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Eroding Soils and Shrinking Cropland

In 1938 and 1939, 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 hundreds and even 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. Others had failed to do so and left only remnants of their illustrious pasts.[1]

In a section of the report of his travels 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."[2]

Now fast forward to a trip in 2002 by a U.N. team to assess the food situation in Lesotho, a tiny country 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, writing in the *Washington Post*, reports 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 people living on it cannot be separated from the health of the land itself. A large share of the world's 840 million hungry live on land where the soils are worn thin by erosion.[4]

Soil Erosion: Wind and Water

The thin layer of topsoil that covers much of the earth's land surface is the foundation of civilization. Today perhaps a third or more of that foundation, the world's cropland, is losing topsoil through erosion faster than new soil is forming, thereby reducing the land's inherent productivity. Where losses are heavy, productive land turns into wasteland or desert.[5]

Some early civilizations, such as that of the Mayans in the lowlands of what is now Guatemala, which flourished from the sixth century B.C. to the ninth century A.D., may well have declined because soil erosion undermined the food supply.[6]

Over long periods of geological time, new soil formation exceeded soil erosion, forming a fertile layer of topsoil over much of the earth. But in recent decades, soil erosion has accelerated, often outpacing the creation of new soil. This loss of soil can be seen in the dust bowls that form as wind erosion soars out of control. Among

those that stand out are the U.S. Dust Bowl in the Great Plains during the 1930s, the Soviet dust bowl in the Virgin Lands in the 1960s, the huge dust bowl that is forming in northwest China, and the dust storms that come out of Africa, crossing the Atlantic with the prevailing winds. Each of these is associated with a well-developed pattern of agricultural expansion onto marginal land followed by retrenchment as the soil begins to disappear.[7]

The erosion of soil can be seen in the silting of reservoirs and from the air in muddy, silt-laden rivers flowing into the sea. Pakistan's two large reservoirs, Mangla and Tarbela, which store Indus River water for that country's vast irrigation network, are losing roughly 1 percent of their storage capacity each year as they slowly fill with silt from their deforested watersheds. And Pakistan is not alone. In varying degrees, reservoirs are plagued with siltation spurred by deforestation and farming, yielding a lose-lose situation where the loss of soil also reduces the supply of irrigation water.[8]

As soils erode, land productivity falls. An analysis of several studies on the effect of soil erosion on crop yields in the United States concluded that for each 1 inch of topsoil lost, wheat and corn yields declined by 6 percent. A 1982 USDA Natural Resource Inventory, which measured the loss of topsoil from U.S. cropland at 3.1 billion tons per year, found that excess erosion was concentrated on a small share of the land. It set the stage for the landmark 1985 Conservation Reserve Program.[9]

Ethiopia, a mountainous country with highly erodible soils on steeply sloping land, is losing an estimated 1 billion tons of topsoil a year. This is one reason why 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.[10]

India is thought to be losing 4.7 billion tons of topsoil a year, mostly through water erosion. Its monsoonal climate, with the concentration of rainfall during a few months of the year, leaves its exposed soils vulnerable to erosion.[11]

In neighboring Nepal, a government report estimated annual soil nutrient loss from erosion at 1.3 million tons—on top of the 500,000 tons of soil nutrients removed through harvesting of crops. Of this total loss of 1.8 million tons, only 300,000 tons are being replaced through the use of organic and mineral fertilizers.[12]

In China, plowing excesses became common in several provinces as agriculture was pushed northward 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 the only sustainable use of much of it was grazing. As a result, Chinese agriculture is now engaged in a strategic withdrawal in these provinces, pulling back to only the land that will sustain crop production.[13]

Since the health of people is closely related to the health of the soil on which they depend, most hunger is found in the mountains and the hills and on semiarid farmlands with marginal rainfall. Little hunger is found on well-watered agricultural plains. In the absence of conservation practices, marginal soils tend to marginalize the people who depend on them. Richard Bilsborrow, an economist/demographer at the University of North Carolina, notes: "Three quarters of the poorest 20 percent in Latin America live on marginal lands. Fifty-seven percent of Asia's poor and 51 percent of Africa's also inhabit marginal lands. Not just the lack of land, but also its *quality*, contributes to world poverty."[14]

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 the land vulnerable to wind and to water erosion and the loss of topsoil.

In the early stages of desertification, the finer particles of soil are removed by the wind, creating dust storms. Once the fine particles are removed, then the coarser particles—the sand—are also carried by the wind. Sand storms are capable of destroying vegetation and of disrupting transportation by blocking highways and railroads with drifting sand. A scientific paper analyzing a particularly severe dust and sand storm in May 1993 in Gansu Province in China's northwest reported that it reduced visibility to zero and described the daytime sky as "dark as a winter night." The storm killed 49 people, destroyed 170,000 hectares (450,000 acres) of standing crops, damaged 40,000 trees, and killed 6,700 cattle and sheep. Forty-two trains were cancelled, delayed, or simply parked to wait until the storm passed and the tracks were cleared of drifting sand.[15]

Large-scale desertification is concentrated in Asia and Africa—two regions that together contain nearly 4 billion of the world's 6.2 billion people. The demands of growing human and livestock populations are simply exceeding the land's carrying capacity.[16]

On the northern edge of the Sahara, Algeria is facing the desertification of its cropland. In December 2000, agriculture ministry officials announced a four-year plan to halt the advancing desert by converting the southernmost 20 percent of Algeria's grainland into fruit and olive orchards, vineyards, and other permanent crops. The government hopes that this barrier of vegetation will halt the northward movement of the Sahara and save the country's fertile northern region.[17]

To the south, Nigeria—Africa's most populous country—is fighting a losing battle with the advancing desert. Each year, it loses 351,000 hectares (877,000 acres) of land to desertification. Affecting each of the 10 northern states, desertification has emerged as Nigeria's leading environmental problem.[18]

In East Africa, Kenya is being squeezed by spreading deserts, and desertification affects up to a third of the country's 32 million people. As elsewhere, the unholy triumvirate of overgrazing, overplowing, and overcutting of trees are all contributing to the loss of productive land.[19]

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, leading to their abandonment. Drifting sands had covered grazing areas, starving livestock and depriving villagers of their livelihood.[20]

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.[21]

China is being affected more by desertification than any other major country. For the outside world, the evidence of this is often seen in the dust storms in late winter and early spring, as described in Chapter 1. These

storms, which regularly reach the Korean peninsula and Japan, sometimes even cross the Pacific, depositing dust in the western United States.[22]

Overgrazing is the principal culprit. After the 1978 economic reforms, when China shifted to a market economy, the government lost control of livestock numbers. As a result, the livestock population soared. The 106 million cattle and 298 million sheep and goats that now range across the land are simply denuding the western and northern part of the country, a vast grazing commons.[23]

A report by a U.S. embassy official in May 2001 after a visit to Xilingol Prefecture in Inner Mongolia notes that official data classify 97 percent of the prefecture as grassland, but that a simple visual survey indicates that a third of the terrain appears to be desert. The report describes the livestock population in the prefecture climbing from 2 million as recently as 1977 to 18 million in 2000. A Chinese scientist doing grassland research in the prefecture says that if recent desertification trends continue, Xilingol will be uninhabitable in 15 years.[24]

A recent U.S. Embassy report entitled "Desert Mergers and Acquisitions" says satellite monitoring shows 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 in this area are regularly inundated by sand dunes.[25]

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 ever more productive land may now rest on stopping the growth in human numbers and in the livestock on which they depend.

Crops and Cars Compete for Land

In addition to the losses to degradation, prime cropland is also being paved over. As the new century begins, the competition between cars and crops for land is intensifying. The addition of 12 million cars each year consumes, in new roads, highways, and parking lots, roughly 1 million hectares of land—enough to feed 9 million people if it were all cropland. Since the world's people are concentrated in the agriculturally productive regions, a disproportionate share of the land paved for cars is cropland.[26]

Millions of hectares of cropland in the industrial world have been paved over for roads and parking lots. Each U.S. car, for example, requires on average 0.07 hectares (0.18 acres) of paved land for roads and parking space. Thus for every five cars added to the U.S. fleet, an area the size of a football field is covered with asphalt. More often than not, it is cropland that is paved simply because the flat, well-drained soils that are well suited for farming are also ideal for building roads.[27]

The United States, with its 214 million motor vehicles, has paved 6.3 million kilometers (3.9 million miles) of roads, enough to circle the earth at the equator 157 times. In addition to roads, cars require parking space. Imagine a parking lot for 214 million cars and trucks. If that is a stretch, try visualizing a parking lot for 1,000 cars and then imagine what 214,000 of these would look like.[28]

However we visualize it, the U.S. area devoted to roads and parking lots covers an estimated 16 million hectares (39 million acres), almost as much as the 20 million hectares that U.S. farmers plant in wheat. But this paving of land in industrial countries is slowing as countries approach automobile saturation. In the United States, there is nearly one vehicle for every person. In Western Europe and Japan, there is typically one for every two people.[29]

In developing countries, however, where automobile

fleets are still small and where cropland is in short supply, the paving is just getting under way. More and more of the 11 million cars added to the world fleet of 531 million are being added in the developing world. This means that the war between cars and crops is being waged over wheat fields and rice paddies in countries where hunger is common. The outcome of this conflict in China and India, which together contain 2.4 billion people, will affect food security everywhere.[30]

Car-centered industrial societies that are densely populated, such as Germany, the United Kingdom, and Japan, which have paved an average of 0.02 hectares per vehicle, have lost some of their most productive cropland in the process. Similarly, China and India also face acute pressure on their cropland base from industrialization. Although China covers roughly the same area as the United States, its 1.3 billion people are concentrated in just one third of the country—a thousand-mile strip on the eastern and southern coast where the cropland is also located.[31]

If China were one day to achieve the Japanese ownership rate of one car for every two people, it would have a fleet of 640 million, compared with only 13 million today. While the idea of such an enormous fleet may seem farfetched, we need only remind ourselves that China has already overtaken the United States in steel production, grain production, and red meat production. It is a huge economy and, since 1980, also the world's fastest growing one.[32]

Assuming the same paved area per vehicle in China as in Europe and Japan, a fleet of 640 million cars would require paving nearly 13 million hectares—most of which would likely be cropland. This would equal almost half of China's 28 million hectares of riceland, which produces 122 million tons of rice, the principal food staple.[33]

The situation in India is similar. While India is geographically only a third the size of China, it too has more than 1 billion people, and it now has 8 million motor vehicles. A land-hungry country projected to add 515 million more people by 2050 cannot afford to cover valuable cropland with roads and parking lots.[34]

There simply is not enough land in China, India, and other densely populated countries such as Indonesia, Bangladesh, Pakistan, Iran, Egypt, and Mexico to support auto-centered transportation systems and to feed their people. The competition between cars and crops for land is becoming a competition between the rich and the poor, between those who can afford automobiles and those who are struggling to buy enough food.

The Land-Hungry Soybean

Sometimes the competition for land to produce grain comes from unexpected sources, such as the soybean, which has emerged as a strategic player in our modern food economy. Widely consumed as food, it is now also the leading vegetable oil for table use and the principal protein supplement for livestock, poultry, and fish rations.

Roughly one tenth of the world soybean harvest is consumed as food, mostly as tofu, as a meat substitute in veggie burgers, or as other products, such as soy sauce—a ubiquitous ingredient in East Asian cuisines. One fifth of the harvest is consumed as vegetable oil. In 2002, the world's soybean harvest exceeded that of all other oilseeds combined, including olives, peanuts, sunflowers, rapeseed, cottonseed, and coconuts. Although coconut oil looms large in the vegetable oil economy of Southeast Asia and olive oil has long been a standby in the Mediterranean countries, it is soybean oil that dominates the world vegetable oil economy.[35]

When crushed, the soybean yields roughly 20 percent

oil and 80 percent meal. Over the last 50 years, soybean meal has emerged as the world's dominant protein supplement in livestock, poultry, and fish rations, exceeding the use of all other high-protein meals combined. The incorporation of small amounts of high-quality soy protein into feed rations boosts sharply the efficiency with which pigs, poultry, and fish convert grain into animal protein, making the soybean invaluable.[36]

The soybean, domesticated in Central China some 5,000 years ago, was imported into the United States in 1804. For nearly a century and a half the soybean languished in the United States, grown largely as a garden novelty crop. But then following World War II, as the global demand for vegetable oil and for animal feed protein supplements soared, U.S. farmers began to expand production rapidly, quickly eclipsing the output in China. In 1973, the soybean harvested area in the United States overtook that of wheat. It surpassed corn in 1999. The U.S. 2002 soybean harvest was worth $13 billion, nearly twice that of wheat.[37]

Rather quickly, the geographic focus of soybean production had shifted to the New World. By 1990, the United States was producing half of the world's soybeans, most of them in the Corn Belt, often in an alternate-year rotation with corn. In Brazil and Argentina, which have discovered in recent decades that the soybean is well adapted to their soils and climate, production has also climbed, collectively overtaking that of the United States in 2003.[38]

Worldwide, the soybean harvest expanded from 17 million tons in 1950 to 194 million tons in 2002. (See Figure 3–1.) This 11-fold gain compares with a threefold gain of the world grain harvest during the same period. Nearly all the growth in grain production since 1950 has come from raising grain yields, whereas the 11-fold

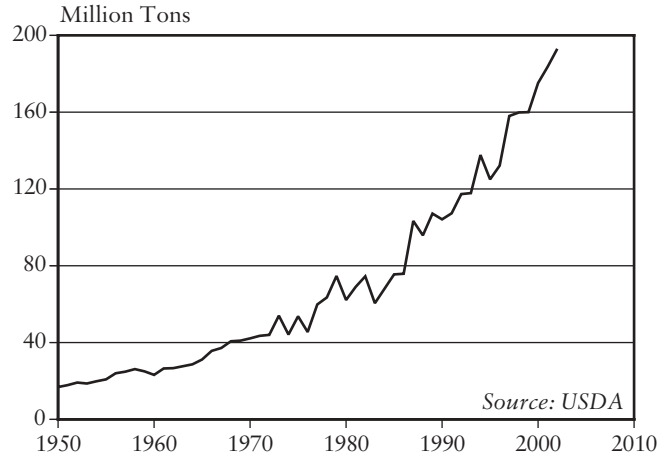

Figure 3–1. *World Soybean Production, 1950–2002*

increase in soybeans depended heavily on a sixfold increase in area. Because the soybean, a legume, devotes much of its metabolic energy to fixing nitrogen in the soil and to producing high-quality protein, yields have risen slowly compared with those of grain. We get more soybeans by planting more soybeans. Given the role of the soybean in boosting the efficiency with which grain is converted into animal protein worldwide, producing more soybeans is essential. But satisfying the growing demand for them will nonetheless take additional land.[39]

Grainland Gains and Losses

The world grain area expanded from 587 million hectares in 1950 to its historical peak of 732 million hectares in 1981. Since then, however, grainland has shrunk, dropping to 647 million hectares in 2002. The first large expansion in grainland after World War II came in the late 1950s with the Soviet Virgin Lands project. Concentrated in what is now the Republic of Kazakhstan, this

involved plowing vast areas of grassland with only marginal rainfall. Within a matter of years, the area cleared for grain exceeded the wheat area in Canada and Australia combined. It was a massive expansion, but it was not ecologically sustainable.[40]

Another major contributor to the expansion of harvested area was the growth in irrigation, which both brought arid land under cultivation and facilitated double cropping. With irrigation, countries with moderate climates could often raise a second crop during the dry season. This enabled northern India, for example, to double crop wheat and rice. On the North China Plain, it enabled farmers to double crop wheat and corn. And in parts of southern China and southern India, rice could be double cropped and even occasionally triple cropped. As the century neared its end, the growth in irrigation slowed and in some countries, such as Saudi Arabia, the irrigated land area began to shrink.[41]

Over the last two decades, some countries that had overplowed were forced to pull back. Kazakhstan's grain area, which was roughly 25 million hectares in 1980, had shrunk to 12 million hectares by 2000. In the United States, the Conservation Reserve Program was created in the 1985 Food Security Act to convert highly erodible cropland back into grass or trees. This program retired some 14 million hectares, roughly one tenth of U.S. cropland, from 1985 onward.[42]

As the last century was ending, the Chinese government, concerned about the dust bowl forming in the country's northwest, launched a conservation program similar to that of the United States—one designed to help farmers plant some 10 million hectares of highly erodible grainland in trees. In addition to this planned cropland retirement, China is losing land for other reasons, as noted earlier. Between 1997 and 2002, its grain harvested

area shrank from 90 million to 81 million hectares, partly from irrigation water shortages and the resultant decline in double cropping and partly from desert encroachment. By crop, more than 7 million hectares of the decline was of wheat and 2 million was of rice.[43]

Cropland is also being converted to fish ponds. China, producer of more than 20 million tons of farmed fish, which is roughly two thirds of the global total, has devoted 5 million hectares of land—much of it cropland—to fish ponds. Dominated by a sophisticated freshwater carp polyculture, this activity is continuing to expand. In the United States, where aquaculture is dominated by catfish, some 44,000 hectares (109,000 acres) of land in Mississippi are devoted to catfish ponds. Much of this bottomland was once used to grow rice.[44]

In this new century, some rainforest is being cleared for oil palm production in Malaysia and Indonesia, but by far the largest cropland expansion initiative under way today is in Brazil to the south and west of the Amazon basin. This savannah-like land, known as the *cerrado*, is being cleared by Brazilian farmers as they both respond to the soaring world demand for soybeans and feed a domestic population of 176 million, which is growing and becoming more affluent. Thus far, land cleared in the *cerrado* has been used largely to produce soybeans. This, combined with a shift of grainland to soybeans, has expanded the soybean area from 10 million hectares in 1990 to nearly 18 million in 2002.[45]

This land expansion, combined with rising yields, has tripled Brazil's soybean harvest since 1990, putting it in a position to soon eclipse the United States as the world's leading soybean producer and exporter. Although the *cerrado* appears well adapted to producing soybeans, it has not yet contributed much to expanding the world grain harvest. It might, however, do so if its

farmers adopt a two-year rotation with soybeans and corn, similar to that used in the U.S. Corn Belt.[46]

Argentina is also contributing to the surge in world soybean output by shifting land from grain and by plowing its grasslands. But this grassland cannot be extensively plowed without encountering serious erosion and wildlife problems.

Brazil's expansion into the *cerrado* stands alone in the early twenty-first century as the only large-scale initiative to increase the world's cropland, one that could exceed in scale the Soviet Virgin Lands project of a half-century ago. If earlier expansion efforts in other countries are any guide, however, Brazil will also overexpand and be forced at some point to pull back.[47]

Spreading Land Hunger

Nowhere is the ubiquitous effect of population growth so visible as in its effect on the size of farms. With the world's grainland area changing relatively little over the last half-century and with population more than doubling, grainland per person shrank by more than half from 1950 to 2000. By 2050, it is projected to shrink further—to less than in India today. And because the nearly 3 billion people to be added by then will be born in developing countries, they will experience a disproportionate shrinkage in grainland.[48]

The shrinkage in India, which is projected to add nearly 500 million people by mid-century, is of particular concern. In 1960 India had 48 million farms, but as land was transferred from one generation to the next and then to the next, and divided each time among the heirs, the number of farms multiplied to 105 million by 1990. Farms that averaged 2.7 hectares in 1960 are less than half that size today. Millions of inherited plots are so small that their owners are effectively landless.[49]

The projected shrinkage in Nigeria, Africa's largest country, is even greater, since its population is expected to increase from 121 million today to 258 million in 2050. With a population in 2050 approaching that in the United States today, squeezed into a country only slightly larger than Texas, the handwriting on the wall is clear.[50]

In the western hemisphere, Mexico's grainland area per person has shrunk by half over the last 50 years. With its small plots being divided and then divided again as each successive generation inherits the family farm, land hunger plagues rural areas. The population is projected to grow from 102 million to 140 million by 2050. Some 400 to 600 people per day are fleeing rural areas, making Mexico City one of the world's largest cities and the United States the principal destination of migrants.[51]

Looking ahead, we are encouraged by the slowing of world population growth over the last two decades. But even so, some countries, including Pakistan, Nigeria, Ethiopia, Colombia, the Philippines, Saudi Arabia, and Iraq, are projected to add more people during the next 50 years than they did during the last 50.[52]

In some countries, the land that a family of five has to produce their wheat, rice, or corn in 2050 will be less than 1 acre—less than the living space of an affluent American family with a house in the suburbs. Among the countries in this situation are Bangladesh, China, Ethiopia, India, Mexico, Nigeria, Pakistan, Tanzania, and Uganda. Even worse, in Egypt, Malaysia, and Rwanda, the grainland per person in 2050 will be scarcely half the size of a tennis court.[53]

Except for those in sub-Saharan Africa, virtually all developing countries have benefited from the enormous gains in land productivity over the last half-century. Unfortunately, for many countries where land productivity has already doubled or tripled, such as Mexico,

Egypt, India, and Pakistan, future gains to offset the shrinkage in grainland per person will be difficult to come by.[54]

Eradicating hunger in a world of eroding soils and shrinking cropland per person will not be easy, but it can be done, as described in Plan B, Part II of this book. We know how to conserve soil and raise the land's fertility. We also know how to plan families and stabilize population.

Although the scale of these issues is new, the issues themselves are not. In his classic USDA report, which is still in print, Walter Lowdermilk proposed an eleventh commandment: "Thou shalt inherit the Holy Earth as a faithful steward, conserving its resources and productivity from generation to generation. Thou shalt safeguard thy fields from soil erosion, thy living waters from drying up, thy forests from desolation, and protect thy hills from overgrazing by thy herds, that thy descendants may have abundance forever. If any shall fail in this stewardship of the land, thy fruitful fields shall become sterile stony ground and wasting gullies, and thy descendants shall decrease and live in poverty or perish from off the face of the earth." Lowdermilk was describing in biblical language the basic principles of what today we call sustainable development.[55]