The Economics of Biodiversity Loss

Dan Biller[1]

The Problem: The Extent of Biodiversity Loss

What is Biodiversity?

Biological diversity, or biodiversity, is defined by the Convention on Biological Diversity (CBD)[2] as: "…the variability among living organisms from all sources including, inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems." Biological resources, which have often been commercialized, are defined as: "…genetic resources, organisms or parts thereof, populations, or any other biotic component of ecosystems with actual or potential use or value for humanity." (UNCBD 2000). In this paper, the use of scientific terms broadly follows the CBD definitions unless otherwise indicated; yet, for ease of reference, the term "biodiversity" encompasses biological resources, ecosystems and habitats.

In economic terms, biodiversity can be metaphorically viewed as "Earth's infrastructure"; therefore, broad policy guidance can be designed in a similar fashion as for man-made infrastructure in public economics. This entails mapping the different economic characteristics that define private and public goods and services against recognized biodiversity products and services[3] (Heal 2000, OECD 2003).

What is being lost?

As implicit in the breadth of its definition, measuring biodiversity is complex and there is a lack of widely accepted and adequate biodiversity indicators. This knowledge gap generates a wide range of estimates of what and how much is being lost. The available

[1] Dan Biller is Lead Economist in the World Bank's East Asia and the Pacific Region, Sustainable Development Department. The findings, interpretations, and conclusions expressed in this paper do not necessarily reflect the views of the Executive Directors of The World Bank and the governments they represent. The World Bank does not guarantee the accuracy of the data included in this work. Comments and research assistance provided by Julien Labonne are gratefully acknowledged. None of those cited bear any responsibility for the contents of this document, which is entirely the responsibility of its author. Correspondence can be addressed to dbiller@worldbank.org.

[2] 190 countries are parties to the CBD, making it one of the most subscribed conventions in the world.

[3] A private good or service is both rival in consumption, that is one person's consumption depletes the good's availability to others, and excludable, that is it is feasible to exclude people (e.g. by charging a price) from consuming the good. A club good or service is excludable but non rival, and an open access good or service is rival but non-excludable. A public good or service is neither rival nor excludable.

proxy indicators seem to indicate that the extinction of species is increasing and the rate of extinction is between 100 and 10,000 times more than their would-be natural rate (IUCN website). Natural habitats are also severely degraded: Between 1980 and 2000, about 25% of the mangrove area worldwide was lost (FAO, 2003); 20% of the world coral reefs have been destroyed, 24% are under imminent risk of collapse and 26% are under a longer term threat of collapse (Wilkinson 2004); the worldwide loss of tropical rainforest, home to biodiversity of large significance, caused by human intervention is around 15 million hectares per year, and if recent rates of tropical forest loss continue for the next 25 years, it is estimated that the number of species in forests would be reduced by 4 to 8 percent (Waller-Hunter and Biller 2001). Several fisheries are under severe threat of collapse due to over fishing and environmental degradation, and threats related to climate change and invasive species (mostly introduced by humans) significantly compound the odds against biodiversity. Only a few ecosystems around the world have not suffered from human intervention, but the full consequences of this intervention are minimally understood. Overall, it appears that biodiversity is already under severe distress or may be in the foreseeable future.

Whether in a developed or developing country, societies rely directly or indirectly on biodiversity, but its value is predominantly implicit rather than explicit. The absence of an economic, or rather, an easily monetized value combined with absent or poorly defined, enforced and traded property rights provide the conditions for over exploitation and unregulated use. In addition, increasing development pressures have led to the problem exemplified above of an unprecedented rate of biodiversity loss directly or indirectly caused by humans. Many of the biodiversity rich areas are located in economically poor countries. Since biodiversity has strong public good characteristics, is difficult to measure and value, and defies simple description, quantification, and monitoring, its conservation and sustainable use are often disregarded when conflicting priorities in the selection of development paths are being faced. Alternatively, it is difficult to conceive a world without biodiversity that can sustain human life.

Why place economic values on biodiversity?

Placing a value on any public good or service is complex. This complexity is expanded for biodiversity due to the difficulties in measuring it and its components. For example, does diversity per se have value or would one focus on the individual components of biodiversity?[4]

This lack of clarity, among other factors, may suggest that biodiversity conservation policies are of low priority simply because biodiversity defies easy description and quantification. The absence of quantification and the difficulty in monitoring and evaluating biodiversity policies thus provide justification to regard the loss of biodiversity as a necessary outcome of development, creating an extra requirement to

[4] For a theoretical analysis of diversity, see Weitzman (1992). OECD (2002) also provides a discussion of less theoretical focus.

substantiate designing and implementing policies that address biodiversity conservation or sustainable use.

Similar to other goods and services that face market failures[5] especially those related to environmental externalities[6], placing economic values on biodiversity is nonetheless important since it (OECD 2001, Nunes et. al. 2003):

a. Supports cost benefit analysis (CBA) of investment projects and policies, which properly incorporates environmental costs and benefits, and this is essential to enable policy makers to choose the investment or policy option that maximizes total net benefits to society.
b. Assists on environmental accounting at the national level (green national accounts), local level (community green accounts) and firm level (environmental reporting), which adjusts the gross domestic product (GDP) and other standard ways of measuring final outputs to take into account any depreciation in the environmental base of the economy and hence improve planning.
c. Enables proper valuation of the benefits [costs] provided by biodiversity and other environmental public goods [bads] in the absence of markets, which is useful in the design of policy instrument to address market failures and essential in order to level the playing field between conservation and economic development.
d. Facilitates Natural Resource Damage Assessment (NRDA) where relevant due to laws resulting in compensation payments for natural resource damage from man-made accidents such as pollution spills, among others.

How to place economic values on biodiversity?

The value of biodiversity is measured through the concept of Total Economic Value (TEV), which is the sum of its use and non-use values. Use values encompass the value of direct use (extractive – e.g. timber and non extractive – e.g. bird watching); the value of indirect use (e.g. environmental services such as flood protection), and the option value of personally enjoying direct and / or indirect use in the future. Non-use values encompass the notions of altruism, bequest and existence; that is, others including future generations enjoying biodiversity and the fact that the existence of biodiversity has a value even when people don't derive or intend to derive direct or indirect uses of it (e.g. knowing that the Siberian Tiger roams the wild while realizing that one will never see one or use Siberian Tiger products). Since estimating the world's biodiversity TEV is

[5] Failure of market forces to allocate the socially optimal level of biodiversity conservation or sustainable use. The four main sources of market failures are: (1) public good / public bad, (2) externality, (3) imperfect information, and (4) monopoly. (OECD 2003)

[6] Externalities can be defined as costs or benefits that result from an activity, but accrue to other than those undertaking the activity in the first place without any mechanism to impute these costs or benefits to the original causers. (OECD 2003)

very difficult, uncertain, and controversial[7], research usually focuses on estimating the benefits of conserving or using biodiversity in a sustainable way in a particular ecosystem or through specific species. In addition, a large share of biodiversity's TEV comes from non-use values. These can be global in nature and are closely linked to biodiversity's public good attributes, making the valuation exercise especially challenging. On the other hand, since the costs of biodiversity conservation and sustainable use of its components are primarily locally borne, cost estimations have been largely absent from the literature.

While the term biodiversity is broad encompassing, as indicated in OECD (2001 and 2002), finding out the precise object to be valued is a key challenge in valuation exercises in general and when specifically valuing biodiversity or a part of it. As discussed, there is a clear distinction between biological resources and biological diversity, but many valuation studies do not make this distinction. They tend to value biological resources rather than biological diversity, which could lead to suboptimal programs to support biodiversity. Projects targeting single species, such as the spotted owl or the tiger, may in biological diversity terms be sub optimal, if these species have a close genetic relative that is not endangered. Moreover, to be relevant for policy making economic valuation of biodiversity should measure marginal or discrete local changes in the availability of biodiversity. For example, land use changes, increased tourism, and increased pollution affect the future flow of services from an ecosystem. It is important to value the impact on this flow when deciding whether to engage in a specific development policy or not.

Examples of economic valuation of biodiversity and its components

Regardless of the shortcomings described above, there is a vast literature on the economic valuation of some benefits linked to biodiversity. Table 1 provides some valuation examples divided in major clusters that capture most valuation studies. On the use value side, they include the benefits of conservation and sustainable use and the costs of degrading biodiversity (forgone benefits of conservation – another way of calculating the benefits of conservation). On the non-use value side, examples of valuing the existence of species are provided. The methods and units used[8], especially for use values, greatly vary. For non-use values of single and multiple species, the stated preference approach is commonly used and values are expressed in monetary currency / per household / year or

[7] Costanza et al. (1997) estimate the minimum biosphere's economic value to be US$ 33 trillion per year compared to the total GDP worldwide at the same time of US$ 18 trillion per year. The study was criticized on various grounds but mostly for using marginal values to estimate the value of the Earth's total stock of biological resources.

[8] Economic valuation methods of environmental issues can be generally divided in Cost / Benefit approach, revealed preference approach and stated preference approach. Detail analysis of each approach is beyond the scope of this paper, but there are several papers and handbooks that address this (see OECD 2006 and Alberini and Kahn 2006 for the most recent).

per person / year[9]. As it is apparent from the list and references, only a few studies provide cost figures and hence the opportunity for calculating B / C ratios.

Table 1: Examples of Economic Valuation of Biodiversity

Area Studied and Source	Benefits included	Cost included	Estimates	Timeframe discount rate
Protected Areas in Madagascar Carret and Loyer (2003)	Biodiversity, tourism, water supply	Management, Opportunity	B= US$88.3/ha C= US$72.6/ha	15 years 10%
Portland Blight Protected Area in Jamaica Cesar (2000)	Fisheries, forestry, tourism, carbon fixation, coastal protection, biodiversity	Management (no opportunity cost)	C= US$19m B= US$41m or 53m depending on the tourism scenario	25 years 10%
Leuser National Park, Indonesia Beukering et al. (2003)	Water supply, fisheries, flood and drought prevention, agriculture, hydro-electricity, tourism, biodiversity, carbon sequestration, NTFP and timber	No cost included formerly but they compare the benefits for three scenarios: deforestation (D), conservation (C) and selective use (SU).	NPV(C)=US$9.5bn NPV(D)=US$7bn NPV(SU)=US$9.1bn	30 years 4%
Mangrove conservation, Thailand Sthirathai (1998)	Direct-use values by local communities and indirect use values for off-shore fisheries and coastline protection	Assess benefits from conversion to shrimp farming (i.e opportunity cost)	NPV(Conservation)>NPV(Conversion to shrimp farming)	20 years 6-10%
Coral reefs in Indonesia – the case of blast fishing Cesar (2000)	Tourism, coastal protection, net-benefit non destructive fishing	Net private benefits of blast fishing	Net Loss to society from blast-fishing= US$ 33.9m-306.8m per km2 of coral reef Economic loss to society=4*net private benefits to	20 years 10%

[9] See Pearce et. al. 2002 and Nunes et. al. 2003 for additional examples.

			blast fishers	
Coral Mining in Indonesia Cesar (2000)	Sales of lime, side-payments	Coastal erosion, increase wood prices, forgone tourism, net fishery loss	B= US$ 355,000 C= US$ 389,000-1.1m depending on the tourism scenario	30 years 9%
Giant Panda in China (Wolong Reserve) Kontoleon et al. (2002)	Potential for increase in eco-tourism by estimating the demand high-quality eco-tourism		B= US$ 145-210/ha per year. Lower bound estimate assumes only 30 tourists per day for 6 months/year	
Black Rhinoceros in Namibia. Swanson et al. (2002)	Non-use values of UK residents		WTP= 5 pounds per household per year.	
Gray Whale Loomis and Larson (1994)			WTP=US$16-18 per household per year	

Source: author

The Solution: A generalized guide for policies to curtail biodiversity loss

Biodiversity is under threat due to pressures caused outside the sphere of influence of biodiversity policies but often linked to human activity. These include: Destruction and degradation of natural habitat (through land use changes, urban expansion, deforestation, coastal zone use changes, over-use of marine and riverine ecosystems), the introduction of non-indigenous species, over-hunting and over-fishing, pollution (e.g. industrial, human and animal waste discharges) and climate change.

Figure 1 provides a schematic representation of different biodiversity goods and services according to their different economic attributes. This assists in building the different policy options to mitigate suboptimal biodiversity loss, starting with the option that has the largest net benefit. All options would benefit from the establishment of a core set of biodiversity indicators to facilitate monitoring and evaluation of biodiversity policies, and diminish uncertainty related to erroneous policies such as the case of most introductions of non-indigenous species, which could actually work if better information is available[10]. Yet, it should be noted that improving the scientific information set of the policy maker alone is not sufficient to mitigate biodiversity loss and hence is not discussed here as an option in itself.

[10] As mentioned in Hill and Greathead (2000), the introduction of non-indigenous species (known as classical biological control – CBC) to combat pests and weed is normally perceived by policy makers as a public good policy. Yet, given the substantial failure rate of CBCs, overall the intervention could be considered a failure. Nonetheless, 27 published ex-post analysis of CBCs yielded significant benefit – cost ratios (B / C ratios ranged from 1 to over 1000), some of which significantly higher than comparable programs and even public goods investment projects.

Option 1: Eliminate Perverse Incentives

Rationale: Perverse incentives are the source of many environmental problems. They encourage environmental damage and biodiversity loss but have little economic basis. They often take the form of different subsidies that encourage environmentally harmful activities, increasing public bads such as pollution (e.g. hydrocarbon based energy subsidies). Yet, they may also include direct payments from government budgets, tax exemptions or reductions, or the subsidized provision of private and public services (e.g. urban sprawl, road infrastructure). Regarding biodiversity, perverse incentives can be especially harmful by generating rents through the consumption of natural resource intensive goods or supporting detrimental activities in important biodiversity economic sectors. For example, direct subsidies to agriculture in OECD countries were estimated to be as much as US$ 361 billion in 1999, while government support for marine capture fisheries amounted to US$ 6.3 billion and for coal production it was US$ 6.2 billion. While some of these funds were used to reduce pressures on biodiversity and the environment, most contribute to further destroying the natural resource base, coastal zone degradation, and pollution generation. Some of this support is crucial to explain the collapse of different fisheries. Even climate change, which may have very detrimental impacts on biodiversity by severely altering ecosystems, is at least in part related to perverse incentives. Perverse incentives deplete scarce government budgets, can be regressive in income affecting the poor more than the rich, and discourage efficient markets by promoting rent seeking behavior[11] (OECD 2003).

Benefits: Major benefits include diminishing rent seeking behavior, decreasing incentives that generate public bads like pollution and biodiversity loss, increasing economic efficiency, among others.

Costs: The opportunity costs of negotiating outcomes such as potential temporary agreements towards sunset clauses related to the disappearance of the perverse incentives / subsidies.

Note: If perverse incentives are clearly identified, the net benefit of this option is likely to be very large as the impacts of their elimination will benefit several sectors of the economy. Freeing scarce public resources to be devoted for the provision of public goods is likely to improve the productivity of public spending. Yet, as government attempts indicate, powerful vested interests may be difficult to change.

Option 2: Privatize the biodiversity that is feasible and involve local communities

Rationale: Biodiversity as a whole is often treated as a public good when in fact there are benefits that can be privately captured and / or provided. When the different attributes of biodiversity are not recognized, there is scope for under provision and degradation.

[11] Rent-seeking behavior can be defined as "expenditure of resources to bring about an uncompensated transfer of goods or services from another person or persons to one's self as the result of a 'favorable' decision on some public policy." (OECD 2003)

Potential providers of ecosystem services have little incentive to provide them. Potential guardians of biological resources become poachers and destroyers of habitats. By taking advantage of the excludability of some biodiversity goods and services, clearly establishing enforceable property rights over them and allowing for trade, policy makers can potentially transform destroyers into conservationists.

Benefits: Major benefits include decreasing incentives that generate public bads like pollution and biodiversity loss, increasing economic efficiency, improving monitoring and enforcement by local communities, improving technical skills of individuals within communities, harnessing international and national private financing by facilitating sustainable use, among others.

Costs: Mainly those related to technical assistance and information provision to increase the likelihood that private biodiversity provision is sustainable.

Note: There are several examples in developing and developed countries with variable degree of success signaling high net benefit. These include private parks in South Africa, local communities in Africa facilitating viewing safaris and controlled trophy hunting, indigenous communities being paid for the provision of ecosystem services such as conservation of watersheds in Mexico. Once again, this option frees scarce public resources to be devoted for the provision of public goods.

Option 3: Bundle non excludable attributes of biodiversity with its private goods and club goods and design economic instruments that take advantage of markets to deliver these attributes

Rationale: In policies targeting man-made infrastructure, a common goal is to unbundled service provision. This promotes competition and may drive technological change. Yet, in the case of biodiversity, certain goods and services are not easily divisible from others, and carry significant public good attributes. Enjoying marketable services together with positive externalities or additional public good aspects may justify some kind of government support or regulation rather than a direct attempt to unbundled biodiversity goods and services (OECD 2003).

Benefits: Major benefits include securing the optimal provision of public goods related to biodiversity, while taking advantage of market forces. Depending on the chosen instrument, this may even generate public funds.

Costs: Depending on the instrument choice (e.g. subsidies), there is potential for rent seeking. Yet, this could be mitigated by sunset clauses, periodic revisions and provision of funds against the delivery of public goods measured by clearly defined indicators.

Note: There are a number of examples that have successfully used markets to enforce regulations (e.g. tradable fishing quotas, tradable hunting quotas, etc). Even public payments if well design can successfully diminish threats to biodiversity, while diminishing the potential for rent seeking.

Option 4: Ensure the provision of biodiversity related public goods

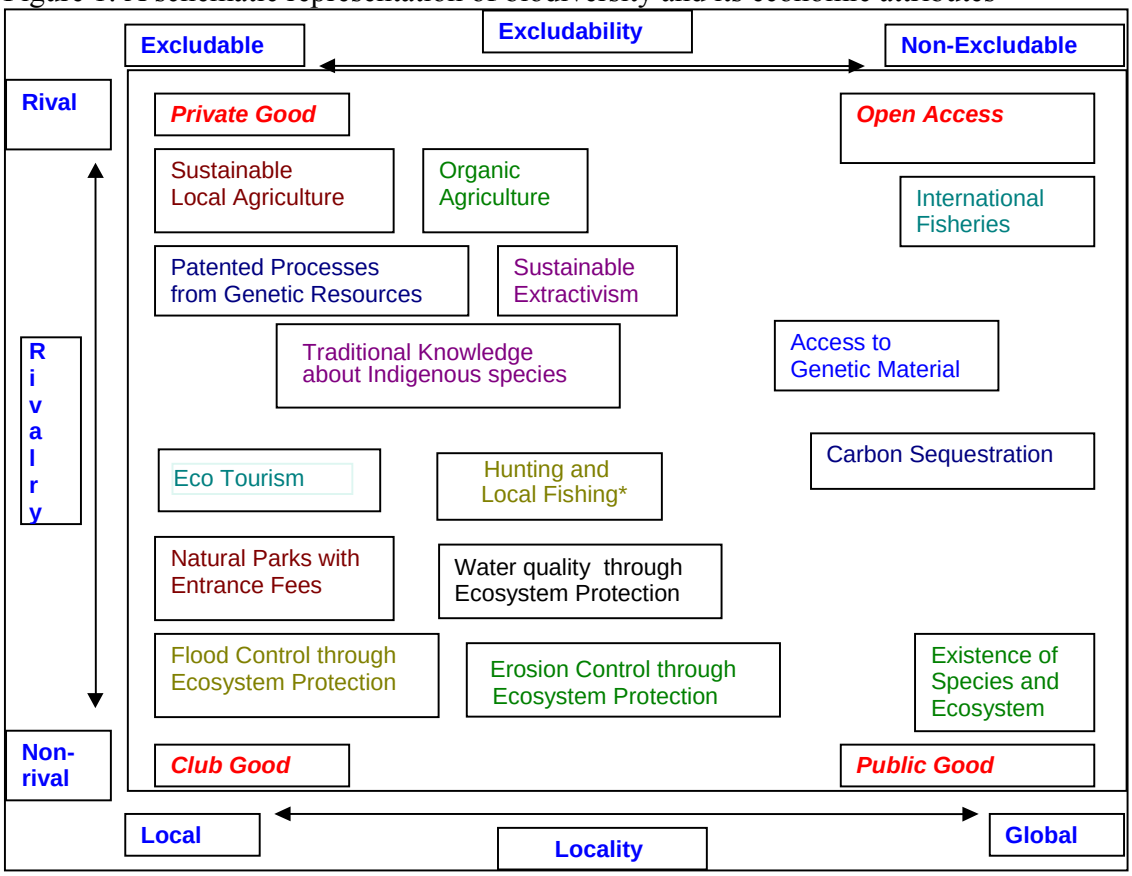
Rationale: As discussed above, the benefits of biodiversity conservation are still not well understood. This uncertainty is in part responsible for inaction – if one can't measure it properly, how can it be prioritized adequately? Yet, extinction is in principle irreversible, and policy makers may wish to secure a certain minimum level of biodiversity to avoid it. This suggests that a certain degree of precaution is advisable even if standard tools of economic analysis such as CBA may be biased against it.

Benefits: Major benefits include securing the minimum provision of public goods related to biodiversity. As information is attained, closer to optimal provision is possible.

Costs: Other policy interventions sacrificed.

Note: If the outcome is irreversible, it may be justifiable to apply the precautionary principle. This is particularly relevant when securing the existence of species and ecosystems, where non use values are likely to play a major role.

Figure 1: A schematic representation of biodiversity and its economic attributes



Source: OECD 2003

Conclusions and Caveats

Demonstrating the value of biodiversity is a fundamental step in its conservation and sustainable use, because it allows biodiversity to participate on the same basis with other competing calls on public funding. In addition, the threats to biodiversity are significant, and engaging in valuation of biodiversity increases the chances that policy makers will introduce incentives for conservation and sustainable use. In this sense, as illustrated by the valuation examples above, including the ones involving CBA, biodiversity conservation and / or sustainable use often comply with rigorous economic analysis.

Yet, attempting to base decisions that impact directly or indirectly biodiversity exclusively on valuation and specifically on CBA is at best dicey. As mentioned in OECD (2006):

> "The central problem is one of uncertainty – the basic fact is that we do not know what these losses are likely to be. Efforts at valuation are therefore important but are unlikely to inform us of the scale of 'tolerable' change. Moreover, if decisions are made and they turn out to be extremely costly, little can be done to reverse them. Finally, if ecologists are right and the systems have thresholds and other non-linearities, maybe the consequences of losing even modest ecosystem areas could be large. Ecosystem [biodiversity] loss thus combines several features:
>
> ● A potential large "scale" effect;
> ● Irreversibility;
> ● Uncertainty.
>
> Economists have long known that this combination dictates a "precautionary" approach (e.g. Dasgupta 1982). To these features we need to add another:
>
> ● Few ecosystems undisturbed by human activity exist.
>
> The relevance of this last point is that the world no longer has a 'reserve' of ecosystems [biodiversity] subject only to natural variation and to which it could turn for genetic and other information. In effect, the information stored over millions of years of evolution is at risk."

Nonetheless, OECD (2006) also explains how CBA could be made compatible with the precautionary principle in the context of decision making:

- It would operate within the constraints of strong sustainability[12].

[12] "Strong sustainability starts from the assertion that certain natural assets are so important or critical (for future, and perhaps current, generations) so as to warrant protection at current or above some other target level. If individual preferences cannot be counted on to fully reflect this importance, there is a paternal role for decision-makers in providing this protection" (OECD 2006).

- As a safe minimum standard; i.e. the B/C ratio for deciding on the loss of biodiversity is much greater than one.
- As an option value, i.e. the forgone costs of not waiting for additional information on the benefits of biodiversity conservation.

Since the importance of biodiversity is self-evident, it is also unclear why, when comparing with alternative policies in other areas, the "burden of proof" is often placed on biodiversity policies. Biodiversity conservation and sustainable use should neither be penalized due to the lack of information associated with it nor punished because it is a new concern among development issues. As discussed, policy makers should be cognizant that the potential for a large scale effect, the irreversibility and uncertainty related to biodiversity may require a precautionary approach rather than dismissal for absence of information or novelty.

Finally, it should be remembered that options that secure the greatest biodiversity gains are likely to coincide with those that also increase economic efficiency. The most important option, likely to generate the largest net benefit, doesn't exclusively targets biodiversity loss. Yet, by eliminating perverse incentives, policy makers have a unique opportunity to prevent biodiversity loss while improving economic gains. This is likely to do society a lot of good.

References

ALBERINI, A AND J. R. KAHN (2006), Handbook On Contingent Valuation, Edward Elgar Publishing.

CARRET, J.C AND D. LOYER (2003) "Comment financer durablement les aires protégées a Madagascar? Apport de l'analyse économique" Agence Française de Développement.

CESAR, H. (2000), Collected Essays on the Economics of Coral reefs,

COSTANZA, R., R. D'ARGE, R DE GROOT, S. FARBER, M. GRASSO, B. HANNON, K. LIMBURG, S. NAEEM, R. O'NEILL, J. PARUELO, R. RASKIN, P. SUTTON AND M VAN DEN BELT (1997). "The Value of the World's Ecosystem Services and Natural Capital", Nature, 387, May 15 1997, 253-260

DASGUPTA, P. (1982), The Control of Resources, Oxford, Blackwell.

PEARCE, D., PEARCE, C., PALMER, C. (2002) Valuing the Environment in Developing Countries: Case Studies. Edward Elgar Publishing.

HEAL, G. (2000). Nature and the Marketplace, First edition, Island Press, Washington D.C., USA.

HILL, G. AND GREATHEAD, D. (2000), "Economic Evaluation in Classical Biological Control", in Perrings, C., Williamson, M. and Dalmazzone, S. The Economics of Biological Invasions, Edward Elgar Publishing.

KONTOLEON, A. ET AL. (2002) "Optimal ecotourism: the economic value of the giant panda in China" in Pearce et al. "Valuing the environment in developing countries: case studies" Edward Elgar Publishing – Cheltenham, UK.

LOOMIS, J.B. and D.M. LARSON (1994). "Total economic value of increasing Gray Whale populations: results from a contingent valuation survey of visitors and households", Marine Resource Economics, 9, pp. 275-286.

NUNES, P., BERGH. J, AND NIJKAMP, P.(2003) The Ecological Economics of Biodiversity: Methods and Policy Applications, Edward Elgar Publishing.

OECD (2001), Valuation of Biodiversity Benefits: Selected Studies, OECD, Paris.

OECD (2002), Handbook of Biodiversity Valuation: A Guide for Policy Makers, Paris.

OECD (2003), Harnessing Markets for Biodiversity: Towards Conservation and Sustainable Use, Paris.

OECD (2006), Cost-Benefit Analysis and the Environment: Recent Developments, Paris.

SATHIRATHAI, S. (1998), Economic Valuation of Mangroves and the Roles of Local Communities in the Conservation of Natural Resources: Case Study of Surat Thani, South of Thailand, EEPSEA Research Report Series, Economy and Environment Program for Southeast Asia, Singapore.

SWANSON, T. ET AL. (2002) "Conflicts in conservation: the many values of the black rhinoceros" in Pearce et al. "Valuing the environment in developing countries: case studies" Edward Elgar Publishing – Cheltenham, UK.

UNCBD (2000). The Convention on Biological Diversity, Text and Annexes. Montreal, Quebec

VAN BEUKERING ET AL. (2003) "Economic Valuation of the Leuser National Park on Sumatra, Indonesia." Ecological Economics. 44: pp 43-62.

WRI, UNEP, UNDP and the World Bank (2000), World Resources 2000 - 2001 - People and Ecosystems: The Fraying Web of Life, Washington, DC.

WALLER-HUNTER, J. AND BILLER, D.(2001), "Valuing Ecosystems – A Key Prerequisite for the Sustainable Management of Natural Resources", Fifth International Conference on the Environmental Management of Enclosed Coastal Seas, EMECS Proceedings.

WEITZMAN, M. (1992). On diversity, Quarterly Journal of Economics, 57, 363-405.

WILKINSON, C. (2004), "Status of Coral Reefs of the World 2004", Global Coral Reef Monitoring Network.

WEBSITES

http://www.fao.org/
http://www.iucn.org/
http://www.worldbank.org/