The Costs and Benefits of Protecting Global Environmental Public Goods

2 Chapter

Raymond Clémençon

University of California, San Diego

This chapter analyses information on the possible costs and benefits of conserving global biological diversity and of mitigating climate change and provides ranges of such costs and benefit estimates. It considers two questions: To what extent is there a broadly shared understanding of costs and benefits? And to what extent is cost-benefit analysis a helpful tool in finding adequate policy responses to global environmental problems?

The chapter first considers modelling of costs and benefits of climate change and of policy measures to control the build-up of greenhouse gases in the atmosphere. It then examines the literature on values of biodiversity and of ecosystem services and on the cost of protecting global biodiversity. It concludes by discussing international efforts to allocate resources for addressing these problems and makes some suggestions on how to increase international funding for protecting global environmental public goods.

This review leads to a rather critical assessment of the value of cost-benefit analysis, particularly for assessing the costs to societies of greenhouse gas mitigation measures. Modelling results claiming high costs of implementing the Kyoto Protocol have often been used to politically frame the issue in a way that has helped special interests to oppose proposals for environmentally motivated energy policies. However modellers have to make far-reaching assumptions about a range of variables such as about the long-term impact of environmental and economic policies, about technological progress and about trends affecting the energy economy. As a result, wildly differing claims about the costs and benefits of environmental policy measures have been made by the political actors most vested in the debate and by economists sympathizing with one side or the other.

Cost-benefit studies have helped a great deal in finding specific cost-effective abatement strategies, but they are poor or misleading tools for assessing aggregate long-term costs and benefits to societies. Estimates of the annual costs of implementing greenhouse gas mitigation measures range from net benefits of 1% of a country's or the world's gross domestic product (GDP) to net losses of 2% of GDP. More recent studies tend to show lower costs or higher benefits than earlier studies. High-cost scenarios generally estimate only direct costs to the hardest hit economic sectors without taking into account transitional regulatory exemptions and governmental support measures, and without estimating public commons benefits. Low-cost studies, on the other hand, have been criticized as overly optimistic about energy conservation potentials, positive employment effects or the speed of renewable energy technology diffusion.

Economic studies attempting to measure the use and non-use value of biodiversity and natural ecosystems have provided more useful input into the political decision-making process than climate policy cost modelling. They work best when focusing on well defined local ecosystems, for which they can show the economic trade-off costs and benefits to local communities—for example, of clear-cutting a forest parcel or of sustainably managing it over decades. Most recent assessments are rather pessimistic about the so-called win-win opportunities—the real potential of protecting biodiversity while realizing economic development gains at the same time. This suggests that non-use values will often be protected only if a global interest in this exists, and if local stakeholders can be compensated for not using the resource.

Empirical findings point to great difficulties in assessing a global economic value of biodiversity based only on economic use values. Contingent valuation studies provide one instrument to estimate the willingness-to-pay of the public for the aesthetic or intrinsic non-use value of biodiversity and wilderness. They find that such a willingness to provide more funding for conservation seems to be considerable. However no systematic efforts have been undertaken by governments to capitalize on this willingness to contribute more towards global conservation goals.

Attempts to aggregate empirical findings on the non-use value of biodiversity and ecosystem services to a national or even global level are hampered by the limited data on biodiversity as well as by the very uneven distribution of biodiversity among countries. But while cost-benefit studies on biodiversity conservation are fraught with problems, they do indicate that a global network of protected areas in developing countries could be built and maintained at relatively low cost compared with what the world spends on other public policy objectives. Annual international investments of less than $10 billion would go very far towards permanently protecting most remaining critical biodiversity around the world. Although this is a very small nominal amount when compared with many other public policy expenditures, it is nevertheless more then 10 times what the international community currently spends on this objective, non-governmental organization (NGO) and philanthropic foundation giving included (Clémençon, this volume, Chapter 3).[1]

Cost-benefit analysis related to environmental public goods has been a growing business over the past decade, and valuable insights have been gained into how to assess economic impacts of large-scale changes to ecosystems and the ecosphere. But the experience also shows that modelling of future developments ultimately remains informed guesswork, no matter how sophisticated the models. The belief that cost-benefit analysis can provide answers for policy-makers may have postponed the introduction of sensible policy measures, which could have been justified with reference to a precautionary approach. Had such policy initiatives—particularly in the energy sector—been initiated more firmly a decade ago, by now this would have led to far different framework conditions for cost-effectively reducing carbon emissions and would have saved consumers hundreds of billions of dollars in energy costs in addition to producing significant health benefits from a reduction in air pollution. Cost-benefit analysis—willingly or not—has long served as the fig-leave for far-reaching policy failure in the energy sector.

International investments into both climate change and biodiversity conservation continue to fall painfully short at a time when progress on strengthening multilateral environmental agreements remains elusive. However, as the following detailed discussion will show, an exact price tag cannot be put on policies to "adequately" protect global environmental goods. More important than attempting to identify exact costs of future policy interventions is designing measures that will gradually but steadily move towards providing predictably increasing financial resources for programmes and projects in developing countries that benefit global environmental objectives. This would help sustain momentum for investing in research, development and marketing of renewable energy technologies and towards provision of incentives for energy conservation. It would help scale up efforts to protect and expand national nature conservation systems, improve park maintenance and allow implementing initiatives for broadly conserving biodiversity in economic productive zones.

A predictable increase in funding is extremely important because it provides the markets with signals that investment opportunities exist and will grow, and it maintains existing capacity on the individual and institutional levels and can build on it. Currently, however, funding specifically for global environmental protection is actually declining in real terms. This trend jeopardizes what has been accomplished so far, particularly in biodiversity conservation, where human resource and institutional capacity can evaporate quickly if financial resource flows cannot be sustained.

Two paths of action must be explored:

- Countries must increase budgetary resources for global environmental protection gradually but predictably over the coming decade.
- New ways of raising funds for global environmental protection efforts must be explored that are independent of national budgetary allocation processes. In the long term some form of global commons tax should be introduced on the international level. It could evolve from voluntary, government-backed fund-raising initiatives that are designed to tap into the public's willingness to pay for provision of global environmental public goods.

Climate change

A stable climate is a global public good. Rapid climate change stresses the ability of ecosystems and of societies to adapt, and there now is little doubt that global warming is taking place as a result of the increased concentration of greenhouse gases and that this increase is caused by human activities (IPCC 2001; Hansen 2004; Dowdeswell 2006; *Science* 2006). Providing for a stable climate implies addressing the anthropogenic factors that cause climate change, an objective that led to the negotiation of the Framework Convention on Climate Change (FCCC) in 1992. Parties to the FCCC agree to stabilize greenhouse gas concentrations in the atmosphere at a level that will "prevent dangerous anthropogenic interference with the climate system".

The only legally binding target for greenhouse gas reductions is contained in the Kyoto Protocol. It commits developed countries to reduce their overall emissions to at least 5% below 1990 levels from 2008 to 2012. The entry into force of the Kyoto Protocol in February

2005 opened the door for formal negotiations on a second commitment period beyond 2012. On 22 March 2005 European Union (EU) heads of state supported a goal of 15–30% cuts in greenhouse gases by developed countries by 2020. EU environment ministers earlier called for emission cuts of 60–80% by 2050 and stated that global temperature increases should be held to less than 2 degrees Celsius over pre-industrial levels (*Europa Newsletter* 2005). However these are not internationally accepted targets, and the United States—the largest emitter of greenhouse gases—is not a party to the Kyoto treaty.

Costs of climate change

Assessing the economic cost of climate change for society is almost impossible. It requires modelling different scenarios of energy economy pathways, emission trajectories and atmospheric concentrations and how they translate into changing global climate patterns. And it requires predicting how climate change might affect ecosystems and the economy. The Third Assessment Report of the Intergovernmental Panel on Climate Change (IPCC 2001) identifies a range of impacts—on agricultural productivity, precipitation patterns and water availability, frequency of extreme weather events such as floods and droughts, inundation of coastal zones and rapid changes to natural ecosystems.

Poor and low-lying developing countries will suffer the most direct consequences from changes in precipitation patterns, extreme weather events and rising sea levels. But in the longer term developed countries will be affected as well. Many recent national and regional assessments have attempted to estimate potential effects of climate change on national economies. Most refrain from estimating actual costs of the potential damage. They do, however, predict significant effects on agricultural productivity, in both developing and developed countries (EEA 2004a; EPA 2004). They also show that the costs of extreme weather events have increased measurably over the past decades, from an average of $5 billion to $11 billion a year in Europe. In 2004 the United States suffered one of the worst hurricane seasons since 1930, costing Florida $30 billion in insured and $20 billion in uninsured damage (*New York Times*, 28 September 2004). The 2005 hurricane season proved even more catastrophic. Hurricane Katrina, which hit New Orleans on 28 August, cost the lives of more than 1,300 people and economic damages estimated to far exceed $100 billion (NOAA/NCDC 2005).

In June 2004 India presented its first comprehensive national communication to the UNFCCC, discussing the country's overall vulnerabilities in great detail. Regional climate models project significant warming for India. The Indian summer monsoon rain is, however, not expected to be greatly affected by warming trends, nor are the simultaneous occurrences of floods in some areas and droughts in others. The Indian national report points to significant ranges in climate modelling results and does not contain any quantitative assessment of potential costs in monetary terms. The report does foresee adverse implications for the agricultural sector, which is seen as undergoing significant transformation over the coming decades due to changing demand and technologies.

Considerable effort is being devoted to developing economic scenarios for projecting emissions and warming trends. But what type of scenarios to use in the next IPCC assessment is a politically contentious issue. Countries disagree on underlying assumptions, such as the extent to which models should include scenarios "with measures" and with "additional measures" and how to deal with uncertainty and how to assign probabilities to "what-if" scenarios (IPCC 2005). Discussions reflect the difficulties in agreeing on how to forecast even just emissions trajectories, let alone environmental and socio-economic consequences. But the ability to model GHG emission trajectories with some degree of confidence is a necessary first step towards modelling costs and benefits of policy measures to reduce emissions.

Cost of abatement measures

Shifting to a less carbon-intensive future will require huge up-front capital investments in carbon-free or less carbon-intensive fuels and technology. Cost-benefit studies try to assess whether such investments are warranted. On the cost side, regulatory costs (such as pollution taxes and emission standards) and opportunity costs of using capital for mitigation measures rather than some other public or private good objective need to be considered. On the benefit side, one first needs to estimate the value of avoided environmental externalities. Such externalities include possible climate change, with all its consequences. Of more immediate concern are environmental and health costs from air pollution caused by burning fossil fuels. Air pollution remains a significant issue not just in developing countries, but also in the United States and Europe, causing 50,000 to 100,000 premature deaths a year in the United

States alone (Schaefer 2002; Pope and others 1995). An integrated approach to air pollution and climate change improves cost-effectiveness of policies that may not be considered cost-effective from a climate change or air pollution perspective alone (see EEA 2004b on this subject). A shift away from a fossil fuel economy to a less carbon-intensive energy economy is also expected to increase employment and reduce energy costs.

The big question is whether the benefits outweigh the costs. Economists come to very different conclusions. There are two basic approaches that modellers use to assess carbon reduction potential and costs: bottom-up and top-down.[2] Bottom-up models try to identify the energy saving or carbon reduction potential available to specific consumers, producers or sectors. Attaching costs to each option makes it possible to determine the least costly ways to reduce greenhouse gases. Top-down models are macroeconomic models of various types (general and partial equilibrium models) based largely on how such macroeconomic indicators as economic growth, energy economy and demographic trends affect each other. Top-down estimates are not concerned with exactly what a consumer or producer does when the price of energy changes, but with what the overall result is in terms of energy consumption.

Top-down cost estimates are typically higher than bottom-up estimates. One explanation is that top-down models are inherently pessimistic about behavioural changes, while bottom-up models are more optimistic about consumer responses to market incentives and government measures (Kolstad and Toman 2001). While bottom-up approaches tend to overestimate carbon abatement potential at the individual and firm levels, the extent to which this potential can be captured depends critically on the policy mix adopted in the model. Top-down assumptions may not sufficiently consider, for example, the effects of gradual policy changes and the advances in technology development they may trigger. Such assumptions tend to emphasize immediate costs to the economic sectors most affected, while assessing long-term benefits much more cautiously—if at all. Many experts argue that this leads to a systematic bias emphasizing short-term costs and neglecting long-term benefits (Repetto and Austin 1997; Krause, Baer, DeCanio and Hoerner 2001; Barker and Ekins 2004). One should add that top-down highly aggregated models also fail to consider the domestic and international distribution of winners and losers.

Newer integrated assessment models combine elements of top-down and bottom-up approaches but do not escape the inherent limitations posed by having to make far-reaching assumptions about key economic, demographic, environmental and social indicators.

The following section discusses a few widely quoted results from such modelling studies. The first costing studies related to climate change emerged in preparation for the Kyoto Protocol negotiations. One of the earliest economic assessment models—GREEN, for General Equilibrium Environmental model—was developed by the Organisation for Economic Co-operation and Development (OECD) Secretariat and has been used extensively for a wide variety of analyses (Cline 1992; OECD 1993, 1995).[3]

The IPCC's Third Assessment Report (2001) goes to great length to sort through the literature on cost estimates of implementing various greenhouse gas abatement scenarios. The IPCC concludes that the range of estimates from top-down models is large—from 0.5% to 2% of GDP—by projecting actual net benefits to overall economic costs (IPCC 2001, p. 503). Bottom-up models discussed by the IPCC showed that energy efficiency gains of 10–30% above baseline trends could be realized at negative to zero costs over the next two or three decades.

In July 1998 the Clinton administration published a study concluding that the costs to the United States of reaching the Kyoto targets would be modest (Council of Economic Advisers 1998). The estimate was that permit prices of $14 to $23 per ton of carbon would increase fuel oil prices by $0.05 to $0.08 per gallon above their projected prices in 2010. Several economists questioned this assessment and asserted that costs for the United States would be much higher (Nordhaus and Boyer 1999).[4] These higher estimates were widely publicized and became politically very influential. The *Wall Street Journal* in 2001 quoted an economist of the 2000–04 Bush administration, Richard Schmalensee, predicting that the United States would have to close all its coal-fired power plants by 2012 just to get halfway to Kyoto's targets. In the same article, Alan Manne, a Stanford University professor and renowned climate modeller, is quoted as saying that implementing Kyoto would amount to a $400 annual tax on every US citizen.

Other economists disagree with the assumptions underlying such estimates. Krause, Baer, DeCanio and Hoener (2001) altered five widely cited federal and university economic simulations so that the models incorporate the full range of approaches the IPCC recommended to soften the Kyoto Protocol's potential economic impact. They find that while such sectors as the coal industry would be seriously affected, the US economy would gain from ratifying the protocol. The five altered models show gains of 0.5–1.0% in GDP instead of drops of 2–4%. Many simulations rule out alternative market outcomes and possibilities for profitable energy efficiency improvements in industry (DeCanio 2003).

Others agree with the premise that modest carbon control can be achieved at marginal costs of less than $100 per ton of carbon—and in some cases considerably less than $100 per ton—if well designed policies are implemented gradually and purposefully (Toman 2003; Rivers and Jaccard 2005). A $100 per ton carbon tax translates to about $12 per barrel of crude oil, or $0.25 per gallon ($0.06 per litre) of gasoline. Implementation costs also strongly depend on assumptions about the extent of emission trading and the price of emission permits (McKibbin and Wilcoxen 1997).

Actual empirical evidence contradicts simulation results that show high costs of carbon mitigation. The recent experience of the Global Environment Facility (GEF) with greenhouse gas mitigation projects shows that few of its active projects in developing countries cost more than $10 per ton of carbon reduced—and many cost considerably less (Eberhard and Tokle 2004, p. 31). Long-term energy efficiency projects turn out to be the most cost-effective ones. Small investments in energy efficiency could produce huge economic savings in many countries (Froggatt and Canzi 2004). However, what is lacking is not only seed capital to develop these projects, but basic knowledge and individual and institutional capacity to identify low-cost or win-win investment opportunities necessary to break out of the traditional local energy economy.

A key methodological criticism of economic assessment models: few consider opportunities for market reforms, technology programme and tax shift reform, and the incremental shifts they can cause. In a comprehensive review of the literature on costs of the Kyoto Protocol, Barker and Ekins (2004) conclude that assumptions and methodologies in top-down models do not hold up well and that if policies "are expected, gradually introduced and well designed", net costs to the United States of mitigation are likely to be insignificant—that is, within a range of +/–1% of GDP. They intentionally leave out bottom-up models, which consistently arrive at more optimistic assessments of the potential of no-cost carbon abatement. Others criticize more fundamentally the dominance of quantitative cost-benefit analysis in the economic analysis of climate policy and the lack of approaches based on precaution and the possibility of extreme events and structural change (Van den Bergh 2004). The experience of European countries with environmental taxation for promoting energy conservation and renewable energy technologies furthermore provides strong evidence that such measures have resulted in environmental and economic benefits (EEA 2006).

One central assumption every model makes is the discount rate to use for assessing the worth of an investment today against its worth tomorrow. A discount rate of 7% means that $100 today is expected to be worth only $93 next year. A high discount rate applied to climate change suggests there is little need for immediate and costly measures; the assumption is that abatement measures will be cheaper in the future. Because of the high degree of uncertainty, many experts suggest discount rates for climate change should be close to zero.[5] Economic assessment models often use higher discount rates, which bias towards showing higher costs for policy measures.

Another assumption is the baseline that future economic costs of policy actions are measured against. Models generally depart from a status quo that locks in significant special interest privileges, such as subsidies and regulatory exemptions, which are not efficient. Negative changes in these sector entitlements then show up as economic costs on the aggregate level.

Another issue often neglected in integrated cost models is valuating non-use benefits of a healthy or stable environment. Direct costs to regulated entities can be assessed rather easily (such as how logging restrictions may affect jobs in a community, or how much it costs to install state-of-the-art air pollution abatement equipment). Direct and indirect benefits are much more difficult to assess because they are mostly non-monetary and their quantification poses significant methodological and ethical problems. What is a human life and good health worth, and is it worth the same in a poor and rich country or in the poor and rich part of town (Markandya 2001; Schaefer 2002)?

Recent energy price developments demonstrate how dependent models are on making the right assumptions about key indicators. Oil prices stood at over $60 a barrel in February 2006, far above what international experts estimated only two years before, when many economists saw prices decline again from the $35 a barrel they had reached after the Iraq war began (TFC Commodity Charts 2006). Oil producers also did misjudge pricing trends, and oil giant BP, for example, almost doubled its price estimates between May 2003 and August 2004 (Verleger 2004).

Most climate change economic assessment models use energy price scenarios much lower than current prices. The Energy Information Administration (EIA) worked with three scenarios. The reference scenario projects stable oil prices at about $20–25 a barrel, and the high price scenario reaches $30 by 2020. In 2003 uncertainties brought about by the Iraq war and strong oil demand increases led the EIA to revise price projections, with the reference scenario now using price estimates of $25–30 by 2020 and the high price scenario reaching $40 in 2020 (EIA 2004). Steep energy price increases in 2005 have created very different overall framework conditions for investments in energy-efficient and renewable energy technologies, with many energy analysts predicting oil prices to continue to raise over the coming years, due both to stagnant production and increasing demand from new economic powerhouses, China and India.

It is now evident that many investments into conservation or renewable energy technology considered too costly in the 1990s would have resulted in economic benefits even without considering environmental benefits. Significantly higher energy taxes in European countries have also contributed to very different trends in car fleet fuel efficiency and per capita CO_2 emissions in European countries compared with the United States (EEA 2006).

The social (and political) construction of costs and benefits. Cost-benefit modelling needs to be considered in a broader political context. It provokes one of the great holy wars in environmental politics between those who advocate more reliance on a precautionary approach and those primarily concerned with cost implications of regulatory intervention to key economic sectors. Since the early 1990s cost-benefit assessments have exerted a growing influence on the policy debate on climate change—for example, in connection with the early debate on joint implementation and emissions trading. Modelling results are often used to argue for or against certain types of policy interventions and—particularly in the United States—against policy intervention in energy markets.

Social scientists have long been interested in the processes that lead to societal recognition of social and environmental problems that are not easily observed and political response to them. They have stressed the role that different actors such as scientists, non-governmental social movement organizations, the business community and government agencies play in calling attention to environmental problems or in challenging claims that have been made by what sociologists call "issue entrepreneurs" (Schneider and Kitsuse 1984; Hannigan 1995; Mertig, Dunlap and Morrison 2002).

The question of how an issue can be successfully framed for political consumption has gained considerable attention in recent years. Some have made the point that the environmental movement has failed to capture the attention of the public despite deteriorating global environmental quality, while interests opposing environmental policies have used environmental-sounding slogans to push through policies that have weakened environmental laws and standards (Shellenberger and Nordhouse 2004; Lakoff 2004). The cost-benefit debate must therefore be understood as part of a political struggle over the distribution of costs and benefits from climate control measures among different segments of society related to the distribution of economic and political power.

Early cost-benefit analysis has focused almost exclusively on the implementation costs of policy measures to particular economic sectors. The cognitive "frame" that greenhouse gas control measures are costly to society at large has since become a dominant perception among the general public, particularly in the United States. Absolute cost figures have also become a staple for most news media hooked on catchy sound bites to drive home political arguments. The cost-benefit debate also reflects the emphases of different disciplines. While economists tend to explain individual behaviour as a rational utility function, psychologists and sociologists focus on cognitive factors and how learning, social change and cultural norms shape beliefs and policy preferences. Political scientists focus on how parliamentary systems, special interest group politics and institutional constraints affect policy decision-making (Almond and Powell 1978; Dunlap and Catton 1979; Schnaiberg and Gould 2000; Rosenbaum 2004). Cost-benefit assessments rarely take account of interdisciplinary insights.

While cost-effectiveness is an important element in building coalitions for change, the rent-seeking behaviour of vested interest groups has little to do with overall economic efficiency and social welfare considerations, but it is often framed as being in the economy's—and therefore the public's—best interest.

The history of the US Clean Air Act is a case in point. This piece of legislation has rightly been heralded as a pioneering piece of lawmaking among developed countries. But it was also critically watered down by politically well connected vested interests in the coal and car industries, and its full implementation has stalled for decades. The costs of abatement measures were systematically advertised as excessive in industry-sponsored studies, while medical studies on the human health impacts of air pollution were systematically being challenged as "junk science" (Dewey 2000; Davis 2002; Bradsher 2002; Barcott 2004; UCS 2004).

Despite progress on environmental issues, persistent policy failures have resulted in gross economic inefficiencies, amounting to hundreds of billions of dollars in direct and indirect subsidies for the coal industry over the past decades, at an arguably significant cost to society. They have prevented industrial countries from more effectively addressing energy conservation and renewable energy technology development, and they have increased dependency on foreign energy sources. They have contributed to a situation where more than 100 million Americans and equal numbers of Europeans live in urban areas that routinely violate minimum clean air standards (OECD 2001; American Lung Association 2004).

The cost-benefit debate has profoundly affected the discussion about what environmental policy instruments are acceptable, and in several countries it has encouraged opposition to environmentally motivated energy taxes. It is also important to note that cost-benefit analysis is generally more widely used in the United States than in European countries, which can be linked to philosophical differences. The United States bases environmental policy on the principle of risk management, building on scientific evidence and cost-effectiveness, while most European countries have adopted the precautionary principle as the basis for environmental legislation (Andrews 2000; Vogel 2001; Rosenbaum 2004).

The purpose of this discussion is not to question the value of cost-benefit assessments in general but to demonstrate that politics and personal preferences cannot be kept out of modelling. A sensible energy policy implemented throughout the 1990s could have encouraged broad-based energy conservation, renewable technology development and market penetration. This would not only have saved consumers hundreds of billions of dollars and helped reduce the growth of greenhouse gases, it would equally have contributed to a significant reduction of dependency on foreign oil of developed countries, an objective that has now moved to the top of the political agenda even of the Bush administration, which for years has only supported measures to increase energy supply.

In hindsight it is clear that most cost-benefit assessments got it seriously wrong but contributed to stalling the phase-in of decisive energy policy measures designed to address both air pollution and greenhouse gas emissions.

International investments in climate change abatement

How much would it cost the international community to adequately mitigate greenhouse gas emissions? This question can only be answered politically, taking into account a qualitative assessment of the severe risks involved in not controlling climate change and the potential benefits of decisive steps towards reducing greenhouse gas emissions. Such an assessment leads to the conclusion that the risk of not controlling emissions is significant and open-ended, while the costs are likely small and declining—or even negative to start with.

Governments around the world are already pouring billions of dollars into renewable energy and energy conservation measures—among them large greenhouse gas emitters such as India and China. But the same governments are investing many times more resources into building traditional coal and oil resources and nuclear power plants. Efforts have been made to accelerate the development of renewable energy markets, but international funding remains very small compared with both the needs and the opportunities. International financial support for developing countries from bilateral and multilateral sources (including the GEF and the Clean Development Mechanism) amounts to perhaps $1.5 billion, although financial resources for renewable energy sources amount to no more than 10% of that (Clémençon this volume, Chapter 3; Compare Clémençon, Chapter 3, Table 3.6, p. 91).[6]

The GEF is the largest grant-providing multilateral institution to support greenhouse gas abatement measures in developing and transition countries. Annual GEF commitments to the climate change focal area have averaged around $150 million annually over the last 8 years, however decreased to about $140 million in recent years. The GEF distributes its funds over four operational programmes, the largest two being the promotion of renewable energy and the removal of barriers to energy efficiency and conservation. The other two programmes target the reduction of the long-term costs of low greenhouse gas–emitting energy technologies and the promotion of environmentally sustainable transport. The GEF has also funded 269 enabling activities to facilitate implementation of effective climate change response measures and preparation of national communications. A new strategic focus is on cross-sectoral capacity building at the individual, institutional and systemic level.

Renewable energy as a target for international cooperation. The GEF is programming about $100 million a year for removal of market barriers to renewable energy technologies. Other multilateral donors have also increased their efforts in this regard. The European Bank for Reconstruction and Development has set up a fund worth €30 million, and the World Bank has pledged to target 20% annual growth of its lending portfolio for renewables and energy efficiency.

But such initiatives have been late in coming and are small compared with needs and opportunities. Many countries have adopted tentative targets for generating 20% of their electricity with renewable technologies by 2020, but much more ambitious targets seem possible. In June 2004 the International Conference for Renewable Energies produced a useful compilation of country actions and commitments to promote renewable energy technology but no breakthrough for a coordinated international commitment (Renewables Conference 2004b).

The good news is that renewable energy has experienced surprisingly strong growth and increased its significance relative to conventional energy. The Renewables 2005 Status Report (2005, p. 4) finds that $30 billion was invested into renewable energy worldwide in 2004 (excluding large hydropower), a figure that compares to conventional power sector investments of $150 billion (also excluding large hydropower, which accounts for another $20–25 billion). While this is encouraging, the potential for a much faster shift towards renewable energy technologies exists, if emerging policy initiatives can be scaled up.

One study puts the gross investment cost for getting the European Union to produce 12% of its electricity with renewable technologies by 2010 at €10–15 billion a year (Zervos 2003). Increasing China's share of renewable energy from 5% to 17% by 2020 is estimated to cost about €49 billion (Renewables Conference 2004a). These estimates reflect pure investment costs and do not consider any cost-benefit assessment of reduced human health and environmental costs or economic returns on the investment from reduced fuel costs.

In 2001 the US EIA conducted a study to assess the costs to American consumers of a national renewable energy standard that would increase renewable energy resources from 2% to 20% by 2020. It concluded that such a standard would generate a range of environmental benefits while costing consumers almost nothing (the increase in electricity prices in 2020 was estimated at 4.3%). The general problem with such modelling has been discussed before. Even before oil prices rose to more than $60 a barrel at the end of 2005, many experts considered the EIA study as much too conservative, arguing that more realistic assumptions about the price of developing renewable technology would result in projected savings to consumers of up to $65 billion a year by 2020 (Clemmer, Nogee and Brower 1999). At least one recent study also suggests that economies of scale could bring down prices for wind technology much faster than anticipated (Junginger, Faaij and Turkenburg 2005).

Policy recommendations relating to covering the costs of global greenhouse gas abatement should focus on massively scaling up activities spearheaded by the GEF and its implementing agencies, as well as bilateral activities, such as the European Union's renewables and conservation programmes. Targets should be set in terms of annual percentage increases in international funding over certain periods. The GEF and other funding sources still do not have the critical mass to tip the scale towards making many renewable energy technologies commercially attractive without subsidies. A concerted effort to provide more financing could create economies of scale and lower prices relatively quickly, particularly for solar photovoltaic sources. To create such markets it makes sense to focus on the highest future greenhouse gas emitters. The GEF is doing this implicitly but could do so more systematically, if allowed. But increasingly such projects should be funded through concessional loans and not through GEF grant money. The GEF for some time to come will have an important role to play to leverage commercial financing for renewable energy technology development. The debate on a GEF resource allocation framework based on global benefits and performance capability may lead the GEF to adopt a more targeted approach. Any scale-up of resource flows needs to address this issue as well.

Biodiversity

Assessing the global value of biodiversity

On 17 November 2004 the Third World Conservation Congress opened amid what the official press release called "an escalating global species extinction crisis" (IUCN 2004). More than a decade after the negotiation of the Convention on Biological Diversity, loss of biodiversity continues unabated (Gibbs 2001; UNEP 2002; Millennium Ecosystem Assessment 2005). Anecdotal evidence of the impoverishment of the world's biodiversity abounds. The decline in amphibians, first reported more than a decade ago, continues and has reached critical levels, with a number of species believed to have become extinct over the past two decades (Mattoon 2001; Amphibiaweb 2006). The habitat of great apes in Africa—chimps, gorillas and bonobos—continues to shrink, with only a small percentage of the original habitat left (*Afrol News* 2004). The Great Apes Survival Project (GRASP), under the auspices of the United Nations Environment Programme (UNEP) and United Nations Educational, Scientific and Cultural Organisation (UNESCO), has been working on a survival plan, but progress is slow and money scarce. GRASP recently received $25 million in support of urgent measures.

This case exemplifies the issues at stake. In the grand scheme of things, the money allocated for GRASP is very little and hardly commensurate with the expressed desire to protect apes in the wild. However, the value—ethical and economic—of keeping apes in their habitat is difficult to estimate, particularly if eco-tourism is better served by concentrating them in a few small wildlife parks.

The case for large expenditures for biodiversity conservation is even more difficult to make if it does not directly involve charismatic poster species. However environmental economists have greatly improved their understanding of the economic non-use value of natural systems, providing critical support for political measures to encourage investments in conservation.

Empirical research also demonstrates that in many specific cases the direct economic benefits of conservation to local communities may not be significant. The degree to which biodiversity should be conserved is therefore ultimately an ethical and philosophical question that cannot be answered based solely on an assessment of its economic usefulness. Conservation in many cases may be justified only if it is considered a global public good. But finding the rationale for considering some rare plant species in a remote area of tropical forest or an indigenous pupfish in a desert salt lake to be of global importance is difficult to make case by case. As a result, decisions on how much financial resources should be allocated for conserving global biodiversity are intrinsically political.

Economic valuation of biodiversity. Natural resource economists have tried to quantify the benefits from protecting wilderness areas and species diversity. In the wake of the Rio Conference the idea was that environmental economics could prove the economic value of sustainably managing biodiversity resources, thereby increasing political support for conservation. This idea created considerable optimism in conservation circles. Bioprospecting, eco-tourism and sustainable use of forest products were seen as potentially significant sources of revenue that could provide incentives for conservation. However the economic benefit argument seems in many instances to be more difficult to make than anticipated. There has not been a bonanza in bioprospecting, and the potential of eco-tourism as a significant source of revenue for local communities appears to be limited to accessible areas with high density of visible wildlife. Sustainable management of forest resources depends on long-term planning and careful project design—only an exception, not a rule. Still the literature on the cost-benefit ratio of conserving rather than using natural resources has advanced impressively, greatly improving our understanding of what is at stake. It also highlights the limits of this analytical tool for making decisions.

Economic valuation distinguishes between use and non-use value of natural resources (see Brown 1994; Bateman and others 2002). The use value results from measuring the economic return from extractive activities such as mining and logging, or converting open space into shopping malls, highways and residential homes. The non-use value is the value of services that the converted ecosystem could have provided long into the future had it been left intact.

Measuring and comparing use and non-use values is very tricky, reminiscent of the methodological and theoretical problems underlying cost assessment of climate change. Measuring use values from timbering and mining is relatively straightforward, essentially a function of production costs and market prices. Assessing environmental externalities and trade-off costs related to foregone non-use opportunities is a different story. It requires modelling future developments, setting a discount rate and making a judgement about the value—economic and intrinsic—of some obscure plant or animal species.

Contingent valuation tries to assess such societal values of non-use of the environment indirectly by measuring individuals' willingness to pay for having a public good provided. If the rationale for biodiversity relied solely on the economic benefits generated for humans, the case for conservation would in many cases be difficult to make. What is interesting and encouraging is that contingent valuation studies show that people are willing to pay for environmental services from which they never expect to directly benefit. A recent contingent valuation study for Brazil showed that households' willingness to pay exceeded resources spent on conserving three endangered species (Mendonça, Sachsida and Loureiro 2003). Studies for developed countries show a similar uncaptured willingness to pay for species protection. However the political and institutional obstacles for actually capturing this willingness tend to be large (Clémençon 2000).

Other indirect valuation methods use proxy values to determine an economic value—for example, of wildlife and nature preserves. Revenues from eco-tourism can be used to assess the value that people assign to particular geographic locations, such as national parks.

Aggregated estimates. One of the first attempts—famous and contested—to aggregate the direct economic value of nature's free services to the world economy put the value at about $38 trillion, compared with the world's GDP of $18 trillion (Costanza and others 1997). Other studies focus more narrowly on the economic value of biogenetic resources for agricultural productivity and pharmaceutical products (Ten Kate and Laird 2000). Despite all the progress in biotechnology, wild relatives of commercial crops remain an invaluable resource for keeping a step ahead of crop diseases that can cost billions of dollars in damage. In 1997 42% of the world's top selling drugs were derived from natural sources, and more than 25% of Western prescriptions contained active ingredients from wild plants (Ten Kate and Laird 2000). The combined value for the agro- and pharmaceutical industries has been estimated at $500–800 billion annually.

One big issue there is little agreement on is the extent to which modern technology will be able to replace such natural components. One argument for bioprospecting is that the complexity of natural components cannot be designed in the laboratory. Others maintain that it is just a question of time until progress in combinatorial chemistry catches up (Macilwain 1998). What is clear is that the big gold rush for bioprospecting and a related increase in financial resource flows to developing countries never materialized after the signing of the Convention on Biological Diversity in 1992.

Recent international efforts have focused on understanding the role that ecosystem services play in national economies beyond direct economic use benefits (WRI 2000; UNEP 2002; Millennium Ecosystem Assessment 2005). Ecosystem services include water filtration and purification, soil regeneration, natural pollution abatement, climate regulation and absorption of greenhouse gases, in addition to supplying a wide range of resources for industrial production, construction and human consumption. In a recent review of the literature on environmental valuation of ecosystem services, Turner and others (2003) show that estimates of ecosystem value are incomplete because most studies focus on single-use, marginal values using economic cost-benefit analysis to support conventional decision-making. Multiple, interdependent ecosystem services are rarely valued.

One exception is a recent valuation study that used multiple criteria analysis and a panel of experts to assign weights to various factors. It illustrates the complexity of the methodological problems associated with such estimates. Ecosystem goods and services were estimated for the 9,000–square kilometre Wet Tropics World Heritage Area in Australia (Curtis 2004). The total value was $145–163 million a year, or $16,000–18,000 per square kilometre.

Although the non-use value of ecosystems may be very large, immediate opportunity costs to local communities of not using natural resources can also be very large. Land conversion can bring significant immediate economic benefits to communities and whole countries. In the example above, the opportunity costs of not converting at least part of this protected area for some economic use may be significant. Huge incentives for present consumption exist in many instances where long-term protection would be in the broader public interest. The boom and bust cycle for Amazon logging operations can be as long as 15–20 years, well beyond the planning horizon of most political entities (Schneider and others 2002). The development of alternative use options is one way to try to address these opportunity costs in conservation projects (Pagiola and others 2002). However experience with integrated development and conservation projects is mixed at best (Robinson and Redford 2004; McShane and Wells 2004).

Several empirical studies have shown that conservation can be costly for local communities, depriving them of access to natural resources that have no value to them if not used for direct consumption. Conservation measures may also prevent locals from killing wildlife that damage crops (Muriithi and Kenyon 2002; Ferraro 2002). A study in rural China showed that local people's willingness to pay for restoring river ecosystem services fell far short of what restoration would cost (Zhongmin and others 2003). Such research shows that conservation and restoration efforts need to be considered in a national, if not global, context and may need to involve some form of compensation payment to local communities. In some instances such compensation could come from higher visitor entrance fees for protected areas. Entrance fees often represent less than 1% of total trip costs incurred by visitors (Gossling 1999). They generally do not reflect visitors' full willingness to pay, and they rarely cover the capital and operating costs of protected areas.

The value to local communities of conservation of protected areas has also been demonstrated in many instances, as for the Bwindi Impenetrable National Park in western Uganda (Makombo 2003). An evaluation of different use models for the Leuser Ecosystem in northern Sumatra over a 30-year period found the total economic value to be $7 billion under the deforestation scenario but $9.5 billion under the conservation scenario (Van Beukering and others 2003). In this case a 4% discount rate was applied. Proving the direct economic benefits of conservation activities may be the best argument for establishing and maintaining protected areas.

Other valuation studies look at the costs of destructive activities beyond protected areas, such as from using fire in the Amazon to clear forest and pasture for agricultural use (Mendonça and others 2004). From a private perspective, fire is a highly efficient way to clear brush and forest, but accidental fire results in significant costs. The Mendonça and others study attempts to quantify social costs associated with respiratory ailments provoked by smoke from fires and the release of carbon into the atmosphere. The damages were valued between $90 million and $5 billion, representing 0.2–9.0% of the region's GDP in 1998. The study points to the potentially large benefits of curbing fires used for clearing, as well as the equally large methodological complexities associated with attempts to measure non-use values or environmental externalities. A similar study for Indonesia finds that slash and burn in 1997–98 resulted in an estimated net loss of $20.1 billion (Varma 2003).

A better understanding of the non-use value of natural resources and environmental economics clearly helps build a case for greater political efforts for conservation and in some cases may provide critical support for political decisions favouring conservation. But valuation studies run into significant problems when analysts are forced to make far-reaching assumptions about the responses of complex ecosystems and the economic consequences of diminishing ecosystem services. The question of how much biodiversity should be preserved cannot be answered with cost-benefit assessments alone but remains fundamentally a political and ethical issue. In this respect the Millennium Ecosystem Assessment report concludes that "the total amount of biodiversity that would be conserved based strictly on utilitarian considerations is likely to be less than the amount present today" (2005, p. 6).

Costs of maintaining protected areas. Valuation studies indicate that conservation and sustainable management of natural resources can generate significant economic and social benefits, but that such benefits are often difficult to quantify and do not always directly benefit the communities adjacent to the areas in question. The other side of the cost-benefit equation relates to the costs of maintaining protected areas and of adequately preserving biodiversity outside such protected areas, in productive zones.

Protected areas are the cornerstones of conservation, and several studies have attempted to broadly estimate the costs of maintaining a worldwide system of protected areas. Despite significant methodological flaws and differences, they all indicate that the costs of conserving a significant proportion of global biodiversity would be relatively small.

James, Green and Paine (1999) conclude that adequately maintaining protected areas would cost \$2.3 billion a year more than is currently spent. This averages \$277 per square kilometre in developing countries and \$1,090 in developed countries. It contrasts with only about \$93 per square kilometre spent in tropical countries when the study was done. The same survey stipulates that buying land to place 10% of the area of each region in strictly protected reserves would require approximately \$164 billion, which translates into annual outlays of approximately \$10.9 billion and annual management costs of another \$3.3 billion. The authors suggest that purchasing and managing a broadly representative system of nature reserves covering nearly 15% of global land area would cost roughly \$16.6 billion a year on top of the \$6 billion governments were estimated to be spending in the late 1990s. A later study (Balmford and others 2002) estimates resource needs for an idealized global system of protected areas at \$45 billion a year. The same study compares this figure with the total economic ecosystem services of this land area, which the authors estimate at between \$4.4 and \$5.3 trillion.

The methodological challenges related to coming up with such figures are huge, and the most that should be taken from such estimates is a sense of the order of magnitude of the costs involved to secure some reasonable degree of global biodiversity conservation. One conclusion to be drawn from such an aggregation is that the cost of conserving global biodiversity is very likely modest compared to what the world invests in other public policy expenditures. But this and other estimates also show that the costs are far above what national governments and the international community are currently covering. A best estimate is that in the years 2000 and 2001 on average between \$350 and \$450 million in bilateral and multilateral official development assistance and \$300 to \$500 million from non-governmental and grant-making foundations went towards all biodiversity conservation projects in developing countries (Clémençon, this volume, Chapter 3). The problems with estimating these numbers are many and include double counting of resources by NGOs and grant-making foundations and generous labelling of official development assistance financing as "biodiversity relevant".[7]

Many conservationists, resigned to dealing with scarce funding, advocate a narrowly targeted approach to conserving the most critical biodiversity, rather than pursuing an ideal system. Central to this approach is the identification of biodiversity "hot spots" (Myers and others 2000; Sanderson 2002). Myers and others believe that safeguarding the hot spots—and thus a large proportion of all species at risk—could be accomplished for an average of $20 million per hot spot a year over the next five years. Given that they identified 25 such hot spots, this would amount to $500 million annually, only a tenth of the resource needs cited earlier for conserving an ideal protected area system. Some believe that a focus on hot spots may be particularly effective, because more than a billion people live in these 25 biodiversity hot spots, and in 16 of them population growth is higher than the world average (Jenkins, Scherr and Inbar 2004).

The hot spot approach raises many questions about how to decide what is worth protecting and what is not. Some approaches adopted by large conservation organizations in developed countries that involve large land purchases for conservation have come under criticism (Chapin 2004). The ecosystem approach, largely advocated by the international community, is a much more comprehensive approach that includes biodiversity outside protected areas.

Biodiversity conservation beyond protected areas. Maintaining an adequate system of protected areas around the world (perhaps 15% of land mass) can be only a first step towards sustainable management of biodiversity resources. Recently the international community has stepped up efforts to conserve biodiversity in productive economic zones. Assessing the costs of this effort is tricky. One study estimates that a truly global conservation plan that includes productive landscapes such as agricultural production zones would cost $300 billion a year (James, Gaston and Balmford 1999). This cost needs to be compared with the tens of trillions of dollars that ecosystem services are worth to the world economy. Again, such estimates must be treated with great caution.

After the Rio Conference and the signing of the Convention on Biological Diversity in 1992, there was great hope that productive landscapes would offer significant opportunities for conservation that produces economic benefits. Recent assessments have come to more sober conclusions. Experience over the past decade suggests that win-win opportunities in integrated conservation and development projects are few and difficult to realize (Dublin, Volonte and Brann 2004; Brown 2004).

The Convention on Biological Diversity

The Convention on Biological Diversity (CBD), signed in Rio de Janeiro in 1992, so far has not attempted to assess the specific resource needs related to implementing the convention and drawn up no priority list of sites where countries should spend scarce resources to maximize conservation of biodiversity. The CBD has a broad mandate related to three interlinked objectives: the conservation of biological diversity, the sustainable use of its components and the fair and equitable sharing of benefits arising from the use of genetic resources. In 2000 the convention adopted the Cartagena Protocol on Biosafety, which addresses the safe transfer, handling and use of living modified organisms that may have an adverse effect on biodiversity, with a specific focus on transboundary movements.

Over the past decade the convention has developed many guidelines and work programmes on all aspects of biodiversity conservation and use, but it has been very slow to develop specific targets and objectives that could serve as quantitative benchmarks for assessing resource needs. The international community has not ventured into the contentious issue of trying to put a price tag on what it might consider "adequate" protection of global biodiversity. Such an assessment would require a definition of "adequate", which would raise sovereignty concerns. Most countries have long opposed the idea that an international forum would determine which parts of a nations' territory should be protected. This may be part of the reason why no estimates for funding needs can be found in the national reports submitted to the convention by large megadiversity countries.[8]

In the hope of giving implementation new momentum, the fifth session of the parties to the convention in 2002 adopted a strategic plan to significantly reduce the current rate of biodiversity loss at the global, regional and national levels by 2010. The plan enumerated some general goals and initiated work on setting specified targets and timetables.

In response to outcomes of the 2002 World Summit on Sustainable Development in Johannesburg, the seventh session of the CBD in early 2004 adopted several new work programmes, among them one on protected areas. The subtargets include conserving at least 10% of each type of ecosystem, protecting areas particularly important for biodiversity, stabilizing populations of certain species now in decline and ensuring that no species of wild flora or fauna are endangered by international trade. Subtargets are to be set in the context of the convention's work programmes (UNEP/CBD/COP/7/21 PART2). The Eighth Conference of the Parties to the CBD in March 2006 in Curitiba, Brazil, did not break new ground or substantially add to these objectives. It was notable for a record participation of the private sector, reflecting the desire to integrate biodiversity concerns more systematically beyond protected areas (IISD 2006).

Estimating costs and benefits of biodiversity conservation is hampered by the fact that still little is known about the extent and relevance of biodiversity. The growing body of high-quality empirical research shines only an occasional spotlight on a small percentage of the world's species richness. Another recent effort of the convention therefore is the Global Taxonomy Initiative, intended to support national monitoring programmes and the development of indicators for assessing conservation efforts.

The GEF and biodiversity conservation. The GEF is the single largest multilateral funding mechanism for biodiversity conservation and the official financial mechanism for the CBD. Since its inception in 1991 the GEF has allocated $1,943 billion to biodiversity conservation, funding over 630 projects (GEF 2005b). The GEF's resource allocation for biodiversity conservation will average about $150 million a year for the period 2003 to 2006 (GEF3), about 5% less than for the previous four-year period (GEF2). As of this writing difficulties with replenishing the GEF at least at the level of GEF3 for a fourth funding period (2006–10) had not been resolved, with the possibility that existing GEF4 replenishment will come in significantly below the GEF3 resource level (Clémençon 2006).

The GEF has contributed substantially to supporting biodiversity conservation in areas of global significance—as the most recent biodiversity programme study points out—and support to protected areas has been central to GEF activities so far (Dublin, Volonte and Brann 2004). But the programme study also identifies several problems with the GEF's programmatic approach and long-term strategy. A key question is to what extent biodiversity projects can and should be expected to become financially sustainable after completion. Related to this issue are unrealistic time frames for project completion and overly ambitious project designs that result from a need to respond to guidance from both the GEF Council and the CBD.

Other problems are the transaction costs of bringing a GEF project to fruition, which involves years of institutional front-loading of technical and administrative resources and provides strong disincentives for project development. Increasing project development costs are the internal policies and procedures of the implementing agencies. These are all problems that need to be addressed in conjunction with the funding shortfall.

Megadiversity countries have become the centre of attention of conservationists and NGOs. Biodiversity is highly concentrated in just a few countries (Mittermeier, Gil and Mittermeier 1997). Just four countries—Brazil, the Democratic Republic of Congo, Indonesia and Madagascar—harbour two-thirds of all primate species and also have the highest level of endemism, with 100% of Madagascar's 55 kinds of lemurs being endemic. In 2002 megadiversity countries formed a group of like-minded countries to better coordinate their interests in international negotiations.[9]

While the GEF does not explicitly target megadiversity countries, these countries have received a large percentage of the GEF's resources for biodiversity conservation. However this translates to very small amounts of international funding even for countries with the highest biodiversity richness. Mexico has received the largest GEF grants for biodiversity ($7 million expressed as an annual average), followed by Brazil ($5.6 million), Indonesia ($4.4 million), China ($3.9 million), Peru ($3.3 million), Ecuador ($2.9 million), Colombia ($2.9 million) and the Philippines and India ($2.3 million). If co-financing is added, the figures look somewhat better. Mexico on average has received $13 million in additional resources per year in the form of co-financing supposedly leveraged by the GEF grant, Brazil ($8 million), Indonesia ($7 million) and China ($6 million). (All calculations here are based on data from UNEP-WCMC 2005 and from the GEF Project Status Report of June 2004, GEF 2004.) Co-financing data includes funding from national governments, bilateral donors, NGOs and occasionally the private sector. It is important to recognize that these amounts usually are also reported in financial reports of these donors, which leads to overcounting total resource flows for conservation if contributions as reported by different sources are simply added up (see also Clémençon this volume, Chapter 3).

Expressed in resource flows per square kilometre of protected area, Costa Rica receives the most GEF grant money, namely $300 a year per square kilometre of protected territory. It should be noted, however, that GEF funding does not go only to protected areas. Large countries receive much less funding: Brazil ($17), India ($16) and China ($7). Smaller countries, therefore, seem to have an advantage when it comes to accessing scarce international resources. The new and controversial resource allocation framework adopted by the GEF Council in September 2005 will likely improve access for large countries, while making it more difficult for small countries to get GEF funding.

James, Green and Paine (1999) have estimated that it would take about $277 per square kilometre on average to secure adequate protection of protected areas in developing countries. While such an estimate must be considered with great caution, it does suggest that GEF resources make for a very small percentage of what is considered necessary.

Conclusion on biodiversity

The CBD has embarked on a far-reaching and ambitious programme to improve information on biodiversity and to set targets and timetables for reaching clearly defined and measurable objectives in coming years. One of the challenges is to set priorities for allocating global funds that reflect the complex and highly uneven distribution of species and threats to species across ecosystems, both within and across countries. Attempts to prioritize come mainly from conservation organizations and recently the GEF, since the convention for political reasons has not been able to prioritize clearly among countries.

Quantitative targets for practically all the CBD's objectives are only now being developed. As a result no agreed official benchmarks are available for assessing resource needs in biodiversity. The Global Taxonomy Initiative has highlighted how little is known about the extent, distribution and value of biodiversity around the world, even in areas that appear fairly well researched. Clearer ideas are needed on how much biodiversity should be considered a global public good, how much of what is left should be supported with international financing and how much should be considered the responsibility of national governments. Such a consensus can only emerge as a result of broad-based discussions involving not just experts and politicians, but an educated public.

General conclusion on costing studies

How much will it cost to solve the most critical global environmental problems? What are the societal and economic costs of preventing a concentration of greenhouse gases that causes "dangerous interference with the climate system" and of conserving global biodiversity at an "adequate" level? Environmental economics has focused on finding quantitative answers to questions about the costs and benefits of environmental policies. This discussion has reviewed some of the literature on cost-benefit modelling and on economic valuation that may hold some answers to the initial question. The conclusion is that cost-benefit assessments are generally poor guides to policy-makers for setting policy targets related to global environmental goods or for deciding on funding needs to address global environmental problems. In fact studies that have attempted to aggregate cost-benefit modelling results to the national or global level to determine optimal and efficient policy intervention may do more harm than good.

Particularly with respect to the costs of controlling greenhouse gas emissions, models pretend to capture the true trade-off costs between action and inaction—even though huge uncertainties about complex future socio-economic developments and societal preferences demand highly subjective assumptions from researchers. Even the most sophisticated models have no scientifically reliable way of dealing with the possibility of non-linear, rapid developments. But by highlighting the short-term costs of the most far-reaching policy proposals on one hand and the uncertainty of long-term environmental and economic benefits on the other, most models are inherently biased towards business as usual. Particularly in the climate change area they have undermined political support for policy measures that could be implemented gradually and would lay the groundwork for stabilizing greenhouse gas emissions at little or no cost to national economies.

The ability to quantify costs and benefits of policy measures would—among other factors—also depend on the availability of clearly defined policy objectives relating to both climate change mitigation and biodiversity conservation. Such officially defined and agreed objectives, however, only exist in the form of tentative first steps. The Kyoto Protocol commits only one group of countries (developed) to a relative small 5% total percentage reduction in emissions by 2012 compared to the baseline of 1990, and talks about possible post-Kyoto commitments have barely begun. Some climate experts believe that an increase of the Earth's global average temperature by more than 2 degrees Celsius must be avoided, because this could be a threshold to major climatic disruptions. But this is not an official international consensus, and even if it were, determining what emission trajectories would be required to keep an increase of average global temperature under this threshold remains a highly complex challenge. The only thing clear is that the need to reduce greenhouse gas emissions is evident and that the potential for scaling up measures for doing so is huge.

The Convention of Biodiversity has only recently launched the type of comprehensive action programme that might eventually lead to a comprehensive understanding of the extent, distribution and value of global biodiversity. A set of quantitative conservation targets is being developed within the convention's many work programmes. Today protected areas cover a little more than 10% of the Earth's land mass. Many conservationists advocate increasing this coverage to 15% while focusing on biodiversity hot spots and megadiversity countries. In the end, though, all targets will ultimately have to be based on national priorities and societal preferences. Science can only provide guidance on the question of how much biodiversity should be protected. Costing studies, however, do suggest that managing protected areas and acquiring additional land to be put under protection would cost relatively little, if put in a larger context. An additional $5–10 billion a year for global biodiversity conservation would go very far towards meeting the objectives set out in the convention.

This chapter has discussed estimated costs of policy measures tied to providing global environmental goods. Although absolute cost frameworks can be suggested only with many caveats, there is wide agreement that countries have reasons to significantly scale up their responses to climate change and the loss of biodiversity. While national activities must provide the bulk of funding for such measures, resource availability from international sources is far from sufficient to compensate developing countries for measures they take that are largely in the global interest, an understanding codified in international environmental agreements. Defining the extent to which responding to climate change and the loss of biodiversity is a national or international responsibility is extremely difficult. Studies have shown that local communities living next to wilderness areas with high biodiversity often have nothing to gain from protecting them and use of such resources provides communities with short-term economic benefits. Equally, many countries have little to gain from being early adopters of low-carbon energy technologies unless they receive financial support. Negotiations within the FCCC and the CBD, however, are not likely to provide any answers to such intrinsically political questions as to who should pay how much for providing global environmental public goods.

Recommendations

Refocus the debate on resource flows. Governments and NGOs are predominantly concerned with how to use existing resources most effectively. No one argues that spending available resources as effectively as possible is not a critical concern. But it cannot be the only concern.

A focus on efficient resource use and allocation is understandable and results partly from pessimistic assumptions about the likelihood that governments will increase budgetary resources for global environmental issues. In this environment costing studies intend to inform policy-makers about where best to invest scarce public resources and how to prioritize among public policy objectives. But global environmental protection objectives are usually considered as part of the development cooperation agenda. As a result it is often suggested that there is a trade-off to be made between spending resources on climate change abatement and biodiversity conservation or spending resources on fighting AIDS, malnutrition and poverty, or simply on economic development.

Such a link, however, is at least conceptually tenuous if not wrong. Resources provided for global environmental protection should be compared to public resources that go into subsidizing economic sectors that exert most pressure on the global environment, or resources that are allocated to national security and defence objectives. Subsidies distort markets and are inefficient, particularly if they mask externalized environmental and social costs, and global environmental problems clearly have a potential of undermining national security. In the end all things are political, and entrenched economic interests tend to have a strong influence on national governments and the budgetary allocation process. However there is no compelling conceptual or theoretical reason to take existing funding levels for global environmental protection as a given.

How to institutionalize effective and predictable fund-raising for protecting global environmental goods has not been a priority issue in international forums since the Rio Conference in 1992. It is a discussion needed at both the international and national levels and one that should be related to the larger issue of global public goods and long-term international development and security objectives. Funding levels for the GEF were determined rather arbitrarily in the early 1990s, and they have in fact declined in real terms since; although the GEF and governments have used creative accounting to claim slightly increasing funding levels in nominal terms (Clémençon 2006). Approximate levels of national contributions were essentially locked in more than a decade ago and are today managed by mid-level civil servants with insufficient political influence or interest to press for a change in national contributions. This inertia is supported by a rigid burden-sharing formula that keeps the GEF's funding level at the mercy of the largest donor least willing to contribute.

Replenish the GEF. The basis for GEF replenishment negotiations needs to be reconsidered. The current burden-sharing arrangement has afforded the most recalcitrant country an effective veto power over the overall size of GEF funding. What this means is that the willingness of the United States to contribute to the GEF determines the contribution of donor countries, who would have contributed at a higher level if it were not for the low US contribution. Donor countries need to consider a majority-based burden-sharing arrangement that lessens the impact of the most reluctant donor on the overall funding level (Clémençon 2006).

Countries could also consider pledging their GEF contribution not as a fixed amount covering four years, but as annual instalments that grow yearly by a certain percentage, such as 10% or 20%. Periodic GEF conferences could discuss the adequacy of the resource flows and adjust not the nominal amounts, but the annual percentage increase. No doubt a new approach to replenishing the GEF would require the rethinking of basic policy principles by national treasuries and parliaments used to allocate fixed amounts for fixed time periods.

Reassessing the replenishment procedures alone will not be sufficient. Given a lack of political leadership, today any increase in resources for global environmental objectives would most likely have to come from budget lines within the development cooperation budget, from which in the case of most countries the GEF is funded. This would quickly limit the extent to which even the more generous donor countries could increase funding for global environmental protection. Countries need to re-examine what budget line the GEF should be funded from. Redirecting some subsidies that now go to the energy or agricultural sectors or linking funding for global environmental protection efforts to the national defence budget might be a better strategy to provide larger resource flows for global environmental objectives. Arguably it would also be a theoretically more compelling approach, although the institutional and political hurdles to implementing such a model are likely to be large, at least in the short term.

Explore new fund-raising mechanisms. There is a need to look at new models for raising funds for global public goods. The UN-type burden-sharing arrangements on which the GEF and other multilateral financing mechanisms are built will probably not provide adequate resources, even if revamped in some form along the lines suggested above. Separate fund-raising efforts outside traditional government channels should therefore be pursued along several avenues.

The more the world moves towards having to provide for global public goods, the greater the need for some form of international fund-raising mechanism that is independent of the vagaries of national budgetary allocation processes.

Global environmental problems would seem to lend themselves best to an argument that resources to fight them should be levied at the international level—for example, through an international tax. For moral and ethical reasons a strong argument can also be made that critical international relief efforts and some development cooperation initiatives for least developed countries should be funded through some type of international charge.

Proposals should be developed that depart from the assumption that the public's willingness to pay for global environmental goods is significantly greater than what governments currently allocate but that this willingness is not captured because of institutional barriers and political constraints. Average per capita contributions to the GEF amount to $0.60 a year for OECD countries, although there are differences from country to country. Polling data generally shows a higher willingness of the general public to pay for environmental protection than what governments allocate (Eurobarometer 2005; Guber 2003).

There are many obstacles to implementing innovative revenue-generating schemes, but political momentum towards considering international charges for funding specific global common objectives has accelerated. In May 2005 EU ministers—based on a French initiative—adopted a voluntary air travel tax to fund the European Union's pledge to more than double development aid to Africa in line with the Millennium Development Goals (BBC News 2005; EU Press Release 2005). A tax on aeroplane tickets is expected to become mandatory in Belgium, France and Germany in 2006, and other countries, including

Brazil and Chile, have expressed support for this innovative form of raising funds for development projects in the poorest developing countries (Der Spiegel 2006). It would be ethically questionable to request that funds raised in this manner for critical development objectives in the poorest countries should be partially diverted to global environmental protection activities. But the successful implementation of an international tax on air travel could help provide political momentum and institutional support to develop similar ideas benefiting global environmental public goods.

The willingness to pay for providing global public goods probably needs to be captured through first voluntary but preferably government-endorsed and government-supported schemes. Very small per capita contributions could raise significant amounts of money, and there are a number of interesting options besides a carbon tax (and the ominous Tolbin exchange rate tax idea) that should be explored systematically. What is important is that such schemes take into account both political acceptability and administrative ease. As elaborated elsewhere, a small surcharge on car registrations clearly earmarked for global environmental protection would be easy to administer and is likely to be politically less contentious than further increases in gasoline or energy taxes (Clémençon 2000).

Distribute existing funds. Also needed is a debate about the usefulness of linking fund-raising efforts for climate change and biodiversity. At a meeting in Geneva in December 1991, lacking a compelling distribution key, a group of government representatives concluded that available funds should be equally distributed among the two key GEF issue areas, climate change and biodiversity.[10] But various evaluation studies led to the conclusion that the GEF is much more likely to contribute critically to biodiversity protection than to climate change abatement, largely because it can bring more critical mass to this issue, while affecting markets and prices for renewable energy technologies is a tall order with such limited funds (see Clémençon 2006 for a more in-depth discussion of this argument). A short-term strategy should therefore be to focus GEF funds increasingly in the biodiversity area, while scaling back climate change activities to capacity-building and educational efforts. The increase in oil prices in 2004 and 2005 from $35 to more than $60 a barrel has created better market conditions for renewable energy technologies and energy conservation. Given a scarce resource environment, relative more attention needs to be paid to biodiversity conservation than climate change.

Transfer philanthropic wealth. Many conservationists hope for a great wave of philanthropic wealth transfer to conservation organizations in the form of inheritances. A systematic effort to solicit such endowments for something like a global biodiversity conservation trust fund has never been undertaken (except by individual NGOs). One could pursue various models for building a trust fund in parallel to increasing government funding levels. Such efforts would need to involve NGOs and grant-making foundations, who obviously compete for such funds. Conceptual work is needed to consider why it would be better to capitalize trust funds rather then spending resources for global environmental benefits as they become available. But the establishment and gradual capitalization of a global biodiversity trust fund, which could fund conservation efforts indefinitely, deserves consideration. There might be considerable interest from governments, grant-giving foundations and the growing class of super-rich individuals.

Notes

1. A best estimate puts international financial flows from all international government and non-governmental sources for biodiversity at \$800 million. This is less than other recent sources have asserted. Previous studies have overestimated funds because of double counting and problems with how countries label their expenditures when they report them to the OECD.
2. For a comprehensive overview, see IPCC/TAR, 2001, Working Group III, Mitigation, pp: 504 ff. See also Toman (2003) and Rivers and Jaccard (2005) for good overviews of economic modelling approaches.
3. For an overview, see WRI (1997).
4. Nordhaus and Boyer (1999) conclude that the costs of the Kyoto Protocol would exceed the benefits by a factor of seven, implying a global economic loss of \$716 billion in present value terms, with the United States bearing two-thirds of that cost (using the RICE-99 model, an improved version of the DICE and RICE models that have been widely applied in climate change studies).
5. For a discussion of discounting the future, see Cline (1992, p. 238); IPCC (2001, p. 466); and Newell and Pizer (2003).
6. The figure was compiled using OECD data (Rio marker) and includes large loans for construction of natural gas utilities or hydropower generation.

7. For example, many NGOs draw significant resources from grant-making foundations, but not all grants for biodiversity go to NGOs. Annual reports of these organizations often do not adequately break down numbers. If biodiversity-related allocations shown in these reports are simply summed, this will result in significant double counting. No consolidated surveys are available.
8. Based on a perusal of national reports made available by megadiversity countries to the Convention on Biological Diversity.
9. The group includes Brazil, China, Colombia, the Democratic Republic of Congo, Ecuador, India, Indonesia, Malaysia, Madagascar, Mexico, Papua New Guinea, Peru, the Philippines, South Africa and Venezuela.
10. Personal recollection.

References

Afrol News. 2004. "West African Chimps Could Be Extinct in 20 Years." 9 June. Available at www.afrol.com/articles/13312.

Almond, Gabriel A., and G. Bingham Powell, Jr. 1978. *Comparative Politics.* Boston: Little, Brown & Company.

American Lung Association. 2004. Various reports on air quality. Available at www.lungusa.org.

AmphibiaWeb. 2005. Information on amphibian biology and conservation. Berkeley, California: AmphibiaWeb. Available at http://amphibiaweb.org/.

Andrews, Richard N. 2000. "Risk-Based Decision-Making." In Norman Vig and Michael Kraft, eds., *Environmental policy*. 4th edition. Washington, D.C.: Congressional Quarterly Press.

Balmford, Andrew, Aaron Bruner, Philip Cooper, Robert Costanza, Stephen Farber, Rhys E. Green, Martin Jenkins, Paul Jefferiss, Valma Jessamy, Joah Madden, Kat Munro, Norman Myers, Shahid Naeem, Jouni Paavola, Matthew Rayment, Sergio Rosendo, Joan Roughgarden, Kate Trumper and R. Kerry Turner. 2002. "Economic Reasons for Conserving Biodiversity." *Science* 297: 950–53.

Barcott, Bruce. 2004. "Changing All the Rules." *New York Times Magazine*, April 4. New York: The New York Times Company.

Barker, Terry, and Paul Ekins. 2004. "The Costs of Kyoto for the US Economy." *The Energy Journal* 25 (3): 53–71.

Bateman, Ian, Richard Carson and Brett Day. 2002. *Economic Valuation with Stated Preference Techniques: A Manual.* Northampton, Mass.: Edgar Elgar Ltd.

BBC News. 2005. "EU ministers agree on tax on flying." 15 May. Available at http://news.bbc.co.uk/1/hi/business/4545123.stm.

Bradsher, Keith. 2002. *High and Mighty: SUVs—The World's Most Dangerous Vehicles and How They Got that Way*. New York: Public Affairs.

Brown, Gardner. 1994. "Estimating Nonuse Values Requires Interdisciplinary Research." In Beat Bürgenmeier, ed., *Economy, Environment, and Technology*. Armonk, N.Y.: M.E. Sharpe.

Brown, Katrina. 2004. "Trade-Off Analysis for Integrated Conservation and Development." In Thomas O. McShane and Michael P. Wells, eds., *Getting Biodiversity Projects to Work: Towards More Effective Conservation and Development*. New York: Columbia University Press.

Castro, Gonzalo. 2003. "Conservation Finance: The Long Road to Sustainability." Presentation to the Workshop on International Biodiversity Financing, University of California San Diego, 5–6 December, La Jolla.

CBD (Convention on Biological Diversity). 2004. *Report of the Seventh Meeting of the Conference of the Parties to the Convention on Biological Diversity*. UNEP/CBD/COP/7/21. 9–20 and 27 February, Kuala Lumpur.

CBS Marketwatch. 2005. "Goldman Sees Oil Price 'Super Spike': Crude Could Reach $105 a Barrel." 26 March. Available at www.marketwatch.com.

Chapin, Marc. 2004. "A Challenge to Conservationists" *World Watch Magazine* (November/December): 17–31.

Clemmer, Steven, Alan Nogee and Michael C. Brower. 1998. "A Powerful Opportunity: Making Renewable Electricity the Standard." Union of Concerned Scientists, Cambridge, Mass.

Cline, William. 1992. *The Economics of Global Warming.* Washington, D.C.: Institute for International Economics.

Clémençon, Raymond. 2000. "Financing Protection of the Global Commons: The Case for a Green Planet Contribution." Working Paper 17. Global Environment Facility, Washington, D.C. Available at www.gefweb.org/Outreach/outreach-PUblications/WP17-Financing_Protection.pdf.

———. 2006. "Resource Needs and Availability for Protecting Global Environmental Public Goods." Chapter 3, this volume.

Costanza, R., R. d'Arge, R. de Groot, S. Farber, M. Grasso, B. Hannon, K. Limburg, S. Naeem, R.V. O'Neill, J. Paruelo, R.G. Raskin, P. Sutton and M. van den Belt. 1997. "The Value of the World's Ecosystem Services and Natural Capital." *Nature* 387 (6230): 255.

Council of Economic Advisers. 1998. "The Kyoto Protocol and the President's Policies to Address Climate Change: Administration Economic Analysis." Washington, D.C.

Curtis, Ian A. 2004. "Valuing Ecosystem Goods and Services: A New Approach." *Ecological Economy* 50 (3 and 4): 163–94.

Davis, Devra. 2002. *When Smoke Ran Like Water: Tales of Environmental Deception and the Battle against Pollution*. New York: Basic Books.

DeCanio, S. 2003. *Economic Models of Climate Change: A Critique*. New York: Palgrave Macmillan.

Der Spiegel. 2006. "Annan unterstützt Steuer auf Flugtickets." 16 February, Hamburg.

Dewey, Scott Hamilton. 2000. *Don't Breath the Air: Air Pollution and U.S. Environmental Politics, 1945–1970*. College Station, Texas: Texas A&M University Press.

Dowdeswell, Julian. 2006. "The Greenland Ice Sheet and Global Sea Level Rise." *Science* 311 (17 February): 963–64.

Dublin, H., C. Volonte and J. Brann. 2004. *GEF Biodiversity Program Study*. Washington, D.C.: Monitoring and Evaluation Unit, Global Environment Facility Secretariat.

Dunlap, R.E., and W.R. Catton. 1979. "Environmental Sociology." *Annual Review of Sociology* 5: 243–73.

Eberhard, Anton, Siv E. Tokle, A. Viggh, A. Del Monaco, H. Winkler and St. Danyo. 2004. *GEF Climate Change Program Study*. Washington, D.C.: Monitoring and Evaluation Unit, Global Environment Facility Secretariat.

EEA (European Environment Agency). 2004a. "Impacts of Europe's Changing Climate: An Indicator-Based Assessment." EEA Report 2/2004. Copenhagen: European Environment Agency.

———. 2004b. "Air pollution and climate change policies in Europe: exploring linkages and the added value of an integrated approach." EEA Technical Report No. 5/2004. Copenhagen: European Environment Agency.

———. 2006. *Using the Market for Cost-Effective Environmental Policy*. EEA Report 1/2006. Copenhagen: European Environment Agency.

EIA (Energy Information Administration), US Department of Energy. 2001. *International Energy Outlook.* Washington, D.C.: Energy Information Administration, US Department of Energy. Available at www.eia.doe.gov/.

———. 2004. *International Energy Outlook*. Washington, D.C.: Energy Information Administration, US Department of Energy. Available at www.eia.doe.gov/.

EPA (US Environmental Protection Agency). 2004. "Global Warming—Impacts." Washington, D.C. Available at www.epa.gov/globalwarming/impacts.

Europa Newsletter. 2005. "Growth, jobs and sustainable development." Issue 52, 24 March. Available at http://europa.eu.int/newsletter.

European Union Press Releases. 2005. "Council Adoption of the EU Strategy for Africa Marks New Era in Euro-African Relations." 12 December. Available at http://europa.eu.int/press_room.

Eurobarometer. 2005. *The Attitudes of European Citizens towards the Environment*. April, Special Eurobarometer 217/Wave 62.1—TNS Opinion & Social. Available at http://europa.eu.int/comm/environment/barometer/report_ebenv_2005_04_22_en.pdf.

Ferraro, Paul J. 2002. "The Local Costs of Establishing Protected Areas in Low-Income Nations: Ranomafana National Park, Madagascar." *Ecological Economics* 43 (2 and 3): 261–75.

Froggatt, Antony, and Germana Canzi. 2004. "Ending Wasteful Energy Use in Central and Eastern Europe: An Essential Step for Climate Change Policy in a Competitive EU-25." World Wildlife Fund, European Policy Office, Brussels.

GEF (Global Environment Facility). 2004. *Project Status Report*. June. Washington, D.C.

———.2005a. "GEF Resource Allocation Framework." Technical note for special meeting of the GEF Council, 31 August–1 September, Paris. GEF/C.26/2/Rev.1. Washington, D.C.

———. 2005b. Work Program Submitted for Council Approval. Secretariat Note. GEF/C.27/6. Washington, D.C.

———. 2005c. "Secretariat Discussion Note on Resource Allocation Framework." 22 February, Washington, D.C.

Gibbs, Wayt W. 2001. "On the Termination of Species." *Scientific American* 285 (5): 40–49.

Gossling, S. 1999. "Ecotourism: A Means to Safeguard Biodiversity and Ecosystem Function?" *Ecological Economics* 29 (2): 303–20.

Guber, Deborah Lynn. 2003. *The Grassroots of Green Revolution: Polling America on the Environment*. Cambridge, Mass.: MIT Press.

Hannigan, John A. 1995. *Environmental Sociology: A Social Constructionist Perspective*. New York: Routledge.

Hansen, James. 2004. "Defusing the Global Warming Time Bomb." *Scientific American* 290 (3): 69–77.

IEA (International Energy Agency). 2004. "Analysis of the Impact of High Oil Prices on the Global Economy." Paris Cedex. Available at www.iea.org/Textbase/Papers/2004/High_Oil_Prices.pdf.

IISD (International Institute for Sustainable Development). 2006. "Final Report on CBD/COP8." *Earth Negotiating Bulletin* 9 (363). Available at www.iisd.ca/biodiv/cop8/.

IPCC (Intergovernmental Panel on Climate Change). 2001. *Third Assessment Report: Climate Change 2001: Mitigation*. World Meteorological Organization. Available at www.ipcc.ch/.

———. 2005. Meeting Report. Workshop on New Emission Scenarios, 29 June–1 July, Laxenburg, Austria. World Meteorological Organization. Available at www.ipcc.ch/.

IUCN (World Conservation Union). 2004. "World's Largest Conservation Gathering Opens to Escalating Global Species Extinction Crisis." Press release, 17 November, Gland, Switzerland. Available at www.iucn.org/congress/documents/press/2004-11-17-opening.htm.

IUCN/WCPA (World Commission on Protected Areas). 1998. "Guidelines for Protected Area Managers: Economic Values of Protected Areas." Task Force on Economic Benefits of Protected Areas and Economics Service Unit, World Conservation Union, Gland, Switzerland.

James, A.N., M.J.B. Green and J.R. Paine. 1999. *Global Review of Protected Area Budgets and Staff*. Cambridge: World Conservation Monitoring Centre.

James, A., S. Kanyamibwa and M.J.B. Green. 2001. "Sustainable Financing for Protected Areas in Sub-Saharan Africa and the Caribbean." In T.L. Anderson and A. James, eds., *The Politics and Economics of Park Management*. Oxford: Rowman and Littlefield.

James, Alexander N., Kevin J. Gaston and Andrew Balmford. 1999. "Balancing the Earth's Account." *Nature* 401 (6751): 323–24.

Jenkins, Michael, Sara J. Scherr and Mira Inbar. 2004. "Markets for Biodiversity Services: Potential Roles and Challenges." *Environment* 46 (6): 32–42.

Junginger, M., A. Faaij and W. C. Turkenburg. 2005. "Global Experience Curves for Wind Farms." *Energy Policy* 33: 133–50.

Kolstad, Charles D., and Michael Toman. 2001. *The Economics of Climate Policy*. Washington, D.C.: Resources for the Future.

Krause, Florentin, Paul Baer, Stephen DeCanio and Andrew Hoerner. 2001. *Cutting Carbon Emissions at a Profit: Opportunities for the United States*. International Project for Sustainable Energy Paths, El Cerrito, Calif.

Leifert, Volker, Andreas Pastowski, Graham Wilkinson and Gerd Winter. 1997. *Air and Maritime Transport Emission User Charges*. Wuppertal: Institute for Climate, Environment and Energy.

Macilwain, C. 1998. "When Rhetoric Hits Reality in Debate on Bioprospecting." *Nature* 392 (6676): 535–41.

Makombo, John. 2003. "A Case Study of Bwindi Impenetrable National Park in Western Uganda." Paper presented at the World Parks Congress, 9 September, Durban, South Africa. Available at www.biodiversity.org/wcpa/.

Manne, Alan, and Richard Richels. 2004. "US Rejection of the Kyoto Protocol: The Impact on Compliance Costs and CO_2 Emissions." *Energy Policy* 32 (4): 447–54.

Markandya, Anil. 2001. "The Valuation of Health Impacts in Developing Countries." In Ronaldo Seroa da Motta, ed., *Environmental Economics and Policy Making in Developing Countries: Current Issues*. Northampton, Mass.: Edward Elgar.

Mattoon, Ashley. 2001. "Deciphering Amphibian Declines." In Lester Brown, Christopher Flavin and Hilary French, eds., *State of the World 2001*. New York: W. W. Norton.

McKibbin, W. J., and P. J. Wilcoxen. 1997. "A Better Way to Slow Global Climate Change." Policy Brief 17. Brookings Institution, Washington, D.C.

McShane, Thomas O., and Michael P. Wells, eds. 2004. *Getting Biodiversity Projects to Work: Towards More Effective Conservation and Development*. New York: Columbia University Press.

Mendelsohn, Robert. 1999. *The Greening of Global Warming*. Washington, D.C.: AEI Press.

Mendonça, Mario Jorge, Adolfo Sachsida and Paulo Loureiro. 2003. "A Study on the Valuing of Biodiversity: The Case of Three Endangered Species in Brazil." *Ecological Economics* 46 (1): 9–18.

Mendonça, Mario Jorge Cardoso de, Maria del Carmen Vera Diaz, Daniel Nepstad, Ronaldo Seroa da Motta, Ane Alencar, Joao Carlos Gomes and Ramon Arigoni Ortiz. 2004. "The Economic Cost of the Use of Fire in the Amazon." *Ecological Economics* 49 (1): 89–105.

Mertig, Angela, Riley Dunlap and Denton Morrison, 2002. "U.S. Environmental Movement." In Riley Dunlap and William Michelson, eds., *Handbook of Environmental Sociology.* London: Greenwood Press.

Millennium Ecosystem Assessment. 2005. *Ecosystems and Human Well-being: Biodiversity Synthesis*. World Resources Institute, Washington, D.C. Available at www.millenniumassessment.org.

Mittermeier, R.A., P.R. Gil and C.G. Mittermeier. 1997. *Megadiversity: Earth's Biologically Wealthiest Nations*. Mexico City: CEMEX, Agrupación Sierra Madre.

Muriithi, Samuel, and Wendy Kenyon. 2002. "Conservation of Biodiversity in the Arabuko Sokoke Forest, Kenya." *Biodiversity and Conservation* 11 (8): 1437–50.

Myers, Norman, Russell A. Mittermeier, Cristina G. Mittermeier, Gustavo A.B. da Fonseca and Jennifer Kent. 2000. "Biodiversity Hot Spots for Conservation Priorities." *Nature* 403 (6772): 853–58.

Newell, Richard G., and William A Pizer. 2003. "Discounting the Distant Future: How Much Do Uncertain Rates Increase Valuations?" *Journal of Environmental Economics and Management* 46 (1): 52–71.

NOAA National Climate Data Center. 2005. Climate of 2005 Summary of Hurricane Katrina. 29 December. Available at www.ncdc.noaa.gov/oa/climate/research/2005/katrina.html.

Nordhaus, W.D., and J. Boyer. 1999. "Requiem for Kyoto: An Economic Analysis of the Kyoto Protocol." *The Energy Journal* 20 (1, special issue): 93–130.

OECD (Organisation for Economic Co-operation and Development). 1992. "Special Issue on the Economic Costs of Reducing CO_2." OECD Economic Studies Report. Paris.

———. 1995. *Global Warming: Economic Dimensions and Policy Responses*. Paris.

———. 2001. *Environmental Outlook*. Paris.

Pagiola, Stefano, Joshua Bishop and Natasha Landell-Mills. 2002. *Selling Forest Environmental Services: Market-Based Mechanisms for Conservation and Development*. London: Earthscan.

Pope, C.A., M.J. Thun, M.M. Namboodiri, D.W. Dockery, J.S. Evans, F.E. Speizer and C.W. Heath, Jr. 1995. "Particulate Air Pollution as a Predictor of Mortality in a Prospective Study of U.S. Adults." *American Journal of Respiratory Critical Care Medicine* 151 (3): 669–74.

Renewables Conference (International Conference for Renewable Energies). 2004a. *International Action Programme*. Bonn. Available at www.renewables2004.de/pdf/International_Action_Programme.pdf.

———. 2004b. *List of Actions and Commitments*. Bonn. Available at www.renewables2004.de.

Repetto, R., and D. Austin. 1997. *The Costs of Climate Protection: A Guide for the Perplexed*. Washington, D.C.: World Resources Institute.

Rivers, Nic, and Mark Jaccard. 2005. "Combining Top-Down and Bottom-Up Approaches to Energy-Economy Modeling Using Discreet Choice Methods." *The Energy Journal* 16 (1): 83–106.

Robinson, John G., and Kent H. Redford. 2004. "Jack of All Trades, Master of None: Inherent Contradictions among ICD Approaches." In Thomas O. McShane and Michael P. Wells, eds., *Getting Biodiversity Projects to Work: Towards More Effective Conservation and Development*. New York: Columbia University Press.

Rootes, Christopher, ed. 1999. *Environmental Movements: Local, National and Global*. London: Frank Cass.

Rosenbaum, Walter A. 2002. *Environmental Politics and Policy.* 4th edition. Washington, D.C.: Congressional Quarterly Press.

———.2004. *Environmental Politics and Policy.* 6th edition. Washington, D.C.: Congressional Quarterly Press.

Sanderson, Steven. 2002. "The Future of Conservation." *Foreign Affairs* 81 (5): 162–74.

Schaefer, Eric, and Abt Associates, Inc. 2002. *Particulate-Related Health Impacts of Emissions in 2001 from 41 Major US Power Plants*. Washington, D.C.: Abt Associates, Inc.

Schnaiberg, Allen, and Kenneth Alan Gould. *Environment and Society: The Enduring Conflict*. Caldwell, N.J.: Blackburn Press.

Schneider, J. W., and J. Kitsuse, eds. 1984. *Studies in the Sociology of Social Problems.* Nordwood, N.J.: Ablex.

Schneider, Robert R., Eugenio Arima, Adalberto Verissimo, Carlos Souza and Paulo Barreto. 2002. *Sustainable Amazon: Limitations and Opportunities for Rural Development*. Technical Paper 515, Environment Series. Washington, D.C.: World Bank.

Science Magazine. 2006. *Climate Change—Breaking the Ice. Special Issue*. 24 March.

Swanson, Timothy, Wang Qiwen, Andreas Kontoleon, Qiao Xuejun and Yang Tao. 2002. *The Economics of Panda Reserve Management*. Published for the Environmental Economics Working Group of the China

Council for International Cooperation on Environment and Development. Gaithersburg, Md.: Balmar Printing and Graphics.

Ten Kate, Kerry and Sarah A. Laird. 2000. "Biodiversity and Business." *International Affairs* 76 (2): 241–64.

TFC Commodity Charts. 2006. Oil price charts. Available at http://futures.tradingcharts.com/chart/CO/M.

Toman, Michael A. 2003. *Economic Analysis and the Formulation of U.S. Climate Policy*. Washington, D.C.: Resources for the Future.

Turner, R. Kerry, Jouni Paavola, Philip Cooper, Stephen Farber, Valma Jessamy and Stavros Georgiou. 2003. "Valuing Nature: Lessons Learned and Future Research Directions." *Ecological Economics* 46 (3): 493–510.

UCS (Union of Concerned Scientists). 2004. *Scientific Integrity in Policy-Making.* Cambridge, Mass.

UNEP (United Nations Environment Programme). 2002. *GEO3: Global Environmental Outlook*. New York: Earthscan.

———. 2004. "Decisions Adopted by the Conference of the Parties to the Convention on Biological Diversity at its Seventh Meeting." Nairobi. UNEP/CBD/COP/7/21 PART2. Available at www.biodiv.org/doc/meetings/cop/cop-07/official/cop-07-21-part2-en.pdf.

UNEP-WCMC (World Conservation Monitoring Centre). 2004. *World Database on Protected Areas.* Available at http://sea.unep-wcmc.org/wdbpa/.

Van Beukering, Pieter J.H., Herman S.J. Cesar and Marco A. Janssen. 2003. "Economic Valuation of the Leuser National Park on Sumatra Indonesia." *Ecological Economics* 44: 43–62.

Van den Bergh, Jeroen C.J.M. 2004. "Optimal Climate Policy is a Utopia: From Quantitative to Qualitative Cost-Benefit Analysis." *Ecological Economics* 44 (1): 385–93.

Varma, Anshuman. 2003. "The Economics of Slash and Burn: A Case Study of the 1997–1998 Indonesian Forest Fires." *Ecological Economics* 46 (1): 159–71.

Verleger, Philip K. 2004. "Why Oil Could Go to $60: As the World Teeters on the Precipice of Another Crisis, It's Time for a Contingency Plan." *International Economy* 18 (4): 22–27.

Vogel, David. 2001. "The Changing Politics of Risk Regulation in Europe and the United States." Working Paper RSC 2001/16. European University Institute, Florence.

Wall Street Journal. 2001. "Eco-Economists Back Bush on Kyoto Pact—Obscure Group Says Accord Contains Serious Flaws; Slower Course Favored." 7 August.

WRI (World Resources Institute). 2000. *World Resources 2000–2001: People and Ecosystems: The Fraying Web of Life.* Washington, D.C.

Yamin, Farhana. 1995. "Biodiversity, Ethics and International Law." *International Affairs* 71 (3): 529–46.

Zervos, Arthouros. 2003. "Updating the Impact of the Community Strategy and Action Plan for Renewable Energy Sources." European Renewable Energy Council, Brussels.

Zhongmin, Xu, Cheng Guodong, Zhang Zhiqiang, Su Zhiyong and John Loomis. 2003. "Applying Contingent Valuation in China to Measure the Total Economic Value of Restoring Ecosystem Services in Ejina Region." *Ecological Economics* 44 (3): 345–58.