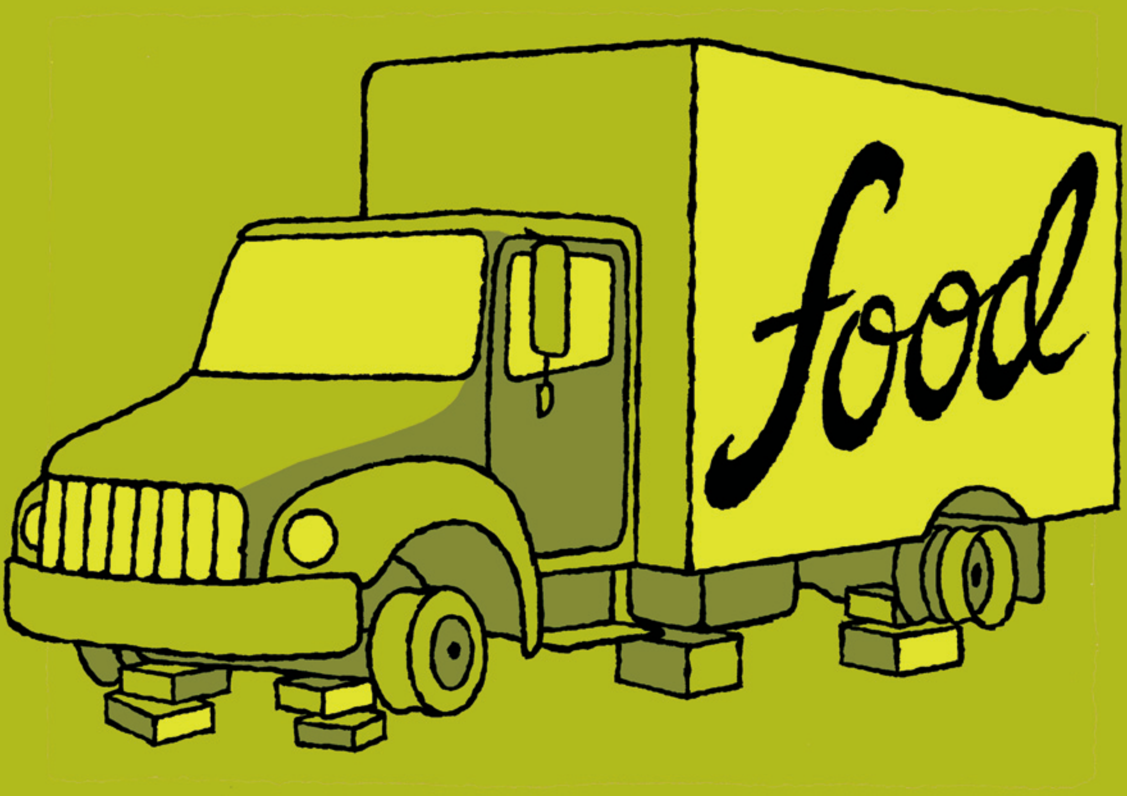
The Post Carbon Reader Series: Food

Tackling the Oldest Environmental Problem: Agriculture and Its Impact on Soil

By Wes Jackson



About the Author

Wes Jackson is one of the foremost figures in the international sustainable-agriculture movement. Founder and president of the Land Institute in Salina, Kansas, he has pioneered research in natural-systems agriculture for more than thirty years. He was a professor of biology at Kansas Wesleyan and later established the environmental studies program at California State University, Sacramento. He is the author of several books including *Becoming Native to This Place* (1994), *Altars of Unhewn Stone* (1987), and *New Roots for Agriculture* (1980). Jackson is a Fellow of Post Carbon Institute.

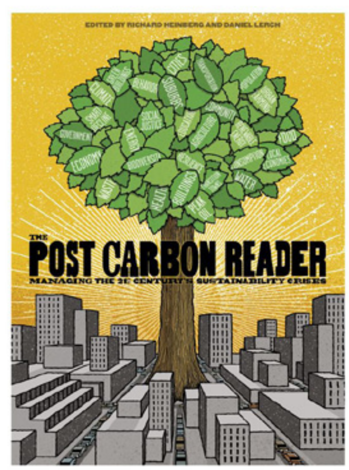


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FIGURE 10.1
Typical illustration depicting sustainable agriculture.

This chapter is adapted from a presentation by Wes Jackson to the Cal Alumni Association at International House, University of California, Berkeley on January 25, 2010.

I want to talk about the 10,000-year-old problem of agriculture and how it is both necessary and possible to solve it. Were it necessary but not possible this idea would be grandiose, and were it possible but not necessary it would be grandiose. But it has passed the test of grandiosity.

Figure 10.1 illustrates what most people think about when they talk about sustainable agriculture. This is part of an ad for a sustainable-agriculture conference in Chicago. Look at the diversity and think hard about how much that informs the sustainable-agriculture movement. There is not a single grain there. And what's wrong with that? The foods shown there represent fewer than 25 percent of the calories that humans eat, and I have a $100 bet that 70 percent of the calories eaten by the people in the most economically important agricultural state, California, come over the Sierra Nevada and up from Mexico in the form of grains.

In the background of all of us organisms on Earth is what I call the 3.45-billion-year imperative. We are a carbon-based planet. The carbon that enters so importantly into our bodies, we all now know, was cooked in the remote past of a dying star. But humans, with the big brain, have been around for only 150,000 to 200,000 years, and only some 11,000 to 13,000 years before the present we got to the first pool of energy-rich carbon, the young pulverized coal of the soil. And we mostly wasted it. With the opening of the North American continent, some soil scientists estimate the United States went from around 6 percent carbon to around 3 percent. I think that's when global warming began, with agriculture 10,000 years ago.

About 5,000 years ago, the second pool of energy-rich carbon, the forests, made it possible to smelt ore and brought on the Bronze Age and the Iron Age. The third pool, 250 years ago, was coal, which brought on

FIGURE 10.2
Pieter Bruegel, *The Harvesters* (1565).

the Industrial Revolution. Then in 1859 Edwin Drake drilled a well in western Pennsylvania and opened up the fourth pool, oil. And then came natural gas, the fifth pool, used not just for lighting and heating but also for fertilizer. These are the five pools of energy-rich carbon that stand behind civilization. I like to think what it would have been like had we not had, first of all, civilization that came from the soil. We wouldn't have had Plato, Aristotle, Jesus of Nazareth. And, of course, if it hadn't been for soil, forest, and coal, we would not have had Darwin—it took the slack that the British Empire had to send a naturalist around the world. I suspect that without oil we would not have had the Hubble Telescope and may not have known about how the elements have been cooked in dying stars. In other words, these five pools have given us knowledge of how the world is. What does this have to do with anything? Well, it gives us a perspective of where we come from and what kind of a thing we are.

Let's study figure 10.2. Is the wheat tall or are the people short? There is a pear tree, and in an apple tree off to the right, barely discernable in the image, someone upside down is picking an apple. Notice that they've limbed those trees up to let light through for the wheat. In this painting, nearly 100 percent of that agricultural landscape is devoted to grains, primarily because they don't have much juice in them, so they can be stored and not rot. Someone advanced the idea that societies that depend on root crops tend not to make war. They can't carry all that water around. I'd like to have someone do a PhD thesis on that—it would probably confuse us all.

Now let's jump to a new continent. We landed here in 1492. Think about how little changed from 1565, the year of Breugel's painting, to 1665, and then to 1765 when the Industrial Revolution was just getting started. Now to the 1860s. In colonial times people wanted free

FIGURE 10.3
Norman Rockwell, *The County Agent* (1948).

Reprinted by permission of the Norman Rockwell Family Foundation.

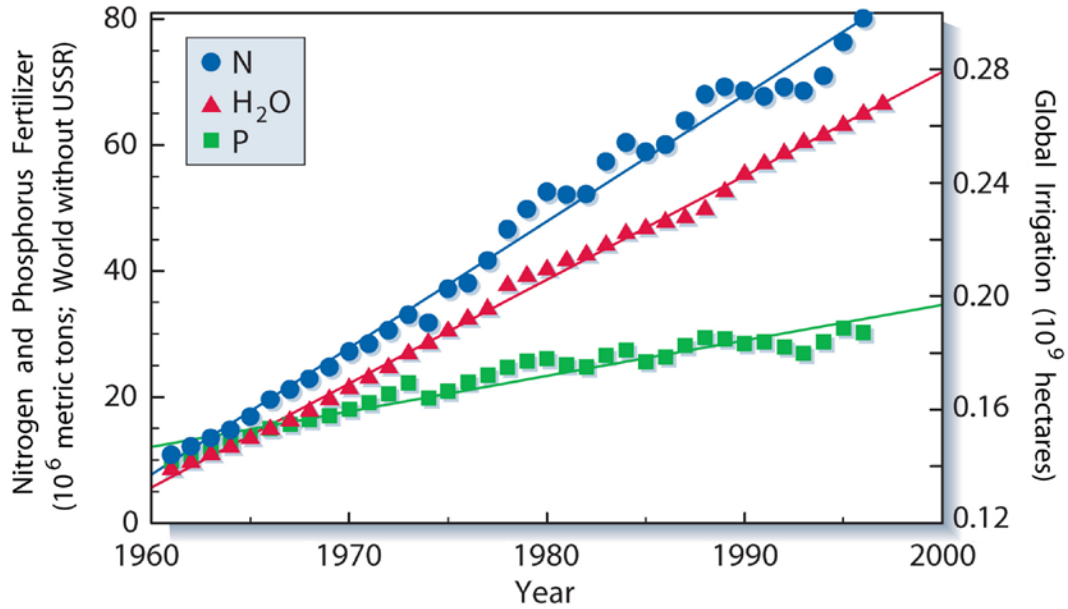
land; our new nation wanted to charge for it because after the Revolutionary War we were broke, but Thomas Jefferson illegally made the Louisiana Purchase in 1803, and people clamored for free land. The South knew that if this were allowed, Northerners were likely to occupy that land. The Confederates fired on Fort Sumter in 1861 and the Civil War began. With the South no longer represented in Washington, in May 1862 the reduced Congress passed the Homestead Act and, within a few months, the Morrill Act, which established the land-grant colleges. Twenty-five years later, in 1887, Congress funded the agricultural experiment stations via the Hatch Act, and then in 1914 they passed the Smith-Lever Act establishing the extension services to connect the work of land-grant colleges to communities.

So here we are on a new continent, with the Louisiana Purchase, with legislation giving us free land, with colleges of agriculture, agricultural research, and extension—and away we go.

In figure 10.3, it is 1948 and the Depression and World War II are behind us. Here is the county agent, perhaps a product of Purdue University because this painting was made in Indiana by Norman Rockwell. There is the dutiful 4-H girl—you can bet her record book has big round letters in it—there's the brother with his poultry project, there's Sis with her sewing project, the dog is pleased with what's going on, Grandpa's intensely interested, Mom is interested, Dad's back there, at left, with a cat on his shoulder. Count the number of eyes focused on expertise and youth. Rockwell was painting not only what was, but also what got writ large. The year 1948 is important to keep in mind. Free land, education, and extension made expertise and youth central. Tradition and experience are peripheral.

Around 1948 we started using incredible amounts of nitrogen, phosphorus, and water; by the 1960s it was really taking off (figure 10.4). The most important invention of the twentieth century came from two Germans who learned how to take atmospheric nitrogen and turn it into ammonia using what's now known as the Haber-Bosch process. Vaclav Smil of the University of Manitoba says, "Without Haber-Bosch

FIGURE 10.4
Global agricultural nitrogen, phosphorus, and water use, 1961-1996.



Source: David Tilman et al., "Agricultural Sustainability and Intensive Production Practices," *Nature* 418, no. 8 (August 2002).

40 percent of humanity wouldn't be here." So away we go applying tons of nitrogen to fields. Another thing that took off about 1948 is the production of pesticides, which, since the publication of Rachel Carson's *Silent Spring* in 1962, has doubled and doubled again. Also about this time, particularly in the early 1950s, farm consolidation began. And not too long after that, U.S. Secretary of Agriculture Ezra Taft Benson said, "Get big or get out." Later, Earl Butz, secretary of agriculture under Richard Nixon, told farmers to plow "fence row to fence row."

Once the loft of the barn was the fuel tank for the farm, dispersing sunlight in the form of hay. And the barn of 1948 was not too different from the barn in Bruegel's time, which had a hay mound. Below was the straw bedding for the animals, and it soaked up their urine and manure. Back to the question: Why was Bruegel's wheat so tall? To absorb the urine and the manure that would then go back to the fields. So, the fuel source (the hay mound) sat atop the nitrogen- and nutrient-management scheme (the bedding). Well, if you don't need that any more, then pretty soon you don't need the barn—you just need a diesel tank, with its dense energy, and an anhydrous ammonia tank.

There is something else that happened. If you look at an aerial view of farm country—at the fields and the county roads and farmsteads and the little towns—what you see are concentrators of sunlight. And, of course, if you've got a lot of energy and you can haul it around, then you don't need those houses, and you don't need the small towns, and you don't need the girl who can make her own dress. The cultural capacity goes down.

I found out the name of that county agent in the Rockwell painting and I called to the town in Indiana and asked for the name Rippey. The first person I got, it turned out, was a relative of the late county agent. From him I learned that the father in the painting, who stands off to the left in the shadows with the cat on his shoulder, farmed until he was killed by a registered bull on his farm. He gave me the name of the 4-H girl holding the calf, the one with her record book displayed, and I called her. She and her sister, the one with the sewing project, left the farm to marry. They never farmed. Their brother, the one with the poultry project, had farmed until he died in 1988. I asked if any of the children of the kids in the painting were farming. The answer was no.

I think there's a general law: High energy destroys information, of a cultural as well as a biological variety. There's a loss of cultural capacity. And from 1750, the beginning of the Industrial Revolution, the graphical curve for the use of high-energy fossil carbon is increasingly steep. A ten-year-old today has been alive for a quarter of all the oil ever burned. The twenty-two-year-old has been through 54 percent of all the oil ever burned.

Now let's come back to the 3.45-billion-year imperative. Bacteria on a petri dish with sugar simply go for it. Fruit flies in a flask with mashed-up bananas just go for it. Deer without a predator just breed and live and expand. I think what humans have is the powerful capacity to create abstractions—and one of the most important abstractions we ever invented was the one that allows us to ignore that our petri dish has a wall. It's called capitalism, growth. Even if you have twice the amount of oil that you think you have, you don't buy much time.

Now there's the reality of climate change. We've gone into overshoot and we are in economic trouble. We look to more economic growth, but once economics and population growth absorb all of the renewables and all of the efficiency, then what? The technological fundamentalist comes along and says, "We will solve the problem through technology." This is just another form of religion. We may get some technological substitutes for the fossil carbons, such as wind turbines, solar collectors, and so on, but I'd like somebody to help me come up with a technological substitute for soil and water. Let's get that on the inventory right away. Are we going to wait another thirty years while the soils of the planet decline? How are we going to keep ourselves fed while desecrating our agricultural lands worldwide and depending on fossil fuels?

I think we must recognize what the United Nations Millennium Ecosystem Assessment[1] said: that on a global basis, agriculture is the largest threat to biodiversity and ecosystem function of any single human activity. So let's look at those vegetables in figure 10.1. Let's look at the distribution of global agricultural acres. Cereals, oilseeds, and pulses (legumes' edible seeds) make up about 68 percent of the calories and about the same acreage. Upland rice is increasingly grown on steep hills in China and Indonesia, where erosion is a big problem. But even on flat land, agriculture can cause erosion, which happens after heavy rains in places like Iowa and Kansas.

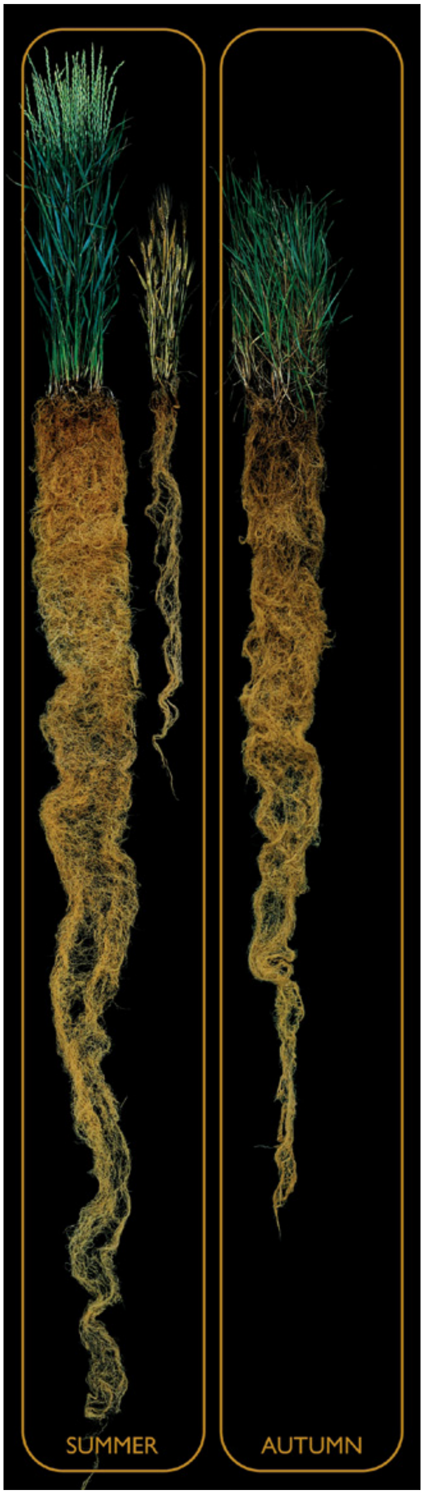
What do we do?

I like to imagine the world before agriculture. And when we do, we see that essentially all of nature's ecosystems feature perennials in mixtures: alpine meadows, tropical rainforests, desert scrub, prairies, and more. All perennial mixes. Why is that? Well, one thing that is interesting about us organisms is that we use only a few atoms to make complex molecules. Chemists will use almost all the atoms to make simple molecules. That's one of the differences between us as chemists and nature's biota. And of the sixteen elements necessary to make organisms, only four are from the global atmospheric commons: hydrogen, carbon, nitrogen, and oxygen. The rest are in the soil.

Let's start at the beginning of our "fallen world." It all began in the Zagros Mountains of western Iran, some 10,000 to 12,000 years ago. Here one plant got civilization started: the wheat plant, an annual. When agriculture began, we reversed what nature's ecosystems do on a landscape. We started featuring annuals, and we grew them in monocultures much as we do today.

Figure 10.5 shows one of our perennial wheat relatives and annual wheat. It's hard to consistently remember that from the topsoil down are most of the elements that go into organisms. But when we do remember, doesn't it make sense that nature's ecosystems feature roots that are there year-round, holding the ecological

FIGURE 10.5
Perennial wheat (at left in the boxes) and annual wheat (at right in the boxes), in summer and in autumn.



Note: Unlike annual crops, which must be replanted every year, the extensive root system of perennial crops retains nutrients in the soil while protecting against soil erosion. Photograph by the Land Institute.

capital as tenaciously as possible? And that banking everything on an annual crop is wrong-headed? The primary killers of soil on the continent are our top annual crops: wheat, corn, and soybeans. And then we promote a biofuels program, even though the energy balance is not good. We went from just over 70 million acres of corn to nearly 90 million acres in 2007. That's what *Homo* the homogenizer does.

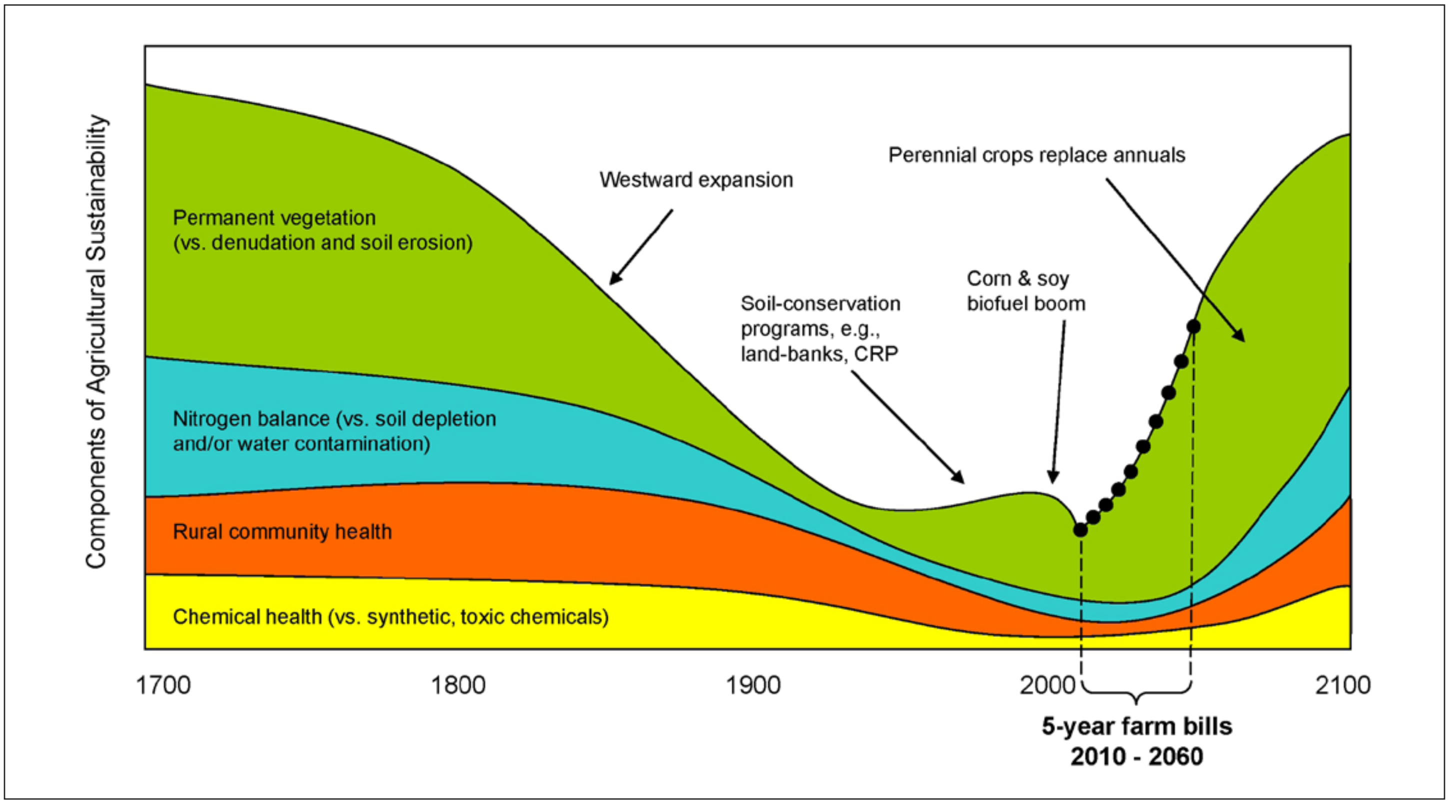
Nebraska, Iowa, Minnesota, and North Dakota: Here we have the richest soils of the world, as the consequence of the glaciers scraping the nutrients off the Canadian Shield. And to reduce erosion and protect them, we say we will apply some human cleverness and come up with things like minimum-till or no-till agriculture. The water coming off a minimum-till or no-till field looks a lot better than the water coming off a conventional-till field. There's only one problem: The nitrogen level of the water from that no-till land is still three times above the acceptable level determined by the Environmental Protection Agency.

Annual systems leak; they are poor micromanagers of nutrients and water. So in the sea we have a dead zone because fertilizer runoff accumulates there and reduces the oxygen available for marine species. In fact, there are several dead zones worldwide. We had Gene Turner, from the Louisiana Universities Marine Consortium, come and talk to our graduate fellows one summer, and he said there were fifty dead zones. The next year Nancy Rabelais, his wife, came and showed a slide with 146 dead zones, and I said, "It's tripled in one year!" She replied, "Oh Wes, there are a thousand." So, here is one of the consequences of the green revolution, of human cleverness.

What we are about at the Land Institute is perennializing the major crops, to be grown in mixtures. On our 600 acres we have about 160 acres of prairie, and most of it has never been ploughed; and on that prairie we have 30 bison. They remind us of the standard, something closer to the original relationship. We work with perennial wheat. We make the crosses in the greenhouse. We produce hybrids, and after we harvest, some of the wheat plants will shoot back up so we say we've got perennials. Maximilian sunflower is a perennial that we're crossing with an annual crop sunflower, and we're working on perennializing a winter-hardy sorghum. We had a good, hard freeze this year—thank goodness, because our breeders need to find out how much "antifreeze" we have in the plants' underground stems.

What is the hope for this? Many of us think that we need a fifty-year farm bill. Wendell Berry, Fred Kirschenmann of Iowa State Univeristy's Leopold Center, and I took a fifty-year farm bill to Washington, D.C. in 2009 and proposed the perennialization of the American farmscape, with the hope that this could catch on and go around the world. The idea is to use the current five-year farm bills as mileposts towards this goal. The five-year farm bills currently are devoted to exports, commodities, subsidies, some soil conservation,

FIGURE 10.6
Effects of the fifty-year farm bill proposal on U.S. agricultural sustainability.



and the food programs. Our fifty-year farm bill would protect soil from erosion, cut wasteful use of water, cut fossil-fuel dependence, eliminate toxic chemicals, manage nitrogen, reduce dead zones, and restore an agrarian way of life. It would do this largely by shifting the makeup of U.S. agriculture from being 80 percent annuals, as it is today, to 80 percent perennials in fifty years. In the short run we need only to change the subsidies so that we increase the amount of perennials and rotations gradually, and then in about twenty years our perennial grains begin to be available.

Figure 10.6 shows what the fifty-year farm bill could accomplish. By steadily replacing annuals with perennials, we can reestablish much—not all—of what we had in 1700.

The history of our country is one of permanent vegetation rather than denudation and soil erosion. In 1700 the nitrogen balance was there, rural community health was there, chemical health was there—there were no synthetics. Then we expanded westward, and on the way we scraped off the permanent vegetation. Wendell Berry said it very well in a letter he wrote to me: As we came across the continent cutting the forests and plowing the prairies, we never knew what we were doing, because we never knew what we were undoing. But what we were undoing was the benefits of those perennial roots.

Dan Luten also said, I think in his wonderful book *Progress Against Growth*: We came as a poor people to a seemingly empty land that was rich in resources, and we built our institutions for that perception of reality. *Poor people, empty land, rich*. Our economic institutions, our educational institutions, and our political institutions are all predicated on *poor people, empty land, rich*. Then Luten said: We've become rich people in an increasingly poor land that's filling up, and those institutions don't hold.

Our challenge is to develop a whole different concept of how to live on the landscape. We have an abundance of knowledge about the way ecosystems work, but that knowledge is mostly gathering dust. This knowledge was accumulated by ecologists and evolutionary biologists out to understand how the world is, or how the world was; they have had the luxury to be descriptive. Agriculturists, on the other hand, have the burden to be prescriptive. So, we have to figure out a way to bring the agronomist who prescribes together with the ecologist who describes, and merge these two cultures. I have to say, it's harder than I thought it would be, because of the nature of our learning.

When we were gatherers and hunters we lived within the natural ecosystem, and then, 10,000 to 12,000 years ago, we got out of phase. And then industrial agriculture came along, and we struggled with sustainable agriculture until now, when we finally must face up to reality. We know we're not voluntarily going back to gathering and hunting or pre-industrial agriculture, so what do we do? I think we can have something close to what I propose here.

Endnotes

1 United Nations Millennium Ecosystem Assessment, *Ecosystems and Human Well-Being: Biodiversity Synthesis* (Washington DC: World Resources Institute, 2005).

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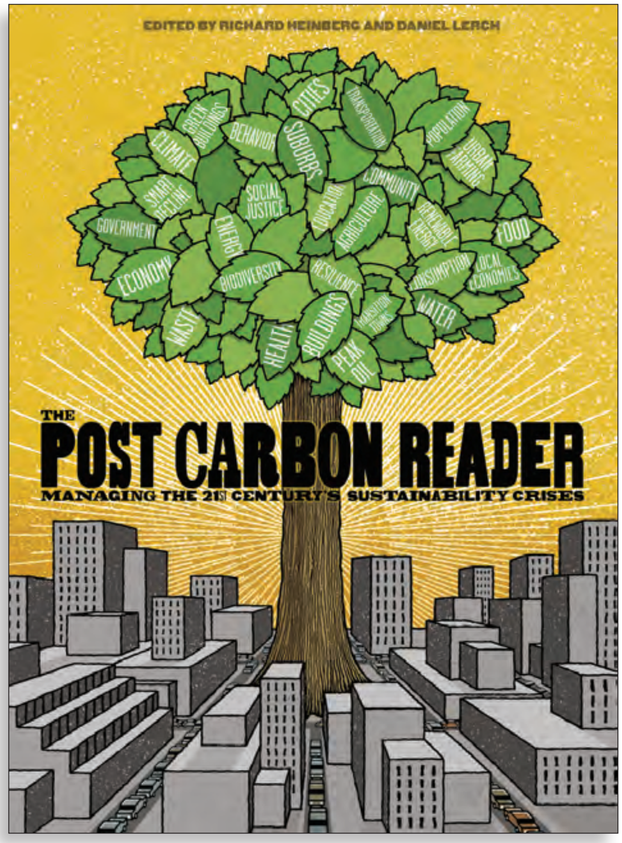

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The Post Carbon Reader

Managing the 21st Century's Sustainability Crises

Edited by RICHARD HEINBERG and DANIEL LERCH

In the 20th century, cheap and abundant energy brought previously unimaginable advances in health, wealth, and technology, and fed an explosion in population and consumption. But this growth came at an incredible cost. Climate change, peak oil, freshwater depletion, species extinction, and a host of economic and social problems now challenge us as never before. *The Post Carbon Reader* features articles by some of the world's most provocative thinkers on the key drivers shaping this new century, from renewable energy and urban agriculture to social justice and systems resilience. This unprecedented collection takes a hard-nosed look at the interconnected threats of our global sustainability quandary—as well as the most promising responses. *The Post Carbon Reader* is a valuable resource for policymakers, college classrooms, and concerned citizens.

Richard Heinberg is Senior Fellow in Residence at Post Carbon Institute and the author of nine books, including *The Party's Over* and *Peak Everything*. **Daniel Lerch** is the author of *Post Carbon Cities*.

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