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Article

The Economics of Ecosystems and Biodiversity: Recent Instances for Debate

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Abstract

After 1992 many conservation biologists thought that the use of economic instruments would be more effective to halt biodiversity loss than policies based on setting apart some natural spaces outside the market. At the same time there was a new elaboration of the concept of ecosystem services and, since 1997, there have been attempts at costing in money terms the loss of ecosystem services and biodiversity, including the high profile TEEB (The Economics of Ecosystems and Biodiversity) project (2008–2011). Our discussion rests on instances showing the analytical implications of three main socio-economic meanings of biodiversity loss: 1) the loss of natural capital; 2) the loss of ecosystem functions; and 3) the loss of cultural values and human rights to livelihood. We review several approaches to include economic considerations in biodiversity conservation. We show cases where monetary valuation is relevant and other cases where it is controversial and even counterproductive, as it undermines the objectives of conservation.

Keywords: natural capital, ecosystem services, commensuration, valuation languages, TEEB, Chevron-Texaco case, Yasuni ITT, GDP of the poor, mangroves, Niyamgiri hill

INTRODUCTION

The Nagoya Conference of the Parties to the Convention on Biological Diversity in October 2010 had the economics of biodiversity as one of its core topics. Some weeks before the meeting, the economic media insisted on the relevance of biodiversity. As an example, *The Economist* devoted fourteen pages to the pressures on the world's forests, mentioning among the responses to save them the information of the TEEB (The Economics of Ecosystems and Biodiversity) initiative (The Economist 2010). The United Nations Environment Programme (UNEP) sponsored the TEEB reports (Kumar 2010; ten Brink 2011) that were born from an initiative in 2007 to carry out an economic analysis of biodiversity loss parallel to that of the Stern Report on climate change. It was expected that economic valuation would make biodiversity loss more visible socially and politically.

Economic growth and human population growth are forces driving biodiversity loss. Therefore, the idea that economics (which generally preaches economic growth) may provide concepts and instruments for biodiversity conservation is at first sight surprising. We side with the sceptics (McCauley 2006; Kosoy and Corbera 2010; Spangenberg and Settele 2010; Kallis et al. 2013) but we understand the logic of those who are keen to apply monetary valuation and payments for ecosystem services. In some instances (for example, a court case for damages to the environment and to human health) money valuation is appropriate, as we see in the Chevron and Shell cases in Ecuador and Nigeria (in the section '*Protecting through monetary valuation?...*' of this article). However, in a dispute on shrimp farming in Ecuador or on bauxite mining in Odisha (described in the sections '*Protecting through monetary valuation?...*' and '*The plurality of values in decisions on biodiversity*'), should cost-benefit analysis be applied (calculating all positive and negative impacts in monetary terms and choosing the option representing the highest economic value), or should the relevant environmental, social, and cultural values have a chance to be deployed in

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their own units of account, as in (some forms of) multi-criteria evaluation?

Chrematistic valuation might enhance the social visibility of biodiversity. However, it also might diminish the visibility of other attributes. At an early TEEB public meeting that took place at the World Conservation Congress in Barcelona in October 2008, an observer wrote:

> TEEB Advisory Board member Joan Martínez-Alier endorsed an approach of epistemic pluralism. The ecological economist supported TEEB for tactical reasons but sparked spontaneous applause when he argued for an 'orchestra of instruments'. Economic valuation is an instrument that some people understand very well, and it is very relevant, but we have a whole orchestra of instruments to talk about different valuations. Territorial rights, aesthetics, ecological sacredness for many people around the world, tribal people, are also very relevant values. There is an incommensurability of values that we have to recognise (Monfreda 2010: 284).

After this introduction, the next section analyses the main driving forces of biodiversity loss and the birth of the economics of conservation as a response to this process. The rest of the article argues, using examples where the authors have been involved to some extent, that economics can be used in different modes. One approach is the monetary valuation of ecosystem products and services (Costanza et al. 1997; Fearnside 1997). If an area of mangroves or tropical rainforest disappears, how much is lost in money terms from the products and services foregone? The article also analyses some efforts to halt or reverse or compensate for biodiversity loss by monetary valuation (the examples are drawn from TEEB studies, analyses of mangrove destruction, and the Chevron-Texaco court case).

Another approach includes proposals to halt biodiversity loss through the protection of ecosystem functions and services, where the assessment does not necessarily involve monetary valuation of all costs and benefits. For instance, as explained below, the European Water Directive asks for certain qualities to be maintained or achieved (in terms of physical, chemical, and biological attributes of a river), and one can then compute the monetary costs of doing so. This is similar to the approach of the Yasuni ITT Initiative in Ecuador, also described below.

A third approach encompasses attempts to halt biodiversity loss through the prevalence of non-chrematistic cultural and livelihood values. In this respect, a section of the article looks at the deployment of plural values, like livelihood, human rights, sacredness, and the Rights of Nature in controversies of conservation, using cases from India (the Niyamgiri hill) and Ecuador (the defence of mangroves by local communities, the enforcement of Rights of Nature). The final section contains the conclusions.

DRIVING FORCES OF BIODIVERSITY LOSS AND THE EMERGENCE OF SOCIO-ECONOMIC APPROACHES TO CONSERVATION

The failure to halt biodiversity loss

The global conservation movement is over one hundred years old; it arose in many countries. Perhaps the figure of John Muir, the nineteenth century naturalist in the United States, is the best known (Worster 2008). The science of conservation biology supporting the movement however is younger. Similarly, the discussion on the human influence on climate change because of excessive carbon dioxide emissions is over one hundred years old (Arrhenius 1896). So we have to ask ourselves why it took so long for biodiversity loss and climate change to become internationally relevant political topics. Not so long ago, wetlands and mangroves were described as 'malarial swamps' that should be drained. Now we have the Ramsar Convention on Wetlands of 1971. Deforestation in order to convert forestland into fields for cultivation or pastures was seen as progress in European history. It was subsidised in Brazil and other Amazon countries until very recently. Now we have Reducing Emissions from Deforestation and Forest Degradation (REDD+), paying for avoided deforestation to reduce carbon dioxide emissions. It took time for biodiversity conservation and climate change to become central to politics.

The term 'biodiversity' is a neologism first used by Walter Rosen (in Wilson and Peter 1988) meaning biological diversity. The most cited definition of biodiversity is that of the 1992 United Nations Convention on Biological Diversity (CBD; Article 2), inspired by conservation biologists, which states that biodiversity means the variability among living organisms at three levels of organisation (genes, species, and ecosystems).

An example from agrobiodiversity can illustrate these three levels, and also in this case, its relationship with human agency. There are more than 256 varieties of maize (*Zea mays*), more than 30 of which are at great risk of disappearance (Machado et al. 1998). This is one single species. It is very likely that this variability is the outcome of the coevolution of the wild plant *teocintle* and 7,000 years of Mesoamerican and Andean cultures. Apart from the genetic level, this variability expresses itself in the agroecological association of maize in traditional fields (*milpa*) with other (also genetically diverse) useful species, like beans, squash, and the maize parasite fungus *huitlacoche,* as well as many other edible weeds. The maize crop has been adapted to different cultural and environmental conditions, creating in Mexico agro-ecosystems as diverse as the *milpa lacandona* (in the tropical rainforest) and the *milpa taraumara* (3,000 m above msl).

This example is similar to that of rice and other crops—they are exceptional among the millions of species that evolved long ago totally independent of human action. Still, it is useful to illustrate how human agency (much before there was a generalised market system) could enhance genetic and phenotype diversity. There is in general an association between

biodiversity and the presence of indigenous groups (Toledo 2000); among the main pressures for the disappearance of maize diversity in Mexico has been the homogenisation of commercial crops and the trade in maize under the North American Free Trade Agreement.

The well-known DPSIR (Driving forces-Pressures-State-Impacts-Responses) scheme (EEA 2011) describes interactions between society and the environment. While we are aware of the critique about the linearity of this approach (Maxim et al. 2009), we still deem it useful to organise information about the relation between socio-economic developments and biodiversity using its terminology. According to the DPSIR approach, social and economic developments (or *drivers*) exert *pressures* on the environment, changing its *state*. As a consequence, there are impacts on the ecosystems—and on the ensuing social benefits obtained from them—which elicit societal responses, feeding back on different stages of the process.

The Millennium Ecosystem Assessment (MA) was an authoritative statement of the situation of the world's ecosystems and the threats to them. It demonstrated an increased intensity and effect of the core driving forces of biodiversity loss, mainly attributed to the trends in land use and the human appropriation of biomass. Economic growth goes together with increased material and energy flows including those in the form of biomass. The MA corroborated thus the *fundamental conflict between biodiversity conservation and economic growth* (Czech 2008).

Such driving forces are worsening the state of biodiversity. The Living Planet Index, a global assessment based on 7,953 populations of 2,544 species of birds, mammals, amphibians, reptiles, and fish, shows a decline of around 30% from 1970 to 2007 (WWF/ZSL 2010). In Europe, the Biodiversity Action Plan failed in its objective of halting biodiversity loss in the region by 2010. The assessment in the EU-25 made by the EEA (2010) indicated that the conservation state of all evaluated taxonomic groups was mostly unfavourable across practically all the EU biogeographic regions.

Looking at big infrastructure projects in Latin America, such as the IIRSA[1] projects (and how they open the field to the transformation of the rainforest to cattle farming or sugarcane and soybean crops), it is clear that the growing social metabolism goes hand in hand with increasing material flows and appropriation of net primary production.

This is reflected in the computations of the Human Appropriation of Net Primary Production (HANPP) (Vitousek et al. 1986; Haberl et al. 2007) including the 'embodied' HANPP in exports (Haberl et al. 2009). For instance, ethanol exports from Brazil do not only imply an increase in the biomass from sugarcane, they also entail the destruction of pre-existing vegetation in the fields now turned into sugarcane plantations, which would also show in the EROI ratio (the energy return on energy invested or on energy input).

If humans consume more biomass, then there is less biomass available for other species. This rests on Wright's 'species richness-energy hypothesis' (Wright 1983), which states that the number of species is related to levels of available energy. There is at least some evidence supporting the hypothesis that more HANPP means less biodiversity (Haberl et al. 2005), and hence, that HANPP might be a suitable indicator of pressure on biodiversity.

The conflict between mangroves and shrimp farming analysed below is a conflict over HANPP (who destroys the NPP, and who benefits from it). Similarly, socio-environmental conflicts surrounding tree plantations and deforestation such as the Chipko movement in Garwhal and Kumaun in the Indian Himalayas (Guha 1989; 2010 edition) may be seen as historical struggles over HANPP, where the actors used different valuation languages. 'Tree plantations are not forests' is a slogan used against eucalyptus, pine, rubber, and palm oil plantations around the world by the World Rainforest Movement, a straightforward struggle for the appropriation of the NPP (Gerber 2011). A study on land grabbing in the Tana Delta in Kenya (Temper 2012) explicitly asks: who gets the NPP? Pastoralists, agriculturalists, wildlife, or the new sugarcane plantations? Local stakeholders ask for a proper economic valuation of the existing ecosystem services thinking that this might be effective against land grabbing: "We will show that conserving the Tana Delta is more valuable for farmers, pastoralists and fishermen than to transform it into sugarcane fields for ethanol" (Serah Munguti, Nature Kenya 2011 pers. comm.).

Certainly, human beings sometimes encourage ecological (and biological) diversity by creating diverse and inhomogeneous habitats, provided they are not too thickly spread on the ground. So, HANPP statistics cannot be used to argue against human presence on Earth. We saw this above in relation to the diversity of maize and its relation with *teocintle*. As Matt Ridley (2010) writes on his blog:

> …the flowers and birds of farmland where I live — cornflowers and peewits and partridges, for example — must have been very few and far between when this was just a monotonous oak forest. Likewise, the cliff-nesting birds that abound now — house martins and sparrows and rock doves — must have been scarce before towns. We create lots of different habitats — urban, rural, agricultural, forested, scrubby and so on — where before there was uniformity. Of course, in the process, we upset balances, drive species locally extinct and so on. But half the time we are taking away what we created… The most sustainable societies on the planet are the ones that don't rely on charcoal for fuel, or wild game for food.

Such anti-environmentalist rhetoric posits that the growing human economy is always good for biodiversity. Nowadays, however, industrial agriculture is leading to a steep decline in biodiversity due to landscape homogenisation and loss of traditional knowledge, as mentioned in the case of maize above.

Three socio-economic approaches to conservation analysis and practices

From the discourse above, we realise the relevance of economic developments as drivers and pressures on the state of biodiversity. The conservation tools that may be used to respond to such pressures are diverse. One main point in this article is that the conservation tools used in each case are consistent with different interpretations given to the impact of biodiversity loss in the socio-environmental literature. Table 1 shows three (contested) socio-economic approaches to biodiversity conservation, the type of assessments consistent with such approaches, and the proposed conservation tools in each case.

The first interpretation—loss of natural capital—is linked to the tradition of economic studies analysing biodiversity under a neoclassical inspiration. Table 2 summarises the main contributions.

Neoclassical economic analysis sees the benefits of global biodiversity as a public good, different from private goods that can be easily traded in markets. That is, individual consumption of the benefits from global biodiversity does not deplete their availability to others (non-rival good) and it is difficult to exclude people from accessing such benefits (non-excludable) through pricing. By the same token, global biodiversity loss is a global public bad that affects all consumers.

Environmental costs are often called 'externalities', precisely because they remain outside of economic accounting. This first approach recommends the use of tools that allow internalising externalities back into the price system. For doing so commensuration (Espeland and Stevens 1998) is a prerequisite. In the discussion on valuation, the emphasis is put on the goods and services fostered by biodiversity. The monetary value of biodiversity at the level of species could be ascertained by contribution to marketed production or by the prices of bioprospecting contracts or by other stated preferences (willingness to pay in contingent valuation). However, there is a difference between biological resources

Table 1

Interpretations of biodiversity loss and socio-economic approaches

Interpretation of biodiversity loss	Type of assessment	Conservation tools
Loss of natural capital	- Cost-benefit analysis (using monetary valuation of biodiversity and bioeconomic optimisation)	- (Re)allocation of access and property rights, including intellectual property rights - Economic instruments (taxes, charges, quotas, etc.) - Net positive impact and habitat trading - Monetary compensations (for environmental liability or restoration costs)
Disruption of ecosystem functioning and ecosystem services provision	- Cost-effectiveness analysis - Multi-criteria evaluation - Risk assessment - MEFA (material and energy flows analysis)	- Regulatory protection - Land use planning (including protected areas such as Natura 2000) - Red lists
Cultural impairment, damage to human rights and Rights of Nature	- Social multi-criteria evaluation - Integrated assessment - Scenario development - Deliberative valuation	- Indigenous territorial rights, Convention 169 of ILO - Defence of institutional capabilities - Claims of ecological debts (not in money terms) - Ecosystem approach to integrated management

ILO=International Labour Organization

Table 2

Contributions of economics of biodiversity from a neoclassical perspective

Topic	Reference	Contribution	Limits
(Biologic) renewable resource management	Gordon 1954	Bioeconomic model of fish bank exploitation (economics of maximum sustainable yield)	- Optimisation methods that allow partial representation of complexity (exclusion of factors in favour of theoretical simplification) - The complete set of states of nature must be known - Biodiversity is mistaken for biological resource
	Clark 1973	Dynamic bioeconomic model of animal species extinction	
	Perrings and Walker 1995	Consequences of discontinuous biotic changes	
	Swanson and Barbier 1992	Biological assets as 'inferior' investment in society's portfolio	
Monetary valuation of biodiversity	Perrings et al. 1995	Components of total economic value of biodiversity	- Evaluation of biological resources rather than integral evaluation of biodiversity
	OECD 2004	Compilation of methods for valuation of biodiversity	- Impossibility of coping with collective values

Source: Rodríguez-Labajos et al. 2009

(which are used in different processes and can be valued with the methods described here) and biological diversity, an abstract good which is not directly available for human use or appropriation. In most valuation processes, the components of biodiversity—the concrete biological resources—are valued, but biodiversity as a whole is not considered.

One could, in theory, imagine an industrial economy where all the environmental costs (counted as damage costs or repair costs) would be included in the accounts. There are immense technical difficulties of doing so; e.g., how to count the economic values of biodiversity loss, what to include, which discount rates to apply. We do not know which species are disappearing. In any case, the pattern of prices would be very different.

Within this approach the analysis focuses on the erosion of the involved economic assets, in monetary terms. The relevant issue is not the loss of biodiversity per se but the effect of this on the flow of environmental services translatable as income. For this reason, substitutability is not only accepted but also promoted as a management strategy. Now that several commercial tuna species (*Thunus thynnus, T. Maccoyii, T. obesus*) are severely depleted at the global scale (Collette et al. 2011), the interest in the exploitation of smaller, but relatively more common *Auxis* sp. (FAO 2011a,b) of similar use in the canning industry, is growing.

Meanwhile hundreds of thousands of unknown species are disappearing. While we could say that a tropical rainforest which has lost only 10% of its surface is still in a relatively good state with respect to ecosystem services, this assessment leaves aside the irreparable loss of many unknown endemic species and their genetic variability in the 10% that has been lost.

The second interpretation given to biodiversity loss is the disruption of ecosystem functioning and ecosystem services provision. Ecosystem service (ES) is a notion that had success since the writings of Gretchen Daily and Rudolf de Groot in the 1990s and onwards (Daily 1997; de Groot et al. 2002).

The MA concluded that 60% of the assessed ecosystem services (15 of 24) were being degraded or used unsustainably (MA 2005). The study also determines that the ES degradation significantly impairs human wellbeing. The MA did not emphasise 'market failure' as much as the TEEB reports would in 2008–2011, and deliberately refrained from calculating monetary values (Norgaard 2010). Similarly, for climate change one may emphasise the main driving forces (economic growth linked to consumption of fossil fuels and therefore increased carbon dioxide emissions), or one may emphasise 'market failure' in a neoclassical welfare economics mould. Among ecological economists, many agree with K.W. Kapp (1950) that market failures are better seen as cost-shifting successes. In economic theory, a zero price should signal non-scarcity of a good or service relative to its demands over the relevant time horizon. However, zero-price paid for the destruction of a mangrove forest, a piece of rainforest or a coral reef, does not indicate so much a market failure as a relation of power (O'Connor 2000).

When we consider biodiversity loss as loss of ecosystem functions and services, the evaluation directly includes indicators for the involved biophysical processes. Cost of action can be included as one element to consider in the decision. However, the evaluation method will not require the translation of all elements in money terms. Metrick and Weitzman (1994) had already introduced the idea of cost-effectiveness analysis (alternatives of action are compared in terms of monetary costs, but their effects are expressed in biophysical units) of 'optimal' biodiversity conservation. However, they worked under the assumption of substitutability between species, which does not differ essentially from the postulates of neoclassical economics.

As explained above, the calculation of HANPP (Vitousek et al. 1986; Haberl et al. 2007) is just one of the methods for the study of social metabolism. The debates on biofuels or agrofuels are debates on the HANPP, on the EROI, and on the 'virtual water'—the water used to grow them. Agrofuels or biofuels increase the HANPP to the detriment of other species, and also to the detriment of some groups of humans. There are links between the increased social metabolism and biodiversity loss. There are also links to environmental justice movements where poor people are often on the side of nature because of their own cultural values and their livelihood needs, as we shall see in the cases of mangroves in Ecuador and bauxite mining in Odisha.

And here, the third interpretation of the impacts of biodiversity loss arises. Some languages of valuation (livelihood, sacredness), that were powerful in the past, are slowly becoming worthless in this era of a generalised market system where even "the fetishism of fictitious commodities" (Kosoy and Corbera 2010) is rising in payments for ecosystem services (PES) schemes. Meanwhile, other non-economic languages (human rights, environmental justice against 'environmental racism,' the Rights of Nature) are gaining in strength. The language of indigenous rights is perhaps also becoming more powerful in megadiverse countries, while the Rights of Nature are included in some new Constitutions in Latin American countries, as is shown later in this article.

Ecological distribution conflicts are expressed as conflicts over valuation, inside a single standard of value or across plural values (Martínez-Alier 2002). As shown in the next section, an agreement with a company or redress for an injustice may be sought by appealing to the common language of monetary valuation, trying to value in a court of law the monetary compensation for damages. Such exercises in commensuration of values are technically difficult to achieve but not impossible. However, monetary reductionism (as well as other forms of reductionism) might harm the social legitimacy of other values.

So far, we have presented three different socio-economic approaches to conservation. In the rest of the article, the strengths and weaknesses of these different approaches will be contextualised to illustrate the situations in which each one may be more or less applicable.

PROTECTING THROUGH MONETARY VALUATION?—THE MANTRA OF SUBSTITUTABILITY

In 1997, Philippe Fearnside published an article on the economic values that a primary forest in Amazonian territory in Brazil (threatened by cattle ranching) could provide if the forest was maintained. One family could survive on 100 ha from their own sustainable collection of products and from the payments for non-timber products, from (notional) payments for carbon uptake (or avoided carbon loss), evapotranspiration (rainwater in Sao Paulo and Buenos Aires comes from the Amazon), and bioprospecting (Fearnside 1997). In the same year, Costanza et al. (1997) published an article on the value of ecosystem services and the world's natural capital. According to the article, all environmental services from ecosystems were supposed to provide per year the equivalent of about twice that of the world's GDP. This article attracted much attention. One major criticism of the article was that one could not easily extrapolate economic value from marginal losses (e.g., the services lost when one hectare of mangrove is lost) to the total economic value of the services provided (e.g., by all standing mangroves in the world).

Since then, there has been a strong movement to see the monetary valuation of ecosystem services (and indeed, PES) as instruments for conservation. Let us now analyse some cases of valuation in different contexts and scales.

Mangroves vs. shrimp: the value of ecosystem services

This case is based on the work by Barbier and Sathiratai (2004), who did a cost-benefit analysis (CBA) of shrimp farming when compared to mangrove preservation. In our typology of socio-economic approaches, this would be a clear example of the first type.

Let us plausibly assume that one shrimp farm produces per ha/year about 4,000 kg of shrimp, selling at a farm price of USD 5 per kg; the gross revenue is then USD 20,000 per ha/year. This is difficult to match by the (market and non-market) economic values provided by one hectare of mangroves.

However, the shrimp pond lasts perhaps only five years, while mangrove destruction is permanent or at least until a few years after shrimp farming ceases when the soil becomes less acidic and allows for replanting. So, we have five years of shrimp revenue to compare, say, to 15 years (5 plus 10) of loss of mangrove revenue. Certainly, we should deduct from the gross revenue, the monetary costs of producing the shrimp such as costs of nutrients and antibiotics.

Moreover, we deduct the amortisation of the investment costs, about USD 10,000 per ha, i.e. USD 2,000 per ha/year. We then deduct externalities, such as the costs of water pollution. There are two methods available: the economic value of the damage produced, or the cost of the abatement of pollution down to the desired level. We also deduct other externalities (e.g., illnesses suffered by women and children collecting seedlings, and new resistance to antibiotics). Moreover, we assume that an obligation is imposed of replanting mangroves once the farm is abandoned after five years. The costs could amount to USD 300 per ha or USD 8,000 per ha according to different sources. Depending then on various assumptions, we have a figure for value added from shrimp production (net of market and non-market costs) equivalent to USD 10,000 per ha/year, or even less.

If, instead, we keep the mangroves, what are the market and non-market revenues produced per hectare? Here we distinguish between direct and indirect economic values. The direct values are derived from the products collected from the mangroves (shells, crabs, fish, honey, wood, etc.) for self-consumption or marketing. A mangrove forest will produce over ten tonnes of biomass per year, mostly as detritus from fallen leaves. A small part of the biomass would be collected by humans, who depend on the mangrove forest for their livelihood.

However, in money terms this biomass in the form of fish, crabs, shellfish, and wood, is not worth much (say, USD 100 or 200 per ha/year) because the prices it would fetch in the market are low. This is what the TEEB report, as we shall see below, calls "the GDP of the poor." Indirectly, the mangroves provide other current or future (optional) benefits that must be valued in money terms in order to complete the CBA. These range from being a nursery for off-coast fisheries to coastline defence, and also include carbon uptake, repository of salinity-resistant genetic resources, and other forms of unused biodiversity, sometimes also including recreational values.

The coastal defence service is valued at the 'replacement cost;' a wall could be built instead. Then, this reaches thousands of dollars per hectare of mangrove forest. For biodiversity, there is no 'replacement cost' (as in a 'Jurassic Park') of the disappearing species. We could resort to extrapolations from payments in bioprospecting contracts, or to 'willingness-to-pay' valuations, or to production losses. Finally, net carbon uptake may be given different values according to the CDM case we take in comparison. This 'price' does not reflect the usefulness of the carbon uptake service for humans and nature but it depends on the Kyoto and post-Kyoto commitments.

Bringing it all together, one could argue that the economic value of the standing mangroves amounts, per ha/year, up to USD 10,000 or more. The benefits from shrimp farming accrue in the first few years, while the benefits from the mangroves are foregone at least until successful replanting. Mangroves may be defended or attacked through CBA. Much depends on the discount rate (see below), and the methods of economic valuation. Nevertheless, it could be that the administrative authority contemplating a fine on an illegal shrimp farm or an environmental group suing a shrimp farm in a court of law for damages, would find such estimates of losses of environmental services quite useful.

With regard to discounting, one could apply Krutilla's rule, putting a very low or a zero rate of discount on the future services from mangroves because they are becoming increasingly scarce (Krutilla 1967). On the other hand, a pro-shrimp economist could reinforce arguments for shrimp farming by plausibly using a high discount rate, by lowering

the estimated replanting costs, and by giving a high value to the export revenues obtained because foreign exchange might be a limiting factor to economic growth.

The discount rate and the optimist's paradox

The results of any CBA depend on the discount rate (Krutilla 1967). John Gowdy criticised in the main TEEB report (Kumar 2010: 264–267) the use of a high discount rate by Nordhaus in his climate change models. Gowdy cautiously praises Stern's approach. But nevertheless, even Stern discounts the future too much as we shall now explain. Gowdy writes that the values of the per capita rate of growth of the economy in the Stern report range between 1.5% and 2.0%, and this is substantial. Discounting the future is justified by the assumption that those living in the future will be better off than those living today. Notice that this future improvement in the standard of living is attributed to economic growth rather than to the population decline that will presumably take place at world level after 'peak population' is reached by 2050.

In the first TEEB report (EC 2008: 30), Martínez-Alier argued that the assumption of growth leads to the "optimist's paradox" because it justifies the present use of more resources and more pollution because our descendants will be better off. The assumption of growth would in fact leave future generations with a degraded environment and a lower quality of life. In other words, applying a high discount rate because of assumed future prosperity leads to compromising this very prosperity by now giving low weight to future resource exhaustion and environmental impacts in terms, for instance, of biodiversity loss, climate change, or production of nuclear waste. Growth turned into faith creates the conviction that it is possible to live beyond one's current sustainable means (economic and environmental) as all liabilities or debts can be paid back (hypothetically) from tomorrow's higher income (Martínez-Alier and Schlüpmann 1987: 156–171; Martínez-Alier 2002: 45–46).

Monetary valuation in a forensic context: environmental liabilities of Chevron-Texaco and Shell, and climate justice

Industrial economies, even without economic growth, need fresh supplies of energy and materials. The energy in the fossil fuels is 'dissipated' by use; it cannot be recycled and used again. The materials (copper, aluminium, steel) are recycled only in part. Moreover the world economy is still growing. Therefore, there is increasing pressure at the 'commodity frontiers' and there are also increasing waste disposal conflicts (like the excessive amounts of carbon dioxide in the atmosphere and the acidification of oceans).

In the balance sheet of any company, there are assets and liabilities (or debts). However, environmental liabilities do not appear in the balance sheets unless they are claimed by the potential creditors through court cases or through direct action, or unless there are state regulations to that effect. As companies do not include environmental liabilities in their accounts, this means that they do not appear in the macro-economic accounts either. Thus the economy works in practice by shifting costs to poor people, to future generations, and to other species.

Such environmental liabilities appear in the public scene when there are complaints, or when there are sudden accidents (e.g., BP in the Gulf of Mexico, 2010, TEPCO in Fukushima, 2011): the pedagogy of catastrophes or *catastrophisme éclairé* that Jean-Pierre Dupuy (2002) relies upon. This section focuses on two court cases related to oil extraction where the costs were assessed (by the plaintiffs and/or the judges) in billions of dollars: the operation of Texaco (now Chevron) in Ecuador between 1965 and 1990, and Shell in the Niger Delta since the 1970s.

Chevron-Texaco in the Ecuadorian rainforest

As in the rest of the Amazon, the biodiversity of the Ecuadorian rainforest provides its inhabitants with food, fibres, and medicinal resources. It is the resource base for the livelihood of indigenous communities, some of which are still voluntarily isolated from the market economy.

Texaco (Chevron) was present from 1965 to 1990 in the northern part of the Amazon of Ecuador. To save costs, the company dumped the 'extraction water' into ponds that frequently overflowed, and which were not lined to prevent seepage. Gas was flared, but (contrary to the Delta of the Niger) this has not been a matter of controversy in the Ecuador court case. Many indigenous groups like the Cofanes, Secoyas, etc. living in the forest suffered greatly. Two groups (Tetetes and Sansahuari) went extinct. While settlers were attracted by the roads opened up by the oil company, they also suffered from pollution.

The origins of the court case go back to 1993 when a 'class action' suit against Texaco was brought to a court in New York under the ATCA (the Alien Tort Claims Act). Indigenous and settler representatives from Ecuador went to New York. The company insisted (as so often happens in other ATCA cases) that the US court was a *forum non conveniens*. In 2003 the case went to Ecuador (Sucumbios), obviously a more convenient place in order to conduct local inspections and ask local witnesses. Chevron agreed to this (Joseph 2012).

On February 14, 2011, Judge Nicolas Zambrano gave a court decision in Sucumbios, Ecuador. This well-argued 188-page decision[2] reviews the case from its commencement in 1993. The judge focused mainly on two issues: first, the dumping of extraction water into the environment (instead of reinjecting it, or keeping it in properly designed ponds); and second, the damage to human health. The evidence was collected during in situ judicial inspections, by listening to the local people in an exercise of 'popular epidemiology' in a territory where there were no reliable official health statistics at the time (Brown 1992; Novotny 1998).

The technology for water reinjection already existed at the time. The judge mentioned a *Primer of oil production* of 1963 co-authored by Texaco engineers. This technology was not applied in the Amazon of Ecuador in order to save costs, thereby increasing profits and increasing also the likelihood

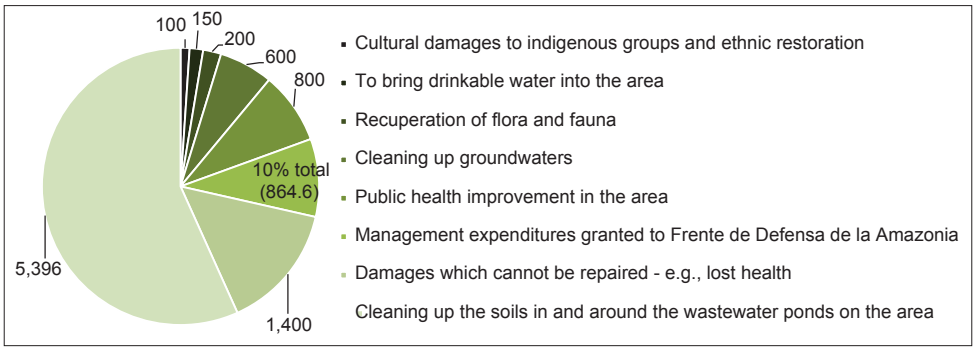


Figure 1
Items in the compensation of the Chevron-Texaco case (in USD million)

of damages. The court decision quotes Chevron-Texaco's own sources admitting to over 15 billion gallons of water dumped in ponds. In fact, standards in the Amazon should have been stricter than in other less vulnerable ecosystems.

The decision fined Chevron-Texaco USD 9.5 billion that would be doubled unless Chevron apologised within 15 days to the victims of pollution. The items in the compensation are presented in Figure 1.

Notice that the main item is a carefully calculated amount (USD 5,396 million) for remediation of the areas with extraction water ponds. There is an unavoidable mixture of items (compensation for irreparable damages together with sums for remediation). Notice also the different values involved (human health, damage to 'fauna and flora' counted at remediation costs, with no item for irreparably lost biodiversity, and only a small item for cultural damages). The judge determined that the payment by Chevron-Texaco must go into a Trust Fund set up by the Frente de Defensa de la Amazonia on behalf of the plaintiffs. The beneficiaries would be tens of thousands of people in Sucumbios and Orellana. There would also be a 10 % additional payment for administration of the Trust Fund.

The court case has been supported by both indigenous and settler populations. From the start of operations in 1970 to 1990, Texaco took 1.5 billion barrels of oil from Ecuador. The payment that Chevron-Texaco must make now is then of the order of USD 6 per barrel. One must take into account the depreciation of the US Dollar and also the time that has passed since then. It is a reasonable amount that Chevron can afford because its annual profits in the last few years have been larger than this. This court decision was appealed before a three-member court in Sucumbios and was ratified on January 3, 2012 (Joseph 2012).[3]

Shell in the Delta of the Niger

The current case against Shell in The Netherlands is also relevant for our discussion on monetary valuation. Over the last 50 years there have been many other attempts to bring Shell to court for damage done in the Delta of the Niger due to oil spills and gas flaring. Nigeria has been the largest oil exporter in Africa, and number 11 in the world. The Delta of the Niger is known as the 'world capital' of oil pollution.

One Nigerian court decision on July 5, 2010, by Judge Ibrahim Buba awarded compensation payments worth USD 105 million to a small community, Ejama Ebubu, for oil spills since 1970 in an area of only 2.5 sq. km. The plaintiffs first went to court in 2001 after the end of the military dictatorship. But Shell was unwilling to pay the compensation. There have been other similar court decisions in Nigeria.

Then, another type of court case against Shell was accepted in 2009, this time in The Netherlands (Macalister 2009). The plaintiffs, fishers and peasants of three communities, claimed that Shell had not used international standards in its operations: their health was affected by oil spills and gas flaring. The case at hand concerns an oil spill on June 26, 2005, in Oruma and spills in two other communities. Shell argued on May 13, 2009, that the court had no jurisdiction on the case. But on December 30, 2009, the court accepted the case, which has since been making slow progress.

Retroactive environmental liabilities and climate justice

Although not directly relevant to a case in Ecuador or Nigeria, in the US a company like Chevron-Texaco would have been very much aware of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), also known as the Superfund. This Law was enacted on December 11, 1980 (just halfway through Texaco's presence in Ecuador). It imposes retroactive obligations: firms have to pay compensation for damages and they have to clean up the pollution left behind. If a firm no longer exists (and the polluted sites are 'orphaned'), then compensation and remediation are to be financed by the Fund constituted by a charge or tax on oil and chemical industries.

The increased social metabolism causes resource extraction, transport, and waste disposal conflicts like those from water and oil pollution and gas flaring in Ecuador and Nigeria. The main waste disposal conflict is related to the excessive amounts of greenhouse gases. Who is the owner of the atmosphere and the oceans as dumping places for carbon dioxide? Who has appropriated for free these climate-regulating services? How do we achieve 'climate justice'?

What does CERCLA have in common with the 'climate debt'? In Copenhagen in 2009 and in Cancun in 2010 some civil society groups and Southern governments pushed forward

claims for the repayment of the 'ecological debt from North to South' (as again in Durban in 2011). Unexpected support for this position came from Jagdish Bhagwati (2010), an economics professor at Columbia University. Leaving aside the activist literature on the 'ecological debt' since 1991[4], Bhagwati wrote that the US, confronted with an internal legacy of pollution after the Love Canal scandal, enacted the 1980 Superfund legislation. This law implied 'strict' liability, applicable even when it was not known at the time that the materials were toxic. According to Bhagwati, this principle should apply to excessive per capita carbon dioxide emissions also. The implication is that the monetary calculations that have been done on the climate debt (see for instance, Srinivasan et al. 2008) could become useful arguments in international negotiations on climate change and even in a court of law. Something similar could be applied to economic calculations of the value of biodiversity loss.

To conclude, claims for environmental liabilities of companies in overseas territories and also in the context of climate change and biodiversity loss, can be expressed sometimes in terms of monetary compensation. Other languages are also available, depending on the context. Instead, Lawrence Summers' principle is applied as a matter of course to resource extraction or waste disposal[5]. No compensations are paid. For the analyst, if justice is not done, this would support the view that the economy regularly achieves cost-shifting successes.

According to standard economic theory, recognising that a good is scarce should result in a positive price. But this mechanism does not work if the demands of those persons—present or future—for whom scarcity means physical non-availability are not heard. Even less if the 'demands' in question come from other species. Pollutants or toxic wastes may be imposed at zero-price in ways that degrade the living habitat of others who are unable to stop the event (O'Connor 2000). Will Chevron-Texaco or Shell (or the citizens of rich countries producing excessive per capita amounts of carbon dioxide), pay at the end of the day a zero-price for the pollution caused?

TEEB: monetary valuations are meant to increase the visibility of biodiversity loss

In 2005, the Supreme Court in India recommended how the value of forestland diverted for non-forest use (like a dam or an open cast mine) could be worked out on economic principles (Chopra 2006). Could we calculate the Net Present Value (NPV) of keeping the forest compared to the NPV of the new industrial development, applying an appropriate discount rate and then reaching a conclusion accepted by society (Temper and Martínez-Alier 2013)? This idea of an increased visibility of biodiversity loss through economic valuation inspired 'The Economics of Ecosystems and Biodiversity' (TEEB) project, that began at the meeting of the G-8 in Potsdam in 2007, with support from Sigmar Gabriel, the then Minister of the Environment in Germany, and the European Commission. Written between 2008 and 2011, the TEEB reports[6] were published under the auspices of UNEP and under the leadership of Pavan Sukhdev, an economist and a banker with a long-standing interest in the economics of nature conservation.

The purpose of the reports was to collect studies showing policy makers the economic benefits of ecosystem products and services, and therefore the costs to human wellbeing of the loss of such ecosystems. TEEB set out to ask, how much does it cost to protect ecosystems (mangroves, coral reefs, tropical rainforests, etc.) in comparison to the market and non-market benefits derived from them? The expected answer was, "very little."

TEEB abounds in numbers of dollars of the benefits provided by different ecosystems in order to impress public administrators and firms with the importance of conservation. Such interesting if not puzzling numbers are not always actual measurements (like species-richness or NPP). The benefits come from supporting or habitat services, provisioning services, regulating services, and cultural services. For instance, a wetland in Australia's Northern Territory (ten Brink 2011: 55) was said to provide in 2008 the following benefits per ha/year: cultural service (for tourists and fishermen's recreation): AUD 57; regulation (water use, carbon sequestration): AUD 298; productive services for crop growing, pastoralism, and crocodile hunting: AUD 31; and finally only 1 AUD as habitat for nature conservation.

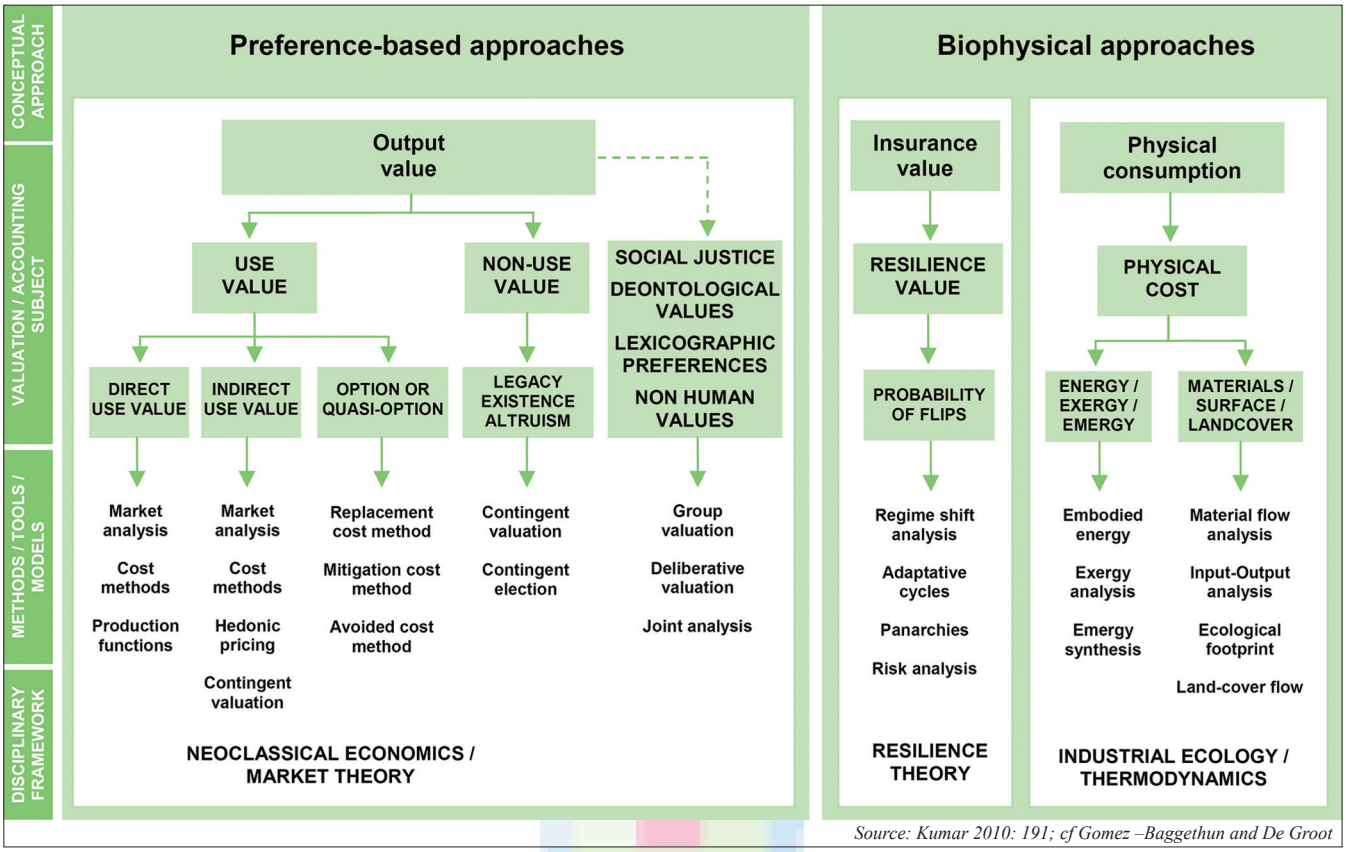
TEEB presented a synthesis of methods of valuation of ecosystem products and services, which is interesting in its wide scope (Figure 2). In practice, the TEEB reports omitted the biophysical approaches [from ecology (resilience theory) and from thermodynamics principles] and also the methods of valuation from political sciences.

The notion of 'the GDP of the poor'

We focus here on one of the most innovative ideas from TEEB. The contribution of forests and other ecosystems to the livelihoods of poor rural households is large in terms of their wellbeing, and therefore there is a significant potential for nature conservation efforts to contribute to poverty reduction. TEEB tries to show that ecosystem services and other non-marketed natural goods account for 47 to 89% of the so-called 'GDP of the poor' (i.e., the total sources of livelihoods of rural and forest-dwelling poor households) in some large developing countries. Imagine a mining company in a tribal village in India that destroys the forests and pollutes the water. The local people have no money to compensate for such loss. Therefore, when poor or indigenous peoples see their livelihoods threatened by the encroachment of extractive industries or the enclosures by tree plantations, they tend to complain—this is often called 'the environmentalism of the poor' (Martínez-Alier 2002).

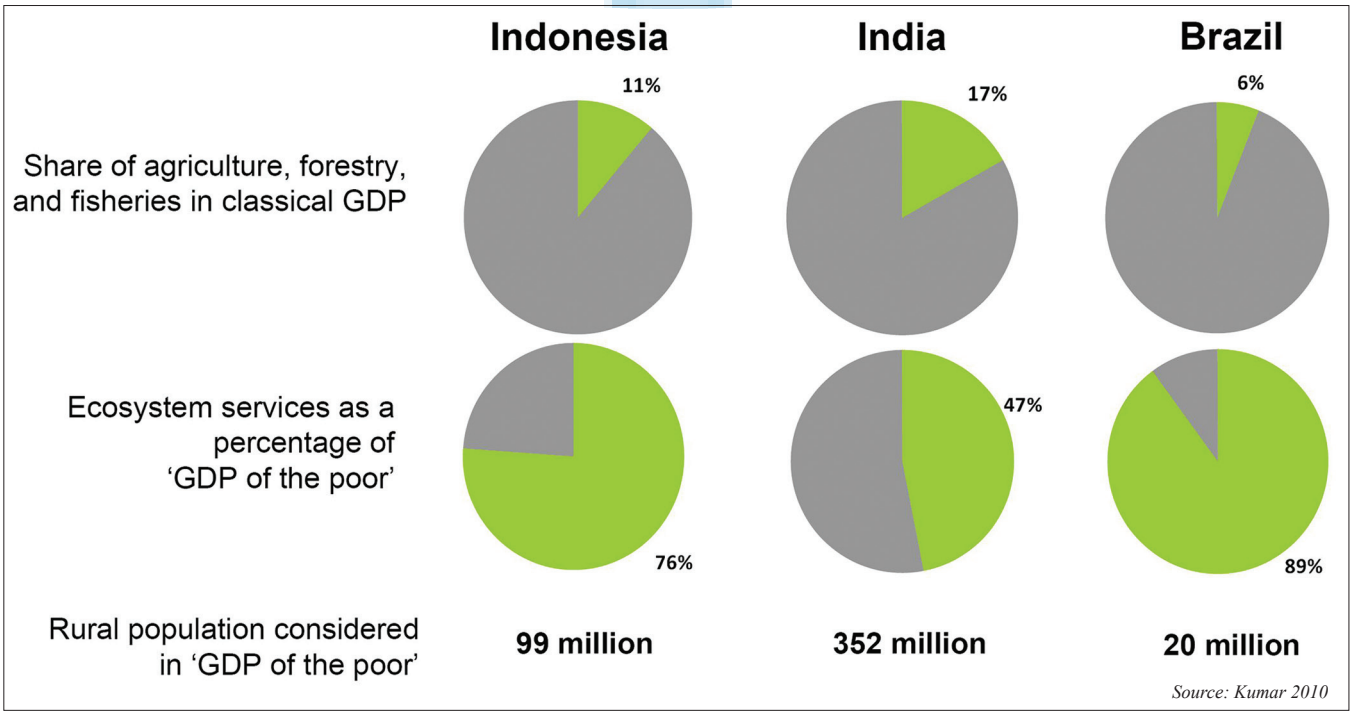
Nature conservation is not a luxury of the rich but a necessity for everybody. The notion of 'GDP of the poor' is a new way of making the old distinction between provisioning through the market and provisioning outside the market, which Aristotle (in *Politics*) called respectively chrematistics and *oikonomia*. This distinction between chrematistics and the real economy was later taken up by many writers, including Karl Marx, Frederick Soddy, Karl Polanyi, and Herman Daly.

It was also the kernel in the 1920s of the Socialist Calculation Debate between Otto Neurath on the one side and Von Mises and Hayek on the other, who argued that without market prices there could not be a rational allocation of resources,



Source: Kumar 2010: 191; cf Gomez –Baggethun and De Groot

Figure 2
TEEB: synthesis of valuation methods



Source: Kumar 2010

Figure 3
GDP of the poor

while Neurath pointed to the radical uncertainties on future availability of resources and future pollution which made it impossible to value them convincingly in money terms (Martínez-Alier and Schlüpmann 1987; O'Neill 1993). Neurath's point about the incommensurability of values and his proposal for accounting 'in kind' were generally lost to economists until he was rediscovered as a proto-ecological economist.

Similarly, the GDP of the poor should not be measured in money but in kind, in terms of contributions to livelihood. However, as explained above, TEEB made an attempt (Figure 3) to translate livelihood values from ecosystem services—which have to do with the second and third approaches to valuation explained in this article—into monetary values to emphasise the importance of the GDP of the poor (ten Brink 2011: 118), to some extent defeating its own purpose.

Economic development often implies the destruction of natural capital, also of so-called human capital (including the many languages which are being lost). Economic development implies the loss of some capabilities, while others are gained. Being forcibly displaced without compensation by a new dam or a new mine, as so often happens, reflects a terrible lack of freedom. The balance should not be drawn in money terms as in a profit-and-loss account or a CBA. It requires a social multi-criteria approach or deliberative valuation that is able to cope with incommensurable values.

All such considerations were not developed in TEEB. However, the introduction of the notion of 'the GDP of the poor' provides an interesting link to a critique of uniform economic development. It also supports the movements of the 'environmentalism of the poor' in defence of biodiversity because this notion signals the importance of ecosystems as a resource base for livelihoods.

Net positive impact: substitute and compensate

While the TEEB recommendations are aware of the importance of the environment for the livelihood of indigenous and poor rural people, some of them 'greenwash' large mining corporations. There are close links between the IUCN (a strong backer of the TEEB initiative) and companies like Shell and Rio Tinto. John Muir would have been horrified. This aside, TEEB explicitly praised proposals (called "net positive impact" by Rio Tinto) to permit the destruction of a habitat if a certificate were presented confirming that an equivalent habitat was 'created' somewhere else. Making the certificates tradable would supposedly create a global market, supporting a flexible and cost-effective biodiversity protection system. Rio Tinto is certainly not the only voice putting forward such a proposal.

However, consider for instance mangrove destruction. Small countries like Ecuador or Honduras would quickly run out of mangroves to be preserved. It does not make sense to destroy ten hectares of mangrove forest in Muisne, Ecuador, and pay for the preservation of ten hectares of an 'equivalent' mangrove in Tanzania.

In summary, this section has critically analysed some cases where monetary valuation of biodiversity loss (and also other environmental damages) is plausible. If the money returns from ecosystem products or services become the main logic of conservation, and if such returns are not high enough (for instance, by the application of relatively high discount rates), money valuation becomes counterproductive. Still, the context might require this kind of valuation, as in a court case on damages from mining or oil extraction. Or economists and politicians might think that monetary valuation will increase the social visibility of biodiversity loss, as in the TEEB reports.

HALTING BIODIVERSITY LOSS THROUGH THE PROTECTION OF ECOSYSTEM FUNCTIONS AND SERVICES?

In contrast to the attempts to value in money terms the positive contribution of ecosystem services to human wellbeing (or to value also in money terms some harms to nature and to humans), this section considers examples where the emphasis is given to the necessary actions to preserve functions of the environment.

Ecosystem functions exist in nature beyond human agency (e.g., the water cycle, soil formation or primary biomass production) although human decisions may affect them to a great extent. In contrast, ecosystem services are socio-ecological processes, the maintenance of which is perceived as beneficial by the socio-economic system. They have a focus on human interests, that is, societies attribute preferences for each ecosystem service, or for a pack of them, and have therefore normative views about their development. Different levels of human involvement are then required for their existence, either cognitive, behavioural or through the application of different forms of human-made capital. While they are linked to material processes that occur in nature, their *raison d'être* is that they are useful to generate either goods (like food production) or services that allow further human achievements (like soil fertility), including the protection against undesired events (like most regulating services).

This approach was vigorously brought into conservation biology, human ecology, and ecological economics by the Millennium Ecosystem Assessment (MA 2005), which not only provided the evidence of declining ecosystem services but also demonstrated their links with the constituents and determinants of human wellbeing. Although humans cannot survive without such services, they are not made available through the market except in some very special cases (payment for pollination services, for instance) (Gallai et al. 2009). Two schemes that make operative the concept of ES management without applying CBA are considered below.

The Water Framework Directive in the EU

The Water Framework Directive (WFD 2000/60/EC) (European Parliament and Council 2000) sees water not only as an economic resource but also as a basic element of ecosystems. The idea is that a better state of aquatic ecosystems

will result in increased quality and quantity of available water. For this reason, the Directive has become a driver of ecological restoration, setting specific normative objectives to be achieved according to a precise calendar. The WFD urges the states of the European Union to maintain and improve the ecological quality of water bodies, applying cost-effective measures.

This influential piece of legislation is relevant in the context of this article because it greatly increased the social visibility of the ecosystem services provided by rivers and other water bodies. Rivers are not merely sources of money in the form of water abstraction, hydroelectricity, fisheries, sand, and commercial or recreational navigation. They have environmental functions and provide services, which extend much beyond the evacuation and dilution of waste.

The WFD's objective is the achievement of appropriate quality in rivers and water bodies regarding chemical pollution, hydro-morphological characteristics, and ecological or biological quality. How much will it cost to achieve or maintain such qualities, and who will pay for it?

For chemical pollution, there is already a tradition of setting norms. But ecological quality demands other characteristics that are not so easy to capture: preservation of biotic integrity, prevention of bioinvasions, and maintenance of environmental flows. As no absolute standards for biological quality can be set which may be applicable across Europe, because of ecological variability, the norms must allow slight departures from the standards which would be expected in conditions of 'minimal' anthropogenic impact. There is not a single figure that is both scientifically and socially validated and therefore stakeholders should have a role in determining how the objectives are expressed in practice.

Moreover, the WFD asks that the fees charged for water management are set according to the 'full cost recovery' principle. In practice they must be sufficient to pay for the costs of water management so that the (roughly defined) objectives are achieved through consumers' payments. Each large river basin must come up with a management plan.

One of the authors of this article worked for four years in a water administration office in charge of implementing the WFD in Catalonia. It was found that social conflicts arise on the biological quality norms to be established (in a process of post-normal science, because there is no total scientific certainty on the relevant issues), on access to available products and services (e.g., irrigation against hydroelectricity against urban water supply), on the geographical distribution of water (interlinking of river basins), and on the costs to be paid for by consumers and the profit margins allowed for the private or public suppliers. The conflicts are on the 'property rights' on the access to water and its products and services.

According to the WFD, no economic comparison is involved between the values of the provisioning, recreational, cultural, and habitat services on the one hand, and the costs of keeping the water bodies and rivers in their appropriate state on the other hand. The approach is that of cost-effectiveness, not that of CBA.

The Yasuni ITT initiative in Ecuador: keep the oil in the ground

The bad experience with oil extraction in the Amazon and the debates on climate change led the environmental justice organisation Acción Ecológica and the Oilwatch network to propose a new initiative in Kyoto in 1997. They suggested it would be a good idea to leave oil in the ground in areas of high biological value and threatened indigenous populations. This was in the aftermath of Texaco's disastrous legacy in Ecuador and of the killing of Ken Saro-Wiwa and other Ogoni activists in Nigeria by the military dictatorship in 1995 because of their complaints and actions against Shell.

Coal, oil, and gas cannot be extracted from the ground and burnt at the present rate because this causes climate disruption. In which areas should the fossil fuels be left in the ground? The answer is in areas where the associated damage values (in their monetary or non-monetary expressions) are highest. Leaving oil in the ground in the Yasuni ITT (Ishpingo-Tambococha-Tiputini) fields in Ecuador would respect local indigenous rights, avoid deforestation, and biodiversity loss, and would have another beneficial side effect: preventing carbon dioxide emissions of about 410 million tons (equivalent to Spain's emissions for one year). These emissions have no local effects. They would come from the oil that would be burnt eventually in the importing countries.

The moratorium proposed by Oilwatch in 1997 was transformed into public policy after Rafael Correa became president of Ecuador in 2007. Two of his closest collaborators were Alberto Acosta, Minister of Energy and Mines (until June 2007, then President of the Constituent Assembly until the end of 2008), and Fander Falconí, Secretary for Economic Planning and then Minister for Foreign Relations (until January 2010). Acosta put forward officially the Yasuni ITT Initiative in early 2007, against the idea of selling the approximately 850 million of barrels of heavy oil from the ITT fields. This represents one-fourth of Ecuador's oil reserves. The Yasuni is biologically an extraordinarily rich area, which as a National Park is excluded in principle from oil exploitation. It is also a refuge for some Waorani peoples in voluntary isolation, the Tagaeri and Taromenane.

Ecuador decided in principle to keep the oil in the ground. Revenue from selling the oil, counted at present value, would perhaps amount to USD 7,200 million. A Trust Fund under UNDP management and with Ecuador's representatives in the majority in the management council was set up on August 3, 2010. Ecuador was ready to make this sacrifice but asked the outside world to contribute to it (USD 3,600 million, over 10 years) on the grounds that Ecuador was contributing to world objectives through this scheme. Ecuador was asking therefore for only half the estimated opportunity cost (Larrea and Warnars 2009; Rival 2010). On August 15, 2013, president Rafael Correa announced that the plan had not been successful and that oil would be taken out. Then social claims for a referendum demanded

to reverse this decision.

Can the Yasuni ITT Initiative be considered an example of PES? An equivalence may be established between the outside compensation asked for, and the avoided carbon dioxide emissions from oil burning, from local gas flaring, and from local deforestation. Assuming outsiders would invest USD 3,600 million, they could be considered to be buying (not transferable) 'carbon credits' in the 'voluntary market' at about 8 USD per ton of carbon dioxide from avoided oil and gas burning. (There are moreover different estimates of the local deforestation avoided, with oil companies claiming that forest destruction would be minimal). However, it is interesting that when the German parliament, the Bundestag, in June 2008 gave support to the Yasuni ITT proposal, it did not mention carbon credits. It mentioned biodiversity values and human rights. Ecuadorean environmentalists strongly disprove of trade in carbon credits (as witnessed in Ecuador's own experience with the Dutch FACE project); they do not want the preservation of the Yasuni ITT area to be interpreted as the buying of carbon credits. It is not to be seen either as the payment for a bundle of services provided by the Yasuni ITT's 'natural capital.' They like to think that the outside contribution would be a payment on account of the rich countries' ecological debts, and also by virtue of the principle of co-responsibility enshrined in the 1992 Rio de Janeiro climate change treaty.

Whatever the final outcome in Ecuador itself, the idea could be applied elsewhere. It has given rise to a new verb in Spanish, *yasunizar*—meaning to leave fossil fuels in the ground to avoid local social and environmental damages and to avoid carbon dioxide emissions. Environmentalists believe that this scheme should be replicated elsewhere (for oil, coal, and also more recently, for shale gas projects), as described in the slogan:

> *Leave the oil in the soil,*
> *leave the coal in the hole,*
> *leave the tar sands in the land*
> —Nmimo Bassey, Klimaforum09 People's Climate Summit

In summary, the two cases in this section analyse the public policy measures taken to avoid the disruption of ecosystem functioning and ecosystem services provision. In both cases we see how economics has a role in biodiversity protection, but the economic analysis does not entail the commensuration of the benefits of biodiversity. Rather, a cost-effectiveness analysis is applied to assess the efforts by human societies in order to maintain a desired level of ES production. The costs of ES management can be applied to induce changes in the state of ecosystems in a way that a specific ES is boosted (e.g., soil conservation practices, aquifer replenishment), or by applying different forms of human-made capital to use an ES more efficiently (e.g., through ecoengineering, biocontrol can be better understood and used to control pests). Relevant opportunity costs could also be accounted for when using a particular ES. For example, agricultural practices can exploit more effectively the food production services at the cost of losses in the regulating services (in terms of water purification or soil retention). There are therefore trade-offs, but also possible synergies. For instance, reducing pesticide use in low-input agriculture increases pollination services.

Besides the cost-effectiveness approach, other possible methodological options that allow a representation of diverse biophysical flows involved would be multi-criteria evaluation (Munda 2008) or other forms of non-monetary assessment, like energy flows accounting. In any case, the objective of protection entails normative conventions on the state of the ecosystems.

THE PLURALITY OF VALUES IN DECISIONS ON BIODIVERSITY

This section considers three instances where the destruction of the environment is challenged by local actors who argue in terms of livelihood needs and/or cultural values or who bring ancestral or new Constitutional rights into the argument. Such values and rights cannot be traded off for money. One case features Afro-Ecuadorian communities defending their right to use mangroves sustainably against shrimp farmers supported by the government. The second case is the famous conflict of the Dongria Kondh in Odisha against the bauxite mining company Vedanta. Finally, we consider a recent legal case in Ecuador on the Rights of Nature as enshrined in the new Constitution of the country.

Back to the mangroves: shrimp farming vs. livelihoods

How can we make the loss of mangroves more visible to the public at large and to public policy makers? Can mangroves be saved through chrematistic valuation and payment for environmental services as shown above? Another type of comparison between mangrove conservation and shrimp farming could be carried out by multi-criteria evaluation, taking into account a variety of incommensurable dimensions expressed in quantitative units or qualitative descriptions. Such a multi-criteria assessment would include some monetary figures. However, would the insistence on money valuation not undermine other valuation languages? Who has the power to impose or to discard valuation languages?

A response to these questions came from a woman in Muisne, Ecuador, in 1998, quoted by Martínez-Alier (2002: 83). She explained the reasons why the *concheras* (shell and crab collectors) and *carboneros* (charcoal makers) defended the mangroves against the *camaroneros* (shrimp farm owners).

> …they want to humiliate us because we are black, because we are poor, but one does not choose the race into which one is born, nor does one choose not to have anything to eat, not to be ill. But I am proud of my race and of being *conchera*. Now we are struggling for something which is ours, our ecosystem, but not because we are professional ecologists but because we

> must remain alive, because if the mangroves disappear, a whole people disappears, we shall no longer be part of the history of Muisne…we shall eat garbage in the outskirts of the city of Esmeraldas or in Guayaquil, we shall become prostitutes… We think, if the *camaroneros* who are not the rightful owners nevertheless now prevent us and the *carboneros* from getting through the lands they have taken, not allowing us to get across the swamps, shouting and shooting at us, what will happen next, when the government gives them (legally) the lands, will they put up big 'Private Property' signs, will they even kill us with the blessing of the President?

The *conchera* did not use economic theory to defend the mangroves. Neither did she call explicitly for any kind of multi-dimensional assessment. She used the valuation language relevant in her culture. She argued in terms of livelihood needs and of ancestral property rights. She argued also in terms of what in the United States would be called environmental justice against 'environmental racism.' Notice that she did not say the mangroves were sacred in her culture, because they are not, and this is in contrast to the following case in Odisha in India.

The defence of the Niyamgiri hill

In the mountains of Odisha there are deposits of bauxite of a total present value said to exceed India's annual GDP (Padel and Das 2010). Open cast mining is practiced in this region. The ratio of bauxite to alumina is 3 to 1. In the Bayer process, bauxite is 'digested' by washing the ore with a hot solution of sodium hydroxide. The mixture of solid impurities is called red mud, and presents a disposal problem. The aluminium hydroxide solution is then cooled, and it precipitates as a white, fluffy solid. Then, when heated to 1050°C (calcined), the aluminium hydroxide decomposes to alumina: large inputs of electricity and water are required. The alumina so produced is then subsequently smelted to produce aluminium. The demand for aluminium is growing quickly in the world. India's per capita consumption is a little more than 1 kg per person/year while in the United States it is 25 kg person/year (Padel and Das 2010).

In 2002 Sterlite-Vedanta (domiciled in London) started to acquire land in Lanjigarh (Kalahandi, Odisha). The first complaints by tribal peoples began here. The sacredness of the Niyamgiri hill with its beautiful sal (*Shorea robusta*) forest immediately became relevant. There was a Memorandum of Understanding between Vedanta and the government of Odisha. The Lanjigarh refinery would be built (and it was built), bauxite would come initially from distant mines by train and truck, but it was foreseen that ore from the nearby Niyamgiri would be exploited at the top of the mountain on 660 ha, to the tune of 3 million tons per year for 25 years. In 2006, after initial displacement of local people and destruction of a small forest, Vedanta started operating the Lanjigarh refinery using bauxite from far away, and dumping red mud as waste. After court appeals and much social unrest, in August 2010, the then Minister of Environment and Forests, Jairam Ramesh, based on the findings of the so-called Saxena Committee, decided against giving permission to Vedanta for mining bauxite from the nearby Niyamgiri hill. The minister specifically argued in a striking decision, that tribal people's rights to previous consultation and consent for taking up their forests had not been respected and indeed had already been violated by Vedanta. After further appeals, in 2013 the local Dongria Kondh were consulted as determined by the Supreme Court, and a decision against mining was made.

As Temper and Martínez-Alier (2013) argue, how many tons of bauxite is a tribe or a species on the edge of extinction worth? And how can you express the relevant values in terms that a minister of finance or a Supreme Court judge can understand? Against the logic of rupees or dollars, the peasant and tribal languages of valuation go often unheeded. These include the language of territorial rights against external exploitation, the ILO Convention 169, which guarantees prior consent for projects on indigenous land, or in India the protection of the adivasi by the Constitution. Ecological and aesthetic values could also be relevant. The Niyamgiri hills are sacred to the Dongria Kondh. Emphasising the incommensurability of values, we could shockingly ask them: how much for your God? How much for the blessings provided by your God?

The Rights of Nature, a rising language

With the widening of the Vilcabamba-Quinara road in southern Ecuador, large quantities of rock and excavation material were dumped into the Vilcabamba river. For three years before 2011, this project promoted by the Provincial Government of Loja was underway without studies on its environmental impact, provoking a risk of disasters from the growth of the river with the winter rains.

Article 71 of the Ecuadorian Constitution of 2008 establishes that any person, belonging to any community or of any nationality will be able to claim from the public authorities the respect to the Rights of Nature. Environmentalists Richard F. Wheeler and Eleanor G. Huddle demanded the observance of this provision in the case of the Vilcabamba river. On March 30, 2011, the Provincial Court of Justice of Loja granted for the first time a Constitutional injunction in favour of the plaintiffs, setting a historical precedent of the enforcement of the Rights of Nature (Greene 2011).

Note that in this case, the Ecuadorian Constitution expressed a collective structure of preferences that in economics would be classified as lexicographic. This means that no amount of any other good or service can compensate for the loss of the Rights of Nature.

Notice also that lack of 'trade offs' also applies to the 1973 Endangered Species Act of the United States requiring that federal agencies ensure that any action authorised, funded or carried out by them does not jeopardise the continued existence of listed species or modify their critical habitat. In principle, no monetary valuation is involved of the costs and benefits of such actions.

The question is not whether economic value can be determined only in existing markets, inasmuch as economists have developed methods for the monetary valuation of environmental goods and services or of negative externalities outside the market (as abundantly shown in the TEEB reports). Judges also give monetary values when the context requires it as in the Chevron-Texaco case (relying sometimes on economists' advice). Rather, the question is whether all evaluations in a given conflict where biodiversity and livelihoods are threatened (e.g., bauxite extraction in Odisha and mangrove destruction in Ecuador) can be made in a single dimension of value. This should be rejected favouring instead the acceptance of a plurality of incommensurable values. What the cases of the Dongria Kondh and the position of the *concheras* in Ecuador also show is that the local poor people (indigenous or not) are often on the side of conservation because of their livelihood needs and their cultural values.

CONCLUSION

Conservationism as a social endeavour has a long history. Conservation biology is a more recent field of science studying threats to biodiversity and the social institutions that are useful to preserve biodiversity, from 'sacred groves' to natural parks, and lately to PES. Perhaps paradoxically, the conservation movement and the associated sciences have grown as biodiversity has been lost over the last fifty years (Kumar and Martínez-Alier 2011).

What are the causes of biodiversity loss? For some analysts, the main point is that avoiding the loss of a public good requires the alignment of incentives and rewards among the different actors who play different games. For other analysts, the answer would parallel Nicholas Stern's famous description of climate change as "the greatest market failure ever." But rather than an 'externality' that we could internalise into the price system, what we have today are cases of 'successful shifting of costs' to future generations and to other species, and to poor and indigenous people. In our view, more attention should be placed on the driving forces than on the price patterns. Moreover, if the monetary returns of conservation are low in the short run, and if the logic of conservation becomes a purely chrematistic logic, conservation might be even more threatened than before.

In this article we have discussed three approaches to make biodiversity loss more visible so as to better defend it. We have drawn upon recent cases in which we have been (to some extent) personally involved, to show how different social actors use or refuse one approach or the other according to the social context.

The first approach is the route of the CBA, as Edward Barbier has often tried to use when assessing the costs of mangrove destruction against the benefits of shrimp farming. This is very much featured in the TEEB reports that argue in favour of money valuation of losses of ecosystem services (at the margin) in order to impress policy makers with the importance of nature conservation. The main idea was less to put biodiversity in the market (although this is also part of TEEB, as in its praise for 'habitat trading') than to give notional monetary values to the loss of ecosystem services in order to make biodiversity socially more visible (to those who think mostly in terms of money). Why not? But is it technically feasible? And, could it be counterproductive? Which social organisations and forces (conservationists, environmental justice networks, business, governments) favour or oppose economic commensuration, and why? Is not economic valuation required in court cases asking for compensatory and punitive damages?

The second path insists on the increasing importance ('value') of the products and services provided by ecosystems. One could expect public policies to be guided by the desire to avoid loss of valuable ecosystems without need for money valuation. Shall we then assess the (actual and future) effects of preservation of biodiversity in a cost-effectiveness or multi-criteria framework?

The third approach consists in acknowledging the 'bottom up' plurality of the values in ecosystems, and applying deliberative techniques (which allow for decisions that acknowledge the incommensurability of values). Perhaps the approach that is the most effective to defend biodiversity is the appeal to the plurality of values. Moreover, environmental values are not more widespread in rich countries and among rich people than in poor countries and among poor people (Martínez-Alier 2002). Thus, the Dongria Kondh's (provisional?) success (together with their allies) is only one more example of struggles in India and elsewhere in defence of nature against mines, dams, tree plantations, and agrofuels, by poor and/or indigenous peoples deploying non-monetary values such as livelihood, territorial rights, indigenous identity, local democracy, and sacredness of the water and the land. Aesthetic and ecological values are also relevant. Similarly, the Rights of Nature may be brought into decision making.

In general the conservation movement, since 1992 until today, has favoured the monetary valuation of ecosystem products and services, while the environmentalism of the poor has tended to appeal to non-economic values. However, as we have shown in this article, real life situations are not so clear. In a forensic context monetary valuation might become the common language to all parties. Climate justice activists are not against monetary calculation of the so-called 'ecological debt.' While the MA wisely refrained from adding money valuation to its outstanding descriptions of the state of the world's ecosystems, the TEEB report focused very much on money valuation but it also introduced the notion of the GDP of the poor, whose significance is badly captured in monetary terms. An environmental justice organisation may ask in the morning for a proper CBA to be carried out (perhaps applying Krutilla's rule that will favour conservation) while in the evening it will perhaps remember the sacredness of the forest or the river under threat.

To conclude, we may say that "shrimp [or bauxite or oil] are valuable items of world economic production and trade," and also, "valuable ecosystems and valuable local cultures are thereby destroyed." The word 'valuable' does not necessarily imply monetary valuation. The monetary valuation of all goods produced and environmental services lost (discounted at present value) as in CBA, may be

recognised as one legitimate perspective among several that reflects real power structures. But it is not the only legitimate perspective. Who then has the power to simplify complexity, imposing a particular standard and procedure of valuation? In this article we have presented instances that point to suitable uses of each one of the three approaches under consideration.

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NOTES

1. Iniciativa para la Integración Regional de Infraestructuras Suramericanas (Initiative for the Regional Integration of the South American Infrastructures; www.iirsa.org).
2. This document is available in Spanish and English at www.business-humanrights.org.
3. On November 12, 2013, the Supreme Court of Ecuador ratified once again the decision on compensatory damages of USD 9.5 billion, but took away the 'punitive damages' that doubled the fine in case Chevron failed to apologise.
4. For more information, see www.deudaecologica.org.
5. In 1991, the then chief economist of the World Bank wrote (or dictated) a memo arguing that pollution should be sent to places where there are no people, or where the people are poor, since "the measurements of the costs of health impairing pollution depends on the foregone earnings from increased morbidity and mortality. From this point of view a given amount of health impairing pollution should be done in the country with the lowest cost, which will be the country with the lowest wages. I think the economic logic behind dumping a load of toxic waste in the lowest wage country is impeccable and we should face up to that." From a strictly economic viewpoint, he was right (The Economist 1992).
6. Available online at www.teebweb.org.

REFERENCES

Arrhenius, S. 1896. On the influence of carbonic acid in the air upon the temperature of the ground. *Philosophical Magazine* 41: 237–276.

Barbier, E.B. and S. Sathiratai. 2004. *Shrimp farming and mangrove loss in Thailand*. London: Edgard Elgar.

Bhagwati, J. 2010. A new approach to tackling climate change. *Financial Times* February 22, 2010.

Brown, P. 1992. Popular epidemiology and toxic waste contamination: lay and professional ways of knowing. *Journal of Health and Social Behavior* 33: 267–281.

Clark, C.W. 1973. Profit maximization and the extinction of animal species. *Journal of Political Economy* 81: 363–372.

Chopra, K. 2006. *Report of the expert committee on net present value (Professor Kanchan Chopra Committee)*. Submitted to the Honourable Supreme Court of India. Delhi: Institute of Economic Growth.

Collette, B.B., K.E. Carpenter, B.A. Polidoro, M.J. Juan-Jordá, A. Boustany, D.J. Die, C. Elfes, et al. 2011. High value and long life—double jeopardy for tunas and billfishes. *Science* 333(6040): 291–292. doi: 10.1126/science.1208730.

Costanza, R., R. d'Arge, R. de Groot, S. Farber, M. Grasso, B. Hannon, S. Naeem, et al. 1997. The value of the world's ecosystem services and natural capital. *Nature* 387: 253–260.

Czech, B. 2008. Prospects for reconciling the conflict between economic growth and biodiversity conservation with technological progress. *Conservation Biology* 22(6): 1523–1739.

Daily, G.C. (ed.). 1997. *Nature's services: societal dependence on natural ecosystems*. Washington, DC: Island Press.

de Groot, R.S., M. Wilson, and R. Boumans. 2002. A typology for the description, classification and valuation of ecosystem functions, goods and services. *Ecological Economics* 41: 393–408.

Dupuy, J.-P. 2002. *Pour un catastrophisme éclairé*. Paris: Seuil.

EC (European Commission). 2008. *The economics of ecosystems and biodiversity. An interim report*. Luxemburg: The Office for Official Publications of the European Communities.

EEA (European Environment Agency). 2010. *EU 2010 Biodiversity baseline*. Luxemburg: EEA Technical Report 12/2010.

EEA (European Environment Agency). 2011. EEA glossary. DPSIR. http://glossary.eea.europa.eu/terminology/concept_html?term=dpsir. Accessed on July 8, 2011.

Espeland, W.N. and M.L. Stevens. 1998. Commensuration as a social process. *Annual Review of Sociology* 24: 312–343.

European Parliament and Council. 2000. Directive 2000/60/EC of the European Parliament and of the Council establishing a framework for the Community action in the field of water policy. *Official Journal of the European Communities*. December 22, 2000.

FAO (Food and Agriculture Organization). 2011a. Species factsheets. *Auxis thazard*. http://www.fao.org/fishery/species/2491. Accessed on July 8, 2011.

FAO (Food and Agriculture Organization). 2011b. Species factsheets. *Auxis rochei*. http://www.fao.org/fishery/species/2492. Accessed on July 8, 2011.

Fearnside, P. 1997. Environmental services as a strategy for sustainable development in rural Amazonia. *Ecological Economics* 20: 53–70.

Gallai, N., G. Carré, G. Enjolras, I. Reginster, J.-M. Salles, and B.E. Vaissière. 2009. Vulnerability in Europe confronted with pollinator decline: a case study comparing Germany and Spain. In: *Assessing biodiversity risks with socio-economic methods: the ALARM experience* (eds. Rodríguez-Labajos, B., J.H. Spangenberg, L. Maxim, J. Martinez-Alier, R. Binimelis, N. Gallai, P. Kuldna, et al.). Pp. 15–30. Sofia: Pensoft.

Gerber, J.-F. 2011. Conflicts over industrial tree plantations in the South: who, how and why? *Global Environmental Change* 21(1): 165–176.

Gordon, H.S. 1954. The economic theory of a common-property resource: The fishery. *Journal of Political Economy* 62(2): 124–142.

Greene, N. 2011. The first successful case of the Rights of Nature implementation in Ecuador. http://therightsofnature.org/first-ron-case-ecuador/. Accessed on October 6, 2011.

Guha, R. 1989. *The unquiet woods: ecological change and peasant resistance in the Himalaya*. 2010 edition. Ranikhet: Permanent Black.

Haberl, H., K.-H. Erb, F. Krausmann, S. Berecz, N. Ludwiczek, J. Martínez-Alier, A. Musel, et al. 2009. Using embodied HANPP to analyze teleconnections in the global land system: conceptual considerations. *Danish Journal of Geography* 109(2): 119–130.

Haberl, H., K.-H. Erb, F. Krausmann, V. Gaube, A. Bondeau, C. Plutzar, S. Gingrich, et al. 2007. Quantifying and mapping the human appropriation of net primary production in earth's terrestrial ecosystems. *Proceedings of the National Academy of Sciences* 104(31): 12942–12947.

Haberl, H., C. Plutzar, K.-H. Erb, V. Gaube, M. Pollheimer, and N.B. Schulz. 2005. Human appropriation of Net Primary Production as determinant of avifauna diversity in Austria. *Agriculture, Ecosystems & Environment* 110(3–4): 119–131.

Joseph, S. 2012. Protracted lawfare: the tale of Chevron Texaco in the Amazon. *Journal of Human Rights and the Environment* 3(1): 70–91.

Kallis, G., E. Gómez-Bagghetun, and C. Zografos. 2013. To value or not to value? That is not the question. *Ecological Economics* 94: 97–105.

Kapp, K.W. 1950. *The social costs of private enterprise*. Cambridge, MA: Harvard University Press.

Kosoy, N. and E. Corbera. 2010. Payments for ecosystem services as commodity *fetishism*. *Ecological Economics* 69(6): 1228–1236.

Krutilla, J.V. 1967. Conservation reconsidered. *American Economic Review* 57(4): 777–786.

Kumar, P. (ed.). 2010. *The Economics of Ecosystems and Biodiversity: ecological and economic foundation*. London and Washington, DC: Earthscan.

Kumar, P. and J. Martínez-Alier. 2011. The economics of ecosystems and biodiversity: an international assessment. *Economic and Political Weekly* XLVI (24): 76–80.

Larrea, C. and L. Warnars. 2009. Ecuador's Yasuni-ITT Initiative: avoiding emissions by keeping petroleum underground. *Energy for Sustainable Development* 13(3): 219–223.

MA (Millennium Ecosystem Assessment). 2005. *Ecosystems and human well-being: biodiversity synthesis.* Washington, DC: World Resources Institute.

Macalister, T. 2009. Shell must face Friends of the Earth Nigeria claim in Netherlands. *The Guardian* (UK). December 30, 2009.

Machado, A.T., M.B. Pereira, M.E. Pereira, C.T.T. Machado, and L.E. Médice. 1998. Avaliação de variedades locais melhoradas de milho em diferentes regiões do Brasil. In: *Milho Crioulo, Conservação e Uso da Biodiversidade* (eds. Soares, A.C., A.T. Machado, B.M. Silva, and J.M. von der Weid). Pp. 93–106. Rio de Janeiro: AS-PTA.

Martínez-Alier, J. 2002. *The environmentalism of the poor. A study of ecological conflicts and valuation*. Cheltenham: Edward Elgar.

Martínez-Alier, J. and K. Schlüpmann. 1987. *Ecological economics: energy, environment and society*. Oxford: Blackwell Publishers.

Maxim, L., J.H. Spangenberg, and M. O'Connor. 2009. An analysis of risks for biodiversity under the DPSIR framework. *Ecological Economics* 69: 12–23.

McCauley, D.J. 2006. Selling out on nature. *Nature* 443: 27–28.

Metrick, A. and M. Weitzman. 1994. Patterns of behaviour in biodiversity preservation. The World Bank: Policy Research Working Paper No. 1358.

Monfreda, C. 2010. Setting the stage for new global knowledge: science, economics, and indigenous knowledge in 'The Economics of Ecosystems and Biodiversity' at the Fourth World Conservation Congress. *Conservation and Society* 8(4): 276–285.

Munda, G. 2008. *Social multi-criteria evaluation for a sustainable economy*. Heidelberg: Springer.

Norgaard, R.B. 2010. Ecosystem services: from eye-opening metaphor to complexity blinder. *Ecological Economics* 69(6): 1219–1227.

Novotny, P. 1998. Popular epidemiology and the struggle for health in the environmental justice movement. In: *The struggle for ecological democracy: environmental justice movements in the United States* (ed. Faber, D.). Pp. 137–158. New York, NY: The Guilford Press.

O'Connor, M. 2000. Towards a typology of environmentally adjusted national sustainability indicators. Report C3ED. Versailles: Université Versailles St. Quentin.

OECD (Organization for Economic Co-operation and Development). 2004. Handbook of market creation for biodiversity. Paris: OECD Publishing.

O'Neill, J. 1993. *Ecology, policy, and politics: human well-being and the natural world*. London: Routledge.

Padel, F. and S. Das. 2010. *Out of this Earth: East India adivasis and the aluminium cartel*. Delhi: Orient Blackswan.

Perrings, C.A., K.-G. Mäler, C. Folke, C.S. Holling, and B.-O. Jansson. 1995. Introduction: Framing the problem of biodiversity loss. In: *Biodiversity loss: economic and ecological issues* (eds. Perrings, C.A., K.-G. Mäler, C. Folke, C.S. Holling, and B.-O. Jansson). Pp. 1–17. Cambridge: Cambridge University Press.

Perrings C.A. and B.H. Walker. 1995. Biodiversity loss and the economics of discontinuous change in semi-arid rangelands. In: *Biodiversity loss: economic and ecological issues* (eds. Perrings, C.A., K.-G. Mäler, C. Folke, C.S. Holling, and B.-O. Jansson). Pp. 190–210. Cambridge: Cambridge University Press.

Ridley, M. 2011. The rational optimist: how prosperity evolves. http://www.rationaloptimist.com/blog/a-paradox-that-is-no.aspx. Accessed on November 15, 2013.

Rival, L. 2010. Ecuador's *Yasuní*-ITT Initiative: the old and new values of petroleum. *Ecological Economics* 70(2): 358–365.

Rodríguez-Labajos, B., J.H. Spangenberg, L. Maxim, R. Binimelis, P. Kuldna, I. Monterroso, K. Peterson, et al. 2009. The socio-economics of biodiversity risk: reasons for and methods of analysis, and their applications in case studies. In: *Assessing biodiversity risks with socio-economic methods: the ALARM experience* (ed. Rodríguez-Labajos, B., J.H. Spangenberg, L. Maxim, J. Martinez-Alier, R. Binimelis, N. Gallai, P. Kuldna, et al). Pp. 15–30. Sofia: Pensoft.

Spangenberg, J.H. and J. Settele. 2010. Precisely incorrect? Monetising the value of ecosystem services. *Ecological Complexity* 7(3): 327–337.

Srinivasan, U.T., S.P. Carey, E. Hallstein, P.A.T. Higgins, A.C. Kerr, L.E. Koteen, A.B. Smith, et al. 2008. The debt of nations and the distribution of ecological impacts from human activities. *Proceedings of the National Academy of Sciences* 105(5): 1768–1773.

Swanson, T. and E. Barbier (eds.) 1992. *Economics for the wilds*. *Wildlife*, *diversity* and *development*. Covelo, CA: Island Press.

Temper, L. 2012. Let them eat sugar: life and livelihood in Kenya's Tana Delta. In: *Ecological economics from the ground up* (eds. Healy, H., J. Martínez-Alier, L. Temper, M. Walter, and J.F. Gerber). London: Routledge.

Temper, L. and J. Martinez-Alier. 2013. The god of the mountain and Godavarman: Net Present Value, indigenous territorial rights and sacredness in a bauxite mining conflict in India. *Ecological Economics* 96: 79-87.

ten Brink, P. (ed.). 2011. *The Economics of Ecosystems and Biodiversity in national and international policymaking.* London: Earthscan.

The Economist. 1992. Let them eat pollution. February 8, 1992.

The Economist. 2010. The world's lungs: forests and how to save them. September 25, 2010.

Toledo, V.M. 2000. Indigenous people and biodiversity. In: *Encyclopedia of biodiversity* (eds. Levin S., G.C. Daily, R.K. Colwell, J. Lubchenco, H.A. Mooney, E.-D. Schulze, and D Tilman et al.). Waltham, MA: Academic Press.

Vitousek, P.M., P.R. Ehrlich, A.H. Ehrlich, and P.A. Matson. 1986. Human appropriation of the products of photosynthesis. *BioScience* 36: 368–373.

Wilson, E.O. and F. Peter (eds.). 1988. *BioDiversity*. Washington, DC: National Academy Press.

Worster, D. 2008. *A passion for nature: the life of John Muir*. Oxford: Oxford University Press.

Wright, D.H. 1983. Species-energy theory – an extension of species-area theory. *Oikos* 41(3): 496–506.

WWF/ZSL (WWF/Zoological Society of London). 2010. *Living Planet Report 2010. Biodiversity, biocapacity and development*. Gland: Switzerland.

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