from Lester R. Brown, *Plan B 2.0 Rescuing a Planet Under Stress and a Civilization in Trouble* (NY: W.W. Norton & Co., 2006).

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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.[1]

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 repeopled again and the cities rebuilt, but now that the soils are gone, all is gone."[2]

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 imbedded 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, reports in the *Washington Post* that nearly half of the children under five in Lesotho are stunted physically. "Many," he says, "are too weak to walk to school."[3]

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 852 million hungry people live on land with soils worn thin by erosion.[4]

Merciless 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.[5]

Shrinking Forests: The 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 basin, home to 400 million people. 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.[6]

At the beginning of the twentieth century, the earth's forested area was estimated at 5 billion hectares. Since then it has shrunk to 3.9 billion hectares—with the remaining forests rather evenly divided between tropical and subtropical forests in

developing countries and temperate/boreal forests in industrial countries.[7]

World forest loss is concentrated in developing countries. Since 1990, the loss in these nations has averaged 13 million hectares a year, an area roughly the size of Kansas. Overall, the developing world is losing 6 percent of its forests per decade. The industrial world is actually gaining an estimated 3.6 million hectares of forestland each year, principally from abandoned cropland that is returning to forests on its own, as in Russia, and from the spread of commercial forestry plantations.[8]

Unfortunately, even these official data from the U.N.'s 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 are still included 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."[9]

Pressures on forests continue to mount. Use of firewood, paper, and lumber is expanding. Of the 3.34 billion cubic meters of wood harvested worldwide in 2003, over half was used for fuel. In developing countries, fuelwood accounts for nearly three fourths of the total.[10]

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 a charcoal industry, a more concentrated form of energy with lower transport costs. 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."[11]

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.[12]

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 97 percent of its Atlantic rainforest, Brazil is now destroying the Amazon rainforest. This huge forest, roughly the size of Europe, was largely intact until 1970. Since then, 20 percent of it has been lost.[13]

The fast-rising demand for palm oil led to an 8-percent annual growth rate in the palm plantation area in Malaysian Borneo (Sarawak and Sabah) between 1998 and 2003. In Kalimantan, the Indonesian part of Borneo, growth in palm oil plantings is higher, at over 11 percent. Now that palm oil is emerging as a leading biodiesel fuel, growth in its cultivation will likely climb even faster. The near-limitless demand for biodiesel now threatens the remaining tropical forests in Borneo and elsewhere.[14]

Haiti, a country of 8 million people, was once largely covered with forests. Now there are forests standing on scarcely 2 percent of its land largely because trees are cut for firewood. In September 2004, tropical storm Jeanne left 1,500 dead and over 1,000 more missing and presumed dead. With the trees gone, the soil had washed away and there was little left to hold the downpour. Once a tropical paradise, Haiti is now a case study of a country committing ecological and economic suicide. As its forests have shrunk and its soils have eroded, Haiti has been caught in an ecological/economic downward spiral from which it has not been able to escape. It is a country sustained by international life-support systems of food aid and economic assistance.[15]

Haiti is a classic case of overshoot and collapse. First the trees go, then the soil, and finally the society itself. Without

food from abroad, Haiti's population might now be declining as a result of hunger. Haiti is a microcosm of what much of the earth will be like if deforestation continues.

Scores of countries are suffering from disastrous flooding as a result of deforestation. In 2000, Mozambique was partially inundated as the Limpopo overflowed its banks, taking thousands of lives and destroying homes and crops on an unprecedented scale. The Limpopo river basin, which has lost 99 percent of its original tree cover, will likely face many more such floods.[16]

The biologically rich rainforest of Madagascar is also disappearing fast. As the trees are cut either to produce charcoal or to clear land in order to grow food for the island's increasing population, the sequence of events is all too familiar. Environmentalists warn that Madagascar could soon become a landscape of scrub growth and sand.[17]

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 farming, however, the amount that runs off and returns to the sea increases dramatically while that which is recycled inland falls alarmingly.[18]

Ecologist Philip Fearnside, who has spent his career studying the Amazon, observes that the agriculturally prominent south-central part of Brazil depends on water that is recycled inland via the Amazon rainforest. If the Amazon is converted into a cattle pasture, he notes, there will be less rainfall to support agriculture.[19]

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 13 million in East Africa, forest cover has shrunk from 47 percent of the country's land area to some 28 percent in a matter of years. The cutting of trees to produce charcoal and to cure tobacco is leading to a sequence of events paralleling that in Haiti.[20]

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 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.[21]

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. For example, the 1998 ban in China following the Yangtze flooding led to sharp increases in logging in Myanmar (formerly Burma) and Russia, much of it illegal.[22]

Losing Soil

The thin layer of topsoil that covers the planet's land surface is the foundation of civilization. This soil, measured in inches over much of the earth, 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 in large areas. Perhaps a third or more of all cropland is losing topsoil faster than new soil is forming, thereby reducing the land's inherent productivity. Today the foundation of civilization is crumbling. The seeds of collapse of some early civilizations, such as the Mayans, may have originated in soil erosion that undermined the food supply.[23]

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 bowls 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.[24]

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 *The Grapes of Wrath*.[25]

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 this resulted in an impressive expansion in Soviet grain production, but the success was short-lived as a dust bowl developed there as well.[26]

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 14 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 8 tons per hectare that farmers get in France, Western Europe's leading wheat producer.[27]

A similar situation exists in Mongolia, where over the last 20 years half the wheatland has been abandoned and wheat yields have also 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.[28]

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 vast 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.[29]

Andrew Goudie, Professor of Geography at Oxford Univer-

sity, 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 Burkino 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.[30]

The Bodélé Depression in Chad is the source of an estimated 1.3 billion tons of wind-borne soil a year, up 10-fold from 1947 when measurements began. 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, hence, its 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 there.[31]

In China, plowing excesses became common in several provinces as agriculture pushed northward and westward into the pastoral zone between 1987 and 1996. In Inner Mongolia (Nei Monggol), for example, the cultivated area increased by 1.1 million hectares, or 22 percent, during this period. Other provinces that expanded their cultivated area by 3 percent or more during this nine-year span include Heilongjiang, Hunan, Tibet (Xizang), Qinghai, and Xinjiang. Severe wind erosion of soil on this newly plowed land made it clear that its only sustainable use was controlled grazing. As a result, Chinese agriculture is now engaged in a strategic withdrawal in these provinces, pulling back to land that can sustain crop production.[32]

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.[33]

Ethiopia, a mountainous country with highly erodible soils on steeply sloping land, is losing an estimated 1 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 accumulate enough grain reserves to provide a meaningful measure of food security.[34]

Deteriorating Rangelands

One tenth of the earth's land surface is cropland, but an area twice this size is rangeland—land that is too dry, too steeply sloping, or not fertile enough to sustain crop production. This area—one fifth of the earth's land surface, most of it semiarid—supports the world's 3.2 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.[35]

An estimated 180 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, northwest China, and much of India. India, with the world's largest cattle herd, depends on cattle not only for milk but also for draft power and fuel.[36]

In other parts of the world, rangelands are exploited by large-scale commercial ranching. Australia, whose land mass is dominated by rangeland, has a flock of 95 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.[37]

Although public attention often focuses on the role of feedlots in beef production, the share of the world's cattle in feedlots at any one time 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.

Beef and mutton tend to dominate meat consumption where grazing land is abundant relative to population size. Among the leading beef consumers are the people of Argentina, Brazil, the United States, and Australia. Mutton looms large in diets in New Zealand and Kazakhstan.[38]

These 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.

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 livestock numbers track the growth in human numbers. In 1950, 238 million Africans relied on 273 million livestock. By 2004, there were 887 million people and 725 million livestock. Demands of the livestock industry, a cornerstone of the African economy virtually everywhere, often exceed grassland carrying capacity by half or more.[39]

Iran—one of the Middle East's most populous countries, with 70 million people—illustrates the pressures facing that region. With more than 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. In a country where sheep and goats outnumber humans, mutton consumption is widespread. With rangelands now pushed beyond their limits, however, the current livestock population is not sustainable.[40]

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 population spiraled upward. While the United States, a country with comparable grazing capacity, has 95 million cattle, China has 107 million. And while the United States has 7 million sheep and goats, China has 339 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.[41]

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.[42]

Land degradation from overgrazing is taking a heavy economic toll in lost livestock productivity. In the early stages of overgrazing, the costs show up as 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.[43]

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 Asia and Africa—two regions that together contain nearly 4.8 billion of the world's 6.5 billion people. Populations in countries across the top of Africa are being squeezed by the northward advance of the Sahara.[44]

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 demands of growing human and livestock numbers are converting more and more land into desert.[45]

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 33 million in 1950 to 132 million in 2005, a fourfold expansion, its livestock population grew from roughly 6 million to 66 million, an 11-fold increase. With the forage needs of Nigeria's 15 million cattle and 51 million sheep and goats exceeding the sustainable yield of the country's grasslands, the northern part of the country is slowly turning to desert. If Nigeria continues toward 258 million people by 2050, the deterioration will only accelerate.[46]

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-Baluchistan, forcing their abandonment. Drifting sands had covered grazing areas, starving livestock and depriving villagers of their livelihood.[47]

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.[48]

China is being affected by desertification more than any other major country. Wang Tao, Director of the Cold and Arid Regions Environmental and Engineering Research Institute, describes the country's accelerating desertification. He reports that from 1950 to 1975 an average of 1,560 square kilometers of land were lost 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.[49]

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.[50]

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 across when it left China, the storm carried millions of tons of topsoil, a vital resource that will take centuries to replace through natural processes.[51]

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.[52]

These two dust storms, among the 10 or so major dust storms that occur each year in China, are one of the externally visible indicators of the ecological catastrophe unfolding in northern and western China. Overgrazing is the principal culprit.[53]

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 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 regions between them are regularly inundated by sand dunes.[54]

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.[55]

In scores of countries, the overgrazing, overplowing, and overcutting that are driving the desertification process are intensifying as the growth in human and livestock numbers continues. Stopping the desertification process from claiming more productive land 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 93 million tons in 1997. This fivefold growth—more than double that of population during this period—raised the wild seafood supply per person worldwide from 7 kilograms in 1950 to a peak of 17 kilograms in 1988. Since then, it has fallen to 14 kilograms.[56]

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. In some fisheries, the breeding stocks have been mostly destroyed.[57]

A 2003 landmark study by a Canadian-German science 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 blue fin tuna, from tropical groupers to Antarctic cod, industrial fishing has scoured the global ocean. There is no blue frontier left."[58]

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."[59]

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.[60]

Atlantic stocks of the heavily fished bluefin tuna, where a large specimen headed for Tokyo's sushi restaurants can bring $50,000, 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, has fallen from a record 27,700 tons in 1977 to 461 tons in 2000. Overfishing, much of it illegal, is responsible for the dramatic drop.[61]

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 the original area of mangrove forests in tropical and subtropical countries has 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.[62]

Damage to coral reefs, breeding grounds for fish in tropical and subtropical waters, is also taking a toll. Between 2000 and 2004, the share of destroyed reefs worldwide expanded from 11 percent to 20 percent. As the reefs deteriorate, so do the fisheries that depend on them.[63]

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.

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.[64]

Fishing subsidies were based on an unfounded belief that past trends in oceanic harvests could be projected into the future—that past growth meant future growth. The advice of marine biologists, who had long warned that marine harvests would someday reach a limit, was largely ignored.[65]

Even among countries accustomed to working together, such as those in the European Union (EU), the challenge of negotiating 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 good news was that the EU finally reached agreement on reducing the catch. The bad news was that these cuts were not sufficient to arrest the decline of the region's fisheries.[66]

In January 2001, the EU went further, announcing a complete ban on fishing for cod, haddock, and whiting during the 12-week

spring spawning period. With the annual cod catch falling from 300,000 tons during the mid-1980s to 50,000 tons in 2000, this step was a desperate effort to save the fishery. 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. In December 2002, the European Union adopted a still stronger fisheries management plan.[67]

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 Senegal, Mauritania, Morocco, Guinea-Bissau, and Cape Verde. They are competing there with fleets from Japan, South Korea, Taiwan, Russia, and China. For impoverished countries like Mauritania and Guinea-Bissau, income from fishing licenses can account for up to half of government revenue.[68]

Unfortunately for the Africans, their fisheries too are collapsing. In Senegal, where local fishers with small boats once could quickly fill their crafts 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."[69]

If the oceans cannot sustain a catch of more than 95 million tons and if world population continues to grow as projected, the oceanic fish catch per person will likely be declining for the foreseeable future. The generation that came of age during World War II saw the fish catch per person double during their lifetimes. Their grandchildren, the children of today, will experience a steady decline in seafood consumption.[70]

The bottom line is that 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, further intensifying the 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 extinc-

tions occurred some 65 million years ago, quite possibly because 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.[71]

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, principally through 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 descendents 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 human population grows, the number of species with which we share the planet shrinks. 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.[72]

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; 23 percent of the world's 4,776 mammal species; and 46 percent of the fish species analyzed.[73]

Among mammals, the 240 known species of primates other than humans are most at risk. The World Conservation Union–IUCN reports that nearly half 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."[74]

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 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, their numbers fell from an estimated 100,000 in 1980 to only 3,000 today. In one human generation, 97 percent of the bonobos have disappeared.[75]

Birds, because of their high visibility, are a useful indicator of the diversity of life. Of the 9,775 known bird species, roughly 70 percent are declining in number. Of these, an estimated 1,212 species are in imminent danger of extinction. Habitat loss and degradation affect 86 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 separate study on the status of the world's birds said, "We are changing the world so much that even birds cannot adapt."[76]

A particularly disturbing recent event is the 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.[77]

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 37 percent of the fish species that once inhabited the lakes and streams of North America are either extinct or in jeopardy. Ten North American freshwater fish species have disap-

peared during the last decade. In semiarid regions of Mexico, 68 percent of native and endemic fish species have disappeared. The situation may be even worse in Europe, where some 80 species of freshwater fish out of a total of 193 are threatened, endangered, or of special concern. Two thirds of the 94 fish species in South Africa need special protection to avoid extinction.[78]

The leatherback turtle, one of the most ancient animal species, and one that 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 nesting colony on Costa Rica's west coast, the number of nesting females dropped from 1,367 in 1989 to 117 in 1999. 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."[79]

A World Resources Institute report on coral reefs in the Caribbean notes that 35 percent of Caribbean 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.[80]

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. Coral reefs play an important role as nurseries for many forms of sea life, including numerous commercial species of fish.[81]

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 plant soybeans and, more recently, to 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 that are designed 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.[82]

Like the Amazon, the *cerrado* is also biologically rich, with thousands of endemic plant and animal species. It contains many large mammals, including the maned wolf, giant armadillo, giant anteater, deer, and several large cats—jaguar, puma, ocelot, and jaguarundi. The *cerrado* contains 837 species of birds, including the rhea, a cousin of the ostrich, which grows six feet tall. More than 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.[83]

One of the newer worldwide threats to species, and one that is commonly underestimated, is the introduction of alien species, which can alter local habitats and communities, driving native species to extinction. For example, non-native species may be responsible for 30 percent of the threatened bird species on the IUCN *Red List*. For plants, alien species are implicated in 15 percent of all the listings.[84]

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. As the number of species with which we share the planet diminishes, so too does the prospect for our civilization.

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, and calling them parks and preserves. Success in this effort depends 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.