



# Protecting the Global Commons



At the end of the 20th century, environmental problems are a matter of both national and global concern. Many of them create spillovers that impose heavy costs not only on those close to the source of the problem but on society as a whole and on future generations. Individual countries have strong economic and social reasons for aggressively protecting their environments by creating incentives to reduce and manage such spillovers.<sup>1</sup> However, an important subset of environmental problems is global in scope. Many countries have contributed to these problems, and no individual country can effectively address them by acting alone. These are the problems of the “global commons,” which will place all countries at risk if no collective action is taken. There are many such issues, including desertification, persistent organic pollutants, the fate of Antarctica, and the environmental health of the high seas and the seabed (box 4.1), but this chapter focuses on three in particular: ozone depletion, global climate change, and threats to biodiversity.

Effective responses to these problems are vital to the struggle for sustainable development. Climate change, for exam-

ple, is likely to raise sea levels, threatening island economies and low-lying countries such as the Maldives and Bangladesh. Climate change also jeopardizes agricultural production in developing countries. The Russian Federation and parts of Africa could see dramatic reductions in their crop yields by 2050 (figure 4.1). The overall impact of a doubling of carbon dioxide in the atmosphere would be to reduce the gross domestic product (GDP) of developing countries by an estimated 2–9 percent (compared with 1.0–1.5 percent of GDP in industrial economies).<sup>2</sup> Within developing countries, the price of inaction is likely to fall particularly on the poorest, who have the fewest resources for responding to climate change. And because of the concentration of biodiverse areas in developing countries, failure to preserve biodiversity would also disproportionately affect poorer nations.

Despite the urgency and importance of environmental issues, building cooperation to address global environmental problems is not simple; it involves contentious issues such as the division of responsibilities and differing capabilities to respond. Industrial countries have cre-

**Box 4.1****Global environmental issues**

Beyond the three cases discussed in detail in this chapter—ozone depletion, climate change, and biodiversity protection—a range of other environmental issues calls for action on a global scale. These issues include desertification and land degradation, Antarctica, persistent organic pollutants (POPs), and the high seas and seabed.

*Desertification and land degradation*

Today 900 million people in about 100 countries are affected by desertification and drought. By 2025 that number will double, and 25 percent of the earth's land area will be degraded. Land degradation, which is closely linked to issues of population, poverty, water use, and biodiversity, increases as growing numbers of people overexploit fragile ecosystems.

By mid-1998 almost 150 countries had ratified the United Nations Convention to Combat Desertification. The convention is a significant first step that will benefit millions of people if it is properly implemented. The convention's thrust is not to set up a separate program to counter desertification but to mainstream efforts toward this objective into a country's overall development strategy, with the support of bilateral and multilateral donors.<sup>3</sup>

*Antarctica*

Since the negotiation of the Antarctic Treaty in 1959, countries that had laid claim to territory on the continent have "frozen" their claims. Under Article IV no signatory nation is allowed to assert its claims or make new ones. Furthermore, signatories are not allowed to deploy military units (except in support of scientific missions), dump radioactive waste, or explode nu-

clear devices on the continent or in the surrounding seas. Since then, two conventions and one protocol to the treaty have aimed to protect seals, the region's unique marine living resources, and the Antarctic environment in general.<sup>4</sup>

*Persistent organic pollutants*

Twelve of these pollutants are currently the subject of international negotiation. POPs are chemical substances used in a variety of activities (including agricultural and industrial production and disease control) that do not break down naturally and that accumulate in the fatty tissues of animals at different levels of the food chain. Because POPs are long-lasting and are frequently able to travel long distances in the atmosphere, they have spread all over the world, even to areas where they have never been used. POPs harm both human and animal populations—in humans, for example, they can cause cancer, diseases of the immune system, and reproductive disorders. The United Nations Environment Programme is leading the development of a global, legally binding agreement to minimize the release of POPs into the environment, with negotiations scheduled to conclude in 2000.<sup>5</sup>

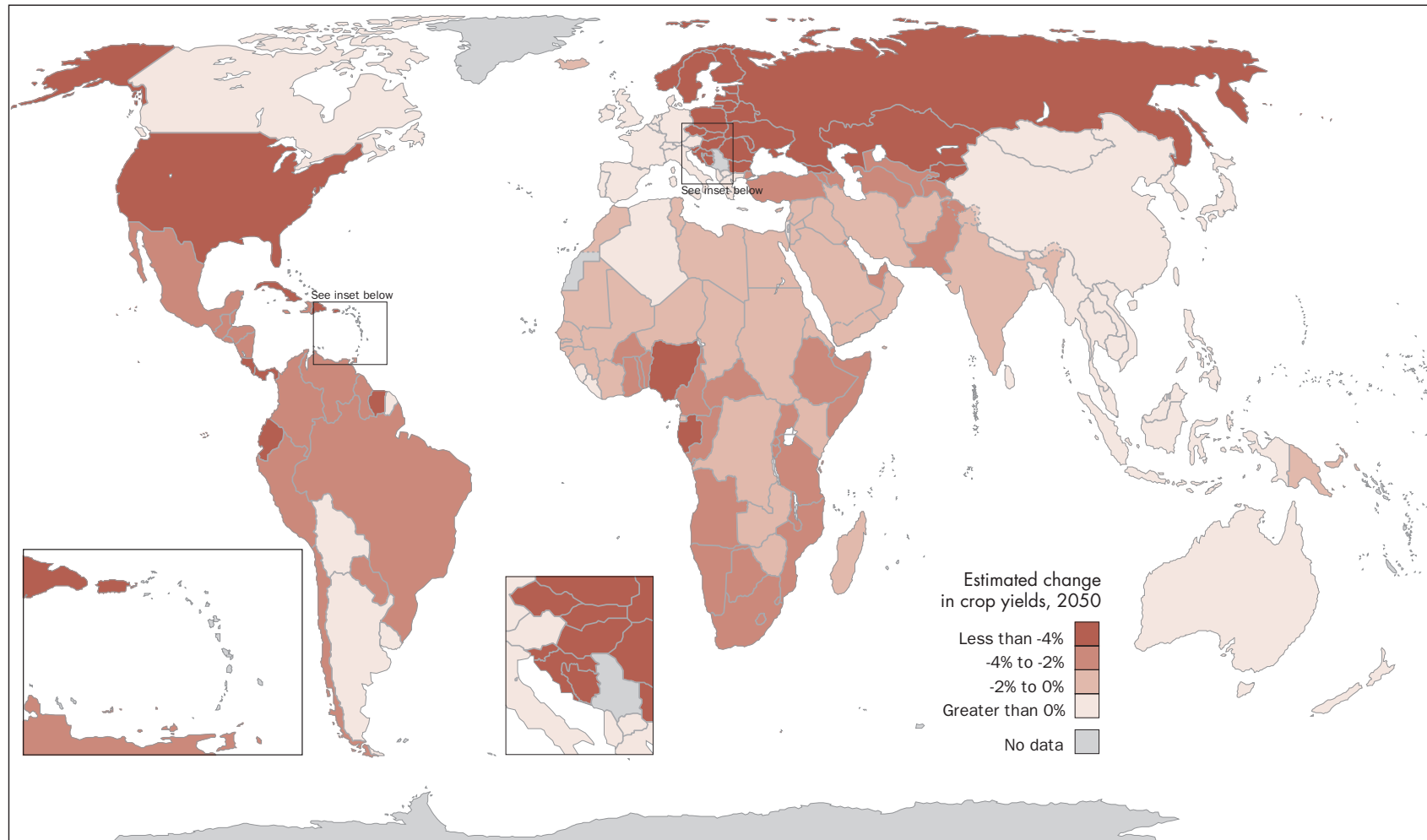
*The high seas and the seabed*

The United Nations Convention on the Law of the Sea (UNCLOS), which incorporated a number of earlier agreements, was adopted in 1982 and entered into force in 1994. Beyond creating exclusive economic zones (box 4.2), UNCLOS stipulates that states must take action to control marine pollution from both land-based sources and vessels at sea. It also sets up a global authority responsible for the environmental health of the seabed.

ated much of the current stock of many transnational environmental problems. In the pursuit of economic advance, they have destroyed much of their own biodiversity and have overexploited fisheries worldwide. They also have the highest levels of energy use and thus bear the overwhelming responsibility for the present level of man-made greenhouse gases in the atmosphere. At the same time, developing countries are unlikely to become actively involved in addressing global environmental problems if the price is slower economic progress. The United Nations Framework Convention on Climate Change and the Convention on Biological Diversity (both agreed at the 1992 Rio Earth Summit) specifically recognized that economic and social development and poverty eradication are developing countries' overriding priorities.<sup>6</sup> For this reason the need for flexible mechanisms that transfer resources from rich to poor countries are central to any solution of global environmental problems.

Even though industrial countries have played a disproportionately large role in causing global environmental problems and should pay the lion's share of the costs of addressing them, developing countries are vital to any long-term solution to these problems and have accepted that they also have a role, under a system of common but differentiated responsibilities.<sup>7</sup> Developing countries are already doing damage to the global commons. Rain forests and coral reefs are rapidly being destroyed in many developing countries. Urbanization, industrialization, and growing numbers of automobiles worldwide mean yet more greenhouse gases in the atmosphere. And overfishing has spread to seas controlled by developing nations. Moreover, regardless of who has done the damage to the global commons, developing countries have a strong interest in ensuring that cooperative steps are taken to address these issues, which will have the greatest effect on their citizens.

**Figure 4.1**  
Climate change jeopardizes crop yields, especially in developing countries



*Note:* Crops modeled are wheat, maize, and rice.  
*Source:* Parry and Livermore 1997.

Already, developing countries are taking steps to combat environmental degradation, including some environmental problems that have global implications. Kazakhstan and Uzbekistan have been taking measures to prevent rapid deforestation, and China has crafted an ambitious set of environmental plans based on the agenda that emerged from the Rio Earth Summit.<sup>8</sup> These efforts have overlapped with a growing movement to tackle global environmental problems in a multinational framework. Since the 1972 Stockholm Conference on the Human Environment, governments have signed more than 130 environmental treaties, with increasingly substantive regulatory provisions.<sup>9</sup> These treaties have contributed to many positive developments, such as reduced water pollution in the Mediterranean and stronger protection for the Antarctic environment.

This chapter begins by discussing national initiatives aimed at improving the local economy or environment that also have some role in slowing climate change and biodiversity loss. Such initiatives illustrate the importance of the complementarities that can emerge from a comprehensive development strategy. Policies designed to improve economic efficiency, for instance, can sometimes have a significant and positive impact on rates of deforestation or energy use. The chapter moves on to a discussion of the need for further international initiatives that address regional and global environmental problems. Although the measures employed to tackle ozone depletion were based in part on circumstances particular to that case, they suggest guidelines for designing global measures that address the complex problems of greenhouse gas emissions and biodiversity preservation. The chapter concludes with a look at the linkages between biodiversity and greenhouse gas emissions, pointing out how these links can be exploited to negotiate more effective international agreements.

### **The link between national and global environmental issues**

Autonomous, self-interested state actions can improve both the environment and economic performance, as emphasized in *World Development Report 1992*. In some fortuitous cases, protecting the local environment will also contribute to addressing a global environmental problem. Exploiting these synergies is vital. Linking actions that have short-term payoffs (such as controlling air pollution) to those with longer-term results (such as controlling the release of carbon dioxide) im-

proves the economic efficiency and political viability of reforms designed to promote sustainable development. For example, the domestic environmental benefits of maintaining forest resources—including reduction of river sedimentation and soil erosion and preservation of water resources and fishing areas—greatly outweigh any economic benefits that might be gained by transforming the forest into poor-quality farmland. Similarly, governments can justify preserving coral reefs solely on the basis of their value to national economies.<sup>10</sup> Preservation, then, supports both the national environment and the national economy. But in both cases, efforts to protect national resources also benefit the global commons by preserving biodiversity and reducing carbon dioxide output.

Governments often take measures to promote economic efficiency (on both the national and international levels) that also reduce environmental degradation. Eliminating subsidies and tax credits for cutting timber and for building roads in forests is economically advantageous. But this policy has another benefit: it significantly reduces deforestation rates, preserving biodiversity and a valuable “carbon sink” that cuts carbon dioxide levels in the air.<sup>11</sup> Similarly, doing away with energy subsidies and imposing taxes on fuel reduces both global carbon dioxide emissions and local pollution such as acid rain and smog. Studies in Mexico suggest that a 1 percent increase in gasoline prices is associated with a 0.8 percent decline in gasoline consumption.<sup>12</sup>

Eliminating energy subsidies could reduce carbon emissions dramatically. If Western Europe and Japan abolished their coal production subsidies and their import restrictions on foreign coal by 2005, global carbon dioxide emissions would drop 5 percent. If the major developing countries simultaneously raised the price of coal to international market levels, the combined effect would be an 8 percent reduction in global emissions.<sup>13</sup> Removing subsidies is often difficult for political reasons, but it is important to note that subsidies rarely benefit the most deserving, especially in the developing world.<sup>14</sup> For example, subsidizing the electricity bills of rich consumers connected to the grid—or the gasoline of those who own cars—certainly does not help the poor in developing countries. A recent World Bank study found that in Malawi rich consumers receive \$6.60 a year in electricity subsidies, while poor consumers receive just \$0.04. Of course, those not connected to the electricity grid receive no subsidy at all.<sup>15</sup>

Even if the complete removal of subsidies is politically impossible, there may be a strong case for better targeting. The cost of protecting a German coal-mining job with per-ton subsidies reached \$79,800 per job in 1995.<sup>16</sup> Much of the value of these subsidies went to the mine owners and operators, not to the workers. If the rationale for a subsidy is to protect jobs or workers' incomes, a per-worker subsidy is a more efficient choice. In Germany switching to a per-worker subsidy would have raised the price of coal closer to market levels (reducing coal consumption) and decreased the overall cost of the subsidies while protecting the mine workers' jobs and incomes.

Beyond national policies, local governments also have a role in countering global problems while tackling local issues. Automobile-related pollution does far more damage in cities than in the countryside because of the high concentration of both cars and people in urban areas. A recent U.S. study estimated that every gallon of gasoline consumed imposed a \$0.10 cost on the country as a whole in terms of the damage caused by increased air pollution but that in Los Angeles the amount can run as high as \$0.62 per gallon.<sup>17</sup> Such differentials suggest that local (and especially urban) governments have an important part to play in tackling pollution issues (see chapter 7). By investing in effective public and nonmotorized transportation networks and providing people with the incentives to use them, cities can reduce the economic and environmental costs of traffic congestion and motorized vehicle use. In the process, they also reduce greenhouse gas emissions.<sup>18</sup>

Preserving the environment involves not only eliminating subsidies that encourage polluting activities and supporting more environmentally efficient alternatives but also ensuring that polluters pay for the environmental damage they cause. These policies can frequently be implemented in ways that help protect the global as well as the local environment and that minimize the economic costs of environmental protection. Carbon taxes, which are applied to energy sources according to the amount of carbon dioxide they produce, have been suggested as one way for industrial and developing countries to reduce greenhouse gas emissions. Controversy often surrounds energy taxes. But proponents argue that such taxes sometimes have a broader base than other taxes commonly imposed in developing countries (such as those on trade) and so can be more economically efficient.<sup>19</sup> Proponents also argue

that a carbon tax that applies to energy imports and local sources of carbon-based energy such as coal mines and oil refineries might also be relatively easy to implement, as only a limited number of industrial operations require monitoring.

Another policy tool that can have a positive effect on both the national and the global environment is the imposition of market discipline on the exploitation of natural resources.<sup>20</sup> For example, making fishing quotas tradable helps create a market that promotes the efficient and sustainable use of fisheries resources (box 4.2). Market-based approaches are likely to be particularly important in international environmental agreements, as discussed later in this chapter.

By removing or reforming subsidies, fostering markets, and confirming property rights, countries acting alone can improve their own environments. To the extent that these unilateral actions also reduce cross-border pollution and environmental damage, they improve the welfare of other countries as well. But if such actions are so advantageous, why have more countries not taken them, and why are they not enough?

Entrenched producer interests account for the political difficulty in removing subsidies. Even better-targeted subsidies may meet resistance from workers. They may feel, for instance, that wage subsidies are demeaning to them in a way that price supports (which are far less efficient) are not.<sup>21</sup> This problem reinforces a point made in chapter 2: that a primary policy concern in the coming decades will be to help regional labor markets adjust to the economic changes caused by reform. It also suggests that international agreements might play a role in stimulating domestic support for environmental reform, much like the role the World Trade Organization (WTO) assumes in encouraging freer trade.

But even if national-level environmental concerns are fully addressed, international market failures call for an international response. Despite the sometimes positive effects of national efforts on international well-being, a focus on local environmental issues frequently leaves global concerns inadequately addressed. For example, catalytic converters can significantly reduce emissions of local pollutants, cutting hydrocarbon emissions by an average of 87 percent, carbon monoxide emissions by 85 percent, and nitrogen oxides by 62 percent. But depending on the type, these converters often have a minimal or negative effect on carbon dioxide output,

**Box 4.2****Preserving the ocean commons: controlling overfishing**

The imposition in the late 1970s of exclusive economic zones (EEZs) that stretch 200 miles from the coastlines of many countries has dramatically reduced the problem of fisheries as an international common pool resource, exploited by many and protected by none. Yet overfishing remains a significant issue. At the international level, regulating the stocks of migratory fish that traverse the EEZs of several countries still presents problems. But since 90 to 95 percent of fish are found within EEZs, such problems cannot account for global overfishing. In fact the most important causes of overfishing are national subsidies, overcapacity in the fishing industry, and governments' inability to enforce fishing limits in their economic zones.

In the underpatrolled waters off the coasts of some African nations, ships from both Europe and Asia fish illegally—and at rates that cannot be sustained.<sup>22</sup> But even legal fishing often depletes local fish populations. Technological advances such as advanced sonar and drift nets have made large boats much more effective. The Food and Agriculture Organization (FAO) estimates that the number of fishing boats more than doubled between 1970 and 1990, reaching some 1.2 million (although many of these are small fishing boats). The European Union alone has about 40 percent more boats than it needs to catch sustainable levels of fish. And as a result of overfishing, fish catches in recent years have not increased, despite the larger fleets. As stocks are exhausted, the fleets actually become less profitable.

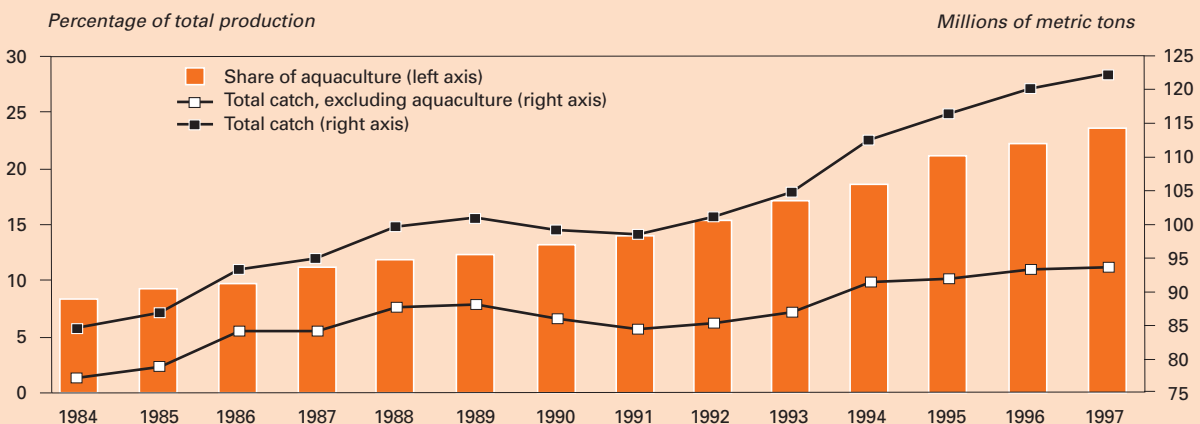
Clearly, enforcing national rights, removing subsidies, and implementing national programs to counter overfishing are very important. Some countries have introduced individual transferable quotas—tradable rights to land a percentage of the annual catch—which, when well implemented, can ensure a sustainable catch for the most efficient fishermen.

Aquaculture may provide a technological solution for overfishing. While marine harvests still account for 80 percent of world seafood supplies, aquaculture is one of the fastest-growing food production industries. Farmed fish production doubled between 1990 and 1996, reaching 26 million tons, and output could reach 39 million tons by 2010. Aquaculture, how-

ever, is no panacea: it takes an estimated 5 kilograms of oceanic fish reduced to fish meal to raise a single kilogram of farmed shrimp, and the 300 to 1,000 kilograms of solid waste produced by each ton of farmed fish can cause problems with water quality, including overnutrification and algae blooms. But freshwater aquaculture at least can be made sustainable.

For transnational or highly migratory stocks of fish or stocks that stray into the high seas, international agreements still play an important part in controlling overfishing. The 1995 United Nations agreement on straddling fish stocks and highly migratory fish stocks struck a careful balance in determining the rights of coastal and distant-fishing states and strengthened the role of regional fishing organizations in controlling fishing on the high seas. Parties to regional agreements have been given powers to board and inspect vessels from any nation, although they have no power to impound the vessels or arrest the crews.<sup>23</sup> Another regional solution is a register of foreign vessels like that set up by the South Pacific Forum Fisheries Agency. Ships must be on this register in order to obtain fishing licenses from any member country, and they can be removed from the list for failure to pay fines.<sup>24</sup> This type of cooperation among states reduces the cost of enforcement.

With the EEZs and the 1995 United Nations agreement in place, is broader international action needed to preserve fisheries? The United Nations Convention on the Law of the Sea stipulates that countries have a duty to conserve fisheries within their EEZs, although the obligations are not clearly spelled out.<sup>25</sup> Some countries have apparently decided to allow overfishing, thus placing a low value on future fish stocks. International sanctions or transfers might change the incentives of the countries that continue to overfish. But for most developing countries, support for more effective fisheries management combined with voluntary sustainable fisheries labeling is likely to be more appropriate. A certification mechanism could also encourage sustainable fishing practices, an idea that has been taken up by the new Marine Stewardship Council. A future international agreement could also call for phasing out fishing subsidies, which clearly stimulate global overfishing.

**Aquaculture's role in the production of fish and shellfish is growing**

Source: FAO, *Fishery Statistics*, various years; FAO, *Aquacultural Production Statistics*, 1999.



the source of so much concern because of its relationship to climate change.<sup>26</sup>

Thus, national environmental policies are designed to benefit individual countries, not the rest of the world, and are likely to fall far short of global environmental goals. For international cooperation in the environmental arena to succeed, governments must consider the implications of domestic environmental policy decisions for other countries. Recognition of the effect that each nation's policies might have on other nations' welfare is an essential precondition for effective international environmental cooperation.

### Moving from national to international action

Every environmental issue involves a unique configuration of scientific factors, stakeholders, costs, benefits, and policy implications. But all global environmental problems have one thing in common: individual countries do not have sufficient incentives to act on them because countries cannot capture all the rewards of doing so. In economic terminology, global environmental resources are public goods that are nonexcludable and nonrivalrous across borders. The atmosphere is a particularly good example. No individual or group can be prevented (excluded) from consuming or using the atmosphere. Furthermore, clean air does not benefit one nation at the expense of others, so countries are not rivals when it comes to consuming these goods. An opposite example is the sea: it can be divided into zones with boundaries that can be enforced, and at least in the case of fishing, one nation's use can be at the expense of another's.

Biodiversity poses a slightly different problem from that presented by the atmosphere. We cannot separate what might be considered the global common resource elements of biodiversity from the ecosystems in which they reside, and these are highly valuable at the national level. Forests and coral reefs both have usage values at this level that far exceed any value that might be gained by destroying them. A recent study in West Kalimantan, Indonesia, found that 95 percent of the forests in the province have an agricultural opportunity cost of less than \$2 per hectare per year.<sup>27</sup> This figure compares poorly with estimates of the benefits of forest preservation that can be captured at the national level. These benefits include extractive values of minor forest products (fruits, latex, medicines, and so on) that average around \$70 per hectare per year, hunting and fishing values of between \$1 and \$16 per hectare per year, and

recreational values (including tourism) of around \$12 per hectare per year. Estimates of the value of the vital ecological functions of forests also overshadow agricultural opportunity costs. These functions include watershed protection (around \$10 per hectare per year), erosion prevention (\$2–\$28), fisheries protection (approximately \$14), and flood prevention (\$2).<sup>28</sup> These figures suggest that the most important method of preserving global biodiversity is to ensure that the functioning of markets and institutions at the national level reflects the value of the services ecosystems provide. Technical assistance and knowledge transfer can support this goal and are already a focus of international efforts to preserve biodiversity under the Global Environment Facility (box 4.3).

Nonetheless, at least some elements of biodiversity can be seen as nonexcludable and nonrivalrous, in common with the atmosphere. Genetic material is arguably a global common resource, yet pharmaceutical companies in industrial countries rarely pay for the genetic material they have extracted from plants in developing countries. A recent cost-benefit analysis of a preservation program for Cameroon's Korup National Park rain forest found that while many benefits of preserving the forest could be captured at the national level, only around 10 percent of the genetic value of the forest's biological resources (including research material for pharmaceuticals, chemicals, and agricultural crop products) could be obtained by Cameroon through existing licensing structures and institutions. The rest would benefit others outside Cameroon. Furthermore, the study did not include the value of carbon storage (reducing carbon dioxide emissions) that forest preservation provides to the global community. Carbon storage is both a useful example of the linkages among global environmental issues (since preserving forests supports climate stability and slows biodiversity loss) and another example of the nonrivalrous, nonexcludable nature of some forest services.<sup>29</sup>

No system has ever been set up to pay for the "existence value" of species in other countries—the value of diversity independent of any expected economic returns from factors such as genetic material or ecological function. This scenario persists unchanged, even though studies conducted in the United States suggest a willingness to pay for the preservation of individual native species at prices that range from \$2 to \$150 per household per year.<sup>30</sup>

When environmental resources have the features of a global public good, it becomes very difficult for pri-

### Box 4.3 The Global Environment Facility

The Global Environment Facility (GEF) provides grants and concessional funds to cover the additional costs incurred when a development project also targets global environmental objectives in four focus areas: biological diversity, climate change, international waters, and depletion of the Earth's ozone layer. The GEF is the interim financial mechanism of both the Convention on Biological Diversity and the United Nations Framework Convention on Climate Change. The GEF leverages its resources through cofinancing and cooperation with other donor groups and the private sector.

The GEF is involved in a range of innovative projects worldwide, including support for the management of protected areas, conservation programs, biomass and energy efficiency projects, solar home systems, and phaseout programs for chlorofluorocarbons (CFCs). In the Czech Republic, for example, GEF support was central to the phaseout of production and use of ozone-depleting substances such as CFCs and their replacement with alternative technologies. In a group of Caribbean countries, a GEF project backed the implementation of the International Convention for the Prevention of Pollution from Ships, which included new legislation, regional cooperation among countries and with cruise lines, and improved port waste management systems. Later in this chapter we discuss a project in Poland designed to improve forest management systems.

The GEF was never intended to cover all of the international financing needs of global environmental programs. As of September 1998, approximately seven years after its establishment, the GEF had allocated a total of just under \$2 billion—less than the maximum allowed for carbon credit transfers under the Kyoto Protocol. On the other hand, where it is involved, the GEF is playing an important role in supporting a range of measures to ensure global environmental sustainability.<sup>31</sup>

vate market forces or national governments acting alone to set prices for them that reflect their value, since anyone can use a nonexcludable good without paying for it and the cost of additional nonrivalrous users enjoying such a good is essentially zero. Because neither markets nor national laws are likely to fully reflect the value of public goods that are shared globally, only international agreements can fully protect these resources. But the costs and benefits of protecting natural resources differ from country to country, as do the levels of resources available for countering environmental degradation, creating a need for effective transfer mechanisms. The Global Environment Facility is one model for such transfers.

Nonetheless, critics often argue that the agreements on biodiversity and climate change signed in the latter

half of the 20th century fall short of attaining the full benefits of global cooperation. The Kyoto agreement is a solid first step away from “business as usual” and toward adaptive management. However, calculations by the Intergovernmental Panel on Climate Change (IPCC) show that emissions reductions well beyond the levels agreed at the Kyoto meeting would eventually be needed if governments wished to stabilize atmospheric concentrations of greenhouse gases at today's levels over the very long term.<sup>32</sup> Specifically, a reduction in emissions of approximately 60 percent from current levels would be required for stabilization. At present, the members of the Organisation for Economic Co-operation and Development (OECD) and the transition economies have agreed to reductions of around 5 percent.<sup>33</sup> This suggests that, if major climate change is to be avoided, there will at some point need to be an agreement with stricter emissions targets encompassing more countries. The situation is much the same with biological diversity loss. While the Convention on Biological Diversity provides a strong framework for future agreements, it has had little effect on forestry practices and coral reef degradation. Unsustainable forestry practices have slowed only marginally since the convention was signed, and coral reef degradation may have increased.

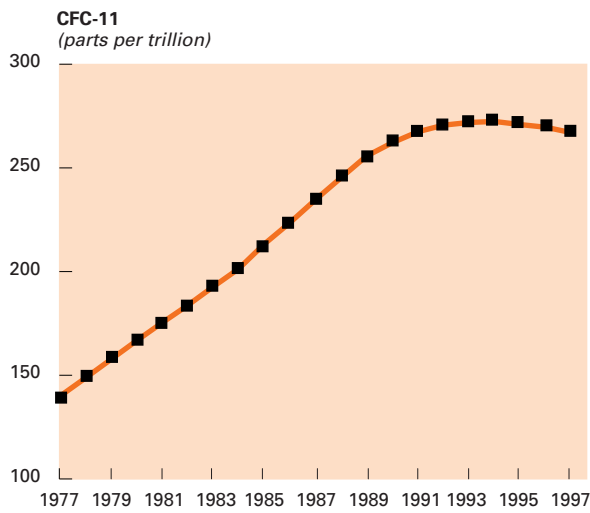
The rest of this chapter focuses on the conditions and mechanisms that determine the success of international agreements designed to counter global environmental problems. International treaties are based on bargaining, financial incentives, and, under some circumstances, limited controls on trade and finance. International funding based on the kinds of transfer mechanisms discussed here can help resolve two of the major problems that hold up such agreements: what kinds of environmental controls the agreements should include, and who should pay for those controls.

#### The ozone treaties: a success story

Concern about declining ozone levels in the upper atmosphere gained worldwide attention in the early and mid-1980s. Scenarios predicting huge increases in the rates of skin cancer and cataracts were widespread. Then, in 1987, the Montreal Protocol emerged as a cooperative effort to slow ozone depletion by reducing output of chlorine and bromine ozone-depleting substances. Twelve years later, thanks to the Protocol and follow-on agreements, concerns over ozone depletion are largely behind us. Global production of CFCs has fallen dramatically, and atmospheric concentrations of



**Figure 4.2**  
**Atmospheric concentrations of ozone-depleting substances first rose, then began to fall**



Note: Figure reports ground-level concentrations of CFC-11 at seven monitoring stations (in Alaska, Hawaii, American Samoa, the South Pole, Canada, the continental United States, and Tasmania).  
 Source: Elkins 1999.

these chemicals have not only stabilized but are beginning to drop (figure 4.2).<sup>34</sup> Not all the problems relating to ozone have been resolved. The black market in CFCs, while declining, is estimated at 20,000 to 30,000 tons per year.<sup>35</sup> But global cooperation to reduce ozone depletion can be broadly declared a success.

The key factors that allowed the negotiators in Montreal to reach a strong international agreement were:

- A consensus that the risks of ozone depletion as a result of CFCs and other substances containing chlorine and bromine had high costs, and that there was the technological and institutional ability to find cost-effective, environmentally benign substitutes.
- The involvement of all parties with a significant role to play in solving the problem, brought about by using both payments and penalties, along with flexibility in setting conditions for meeting the treaty's goals.

### *Consensus on high net benefits*

At the time of the Vienna Convention for the Protection of the Ozone Layer in 1985, a consensus on the impact of chlorine and bromine ozone-depleting sub-

stances did not yet exist. So, although the Vienna talks created a framework for future agreements, they did not contain a protocol limiting the use of CFCs. The discovery of an ozone hole over the Antarctic in the winter of 1985 pushed the issue into the news and helped create consensus on the need for international action.<sup>36</sup> Six months after the 1987 Montreal meetings, the International Ozone Trends Panel report heralded the first occasion on which the link between CFCs and ozone depletion, along with evidence of depletion occurring over the populated mid- and high latitudes of the Northern Hemisphere, was reported by the scientific community and accepted by policymakers from key CFC-producing countries.<sup>37</sup> This stronger acceptance led to agreements being signed at the London meeting of the parties in 1990 that greatly accelerated the timetable for abandoning ozone-damaging chemicals. This agreement and its successors covered 97 ozone-depleting chemicals—far more than the 8 covered by the Montreal Protocol.

When the first treaty limiting CFC production was signed in Montreal in 1987, little or no evidence existed that ozone had thinned anywhere but over the Antarctic—nor that CFCs had caused the ozone hole, nor that increased ultraviolet radiation was already starting to reach the earth.<sup>38</sup> Montreal was the first significant treaty to accept the “precautionary principle,” which holds that scientific uncertainty should not delay an international policy response if the delay might result in irreversible damage.<sup>39</sup> Nonetheless, growing scientific consensus on the costs of continued CFC production and possible substitutes was vital to the passage of the treaties. The process of coming to such a consensus was hastened by the Assessment Panel mechanism created as part of the Montreal treaty. These international panels of economic, scientific, and technical experts described the advancing status of scientific understanding and technical response options in the run-up to meetings of the parties.<sup>40</sup>

The high ratio of expected benefits to costs also helped the passage of the CFC agreements. One reason the costs were relatively low was that research into alternate technologies had been under way for some time. In response to earlier public pressure, some countries had begun introducing restrictions on CFCs in aerosol sprays in the late 1970s.<sup>41</sup> The United States, which had begun regulating CFCs in 1977, banned all nonessential CFC aerosol sprays in 1978, giving CFC producers time (and the incentive) to research alterna-

tive production methods before all uses of CFCs were banned.<sup>42</sup> At the same time, the costs of policing compliance with CFC-reduction targets were relatively low because the production of CFCs was largely concentrated in a few countries and was controlled by relatively few companies. This, combined with the large potential benefits of an international agreement to limit CFC production, gave OECD countries a strong incentive to negotiate. This was especially so given that the threat of skin cancer as a result of exposure to increased ultraviolet radiation was far greater in OECD countries than elsewhere.

Nongovernmental organizations (NGOs) also played a role by helping to put pressure on governments to negotiate deals. By raising public awareness of the possibly catastrophic dangers of ozone depletion and the links with chlorine- and bromine-containing substances, NGOs worked with the scientific community to create popular support for an agreement (box 4.4). The role of NGOs is in line with one of the themes of this report: that civil society can have an important place in the international policymaking arena.

### *Global participation*

A vital element in the success of the ozone treaties was the participation of all countries that produced or consumed (or seemed likely to produce or consume) significant amounts of ozone-depleting substances—including developing countries. The post-Montreal consensus on ozone damage served as a dramatic testimonial to the importance of including developing countries in an agreement. The World Resources Institute estimated that if Brazil, China, India, and Indonesia alone increased CFC production to the levels allowed in the Montreal Protocol, global production of ozone-depleting substances would double from the 1986 base level. The impact of such an increase on ozone levels would be profound.<sup>43</sup> Not involving developing countries, especially in the more stringent targets set at London, would have also threatened the treaty with “leakage”—that is, companies moving CFC factories from OECD sites to developing countries with higher production limits.

But developing countries needed an incentive to agree to tighter restrictions. They feared that substitutes for ozone-depleting substances would be more expensive, and they felt in a poor position to bear such costs.<sup>44</sup> Questions of international equity took center stage. To secure their cooperation, developing countries were of-

### **Box 4.4** **NGOs and efforts to preserve the international environment**

Nonstate actors are playing an increasingly important role in the negotiations surrounding international agreements. Groups such as nongovernmental organizations (NGOs) often make an enormous contribution by serving as conduits for information on the environmentally damaging activities of countries and governments.

The Montreal Protocol negotiations were open to representatives from NGOs representing business and science. The World Meteorological Organization, with the United Nations Environment Programme (UNEP), played an important role in presenting numerous reports by the scientific community that illustrated the linkages between chlorine- and bromine-containing substances and ozone depletion.<sup>45</sup> Outside the formal negotiating process, Friends of the Earth UK led a boycott of CFC aerosol products that lasted until 1987. The boycott resonated with the public and put pressure on the U.K. government to push for a strong treaty.

NGOs are also essential players in efforts to support best environmental practices and to discourage unsustainable behavior. *World Development Report 1998/99* cited the role of the West African Newsmedia and Development Center, a regional NGO based in Benin, in disseminating environmental information through print and broadcast media.<sup>46</sup> NGOs are also working with industry to create and advertise standards for areas such as fishing and forestry. NGOs and representatives from the timber trade and forestry profession have formed the Forest Stewardship Council, an international association aimed at promoting sustainable forestry practices. The council's international labeling scheme for forest products provides a credible guarantee that the products bearing the labels come from forests meeting the standards laid out in the council's Principles and Criteria for Forest Stewardship.

ferred a grace period of exclusion from controls on chlorine and bromine ozone-depleting substances. They would also have access to a fund set up to cover adjustment costs and finance technical assistance.<sup>47</sup> The initial fund introduced at the London meeting provided \$160 million (paid for by OECD countries) and an additional \$80 million if China and India signed the protocols.<sup>48</sup>

The Montreal agreement also banned international trade between signatories and nonsignatories of CFCs, products containing CFCs, and CFC technology. The significance of this provision was made clear when the threat of trade sanctions (combined with increased funding from a number of OECD countries and the Global Environment Facility) encouraged Russia to agree to meet its commitments to phase out CFC production by

2000.<sup>49</sup> Payments and trade mechanisms to support compliance, along with flexibility in treaty restrictions, were vital in creating a strong global agreement. But the payments and flexibility were possible and the trade sanctions credible only because eliminating CFCs would provide industrial countries with substantial net benefits. The potential benefits, plus the threat of sanctions gave these countries an incentive to sign the treaties, despite the financial burden the agreements imposed.<sup>50</sup>

Finally, restrictions on CFC production were made as flexible as possible. For example, Japan was reconciled to the treaty despite a high reliance on CFC-113 for cleaning computer chips by a mechanism that set a limit on total production of ozone-depleting chemicals and allowed countries to use any combination of CFCs within their overall limit.<sup>51</sup>

### Climate change

Why have attempts to cut global greenhouse gas emissions been less successful so far than efforts to halt production of ozone-depleting substances? The contrast between the progress that has been made in tackling these two global environmental concerns highlights the importance of a consensus that actions to address the problems have clear net benefits.

### Costs and benefits

At the global level the benefits of stabilizing or reducing carbon emissions are potentially substantial. As noted above, the IPCC estimates that a doubling of carbon dioxide in the atmosphere would result in costs for developing countries equal to 2–9 percent of GDP.<sup>52</sup> The quantifiable costs are lower as a percentage of GDP for industrial countries but are still around 1.0–1.5 percent of GDP. These estimates include only costs that can be easily quantified, omitting the effects of factors (such as species extinction) for which it is hard to assign a monetary value.

While the benefits of controlling greenhouse gases appear lower for industrial countries, estimates of the costs of controlling emissions suggest the reverse—that costs are higher in industrial economies than in developing countries. Holding carbon dioxide output in the United States at 1990 levels until 2010 will reduce the country's GDP by an estimated 0.2–0.7 percent. Lowering output by 20 percent will cost 0.9–2.1 percent of GDP. The costs are certainly far lower for developing countries. One recent study suggests that the cost of re-

ducing carbon dioxide emissions in the Arab Republic of Egypt and Zimbabwe by 20 percent would actually be negative, since the government would only have to remove inefficient subsidies—a net gain.<sup>53</sup>

The benefits of efforts to prevent climate change will become apparent only in the long term, while the costs of such mitigation must be paid today. And while controlling climate change offers potentially significant benefits, the costs of reducing carbon dioxide emissions are also significant—far greater than the costs of controlling ozone-depleting substances. With climate change, then, the costs of prevention are higher and the relative scale of benefits is lower, especially for industrial countries. While mechanisms such as carbon trading will reduce this disparity, it does suggest a reason for the greater political complexity of negotiating strong greenhouse gas accords: unlike the relatively narrow range of activities that affect the ozone layer, the major sources of greenhouse gas production are ubiquitous, including power generation, industrial energy use, transportation, and farming.<sup>54</sup> These activities account for a huge share of global GDP and are deeply entrenched in the production structures of industrial and developing economies alike.

Moreover, much of the technology required to make the switch to cleaner production methods is comparatively expensive, suggesting a greater economic and political burden in technology switching than in the case of ozone-depleting substances. In the long term, renewable energy sources may play a more important role in production, but wind and solar energy are not yet feasible economic substitutes for fossil fuels on a large scale. Even in areas where they are economically feasible today, market distortions and entry barriers limit their use (box 4.5). It should be noted, however, that economic reform and funding for research could make renewable energy sources more attractive.

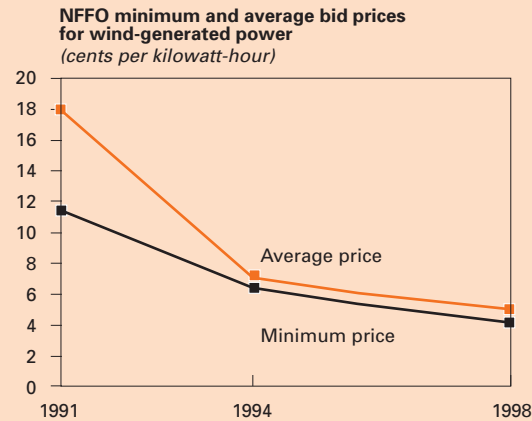
Indeed, increased support for research on new technologies can lower the long-term costs of complying with stricter carbon emissions limits worldwide. Three of the most successful technologies supported by the U.S. Department of Energy—heat-reflecting windows, electronic ballasts for fluorescent lights, and variable-capacity supermarket refrigeration units—are now saving enough energy to justify the department's entire efficiency research budget.<sup>55</sup> Despite such remarkable results, "efficiency and renewables" research received only about 23 percent of the rapidly shrinking U.S.

**Box 4.5****Falling costs for renewable energy**

Renewable energy resources offer enormous potential for producing electricity, particularly in developing countries, which often have an abundant supply of sun, water, wind, biomass, and other energy sources. This potential remains largely untapped, mainly because of lack of familiarity with renewable energy technologies and because of their relatively high up-front costs. But two trends indicate that the future may be brighter for renewable energy sources in developing countries.

First, in certain niche areas, the costs of renewable energy are already competitive with conventional energy resources, even at the low fossil fuel prices of the late 1990s. Conventional power generation has two less costly competitors: mini-hydropower sites and biomass cogeneration facilities. These facilities are located close to population centers or to transmission lines (into which they feed their power). A number of solar photovoltaic systems are feasible for off-grid power generation. These systems are most useful in rural areas far from the main power grid and in sparsely populated areas where low demand makes the cost of extending the grid prohibitive.

Second, it has become clear that creating competitive, market-type conditions significantly reduces the costs of using renewable energy technologies. In Indonesia, once it became known that the World Bank and the GEF would finance a large renewable power project, potential vendors began to cut prices to secure their position in the emerging market. Competition also reduced the costs of wind-generated power under the United Kingdom's Non-Fossil Fuel Obligation (NFFO) scheme. Under the NFFO, renewable energy projects are selected in competitive bidding and receive an output subsidy financed by a levy on electricity generated with fossil fuels that applies to all electricity consumers. By November 1998, five NFFO bidding rounds had taken place. As the figure shows, bid prices—the lowest as well as the average bid—for wind energy de-

**Competition has reduced the cost of wind-generated power in the United Kingdom**

Source: World Bank data.

clined dramatically, falling from an average of around 18 cents per kilowatt-hour in 1991 to 5.1 cents per kilowatt-hour in 1998. (Declining prices for fossil fuels during this period meant that the relative costs of renewable technology fell more slowly.)

Although technological progress is clearly essential to reducing the costs of using renewable energy technologies, sector reform, including the removal of subsidies on fossil fuels and open competition, can also be an important factor. Whether managed, as in the United Kingdom, or spontaneous, as in Indonesia, reform has helped drive technological advance and has encouraged the efficient use of technology.

budget for energy research and development in 1997.<sup>56</sup> Redirected and increased expenditure on research, better coordinated at the international level, is a win-win international response to climate change.

Governments can take several steps to encourage private sector investment in alternative energy research, as well. Early and concrete moves toward carbon emissions limits will push firms to start looking at other energy sources. Turning from subsidizing carbon-based fuels to taxing them instead (or raising such taxes gradually) while offering support for research on alternative energy sources can change incentives. The recent commitment of some of the world's major oil companies to reducing their carbon emissions is a hopeful sign that the early negotiations on greenhouse gases have already encouraged private sector responses that will lower the cost of future emissions compliance. Even so, the chicken-and-egg problem—progress toward energy

alternatives requires emissions treaties, and treaties only happen when costs of agreement are lower—seems likely to plague greenhouse gas negotiations for some time to come.

The long-term approach of reaching an international agreement on reducing greenhouse gas output might include agreements on common policies and measures, such as fuel efficiency standards for cars. But it is also likely to involve negotiating either an internationally coordinated tax or a system of quotas on carbon emissions, which might be tradable between countries. Either approach will face many practical difficulties (box 4.6). This is one more reason that the perceived benefits of treaty making will have to rise far above the costs to create the flexibility needed to sign such a tough agreement.

In short, a number of reasons suggest that coming to an international agreement on greenhouse gas emis-

**Box 4.6****Taxes and quotas to reduce emissions**

Two competing mechanisms are frequently suggested for use in a global agreement on reducing greenhouse gas output. The first, which was used in the Kyoto agreement, sets caps on each country's output of greenhouse gases. Many economists favor auctioning off emissions permits, up to the quantity of the cap, that can be traded both within a country and across national boundaries. The second main approach would involve implementing national carbon taxes at globally agreed levels.

The mechanics of incorporating either approach into an international agreement are complicated, however, because the costs and benefits of reducing greenhouse gases vary considerably across countries. Energy taxes and energy efficiency also differ vastly across countries, raising the question of how to set a baseline for either tax rates or output.

With a globally agreed tax on emissions applied equally, countries with low marginal benefits from emissions would spend more on abatement measures than those with high marginal benefits. While the tax system would also generate healthy revenues for governments (and especially in the developing world, carbon taxes may be more efficient than the present tax regime), an equal tax regime would probably lead developing countries to abate more than those industrial countries with higher marginal costs of abatement. To equalize the pain of reducing output, tax rates might have to vary across countries. But that would create incentives for leakage, with high-polluting industries moving to countries with the lowest tax rather than reducing their greenhouse gas output. A global carbon tax agreement would also have to specify exactly which emissions were to be taxed. Certain emissions, such as those from livestock, paddy fields, and wood-burning stoves, are regarded as largely "untaxable." These types of emissions differ dramatically across countries, which adds to the difficulties of allowing certain activities to be exempt from an emissions tax. Finally, nations would have to agree whether the emissions taxes would be kept by each nation or shared to some extent across nations.

Under a global binding agreement on national emissions levels, the added flexibility of being able to negotiate national

quotas could allow a more equitable distribution of the costs of treaty compliance than a tax agreement. Quotas could also be used to transfer resources from industrial to developing countries. This "cap and trade" system does present problems, however. Assigning quota allocations is not a simple process. For example, the Kyoto Protocol is based on the assumption that countries will make broadly similar percentage reductions, starting from 1990 levels. Future, more encompassing agreements will have difficulty with the assumption of broadly equal reductions from treaty-start levels; developing countries will find such reductions unacceptable because they expect to consume more energy as they develop. A mixed approach would be needed that sets quotas according to several factors, including present absolute output, output per capita, and level of development. Quotas could also be based on a target rate of improvement in energy intensity (use of energy per unit of GDP). Further problems remain, however:

- If developing countries are to be enticed into the system, the net quota trade would need to run from the developing to the industrial world, which creates the potential for large economic transfers. The political viability of this transfer mechanism is questionable, however, since transfers would be made without regard to the political and economic activities of recipient countries.<sup>57</sup>
- What has been termed the problem of "low-hanging fruit" might also affect the carbon-trading mechanisms proposed at Kyoto. This arises when developing countries have traded away the cheapest methods of reducing carbon emissions, and have to pay for more costly measures in order to meet their international obligations.
- Certifying that countries have met their obligations is likely to prove a major challenge, both in enforcing the Kyoto agreements and beyond. As has been mentioned, many activities contribute in some way to climate change. And issues such as how to measure carbon sequestration (if that is to be included as part of the treaty mechanism) are still far from settled.

sions as comprehensive as those on ozone will be a much more complex task. And it is not surprising that in many developing countries there are mixed feelings about controlling emissions. The Alliance of Small Island States (AOSIS) and some other low-lying countries such as Bangladesh give the most urgent priority to curbing climate change, for understandable reasons. A 1-meter increase in the sea level would force about 70 million people to move and would have a dramatic effect on food security in Bangladesh (figure 4.3). But even most developing countries would still rank such activities as burning forests for agriculture (releasing carbon dioxide and removing a carbon sink), raising livestock and growing rice (releasing methane), and

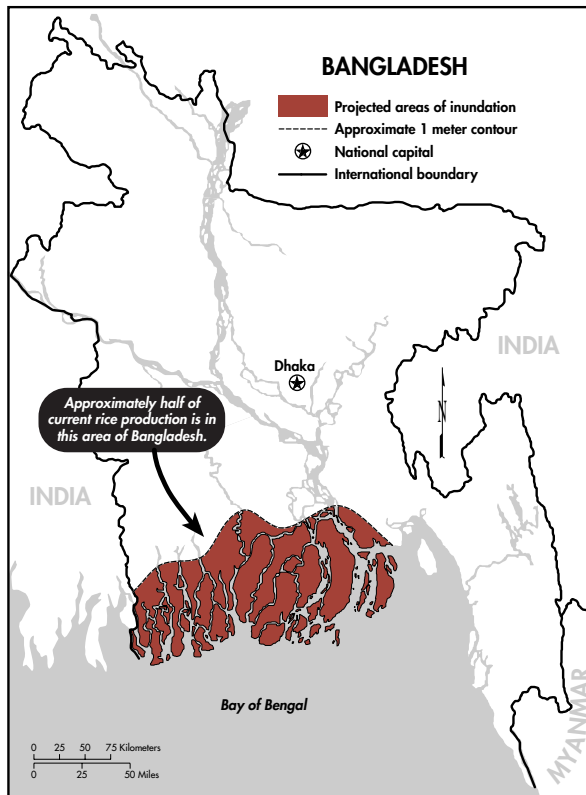
burning fossil fuels (releasing carbon dioxide) as more beneficial social priorities than reducing emissions of greenhouse gases. Thus while the AOSIS, for example, has adopted unilateral carbon abatement measures, until the coalition is larger, this first step is unlikely to translate into stronger multilateral accords.<sup>58</sup> Nonetheless, the world is moving toward increased global cooperation on climate change.

***Increasing participation***

Industrial countries are responsible for most of the increase in man-made greenhouse gases in the atmosphere. But before the middle of the next century, energy consumption in developing countries is projected



**Figure 4.3**  
A 1-meter rise in sea level would cut Bangladesh's rice production approximately in half

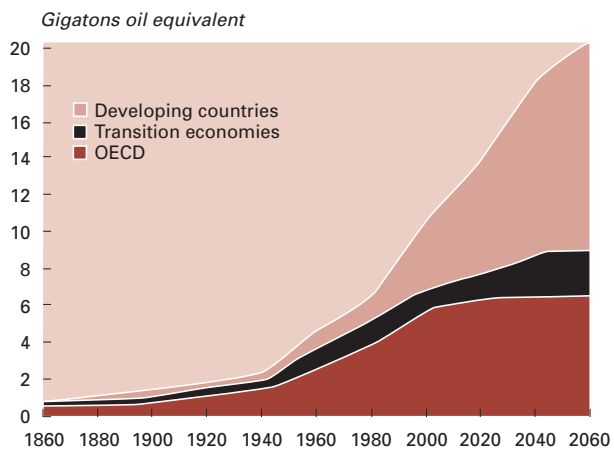


Source: World Bank 1998f.

to be more than twice that of OECD countries, even though per capita consumption will remain much lower, as it is now (figures 4.4 and 4.5). Developing countries must be included in global greenhouse gas agreements, both because of the likelihood that they will someday bear the responsibility for most greenhouse gas emissions and because without their cooperation, any progress could be offset by leakages to developing countries (box 4.6). For example, if a steel plant tries to avoid emissions limits by moving its operations from a relatively energy-efficient industrial country to an energy-inefficient country not covered by an agreement, total greenhouse gas output could rise.<sup>59</sup>

But although drawing developing countries into binding agreements on greenhouse gas emissions is vital, industrial countries are still expected to take the lead on such an agreement, for several reasons:

**Figure 4.4**  
Energy consumption in developing countries is forecast to outstrip industrial country consumption



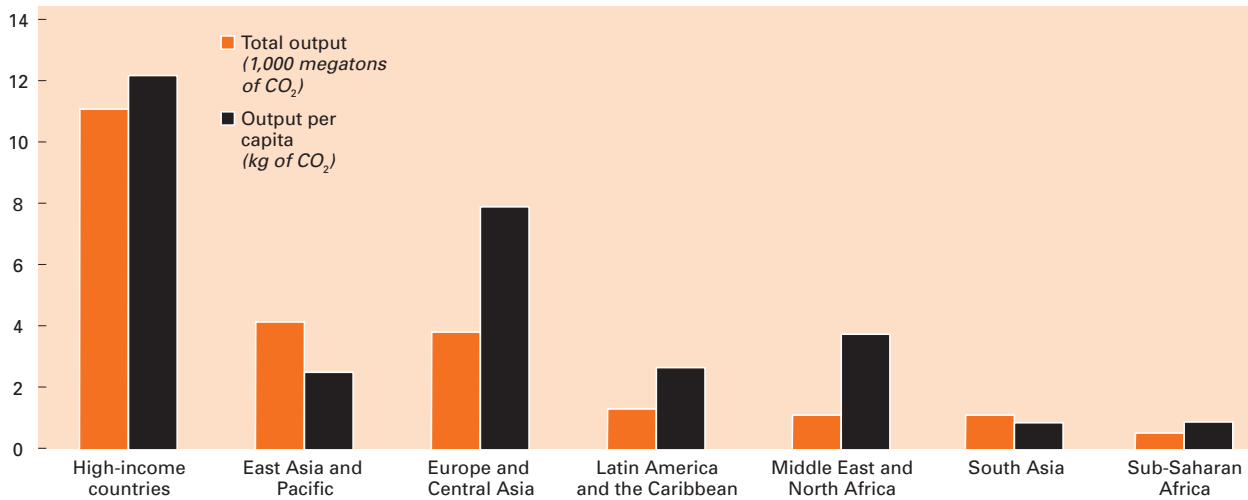
Note: Data for the period 2000–2060 show a scenario of future energy consumption based on current trends.

Source: World Energy Council; World Bank.

- Current and historical emissions of greenhouse gases in developing countries are much lower than in either industrial or transition economies. Per capita emissions are also likely to remain lower for the foreseeable future.
- Industrial countries have greater economic, technical, and institutional capacity to address the issue.
- The imperatives of social and economic development argue for increasing energy use in developing countries.

The Kyoto Protocol encompasses transition economies and involves developing countries through a system of limited and voluntary cooperation. Industrial countries can meet their commitments for lower emissions not only by reducing emissions within their countries but also by trading obligations with countries that have committed to targets or by funding emissions reduction projects in developing countries. For transition economies that have agreed to emissions targets, the treaty allows for commitment trading, while the Joint Implementation scheme enables industrial countries to acquire emissions trading permits in return for supporting emissions reduction projects in those economies.<sup>60</sup> After 2000, the Clean Development Mechanism may allow industrial nations to buy project-based emissions

**Figure 4.5**  
**High-income countries use energy more intensively than countries in low-income regions**



Source: World Bank, *World Development Indicators*, 1998.

rights from developing countries that have not agreed to binding emissions targets, with a portion of the proceeds being used for administration costs and to help particularly vulnerable developing countries meet the costs of adapting to climate change.

These limited trading mechanisms should have a significant effect on the costs of emissions reductions. Estimates vary, but one model suggests that the marginal tax or quota price for the United States to meet the Kyoto target (93 percent of 1990 levels by 2012) would be about 72 percent lower if quota trading were allowed among industrial and transition economies. Adding some key developing countries to the trading network would reduce permit prices even further, to an estimated 12 percent of the autarky price.<sup>61</sup>

The scale of trading—and thus of transfers among countries—is likely to be large. The OECD countries emit about 3 billion tons of carbon a year. The Kyoto agreement alone will reduce the emissions these countries would have produced without the agreement by at least 30 percent. If carbon is valued at \$23 a ton, and only half the reductions are met through quota trading, the global quota market will be worth \$11.5 billion a year—more than the total U.S. aid budget.

In the long term, the Kyoto Protocol's Clean Development Mechanism is not a full solution to the greenhouse gas problem, in part because it does not solve the

problem of leakage. It could also create perverse incentives for carbon trading among industrial and developing countries (see box 4.6). Still, it is an important first step toward global involvement in the reduction of greenhouse gas output.<sup>62</sup> As noted, involving developing countries at some level and as early as possible is very important for controlling future greenhouse gas emissions. The demand for electric power in developing countries is rising rapidly and is projected to climb by up to 300 percent between 1990 and 2010, outpacing by far the 20 percent rise expected in industrial countries.<sup>63</sup> Joint Implementation and the Clean Development Mechanism can be used to ensure that a significant proportion of the projected generating capacity in developing countries is based on low-carbon-dependent technology.<sup>64</sup>

To further the goal of reducing greenhouse gas output in developing countries, the World Bank has begun a series of projects under the pilot phase of Activities Implemented Jointly established at the Rio Summit. The Ilumex project in Monterrey and Guadalajara in Mexico has replaced some 200,000 ordinary incandescent light bulbs with compact fluorescent light bulbs. Because the new bulbs use far less energy than conventional lighting, power stations need to provide less electricity, permanently reducing the demand for fuel. The project should also help Mexico reach its own goals for reduc-

ing emissions of sulfur dioxide and nitrogen oxides. In Burkina Faso a sustainable energy management project will promote solar power systems and kerosene cooking stoves while supporting community-based sustainable forestry management and efficient carbonization techniques. The project will abate more than 300,000 tons of carbon emissions a year for just \$2.5 million, or \$8.30 per ton of carbon.<sup>65</sup>

### **Biodiversity**

The Convention on Biological Diversity signed at the Rio Earth Summit in 1992 has been ratified by 169 countries. Signatories to the convention are obliged to conserve and ensure the sustainable use of their own biological diversity.<sup>66</sup> Those countries with the greatest biodiversity are concentrated in the developing world. Only one of the eight countries that are home to the largest number of native mammal species is industrial. Of the countries with more than 10,000 species of higher plants, 18 out of 20 are developing countries, and 12 of the 17 countries with more than 500 threatened species of higher plants are developing countries.<sup>67</sup> Developing countries are thus key to meeting the goals set at Rio, and the Convention on Biological Diversity was passed with widespread support from these countries.

Like the Framework Convention on Climate Change, the Biodiversity Convention recognized economic and social development as the top priorities for developing countries. It also stated that the extent to which developing country parties would effectively implement their commitments to preserve biodiversity would depend on industrial country commitments related to financial resources and transfer of technology.

### ***The benefits of biodiversity and the costs of preservation***

As we have seen, the ecosystems (and the species) in which genetic material resides provide valuable services at the national level. For this reason, the primary role of international agencies and bilateral support in the area of biodiversity should be to transfer knowledge and provide technical assistance to help overcome national market failures and create national markets for ecological benefits.

The GEF was chosen as the formal interim financing mechanism for the Convention on Biological Diversity. Total GEF financing for biodiversity projects comes to over \$800 million and has already been used to support a range of technical and institutional proj-

ects. In Poland, for example, the Forest Biodiversity Protection Project has provided institutional support to the country's environment ministry, funded pilot investments in air- and soil-monitoring equipment and a forest gene bank, and supported farmers in the Bialowieza Primeval Forest who are making the transition to "ecological agriculture." In Algeria the El Kala National Park and Wetlands Management Project introduced actions to stop degradation within the complex and supported assessment activities that included surveys, studies, and public education programs aimed at bolstering long-term preservation efforts.

While such support may form the backbone of international efforts to preserve biodiversity, the global commons issues connected with existence value and exploitation of genetic resources remain. The economics of these issues is complicated by disagreement on what exactly is being valued—whether it is the right of plants or animals to exist, the material benefits that diversity offers, or the just the pleasure that the existence of many living organisms brings to people. Even basic facts such as the total number of species on earth and the rate of species extinction worldwide are not fully clear. The UNEP's Global Biodiversity Assessment estimates the number of species on the planet at 7 million–20 million and the expected loss of species over the next 25 years at between 140,000 and 5 million. Combining the lower-bound estimates suggests that 2 percent of all species are at risk; combining the upper-bound estimates produces an estimate of 25 percent (although it should be noted that even the lower rate of extinction is approximately 1,000 times the natural rate).<sup>68</sup>

Many of the benefits of preserving genetic material are also difficult to quantify in monetary terms. How is a dollar value to be placed on the rights of organisms to exist or on the pleasure people derive from their existence? Among the more quantifiable benefits is the medicinal use of genetic resources. The United Nations has estimated that medicines originally developed from plant material are worth about \$43 billion a year.<sup>69</sup> The rosy periwinkle from Madagascar's rain forest, for example, provided a rare genetic trait that was used in developing pharmaceuticals to treat childhood leukemia. Two of the drugs one company has developed from this plant have sales worth \$100 million a year. (None of these proceeds, it should be noted, goes to Madagascar.)<sup>70</sup> But even calculating the marginal benefit of the genetic material in a species is no easy task. The drugs

developed from plants must be collected, refined, tested, and developed for the market, and sharing the profits along this value chain is clearly a complex issue. Genetic materials are also likely to be present in more than one species. This fact helps explain why estimates of the marginal value of species existence (put another way, the marginal value of preventing species extinction) are so uncertain. They have been put at anywhere from \$44 to \$23.7 million for an untested species.<sup>71</sup>

### *Expanding participation*

Even if the value of genetic material is hard to estimate, it is certainly true that the international community continues to exploit it without paying—a scenario that constitutes a market failure. As a result, biodiversity may be undervalued in developing countries. An additional mechanism for promoting the preservation of genetic resources would be the extension of property rights to a country's genetic material. This subject was raised at the Convention on Biological Diversity, but no agreement was reached on what should be done about the situation.<sup>72</sup> One model for resource transfer might be that of Costa Rica's private, nonprofit National Biodiversity Institute (INBio), which struck a deal with U.S.-based pharmaceutical firm Merck and Company to help underwrite INBio's biodiversity prospecting plans.<sup>73</sup> The Merck deal will pay INBio \$1.1 million plus royalties for any product Merck develops from Costa Rican resources. In return INBio provides Merck with samples from all over Costa Rica. Ten percent of the up-front money and 50 percent of any royalties are allocated to inventory, bioprospecting, and conservation.<sup>74</sup>

A number of doubts have been raised about such mechanisms. The Costa Rica–Merck agreement, for example, does not involve enough resources to pay for significant increases in protected reserves. The scheme might also not be widely replicable. One recent estimate suggests that even in western Ecuador, one of the areas richest in endemic species, the per-hectare value of genetic material to drug companies is only about \$20.<sup>75</sup> Furthermore, by claiming royalties on products developed from plants and animals that may be found in more than one country, INBio is effectively reducing the incentive of neighboring countries to take similar measures to protect their genetic diversity. This problem is likely to be widespread: the rosy periwinkle was not endemic to Madagascar, for example. Moreover, it is unclear how such a scheme could work to protect areas that

have already been explored for genetic material. Thus, while establishing limited property rights to genetic material may encourage developing countries to participate in preservation efforts, they represent only a partial solution. If industrial countries feel that additional incentives to preserve genetic material are required (to cover, as it might be, the existence value of species, regardless of their economic uses) the simplest method would be to expand direct international support for this purpose.

Biodiversity covers many different activities, including farming, forestry, coral reef protection, and others. This diversity calls for great flexibility in approach toward agreements on different biodiversity issues, at both the regional and global levels.<sup>76</sup> Technical and institutional support and flexible transfer payments are two such approaches. Sanctions have also been used. When biodiverse habitats are exploited in order to produce a tradable good—including tropical fish, tropical timber, and many of the animals covered by the Convention on International Trade in Endangered Species (CITES)—formal trade limits or certification schemes with strong penalties for noncompliance can play an important role. One way to protect coral, for example, might be to ban trade in fish caught by using cyanide, a significant source of coral degradation. Similar incentives have been widely used in a range of environmental treaties. Although questions remain about the risk of overusing trade measures to counter environmental threats (and thus using the environment as an excuse to strangle trade as a wealth-creating force), trade measures can be a very effective method of pursuing environmental goals under some circumstances (box 4.7).

### **Exploiting the links between global environmental problems**

Climate change and biodiversity are not only serious issues in their own right but are also linked with each other and with a wide range of other environmental concerns. Depending on the rate of climate change, forest species may be unable to adapt fast enough to avoid severe population declines.<sup>83</sup> Aquatic ecosystems such as mangroves and coral reefs adapt even more slowly.<sup>84</sup> The loss of species and genetic material can increase the vulnerability of ecosystems to other environmental stresses, such as pollution.<sup>85</sup> To complete the circle, the destruction of forests has a dramatic impact on climate change because forests release significant quantities of carbon dioxide as they burn.<sup>86</sup>

**Box 4.7****Trade measures in international environmental agreements**

The earliest environmental treaty to use trade measures was the International Convention Respecting Measures to be Taken against the *Phylloxera Vastatrix*, which in 1881 banned trade in torn vines and dried shoots to prevent relocating the plant louse to other vineyards.<sup>77</sup> Other environmental agreements with trade measures include:

- CITES, which allows trade in listed species or products made from them with nonparties to the agreement only when competent authorities in the nonparty country issue documentation comparable to that required of treaty members. The convention also allows members to impose trade bans on other members that do not comply with the restrictions. In 1991 the CITES standing committee recommended that all trade with Thailand in flora and fauna species covered by the convention be stopped because of noncompliance.
- The United Nations agreement on the Conservation and Management of Straddling Fish Stocks and Highly Migratory Fish Stocks, which allows members to prohibit the landing or transshipment of fish caught using methods that undermine the effectiveness of conservation and management measures.<sup>78</sup>
- The Montreal Protocol, which requires parties to ban the import of controlled ozone-depleting substances from non-signatories unless the non-signatories are found to be in full compliance with the protocol regime.<sup>79</sup>

Trade measures can be an appropriate tool for addressing global environmental problems because they, like the problem, are global in nature. They can also be justified on the grounds

that free trade is considered a global good because it maximizes welfare. If trade is instead causing serious environmental damage, then, it can be argued, it must be limited. Trade may be especially intertwined with certain environmental risks: damage from relocation; insect infestation of previously unexposed crops from imported infected fruit; negative disposal effects like those posed by imports of toxic waste; negative transport effects such as oil spills; and negative profit effects—as when trade ends up financing a decline in biodiversity.<sup>80</sup>

Three recent international trade rulings suggest that international trade agreements allow little flexibility on the unilateral introduction of environmental trade bans: the WTO's ruling against U.S. laws banning the import of shrimp caught in nets that also trap turtles, and two rulings by the General Agreement on Tariffs and Trade (GATT) dispute panel on tuna caught in nets that also trap dolphins. But the WTO ruling does support the right of states to impose sanctions as part of an international treaty. Distinguishing between unilateral and multilateral trade bans keeps environmental sanctions from being used as a cover for protectionist interests.<sup>81</sup>

Trade bans should also be limited to areas in which they can be effective. The international ivory trade (as well as mismanagement of elephant stocks) must be seen as an important reason for the drastic decline in elephant populations between 1979 and 1989.<sup>82</sup> In situations in which trade is the dominant outlet for production, as it is for ivory, sanctions can have a major effect. Often, however, trade sanctions are too far from the source of the problem to be effective—which might limit the effectiveness of trade bans to counter greenhouse gas emissions.

Exploiting such links can greatly reduce the cost of environmental protection. For example, whether land use activities should be eligible under the Clean Development Mechanism is an issue being decided by the parties to the Kyoto Protocol. But counting the preservation of developing country carbon sinks against emissions commitments could provide powerful synergies with local environmental and biodiversity protection needs.<sup>87</sup>

Costa Rica has already begun trading Certified Tradable Offsets (CTOs)—carbon credits priced at \$10 a ton—in ways that exploit such links. The profits from these credits are designed to support sustainable forestry practices on private land or to finance the conservation of land as national parks and bioreserves.<sup>88</sup> So far, sustainable practices have been introduced on 3,000 farms covering 150,000 hectares. The bioreserve project has conserved another 530,000 hectares.<sup>89</sup> Although there have been few early takers for the credits, Costa Rica's experiences with the system, combined with continued

international research, could lead to greater exploitation of this synergy between biodiversity preservation and the prevention of climate change.

These links across global environmental issues suggest that the international community needs to move beyond simply negotiating separate agreements for each environmental issue. As agreements such as CITES demonstrate, treaties are often agreed to only because complex problems are broken up into smaller units. But in some cases, agreements that cover many areas are easier to negotiate because of the potential for trade-offs or synergies between related issues. This pattern has prevailed in multilateral trade negotiations, for example, when countries that feel strongly about certain provisions have offered concessions in areas that concern them less. Global environmental protection can also be hastened by improving coordination between treaty and convention secretariats, including integration of meetings, scientific assessments, reporting require-



ments, publicity, training, and capacity-building efforts and improved coordination under the UNEP.

• • •

The world's countries have come far in cooperating to address global environmental issues, and the ozone accords provide a model for future agreements. Although drawing up international agreements on biodiversity and climate change that are as effective as the ozone agreements has been difficult, the basic mechanics of successful international environmental agreements are

becoming clearer. Moreover, even taking preliminary steps toward a partial agreement encourages private actors to prepare for stricter agreements and thus lowers the cost of future actions to resolve environmental concerns. Consensus on biodiversity, climate change, and other global environmental issues will only expand over time. Furthermore, the growing understanding of linkages among environmental concerns will create more opportunities to exploit both synergies and trade-offs, helping to foster coalitions that support concerted global action.