cap and trade systems match the problem well.

In the case of tourism, the connection between public goods and markets is less clear. What is happening in this case is that public and private goods are being bundled. The

reason is that public goods can affect willingness to pay for private goods. We have long known that local public goods affect property values. Schools are the canonical example: house prices reflect access to good public schools. This is also true for environmental public goods. Recent econometric studies (Sieg Smith Banzhaf and Walsh, Chay and Greenstone) indicate that house prices are positively affected by local environmental quality. Lately some property developers, seemingly aware of this, have deliberately conserved environmental assets and provided local public goods as a part of profit-maximizing development strategies.

Two examples capture well the key issue. Spring Island off the coast of South Carolina has long been highly valued as a nature reserve. Zoned for development, it was auctioned in 1990. The State of South Carolina bid, hoping to purchase the land for conservation, but was outbid by a developer. The latter, instead of constructing the 5,500 homes permitted, built only 500 high-value properties and deeded the balance of the land to a land management trust whose objective is to conserve the natural environment. He subsequently explained that this was his most profitable strategy. Proximity to a nature reserve boosted buyers' willingness-to-pay, so that limiting development in this way raised the value of the homes sufficiently to compensate for the reduced number. (The tax deduction on the donation to a conservation foundation also helped.) (Thacker) A similar story relates to hunters in Montana, who had long hunted over many thousands of acres of unspoiled land. Concerned that second home development might end their hunting, they borrowed money to buy the land and finance the construction of a small number of luxury homes. The hunters placed a conservation easement on the remainder of the land, reserving the right to hunt on it themselves, and sold the houses for more than the total cost of buying the land and building the houses (Heal 2000).

What do these examples suggest? Clearly proximity to a unique and beautiful environmental site (a public good) enhances property values, and some developers believe that this is sufficient to justify conserving such sites even when developing them is an option. In other words, the conflict between development and conservation may not be as sharp as generally thought: there may be cases in which the most profitable development requires some measure of conservation. To put this in more economic terms, bundling an environmental public good with homes may be a profitable strategy.

An interesting recent study by Taylor and Smith confirms more generally that access to environmental amenities can be a source of market power and product differentiation. In fact this point is now widely known: developers and urban planners now refer to this strategy as smart growth. An early illustration emerges from the history of New York's Central Park. When the designer Frederick Law Olmsted was asked how the City could pay for the park, he responded that its presence would raise property values and the extra tax revenues would easily repay the construction costs. History shows that was correct. (Lerner and Poole)

These observations naturally prompt us to examine in more detail the incentives for bundling environmental public goods with private goods. It would be interesting if there were conditions under which a profit-maximizing supplier of a private good would provide an associated public good at the economically optimal level. Given our normal scepticism about the ability of markets to provide public goods optimally, this appears at first sight an unlikely outcome. But I show in (Heal 2001) that there are in fact reasonable and robust conditions under which this occurs. When viewed from the appropriate perspective, this result is intuitive.

The precise result proven is the following. A price discriminating monopolist provides a private good and can also provide a public good. The latter can be bundled with the former, affecting buyers' willingness to pay for the private good. Then the monopolist will provide the public good at its economically efficient level. I also establish various generalizations of this: the central feature of the argument is not the public nature of the good bundled with the private good but the fact that there is no market for it. The same result holds when we replace public goods by untraded goods.

This result has some connections to earlier results on price discrimination in markets with private goods and increasing returns. There is also a close connection with the literature on the provision of local public goods in competing jurisdictions, especially with a result due to Scotchmer. There are also references in recent literature to the bundling of public and private goods - both Holm-Muller and Henderson and Thisse address this issue.

Although this research was motivated initially by environmental examples, the results are more general. There are many examples of sellers bundling public or other non-traded

goods with private goods. Security is often bundled with other products, as in gated communities: the security of the community is a local public good that contributes to the value that its inhabitants place on the private goods it contains, houses.² And in a post 9/11 world all airlines are to some degree bundling security with transportation. Going further afield, Reuters and other securities information sellers have long realized that information, being non-rival in consumption, has some of the aspects of a public good, and have relied in their business models on bundling it with private goods such as analytical capabilities and access to proprietary networks. One reason for the greater profitability of AOL relative to other Web portals has been their bundling the private good internet access (as an ISP) with the information gateway function of a portal. Returning to the environmental area, another illustration is the activity of the Forest Stewardship Council (FSC).³ FSC certifies tropical hardwoods as having been sustainably logged. Many timber retailers and furniture makers now sell only imported hardwoods certified by the FSC. Their customers are willing to pay extra for this type of wood. When purchasing certified timber, customers are again buying two commodities - the timber itself and also the preservation of tropical forests, a public good.

Bundling public and private goods

Next I summarize a formal model that justifies the statements made above about bundling public and private goods. The full development of this model can be found in (Heal 2001). We assume that a developer owns the exclusive right to develop a site that is an environmental asset valued by local population. Maximum development of this will destroy its environmental value totally, but is permitted by current zoning regulations. More development means more houses but less of the environmental public good, which may affect population's willingness to pay for houses. The developer has to find the most profitable tradeoff here. House buyer's preferences are represented by $u_i(y_i, h_i, e)$, where y_i is i 's income or wealth, h_i is the level of housing consumed by i in the area to be developed and e , a local public good, is the quantity of a local environmental asset

² We could also think of this as a club. However in general clubs do not operate by bundling public and private goods but by collectively providing an excludable public good. Many of the bundling examples cited below can clearly not be interpreted as clubs.

³ <http://www.fscoax.org/principal.htm>

preserved. We assume that u_i is strictly concave and that buyers have initial endowments given by $(y_{i,0}, h_{i,0}, e_0)$. As a result of development of the area the amounts of housing and public good change to $(h_{i,0} + \Delta h_i, e_0 + \Delta e)$.

Define agent i 's willingness to pay for a change as the value w_i that solves

$$u_i(y_{i,0}, h_{i,0}, e_0) = u_i(y_{i,0} - w_i, h_{i,0} + \Delta h_i, e_0 + \Delta e)$$

The problem facing the developer is to choose levels of housing development Δh_i and conservation Δe so as to maximize profits, which are given by

$$\max \sum w_i - c(\Delta h_1, \dots, \Delta h_N, \Delta e)$$

where $c()$ is the cost of development and conservation. It is now straightforward to prove:

Proposition: *If utility functions are strictly concave and the cost function strictly convex, a profit-maximizing developer who has exclusive development rights and can practice first order price discrimination will provide an economically efficient combination of the private goods involved in housing and the public goods involved in environmental conservation.*

In Heal 2001 this basic model is extended in several ways. One extension is to discrete choices, describing situations where the public good is either provided or not provided. An area is either conserved or not – there are no intermediate possibilities. This is relevant to the ecotourism cases mentioned above: in Africa one can either ranch cattle or restore the original animal populations. But as lions and leopard will eat cattle, combinations are not readily possible. In this case the same results carry over: the profit maximizing outcome is efficient.

Another extension is to the important case of imperfect ability to extract the willingness-to-pay for conservation of the environmental asset. Again this is important in the case of ecotourism, as tourist sites in Africa can only capture the willingness-to-pay of those who actually travel there. There are surely many others who are willing to pay for conservation but who will never actually visit southern Africa. In this case I show in Heal 2001 that for discrete conservation projects there is a fraction f , $0 < f < 1$, such that if developer can extract more than fraction f of willingness-to-pay then the profit-maximizing outcome is efficient.

Globalization and the environment

I have argued above that globalization, of a specific type, has the potential to help the conservation of biodiversity. Are there other relationships between globalization and the environment? There have been suggestions that globalization will provide corporations with the opportunity to avoid environmental regulations by moving to countries with low environmental standards. The idea here is that meeting the environmental standards of the US or the European Union is costly and places companies at a disadvantage relative to their competitors located in countries without such standards. Conceptually this is clearly possible: whether it matters is an empirical question. The evidence available to date suggests that it does not (Eskeland and Harrison). This is perhaps not surprising: as Harrison and note, the costs of environmental compliance are usually a small part of a plant's total costs and rarely sufficient to justify relocation to a different country. Even if it were the case that corporations relocate to take advantage of lower environmental standards, it is not clear that this would affect the conservation of biodiversity: this is a rather different problem from pollution control, which is what is at issue in the arguments about footloose industries.

It is also possible that globalization leads to incentives to clear land for agricultural production for export, and through this mechanism accelerates deforestation and the loss of biodiversity. Opening up overseas markets for timber may also accelerate deforestation for timber. My impression is that at least currently most forest clearing for food production is for domestic consumption rather than for export, although this was probably not always true. It is hard to find firm number on this issue. But opening up export markets undoubtedly has contributed to logging and so to deforestation, and this is an aspect of global trade that we need to address. Mechanisms such as the Forest Stewardship Council mentioned above are a part of the solution, though are not on their own sufficient to provide a solution. Recently there have been moves to have some of the trees most threatened by logging declared as endangered species and brought within the scope of CITES, the Convention on International Trade in Endangered Species. This could also be a move in the right direction, but again is at best a partial solution. Non-endangered trees may support endangered animals. Ultimately the solution lies in more not less globalization, but perhaps of a different type – in the development of the

mechanisms discussed earlier for transferring willingness-to-pay for conservation from rich to poor countries. Then there would be adequate returns to the conservation of forests.

Conclusions

Biodiversity loss is a global problem, and needs global solutions. It is not caused by the globalization of trade and capital markets, but by the growth of the world's population and by the desire for higher standards of living, particularly with respect to food consumption. The solution must involve internalizing some of the external effects associated with biodiversity conservation, and these external effects are often global in scope. Another way of looking at the same phenomenon is as channeling some of the willingness-to-pay for conservation of the rich countries to the poor countries. Ecotourism and markets for carbon sequestration are two very different mechanisms for doing this, but we need more. The fact that many of the services of biodiversity are public in nature does not necessarily rule out the use of market mechanisms for its support.

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