

Agriculture: Land and Food

“Growing crops is nothing else but a more or less astute management of peculiarly simplified ecosystems.”¹ In the last half century, however, agricultural management has ignored the lessons of nature. The net loss of topsoil annually may be as much as twenty-five billion tons,² which is catastrophic, because it takes up to five hundred years for nature to create an inch of topsoil.³ Also, deforestation has increased water runoff and affected rainfall, causing a loss of about fifteen million acres of fertile land each year to desertification.⁴

Irrigation has increased crop yields, but has made a quarter of the world’s farmland less fertile due to salt left in the soil by evaporation, or waterlogged if the land was not properly drained. Even though only 17 percent of the world’s cropland is irrigated, that portion produces 40 percent of the global harvest. This disproportionate share is largely the result of the capability of irrigated lands to produce two or even three crops in a year.⁵ Because of irrigation, however, water tables are falling, and underground aquifers are being depleted. Modern industrialized agriculture severely strains the world’s water resources, and in the United States consumes 85 percent of all available freshwater.⁶

The use of artificial fertilizer has produced higher crop yields, but degraded the soil. In fields watered by rain only about 40 percent of the nitrogen in artificial fertilizer is taken up by the crops, and in rice paddies as little as 20 percent of the nitrogen in fertilizer is utilized.⁷ Des Moines, Iowa, draws its drinking water from the Des Moines River, but when nitrogen runoff is heaviest in the spring, the city issues “blue baby alerts” that warn parents not to give their children tap water, because: “The nitrates in the water bind to hemoglobin, compromising the blood’s ability to carry oxygen to the brain.”⁸

Agricultural runoff of nitrogen compounds into streams has led to at least fifty dead zones in the oceans, including one in the Gulf of Mexico the size of New Jersey.⁹ “We have perturbed the global nitrogen cycle,” Czech scientist Vaclav Smil asserts, “more than any other, even carbon.”¹⁰

Modern agriculture is productive, but also precarious. “The world’s food supply hangs by a slender thread of biodiversity. Ninety percent is provided by slightly more than a hundred plant species out of a quarter-million known to exist. Twenty species carry most of the load, of which only three—wheat, maize [corn], and rice—stand between humanity and starvation.”¹¹ What should our ethical presumptions be? I argue that (1) agriculture should be modeled on nature, (2) poor farmers can feed themselves and their communities when their human rights are protected, and (3) farming can and should be environmentally sustainable.

Nature’s Cycles

Plants depend on nitrogen, phosphorus, and potassium, and the soil’s *humus* is rich in these elements. “Humus is what’s left of organic matter after it has been broken down by the billions of big and small organisms that inhabit a spoonful of earth.”¹² An ecosystem naturally maintains the humus required by plants.

Nitrogen is the most important nutrient for plant growth, but plants can only use nitrogen that is fixed by bacteria. Legumes (members of the bean family) form “symbiotic

relationships with nitrogen fixing bacteria. In exchange for some nitrogen, the bacteria receive from the plants carbohydrates and special structures (nodules) in roots where they can exist in a moist environment. Scientists estimate that biological fixation globally adds approximately 140 million metric tons of nitrogen to ecosystems every year.”¹³

Nitrogen plays a major role in protein and chlorophyll production, and chlorophyll enables plant cells to carry on photosynthesis, which uses solar energy to transform carbon dioxide into sugars. The *nitrogen cycle* is crucial for agriculture, but adding more fixed nitrogen to the soil will not increase yields without a sufficient amount of phosphorus. Phosphorus is required by the enzymes in plants that accumulate and convert carbon dioxide into sugars in photosynthesis and is also needed for the construction and reproduction of DNA.¹⁴

In the *phosphorus cycle* rain removes phosphates from rocks and carries them through the soil, where plants take them up. Phosphates move “from plants to animals when herbivores eat plants and carnivores eat plants or herbivores. The phosphates absorbed by animal tissue through consumption eventually return to the soil through the excretion of urine and feces, as well as from the final decomposition of plants and animals after death.”¹⁵

Potassium regulates the water content in plants and the use of nutrients, resists plant diseases and drought, and increases the efficiency of photosynthesis. The *potassium cycle* takes place in the soil and in plants. In agricultural ecosystems, crops take various amounts of potassium from the soil. Thus the amount of potassium in the soil depends on the methods of cultivating and harvesting the crops.

The use of artificial fertilizer raises levels of nitrogen, phosphorus, and potassium in the soil and increases plant growth, but disrupts the natural cycles of these elements. Furthermore, using pesticides with artificial fertilizers, which is standard practice in industrial agriculture, degrades the humus that maintains soil fertility.

Industrial Agriculture

“Mother earth never attempts to farm without livestock; she always raises mixed crops; great pains are taken to preserve the soil and to prevent erosion; the mixed vegetable and animals wastes are converted into humus; there is no waste; the processes of growth and the processes of decay balance one another; the greatest care is taken to store the rainfall; both plants and animals are left to protect themselves against disease.”¹⁶

Industrial agriculture ignores these lessons. It replaces farm animals with machines, diverse crops and crop rotation with a single crop, natural fertilizer with artificial fertilizer, and grazing with barns and stockyards where livestock are fed grain treated with hormones and antibiotics to fatten the animals and resist the bacteria that thrive in such artificial environments.

Inputs

Cheap fossil fuels (which are “cheap” only because of government subsidies) have made industrial agriculture feasible. Artificial fertilizer is made from natural gas and pesticides are made from oil. Gasoline powers tractors and irrigation pumps, equipment in the livestock barns, trucks that transport food to processing plants and markets, and processing and refrigeration for much of the food.¹⁷ The food industry burns almost one-fifth of all the petroleum consumed in the United States (about as much as cars do). The US food

production system uses seven to ten calories of fossil fuel energy to deliver one calorie of food energy.¹⁸

Much the same is true for fish farming (aquaculture), because fishing fleets need to catch the cheap fish to make the fishmeal that is fed to the fish being farmed. For instance, fishing boats burn about five gallons of diesel fuel for each ten pounds of Canadian farmed salmon harvested.¹⁹

The development of higher yield hybrid seeds led to what is called the Green Revolution, which increased world grain production between 1950 and 1984 by 250 percent. By 1994, however, it took four hundred gallons of oil to feed each US citizen. Since 1994 the energy input in agriculture has continued to grow, but this increased input has not meant a higher yield, because the soil has been degraded and pesticides have become less effective.²⁰

Artificial fertilizers increase yields,²¹ but with great waste. Growing a single crop makes using machinery easier (to cultivate and fertilize), but attracts pests. To fight pests, about 1.2 billion pounds of pesticides are used annually in the United States, which is about five pounds for every person. But pests have evolved resistance to these chemicals. Despite a tenfold increase in pesticide use since the 1950s, *crop losses to pests have doubled*.²²

Over the past four decades, major crop losses have increased in relative terms largely due to:

- Planting crops that are increasingly susceptible to insects.
- Killing the natural enemies of pests by using pesticides.
- The development of greater pesticide resistance in insects.
- Reduced use of crop rotation and diversity, which limit pest damage.
- Planting in climatic regions where crops are more susceptible to insects.
- Using pesticides that make crops more susceptible to insects.²³

To reduce losses to pests, US farm policy has adopted integrated pest management (IPM), which was designed to manage “pests in an ecologically and economically sound way. Pesticides were to be applied only as needed, and decisions to treat were to be based on regular monitoring of pest populations and natural enemies (or antagonists) of pests in the target system.”²⁴ In 2001, however, a report by the General Accounting Office (GAO) found that the total use of agricultural pesticides had actually increased since the IPM initiative began, because farmers were ignoring the IPM guidelines.

It is the same worldwide. The World Bank (WB) requires that agricultural projects “reduce reliance on pesticides and promote farmer-driven, ecologically based integrated pest management.” However, in 1993 a WB report concluded that both national governments and agribusiness were promoting excessive use of chemical pesticides.²⁵

Agribusiness

The shift to industrial agriculture began in the 1970s. Bankers offered low-interest loans, and farmers were persuaded that they would do better by taking out loans to invest in more land and equipment so they could increase production. When inflation raised interest rates, farmers were unable to repay their loans, because the surplus of food they were producing had driven prices down.

In the 1980s thousands of farmers went bankrupt, and much of their land was bought up by corporations. Many surviving farmers in the United States have agreed to the “contract

growing of chickens, hogs, and cattle owned by or committed to the processing companies,”²⁶ although this requires that they bear all the risk. Today 95 percent of the chickens in the United States are raised by contract growers, and half of these are owned by four food processors.²⁷ Four firms—Archer Daniels Midland (ADM), Cargill, Cenex Harvest Services, and General Mills—own 60 percent of the grain-handling facilities in the United States.²⁸

When four companies control 40 percent or more of a market, they control the price of goods. In 1996 Archer Daniels Midland (ADM) pled guilty to price fixing and paid an antitrust fine of \$100 million. A year before the lawsuit was filed, ADM’s chairman admitted that: “The only place you see a free market is in the speeches of politicians.”²⁹

Federal farm policy has undercut effective market pricing. In the midst of the Great Depression the federal government began to use price supports and loans to help farmers survive. In the 1970s the Nixon administration changed to direct subsidies, primarily for wheat, corn, soybeans, rice, and cotton. Paying farmers “directly for the shortfall in the price of corn was revolutionary, as its proponents surely must have understood.”³⁰ Instead of removing corn and other commodities supported by the federal farm bill “out of a falling market, as the old loan programs and federal granary had done, the new subsidies encouraged farmers to sell their corn [and other commodities] at any price, since the government would make up the difference.”³¹

Under this system of subsidies farmers try to maximize their yield on the land they plant, which makes sense given their fixed costs for loans and equipment. They buy more fertilizer and pesticide, which increases their input costs and also their yield. Higher productivity has generally led to declining market prices, less profit for farmers overall, and the consolidation of agricultural land under corporate ownership—as independent farmers have often been unable to pay their debts.

In 2007, however, there was a dramatic change, at least for those growing corn. Federal subsidies for the production of ethanol began driving up the market price of corn, making independent farmers rich and agribusiness richer. In 2011 corn prices almost doubled between January and July, as about 40 percent of the field corn crop was converted to ethanol.³² Senator Richard Lugar, an Indiana farmer and former chairman of the Senate Agriculture Committee, admits that federal farm subsidies, which are “narrowly focused on certain crops and are excessive,” have become “ridiculous given the exploding possibilities to grow crops for biofuels production.”³³

Opponents of the US farm legislation argue that it subsidizes the overproduction of corn and soy, which in our food chain increase obesity and diabetes. Instead, they say, the farm bill should support sustainable and organic food production and put a higher priority on fresh local fruits and vegetables.³⁴ A *New York Times* editorial concludes that farm legislation “preserves an indefensible program of direct payments amounting to about \$5 billion a year that flow in good times and bad. It raises support levels for wheat and soybeans, while adding several new crops to the list in a way that will make it easier for farmers to raid the federal Treasury even when prices go up.”³⁵

Clearly farm legislation has favored agribusiness.³⁶ Ten percent of America’s largest and richest farms collect almost three-fourths of federal farm subsidies, payments that too often promote harmful environmental practices.³⁷ Between 1995 and 2010 the largest and wealthiest operations (10 percent of the total farms subsidized) received 76 percent of all

the commodity payments, with an average payment of \$447,873 per recipient each year. Reforms introduced into the 2008 farm bill had only a slight impact, reducing the take by the top 10 percent of recipients to 63 percent of the total commodity subsidies paid in 2010.³⁸

Therefore, the 2012 farm bill should cut the \$5 billion in direct payments sent to farm businesses every year regardless of need. The bill should also limit crop insurance, which grew from \$2.1 billion in 2002 to \$8.8 billion in 2011. “Requiring minimum conservation standards and focusing insurance on helping farmers survive a crippling crop failure would save billions, improve the environment and end insurance companies’ windfall profits.”³⁹

Agribusiness not only controls federal farm policy—as well as seeds, livestock, and food processing—but also food retailing. In 1992 the top five retailers—Albertson’s, Ahold USA, Kroger, Safeway, and Wal-Mart—had only 19 percent of the national market, but by 2004 these five corporations had captured over 45 percent of the national market and almost 75 percent of the market in the largest cities.⁴⁰ Pillsbury and General Mills merged in 2000, and Tyson and IPB in 2001. By 2005, 84 percent of the beef sold in the United States was packed by only four corporations.⁴¹

Agribusiness also controls international trade. The North American Free Trade Agreement (NAFTA) has “encouraged concentration in the food processing industry and the expansion of factory farms and agribusiness in all three NAFTA countries [Mexico, Canada, and the United States].”⁴² Half of Mexico’s small farmers have been pushed off the land, and Mexico now imports more than ten times as much corn from the United States as it did before NAFTA. The gap between rich and poor in Mexico and in the United States has grown, which increased the number of Mexicans coming illegally into the United States to look for work.⁴³

In 2002 the World Trade Organization (WTO) reported “that the rich nations subsidize their agricultural producers at a rate of \$1 billion a day, or more than six times the level of development aid they give to poor nations.”⁴⁴ Trade agreements under the WTO, International Monetary Fund, and WB reveal the impact of subsidies in rich countries. In Tanzania, for instance, “the overall impact on food security of the liberalization of agricultural trade is profoundly negative. Farmer incomes are declining, and, at the same time, school and medical fees have been reintroduced under the Structural Adjustment Program.”⁴⁵ Farmers have to part with some of the little money they earn, and have less to meet farming costs and to buy food in times of shortage.⁴⁶

Between 1995 and 2005 in India, more than twenty-five thousand farmers in prosperous regions killed themselves because they were unable to pay their debts, which had become overwhelming because of the rising input costs of corporate seeds, pesticides, and fertilizers, and the declining market prices for their crops.⁴⁷ Similarly, US cotton subsidies have had a devastating impact on West African families producing cotton. Oxfam International asserts: “More than 1 million children in West Africa would not go to bed hungry if Washington stopped providing subsidies to America’s cotton growers.”⁴⁸

Kofi Annan, the former UN secretary general, writes: “I think the average American should know that the world trading system is not fair. You take the area of agriculture. If US farmers are getting huge subsidies, European farmers are getting huge subsidies and are competing on the global market with a farmer from Burkina Faso or Kenya, how do they compete?”⁴⁹

Corn

Farmers growing corn for ethanol production⁵⁰ have recently benefited from higher prices for corn, but these higher profits are unsustainable. Growing corn requires more fertilizer than growing other crops.⁵¹ Fertilizer is made from natural gas, and as the price of this fossil fuel rises due to increased demand, the price of growing corn (and all products made using corn) will also rise. In addition, growing corn requires a lot of water, but the aquifers are being depleted beneath the midwestern states where the corn is grown. There will soon be less water, and it will cost more, which will also push up the price of corn (and everything containing corn).

Utilizing more corn in the production of ethanol is increasing prices for other goods, making it harder for people with low incomes to buy food. The growing demand for biofuels has shifted the use of land from growing food to producing crops for fuel. Shortsighted policies in the United States and other affluent countries are largely to blame.⁵²

Having water to drink—and to use in growing crops to eat—cannot be left to supply and demand, nor can access to food, because markets do not protect human rights. “A long-held basic human right, the right to adequate food for the world’s 854 million hungry people, is being threatened once again—this time by the conversion of wheat, sugar, palm oil and maize into agricultural fuel.”⁵³

The price of palm oil, for instance, which is widely used for cooking in many countries, jumped nearly 70 percent between 2007 and 2008. For most readers cooking oil may seem unimportant as a cost, but in the developing world it is a major expense for poor families, who grow much of their food but have to buy oil for cooking. Moreover, for these families cooking oil is a crucial source of calories.

The palm is a highly efficient producer of vegetable oil: an acre of oil palms produces as much oil as eight acres of soybeans, which is the main rival for oil palms. Rapeseed, which is used to make canola oil, has a much lower yield. Among major crops, only sugar cane rivals oil palms in producing calories of human food per acre. As the price of palm oil rises, corporations are clearing hundreds of thousands of acres of tropical forest for palm oil plantations.⁵⁴

Rising corn prices will increase the price of most processed foods (which contain corn syrup). Consider these typical items sold at McDonald’s: soda (100 percent corn), milk shake (78 percent corn), salad dressing (65 percent corn), chicken nuggets (56 percent corn), cheeseburger (52 percent corn), and french fries (23 percent corn). In addition to paying higher prices for food, consumers will continue to pay for the health costs that result from eating these high-calorie foods—heart disease, obesity, and type II diabetes.

For the global poor, America’s addiction to high-calorie foods rich in corn is already a disaster, because our fast-food economy is using up much more than our fair share of the energy being captured by plants and stored as carbohydrates. About half of the grain grown today is fed to livestock,⁵⁵ and much of this grain is corn. “To eat corn directly (as Mexicans and Africans do) is to consume all the energy in that corn, but when you feed that corn to a steer or a chicken, 90 percent of its energy is lost—to bones or feathers or fur, to living and metabolizing as a steer or chicken.”⁵⁶

Processing food also requires energy, and this adds to the inefficiency of food production. So eating processed food, which has a higher profit margin for the producer than

unprocessed food, also makes it harder for billions of poor people to obtain the food they need to survive.

Those who defend industrial agriculture and trade liberalization policies argue that traditional forms of agriculture cannot feed the world's growing population. However, because industrial agriculture is unsustainable, its defenders bear the burden of demonstrating that change is unwise.⁵⁷ Sustainable agriculture is now feeding poor farmers in India and elsewhere and may be able to feed the world—if population growth levels off *and* if more of us eat lower on the food chain.

Poor Farmers

The law should ensure that the poor have access to financial capital at fair interest rates and are able to exercise their civil right to participate in local economic decisions.⁵⁸ This enables them to use land and water in sustainable agriculture to produce the food they need.

Population Control

Birthrates are declining where women are taking charge of their lives, rather than waiting for governments or NGOs to change their conditions.⁵⁹ Moreover, in most developing countries these rural women produce between 60 and 80 percent of the food that is consumed.⁶⁰

Gita Sen criticizes those promoting population control in poor countries who identify women as “targets” of family planning and as “the necessary locus of contraceptive technology, and reproductive manipulation.”⁶¹ Instead, Sen suggests, family-planning programs should be explained in the context of health and making a livelihood and should support women's reproductive health and rights.⁶² When a poor woman is able to improve her health and provide sufficient food for her family, she is more likely to limit the number of her children.⁶³

Empowering Women

A model for this approach is found in Andhra Pradesh, a state in southern India on the semiarid Deccan Plateau, where government policies favoring rice and wheat production almost caused the collapse of coarse grain production (such as sorghum and pearl millet). The higher costs of modern agricultural inputs also made it hard for marginal farmers to maintain production. In addition, the government encouraged the production of sugar cane for export by providing loans to dig wells and setting up a sugar factory to process the cane. The wealthy farmers who received these loans used more groundwater, which lowered the water table and dried up the shallow wells of poor farmers.⁶⁴

In 1983 a few professional men set up the Deccan Development Society (DDS) to help poor communities. Initially the DDS worked with poor men, but it soon discovered that men's groups are easily split by political affiliations and conflicts over leadership. So the DDS turned to poor women, who suffer from the triple burden of gender, caste, and class. With the help of the DDS, women's *sanghams* (voluntary associations) have pooled savings to create revolving loan funds, which lend money to women at 12 percent interest annually (rather than at the 60 percent charged by local money lenders).

The problems these women face are staggering: “A major impact of the poor conditions of agriculture lands and small family holdings is that they are left fallow. Big landlords also

cultivate only part of their holdings to grow sugar cane and other irrigated crops while leaving the rest fallow. This leads to (1) lack of employment; (2) lack of basic food since farm laborers are paid in kind when they harvest crops; (3) high rates of soil erosion; and eventually (4) forced migration of landless, small, and marginal farmers.”⁶⁵

The vulnerability of the poor fosters inhumane practices such as bondage of young boys (for a very small wage), which prevents them from going to school. Young women belonging to poor families are sexually harassed, so girls are married off when they are ten to twelve years old to protect them.⁶⁶ Strategies used by women’s groups to address these problems include working together to improve the quality of land owned by group members, pooling their resources to lease land, and creating seed banks.

Today the women’s groups of the DDS are active in seventy-five villages and include over five thousand members. Since 1985 these women’s groups have brought into cultivation ten thousand acres of degraded land. This has enabled them to raise more than three million kilos of grain every year, which is six times greater than what they produced before.⁶⁷

To ensure sustainability and avoid the mistakes of the Green Revolution, the farming procedures are organic and based on local knowledge. The women do not use artificial fertilizers.⁶⁸ These Indian women’s groups have demonstrated that even “very poor farmers, once in control of their agriculture and natural resources, with a bit of help and access to financial resources, can feed themselves and the non-food producing members of their community.”⁶⁹

The ability of poor women to limit as well as feed their families is also verified by the Grameen Bank, a microcredit initiative in Bangladesh that as of September 2011 had 8.34 million members, 97 percent of whom are women. The Grameen Bank provides credit to the poorest of the poor in rural Bangladesh, without any collateral. Working in 97 percent of the villages in the country, it provides loans based on mutual trust, accountability, participation, and creativity.⁷⁰ The Grameen Bank has loaned more than \$11 billion to its members and has a loan recovery rate of 96.5 percent. In 2010 the minimum interest paid on savings deposits was 8.5 percent.⁷¹

Conventional banks threaten a borrower who is late making payments on a loan. The Grameen Bank, however, allows such borrowers to reschedule their loans “without making them feel that they have done anything wrong (indeed, they have not done anything wrong).” When a borrower dies, the Grameen Bank does not require the borrower’s family to pay the loan. An insurance fund covers the outstanding amount with interest.⁷²

The Grameen system encourages borrowers to adopt goals to improve their lives and their communities. These are known as “Sixteen Decisions” (no dowry, education for children, sanitary latrine, planting trees, eating vegetables to combat night-blindness among children, arranging clean drinking water, keeping the family small, etc.). Studies have shown that the women participating in the Grameen Bank are 50 percent more likely than other Bangladeshi women to have fewer children.⁷³

The UN Food and Agriculture Organization confirmed in 2002 that poverty, not food scarcity, is the cause of hunger.⁷⁴ Rapidly rising commodity prices worldwide is evidence that too much grain is being used for cattle feed and ethanol production, rather than for

food.⁷⁵ Raising the input costs of agriculture, by using more artificial fertilizers and pesticides or expensive seeds, exacerbates this problem.

Sustainable Farming

Plants transform solar energy and nutrients into edible leaves, roots, and seeds. Many plants are needed to feed a smaller number of herbivores, and even fewer carnivores are able to live off these herbivores. “In the typical food chain, the energy available declines by a factor of ten at each trophic (feeding) level, although the ratio can vary. Thus the efficiency of agriculture in feeding people depends a great deal on where food is taken from the chain.”⁷⁶ At each level, energy is lost as heat and waste.

Also, efficiency in farming depends on energy inputs. Traditional agriculture uses solar power, farmworkers, and farm animals to plow and fertilize the land. Pests are managed by planting a variety of species in smaller plots and rotating crops, and these practices also replenish the soil as nutrients are removed. Livestock graze on the grasses that grow because of solar energy, and grazing maintains the health of the grasses as well as the fertility of the soil.

Agroecology

Sustainable agriculture, or “farming with nature,” is “an agroecology that promotes biodiversity, recycles plant nutrients, protects soil from erosion, conserves and protects water, uses minimum tillage, and integrates crop and livestock enterprises on the farm.”⁷⁷ There are three objectives: (1) economic profit, (2) social benefits to the farm family and the farming community, and (3) environmental conservation.⁷⁸

This is *agricultural biomimicry*. Farms become environmentally sustainable by imitating natural systems—creating a farm landscape that mimics the complexity of healthy ecosystems. Nature works in cycles, so the waste from one process becomes a nutrient for another. In contrast, industrial agriculture has a linear model like a factory—inputs become products and waste.

Some call this philosophy of mimicking natural processes *organic* farming. In 1991 the European Commission (EC) set the first official standards, and the International Federation of Organic Agricultural Movements (IFOAM) was founded a year later. In 2002 the US Department of Agriculture established production standards to regulate the commercial use of the label “organic.” Some critics argue that in the United States “organic farming has increasingly come to resemble the industrial system it originally set out to replace.”⁷⁹ To create an international standard, in 2005 IFOAM published “The Principles of Organic Agriculture.”⁸⁰

Sustainable practices in agriculture are more important than achieving a consensus on what “organic” means. Industrial farming takes a huge risk by planting a single crop (a monoculture), such as wheat, corn, or soybeans, because then the farmer is vulnerable to natural disasters and changes in market prices. To reduce risk, sustainable farming involves growing a diversity of crops and integrating plant and animal agriculture. The model for sustainable farming is an ecosystem, not a factory.

Sustainable agriculture works with *four natural processes*: (1) energy capture, (2) water cycles, (3) mineral cycles, and (4) ecosystem dynamics. *Energy capture* involves maximizing “the leaf area available for photosynthesis, and efficiently cycling the stored

solar energy through the food chain. Off-season cover crops, perennial vegetation, and intercropping are among the tools for capturing more solar energy.”⁸¹

The *water cycle* may be improved by adding ground cover and organic matter to the soil. A layer of mulch increases water intake while slowing evaporation and protects the soil from erosion. Minimizing tillage, cultivating cover crops, and adding compost or manure to the soil helps to maintain ground cover and increases the richness of the soil.⁸²

The *mineral cycle* involves transferring nutrients from the soil to the crops and animals and then returning these nutrients to the soil. Erosion, leaching nutrients from the soil, depleting organic matter, and selling hay off the farm reduce the farm’s sustainability. Practices that contribute to the mineral cycle include feeding livestock on the farm, managing manure and crop residues, using catch crops to reduce nutrient leaching, and practices that prevent erosion.

For sustainable farming, fertilizers containing anhydrous ammonia and potassium chloride should not be used, because these chemicals harm the soil and organisms in it that are beneficial for crops. Monoammonium phosphate (12–50–0), usually called MAP, offers a more environmentally friendly way to make the transition from industrial agriculture to sustainable agriculture.

Agroecology relies on a mixture of organisms with genetic diversity within species to create greater stability and control pests. Crop rotation increases biodiversity on the farm, which helps break weed and pest life cycles and provides natural fertilization by the planting sequence. Strip intercropping creates even more biodiversity and also increases sunlight capture. Growing plants that provide habitats for natural enemies of pests and incorporating perennial crops, shrubs, and trees add to the diversity and stability of the farmscape.

Integrated pest management requires knowing a pest’s life cycle and its natural enemies, so growers can utilize insects, mites, bacteria, fungi, viruses, and nematodes to control pests.⁸³ When IPM tactics are unable to check insect pest populations, farmers committed to sustainability usually use one of the “biorational” pesticides, which are pest-specific and nonpersistent, to minimize the harm to beneficial organisms in the farmscape.⁸⁴

Weed control involves crop rotation, which makes it harder for the seeds of weeds to set or to migrate from outside the field, and also planting crops that outgrow weeds. In northern states, oats are often used as a “nurse crop” for clover, alfalfa, and legume-grass mixtures, because the oats fill the spaces where weeds would grow between the alfalfa plants. In addition, mulch and grazers, such as sheep or goats, may be used to minimize weeds.

Food for Everyone?

The higher yields of the Green Revolution are unsustainable due to increased input costs for seed, fertilizer, and pesticides. Also, the industrial farming style of the Green Revolution has led to the loss of topsoil, the degradation of the environment from nutrient and pesticide runoff, and crop losses from resistant pests. When the price of oil increased in 2007 and 2008—as a result of demand, speculation in commodity markets by investors,⁸⁵ and limited refining capacity—the price of food also went up.

“At a time when philanthropists like Bill Gates have become entranced by the possibility of a Green Revolution for Africa, the New Rices for Africa, as scientists call the wonder seeds, offer a clear warning. Even the most promising new crop varieties will not by

themselves bring the plentiful harvests that can end poverty. New ways to get seeds into the hands of farmers are needed, as well as broader investment in the basic ingredients of a farm economy: roads, credit and farmer education, among others.”⁸⁶

Before the end of the twenty-first century, oil and natural gas production will likely peak and begin to decline. Thus, food and everything else that depends on the price of fossil fuels is bound to become more costly. It is foreseeable that rising ozone levels in the lower atmosphere will cut plant productivity, the depletion of aquifers will reduce the water available for irrigation, and climate change will require more drought-resistant plants.⁸⁷

It is impossible to use cost-benefit analysis to weigh the consequences of continuing industrial agriculture versus making a transition to sustainable agriculture. There are, however, estimates of some of the annual global costs of industrial agriculture:

- Subsidies for agriculture—\$362 billion
- Subsidies for water—\$247 billion
- Losses due to soil erosion—\$150 billion
- Losses due to desertification—\$42 billion⁸⁸

There are also estimates of the annual US costs of industrial agriculture:

- Subsidies for agriculture—\$75 billion (or more)⁸⁹
- Higher food prices—\$25 billion
- Subsidized grazing fees for use of federal land—\$50 million
- Subsidizes to farmers using Bureau of Reclamation water—\$2.5 billion
- Irrigation subsidies in western states—\$4.4 billion⁹⁰

Drugs derived from plants provide health benefits worldwide worth \$400 billion, and the total value of goods and services from biodiversity is about \$3 trillion. Thus, only a 10 percent loss in biodiversity could mean a loss in value of \$300 billion. Yet forests are being cut to clear land for cattle grazing. This tropical deforestation leads to less soil cover and the loss of all its benefits, which in India alone are worth around \$10 billion per year. Moreover, tropical forests absorb carbon dioxide, and the loss of this benefit might cost over \$3 trillion.⁹¹

Waste is also endemic in the industrial farming system of producing food. In Kenya “35 percent of the bean crop grown for export is thrown away because it does not meet the super-market specification that beans must be straight, or an exact diameter and length, and cosmetically perfect.”⁹²

In Honduras, however, farmers are creating a meter of soil in ten years by growing velvet-beans between the rows of corn, because the velvet-bean fixes large amounts of nitrogen and when it rots creates new fertile soil. In Bangladesh this *intercropping* might involve a hundred species of fruit and vegetables in the same field, some planted largely to enrich the soil. In New York farmers are preventing the root rot that decimates dry beans by planting buckwheat in alternating years.⁹³

In Indonesia, after pesticides killed the natural enemies of the brown planthopper, rice losses rose to \$1.5 billion annually. When the government slashed subsidies for pesticides and banned most of them, use of pesticides fell by 60 percent. Then, as the natural enemies of the planthopper repopulated the fields, the rice harvest yields rose by 15 percent, for a savings during 1986–1990 of \$1 billion.⁹⁴ In Kenya, scientists isolated the

“semiochemicals” that plants produce to manage pests and then applied this knowledge to reduce the damage done by corn borer insects.⁹⁵

Genetically modified (GM) food may offer some benefits in productivity or resistance to a disease or pest,⁹⁶ but it will not solve the problem of increasing costs for herbicides, pesticides, water for irrigation, and the transport of food, and it poses a threat of contaminating other species.⁹⁷ GM food will also raise the price of seeds, as corporations seek to maximize the profit from their research and patents. Moreover, these technological innovations do not address the inequitable distribution of food.

Finally, GM food may replace traditional foods that are naturally healthier and grow more efficiently. For instance, vitamin A-rich golden rice increases water abuse in agriculture. Golden rice contains 30 micrograms of vitamin A per 100 grams of rice. On the other hand, greens such as amaranth and coriander contain five hundred times more vitamin A and use a fraction of the water needed by golden rice. In terms of water use, genetically engineered rice is fifteen hundred times less efficient in providing children with vitamin A, which is necessary for preventing blindness.⁹⁸

In an unusually sharp editorial, the *New York Times* states that the “so-called efficiency of industrial animal production is an illusion, made possible by cheap grain, cheap water and prisonlike confinement systems. In short, animal husbandry has been turned into animal abuse. Manure—traditionally a source of fertilizer—has been turned into toxic waste that fouls the air and adjacent water bodies. Crowding creates health problems, resulting in the chronic overuse of antibiotics. And, because the modest profits in confinement operations require the lowest possible labor costs, including automated feeding, watering and manure-handling systems, these operations have helped empty and impoverish rural America.”⁹⁹

Ecological and innovative food production will mean a more humane and ecological way of raising animals. It will also mean replacing large machinery with human labor and smaller technology, because large equipment cannot be used efficiently where crops are mixed. Even World Bank economists now admit that farming involving the “redistribution of land to small farmers would lead to greater overall productivity.”¹⁰⁰

Farming and Food: An Answer

First, there should be a *transition to agroecological farming*. This requires government policies that phase out commodity subsidies and offer incentives for independent farmers using the methods of sustainable agriculture.¹⁰¹ There is little political support now for this change in the United States, but pressure will grow as the costs of fossil fuels increase and more people realize that industrial agriculture is economically as well as environmentally unsustainable.

Second, *governments and citizens should support urban farms and markets*. To reduce the fossil fuel costs of transportation, more of our food has to be grown closer to where we live.¹⁰² This change will require political leadership as well as consumer support. We need to do more to revitalize farmers’ markets,¹⁰³ grow food on city lots and building roofs, and in urban areas treat and return to the soil the nutrients in organic garbage and waste that are now being wasted.¹⁰⁴

Third, *those who are affluent should eat lower on the food chain*. The average American obtains about 30 percent of his calories from animal sources. If everyone in the world ate

this way, there would only be enough food for about half the world's people. If everyone ate like the average Latin American, deriving only 10 percent of their calories from animal sources, four billion people could be fed.¹⁰⁵

To feed the world's more than 7 billion inhabitants, most people will have to obtain the bulk of their protein from sources other than meat, and those of us now eating a lot of meat will need to reduce our consumption substantially.

NOTES

1. Vaclav Smil, *Feeding the World: A Challenge for the Twenty-First Century*, xvi.
2. William Ophuls and A. Stephen Boyan, Jr., *Ecology and the Politics of Scarcity Revisited*, 49–50.
3. David Pimentel and Mario Giampietro, *Food, Land, Population and the U.S. Economy*, in Dale Allen Pfeiffer, *Eating Fossil Fuels: Oil, Food and the Coming Crisis in Agriculture*, 11.
4. Ophuls and Boyan, *Ecology and the Politics of Scarcity Revisited*, 50–51.
5. Pfeiffer, *Eating Fossil Fuels*, 15.
6. Ibid. See Sandra L. Postel, Gretchen C. Caily, and Paul R. Ehrlich, "Human Appropriation of Renewable Fresh Water," *Science* 271 (February 9, 1996): 785.
7. "Prevailing fertilizer applications are accompanied by large nutrient losses; nitrogen leakage is particularly large due to leaching, erosion, volatilization [loss due to evaporation], and denitrification [changing usable oxidized forms of nitrogen into nitrogen gas]." Smil, *Feeding the World*, xviii.
8. Michael Pollan, *Omnivore's Dilemma: A Natural History of Four Meals*, 46–47.
9. James Gustave Speth, *Red Sky at Morning*, 16.
10. Pollan, *Omnivore's Dilemma*, 47.
11. Edward O. Wilson, *The Future of Life*, 114. Ecosystems are naturally diverse and thus more fit to survive a change in climate or other distressing event. See James Trefil, *Human Nature*, 193.
12. Pollan, *Omnivore's Dilemma*, 147.
13. "The Nitrogen Cycle," in *Fundamentals of Physical Geography*, 2nd ed. (2006), <http://www.physicalgeography.net/fundamentals/9s.html>.
14. "Phosphorus Cycle," Environmental Literacy Council, <http://www.enviroliteracy.org/article.php/480.html>.
15. Ibid.
16. Pollan, *Omnivore's Dilemma*, 149.
17. Pfeiffer, *Eating Fossil Fuels*, 1. Fisheries, as well as agriculture, depend on "cheap seemingly super-abundant fossil fuels." Donald Kennedy, ed., *Science Magazine's State of the Planet: 2006–2007*, 34.
18. Pollan, *Omnivore's Dilemma*, 183.
19. John Ryan, "Feedlots of the Sea," *World Watch Magazine* 16, no. 5 (September/October 2003), in Peter Singer and Jim Mason, *The Way We Eat*, 123.
20. Pollan, *Omnivore's Dilemma*, 8–9. In India farmers argue that artificial pesticides have depleted the soil, and doctors find increasing health problems that seem to be related to the use of artificial pesticides. See Daniel Pepper, "Some Indians Fear Green Revolution Is a Killer," *San Francisco Chronicle*, July 28, 2008, A12, <http://www.sfgate.com/cgi-bin/article.cgi?f=/c/a/2008/07/27/MN3M11LLJQ.DTL>.
21. "More than half of all the synthetic nitrogen made today is applied to corn, whose hybrid strains can make better use of it than any other plant. Growing corn, which from a biological perspective had always been a process of capturing sunlight to turn it into food, has in no small measure become a process of converting fossil fuels into food." Pollan, *Omnivore's Dilemma*, 45.

22. Francis Moore Lappé and Anna Lappé, *Hope's Edge*, 258. See David Pimentel et al., "Environmental and Economic Impacts of Reducing U.S. Agricultural Pesticide Use," in *Handbook of Pest Management in Agriculture*, vol. 1, 679–718, also printed in Pimentel and Lehmen, eds., *The Pesticide Question: Environment, Economics and Ethics*, 223–278, in Lappé and Lappé, *Hope's Edge*, 258.
23. David Pimentel, "Is Silent Spring Behind Us?" in G. J. Marco, R. M. Hollingsworth, and E. Durham, eds., *Silent Spring Revisited*, in Louis P. Pojman and Paul Pojman, eds., *Environmental Ethics*, 536. Pimentel offers three additional reasons for crop losses: "reduced FDA tolerance and increased cosmetic standards of processors and retailers for fruits and vegetables"; "reduced field sanitation including less destruction of infected fruit and crop residues"; and "reduced tillage, leaving more crop remains on the land surface to harbor pests for subsequent crops."
24. Lester E. Ehler, "Integrated Pest Management: A National Goal?" *Issues in Science and Technology* (Fall 2005), <http://www.issues.org/22.1/stalk.html>.
25. FAO Corporate Document Repository, "Crop Protection in the Context of Agricultural Development," <http://www.fao.org/WAIRDOCS/TAC/Y4847E/y4847e05.htm>.
26. George Pyle, *Raising Less Corn, More Hell: The Case for the Independent Farm and Against Industrial Food*, 12.
27. The four main food processors are Gold Kist, Perdue Farms, Pilgrim's Pride, and Tyson. Cargill/Excel, Smithfield, Swift, and Tyson/IBP control about two-thirds of the national pork market. *Ibid.*, 13, 16.
28. Four other companies—Monsanto, Novartis, Dow Chemical, and DuPont—sell about three-quarters of the corn seed and two-thirds of the soybean seed being sown. *Ibid.*, 17.
29. Dwayne Andreas, quoted by Dan Carney in "Dwayne's World," *Mother Jones* (January 1995), in Lappé and Lappé, *Hope's Edge*, 300.
30. Pollan, *Omnivore's Dilemma*, 52.
31. *Ibid.* "Or, as it turned out, make up some of the difference, since just about every farm bill since has lowered the target price in order, it was claimed, to make American grain more competitive in world markets."
32. Elizabeth Weise, "Ethanol Pumping Up Food Prices," *USA Today*, February 14, 2011, http://www.usatoday.com/money/industries/food/2011-02-09-corn-low_N.htm.
33. Dan Morgan, "Corn Farms Prosper, but Subsidies Still Flow," *Washington Post*, September 27, 2007, A01, <http://www.washingtonpost.com/wp-dyn/content/article/2007/09/27/AR2007092702054.html>.
34. Carol Ness, "The New Food Crusade," *San Francisco Chronicle*, July 10, 2007, A1, <http://sfgate.com/cgi-bin/article.cgi?f=/c/a/2007/07/10/MNGNUQTQIT1.DTL>. See also Michael Pollan, "You Are What You Grow," *New York Times*, April 22, 2007, <http://www.nytimes.com/2007/04/22/magazine/22wwlnlede.t.html>.
35. Editorial, "A Disgraceful Farm Bill," *New York Times*, May 16, 2008, <http://www.nytimes.com/2008/05/16/opinion/16fri3.html>. "According to Oxfam, the largest 10 percent of producers receive about 75 percent of the \$20 billion in US commodity subsidies each year." Caitlin G. Johnson, "Mixed Reactions to US Farm Bill," *Common Dreams*, May 23, 2008, www.commondreams.org/archive/2008/05/23/9145.
36. In 1997 hundreds of farmers filed a lawsuit, *Pigford v. Glickman*, alleging pervasive discrimination against black farmers by the USDA between 1981 and 1997. In 2011 a federal judge approved a \$1.25 billion settlement to black farmers discriminated against by the USDA. Kaitlin Olsen, "Home Politics Economy Q&A: Justice for Black Farmers," National Black Farmers Association (November 7, 2011), <http://www.blackfarmers.org/news.html>.
37. "Farming: Farm Subsidies," Environmental Working Group, <http://www.ewg.org/farmsubsidie>.
38. "Despite Claims of Reform, Subsidy Band Marches On," Environmental Working Group (June 23, 2011), <http://www.ewg.org/release/despite-claims-reform-subsidy-band-marches>.
39. Tyler Cowen, "End Subsidies and Treat Animals Better," *New York Times*, February 21, 2012, <http://www.nytimes.com/roomfordebate/2012/02/21/the-farm-bill-beyond-the-farm/end-farm-subsidies-and-treat-animals-better>.

40. In 2011 the largest five food retailers in the United States were Walmart, Kroger, Cosco, Supervalu (which bought out Albertsons), and Safeway.
41. "Horizon Consolidation and Buyer Power in the Beef Industry," *Food & Water Watch* (July 2010), <http://documents.foodandwaterwatch.org/BeefConcentration.pdf>.
42. Gary Holthaus, *From the Farm to the Table: What All Americans Need to Know about Agriculture*, 210. See the Institute for Agriculture and Trade Policy, <http://www.iatp.org>.
43. Holthaus, *From the Farm to the Table*, 216–219. A study by the Pew Hispanic Center and the RAND Corporation concludes that illegal immigration has waned. "The number of Mexicans annually leaving Mexico for the U.S. declined from more than one million in 2006 to 404,000 in 2010—a 60% reduction," the report states. Brianna Lee, "Study Finds Mexican Immigration to the U.S. on the Decline," *PBS: The Daily Need*, August 18, 2011, <http://www.pbs.org/wnet/need-to-know/the-daily-need/study-finds-mexican-immigration-to-the-u-s-on-the-decline/10859/>.
44. "Background Paper: The WTO's 2-Year Strategy Comes to Fruition" (January 2002), para. 17, http://www.wto.org/english/news_e/news_e.htm, in Peter Singer, *One World*, 95.
45. "Through conditionalities, Structural Adjustment Programs [SAPs] generally implement 'free market' programs and policy. These programs include internal changes (notably privatization and deregulation) as well as external ones, especially the reduction of trade barriers. Countries which fail to enact these programs may be subject to severe fiscal discipline. Critics argue that financial threats to poor countries amount to blackmail; that poor nations have no choice but to comply." [Http://en.wikipedia.org/wiki/Structural_adjustment](http://en.wikipedia.org/wiki/Structural_adjustment).
46. John Madeley, ed., *Trade and Hunger: An Overview of Case Studies on the Impact of Trade Liberalisation on Food Security*, Swedish NGOs Forum Synod, Diakonia, Church of Sweden Aid and the Swedish Society for Nature Conservation, in Holthaus, *From the Farm to the Table*, 219. It is much the same in Kenya, where women produce 75 percent of the food: "As a result of the country's SAP and liberalization of agricultural trade, many women cannot afford adequate chemicals and fertilizers, and farm output has declined. Liberalization has led to an increase in food imports into the country and caused food dumping (cheap surplus food from the North) in local markets, hitting the country's own farmers. Liberalization has also led to an increase in the prices of farm inputs, putting them beyond the reach of most small farmers." *Ibid.*, 220.
47. Girish Mishra, "Why Suicides by Farmers?" *ZNet*, December 20, 2005, <http://www.zmag.org/znet/viewArticle/4785>.
48. Haider Rizvi, "US Cotton Subsidies Cost W. Africa Millions—Report," *Common Dreams*, June 26, 2007, www.commondreams.org/archive/2007/06/26/2116.
49. Kofi Annan, quoted in "Annan: World Must Help African Nations Tackle Food Crisis," *The NewsHour*, June 11, 2008, http://www.pbs.org/newshour/bb/africa/jan-june08/annan_06-11.html.
50. In 2008, "about a quarter of US corn [went] to feeding ethanol plants instead of poultry or livestock." Steven Mufson, "Siphoning Off Corn to Fuel Our Cars," *Washington Post*, April 30, 2008, A01, <http://www.washingtonpost.com/wp-dyn/content/article/2008/04/29/AR2008042903092.html>. "Brazil and the United States account for a total of more than 70 percent of global ethanol production." Edmund L. Andrews and Larry Rohter, "US and Brazil Seek to Promote Ethanol in West," *New York Times*, March 3, 2007, <http://www.nytimes.com/2007/03/03/business/worldbusiness/03ethanol.html>.
51. Pollan, *Omnivore's Dilemma*, 41.
52. Editorial, "Priced Out of the Market," *New York Times*, March 3, 2008, <http://www.nytimes.com/2008/03/03/opinion/03mon1.html>.
53. Talif Deen, "Dash to Convert Food into Fuels Is Recipe for Disaster," *CommonDreams.org*, November 7, 2007, <http://www.commondreams.org/archive/2007/11/07/5088>.
54. "But an oil palm takes eight years to reach full production." Keith Bradsher, "An Oil Quandary: Costly Fuel Means Costly Calories," *New York Times*, January 19, 2008, <http://www.nytimes.com/2008/01/19/business/worldbusiness/19palmoil.html>.

55. Speth, *Red Sky at Morning*, 72.
56. Pollan, *Omnivore's Dilemma*, 118.
57. This is also true for fish farming (aquaculture). See Peter Singer and Jim Mason, *The Way We Eat*, 122–124.
58. See Jazmine Rodriguez, "Hungry Farmers Urge Local Control Over Food," *Prism Webcast News*, June 14, 2008, <http://prismwebcastnews.com/2008/06/14/hungry-farmers-urge-local-control-over-food/>.
59. Barbara Crossette, "Population Estimates Fall as Poor Women Assert Control," *New York Times*, March 10, 2002, 3, <http://www.nytimes.com/2002/03/10/world/population-estimates-fall-as-poor-women-assert-control.html>.
60. Yifat Susskind from MADRE, an international women's human rights organization. Ida Wahlstrom, "Small Farmers 'Underserved' by Rome Summit," *Prism Webcast News*, June 7, 2008, <http://prismwebcastnews.com/2008/06/07/small-farmers-underserved-by-rome-summit/>.
61. Gita Sen, "Women, Poverty, and Population: Issues for the Concerned Environmentalist," in W. Harcourt, ed., *Feminist Perspectives on Sustainable Development*, 216–225, in David Schmidtz and Elizabeth Willott, eds., *Environmental Ethics*, 248.
62. *Ibid.*, 252.
63. Lappé and Lappé, *Hope's Edge*, 298.
64. V. Rukmini Rao, "Women Farmers of India's Deccan Plateau: Ecofeminists Challenge World Elites," in Schmidtz and Willott, *Environmental Ethics*, 255.
65. *Ibid.*, 257.
66. *Ibid.*
67. Deccan Development Society, "About Us," <http://www.ddsindia.com/www/default.asp>.
68. The use of fertilizer in Malawi, however, seems to have ended famine there. "Over the past 20 years, the World Bank and some rich nations that Malawi depends on for aid have periodically pressed this small, landlocked country to adhere to free market policies and cut back or eliminate fertilizer subsidies, even as the United States and Europe extensively subsidized their own farmers. But after the 2005 harvest, the worst in a decade, Bingu wa Mutharika, Malawi's newly elected president, decided to follow what the West practiced, not what it preached. Stung by the humiliation of pleading for charity, he led the way to reinstating and deepening fertilizer subsidies despite a skeptical reception from the United States and Britain. Malawi's soil, like that across sub-Saharan Africa, is gravely depleted, and many, if not most, of its farmers are too poor to afford fertilizer at market prices." Celia W. Dugger, "Ending Famine Simply by Ignoring the Experts," *New York Times*, December 2, 2007, <http://www.nytimes.com/2007/12/02/world/africa/02malawi.html>.
69. *Ibid.*
70. "Introduction," Grameen Bank, <http://www.grameen-info.org/index.php>.
71. "GB at a Glance," Grameen Bank, <http://www.grameen-info.org/index.php>.
72. "Is Grameen Bank Different?" Grameen Bank, <http://www.grameen-info.org/index.php>.
73. *Ibid.*
74. George Pyle, *Raising Less Corn, More Hell*, 159.
75. As diverting corn to make ethanol has driven up food prices, investors have begun to promote making biofuel from nonfood crops like reeds and wild grasses. But scientists warn that these "invasive species—that is, weeds—have an extraordinarily high potential to escape biofuel plantations, overrun adjacent farms and natural land, and create economic and ecological havoc." Elisabeth Rosenthal, "New Trends in Biofuels Has New Risks," *New York Times*, May 21, 2008, <http://www.nytimes.com/2008/05/21/science/earth/21biofuels.html>.
76. Ophuls and Boyan, *Ecology and the Politics of Scarcity Revisited*, 38–39.

77. Richard Earles, revised by Paul Williams, "Sustainable Agriculture: An Introduction," *National Sustainable Agriculture Information Service* (2005), <http://www.attra.org/attra-pub/sustagintro.html>.
78. Preston Sullivan, "Applying the Principles of Sustainable Farming: Fundamentals of Sustainable Agriculture," *National Sustainable Agriculture Information Service* (2003), <http://www.attra.org/attra-pub/trans.html>.
79. Pollan, *Omnivore's Dilemma*, 151.
80. "The Principles of Organic Agriculture," IFOAM, http://www.ifoam.org/about_ifoam/principles/index.html. "Worldwide, demand for certified organic products is increasing at 10 percent annually." Singer and Mason, *The Way We Eat*, 197.
81. Sullivan, "Applying the Principles of Sustainable Farming."
82. Industrial agricultural has altered the hydrology of the land, making flooding in places like Iowa more likely. In early June 2008, "the heavy rains fell on a landscape radically reengineered by humans. Plowed fields have replaced tall grass prairies. Fields have been meticulously drained with underground pipes. Streams and creeks have been straightened. Most of the wetlands are gone. Flood plains have been filled and developed." Joel Achenbach, "Iowa Flooding Could Be an Act of Man, Experts Say," *Washington Post*, June 19, 2008, A01, <http://www.washingtonpost.com/wp-dyn/content/article/2008/06/18/AR2008061803371.html>.
83. "Nematodes are simple roundworms," in *Biological Control: A Guide to Natural Enemies in North America*, <http://www.nysaes.cornell.edu/ent/biocontrol/pathogens/nematodes.html>.
84. Sullivan, "Applying the Principles of Sustainable Farming."
85. As grain prices soared in the summer of 2007, "[i]nvestors fleeing Wall Street's mortgage-related strife plowed hundreds of millions of dollars into grain futures, driving prices up even more." Anthony Faiola, "The New Economics of Hunger," *Washington Post*, April 27, 2008, A01, <http://www.washingtonpost.com/wp-dyn/content/story/2008/04/26/ST2008042602333.html>. Diana B. Henriques, "A Bull Market Sees the Worst in Speculators," *New York Times*, June 13, 2008, www.nytimes.com/2008/06/13/business/13speculate.html; "Oil Trading's Powerful 'Dark Markets,'" *CBS News*, June 17, 2008, <http://www.cbsnews.com/stories/2008/06/17/broadcasts/main4188620.shtml>.
86. Celia W. Dugger, "In Africa, Prosperity from Seeds Falls Short," *New York Times*, October 10, 2007, <http://www.nytimes.com/2007/10/10/world/africa/10rice.html>.
87. David Fogarty, "Farmers Face Climate Challenge in Quest for More Food," *Reuters*, May 4, 2008, <http://www.reuters.com/article/environmentNews/idUSSP28472120080504>.
88. Norman Myers and Jennifer Kent, *Perverse Subsidies*, 12, 13, 14, 27.
89. Morgan, "Corn Farms Prosper but Subsidies Still Flow."
90. Myers and Kent, *Perverse Subsidies*, 46, 50, 136. "In this dry region, irrigation accounts for 86 percent of water use. Ironically, irrigation is used to grow crops that are officially in surplus and subject to other expensive federal programs to reduce production."
91. Myers and Kent, *Perverse Subsidies*, 27–28.
92. Felicity Lawrence, "Global Banquet Runs Out of Control," *New Agriculturist*, May 1, 2005, <http://www.new-ag.info/en/view/point.php?a=1237>, in Bill McKibben, *Eaarth: Making a Life on a Tough New Planet*, 180.
93. McKibben, *Eaarth*, 166–174.
94. Myers and Kent, *Perverse Subsidies*, 59. In New Zealand subsidies are not necessary for agriculture to be profitable. Wayne Arnold, "Surviving Without Subsidies," *New York Times*, August 2, 2007, <http://www.nytimes.com/2007/08/02/business/worldbusiness/02farm.html>.
95. McKibben, *Eaarth*, 169–170.
96. Even as there are benefits from the Green Revolution, there are also benefits from GM plants. For instance, "Researchers at the University of Washington have genetically altered poplar trees to pull toxins

out of contaminated ground water, offering a cost-effective way of cleaning up environmental pollutants. A group of British researchers, meanwhile, has developed genetically altered plants that can clean residues of military explosives from the environment.” Julie Steenhuysen, “Genetically Modified Plants Vacuum Up Toxins,” *Reuters*, October 15, 2007, <http://www.reuters.com/article/scienceNews/idUSN1525312420071015>.

97. The Center for Food Safety and the Sierra Club are suing Monsanto. “The groups said the wind-pollinated biotech sugar beets will cross-pollinate and contaminate conventional sugar beets, organic chard and table beet crops. As well, the groups said the biotech sugar beets will increase the recent rise of weeds resistant to herbicide, which have been reported on 2.4 million acres of US cropland.” Carey Gillam, “Biotech Critics Challenging Monsanto GM Sugar Beet,” *Reuters*, January 23, 2008, <http://www.reuters.com/article/healthNews/idUSN2359954920080123>.

98. Shiva, *Water Wars*, 115.

99. Editorial, “The Worst Way of Farming,” *New York Times*, May 31, 2008, <http://www.nytimes.com/2008/05/31/opinion/31sat4.html>. The report funded by the Pew Charitable Trust “recommends new laws regulating pollution from industrial farms as rigorously as pollution from other industries, a phasing-out of confinement systems that restrict ‘natural movement and normal behavior,’ a ban on antibiotics used only to promote animal growth, and the application of antitrust laws to encourage more competition and less concentration.”

100. McKibben, *Eaarth*, 167.

101. This means significant changes in developed countries and world trade agreements, as well as in developing countries. Jazmine Rodriguez, “Hungry Farmers Urge Local Control Over Food,” *Prism Webcast News*, June 14, 2008, <http://prismwebcastnews.com/2008/06/14/hungry-farmers-urge-local-control-over-food/>.

102. We should, however, support international fair trade. An Oxfam report notes: “History makes a mockery of the claim that trade cannot work for the poor. Participation in world trade has figured prominently in many of the most successful cases of poverty reduction—and, compared with aid, it has far more potential to benefit the poor.” Singer and Mason, *The Way We Eat*, 154.

103. McKibben, *Eaarth*, 139. McKibben reports that “farmers’ markets are the fastest-growing part of our food economy.”

104. Pfeiffer, *Eating Fossil Fuels*, 70. See Robin Shulman, “Fed Up by Costs, Many Grow It Alone,” *Washington Post*, August 3, 2008, A03, <http://www.washingtonpost.com/wp-dyn/content/article/2008/08/02/AR2008080201397.html>.

105. Ophuls and Boyan, *Ecology and the Politics of Scarcity Revisited*, 44, 49.