1

A Planet Under Stress

As world population has doubled and as the global economy has expanded sevenfold over the last half-century, our claims on the earth have become excessive. We are asking more of the earth than it can give on an ongoing basis, creating a bubble economy.

We are cutting trees faster than they can regenerate, overgrazing rangelands and converting them into deserts, overpumping aquifers, and draining rivers dry. On our cropland, soil erosion exceeds new soil formation, slowly depriving the soil of its inherent fertility. We are taking fish from the ocean faster than they can reproduce.

We are releasing carbon dioxide (CO_2) into the atmosphere faster than nature can absorb it, creating a greenhouse effect. As atmospheric CO_2 levels rise, so does the earth's temperature. Habitat destruction and climate change are destroying plant and animal species far faster than new species can evolve, launching the first mass extinction since the one that eradicated the dinosaurs 65 million years ago.

Throughout history, humans have lived on the earth's sustainable yield—the interest from its natural endowment. But now we are consuming the endowment itself. In ecology, as in economics, we can consume principal

along with interest in the short run, but in the long run it leads to bankruptcy.

In 2002, a team of scientists led by Mathis Wackernagel, an analyst at Redefining Progress, concluded that humanity's collective demands first surpassed the earth's regenerative capacity around 1980. Their study, published by the U.S. National Academy of Sciences, estimated that our demands in 1999 exceeded that capacity by 20 percent. We are satisfying our excessive demands by consuming the earth's natural assets, in effect creating a global bubble economy.[1]

Bubble economies are not new. American investors got an up-close view of this when the bubble in high-tech stocks burst in 2000 and the NASDAQ, an indicator of the value of these stocks, declined by some 75 percent. Japan had a similar experience in 1989 when the real estate bubble burst, depreciating stock and real estate assets by 60 percent. The bad-debt fallout and other effects of this collapse have left the once-dynamic Japanese economy dead in the water ever since.[2]

The bursting of these two bubbles affected primarily people living in the United States and Japan, but the global bubble economy that is based on the overconsumption of the earth's natural capital assets will affect the entire world. When the food bubble economy, inflated by the overpumping of aquifers, bursts, it will raise food prices worldwide. The challenge for our generation is to deflate the economic bubble before it bursts.

Unfortunately, since September 11, 2001, political leaders, diplomats, and the media worldwide have been preoccupied with terrorism and, more recently, the invasion of Iraq. Terrorism is certainly a matter of concern, but if it diverts us from the environmental trends that are undermining our future until it is too late to reverse them, Osama Bin Laden and his followers will have achieved their goal of bringing down western civilization in a way they could not have imagined.

In February 2003, U.N. demographers made an announcement that was in some ways more shocking than the September 11th attack: the worldwide rise in life expectancy has been dramatically reversed for a large segment of humanity—the 700 million people living in sub-Saharan Africa. The HIV epidemic has reduced life expectancy among this region's people from 62 to 47 years. The epidemic may soon claim more lives than all the wars of the twentieth century. If this teaches us anything, it is the high cost of neglecting newly emerging threats.[3]

The HIV epidemic is not the only emerging mega-threat. Numerous countries are feeding their growing populations by overpumping their aquifers—a measure that virtually guarantees a future drop in food production when the aquifers are depleted. In effect, these countries are creating a food bubble economy—one where food production is artificially inflated by the unsustainable use of groundwater.

Another mega-threat—climate change—is not getting the attention it deserves from most governments, particularly that of the United States, the country responsible for one fourth of all carbon emissions. Washington wants to wait until all the evidence on climate change is in, by which time it will be too late to prevent a wholesale warming of the planet. Just as governments in Africa watched HIV infection rates rise and did little about it, the United States is watching atmospheric CO_2 levels rise and doing little to check the increase.[4]

Other mega-threats being neglected include eroding soils and expanding deserts, which are threatening the livelihood and food supply of hundreds of millions of the world's people. These issues do not even appear on the radar screen of many national governments.

Thus far, most of the environmental damage has been local: the death of the Aral Sea, the burning rainforests of Indonesia, the collapse of the Canadian cod fishery, the melting of the glaciers that supply Andean cities with water, the dust bowl forming in northwestern China, and the depletion of the U.S. Great Plains aquifer. But as these local environmental events expand and multiply, they will progressively weaken the global economy, bringing closer the day when the economic bubble will burst.[5]

Ecological Bills Coming Due

Humanity's demands on the earth have multiplied over the last half-century as our numbers have increased and our incomes have risen. World population grew from 2.5 billion in 1950 to 6.1 billion in 2000. The growth during those 50 years exceeded that during the 4 million years since we emerged as a distinct species.[6]

Incomes have risen even faster than population. Income per person worldwide nearly tripled from 1950 to 2000. Growth in population and the rise in incomes together expanded global economic output from just under $7 trillion (in 2001 dollars) of goods and services in 1950 to $46 trillion in 2000, a gain of nearly sevenfold.[7]

Population growth and rising incomes together have tripled world grain demand over the last half-century, pushing it from 640 million tons in 1950 to 1,855 million tons in 2000. To satisfy this swelling demand, farmers have plowed land that was highly erodible—land that was too dry or too steeply sloping to sustain cultivation. Each year billions of tons of topsoil are being blown away in dust storms or washed away in rainstorms, leaving farmers to try to feed some 70 million additional people, but with less topsoil than the year before.[8]

Demand for water also tripled as agricultural, industrial, and residential uses climbed, outstripping the sustainable supply in many countries. As a result, water tables are falling and wells are going dry. Rivers are also being drained dry, to the detriment of wildlife and ecosystems.[9]

Fossil fuel use quadrupled, setting in motion a rise in carbon emissions that is overwhelming nature's capacity to fix carbon dioxide. As a result of this carbon-fixing deficit, atmospheric CO_2 concentrations climbed from 316 parts per million (ppm) in 1959, when official measurement began, to 369 ppm in 2000.[10]

The sector of the economy that seems likely to unravel first is food. Eroding soils, deteriorating rangelands, collapsing fisheries, falling water tables, and rising temperatures are converging to make it more difficult to expand food production fast enough to keep up with demand. In 2002, the world grain harvest of 1,807 million tons fell short of world grain consumption by 100 million tons, or 5 percent. This shortfall, the largest on record, marked the third consecutive year of grain deficits, dropping stocks to the lowest level in a generation.[11]

Now the question is, Can the world's farmers bounce back and expand production enough to fill the 100-million-ton shortfall, provide for the more than 70 million people added each year, and rebuild stocks to a more secure level? In the past, farmers responded to short supplies and higher grain prices by planting more land and using more irrigation water and fertilizer. Now it is doubtful that farmers can fill this gap without further depleting aquifers and jeopardizing future harvests.[12]

In 1996, at the World Food Summit in Rome, hosted by the U.N. Food and Agriculture Organization (FAO), 185 countries plus the European Community agreed to reduce hunger by half by 2015. Using 1990–92 as a base, governments set the goal of cutting the number of people who were hungry—860 million—by roughly 20 million per

year. It was an exciting and worthy goal, one that later became one of the U.N. Millennium Development Goals.[13]

But in its late 2002 review of food security, the United Nations issued a discouraging report: "This year we must report that progress has virtually ground to a halt. Our latest estimates, based on data from the years 1998–2000, put the number of undernourished people in the world at 840 million…a decrease of barely 2.5 million per year over the eight years since 1990–92."[14]

Since 1998–2000, world grain production per person has fallen 5 percent, suggesting that the ranks of the hungry are now expanding. As noted earlier, life expectancy is plummeting in sub-Saharan Africa. If the number of hungry people worldwide is also increasing, then two key social indicators are showing widespread deterioration in the human condition.[15]

Farmers Facing Two New Challenges

As we exceed the earth's natural capacities, we create new problems. For example, farmers are now facing two new challenges: rising temperatures and falling water tables. Farmers currently on the land may face higher temperatures than any generation since agriculture began 11,000 years ago. They are also the first to face widespread aquifer depletion and the resulting loss of irrigation water.

The global average temperature has risen in each of the last three decades. The 16 warmest years since recordkeeping began in 1880 have all occurred since 1980. With the three warmest years on record—1998, 2001, and 2002—coming in the last five years, crops are facing heat stresses that are without precedent.[16]

Higher temperatures reduce crop yields through their effect on photosynthesis, moisture balance, and fertilization. As the temperature rises above 34 degrees Celsius (94 degrees Fahrenheit), photosynthesis slows, dropping

to zero for many crops when it reaches 37 degrees Celsius (100 degrees Fahrenheit). When temperatures in the U.S. Corn Belt are 37 degrees or higher, corn plants suffer from thermal shock and dehydration. They are in effect on sick leave. Each such day shrinks the harvest.[17]

In addition to decreasing photosynthesis and dehydrating plants, high temperatures also impede the fertilization needed for seed formation. Researchers at the International Rice Research Institute in the Philippines and at the U.S. Department of Agriculture have together developed a rule of thumb that each 1-degree-Celsius rise in temperature above the optimum during the growing season reduces grain yields by 10 percent.[18]

These recent research findings indicate that if the temperature rises to the lower end of the range projected by the Intergovernmental Panel on Climate Change, grain harvests in tropical regions could be reduced by an average of 5 percent by 2020 and 11 percent by 2050. At the upper end of the range, harvests could drop 11 percent by 2020 and 46 percent by 2050. Avoiding these declines will be difficult unless scientists can develop crop strains that are not vulnerable to thermal stress.[19]

The second challenge facing farmers, falling water tables, is also recent. With traditional animal- or human-powered water-lifting devices it was almost impossible historically to deplete aquifers. With the worldwide spread of powerful diesel and electric pumps during the last half-century, however, overpumping has become commonplace.

As the world demand for water has climbed, water tables have fallen in scores of countries, including China, India, and the United States, which together produce nearly half of the world's grain. Water tables are falling throughout the northern half of China. As the water table falls, springs and rivers go dry, lakes disappear, and

wells dry up. Northern China is literally drying out. Water tables under the North China Plain, which accounts for a fourth or more of China's grain harvest, are falling at an accelerating rate.[20]

In India, water tables are also falling. As India's farmers try to feed an additional 16 million people each year, nearly the population equivalent of another Australia, they are pumping more and more water. This is dropping water tables in states that together contain a majority of India's 1 billion people.[21]

In the United States, the third major grain producer, water tables are falling under the southern Great Plains and in California, the country's fruit and vegetable basket. As California's population expands from 26 million to a projected 40 million by 2030, expanding urban water demands will siphon water from agriculture.[22]

Scores of other countries are also overpumping their aquifers, setting the stage for dramatic future cutbacks in water supplies. The more populous among these are Pakistan, Iran, and Mexico. Overpumping creates an illusion of food security that is dangerously deceptive because it enables farmers to support a growing population with a practice that virtually ensures a future drop in food production.

The water demand growth curve over the last half-century looks like the population growth curve, except that it climbs more steeply. While world population growth was doubling, the use of water was tripling. Once the growing demand for water rises above the sustainable yield of an aquifer, the gap between the two widens further each year. As this happens, the water table starts to fall. The first year after the sustainable yield is surpassed, the water table falls very little, with the drop often being scarcely perceptible. Each year thereafter, however, the annual drop is larger than the year before.

In addition to falling exponentially, water tables are also falling simultaneously in many countries. This means that cutbacks in grain harvests will occur in many countries at more or less the same time. And they will occur at a time when the world's population is growing by more than 70 million a year.[23]

These, then, are the two new challenges facing the world's farmers: rising temperatures and falling water tables. Either one by itself could make it difficult to keep up with the growth in demand. The two together provide an early test of whether our modern civilization can cope with the forces that threaten to undermine it.

Ecological Meltdown in China

In the deteriorating relationship between the global economy and the earth's ecosystem, food is the most vulnerable economic sector, but geographically it is China that is on the leading edge. A human population of 1.3 billion and their 400 million cattle, sheep, and goats are weighing heavily on the land. Huge flocks of sheep and goats in the northwest are stripping the land of its protective vegetation, creating a dust bowl on a scale not seen before. Northwestern China is on the verge of a massive ecological meltdown.[24]

Since 1980, the Chinese economy has expanded more than fourfold. Incomes have also expanded by nearly fourfold, lifting more people out of poverty faster than at any time in history. Like many other countries, China is exceeding the carrying capacity of its ecosystem—overplowing its land, overgrazing its rangelands, overcutting its forests, and overpumping its aquifers. In its determined effort to be self-sufficient in grain, it cultivated highly erodible land in the arid northern and western provinces, land that is vulnerable to wind erosion.[25]

While overplowing is now being partly remedied by

paying farmers to plant their grainland in trees, overgrazing is destroying vegetation and increasing wind erosion. China's cattle, sheep, and goat population more than tripled from 1950 to 2002. The United States, a country with comparable grazing capacity, has 97 million cattle, while China has 106 million. For sheep and goats, the figures are 8 million versus 298 million. Concentrated in the 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.[26]

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. And worse, the growing deserts are gaining momentum, occupying an ever-larger piece of China's territory each year.

China's expanding ecological deficits are converging to create a dust bowl of historic dimensions. With little vegetation remaining in parts of northern and western China, the strong winds of late winter and early spring can remove literally millions of tons of topsoil in a single day—soil that can take centuries to replace.

For the outside world, it is these storms that draw attention to the dust bowl forming in China. On April 12, 2002, for instance, South Korea was engulfed by a huge dust storm from China that left residents of 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. Japan also suffers from dust storms originating in China. Although not as directly exposed as Koreans are, the Japanese complain about the dust and the brown rain that streaks their windshields and windows.[27]

Each year, residents of eastern Chinese cities such as Beijing and Tianjin hunker down as the dust storms begin. Along with the difficulty in breathing and the dust that stings the eyes, there is the constant effort to keep dust out of homes and to clean doorways and sidewalks of dust and sand. Farmers and herders, whose livelihoods are blowing away, are paying an even heavier price.

Desert expansion has accelerated with each successive decade since 1950. China's Environmental Protection Agency reports that the Gobi Desert expanded by 52,400 square kilometers (20,240 square miles) from 1994 to 1999, an area half the size of Pennsylvania. With the advancing Gobi now within 150 miles of Beijing, China's leaders are beginning to sense the gravity of the situation.[28]

The fallout from the dust storms is social as well as economic. Millions of rural Chinese may be uprooted and forced to migrate eastward as the deserts claim their land. Desertification is already driving villagers from their homes in Gansu, Inner Mongolia (Nei Monggol), and Ningxia provinces. A preliminary Asian Development Bank assessment of desertification in Gansu Province reports that 4,000 villages risk being overrun by drifting sands.[29]

The U.S. Dust Bowl of the 1930s forced some 2.5 million "Okies" and other refugees to leave the land, many of them heading west from Oklahoma, Texas, and Kansas to California. But the dust bowl forming in China is much larger, and during the 1930s the U.S. population was only 150 million—compared with 1.3 billion in China today. Whereas the U.S. migration was measured in the millions, China's may measure in the tens of millions. And as a U.S. embassy report entitled *The Grapes of Wrath in Inner Mongolia* noted, "unfortunately, China's

twenty-first century 'Okies' have no California to escape to—at least not in China."[30]

Food: A National Security Issue

The ecological deficits just described are converging on the farm sector, making it more difficult to sustain rapid growth in world food output. No one knows when the growth in food production will fall behind that of demand, driving up prices, but it may be much closer than we think. The triggering events that will precipitate future food shortages are likely to be spreading water shortages interacting with crop-withering heat waves in key food-producing regions. The economic indicator most likely to signal serious trouble in the deteriorating relationship between the global economy and the earth's ecosystem is grain prices.

Food is fast becoming a national security issue as growth in the world harvest slows and as falling water tables and rising temperatures hint at future shortages. More than 100 countries import part of the wheat they consume. Some 40 import rice. While some countries are only marginally dependent on imports, others could not survive without them. Iran and Egypt, for example, rely on imports for 40 percent of their grain supply. For Algeria, Japan, South Korea, and Taiwan, among others, it is 70 percent or more. For Israel and Yemen, over 90 percent. Just six countries—the United States, Canada, France, Australia, Argentina, and Thailand—supply 90 percent of grain exports. The United States alone controls close to half of world grain exports, a larger share than Saudi Arabia does of oil.[31]

Thus far the countries that import heavily are small and middle-sized ones. But now China, the world's most populous country, is likely to soon turn to world markets in a major way. When the former Soviet Union unexpectedly turned to the world market in 1972 for roughly a tenth of its grain supply, following a weather-reduced harvest, world wheat prices climbed from $1.90 to $4.89 a bushel. Bread prices soon rose too.[32]

If China depletes its grain reserves and turns to the world grain market to cover its shortfall, now 40 million tons per year, it could destabilize world grain markets overnight. Turning to the world market means turning to the United States, presenting a potentially delicate geopolitical situation in which 1.3 billion Chinese consumers with a $100-billion trade surplus with the United States will be competing with American consumers for U.S. grain. If this leads to rising food prices in the United States, how will the government respond? In times past, it could have restricted exports, even imposing an export embargo, as it did with soybeans to Japan in 1974. But today the United States has a stake in a politically stable China. With an economy growing at 7–8 percent a year, China is the engine that is powering not only the Asian economy but, to some degree, the world economy.[33]

For China, becoming dependent on other countries for food would end its history of food self-sufficiency, leaving it vulnerable to world market uncertainties. For Americans, rising food prices would be the first indication that the world has changed fundamentally and that they are being directly affected by the growing grain deficit in China. If it seems likely that rising food prices are being driven in part by crop-withering temperature rises, pressure will mount for the United States to reduce oil and coal use.

For the world's poor—the millions living in cities on $1 per day or less and already spending 70 percent of their income on food—rising grain prices would be life-threatening. A doubling of world grain prices today could impoverish more people in a shorter period of time

than any event in history. With desperate people holding their governments responsible, such a price rise could also destabilize governments of low-income, grain-importing countries.[34]

When I projected in 1995 in *Who Will Feed China?* that China would one day turn abroad for part of its grain, the U.S. National Intelligence Council, the umbrella over all the U.S. intelligence agencies, launched the most detailed assessment of China's food prospect ever undertaken. The council was concerned precisely because such a move by China could drive up world grain prices and destabilize governments in developing countries. An interdisciplinary team led by Michael McElroy, Chairman of Harvard's Department of Earth and Planetary Sciences, conducted this extraordinarily ambitious study. Relying on an interdisciplinary approach and a vast array of resources, including 35 years of CIA satellite data on land use and the Sandia National Laboratories to model the water supply-demand balance of every river basin in China, the team concluded in its "most likely" scenario that China would one day have to import massive quantities of grain.[35]

The team then decided that the world would not have any difficulty in supplying grain on such a vast scale. The shortcoming of this conclusion, in my opinion, was that it relied too heavily on extrapolating late twentieth-century grain production trends into the twenty-first century, failing to take into account emerging constraints on harvests, such as aquifer depletion and rising temperatures.

When grain prices began to climb in 1972–74, it did not take long for a politics of food scarcity to emerge. Pressure from within grain-exporting countries to restrict exports in order to check the rise in domestic food prices was common.[36]

More recently, the Canadian Wheat Board, which handles the nation's wheat exports, announced in early September 2002 that it had no more to sell. This abrupt withdrawal from the market—even before that year's drought-reduced harvest was complete—illustrates the kind of action that exporters can take when confronted with scarcity. Instead of letting the world market allocate scarce supplies of high-quality wheat, the Board decided that it would protect domestic supplies, then sell only to traditional clients, leaving other importers to fend for themselves. In late October, Australia—also experiencing a severe drought—announced that it would ration wheat and barley exports among its best customers, excluding all other potential buyers.[37]

Historically, the world had two food reserves: the global carryover stocks of grain and the cropland idled under the U.S. farm program to limit production. The latter could be brought into production within a year. Since the U.S. land set-aside program ended in 1996, however, the world has had only carryover stocks as a reserve.[38]

Food security has changed in other ways. Traditionally it was largely an agricultural matter. But now it is something that our entire society is responsible for. National population and energy policies may have a greater effect on food security than agricultural policies do. With most of the 3 billion people to be added to world population by 2050 being born in countries already facing water shortages, childbearing decisions may have a greater effect on food security than crop planting decisions. Achieving an acceptable balance between food and people today depends on family planners and farmers working together.[39]

Climate change is the wild card in the food security deck. It is perhaps a measure of the complexity of our time that decisions made in the Ministry of Energy may

have a greater effect on future food security than those made in the Ministry of Agriculture. The effect of population and energy policies on food security differ in one important respect: population stability can be achieved by a country acting unilaterally. Climate stability cannot.

The Case for Plan B

Thus far, this chapter has focused primarily on how environmental changes can affect the food prospect, but there could be other wake-up calls, including more destructive storms or deadly heat waves.

Unless we quickly reverse the damaging trends that we have set in motion, they will generate vast numbers of environmental refugees—people abandoning depleted aquifers and exhausted soils and those fleeing advancing deserts and rising seas. In a world where civilization is being squeezed between expanding deserts from the interior of continents and rising seas on the periphery, refugees are likely to number not in the millions but in the tens of millions. Already we see refugees from drifting sand in Nigeria, Iran, and China.[40]

We are now looking at the potential wholesale evacuation of cities as aquifers are depleted and wells go dry. Sana'a, the capital of Yemen, and Quetta, the capital of Pakistan's Baluchistan province, may become the early ghost towns of the twenty-first century.[41]

A reversal of the basic trends of social progress of the last half-century has long seemed unthinkable. Progress appeared inevitable. But now we are seeing reversals. As noted earlier, the number of hungry may be increasing for the first time since the war-torn decade of the 1940s. And a rise in life expectancy—a seminal measure of economic and social progress—has been interrupted in sub-Saharan Africa as a result of the HIV epidemic. As millions of able-bodied adults die, families are often left with no one

to work in the fields. The disease and spreading hunger are both weakening immune systems and reinforcing each other, something epidemiologists had not reckoned on.

The failure of governments to deal with falling water tables and the depletion of aquifers in the Indian subcontinent could be as disruptive for the 1.3 billion living there as the HIV epidemic is for the people in sub-Saharan Africa. With business as usual, life expectancy could soon begin to fall in India and Pakistan as water shortages translate into food shortages, deepening hunger among the poor.[42]

The world is moving into uncharted territory as human demands override the sustainable yield of natural systems. The risk is that people will lose confidence in the capacity of their governments to cope with such problems, leading to social breakdown. The shift to anarchy is already evident in countries such as Somalia, Afghanistan, and the Democratic Republic of the Congo.

Business as usual—Plan A—is clearly not working. The stakes are high, and time is not on our side. Part I details the mounting evidence that our modern civilization is in trouble. The good news, as outlined in Part II of this book, is that there are solutions to the problems we are facing. The bad news is that if we continue to rely on timid, incremental responses, our bubble economy will continue to grow until eventually it bursts. This book argues for a new approach—for Plan B—an urgent reordering of priorities and a restructuring of the global economy in order to prevent that from happening.