POLICY PERSPECTIVE

Getting serious about maintaining biodiversity

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Abstract

Biodiversity is neither a marketable good or product, nor a service; it is the living web that connects the tangible and intangible elements of healthy ecosystems, which is the essence of so-called *renewable natural capital*. The maintenance of biodiversity is therefore not just an ecosystem service among many—it is the *sine qua non* of ensuring a sustainable future. That is why the maintenance of biodiversity, partly through the augmentation, or restoration, of renewable natural capital, requires the full attention and action of policy-makers, practitioners, and scientists concerned with sustainability. This, in turn, requires a new approach to accounting and valuation of ecological restoration of damaged or degraded ecosystems. Here we seek to clarify the relation of biodiversity maintenance to ecosystem services, and to outline a new approach to the economic valuation of the restoration of renewable natural capital. A key element in this approach to economic valuation is the development and application of *negative* discount rates. Changing the way we think about the discount rate and, more broadly, the way we calculate costs and benefits related to restoration can contribute much to advance the maintenance of biodiversity.

Introduction

Our future is going to be different from what we have known in the past. Until recently humans have lived in an "empty world" where our ecological and ecosystem footprint was smaller than the ecosystem goods and services produced on a global scale. Over the past 50 years, this has changed. Now we live in a "full" and crowded world where the eco-footprint of humans substantially exceeds the annual production of ecosystem goods and services (Wackernagel *et al.* 2002; Daly & Farley 2004; Palmer *et al.* 2004; GFN 2006). This is due to population increase, but also due to increasing per capita consumption of natural capital especially in relation to energy. Human consumption of natural capital has crossed a carrying capacity threshold and we are now living with a deficit in terms of flows of ecosystem goods and services.

It is therefore encouraging to see that more and more professionals in the disciplines of economics, ecological engineering, and applied ecology are reorienting their thinking to face up to this new, uncertain, and highly risky future. One key practical ingredient to mitigate this risk is the restoration of natural capital (Cairns 2005; Aronson *et al.* 2007; www.rncalliance.org). Restoration of natural capital enhances ecosystem goods and services delivery by augmenting renewable natural capital and providing more ecosystem goods and services. The goal is to progressively reduce and, one day, eliminate the above-stated shortfall. This implies a greater appreciation of the real importance of natural capital to society, ideally by all 6.5 billion citizens.

The purpose here is twofold: (1) to clarify the relation of biodiversity maintenance to ecosystem services, and (2) to outline a new approach to the economic valuation of restoration of renewable natural capital, that is, biodiversity and the "healthy" ecosystems, which sustain it. One key element in this new approach is the development and application of negative discount rates, as will be explained below.

Conceptualizing natural capital, ecosystem services, and biodiversity

To understand what scientists, engineers, elected and appointed officials, and citizens can do to forge a sustainable and desirable future, and how restoration of natural capital—the *replenishment of natural capital stocks to improve long-term human well-being and ecosystem health* (Aronson *et al.* 2007)—can contribute to achieving this goal, we must understand three things: (1) what natural capital is, (2) how ecosystem services relate to natural capital, and (3) what is the role of biodiversity.

The term "capital" refers to any stock that yields a flow of goods in the future (Daly & Farley 2004). When considering natural capital in particular, we note that it consists of renewable natural capital (living species and ecosystems), nonrenewable natural capital (e.g., fossil fuels, minerals), replenishable natural capital (e.g., the atmosphere, potable water, arable soils), and cultivated natural capital (e.g., crops and forest plantations) (Rees 1995; MA 2005). Thus, natural ecosystems and the biodiversity they contain and sustain constitute renewable natural capital, and this is the primary object, or target, of most attempts at ecological restoration. However, it should be noted that cultivated natural capital "arises at the dynamic interface of human, social and renewable natural capital. It forms a continuum between renewable natural capital and manufactured capital and may be closer to one or the other, depending on the degree of transformation of the landscape, the genetic material, and the subsidies (e.g., energy, water, nutrients, seeding, weeding, pest-control, etc.) required for maintaining the system" (Aronson *et al.* 2007:4–5). That being said, our focus in the remainder of this perspective will be on "natural" rather than cultivated ecosystems. While natural capital is essential, it is the flows or fluxes that we value most explicitly. These flows are the raw materials extracted and transformed into economic goods and services, and the flux are those benefits whose provision does not require the physical transformation of the natural capital stocks (Georgescu-Roegen 1971).

Biodiversity, however, is neither a good, nor a single service, but rather the living web that connects the various elements of renewable natural capital. Here we review some of the attempts at classification and "taxonomy" proposed in the recent past and offers our own views on the appropriate way to consider biodiversity *vis à vis* ecosystem services. This will set the stage for discussing how restoration should be valued from an ecological economics perspective.

Maintenance of biodiversity: recent historical treatments

In his landmark book, *The Functions of Nature*, Rudolf de Groot (1992:192) appropriately treated "biodiversity maintenance" as one of several "regulating functions" that keep ecosystems intact, self-organizing, and effectively adapting to change in an evolutionary sense. Subsequently, in the introduction to the highly influential, edited volume, *Nature's Services*, Gretchen Daily (1997:3–4) adopted de Groot's approach but replaced the word "functions" with "services", and proposed a list of 13 ecosystem services that has been widely adapted. However, in the expanded list of 17 ecosystem services and functions listed in the much-cited article by Costanza *et al.* (1997:254) and, 8 years later, in the four categories of ecosystem services (Table 1) used in the Millennium Ecosystem Assessment (MA 2005), *biodiversity*, per se, somehow got pushed into the background. This does not imply that the MA authors do not recognize biodiversity's importance. On the contrary, they do acknowledge

Table 1 Ecosystem services as defined by the Millennium Ecosystems Assessment (MA 2005:57)

Provisioning services	Regulating services	Cultural services	Supporting services
Products obtained from ecosystems	Benefits obtained from regulation of ecosystem processes	Nonmaterial benefits obtained from ecosystems	Services necessary for the productionof all other ecosystem services
• Food	• Climate regulation	• Spiritual and religious	• Soil formation
• Fresh water	• Disease regulation	• Recreational and tourism	• Nutrient cycling
• Fuelwood	• Water regulation	• Aesthetic	• Primary production
• Fiber	• Water purification	• Inspirational	
• Biochemicals	• Pollination	• Educational	
• Genetic resources		• Sense of place	
		• Cultural heritage	

Note that the word "biodiversity" appears nowhere in the table.

it in saying "...the supply and the resilience of ecosystem services are affected by changes in biodiversity" (MA 2005:46), but they do not make this statement emphatically enough or back it up elsewhere in their documents. They focus predominantly on the services derived from biodiversity, while the importance of biodiversity itself is addressed only in passing. In trying to communicate and justify the need for global society to invest much more seriously in nature conservation, and to use natural resources and biodiversity more prudently, biodiversity and its maintenance lost its initial place and prominence, as established by de Groot and Daily. This, we think, is unfortunate and bad news for those concerned with the actual planning, evaluating, valuing and implementing of conservation, restoration, and related activities addressing ecosystems, ecosystem services and biodiversity. In the same vein, global programs, such as the Global Environmental Facility, only use species richness as measure of biodiversity. They tend to omit, or fail to capture, other facets of biodiversity such as beta-diversity, that is, the rate of change, or turnover, in diversity, between habitats. Furthermore, along the same lines, recent work has shown that an area or environment can be both a biodiversity hotspot, in the well-accepted sense, and a "coldspot," sensu Price (2002), depending on the measure used for assessment. To conclude this section, for ecosystems to function properly and deliver their services, both system resilience and system robustness have to be retained (Walker & Salt 2006). We have to be serious about biodiversity if we wish to seek to improve ecosystem services.

Reinstating the notion of the maintenance of biodiversity

We call for a return to de Groot and Daily, and argue that biodiversity and its *maintenance*—a concept with a strong economic lineage—should be made explicit when considering the management and practice of nature conservation and restoration; see also Rees (2004) and Nunes *et al.* (2003) on integrated ecological-economic modeling and analysis of biodiversity, and Rauh *et al.* (2007:23–31) on law and policy of ecosystem services. It should also be carefully linked, in all laws, policies, and actions that address climate change and desertification (Blignaut *et al.* 2008), the other two "big" issues addressed in the Rio Conventions of 1992. The maintenance of biodiversity is an overarching desideratum, not an ecosystem service among many.

We emphasize that the word *maintenance*, as it was used by de Groot, should be understood as any action performed to keep some machine or system functioning or in service. Maintenance is by definition forward-looking. It is a "deliberate activity" undertaken today, oriented toward some future management objective that will—if implemented appropriately—lead to a better future outcome. Without maintenance, the machine or system will run itself down, to the detriment of both the machine and the people who depend on its carrying out its functions. The term "maintenance" also refers to *preservation*, and *repair*, that is, the upholding, protection, or safeguarding of an asset, whose antonyms are *destruction* and *neglect*. In this context, the word *repair* refers to both ecological restoration and rehabilitation as well as to some of the activities of ecological engineering.

One fascinating characteristic of natural capital is that, unlike built capital, it is capable of maintaining itself. However, that ability of natural capital to maintain itself depends on its "health." If critical ecological thresholds are crossed, ecosystems may not only lose their capacity to maintain, renew and replenish themselves, but may also begin to deteriorate spontaneously (Suding *et al.* 2004; Suding & Gross 2007). Human intervention under these circumstances may be able to maintain and restore the ecosystems, but unless their health is restored to the point where the systems become self-maintaining, such intervention will require a constant flow of human intervention and resources. The more degraded a system is, the more it will cost to restore its health, especially when a specific ecosystem or species is essential to human well-being with no known substitutes. Under these circumstances, its maintenance is essential. While the time lag between an ecosystem degrading to the point where it can no longer reproduce itself and its collapse may range from years to centuries, this is also our opportunity for restoration—and the longer we delay, the more difficult and expensive it becomes.

Summarizing then, it is biodiversity—and the ecosystems that sustain it and depend on it at the same time—that provide people with a suite of vital ecosystem goods and services, even in a human-dominated and progressively "gardenified" world, sensu Janzen (1998). Maintenance is therefore a better term than *conservation* here, since the biodiversity we maintain continues to function, into the future, in the context of the various ecosystems that we consciously maintain, manage, preserve, and repair.

As stated, biodiversity is not just one ecosystem service or function among many; it is the sine qua non of renewable natural capital. It requires in today's crowded world not only maintenance, but also restoration. But how should we value such an investment in natural capital? This is the topic to which we now turn.

Renewable natural capital and the economic value thereof

The customary way to estimate the value of natural capital is either to use market prices, or to estimate the discounted net present value of the sum of the future income stream derived from such an asset (United Nations 1993). Market values are seldom available, of course, so the only remaining option is to estimate the net present value of a resource and of a desired use for it. This is done by first estimating the present value—that is, the value of tomorrow's money in today's terms—of the future benefit stream flowing from the asset. Then, the present value of the cost of acquiring and maintaining the asset is subtracted from the present value of the benefit stream to determine the *net* present value.

Using the conventional approach, the cost of acquiring an asset is an upfront cost payable today, as in the case of eco-restoration, is considered "expensive" money. That is because today's money is worth more than tomorrow's, based on the notion of the time preference of money whereby it is assumed that people desire to consume today rather than tomorrow. Indeed this preference is often thought to be exponential, as reflected by the customary use of a positive discount rate. It should be noted, however, that this notion of an exponential decline in the time preference of money has been recently challenged (Voinov & Farley 2007). The benefits or restoration, however, are deferred into the future. Using positive discount rates implies that those benefits are increasingly worth less to society over time. No wonder, then, that it is hard to make a business case for restoration using the conventional discount rate.

But this is not the correct way to value restoration because natural capital's properties are distinctly different from those of both manufactured and financial capital. The value of manufactured and financial capital depreciates over time due to risk, inflation, and the declining performance of manufactured capital due to technological advances and existing equipment falling out of date. Renewable natural capital, on the contrary, will only under exceptional circumstances depreciate in value since it does not become dated or undesired. Moreover, when it is intact or restored it generates and regenerates resilience and acts as a hedge against future risk. It therefore continues to provide, at a minimum, an equal stream of the same quality of ecosystem goods and services in future as it does today, provided it is kept intact or maintained.

Given its characteristics as described above, natural capital can only depreciate in value if new and cheaper substitutes for it have been developed—one example being the decline in the price of copper during the 1990s due to the increased use of fiber-optic cables. Conversely, the value of copper would increase if we developed new uses for it, such, again, as indeed has happened with copper during the past decade. Often, indeed, it does seem that technicians and engineers develop new uses for natural capital faster than substitutes. It is, however, impossible to develop substitutes for most ecosystem services, and it is almost certainly impossible to develop substitutes for biodiversity. The importance of biodiversity—and the need to "get serious about it," and to value it appropriately—is emphasized by the rapid increase in the global human population. With this increase in population and its seemingly insatiable hunger for more consumption, we are witnessing an increase in the transformation of natural capital into other forms of wealth. As a result, natural capital becomes increasingly scarce in both relative and absolute terms (Wackernagel *et al.* 2002; GFN 2006). The transformation of natural to human-made capital is quite simply a form of "mining" the stocks of renewable, replenishable and nonrenewable natural capital, and thereby reduces the amount available for future use and function. We therefore have to take note that while the value of natural capital can be estimated and expressed in monetary terms, *it is not money*, and *does not behave like money*, or *even share money and manufactured capital's basic characteristics*. All of this has direct bearing on how we apply economic tools, such as the calculation of net present value, to restoration—which now appears essential to the overall objective of maintaining biodiversity—and hence to the need to get serious about maintaining biodiversity.

Cost and benefits of restoration

Let us now consider the cost and the benefits of restoration in more detail. While restoration costs are generally high and payable upfront, the cost today is likely to be less than the cost tomorrow. By not restoring today and by allowing an ecosystem to degrade even further—and thereby to allow its biodiversity and resilience to dwindle, or plunge, still more—the cost of restoration will almost certainly increase, perhaps substantially. Not only is the magnitude of the problem likely to be bigger in future, thus requiring a bigger effort, the capital and labor costs related to restoration are likely to be higher as well, not to mention the growing risk of being unable to restore a system altogether as a result of species extinctions, topsoil losses, and the like. Restoration should therefore not be postponed. It will almost always cost more in the future, perhaps exponentially so.

Turning now to the benefits of natural capital, that is, the benefits that people derive from natural capital's flow of ecosystem goods and services, the value of those benefits does not decline or depreciate as do those of manufactured or financial capital. In fact, its value increases over time. Indeed, natural capital's deferred values increase at least at the same rate as human population increase, so as to keep the unitary value of ecosystem goods and services available per person constant, assuming no further depletion of natural capital. Thus, *the value of the remaining natural capital must increase by at least an equivalent percentage as that of the rate of depletion and population rate increase combined.*

One can, however, argue that the value of the remaining natural capital increases by more than that of the rate of depletion and the population rate combined since, in many cases, ecosystem goods and services, and the supporting stocks of natural capital, are nonsubstitutable. If a resource is essential and nonsubstitutable it exhibits inelastic demand, which means that a 1% decrease in quantity leads to a greater than 1% increase in price. To further this argument, it should be pointed out that the marginal unit of a market good is worth what the individual who values it most is willing to pay. In contrast, many ecosystem services are nonrival—meaning that one person's use of a resource does not exclude someone else's use thereof. This in turn implies that the marginal unit is worth what everyone together is willing to pay. The value of ecosystem services will therefore unequivocally increase with increasing population. It can also be argued that given biodiversity's nonsubstitutability, the opportunity cost of losing it will rise exponentially until it reaches infinity. Maintaining biodiversity—through, among other things, restoration—constitutes avoided opportunity cost and the value of it therefore also increases at the same rate of the opportunity cost if restoration was not carried out.

Such an increasing appreciation in the value of an asset can be estimated by using negative discount rates, the subject of the next section.

Negative discount rates

The use of negative discount rates in valuing natural capital is gaining momentum among economists (Price 2000; Dasgupta & Maskin 2005; Hoel & Sterner 2006; Brouwer *et al.* 2008; Rees *et al.* 2007) and we suggest adapting it with regards eco-restoration. To date, few authors have tried to calculate the economic benefits of restoration. Those who have done so have calculated the known beneficiaries' willingness-to-pay through so-called "contingent valuation" studies, which is a method used to capture the nonuse value of a resource or of natural capital. These studies have indicated an exponential rise in the demand for ecosystem goods and services provided by restoration as the natural system becomes more intact through restoration. In other words, the more a system is restored, the more people benefit from it, and the more they demand services from its restored natural capital, and the more they are willing to pay for it (Gren 1995; Balmford *et al.* 2002; Hougner *et al.* 2006; Milon & Scrogin 2006). This is an indication of the increasing future value of restoration, and of the pertinence of applying negative discount rates in this context.

Valuing restoration or the maintenance of biodiversity

A more complete way of dealing with the value of restoration would consider the benefits of restoring as including the opportunity cost of not restoring—if we do not restore today, we will pay dearly for it tomorrow. Another way of expressing the opportunity cost of not restoring is to conduct a cost-benefit analysis with and without restoration. Should the net present value of the "with" restoration scenario be higher than the "without" scenario, then one should proceed with restoration. The benefits under the "with" restoration scenario are equal to the total of the following four elements: (1) the sum of the future benefits provided by the restored ecosystem using a negative discount rate that reflects its increasing scarcity; (2) the opportunity cost of capital that reflects the difference in cost of restoration in future if the required restoration is not done today; (3) the cost avoided by the restoration activity, which includes both the mitigation and adaptation costs that will be borne if the ecosystem is not restored; and (4) any other additional benefit such as training, job creation—the value of which could approach the total wage bill in conditions of high unemployment—as well as cultural and other intrinsic values.

Conclusion: the way forward

We have entered an era of ecological overshoot (Wackernagel *et al.* 2002; GFN 2006), which means that humanity's ecological footprint exceeds the Earth's bio-capacity: we are now consuming on an annual basis more than the Earth can replenish. We have to plan and cooperate toward a better future by conserving biodiversity, maintaining ecosystem services, and securing and augmenting natural capital as best we can, that is, "restoring the future" (Clewell & Aronson 2007) This requires clearly understanding that the flow of ecosystem goods and services is dependent on renewable natural capital, that is, functioning ecosystems and native biodiversity. This, in turn, requires us to get serious about biodiversity, and its maintenance, full knowing that biodiversity is an overarching desideratum, not just one ecosystem service among many. Getting serious about biodiversity implies that we must develop and apply new accounting rules for the science, business, and practice of restoring natural capital. Changing the way we think about the discount rate and the benefits derived from restoration to reflect the increasing scarcity value of natural capital is a good place to start.

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