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Restoring the Earth

We are dependent on the earth's natural systems for goods, ranging from building materials to seafood, as well as services, ranging from flood control to crop pollination. If croplands are eroding and harvests are shrinking, if water tables are falling and wells are going dry, if grasslands are turning to desert and livestock are dying, we are in trouble. If civilization's environmental support systems continue to decline, eventually civilization itself will follow.

In Chapter 5 we discussed the deforestation, soil erosion, and devastation of Haiti's countryside. After looking at the desperate situation in Haiti, Craig Cox, Executive Director of the U.S.-based Soil and Water Conservation Society, wrote, "I was reminded recently that the benefits of resource conservation—at the most basic level—are still out of reach for many. Ecological and social collapses have reinforced each other in a downward spiral into poverty, environmental degradation, social injustice, disease, and violence." Unfortunately, the situation Cox describes is what lies ahead for more and more countries if we do not restore the earth's health.[1]

Restoring the earth will take an enormous international

effort, one far larger and more demanding than the often-cited Marshall Plan that helped rebuild war-torn Europe and Japan. And such an initiative must be undertaken at wartime speed lest environmental deterioration translate into economic decline and state failure, just as it did for earlier civilizations that violated nature's thresholds and ignored its deadlines.

Protecting and Restoring Forests

Protecting the earth's nearly 4 billion hectares of remaining forests and replanting those already lost are both essential for restoring the earth's health, an important foundation for the new economy. Reducing rainfall runoff and the associated flooding and soil erosion, recycling rainfall inland, and restoring aquifer recharge depend on simultaneously reducing pressure on forests and on reforestation.[2]

There is a vast unrealized potential in all countries to lessen the demands that are shrinking the earth's forest cover. In industrial nations the greatest opportunity lies in reducing the quantity of wood used to make paper, and in developing countries it depends on reducing fuelwood use.

The rates of paper recycling in the top 10 paper-producing countries range widely, from China and Finland on the low end, recycling 33 and 38 percent of the paper they use, to South Korea and Germany on the high end, at 77 and 66 percent. The United States, the world's largest paper consumer, is far behind South Korea, but it has raised the share of paper recycled from roughly one fourth in the early 1980s to 50 percent in 2005. If every country recycled as much of its paper as South Korea does, the amount of wood pulp used to produce paper worldwide would drop by one third.[3]

The use of paper, perhaps more than any other single product, reflects the throwaway mentality that evolved during the last century. There is an enormous possibility for reducing paper use simply by replacing facial tissues, paper napkins, disposable diapers, and paper shopping bags with reusable cloth alternatives.

The largest single demand on trees—the need for fuel—accounts for just over half of all wood removed from forests. Some international aid agencies, including the U.S. Agency for International Development (AID), are sponsoring fuelwood

efficiency projects. One of AID's more promising projects is the distribution of 780,000 highly efficient wood cookstoves in Kenya that not only use far less wood than a traditional stove but also pollute less.[4]

Kenya is also the site of a solar cooker project sponsored by Solar Cookers International. These inexpensive cookers, made from cardboard and aluminum foil and costing $10 each, cook slowly, much like a crockpot. Requiring less than two hours of sunshine to cook a complete meal, they can greatly reduce firewood use at little cost. They can also be used to pasteurize water, thus saving lives.[5]

Over the longer term, developing alternative energy sources is the key to reducing forest pressure in developing countries. Replacing firewood with solar thermal cookers, or even with electric hotplates fed by wind-generated electricity or with some other energy source, will lighten the load on forests.

Despite the high value to society of intact forests, only about 290 million hectares of global forest area are legally protected from logging. An additional 1.4 billion hectares are economically unavailable for harvesting because of geographic inaccessibility or low-value wood. Of the remaining area available for exploitation, 665 million hectares are undisturbed by humans and nearly 900 million hectares are semi-natural and not in plantations.[6]

Forests protected by national decree are often safeguarded not so much to preserve the long-term wood supply capacity as to ensure that they continue to provide invaluable services such as flood control. Countries that provide legal protection for forests often do so after they have suffered the consequences of extensive deforestation. The Philippines, for example, has banned logging in most remaining old-growth and virgin forests largely because the country has become so vulnerable to flooding, erosion, and landslides. The country was once covered by rich stands of tropical hardwood forests, but after years of massive clearcutting, it lost the forest's products as well as its services and became a net importer of forest products.[7]

Although nongovernmental organizations (NGOs) have worked for years to protect forests from clearcutting, sustainable forestry is now seen as another way to protect forests. If only mature trees are felled, and on a selective basis, a forest and its productivity can be maintained in perpetuity. The World Bank has only recently begun to systematically consider sustainable forestry projects. In 1997, the Bank joined forces with the World Wide Fund for Nature to form the Alliance for Forest Conservation and Sustainable Use; by 2005 they had helped designate 55 million hectares of new forest protected areas and certify 22 million hectares of forest. In mid-2005, the Alliance announced a goal of reducing global net deforestation to zero by 2020.[8]

There are several additional forest product certification programs that inform environmentally conscious consumers about the sustainable management of the forest where wood products originate. The most rigorous international program, certified by a group of NGOs, is the Forest Stewardship Council (FSC). Some 88 million hectares of forests in 76 countries are certified by FSC-accredited bodies as responsibly managed. Among the leaders in certified forest area are Canada, with nearly 18 million hectares; Russia, with more than 15 million hectares; Sweden, with 11 million hectares; the United States, with 9 million hectares; and Poland and Brazil, each with close to 5 million hectares.[9]

Forest plantations can reduce pressures on the earth's remaining forests as long as they do not replace old-growth forest. As of 2005, the world had 205 million hectares in forest plantations, an area equal to nearly one third of the 700 million hectares planted in grain. Tree plantations produce mostly wood for paper mills or for wood reconstitution mills. Increasingly, reconstituted wood is substituting for natural wood as the world lumber and construction industries adapt to a shrinking supply of large logs from natural forests.[10]

Production of roundwood (logs) on plantations is estimated at 432 million cubic meters per year, accounting for 12 percent of world wood production. This means that the lion's share, some 88 percent of the world timber harvest, comes from natural forest stands.[11]

Six countries account for 60 percent of tree plantations. China, which has little original forest remaining, is by far the largest, with 54 million hectares of plantations. India and the United States follow, at 17 million hectares each. Russia, Canada, and Sweden are close behind. As tree farming expands, it is shifting geographically to the moist tropics. In contrast to grain

yields, which tend to rise with distance from the equator and the longer summer growing days, tree plantation yields rise with proximity to the equator and year-round growing conditions.[12]

In eastern Canada, the average hectare of forest plantation produces 4 cubic meters of wood per year. In the southeastern United States, where U.S. plantations are concentrated, the yield is 10 cubic meters. But in Brazil, newer plantations may be getting close to 40 cubic meters. While corn yields in the United States are nearly triple those in Brazil, timber yields are the reverse, favoring Brazil by nearly 4 to 1. To satisfy a given demand for wood, Brazil requires only one fourth as much land as the United States, which helps explain why growth in pulp capacity is now concentrated in equatorial regions.[13]

Projections of future growth show that plantations can sometimes be profitably established on already deforested, often degraded, land. They can also come at the expense of existing forests. And there is competition with agriculture as well, since land that is suitable for crops is also good for growing trees. Water scarcity is yet another constraint. Fast-growing plantations require abundant moisture.

Nonetheless, the U.N. Food and Agriculture Organization (FAO) projects that as plantation area expands and yields rise, the harvest could more than double during the next three decades. It is entirely conceivable that plantations could one day satisfy most of the world's demand for industrial wood, thus helping to protect the world's remaining forests.[14]

Reed Funk, professor of plant biology at Rutgers University, believes the vast areas of deforested land can be used to grow trillions of trees bred for food (mostly nuts), fuel, and other purposes. Funk sees nuts used to supplement meat as a source of high-quality protein in developing-country diets. He also sees trees grown on this deforested land being converted into ethanol for automotive fuel.[15]

Historically, some highly erodible agricultural land in industrial countries has been reforested by natural regrowth. Such is the case for New England in the United States. Settled early by Europeans, this geographically rugged region was suffering from cropland productivity losses because soils were thin and the land was rocky, sloping, and vulnerable to erosion. As highly productive farmland opened up in the Midwest and the Great

Plains during the nineteenth century, pressures on New England farmland lessened, permitting cropped land to return to forest. New England's forest cover has increased from a low of roughly one third two centuries ago to four fifths today, slowly regaining its original health and diversity.[16]

A somewhat similar situation exists now in parts of the former Soviet Union and in several East European countries. As central planning was replaced by market-based agriculture in the early 1990s, unprofitable marginal land was abandoned. Precise figures are difficult to come by, but millions of hectares of farmland are now returning to forest.[17]

South Korea is in many ways a reforestation model for the rest of the world. When the Korean War ended, half a century ago, the mountainous country was largely deforested. Beginning around 1960, under the dedicated leadership of President Park Chung Hee, the South Korean government launched a national reforestation effort. Relying on the formation of village cooperatives, hundreds of thousands of people were mobilized to dig trenches and to create terraces for supporting trees on barren mountains. Se-Kyung Chong, researcher at the Korea Forest Research Institute, writes, "The result was a seemingly miraculous rebirth of forests from barren land."[18]

Today forests cover 65 percent of the country, an area of roughly 6 million hectares. While driving across South Korea in November 2000, it was gratifying for me to see the luxuriant stands of trees on mountains that a generation ago were bare. We can reforest the earth![19]

In Turkey, a mountainous country largely deforested over the millennia, a leading environmental group, TEMA (Türkiye Erozyona Mücadele, Agaclandirma) has made reforestation its principal activity. Founded by two prominent Turkish businessmen, Hayrettin Karuca and Nihat Gokyigit, TEMA launched in 1998 a 10-billion-acorn campaign to restore tree cover and reduce runoff and soil erosion. During the years since, 850 million oak acorns have been planted. The program is also raising national awareness of the services that forests provide.[20]

On the other side of the world, in Niger, farmers faced with severe drought and desertification in the 1980s began leaving some emerging acacia tree seedlings in their fields as they prepared the land for crops. As these trees matured they slowed

wind speeds, thus reducing soil erosion. The acacia, a legume, fixes nitrogen, thus enriching the soil and helping to raise crop yields. During the dry season the leaves and pods provide fodder for livestock. The trees also supply firewood.[21]

This approach of leaving 20–150 seedlings per hectare to mature on some 3 million hectares has revitalized farming communities in Niger. Assuming an average of 40 trees per hectare reach maturity, this comes to 120 million trees. This practice also has been central to reclaiming 250,000 hectares of abandoned land. The key to this success story was the shift in tree ownership from the state to individual farmers, giving them the responsibility for protecting the trees.[22]

Shifting subsidies from building logging roads to planting trees would help protect forest cover worldwide. The World Bank has the administrative capacity to lead an international program that would emulate South Korea's success in blanketing mountains and hills with trees.

In addition, FAO and the bilateral aid agencies can work with individual farmers in national agroforestry programs to integrate trees wherever possible into agricultural operations. Well-chosen, well-placed trees provide shade, serve as windbreaks to check soil erosion, and can fix nitrogen, reducing the need for fertilizer.

Reducing wood use by developing more-efficient wood stoves and alternative cooking fuels, systematically recycling paper, and banning the use of throwaway paper products all lighten pressure on the earth's forests. But a global reforestation effort cannot succeed unless it is accompanied by the stabilization of population. With such an integrated plan, coordinated country by country, the earth's forests can be restored.

Conserving and Rebuilding Soils

In reviewing the literature on soil erosion, references to the "loss of protective vegetation" occur again and again. Over the last half-century, we have removed so much of that protective cover by clearcutting, overgrazing, and overplowing that we are fast losing soil accumulated over long stretches of geological time. Preserving the biological productivity of highly erodible cropland depends on planting it in grass or trees before it becomes wasteland.

The 1930s Dust Bowl that threatened to turn the U.S. Great Plains into a vast desert was a traumatic experience that led to revolutionary changes in American agricultural practices, including the planting of tree shelterbelts (rows of trees planted beside fields to slow wind and thus reduce wind erosion) and strip-cropping, the planting of wheat on alternate strips with fallowed land each year. Strip-cropping permits soil moisture to accumulate on the fallowed strips, while the alternating planted strips reduce wind speed and hence erosion on the idled land.[23]

In 1985, the U.S. Congress, with strong support from the environmental community, created the Conservation Reserve Program (CRP) to reduce soil erosion and control overproduction of basic commodities. By 1990 there were some 14 million hectares (35 million acres) of highly erodible land with permanent vegetative cover under 10-year contracts. Under this program, farmers were paid to plant fragile cropland to grass or trees. The retirement of 14 million hectares under the CRP, together with the use of conservation practices on 37 percent of all cropland, reduced U.S. soil erosion from 3.1 billion tons to 1.9 billion tons during the 15 years between 1982 and 1997. The U.S. approach offers a model for the rest of the world.[24]

Another tool in the soil conservation toolkit—and a relatively new one—is conservation tillage, which includes both no-till and minimum-tillage. Instead of the traditional cultural practices of plowing land, discing or harrowing it to prepare the seedbed, and then using a mechanical cultivator to control weeds in row crops, farmers simply drill seeds directly through crop residues into undisturbed soil, controlling weeds with herbicides. The only soil disturbance is the narrow slit in the soil surface where the seeds are inserted, leaving the remainder of the soil undisturbed, covered by crop residues and thus resistant to both water and wind erosion. In addition to reducing erosion, this practice helps retain water, raises soil carbon content, and reduces energy use.[25]

In the United States, where farmers during the 1990s were required to implement a soil conservation plan on erodible cropland to be eligible for commodity price supports, the no-till area went from 7 million hectares in 1990 to 25 million hectares in 2004. Now widely used in the production of corn and soybeans, no-till has spread rapidly in the western hemisphere, cov-

ering 25 million hectares in 2006 in Brazil, 20 million hectares in Argentina, and 13 million in Canada. Australia, with 9 million hectares, rounds out the five leading no-till countries.[26]

Once farmers master the practice of no-till, its use can spread rapidly, particularly if governments provide economic incentives or require farm soil conservation plans for farmers to be eligible for crop subsidies. Recent FAO reports describe the early growth in no-till farming over the last few years in Europe, Africa, and Asia.[27]

Other approaches are being used to halt soil erosion and desert encroachment on cropland. Algeria, trying to halt the northward advance of the Sahara Desert, announced in December 2000 that it was concentrating its orchards and vineyards in the southern part of the country, hoping that these perennial plantings will halt the desertification of its cropland. In July 2005, the Moroccan government, responding to severe drought, announced that it was allocating $778 million to cancel farmers' debts and to convert cereal-planted areas into less vulnerable olive and fruit orchards.[28]

Sub-Saharan Africa faces a similar situation, with the desert moving southward all across the Sahel, from Senegal on the west coast to Djibouti on the east coast. Countries are concerned about the growing displacement of people as grasslands and croplands turn to desert. As a result, the African Union has launched the Green Wall Sahara Initiative. This plan, originally proposed by Olusegun Obasanjo when he was President of Nigeria, calls for the planting of 300 million trees on 3 million hectares of land, in a long band stretching across Africa. Senegal, which is currently losing 50,000 hectares of productive land each year, would anchor the green wall on the western end. Senegal's Environment Minister Modou Fada Diagne says, "Instead of waiting for the desert to come to us, we need to attack it."[29]

China is likewise planting a belt of trees to protect land from the expanding Gobi Desert. This green wall, a modern version of the Great Wall, is projected to reach some 4,480 kilometers (2,800 miles) in length, stretching from outer Beijing through Inner Mongolia. In addition to its Great Green Wall, China is paying farmers in the threatened provinces to plant their cropland in trees. The goal is to plant trees on 10 million hectares of grainland, easily one tenth of China's current grainland area.[30]

In Inner Mongolia (Nei Monggol), efforts to halt the advancing desert and to reclaim the land for productive uses rely on planting desert shrubs to stabilize the sand dunes. And in many situations, sheep and goats have been banned entirely. In Helin County, south of the provincial capital of Hohhot, the planting of desert shrubs on abandoned cropland has now stabilized the soil on the county's first 7,000-hectare reclamation plot. Based on this success, the reclamation effort is being expanded.[31]

The Helin County strategy centers on replacing the large number of sheep and goats with dairy cattle, increasing the number of dairy animals from 30,000 in 2002 to 150,000 by 2007. The cattle are kept within restricted areas, feeding on cornstalks, wheat straw, and the harvest from a drought-tolerant forage crop resembling alfalfa, which is grown on reclaimed land. Local officials estimate that this program will double incomes within the county during this decade.[32]

To relieve pressure on the country's rangelands, Beijing is asking herders to reduce their flocks of sheep and goats by 40 percent. But in communities where wealth is measured in livestock numbers and where most families are living in poverty, such cuts are not easy or, indeed, likely, unless alternative livelihoods are offered to pastoralists along the lines proposed in Helin County.[33]

The only viable way to eliminate overgrazing on the two fifths of the earth's land surface classified as rangelands is to reduce the size of flocks and herds. Not only do the excessive numbers of cattle, and particularly sheep and goats, remove the vegetation, but their hoofs pulverize the protective crust of soil that is formed by rainfall and that naturally checks wind erosion. In some situations, the only viable option is to keep the animals in restricted areas, bringing the forage to them. India, which has successfully adopted this practice for its thriving dairy industry, is the model for other countries.[34]

Protecting the earth's soil also warrants a worldwide ban on the clearcutting of forests in favor of selective harvesting, simply because with each clearcut there are heavy soil losses until the forest regenerates. Thus with each subsequent cutting, productivity declines further. Restoring the earth's tree and grass cover, as well as practicing conservation agriculture, protects soil from erosion, reduces flooding, and sequesters

carbon. It is one way we can restore the earth so that it can support the next generation.

Regenerating Fisheries

For decades governments tried to save specific fisheries by restricting the catch of individual species. Sometimes this worked; sometimes it failed and fisheries collapsed. In recent years, support for another approach—the creation of marine reserves or marine parks—has been gaining momentum. These reserves, where fishing is restricted, serve as natural hatcheries, helping to repopulate the surrounding area.

In 2002, at the World Summit on Sustainable Development in Johannesburg, coastal nations pledged to create national networks of marine parks, which together could constitute a global network of such parks. At the World Parks Congress in Durban in 2003, delegates recommended protecting 20–30 percent of each marine habitat from fishing. This would be up from 0.6 percent of the oceans that are currently included in marine reserves of widely varying size. It compares with the nearly 13 percent of the earth's land area that is in parks.[35]

A U.K. team of scientists led by Dr. Andrew Balmford of the Conservation Science Group at Cambridge University analyzed the costs of operating marine reserves on a large scale based on data from 83 relatively small, well-managed reserves. They concluded that managing reserves that covered 30 percent of the world's oceans would cost $12–14 billion a year. This did not take into account the likely additional income from recovering fisheries, which would reduce the actual cost.[36]

At stake in the creation of a global network of marine reserves is the protection and possible increase of an annual oceanic fish catch worth $70–80 billion. Balmford said, "Our study suggests that we could afford to conserve the seas and their resources in perpetuity, and for less than we are now spending on subsidies to exploit them unsustainably."[37]

Coauthor of the U.K. study, Callum Roberts of the University of York, noted: "We have barely even begun the task of creating marine parks. Here in Britain a paltry one-fiftieth of one percent of our seas is encompassed by marine nature reserves and only one-fiftieth of their combined area is closed to fishing." Still the seas are being devastated by unsustainable fishing,

pollution, and mineral exploitation. The creation of the global network of marine reserves—"Serengetis of the seas," as some have dubbed them—would create more than 1 million jobs. Roberts went on to say, "If you put areas off limits to fishing, there is no more effective way of allowing things to live longer, grow larger, and produce more offspring."[38]

Jane Lubchenco, former President of the American Association for the Advancement of Science, strongly underlined Roberts' point when releasing a statement signed by 161 leading marine scientists calling for urgent action to create the global network of marine reserves. Drawing on the research on scores of marine parks, she said: "All around the world there are different experiences, but the basic message is the same: marine reserves work, and they work fast. It is no longer a question of whether to set aside fully protected areas in the ocean, but where to establish them."[39]

The signatories noted how quickly sea life improves once the reserves are established. A case study of a snapper fishery off the coast of New England showed that fishers, though they violently opposed the establishment of the reserve, now champion it because they have seen the local population of snapper increase 40-fold. In a study in the Gulf of Maine, all fishing methods that put ground fish at risk were banned within three marine reserves totaling 17,000 square kilometers. Unexpectedly, scallops flourished in this undisturbed environment, and their populations increased by up to 14-fold within five years. This population buildup within the reserves also greatly increased the scallop population outside the reserves. The 161 scientists noted that within a year or two of establishing a marine reserve, population densities increased 91 percent, average fish size went up 31 percent, and species diversity rose 20 percent.[40]

While the creation of marine reserves is clearly the overriding priority in the long-standing effort to protect marine ecosystems, other measures are also required. One is to reduce the nutrient flows from fertilizer runoff and untreated sewage that create the world's 200 or so dead zones.[41]

In the end, governments need to eliminate fishery subsidies. There are now so many fishing trawlers that their catch potential is nearly double any yield the oceans can sustain. Managing

a network of marine reserves governing 30 percent of the oceans would cost only $12–14 billion—less than the $22 billion in harmful subsidies that governments dole out today to fishers.[42]

Protecting Plant and Animal Diversity

The two steps essential to protecting the earth's extraordinary biological diversity are the stabilization of both the human population and the earth's climate. If the world's population increases to 9 billion by mid-century as projected, countless more plant and animal species may simply be crowded off the planet. If carbon dioxide levels and temperatures continue to rise, every ecosystem will change.

One reason for our goal of stabilizing population at 8 billion by 2040 is to protect the earth's rich diversity of life. As it becomes more difficult to raise land productivity, continuing population growth will force farmers to clear ever more tropical forests in the Amazon and Congo basins and the outer islands of Indonesia.[43]

Water management at a time of growing water shortages is a key to protecting fresh water and marine species. When rivers are drained dry to satisfy growing human needs for irrigation and for urban water, fish species cannot survive.

Perhaps the best known and most popular way of trying to protect plant and animal species is to create reserves. Millions of square kilometers have been set aside as parks. Indeed, some 13 percent of the earth's land area is now included in parks and nature preserves. With more resources for enforced protection, some of these parks in developing countries that now exist only on paper could become a reality.[44]

Some 20 years ago, Norman Myers and other scientists conceived the idea of biodiversity "hotspots"—areas that were especially rich biologically and thus deserving of special protection. The 34 hotspots identified once covered nearly 16 percent of the earth's land surface but, largely because of habitat destruction, they now cover less than 3 percent. Concentrating preservation efforts in these biologically rich regions is now a common strategy among conservation groups and governments.[45]

In 1973 the United States enacted the Endangered Species Act. This legislation prohibited any activities, such as clearing

new land for agriculture and housing developments or draining wetlands, that would threaten an endangered species. There are numerous species in the United States, such as the bald eagle, that might now be extinct had it not been for this legislation. And now this act is seen by some conservationists as a potential leverage point in battling global warming because of the need to protect species particularly threatened by warmer temperatures, including coral and polar bears.[46]

The traditional approach to protecting biological diversity by building a fence around an area and calling it a park or nature preserve is no longer sufficient. If we cannot stabilize human numbers and stabilize the climate, there is not an ecosystem on earth that we can save.

As a species, humans have an enormous influence on the habitability of the planet for the millions of other species with which we share it. This influence brings with it responsibility.

Planting Trees to Sequester Carbon

As of 2007, the shrinking forests in the tropical regions were releasing 2.2 billion tons of carbon per year. Meanwhile, expanding forests in the temperate regions were absorbing 0.7 billion tons of carbon annually. On balance, a net of some 1.5 billion tons of carbon were being released into the atmosphere each year, contributing to global warming.[47]

The tropical deforestation in Asia is driven primarily by the fast-growing demand for timber. In Latin America, by contrast, it is the growing demand for soybeans and beef that is deforesting the Amazon. In Africa, it is mostly the gathering of fuelwood and the clearing of new land for agriculture as existing cropland is degraded and abandoned. Two countries, Indonesia and Brazil, account for more than half of all deforestation. The Democratic Republic of the Congo, also high on the list, is a failing state, making forest management difficult.[48]

The Plan B goals are to end net deforestation worldwide and to sequester carbon through a variety of tree planting initiatives and the adoption of improved agricultural land management practices. Today, because the earth's forests are shrinking, they are a major source of CO_2. The goal is to expand the earth's tree cover, growing more trees to soak up CO_2.

Although banning deforestation may seem farfetched, envi-

ronmental reasons have pushed three countries—Thailand, the Philippines, and China—to implement complete or partial bans on logging. All three bans were imposed following devastating floods and mudslides resulting from the loss of forest cover. After suffering record losses from several weeks of nonstop flooding in the Yangtze River basin, Beijing noted that when forest policy was viewed not through the eyes of the individual logger but through those of society as a whole, it simply did not make economic sense to continue deforesting. The flood control service of trees standing, they said, was three times as valuable as the timber from trees cut. With this in mind, Beijing then took the unusual step of paying the loggers to become tree planters—to reforest instead of deforest.[49]

Other countries cutting down large areas of trees will also face the environmental effects of deforestation, including flooding. If Brazil's Amazon rainforest continues to shrink, it may also continue to dry out, becoming vulnerable to fire. If the Amazon rainforest disappears, it would be replaced largely by desert and scrub forestland. The capacity of the rainforest to cycle water to the interior, including to the agricultural areas to the south, would be lost. At this point, a fast-unfolding local environmental calamity would become an economic disaster, and because the burning Amazon would release billions of tons of carbon into the atmosphere, it would accelerate global warming.[50]

Just as national concerns about the effects of continuing deforestation eventually eclipsed local interests, now global interests are beginning to eclipse national ones as deforestation has become a major driver of global warming. Deforestation is no longer just a matter of local flooding, but also rising seas worldwide and the many other effects of climate change. Nature has just raised the ante on protecting forests.

Reaching a goal of zero net deforestation will require reducing the pressures to deforest that come from population growth, rising affluence, the construction of ethanol distilleries and biodiesel refineries, and the fast-growing use of paper. Protecting the earth's forests means halting population growth as soon as possible, and, for the earth's affluent residents who are responsible for the growing demand for beef and soybeans that is deforesting the Amazon basin, it means moving down the food chain. A successful deforestation ban may require a ban on the construction of additional biodiesel refineries and ethanol distilleries.

Against this backdrop of growing concern about the forest-climate relationship, a leading Swedish energy firm, Vattenfall, has examined the large-scale potential for foresting wasteland to sequester carbon dioxide. They begin by noting that there are 1.86 billion hectares of degraded land in the world—land that was once forestland, cropland, or grassland—and that half of this, or 930 million hectares, has a decent chance of being profitably reclaimed. Some 840 million hectares of this total are in the tropical regions, where reclamation would mean much higher rates of carbon sequestration. (Every newly planted tree seedling in the tropics removes an average of 50 kilograms of CO_2 from the atmosphere each year during its growth period of 20–50 years, compared with 13 kilograms of CO_2 per year for a tree in the temperate regions.)[51]

Vattenfall estimates that the maximum technical potential of these 930 million hectares is to absorb roughly 21.6 billion tons of CO_2 per year. If, as part of a global climate stabilization strategy, carbon sequestration were valued at $210 per ton of carbon, the company believes that 18 percent of this technical potential could be realized. If so, this would mean planting 171 million hectares of land to trees. This area—larger than that planted to grain in India—would sequester 3.5 billion tons of CO_2 per year, or over 950 million tons of carbon. The total cost of sequestering carbon at $210 per ton would be $200 billion. Spread over a decade, this would mean investing $20 billion a year to give climate stabilization a large and potentially decisive boost. This global forestation plan to remove atmospheric CO_2, most of it put there by industrial countries, would be funded by them. An independent body would be set up to administer, fund, and monitor the vast tree planting initiative.[52]

Aside from the Vattenfall forestation idea, there are already many tree planting initiatives under way that are driven by a range of concerns, from climate change to desert expansion, to soil conservation, to making cities more habitable. These include the worldwide Billion Tree Campaign launched in 2007, urban tree planting initiatives in many cities, the Great Green Wall being planted in China, and the Saharan Green Wall of

Africa, as well as a big push to expand tree plantations within a number of countries.

The Billion Tree Campaign was inspired by Kenyan Nobel laureate Wangari Maathai, who had earlier organized women in Kenya and several nearby countries to plant 30 million trees. The United Nations Environment Programme, which is administering the Billion Tree Campaign, reported as of October 2007 that it had received pledges to plant a total of 1.2 billion trees by year end. Of that total, 431 million already had been planted. Among the leaders are Mexico, which pledged to plant 250 million trees, and Ethiopia, which promised to plant 60 million trees to commemorate its millennium celebration. Senegal signed up for 20 million trees.[53]

Some state and provincial governments have also joined in. In Brazil, the state of Paraná, which launched an effort to plant 90 million trees in 2003 to restore its riparian zones, committed to planting 20 million trees in 2007. Uttar Pradesh, India's most populous state, mobilized 600,000 people to plant 10.5 million trees in a single day in July 2007, planting the trees on farmland, in state forests, and on school grounds. If the goal of 1 billion trees is reached and half of them survive, these trees would sequester 5.6 million tons of carbon per year.[54]

Independent of the Billion Tree Campaign, in September 2007 New Zealand Prime Minister Helen Clark announced an impressive package of steps to cut carbon emissions, including expanding forested area by 250,000 hectares (617,000 acres) by 2020. This would roughly total some 125 million trees, or 30 for each New Zealander.[55]

Many of the world's cities are planting trees. Tokyo, for example, has been planting trees and shrubs on the rooftops of buildings to help offset the urban heat island effect and cool the city. Washington, D.C., is in the early stages of a campaign to greatly restore its tree canopy.[56]

An analysis of the value of planting trees on the streets and in the parks of five western U.S. cities—from Cheyenne, Wyoming, to Berkeley, California—concluded that for every dollar spent on planting and caring for trees, the benefits to the community exceeded two dollars. A mature tree canopy in a city shades buildings and can reduce air temperatures by 5–10 degrees Fahrenheit, thus reducing the energy needed for air conditioning. In cities with severe winters like Cheyenne, the reduction of winter wind speed by evergreen trees cuts heating costs. Real estate values on tree-lined streets are typically 3–6 percent higher than where there are few or no trees.[57]

Planting trees is just one of many activities that will remove meaningful quantities of carbon from the atmosphere. One activity that involves a good use of wasteland is the planting in Africa and Asia of jatropha, a four-foot perennial shrub that produces seeds that can be used to produce biodiesel. This covers wasteland and sequesters carbon.[58]

A number of agricultural practices can also increase the carbon stored as organic matter in soils. Farming practices that reduce soil erosion and raise cropland productivity usually also lead to higher carbon content in the soil. Among these are shifting from conventional tillage to minimum-till and no-till, the more extensive use of cover crops, the return of all livestock and poultry manure to the land, expansion of irrigated area, a return to more mixed crop-livestock farming, and the forestation of marginal farmlands.

Rattan Lal, a Senior Agronomist with the Carbon Management and Sequestration Center at Ohio State University, has calculated the range of potential carbon sequestration for each of many practices, such as those just cited. For example, expanding the use of cover crops to protect soil during the off-season can store from 68 million to 338 million tons of carbon worldwide each year. Calculating the total carbon sequestration for the practices he cites, using the low end of the range for each, shows a potential for sequestering 400 million tons of carbon each year. Aggregating the numbers from the more optimistic high end of the range for each practice yields a total of 1.2 billion tons of carbon per year. For our carbon budget we are assuming, perhaps conservatively, that 600 million tons of carbon can be sequestered as a result of adopting these carbon-sensitive farming and land management practices.[59]

The Earth Restoration Budget

Although we lack detailed data in some cases, we can roughly estimate how much it will cost to reforest the earth, protect topsoil, restore rangelands and fisheries, stabilize water tables, and protect biological diversity. Where data and information are

lacking, we fill in with assumptions. The goal is to have not a set of precise numbers but a set of reasonable estimates for an earth restoration budget. (See Table 8–1.)[60]

Calculating the cost of reforestation is complicated by the range of approaches used. As noted, the big national success story is South Korea, which has reforested its once denuded mountains and hills using locally mobilized labor. Other countries, including China, have tried extensive reforestation, but mostly under more arid conditions and with less success.[61]

In calculating reforestation costs, the focus is on developing countries since forested area is already expanding in the northern hemisphere's industrial countries. Meeting the growing fuelwood demand in developing countries will require an estimated 55 million additional hectares of forested area. Conserving soils and restoring hydrological stability would require roughly another 100 million hectares located in thousands of watersheds in developing countries. Recognizing some overlap between these two, we will reduce the 155 million total to 150 million hectares. Beyond this, an additional 30 million hectares will be needed to produce lumber, paper, and other forest products.[62]

Table 8–1. *Plan B Budget: Additional Annual Funding Needed to Restore the Earth*

Activity	Funding
	(billion dollars)
Planting trees to reduce flooding and conserve soil	6
Planting trees to sequester carbon	20
Protecting topsoil on cropland	24
Restoring rangelands	9
Restoring fisheries	13
Protecting biological diversity	31
Stabilizing water tables	10
Total	113

Source: See endnote 60.

Only a small share of this tree planting will likely come from plantations. Much of the planting will be on the outskirts of villages, along field boundaries and roads, on small plots of marginal land, and on denuded hillsides. The labor for this will be local; some will be paid labor, some volunteer. Much of it will be rural off-season labor. In China, farmers now planting trees where they once planted grain are compensated with grain from state-held stocks over a five-year period while the trees are becoming established.[63]

If seedlings cost $40 per thousand, as the World Bank estimates, and if the typical planting rate is roughly 2,000 per hectare, then seedlings cost $80 per hectare. Labor costs for planting trees are high, but since much of the labor for planting these trees would consist of locally mobilized volunteers, we are assuming a total of $400 per hectare, including both seedlings and labor. With a total of 150 million hectares to be planted over the next decade, this will come to roughly 15 million hectares per year at $400 each for an annual expenditure of $6 billion.[64]

Planting trees to conserve soil, reduce flooding, and provide firewood sequesters carbon. But because climate stabilization is essential, we tally the cost of planting trees for carbon separately. Doing so along the lines proposed by Vattenfall would reforest or afforest 171 million hectares of wasteland over 10 years. Because it would be a more highly commercialized undertaking focused exclusively on wasteland reclamation and carbon sequestration, it would be more costly. Using the value of sequestered carbon of $210 per ton, it would cost close to $20 billion per year. For comparison, this is less than two months of U.S. military spending in Iraq.[65]

Conserving the earth's topsoil by reducing erosion to the rate of new soil formation or below involves two principal steps. One is to retire the highly erodible land that cannot sustain cultivation—the estimated one tenth of the world's cropland that accounts for perhaps half of all excess erosion. For the United States, that has meant retiring 14 million hectares (nearly 35 million acres). The cost of keeping this land out of production is close to $50 per acre or $125 per hectare. In total, annual payments to farmers to plant this land in grass or trees under 10-year contracts approached $2 billion.[66]

The second initiative consists of adopting conservation practices on the remaining land that is subject to excessive erosion—that is, erosion that exceeds the natural rate of new soil formation. This initiative includes incentives to encourage farmers to adopt conservation practices such as contour farming, strip cropping, and, increasingly, minimum-till or no-till farming. These expenditures in the United States total roughly $1 billion per year.[67]

In expanding these estimates to cover the world, it is assumed that roughly 10 percent of the world's cropland is highly erodible and should be planted to grass or trees before the topsoil is lost and it becomes barren land. In both the United States and China, the two leading food-producing countries, which account for a third of the world grain harvest, the official goal is to retire one tenth of all cropland. In Europe, it likely would be much less than 10 percent, but in Africa and the Andean countries it could be substantially higher than that. For the world as a whole, converting 10 percent of cropland that is highly erodible to grass or trees seems a reasonable goal. Since this costs roughly $2 billion in the United States, which represents one eighth of the world cropland area, the total for the world would be roughly $16 billion annually.[68]

Assuming that the need for erosion control practices for the rest of the world is similar to that in the United States, we again multiply the U.S. expenditure by eight to get a total of $8 billion for the world as a whole. The two components together—$16 billion for retiring highly erodible land and $8 billion for adopting conservation practices—give an annual total for the world of $24 billion.[69]

For cost data on rangeland protection and restoration, we turn to the United Nations Plan of Action to Combat Desertification. This plan, which focuses on the world's dryland regions, containing nearly 90 percent of all rangeland, estimates that it would cost roughly $183 billion over a 20-year restoration period—or $9 billion per year. The key restoration measures include improved rangeland management, financial incentives to eliminate overstocking, and revegetation with appropriate rest periods, when grazing would be banned.[70]

This is a costly undertaking, but every dollar invested in rangeland restoration yields a return of $2.50 in income from the increased productivity of the rangeland ecosystem. From a societal point of view, countries with large pastoral populations, where the rangeland deterioration is concentrated, are invariably among the world's poorest. The alternative to action—ignoring the deterioration—brings a loss not only of land productivity but of livelihood, and ultimately leads to millions of refugees. Though not quantified here, restoring this vulnerable land will also have carbon sequestration benefits.[71]

The restoration of oceanic fisheries centers primarily on the establishment of a worldwide network of marine reserves, which would cover roughly 30 percent of the ocean's surface. For this exercise we use the detailed calculations by the U.K. team cited earlier in the chapter. Their estimated range of expenditures centers on $13 billion per year.[72]

For wildlife protection, the bill is somewhat higher. The World Parks Congress estimates that the annual shortfall in funding needed to manage and to protect existing areas designated as parks comes to roughly $25 billion a year. Additional areas needed, including those encompassing the biologically diverse hotspots not yet included in designated parks, would cost perhaps another $6 billion a year, yielding a total of $31 billion.[73]

For stabilizing water tables, we have only a guess. The key to stabilizing water tables is raising water productivity, and for this we have the experience gained when the world started to systematically raise land productivity beginning a half-century ago. The elements needed in a comparable water model are research to develop more water-efficient irrigation practices and technologies, the dissemination of these research findings to farmers, and economic incentives that encourage farmers to adopt and use these improved irrigation practices and technologies.

The area for raising irrigation water productivity is much smaller than that for land productivity. Indeed, only about one fifth of the world's cropland is irrigated. In disseminating the results of irrigation research, there are actually two options today. One is to work through agricultural extension services, which were created to funnel new information to farmers on a broad range of issues, including irrigation. Another possibility is to work through the water users associations that have been formed in many countries. The advantage of the latter is that they are focused exclusively on water.[74]

Effectively managing underground water supplies requires knowledge of the amount of water being pumped and aquifer recharge rates. In most countries this information is simply not available. Finding out how much is pumped may mean installing meters on irrigation well pumps, much as has been done in Jordan and Mexico.[75]

In some countries, the capital needed to fund a program to raise water productivity can come from eliminating subsidies that now often encourage the wasteful use of irrigation water. Sometimes these are energy subsidies, as in India; other times they are subsidies that provide water at prices well below costs, as in the United States. Removing these subsidies will effectively raise the price of water, thus encouraging its more efficient use. In terms of additional resources needed worldwide, including research needs and the economic incentives for farmers to use more water-efficient practices and technologies, we assume it will take additional expenditures of $10 billion.[76]

Altogether, restoring the earth will require additional expenditures of $113 billion per year. Many will ask, Can the world afford this? But the only appropriate question is, Can the world afford to not make these investments?