from Lester R. Brown, *Outgrowing the Earth: The Food Security Challenge in an Age of Falling Water Tables and Rising Temperatures* (NY: W.W. Norton & Co., 2005).

5

Protecting Cropland

On April 18, 2001, the western United States—from the Arizona border north to Canada—was blanketed with dust. The dirt 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 up to 100 million tons of topsoil, a vital resource that would take centuries to replace through natural processes.[1]

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.[2]

These two dust storms, among some 20 or more major dust storms in China during 2001 and 2002, are one of the externally visible indicators of the ecological catastrophe unfolding in northern and western China. Overgrazing and overplowing are converting productive land to desert on an unprecedented scale. Other dust storms are occurring in Africa, mostly in the southern

Sahara and the Sahelian zone. Scientists estimate that Chad alone may be exporting 1.3 billion tons of topsoil each year to the Atlantic Ocean, the Caribbean islands, and even Florida in the United States. Wind erosion of soil and the resulting desert creation and expansion are shrinking the cropland base in scores of countries.[3]

Another powerful pressure on cropland is the automobile. Worldwide, close to 400,000 hectares (1 million acres) of land, much of it cropland, are paved each year for roads, highways, and parking lots. In densely populated, low-income developing countries, the car is competing with farmers for scarce arable land.[4]

The addition of more than 70 million people each year requires land for living and working—driving the continuous construction of houses, apartment buildings, factories, and office buildings. Worldwide, for every 1 million people added, an estimated 40,000 hectares of land are needed for basic living space.[5]

These threats to the world's cropland, whether advancing deserts, expanding automobile fleets, or housing developments, are gaining momentum, challenging some of the basic premises on which current population, transportation, and land use policies rest.

Losing Soil and Fertility

Soil erosion is not new. It is as old as the earth itself. But with the advent of agriculture, the acceleration of soil erosion on mismanaged land increased to the point where soil loss often exceeded new soil formation. Once this threshold is crossed, the inherent fertility of the land begins to fall.

As soil accumulated over millennia, it provided a medium in which plants could grow. Plants protected the soil from erosion. The biological fertility of the earth is due to the accumulation of topsoil over long stretches of geologic time—the product of a mutually beneficial relationship between plants and soil. But as the human enterprise expanded, soil erosion began to exceed new soil formation in more and more areas, slowly thinning the layer of topsoil that had built up over time. Each year the world's farmers are challenged to feed another 70 million or more people but with less topsoil than the year before.[6]

Erosion of soil by water and wind reduces the fertility of rangeland and cropland. For the rangelands that support the nearly 3.1 billion head of cattle, sheep, and goats in our custody, the threat comes from the overgrazing that destroys vegetation, leaving the land vulnerable to erosion. Rangelands, located mostly in semiarid regions of the world, are particularly vulnerable to wind erosion.[7]

In farming, erosion comes from plowing land that is steeply sloping or too dry to support adequate soil protection with ground cover. Steeply sloping land that is not protected by terraces, by perennial crops, or some other way loses soil when it rains heavily. Thus the land hunger that drives farmers up mountainsides fuels erosion. Land that is excessively dry, usually receiving below 25 centimeters (10 inches) of rain a year, is highly vulnerable to wind erosion once vegetation, typically grass, is cleared for cropping or by overgrazing. Under cultivation, this soil often begins to blow away.[8]

In the United States, wind erosion is common in the semiarid Great Plains, where the country's wheat production is concentrated. In the U.S. Corn Belt, where most of the country's corn and soybeans are grown, the principal erosion threat is from water. This is particularly true in the states with rolling land and plentiful rainfall, such as Iowa and Missouri.[9]

Land degradation from both water and wind erosion in the world's vulnerable drylands is extensive, affecting some 900 million hectares (see Table 5–1), an area substantially larger than the world's grainlands (some 670 million hectares). Two thirds of this damaged land is in Africa and Asia, including the Middle East. These also are the world's two most populous regions. And they are where fully two thirds of the 3 billion people expected to be added to world population by 2050 will live. If more people translate into more livestock, as historically has been the case, the damage will spread to still more land.[10]

Table 5–1. *Soil Degradation by Region in Susceptible Drylands, 1990s*

	Water Erosion	Wind Erosion	Total
		(million hectares)	
North America	38	38	76
South America	35	27	62
Europe	48	39	87
Africa	119	160	279
Asia	158	153	311
Australasia	70	16	86
Total	468	433	901

Source: See endnote 10.

The enormous twentieth-century expansion in world food production pushed agriculture onto highly vulnerable land in many countries. The overplowing of the U.S. Great Plains during the late nineteenth and early twentieth century, 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 movement immortalized in John Steinbeck's *The Grapes of Wrath*.[11]

Three decades later, history repeated itself in the Soviet Union. The Virgin Lands Project, a huge effort to convert grassland into grainland between 1954 and 1960, led to the plowing of an area for wheat that exceeded 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 too.[12]

Kazakhstan, at the center of the Virgin Lands Project, saw its grainland area peak and begin to decline around 1980. After reaching a historical high of just over 25 million hectares, it shrank to barely half that size—13 million hectares. Even on the remaining land, however, the average wheat yield is only 1.1 tons per hectare, a far cry from the nearly 7 tons per hectare that farmers get in France, Western Europe's leading wheat producer and exporter. This precipitous drop in Kazakhstan's grain harvest illustrates the price that other countries will have to pay for overplowing and overgrazing.[13]

In the closing decades of the twentieth century, yet another dust bowl—perhaps the biggest of all—began developing in China. As described in Chapter 8, it is the result of overgrazing, overplowing, overcutting of trees, and overpumping of aquifers, all of which make the land in northern and western China more vulnerable to erosion.[14]

Africa, too, is suffering from heavy losses of topsoil as a result of wind erosion. Andrew Goudie, Professor of Geography at Oxford University, reports that dust storms originating over the Sahara—once so rare—are now commonplace. He estimates they have increased tenfold during the last half-century. Among the countries most affected by topsoil loss via dust storms are Niger, Chad, 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.[15]

The Bodélé Depression in Chad is the source of an estimated 1.3 billion tons of dust a year, up tenfold from 1947, when measurements began. Dust storms leaving Africa travel westward across the Atlantic, depositing so much dust in the Caribbean that they damage coral reefs there. When the dust is carried northward and deposited on Greenland, it reduces the reflectivity of the ice, leading to greater heat absorption and accelerated ice melting. 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.[16]

Dust storms and sand storms are a regular feature of life in the Middle East as well. The Sistan Basin on the border of Afghanistan and Iran is now a common source of dust storms in that region. Once a fertile complex of lakes and marshes fed by the Helmand River, which originates in the highlands of eastern Afghanistan, the area has become largely a desert as the river has been drained dry by the increasing water withdrawals by Afghan farmers for irrigation.[17]

The bottom line is that the accelerating loss of topsoil from wind and water erosion is slowly but surely reducing the earth's inherent biological productivity. Unless governments, farmers, and herders can mobilize to reverse this trend, feeding 70 million more people each year will become progressively more difficult.

Advancing Deserts

Roughly one tenth of the earth's land surface is used to produce crops. Two tenths is grassland of varying degrees of productivity. Another two tenths is forest. The remaining half of the land is either desert, mountains, or covered with ice. The area in desert is expanding, largely at the expense of grassland and cropland. Deserts are advancing in Africa both north and south of the Sahara and throughout the Middle East, the Central Asian republics, and western and northern China. (See Table 5–2.) (The effect of desertification on China's food pro-

Table 5–2. *Selected Examples of Desertification Around the World*

Country	Extent of Desertification
Afghanistan	In the Sistan basin, windblown dust and sand have buried more than 100 villages. In the northwest, along the Amu Darya River, a sand dune belt that is some 300 kilometers (186 miles) long and 30 kilometers wide is expanding by up to 1 meter a day.
Brazil	Approximately 58 million hectares of land have been affected. Economic losses associated with desertification are estimated at $300 million a year.
China	Nationwide, deserts are expanding by 360,000 hectares a year. Some 400 million Chinese are affected by the dust storms of late winter and early spring.
India	Various forms of desertification affect 107 million hectares, one third of India's land area.
Iran	In the eastern provinces of Baluchistan and Sistan, some 124 villages have been buried by drifting sand.
Kenya	More than 80 percent of its land is vulnerable to desertification, affecting up to a third of the country's 32 million people and half its livestock.
Mexico	Some 70 percent of all land in Mexico is vulnerable to desertification. Land degradation prompts some 700,000 Mexicans to leave the land each year in search of jobs in Mexican cities or the United States.
Nigeria	Each year 351,000 hectares of land are lost to desertification, which affects each of the 10 northern states.
Yemen	Some 97 percent of the land in this country of 19 million people shows some degree of desertification.

Table 5–2. *continued*

Source: See endnote 18.

duction is discussed in more detail in Chapter 8.)[18]

Nigeria, Africa's most populous country, is losing 351,000 hectares of rangeland and cropland to desertification each year. While Nigeria's human population has increased from 30 million in 1950 to 130 million in 2004, a fourfold expansion, its livestock population has grown from roughly 6 million to 65 million head, a tenfold increase. With the forage needs of Nigeria's 15 million head of cattle and nearly 50 million sheep and goats exceeding the sustainable yield of the country's grasslands, the country is slowly turning to desert.[19]

The government of Nigeria considers the loss of productive land to desert to be far and away its leading environmental problem. No other environmental change threatens to undermine its economic future so directly as the conversion of productive land to desert. Conditions will only get worse if Nigeria continues on its current population trajectory toward 258 million people by 2050.[20]

In the vast swath of Africa between the Sahara Desert and the forested regions to the south lies the Sahel. In countries from Senegal and Mauritania in the west to Sudan, Ethiopia, and Somalia in the east, human and livestock pressures are converting more and more land into desert.[21]

A similar situation exists along the Sahara's northern edge, the tier of largely semiarid countries across the top

After sand storms, electricity and telephone poles are often buried in the drifting sand dunes. In order to keep systems working, soldiers have to raise the lines by extending the pole. Photo: Lu Tongjing.

of Africa. Algeria, in particular, is being squeezed between the Mediterranean Sea and the Sahara Desert as the latter advances northward. In a desperate effort to halt this encroachment, Algeria has decided to convert the southernmost 20 percent of its grainland to perennial crops, such as olive orchards or grape vineyards, that will hold the soil better. Whether this will halt the advancing desert remains to be seen. At a minimum, it will be a difficult sacrifice in a country that already imports 40 percent of its grain.[22]

After more sand storms, the accumulating sand is carried to another location, leaving the extended pole far above the lowered land surface. Photo: Lu Tongjing.

Some of the most severe desertification found anywhere is in China, where 360,000 hectares of land become desert each year. In parts of northern and western China, deserts have expanded to the point where they are beginning to merge. In China's Xinjiang Province, the huge Taklamakan and the smaller Kumtag deserts are approaching each other and appear headed for a merger. On the southwestern edge of Inner Mongolia, the 5-million-hectare (12-million-acre) Bardanjilin desert is moving toward the 3-million-hectare Tengry desert.[23]

In these regions of desert expansion, sandstorms are common, often forcing the abandonment of villages. Keeping highways passable becomes a major challenge as sand dunes advance across roadways. Keeping power lines and telephone lines above the drifting sand is itself a challenge. Special crews periodically follow the phone lines across the countryside looking for poles that may be about to be inundated with drifting sand. They then extend the poles to make sure the lines remain above the sand. But a few months later, the sand may be blown away, leaving the wires suspended far above the ground.[24]

Converting Cropland to Other Uses

In addition to losing cropland to severe soil erosion and desert expansion, the world is also losing cropland to various nonfarm uses, including residential construction, industrial construction, the paving of roads and parking lots, and airports, as well as to recreational uses, such as tennis courts and golf courses. If for every million people added to the world's population, 40,000 hectares of land are needed for nonfarm uses, adding more than 70 million people each year claims nearly 3 million hectares, part of which is agricultural land. The cropland share of land converted to nonfarm uses varies widely both within and among countries, but since cities are typically located on the most fertile land, it is often high—sometimes 100 percent.[25]

China is currently working to create 100 million jobs in the manufacturing sector. With the average factory in China employing 100 workers, China needs to build 1 million factories—many of which will be sited on former cropland. India, with the annual addition of 18 million people and with accelerating economic growth, is facing similar pressures to convert cropland to other uses.[26]

Residential building claims on cropland are also heavy. If we assume each dwelling houses on average five

people, then adding 70 million or more people to world population each year means building 14 million houses or apartments annually.[27]

While population growth spurs housing demand, rising incomes spur automobile ownership. The world automobile fleet is expanding by roughly 9 million per year. (See Figure 5–1.) Each car requires the paving of some land, with the amount paved ranging from a high of 0.07 hectares per vehicle in sparsely populated countries such as the United States, Canada, or Brazil to a low of 0.02 hectares in densely populated areas such as Europe, Japan, China, and India.[28]

As long as a fleet is growing, the country has no choice but to pave more land if it wants to avoid gridlock. In India, a country of only 8 million cars, each new million cars require the paving of roughly 20,000 hectares of land. If it is cropland, and of average productivity, this translates into roughly 50,000 tons of grain, enough to feed 250,000 people at the country's current meager food con-

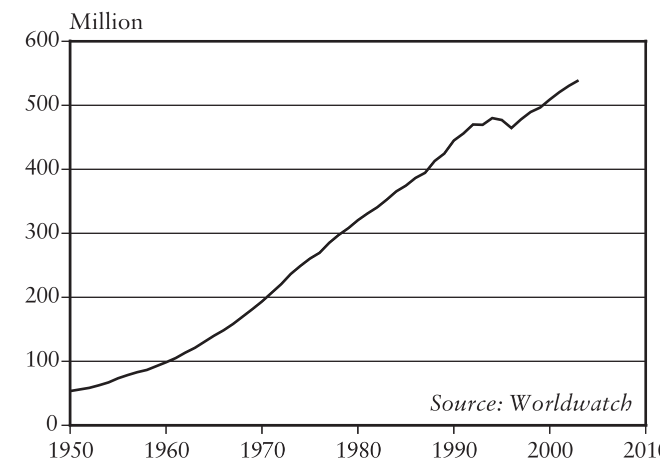

Figure 5–1. *World Automobile Fleet, 1950–2003*

sumption level. A country that will need to feed an additional 515 million people by 2050 cannot afford to cover scarce cropland with asphalt for roads and parking lots.[29]

As the world's affluent turn to the automobile, they are competing for land with those who are hungry and malnourished. Governments in developing countries are essentially using their financial resources to underwrite the public infrastructure for the automobile often at the expense of the hungry.

In the United States, where 0.07 hectares of paved land is required for each car, every five cars added to the fleet require paving an area the size of a football field. Thus the 2 million cars added to the U.S. fleet each year require asphalting an area equal to nearly 400,000 football fields.[30]

Just parking the 214 million motor vehicles owned by Americans requires a vast area of land. Imagine a parking lot with a fleet of 214 million vehicles. If that is difficult, try visualizing a parking lot for 1,000 cars, and then imagine 214,000 such parking lots. The 16 million hectares (61,000 square miles) of U.S. land devoted to roads, highways, and parking lots compares with 21 million hectares that American farmers planted in wheat in 2004.[31]

As the new century gets under way, the competition between cars and crops for land is heating up. Until recently the paving over of cropland has occurred largely in industrial countries, where four fifths of the world's 539 million automobiles are found. But now more and more farmland is being sacrificed in developing countries with hungry populations, calling into question the future role of the car.[32]

There is not enough land in China, India, and other densely populated countries like Indonesia, Bangladesh, Pakistan, Iran, Egypt, and Mexico to both support automobile-centered transportation systems and feed people. The competition between cars and crops for land is thus becoming a struggle between the rich and the poor—between those who can afford automobiles and those who are struggling to get enough food to survive.

Conserving Topsoil

In contrast to the loss of cropland to nonfarm uses, which is often beyond the control of farmers, the losses of soil and eroded land from severe erosion are within their control. Reducing soil losses caused by wind and water erosion to below the rate of new soil formation will take an enormous worldwide effort. Based on the experience of leading food producers such as China and the United States, as well as numerous smaller countries, easily 5 percent of the world's cropland is highly erodible and should be converted back to grass or trees before it becomes wasteland. The first step to halting the decline in inherent land fertility is to pull back from this fast-deteriorating margin.[33]

The key to controlling wind erosion is to keep the land covered with vegetation as much as possible and to slow wind speeds at ground level. Ground-level wind speeds can be slowed by planting shrubs or trees on field borders and by leaving crop residues on the surface of the soil. For areas with strong winds and in need of electricity, such as northwestern China, wind turbines can simultaneously slow wind speeds and provide cheap electricity. This approach converts an agricultural liability—strong winds—into an economic asset.

One time-tested method for dealing with water erosion is terracing, as is so common in rice paddies throughout the mountainous regions of Asia. On less steeply sloping land, contour strip farming, as found in the U.S. Midwest, works well.[34]

Another tool in the soil conservation toolkit—and a relatively new one—is conservation tillage, which includes both no-till and minimum tillage. Farmers are learning that less tillage may be better for their crops. Instead of the traditional cultural practices of plowing land, discing or harrowing it to prepare the seedbed, and then planting with a seeder and cultivating row crops with a mechanical cultivator two or three times to control weeds, farmers simply drill seeds directly through crop residues into undisturbed soil. Weeds are controlled with herbicides. The only soil disturbance is the creation of a narrow slit where the seeds are inserted just below the surface.[35]

This practice, now widely used in the production of corn and soybeans in the United States, has spread rapidly in the western hemisphere over the last two decades. (See Table 5–3.) Data for crop year 2003/04 show the United States with nearly 24 million hectares of land under no-till. Brazil had nearly 22 million hectares, Argentina 16 million, and Canada 13 million. Australia's 9 million hectares rounds out the five leading no-till countries.[36]

In the United States, the combination of retiring highly erodible land under the landmark Conservation Reserve Program that began in 1985, and required farmers to develop conservation plans on cropland eroding excessively, has sharply reduced soil erosion. In addition to the no-till cropland, 19 million more hectares were minimum-tilled, for a total of 43 million hectares of conservation tillage. Conservation tillage was used on 37 percent of the corn crop, 57 percent of the soybean crop, and 30 percent of wheat and other small grains.[37]

Once farmers master the practice of no-till, its use can spread rapidly, particularly if governments provide economic incentives or require farm soil conservation plans for farmers to be eligible for crop subsidies. In the United States, the no-till area went from 7 million hectares in 1990 to nearly 24 million hectares in 2003/04, more than tripling. Recent FAO reports describe the growth in no-

Table 5–3. *Cropland Under No-Till in Key Countries, 2003/04*

Country	Area (million hectares)
United States	23.7
Brazil	21.9
Argentina	16.0
Canada	13.4
Australia	9.0
Paraguay	1.5
Pakistan/Northern India	1.5
Bolivia	0.4
South Africa	0.3
Spain	0.3
Venezuela	0.3
Uruguay	0.3
France	0.2
Chile	0.1
Others	1.2
Total	90.1

Source: See endnote 36.

till farming over the last few years in Europe, Africa, and Asia. In addition to reducing both wind and water erosion, and particularly the latter, this practice also helps retain water, raises soil carbon content, and reduces the energy needed for crop cultivation.[38]

Saving Cropland

Every person added to the world's population in a land-scarce time provides another reason for protecting cropland from conversion to nonfarm uses. Ideally, we would build our homes, offices, factories, shopping malls, roads, and parking lots only on land that is unsuitable for farming. Unfortunately, people are concentrated where the best cropland is located—either because they are farmers or because land that is good for crops is typically the flat, well-drained land that is also ideal for cities and the construction of roads.

This reality underscores the importance of land use planning in the development of human settlements and also in the formulation of transportation policy. The U. S. sprawl model of development is not only land-intensive, it is also energy-inefficient and aesthetically unappealing. Urban sprawl leaves people trapped in communities not densely populated enough to support a first-class public transport system, thus forcing them to commute by car, with all the attendant congestion, pollution, and frustration.

Automobiles promised mobility, and in largely rural societies they provided it. But in urban situations a continually increasing number of cars eventually brings immobility. There is an inherent conflict between the car and the city. After a point, the more cars, the less mobility. Some cities are now taxing cars every time they enter a city or the center district. Initially Singapore but now also Melbourne, Oslo, and, most recently, London have adopted this disincentive to encourage commuters to shift to public transportation, which takes much less land.[39]

European governments, which have followed a very different development model from the United States, have carefully zoned their urban development, leading to a much more land-efficient, energy-efficient, aesthetically pleasing approach. Ironically, Americans often spend their vacations biking in the English or French countrysides, so they can enjoy picturesque rural settings not destroyed by sprawl.

In developing countries facing acute land scarcity, there is now another pressing reason for protecting cropland from the automobile and urban sprawl. China, for example, has been blindly following the western industrial development model. In 1994, it announced that it was going to develop an auto-centered transportation system, inviting manufacturers such as Toyota, General Motors, and Volkswagen to submit proposals for building assembly plants in China.[40]

Within a matter of months a group of senior Chinese scientists, including members of the Academy of Sciences, had produced a white paper challenging this decision. They noted the oil import needs this policy entailed, along with the traffic congestion and air pollution. But their principal question was whether China had enough land both to feed its people and to support an auto-centered transportation system. Their conclusion was that it did not and that the government should build an alternative urban transportation model that used far less land—a system centered on light rail, buses, and bicycles.[41]

We are indebted to these scientists for recognizing early on that the automobile-centered, western industrial development model is simply not appropriate for densely populated developing countries. Nor over the long term is this model likely to be viable in industrial countries either. Numerous European cities are not only investing in first-rate public transportation systems, they are also actively encouraging the use of bicycles for travel within the city. Amsterdam and Copenhagen, where up to 40 percent of all trips within the city are taken by bicycle, are leading the way.[42]

When industrial countries were rapidly urbanizing during the twentieth century, agricultural land was considered a surplus commodity. Now it is a scarce resource.

In today's densely populated developing countries, the amount of land used by transportation systems directly affects food production. In a world of 6 billion people, transportation policy and food security are intimately related.[43]

Data for figures and additional information can be found at www.earth-policy.org/Books/Out/index.htm.