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# *Natural Systems Under Stress*

In 1938, Walter Lowdermilk, a senior official in the Soil Conservation Service of the U.S. Department of Agriculture (USDA), traveled abroad to look at lands that had been cultivated for thousands of years, seeking to learn how these older civilizations had coped with soil erosion. He found that some had managed their land well, maintaining its fertility over long stretches of history, and were thriving. Others had failed to do so and left only remnants of their illustrious pasts.<sup>1</sup>

In a section of his report entitled “The Hundred Dead Cities,” he described a site in northern Syria, near Aleppo, where ancient buildings were still standing in stark isolated relief, but they were on bare rock. During the seventh century, the thriving region had been invaded, initially by a Persian army and later by nomads out of the Arabian Desert. In the process, soil and water conservation practices used for centuries were abandoned. Lowdermilk noted, “Here erosion had done its worst....if the soils had remained, even though the cities were destroyed and the populations dispersed, the area might be re-peopled again and the cities rebuilt, but now that the soils are gone, all is gone.”<sup>2</sup>

Now fast-forward to a trip in 2002 by a U.N. team to assess the food situation in Lesotho, a small country of 2 million people embedded within South Africa. Their finding was straightforward: “Agriculture in Lesotho faces a catastrophic future; crop production is declining and could cease altogether over large tracts of the country if steps are not taken to reverse soil erosion, degradation, and the decline in soil fertility.” Michael Grunwald reported in the *Washington Post* that nearly half of the children under five in Lesotho are stunted physically. “Many,” he wrote, “are too weak to walk to school.”<sup>3</sup>

Whether the land is in northern Syria, Lesotho, or elsewhere, the health of the people living on it cannot be separated from the health of the land itself. A large share of the world’s 862 million hungry people live on land with soils worn thin by erosion.<sup>4</sup>

Mercilessly expanding human demands are putting stresses on forests, rangelands, and fisheries that they cannot withstand. We are also destroying many of the plant and animal species with which we share the planet. Worldwide, species are now disappearing at 1,000 times the rate at which new species evolve. We have put the extinction clock on fast-forward.<sup>5</sup>

### Shrinking Forests: The Many Costs

In early December 2004, Philippine President Gloria Macapagal Arroyo “ordered the military and police to crack down on illegal logging, after flash floods and landslides, triggered by rampant deforestation, killed nearly 340 people,” according to news reports. Fifteen years earlier, in 1989, the government of Thailand announced a nationwide ban on tree cutting following severe flooding and the heavy loss of life in landslides. And in August 1998, following several weeks of record flooding in the Yangtze River basin and a staggering \$30 billion worth of damage, the Chinese government banned all tree cutting in the upper reaches of the basin. Each of these governments had belatedly learned a costly lesson, namely that services provided by forests, such as flood control, may be far more valuable to society than the lumber in those forests.<sup>6</sup>

At the beginning of the twentieth century, the earth’s forested area was estimated at 5 billion hectares. Since then it has shrunk to just under 4 billion hectares, with the remaining forests rather evenly divided between tropical and subtropical

forests in developing countries and temperate/boreal forests in industrial countries.<sup>7</sup>

Since 1990, the developing world has lost some 13 million hectares of forest a year. This loss of about 3 percent each decade is an area roughly the size of Greece. Meanwhile, the industrial world is actually gaining an estimated 5.6 million hectares of forestland each year, principally from abandoned cropland returning to forests on its own and from the spread of commercial forestry plantations. Thus, net forest loss worldwide exceeds 7 million hectares per year.<sup>8</sup>

Unfortunately, even these official data from the U.N. Food and Agriculture Organization (FAO) do not reflect the gravity of the situation. For example, tropical forests that are clearcut or burned off rarely recover. They simply become wasteland or at best scrub forest, yet they still may be counted as “forest” in official forestry numbers. Plantations, too, count as forest area, yet they also are a far cry from the old-growth forest they sometimes replace.

The World Resources Institute (WRI) reports that of the forests that do remain standing, “the vast majority are no more than small or highly disturbed pieces of the fully functioning ecosystems they once were.” Only 40 percent of the world’s remaining forest cover can be classified as frontier forest, which WRI defines as “large, intact, natural forest systems relatively undisturbed and big enough to maintain all of their biodiversity, including viable populations of the wide-ranging species associated with each type.”<sup>9</sup>

Pressures on forests continue to mount. Use of firewood, paper, and lumber is expanding. Of the 3.5 billion cubic meters of wood harvested worldwide in 2005, just over half was used for fuel. In developing countries, fuelwood accounts for nearly three fourths of the total.<sup>10</sup>

Deforestation to supply fuelwood is extensive in the Sahelian zone of Africa and the Indian subcontinent. As urban firewood demand surpasses the sustainable yield of nearby forests, the woods slowly retreat from the city in an ever larger circle, a process clearly visible from satellite photographs taken over time. As the circles enlarge, the transport costs of firewood increase, triggering the development of an industry for charcoal, a more concentrated form of energy. March Turnbull

writes in *Africa Geographic Online*: “Every large Sahelian town is surrounded by a sterile moonscape. Dakar and Khartoum now reach out further than 500 kilometers for charcoal, sometimes into neighboring countries.”<sup>11</sup>

Logging for lumber also takes a heavy toll, as is most evident in Southeast Asia and Africa. In almost all cases, logging is done by foreign corporations more interested in maximizing a one-time harvest than in managing for a sustainable yield in perpetuity. Once a country’s forests are gone, companies move on, leaving only devastation behind. Nigeria and the Philippines have both lost their once-thriving tropical hardwood export industries and are now net importers of forest products.<sup>12</sup>

Perhaps the most devastating development affecting the earth’s remaining natural forests in this new century is the explosive growth of the wood products industry in China, now supplying the world with furniture, flooring, particle board, and other building materials. In supplying domestic and foreign markets, China has gone on a logging orgy outside its borders, often illegally, to procure logs from Indonesia, Myanmar, Papua New Guinea, and Siberia. And now Chinese logging firms are moving into the Amazon and the Congo Basin.<sup>13</sup>

In a landmark article in April 2007, *Washington Post* reporters Peter Goodman and Peter Finn described how the Chinese went after one of the world’s few remaining natural stands of teak across the border in Myanmar. They reported that a Chinese logging boss “handed a rice sack stuffed with \$8,000 worth of Chinese currency to two agents with connections in the Burmese borderlands....They used that stash to bribe everyone standing between the teak and China. In came Chinese logging crews. Out went huge logs, over Chinese-built roads.”<sup>14</sup>

Forest Trends, a nongovernmental organization consisting of industry and conservation groups, estimates that at the current rate of logging, the natural forests in Indonesia and Myanmar will be gone within a decade or so. Those in Papua New Guinea will last 16 years. Those in the Russian Far East, vast though they are, may not last much more than 20 years.<sup>15</sup>

Forest losses from clearing land for farming and ranching, usually by burning, are concentrated in the Brazilian Amazon, the Congo Basin, and Borneo. After having lost 93 percent of its Atlantic rainforest, Brazil is now destroying the Amazon rain-

forest. This huge forest, roughly the size of Europe, was largely intact until 1970. Since then, close to 20 percent has been lost.<sup>16</sup>

Africa’s Congo Basin, the world’s second largest rainforest, spans 10 countries. Like the Amazon rainforest, it is also under assault, primarily from loggers, miners, and farmers. This 190-million-hectare rainforest—home to 400 species of mammals, including the world’s largest populations of gorillas, bonobos, chimpanzees, and forest elephants—is shrinking by 1.6 million hectares a year.<sup>17</sup>

The fast-rising demand for palm oil led to an 8-percent annual expansion in the palm plantation area in Malaysian Borneo (Sarawak and Sabah) between 1998 and 2003. In Kalimantan, the Indonesian part of Borneo, growth in oil palm plantings is higher, at over 11 percent. Now that palm oil is emerging as a leading biodiesel fuel, growth in oil palm cultivation will likely climb even faster. The near-limitless demand for biodiesel now threatens the remaining tropical forests in Borneo and elsewhere.<sup>18</sup>

Haiti, a country of 9.6 million people, was once largely covered with forests, but growing firewood demand and land clearing for farming have left forests standing on scarcely 4 percent of its land. First the trees go, then the soil.<sup>19</sup>

Once a tropical paradise, Haiti is a case study of a country caught in an ecological/economic downward spiral from which it has not been able to escape. It is a failed state, a country sustained by international life-support systems of food aid and economic assistance.

The biologically rich rainforest of Madagascar, an island country with 18 million people, is following in Haiti’s footsteps. As the trees are cut, either to produce charcoal or to clear land to grow food, the sequence of events is all too familiar. Environmentalists warn that Madagascar could soon become a landscape of scrub growth and sand.<sup>20</sup>

While deforestation accelerates the flow of water back to the ocean, it also can reduce the recycling of rainfall inland. Some 20 years ago two Brazilian scientists, Eneas Salati and Peter Vose, pointed out in *Science* that when rainfall coming from clouds moving in from the Atlantic fell on healthy Amazon rainforest, one fourth of the water ran off and three fourths evaporated into the atmosphere to be carried further inland to provide more rainfall. When land is cleared for grazing or farm-

ing, however, the amount that runs off and returns to the sea increases while that which is recycled inland falls alarmingly.<sup>21</sup>

Ecologist Philip Fearnside, who has spent his career studying the Amazon, observes that agriculturally prominent south-central Brazil depends on water that is recycled inland via the Amazon rainforest. As more and more land is cleared for grazing and farming, the forest begins to dry out. At some point, the weakened rainforest becomes vulnerable to fire as lightning strikes. As the Amazon rainforest weakens, it is approaching a tipping point beyond which it cannot be saved.<sup>22</sup>

A similar situation may be developing in Africa, where deforestation and land clearing are proceeding rapidly as firewood use mounts and as logging firms clear large tracts of virgin forests. In Malawi, a country of 14 million people in East Africa, forest cover has shrunk by nearly a quarter since the early 1970s, a loss of up to 1 million hectares. The cutting of trees to produce charcoal and to cure tobacco is leading to a sequence of events paralleling that in Haiti.<sup>23</sup>

As the trees disappear, rainfall runoff increases and the land is deprived of the water from evapotranspiration. Consulting hydrogeologist Jim Anscombe notes: “Driven by energy from the sun, the trees pump water from the water table, through the roots, trunk and leaves, up into the atmosphere through the process of transpiration. Collectively the forest pumps millions of liters of water daily to the atmosphere.” Given the local climate conditions, this evapotranspiration translates into summer rainfall, helping to sustain crops. When the forests disappear, this rainfall declines and crop yields follow.<sup>24</sup>

More and more countries are beginning to recognize the risks associated with deforestation. Among the countries that now have total or partial bans on logging in primary forests are China, New Zealand, the Philippines, Sri Lanka, Thailand, and Viet Nam. Unfortunately, all too often a ban in one country simply shifts the deforestation to others or drives illegal logging.<sup>25</sup>

### Losing Soil

The thin layer of topsoil that covers the planet’s land surface is the foundation of civilization. This soil, typically six inches or so deep, was formed over long stretches of geological time as new soil formation exceeded the natural rate of erosion. As soil

accumulated over the eons, it provided a medium in which plants could grow. In turn, plants protect the soil from erosion. Human activity is disrupting this relationship.

Sometime within the last century, soil erosion began to exceed new soil formation over large areas. Now, perhaps a third of all cropland is losing topsoil faster than new soil is forming, reducing the land’s inherent productivity. The foundation of civilization is crumbling.<sup>26</sup>

The accelerating soil erosion over the last century can be seen in the dust bowls that form as vegetation is destroyed and wind erosion soars out of control. Among those that stand out are the Dust Bowl in the U.S. Great Plains during the 1930s, the dust bowl in the Soviet Virgin Lands in the 1960s, the huge one that is forming today in northwest China, and the one taking shape in the Sahelian region of Africa. Each of these is associated with a familiar pattern of overgrazing, deforestation, and agricultural expansion onto marginal land, followed by retrenchment as the soil begins to disappear.<sup>27</sup>

Twentieth-century population growth pushed agriculture onto highly vulnerable land in many countries. The overplowing of the U.S. Great Plains during the late nineteenth and early twentieth centuries, for example, led to the 1930s Dust Bowl. This was a tragic era in U.S. history, one that forced hundreds of thousands of farm families to leave the Great Plains. Many migrated to California in search of a new life, a move immortalized in John Steinbeck’s novel *The Grapes of Wrath*.<sup>28</sup>

Three decades later, history repeated itself in the Soviet Union. The Virgin Lands Project between 1954 and 1960 centered on plowing an area of grassland for wheat that was larger than the wheatland in Canada and Australia combined. Initially, the result was an impressive expansion in Soviet grain production, but the success was short-lived as a dust bowl developed there as well.<sup>29</sup>

Kazakhstan, at the center of this Virgin Lands Project, saw its grainland area peak at just over 25 million hectares around 1980, then shrink to 15 million hectares today. Even on the remaining land, however, the average wheat yield is scarcely 1 ton per hectare, a far cry from the nearly 7 tons per hectare that farmers get in France, Western Europe’s leading wheat producer.<sup>30</sup>

A similar situation exists in Mongolia, where over the last 20

years half the wheatland has been abandoned and wheat yields have fallen by half, shrinking the harvest by three fourths. Mongolia—a country almost three times the size of France with a population of 2.6 million—is now forced to import nearly 60 percent of its wheat.<sup>31</sup>

Dust storms originating in the new dust bowls are now faithfully recorded in satellite images. On January 9, 2005, the National Aeronautics and Space Administration (NASA) released images of a vast dust storm moving westward out of central Africa. This huge cloud of tan-colored dust stretched over some 5,300 kilometers (roughly 3,300 miles). NASA noted that if the storm were relocated to the United States, it would cover the country and extend into the oceans on both coasts.<sup>32</sup>

Andrew Goudie, Professor of Geography at Oxford University, reports that Saharan dust storms—once rare—are now commonplace. He estimates they have increased 10-fold during the last half-century. Among the countries in the region most affected by topsoil loss from wind erosion are Niger, Chad, Mauritania, northern Nigeria, and Burkina Faso. In Mauritania, in Africa's far west, the number of dust storms jumped from 2 a year in the early 1960s to 80 a year today.<sup>33</sup>

The Bodélé Depression in Chad is the source of an estimated 1.3 billion tons of wind-borne soil a year, up 10-fold since measurements began in 1947. The 2–3 billion tons of fine soil particles that leave Africa each year in dust storms are slowly draining the continent of its fertility and biological productivity. In addition, dust storms leaving Africa travel westward across the Atlantic, depositing so much dust in the Caribbean that they cloud the water and damage coral reefs.<sup>34</sup>

Water erosion also takes a toll on soils. This can be seen in the silting of reservoirs and in muddy, silt-laden rivers flowing into the sea. Pakistan's two large reservoirs, Mangla and Tarbela, which store Indus River water for the country's vast irrigation network, are losing roughly 1 percent of their storage capacity each year as they fill with silt from deforested watersheds.<sup>35</sup>

Ethiopia, a mountainous country with highly erodible soils on steeply sloping land, is losing close to 2 billion tons of topsoil a year, washed away by rain. This is one reason Ethiopia always seems to be on the verge of famine, never able to accu-

multate enough grain reserves to provide a meaningful measure of food security.<sup>36</sup>

### From Grassland to Desert

One tenth of the earth's land surface is cropland, but an area four times this size is rangeland—land that is too dry, too steeply sloping, or not fertile enough to sustain crop production. This area—two fifths of the earth's land surface, most of it semiarid—supports the majority of the world's 3.3 billion cattle, sheep, and goats. These livestock are ruminants, animals with complex digestive systems that enable them to digest roughage, converting it into beef, mutton, and milk.<sup>37</sup>

An estimated 200 million people worldwide make their living as pastoralists tending cattle, sheep, and goats. Many countries in Africa depend heavily on their livestock economies for food and employment. The same is true for large populations in the Middle East, Central Asia, Mongolia, and northwest China. Since most land is held in common in these pastoral societies, controlling overgrazing is difficult.<sup>38</sup>

In other parts of the world, rangelands are owned by individual ranchers. Australia, whose land mass is dominated by rangeland, has a flock of 100 million sheep, five times its human population. Grass-based livestock economies also predominate in Argentina, Brazil, Mexico, and Uruguay. And in the Great Plains of North America, semiarid lands that are not suited to growing wheat are devoted to grazing cattle.<sup>39</sup>

The same ruminants that are uniquely efficient at converting roughage into food also supply leather and wool. The world's leather goods and woolen industries, the livelihood of millions, depend on rangelands for raw materials.

Although public attention often focuses on the role of feedlots in beef production, the share of the world's cattle in feedlots is a tiny fraction of the vast numbers feeding on grass. Even in the United States, which has most of the world's feedlots, the typical steer is in a feedlot for only a matter of months.

Worldwide, almost half of all grasslands are lightly to moderately degraded and 5 percent are severely degraded. The problem is highly visible throughout Africa, the Middle East, Central Asia, and India, where the growth in livestock numbers tracks that in human numbers. In 1950, 238 million Africans

relied on 273 million livestock. By 2006, there were nearly 926 million people and 738 million livestock. Demands of the livestock industry now often exceed grassland carrying capacity by half or more.<sup>40</sup>

Iran—with 71 million people—illustrates the pressures facing the Middle East. With 9 million cattle and 80 million sheep and goats—the source of wool for its fabled rug-making industry—Iran's rangelands are deteriorating from overstocking.<sup>41</sup>

China faces similarly difficult challenges. After the economic reforms in 1978 that shifted the responsibility for farming from state-organized production teams to farm families, the government lost control of livestock numbers. As a result, China's cattle, sheep, and goat populations spiraled upward. While the United States, a country with comparable grazing capacity, has 97 million cattle, China has a slightly larger herd of 115 million. But while the United States has only 9 million sheep and goats, China has 366 million. Concentrated in China's western and northern provinces, sheep and goats are destroying the land's protective vegetation. The wind then does the rest, removing the soil and converting productive rangeland into desert.<sup>42</sup>

Fodder needs of livestock in nearly all developing countries now exceed the sustainable yield of rangelands and other forage resources. In India, the demand for fodder greatly outpaces the supply, leaving millions of emaciated, unproductive cattle.<sup>43</sup>

Land degradation from overgrazing is taking a heavy economic toll in lost livestock production. In the early stages of overgrazing, the costs show up in lower land productivity. But as the process continues, it destroys vegetation, leading to erosion and the eventual creation of wasteland and desert. At some point, growth in the livestock population begins to shrink the biologically productive area and thus the earth's capacity to sustain civilization.<sup>44</sup>

### Advancing Deserts

Desertification, the process of converting productive land to wasteland through overuse and mismanagement, is unfortunately all too common. Anything that removes protective grass or trees leaves soil vulnerable to wind and water erosion. In the early stages of desertification, the finer particles of soil are removed by the wind, creating the dust storms described earlier.

Once the fine particles are removed, then the coarser particles—the sand—are also carried by the wind in localized sand storms.

Large-scale desertification is concentrated in Africa and Asia—two regions that together contain 5 billion of the world's 6.7 billion people. Populations in countries across the north of Africa are being squeezed by the northward advance of the Sahara.<sup>45</sup>

In the vast east-to-west swath of semiarid Africa between the Sahara Desert and the forested regions to the south lies the Sahel, a region where farming and herding overlap. In countries from Senegal and Mauritania in the west to Sudan, Ethiopia, and Somalia in the east, the explosive demands of growing human and livestock numbers are converting land into desert.<sup>46</sup>

Nigeria, Africa's most populous country, is losing 351,000 hectares of rangeland and cropland to desertification each year. While Nigeria's human population was growing from 34 million in 1950 to 145 million in 2006, a fourfold expansion, its livestock population grew from roughly 6 million to 67 million, an 11-fold increase. With the forage needs of Nigeria's 16 million cattle and 51 million sheep and goats exceeding the sustainable yield of grasslands, the northern part of the country is slowly turning to desert. If Nigeria continues toward its projected 289 million people by 2050, the deterioration will only accelerate.<sup>47</sup>

Iran is also losing its battle with the desert. Mohammad Jarian, who heads Iran's Anti-Desertification Organization, reported in 2002 that sand storms had buried 124 villages in the southeastern province of Sistan-Balochistan, forcing their abandonment. Drifting sands had covered grazing areas, starving livestock and depriving villagers of their livelihood.<sup>48</sup>

Neighboring Afghanistan is faced with a similar situation. The Registan Desert is migrating westward, encroaching on agricultural areas. A U.N. Environment Programme (UNEP) team reports that “up to 100 villages have been submerged by windblown dust and sand.” In the country's northwest, sand dunes are moving onto agricultural land in the upper reaches of the Amu Darya basin, their path cleared by the loss of stabilizing vegetation from firewood gathering and overgrazing. The UNEP team observed sand dunes 15 meters high blocking roads, forcing residents to establish new routes.<sup>49</sup>

China's desertification may be the worst in the world. Wang

Tao, one of China's leading desert scholars, reports that from 1950 to 1975 an average of 1,560 square kilometers of land turned to desert each year. Between 1975 and 1987, this climbed to 2,100 square kilometers a year. From then until the century's end, it jumped to 3,600 square kilometers of land going to desert annually.<sup>50</sup>

China is now at war. It is not invading armies that are claiming its territory, but expanding deserts. Old deserts are advancing and new ones are forming like guerrilla forces striking unexpectedly, forcing Beijing to fight on several fronts. Wang Tao reports that over the last half-century, some 24,000 villages in northern and western China have been entirely or partly abandoned as a result of being overrun by drifting sand.<sup>51</sup>

People in China are all too familiar with the dust storms that originate in the northwestern area and western Mongolia, but the rest of the world typically learns about this fast-growing ecological catastrophe from the massive dust storms that travel outside the region. On April 18, 2001, the western United States—from the Arizona border north to Canada—was blanketed with dust. It came from a huge dust storm that originated in northwestern China and Mongolia on April 5. Measuring 1,800 kilometers (1,200 miles) across when it left China, the storm carried millions of tons of topsoil, a resource that will take centuries to replace through natural processes.<sup>52</sup>

Almost exactly one year later, on April 12, 2002, South Korea was engulfed by a huge dust storm from China that left people in Seoul literally gasping for breath. Schools were closed, airline flights were cancelled, and clinics were overrun with patients having difficulty breathing. Retail sales fell. Koreans have come to dread the arrival of what they now call “the fifth season,” the dust storms of late winter and early spring.<sup>53</sup>

These two dust storms, among the 10 or so major dust storms that now occur each year in China, offer visual evidence of the ecological catastrophe unfolding in northern and western China. Overgrazing is the principal culprit.<sup>54</sup>

A U.S. Embassy report entitled “Desert Mergers and Acquisitions” describes satellite images showing two deserts in north-central China expanding and merging to form a single, larger desert overlapping Inner Mongolia (Nei Monggol) and Gansu provinces. To the west in Xinjiang Province, two even larger

deserts—the Taklimakan and Kumtag—are also heading for a merger. Highways running through the shrinking region between them are regularly inundated by sand dunes.<sup>55</sup>

In Latin America, deserts are expanding in both Brazil and Mexico. In Brazil, where some 58 million hectares of land are affected, economic losses from desertification are estimated at \$300 million per year, much of it concentrated in the country's northeast. Mexico, with a much larger share of arid and semi-arid land, is even more vulnerable. The degradation of cropland now prompts some 700,000 Mexicans to leave the land each year in search of jobs in nearby cities or in the United States.<sup>56</sup>

In scores of countries, the overgrazing, overplowing, and overcutting that are driving desertification are intensifying as human and livestock populations continue to grow. Stopping the conversion of productive land to desert may now rest on stopping the growth in human and livestock numbers.

### Collapsing Fisheries

After World War II, accelerating population growth and steadily rising incomes drove the demand for seafood upward at a record pace. At the same time, advances in fishing technologies, including huge refrigerated processing ships that enabled trawlers to exploit distant oceans, enabled fishers to respond to the growing world demand.

In response, the oceanic fish catch climbed from 19 million tons in 1950 to its historic high of 96 million tons in 2000. This fivefold growth—more than double that of population during this period—raised the wild seafood supply per person worldwide from 7 kilograms (15.4 pounds) in 1950 to a peak of 17 kilograms in 1988. Since then, it has fallen to 14 kilograms.<sup>57</sup>

As population grows and as modern food marketing systems give more people access to these products, seafood consumption is growing. Indeed, the human appetite for seafood is outgrowing the sustainable yield of oceanic fisheries. Today 75 percent of fisheries are being fished at or beyond their sustainable capacity. As a result, many are in decline and some have collapsed.<sup>58</sup>

While oceanic fisheries face numerous threats, it is overfishing that directly threatens their survival. Oceanic harvests expanded as new technologies evolved, ranging from sonar for

tracking schools of fish to vast driftnets that are collectively long enough to circle the earth many times over.

A 2003 landmark study by a Canadian-German research team published in *Nature* concluded that 90 percent of the large fish in the oceans had disappeared over the last 50 years. Ransom Myers, a fisheries biologist at Canada's Dalhousie University and lead scientist in this study, says: "From giant blue marlin to mighty bluefin tuna, from tropical groupers to Antarctic cod, industrial fishing has scoured the global ocean. There is no blue frontier left."<sup>59</sup>

Myers goes on to say, "Since 1950, with the onset of industrialized fisheries, we have rapidly reduced the resource base to less than 10 percent—not just in some areas, not just for some stocks, but for entire communities of these large fish species from the tropics to the poles."<sup>60</sup>

Fisheries are collapsing throughout the world. The 500-year-old cod fishery of Canada failed in the early 1990s, putting some 40,000 fishers and fish processors out of work. Fisheries off the coast of New England were not far behind. And in Europe, cod fisheries are in decline, approaching a free fall. Like the Canadian cod fishery, the European ones may have been depleted to the point of no return. Countries that fail to meet nature's deadlines for halting overfishing face fishery decline and collapse.<sup>61</sup>

Atlantic stocks of the heavily fished bluefin tuna—a large specimen of which, headed for Tokyo's sushi restaurants, can bring in \$100,000—have been cut by a staggering 94 percent. It will take years for such long-lived species to recover, even if fishing were to stop altogether. The harvest of the Caspian Sea sturgeon, source of the world's most prized caviar, fell from a record 27,700 tons in 1977 to just 461 tons in 2000. The quota for 2007 was set at 368 tons. Overfishing, much of it illegal, is primarily responsible for the dramatic drop.<sup>62</sup>

The U.S. Chesapeake Bay, which yielded more than 35 million pounds of oysters per year a half-century ago, now produces scarcely 1 million pounds per year. A deadly combination of overharvesting, pollutants, oyster disease, and siltation from soil erosion is responsible.<sup>63</sup>

Even among countries accustomed to working together, such as those in the European Union (EU), the challenge of negotiat-

ing catch limits at sustainable levels can be difficult. In April 1997, after prolonged negotiations, agreement was reached in Brussels to reduce the fishing capacity of EU fleets by 30 percent for endangered species, such as cod, herring, and sole in the North Sea, and by 20 percent for overfished stocks, such as cod in the Baltic Sea, the bluefin tuna, and swordfish off the Iberian Peninsula. The EU had finally reached agreement on reducing the catch but the cuts were not sufficient to arrest the decline of the region's fisheries.<sup>64</sup>

The catch of North Sea cod, the mainstay of U.K. fisheries, fell from 300,000 tons per year in the mid-1980s to below 50,000 tons in recent years. For 2006, the annual quota was dropped to 23,000 tons, but the fishery continued to decline, leading to an additional 14 percent quota cut in 2007. The history of EU fishery management and the reduction of quotas has been a matter of too little, too late. EU officials are all too aware that Canada's vast Newfoundland cod fishery has not recovered since collapsing in 1992, despite the total ban on fishing imposed then, but even so they have consistently failed to move quickly enough.<sup>65</sup>

When some fisheries collapse, it puts more pressure on those that remain. Local shortages quickly become global shortages. With restrictions on the catch in overfished EU waters, the heavily subsidized EU fishing fleet has turned to the west coast of Africa, buying licenses to fish off the coasts of Cape Verde, Guinea-Bissau, Mauritania, Morocco, and Senegal. They are competing there with fleets from China, Japan, Russia, South Korea, and Taiwan. For impoverished countries like Mauritania and Guinea-Bissau, income from fishing licenses can account for up to half of government revenue.<sup>66</sup>

Unfortunately for the Africans, their fisheries too are collapsing. In Senegal, where local fishers with small boats once could quickly fill their craft with fish, on many days now they cannot catch enough fish to cover even their fuel costs. As one Senegalese tribal elder said, "Poverty came to Senegal with these fishing agreements."<sup>67</sup>

To the north, John Miller, reporting in the *Wall Street Journal* from the Mauritanian port town of Nouadhibou, describes how a 39-year-old fisherman and father of six, Sall Samba, had beached two of the three fishing boats he used to harvest octo-



pus. “You used to be able to fish right in the port,” he said, “but now the only thing you can catch here is water.”<sup>68</sup>

Overfishing is not the only threat to the world’s seafood supply. Some 90 percent of fish residing in the ocean rely on coastal wetlands, mangrove swamps, or rivers as spawning areas. Well over half of the mangrove forests in tropical and subtropical countries have been lost. The disappearance of coastal wetlands in industrial countries is even greater. In Italy, whose coastal wetlands are the nurseries for many Mediterranean fisheries, the loss is a whopping 95 percent.<sup>69</sup>

Damage to coral reefs from higher ocean temperatures and ocean acidification caused by higher atmospheric carbon dioxide levels, as well as damage from pollution and sedimentation, are threatening these breeding grounds for fish in tropical and subtropical waters. Between 2000 and 2004, the worldwide share of destroyed reefs, those that had lost 90 percent of live corals, expanded from 11 percent to 20 percent. The Global Coral Reef Monitoring Network reports that 24 percent of the remaining reefs are at risk of imminent collapse, with another 26 percent facing significant loss in the next few decades, due to mounting human pressures. As the reefs deteriorate, so do the fisheries that depend on them.<sup>70</sup>

A World Resources Institute report on coral reefs in the Caribbean notes that 35 percent of these reefs are threatened by sewage discharge, water-based sediment, and pollution from fertilizer and that 15 percent are threatened by pollution from cruise ship discharges. In economic terms, the Caribbean coral reefs supply goods and services worth at least \$3.1 billion per year.<sup>71</sup>

The spectacular coral reefs of the Red Sea, some of the most strikingly beautiful reefs anywhere, are facing extinction due to destructive fishing practices, dredging, sedimentation, and sewage discharge. Anything that reduces sunlight penetration in the sea impairs the growth of corals, leading to die-off.<sup>72</sup>

Pollution is taking a devastating toll, illustrated by the dead zones created by nutrient runoff from fertilizer and from sewage discharge. In the United States, the Mississippi River carries nutrients from the Corn Belt and sewage from cities along its route into the Gulf of Mexico. The nutrient surge creates huge algal blooms that then die and decompose, consuming the free oxygen in the water, leading to the death of fish. This creates a

dead zone each summer in the Gulf that can reach the size of New Jersey.<sup>73</sup>

UNEP reported in 2006 that there were more than 200 dead zones in the world’s oceans and seas, up from 149 two years earlier. Among the dead zones they counted were ones in the Baltic Sea, the Black Sea, the Gulf of Thailand, Ghana’s Fosu Lagoon, and Uruguay’s Montevideo Bay. In these oceanic “deserts” there are no fishing trawlers because there are no fish.<sup>74</sup>

Commercial fishing is now largely an economics of today versus tomorrow. Governments are seeking to protect tomorrow’s catches by forcing fishers to keep their ships idle; fishing communities are torn between the need for income today versus the future. Ironically, one reason for excess fleet capacity is long-standing government subsidized loans for investing in new boats and fishing gear.<sup>75</sup>

The growing worldwide demand for seafood can no longer be satisfied by expanding the oceanic fish catch. If it is to be satisfied, it will be by expanding fish farming. But once fish are put in ponds or cages they have to be fed, most often corn and soybean meal, putting further pressure on land resources.

### Disappearing Plants and Animals

The archeological record shows five great extinctions since life began, each representing an evolutionary setback, a wholesale impoverishment of life on earth. The last of these mass extinctions occurred some 65 million years ago, most likely when an asteroid collided with our planet, spewing vast amounts of dust and debris into the atmosphere. The resultant abrupt cooling obliterated the dinosaurs and at least one fifth of all other extant life forms.<sup>76</sup>

We are now in the early stage of the sixth great extinction. Unlike previous extinction events, which were caused by natural phenomena, this one is of human origin. For the first time in the earth’s long history, one species has evolved, if that is the right word, to where it can eradicate much of life.

As various life forms disappear, they diminish the services provided by nature, such as pollination, seed dispersal, insect control, and nutrient cycling. This loss of species is weakening the web of life, and if it continues it could tear huge gaps in its fabric, leading to irreversible changes in the earth’s ecosystem.

Species of all kinds are threatened by habitat destruction. One of the leading threats to the earth's biodiversity is the loss of tropical rainforests. As we burn off the Amazon rainforest, we are in effect burning one of the great repositories of genetic information. Our descendants may one day view the wholesale burning of this genetic library much as we view the burning of the library in Alexandria in 48 BC.

Habitat alteration from rising temperatures, chemical pollution, or the introduction of exotic species can also decimate both plant and animal species. As the human population grows, the number of species with which we share the planet shrinks. Yet we cannot separate our fate from that of all life on the earth. If the rich diversity of life that we inherited is continually impoverished, eventually we will be impoverished as well.

The share of birds, mammals, and fish that are vulnerable or in immediate danger of extinction is now measured in double digits: 12 percent of the world's nearly 10,000 bird species; 20 percent of the world's 5,416 mammal species; and 39 percent of the fish species analyzed.<sup>77</sup>

Among mammals, the 296 known species of primates other than humans are most at risk. The World Conservation Union-IUCN reports that 114 of these species are threatened with extinction. Some 95 of the world's primate species live in Brazil, where habitat destruction poses a particular threat. Hunting, too, is a threat, particularly in West and Central Africa, where the deteriorating food situation and newly constructed logging roads are combining to create a lively market for "bushmeat."<sup>78</sup>

The bonobos of West Africa, great apes that are smaller than the chimpanzees of East Africa, may be our closest living relative both genetically and in social behavior. But this connection is not saving them from the bushmeat trade or the destruction of their habitat by loggers. Concentrated in the dense forest of the Democratic Republic of the Congo, a failing state with a prolonged civil conflict, their numbers fell from an estimated 100,000 in 1980 to as few as 10,000 today. In one human generation, 90 percent of the bonobos have disappeared.<sup>79</sup>

Birds, because of their high visibility, are a useful indicator of the diversity of life. Of the 9,817 known bird species, roughly 70 percent are declining in number. Of these, an estimated 1,217 species are in imminent danger of extinction. Habitat loss

and degradation affect 91 percent of all threatened bird species. For example, 61 bird species have become locally extinct with the extensive loss of lowland rainforest in Singapore. Some once-abundant species may have already dwindled to the point of no return. The great bustard, once widespread in Pakistan and surrounding countries, is being hunted to extinction. Ten of the world's 17 species of penguins are threatened or endangered, potential victims of global warming. Stanford University biologist Çagan Sekercioglu, who led a study on the status of the world's birds said, "We are changing the world so much that even birds cannot adapt."<sup>80</sup>

Particularly disturbing is the recent precipitous decline in the populations of Britain's most popular songbirds. Within the last 30 years the populations of well-known species such as the willow warbler, the song thrush, and the spotted flycatcher have fallen 50–80 percent; no one seems to know why, although there is speculation that habitat destruction and pesticides may be playing a role. Without knowing the source of the decline, it is difficult to take actions that will arrest the plunge in numbers.<sup>81</sup>

Another decline, which began in late 2006 and had direct economic consequences, is that of the honeybee, the principal pollinator of U.S. fruit and vegetable crops. A survey of U.S. beekeepers, conducted from September 2006 to March 2007 by the Apiary Inspectors of America, found that the bees in nearly one quarter of U.S. bee colonies had simply disappeared as a result of what scientists are calling "colony collapse disorder." Large numbers of colonies have suffered the same fate in Europe, Brazil, and Guatemala.<sup>82</sup>

Scientists are baffled by what the French have labeled "mad bee disease." Bees leaving their hives on pollination forays apparently become disoriented and never return. The principal suspect at this writing is the Israeli acute paralysis virus, which may have originated in Australia. If scientists cannot quickly diagnose this bee malady and devise preventive measures, the world could face an unprecedented disruption of fruit and vegetable production.<sup>83</sup>

The threat to fish may be the greatest of all. The principal causes are overfishing, water pollution, and the excessive extraction of water from rivers and other freshwater ecosystems. An estimated 65 percent of the fish species evaluated by IUCN that

once inhabited the lakes and streams of North America are either extinct or in jeopardy. In Europe, some 109 species of freshwater fish out of the 265 that were evaluated are threatened, endangered, or of special concern. One third of the 97 fish species in South Africa need special protection to avoid extinction.<sup>84</sup>

The leatherback turtle, one of the most ancient animals, which can reach a weight of 360 kilograms (800 pounds), also is fast disappearing. Its numbers dropped from 115,000 in 1982 to 34,500 in 1996. At the Playa Grande and Playa Langosta nesting colonies on Costa Rica's west coast, the number of nesting females dropped from 1,504 in 1989 to 62 in 2003, then rose slightly to 174 in 2004. Writing in *Nature*, James Spotila and colleagues warn that "if these turtles are to be saved, immediate action is needed to minimize mortality through fishing and to maximize hatchling production."<sup>85</sup>

One of the fastest-growing threats to the diversity of plant and animal life today is the extraordinary agricultural expansion now under way in Brazil as land is cleared to graze cattle, plant soybeans, and, more recently, produce sugarcane for ethanol. Farmers and ranchers are opening up vast areas in the Amazon basin and in the *cerrado*, a Europe-sized savanna-like region south of the Amazon basin. Although there are mechanisms in place to protect the rich biological diversity of the Amazon, such as the requirement that landowners clear no more than one fifth of their land, the government lacks enforcement capacity.<sup>86</sup>

Like the Amazon, the *cerrado* is biologically rich, home to many large mammals, including the maned wolf, giant armadillo, giant anteater, deer, and several large cats—jaguar, puma, ocelot, and jaguarundi. The *cerrado* contains 607 species of birds, including the rhea, a cousin of the ostrich, which grows up to five feet tall. An estimated 1,000 species of butterflies have been identified. Conservation International reports that the *cerrado* also contains some 10,000 plant species—at least 4,400 of which are endemic, not found anywhere else.<sup>87</sup>

Another worldwide threat to species, and one that is commonly underestimated, is the introduction of non-native species, which can alter local habitats and communities, driving native species to extinction. For example, non-native species

may be responsible for 29 percent of the threatened bird species on the IUCN Red List. For plants, alien species are implicated in 5 percent of all the listings.<sup>88</sup>

Efforts to save wildlife traditionally have centered on the creation of parks or wildlife reserves. Unfortunately, this approach may now be less effective, for if we cannot stabilize climate, there is not an ecosystem on earth that we can save. Everything will change.

In the new world we are entering, protecting the diversity of life on earth is no longer simply a matter of setting aside tracts of land, fencing them off, and calling them parks and preserves. Success in this effort depends also on stabilizing both climate and population.

On the plus side, we now have more information on the state of the earth and the life on it than ever before. While knowledge is not a substitute for action, it is a prerequisite for saving the earth's natural systems—and the civilization that they support.