Transformations of the Earth: Toward an Agroecological Perspective in History

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Forty years ago a wise, visionary man, the Wisconsin wildlife biologist and conservationist Aldo Leopold, called for "an ecological interpretation of history," by which he meant using the ideas and research of the emerging field of ecology to help explain why the past developed the way it did.[1] At that time ecology was still in its scientific infancy, but its promise was bright and the need for its insights was beginning to be apparent to a growing number of leaders in science, politics, and society. It has taken a while for historians to heed Leopold's advice, but at last the field of environmental history has begun to take shape and its practitioners are trying to build on his initiative.

Leopold's own suggestion of how an ecologically informed history might proceed had to do with the frontier lands of Kentucky, pivotal in the westward movement of the nation. In the period of the revolutionary war it was uncertain who would possess and control those lands: the native Indians, the French or English empires, or the colonial settlers? And then rather quickly the struggle was resolved in favor of the Americans, who brought along their plows and livestock to take possession. It was more than their prowess as fighters, their determination as conquerors, or their virtue in the eyes of God that allowed those agricultural settlers to win the competition; the land itself had something to contribute to their success. Leopold pointed out that growing along the Kentucky bottomlands, the places most accessible to newcomers, were formidable canebrakes, where the canes rose as high as fifteen feet and posed an insuperable barrier to the plow. But fortunately for the Americans, when the cane was burned or grazed out, the magic of bluegrass sprouted in its place. Grass replaced cane in what ecologists call the pattern of secondary ecological succession, which occurs when vegetation is disturbed but the soil is not destroyed, as when a fire sweeps across a prairie or a hurricane levels a forest; succession refers to the fact that a new assortment of species enters and replaces what was there before. In Kentucky, the foremost of those new species was bluegrass, and a wide expanse of bluegrass was all that any rural pioneer, looking for a homestead

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[1] Aldo Leopold, *A Sand County Almanac, and Sketches Here and There* (1949; reprint, New York, 1987), 205.

and a pasture for his livestock, could want. Discovering that fact, Americans entered Kentucky by the thousands, and the struggle for possession was soon over. "What if," Leopold wondered, "the plant succession inherent in this dark and bloody ground had, under the impact of these forces, given us some worthless sedge, shrub, or weed?" Would Kentucky have become American territory as, and when, it did?[2]

Actually, the facts in the case are more complicated than Leopold could explore in the confines of his essay, and they argue for something more than a simple form of environmental determinism, which is what a casual reader might see in his example. Kentucky bluegrass was not a native species, but a European import.[3] Brought by immigrants to the country in the holds of ships, its seed spread through the travels and droppings of their cattle, sprouting first around salt licks, where the animals congregated, then spreading into newly disturbed land like the canebrakes, where it gained ascendancy over its indigenous competitors, much as the colonists were doing over the Indians. The winning of Kentucky was, in other words, helped immensely by the fact that the human invaders inadvertently brought along their plant allies. So, on continent after continent, went the triumph of what Alfred Crosby, Jr., has called "ecological imperialism."[4]

It is with such matters that the new field of ecological or environmental history (most practitioners prefer to use the latter label as more inclusive in method and material) deals. This new history rejects the common assumption that human experience has been exempt from natural constraints, that people are a separate and uniquely special species, that the ecological consequences of our past deeds can be ignored. The older history could hardly deny that people have been living for a long while on this planet, but its general disregard of that fact suggested that they were not and are not truly part of the planet. Environmental historians, on the other hand, realize that scholarship can no longer afford to be so naïve.

The field of environmental history began to take shape in the 1970s, as conferences on the global predicament were assembling and popular environmentalist movements were gathering momentum. It was a response to questions that people in many nations were beginning to ask: How many humans can the biosphere support without collapsing under the impact of their pollution and consumption? Will man-made changes in the atmosphere lead to more cancer or poorer grain harvests or the melting of the polar ice caps? Is technology making people's lives more dangerous, rather than more secure? Does *Homo sapiens* have any moral obligations to the earth and its circle of life, or does that life exist merely to satisfy the infinitely expanding wants of our own species? History was not alone in being touched by

[2] *Ibid.* When the soil is destroyed by a volcanic eruption or some other catastrophe, another process called primary succession begins, in which species that can gain a foothold on bare rock or subsoil invade and proliferate. A clear discussion of both types of succession can be found in Paul R. Ehrlich, *The Machinery of Nature* (New York, 1986), 268–71.

[3] Leopold was aware that the story had more complexity to it; "we do not even know," he admitted, "where the bluegrass came from—whether it is a native species, or a stowaway from Europe." Leopold, *Sand County Almanac*, 206.

[4] I take the phrase from Alfred Crosby, Jr., *Ecological Imperialism: The Biological Expansion of Europe, 900–1900* (New York, 1986).

the rising concern; scholars in law, philosophy, economics, sociology, and other areas were likewise responsive. It is surely a permanent response, gaining significance as the questions prompting it increase in urgency, frequency, and scope. Environmental history was born out of a strong moral concern and may still have some political reform commitments behind it, but as it has matured, it has become an intellectual enterprise that has neither any simple, nor any single, moral or political agenda to promote. Its goal is to deepen our understanding of how humans have been affected by their natural environment through time, and conversely and perhaps more importantly in view of the present global predicament, how they have affected that environment and with what results.[5]

Much of the material for environmental history, coming as it does from the accumulated work of geographers, natural scientists, anthropologists, and others, has been around for generations and is merely being absorbed into historical thinking in the light of recent experience. It includes data on tides and winds, ocean currents, the position of continents in relation to each other, and the geological and hydrological forces creating the planet's land and water base. It includes the history of climate and weather, as these have made for good or bad harvests, sent prices up or down, promoted or ended epidemics, or led to population increase or decline. All these have been powerful influences on the course of history, and they continue to be so. In a somewhat different category from these physical factors are the living resources of the earth, or the biota, which the ecologist George Woodwell calls the most important of all to human well-being: the plants and animals that, in his phrase, "maintain the biosphere as a habitat suitable for life."[6] Those living resources have also been more susceptible to human manipulation than nonbiological factors, and at no point more so than today. We must include the phenomenon of human reproduction as a natural force giving form to history, and by no means a negligible force, as the last few decades of explosive global fertility have amply demonstrated.

Defined in the vernacular then, environmental history deals with the role and place of nature in human life. It studies all the interactions that societies in the past have had with the nonhuman world, the world we have not in any primary sense created. The technological environment, the cluster of things that people have made, which can be so pervasive as to constitute a kind of "second nature" around them, is also part of this study, but in the very specific sense that technology is a product of human culture as conditioned by the nonhuman environment. But with such phenomena as the desert and the water cycle, we encounter autonomous, independent energies that do not derive from the drives and inventions of any culture. It might be argued that as the human will increasingly makes its imprint on forests,

[5] The best effort to trace the emergence of the field, at least in one influential part of the world, is Richard White, "American Environmental History: The Development of a New Historical Field," *Pacific Historical Review*, 54(Aug. 1985), 297–335. White argues that the study of frontier and western history has been the formative influence on this field. Another important source of ideas, quite removed from the influence of Frederick Jackson Turner, has been French historians and geographers, particularly Fernand Braudel, Lucien Febvre, and Emmanuel Le Roy Ladurie, all associated with the journal *Annales*.

[6] George Woodwell, "On the Limits of Nature," in *The Global Possible: Resources, Development, and the New Century*, ed. Robert Repetto (New Haven, 1985), 47.

gene pools, and even oceans, there is no practical way to distinguish between the natural and the cultural. However, most environmental historians would argue that the distinction is worth keeping, for it reminds us that not all the forces at work in the world emanate from humans. Wherever the two spheres, the natural and the cultural, confront or interact with one another, environmental history finds its essential themes.

There are three levels on which the new history proceeds, each drawing on a range of other disciplines and requiring special methods of analysis. The first involves the discovery of the structure and distribution of natural environments of the past. Before one can write environmental history one must first understand nature itself—specifically, nature as it was organized and functioning in past times. The task is more difficult than might first appear, for although nature, like society, has a story of change to tell, there are few written records to reveal most of that story. To make such a reconstruction, consequently, the environmental historian must turn for help to a wide array of the natural sciences and must rely on their methodologies, sources, and evidence, though now and then the documentary materials with which historians work can be a valuable aid to the scientists' labors.[7]

The second level of environmental history is more fully the responsibility of the historian and other students of society, for it focuses on productive technology as it interacts with the environment. For help on understanding this complicated level, in which tools, work, and social relations are intermixed, historians in the new field have begun to turn to the extensive literature dealing with the concept of "modes of production," emphasizing (as most of those who use the phrase have not) that those modes have been engaged not merely in organizing human labor and machinery but also in transforming nature.[8] Here the focus is on understanding how technology has restructured human ecological relations, that is, with analyzing the various ways people have tried to make nature over into a system that produces resources for their consumption. In that process of transforming the earth, people have also restructured themselves and their social relations. A community organized to catch fish at sea may have had very different institutions, gender roles, or seasonal rhythms from those of one raising sheep in high mountain pastures. A hunting society may have had a very different configuration from that of a peasant agricultural one. On this level of inquiry, one of the most interesting questions is who has gained and who has lost power as modes of productions have changed.[9]

[7] A good guide to this field is J. Robert Dodd and Robert J. Stanton, *Paleoecology: Concepts and Applications* (New York, 1981).

[8] The phrase "modes of production" originated with Karl Marx, who used it in more than one way. In some cases he was referring to "the material mode," defined by G. A. Cohen as "the way men work with their productive forces, the kinds of material process they set in train, the forms of specialization and division of labour among them." In other cases, Marx employed the phrase to denote "social properties of the production process," including the purpose controlling production (whether for use or exchange), the form of the producer's surplus labor, and the means of exploiting producers. Then, again, at times he seems to have meant both material and social aspects at once. See G. A. Cohen, *Karl Marx's Theory of History: A Defense* (Princeton, 1978), 79–84.

[9] Useful theoretical background for this study are Julian H. Steward, *The Theory of Culture Change: The Methodology of Multilinear Evolution* (Urbana, 1955), 30–42; and Marvin Harris, *Cultural Materialism: The Struggle for a Science of Culture* (New York, 1979), 46–76.

Finally, forming a third level for the environmental historian is that more intangible, purely mental type of encounter in which perceptions, ideologies, ethics, laws, and myths have become part of an individual's or group's dialogue with nature. People are continually constructing cognitive maps of the world around them, defining what a resource is, determining which sorts of behavior may be environmentally degrading and ought to be prohibited, and generally choosing the ends to which nature is put. Such patterns of human perception, ideology, and value have often been highly consequential, moving with all the power of great sheets of glacial ice, grinding and pushing, reorganizing and recreating the surface of the planet.

The great challenge in the new history does not lie in merely identifying such levels of inquiry, but in deciding how and where to make connections among them. Do the lines of historical causality run from the first, the level of nature, through technology and on to ideology, as a strict environmental determinist would insist? Or do the lines run in precisely the opposite direction, so that nature itself is finally nothing more than the product of human contrivance or desire? This is, of course, an age-old debate over explanation, one that the new history has only inherited, not invented; the debate is too large and complex to reproduce, let alone pretend to resolve, here. Suffice it to observe that most environmental historians seem to have settled philosophically on a position that is at once materialist and idealist; they commonly maintain that the historian cannot rigidly adhere a priori to any single theory of causality but must be open to context and time. In some cases the shifting patterns of the natural order—a sustained condition of severe aridity, for instance, or an abrupt shift from a wet to a dry cycle—have been powerful, forcing people to adapt on both the productive and the cognitive levels. In other cases, however, and increasingly in modern times, when the balance of power has shifted more and more away from nature and in favor of humans, the third level, the sum of people's perceptions and ideas about nature, has clearly become the decisive one in promoting change.

The gathering strength of the human imagination over nature is so obvious and dramatic that it is in no danger of being neglected by historians. What has been neglected, however, or left conceptually underdeveloped, is the second level of inquiry I mentioned. And it is to that middle level, the analysis of modes of production as ecological phenomena, and particularly as they are articulated in agriculture, that the rest of this essay is devoted. The intention here is not to make a definitive theoretical statement about this subject, but to review, especially with nonspecialists in mind, some of the broader themes and to identify areas where more research is needed.

Humans have extracted an extraordinarily diverse array of resources from the natural world, and the number and magnitude of them is growing all the time. But the most basic and revealing of them in the study of human ecology have been the resources we call food. Every group of people in history has had to identify such resources and create a mode of production to get them from the earth and into their

bellies. Moreover, it is through that process that they have been connected in the most vital, constant, and concrete way to the natural world. Few of those modes of producing food, however, have been approached by historians from an ecological perspective. If we are to make further progress in understanding the linkages human beings make to nature, developing that perspective and applying it to food production must be one of the major activities of the new field.

To undertake this project, the historian might begin by adopting the scientist's concept of the *ecosystem* and then asking how it might be applied to the agriculture practiced in any setting or period. There is a tall pile of books and scientific papers on the complicated ways in which ecosystems are structured, work, and evolve; but in simplest terms, one might define an ecosystem as the collective entity of plants and animals interacting with one another and the nonliving (abiotic) environment in a given place. Some ecosystems are fairly small and easily demarcated, like a single pond in New England, while others are sprawling and ill defined, as hugely ambiguous as the Amazonian rain forest or the Serengeti plain. Until rather recently, all those ecosystems have been understood by ecologists to have self-equilibrating powers, like automatic mechanisms that slow themselves when they get too hot or speed up when they begin to sputter and stall. Outside disturbances might affect equilibrium, throwing the system temporarily off its regular rhythm, but always (or almost always) it was supposed to return to some steady state. The number of species constituting an ecosystem was believed to fluctuate around some determinable point, the flow of nutrients and energy through the system staying more or less constant. A dominant concern among ecologists has been to explain how such systems manage to cohere, to maintain order and balance, in the midst of all the perturbations to which they are subject.[10]

But historians wanting to undertake an ecological analysis should be aware that lately the conventional ecosystem model sketched above has been coming under considerable criticism from some scientists, and there is no longer any consensus on how it functions or how resilient it is. Are ecosystems as stable as scientists have assumed, the critics ask, or are they all susceptible to easy upset? Is it accurate to described them as firmly balanced and orderly until humans arrive on the scene, as some of the older textbooks suggested, or is human disturbance only one of the many sources of instability in nature? Even more disputed are these questions: How and when do people begin to produce changes in ecosystems that might be called damaging, and when does that damage become irreversible? No one really disputes that the death of all its trees, birds, and insects would mean the death of a rain forest, or that the draining of a pond would spell the end of that ecosystem; but most changes, induced by humans or otherwise, are not so catastrophic, and the concept of damage has no clear definition or easy method of measurement. Dependent as it is on ecological theory for assistance in analysis and explanation, the new field of environmental history finds itself in a very awkward position—caught in the

[10] The classic explication of the ecosystem concept is Eugene Odum, *Fundamentals of Ecology* (Philadelphia, 1971), 8–23.

middle of a revisionist swing that has left in some disarray the notion of what an ecosystem is and how it works, that has even cast doubt on such old intuitive notions as "the balance of nature" and the role of diversity in promoting ecological stability.[11] Historians have long had to deal with such revisionism in their own field and are only too familiar with the resulting confusion. Learning from that experience, they should not rush to assume that the latest scientific paper on the ecosystem is the true gospel or that yesterday's notions are now completely wrong; on the other hand, if they want to work collaboratively with scientists, they must be careful not to borrow their ideas of nature unthinkingly or innocently from outmoded textbooks or discarded models.

Those theoretical disputes should not obscure the fact that ecological science continues to describe a natural world that is marvelously organized and vital to human existence. Nature, in the eyes of most ecologists, is not an inert or formless or incoherent world that awaits the hand of people. It is a world of living things that are constantly at work, in discernible patterns, producing goods and services that are essential for the survival of one another. Microorganisms, for example, are endlessly busy breaking down organic matter to form the constituents of soil, and other organisms in turn make use of that soil for their own nutrition and growth. The science of ecology still reveals a realm beyond our human economies, and beyond the work we do in them, a realm that has been described as a vast, elaborate, complex "economy of nature," an organized realm that is working energetically and skillfully to satisfy the needs of all living things, creating what might be called the indispensable "values" of existence. Without the smooth functioning of that greater economy, without those values that are brought into being by a hardworking nature, no group of people could survive for an hour, and the making of history would come to an abrupt end.

An ecosystem then is a subset of the global economy of nature—a local or regional system of plants and animals working together to create the means of survival. Starting from this understanding, the historian ought to ask how we can best proceed from the ecosystem concept to understand the human past more completely. Taking that next step requires us to adopt still another concept—what some have begun to call an *agroecosystem*, which, as the name suggests, is an ecosystem reorganized for agricultural purposes—a domesticated ecosystem. It is a restructuring of the trophic processes in nature, that is, the processes of food and energy flow in the economy of living organisms. Everywhere such a restructuring involves forcing the productive energies in some ecosystem to serve more exclusively a set of conscious purposes often located outside it—namely, the feeding and prospering of a group of humans. Whatever its place in time, whether its human designers are

[11] The debate is summarized in Paul R. Ehrlich and Jonathan Roughgarden, *The Science of Ecology* (New York, 1987), 541–52. Detailed criticisms of the stable ecosystem idea include Robert May, *Stability and Complexity in Model Ecosystems* (Princeton, 1973); Paul Colinvaux, *Why Big Fierce Animals Are Rare* (Princeton, 1978), 199–211; Margaret B. Davis, "Climatic Instability, Time Lags, and Community Disequilibrium," in *Community Ecology*, ed. Jared Diamond and Ted J. Case (New York, 1986), 269–84; and S. J. McNaughton, "Diversity and Stability," *Nature*, May 19, 1988, pp. 204–5.

primitive or advanced, every agroecosystem has at least two general characteristics. It is always a truncated version of some original natural system: There are fewer species interacting within it, and many lines of interaction have been shortened and directed one way. Commonly, it is a system of export, some of the foodstuffs produced being harvested and removed, sometimes only a little distance to a village of folk agriculturists, sometimes a good way off to an international port, in either case leaving the system in danger of becoming depleted and degraded. To survive for very long, the agroecosystem must achieve a balance between its exports and imports, or it loses its productivity and people slide downward into poverty and hunger.[12]

Though something of a human artifact, the agroecosystem remains inescapably dependent on the natural world—on photosynthesis, biochemical cycles, the stability of the atmosphere, and the services of nonhuman organisms. It is a rearrangement, not a repeal, of natural processes. That is as true of a modern factory farm in California or a Douglas fir plantation in Oregon as it is of an ancient rice paddy in China. Whatever the differences among agroecosystems, they are all subject to the laws of ecology, and those same laws govern wild forests, grasslands, savannahs, and heaths, determining just how stable or resilient or sustainable they are as collective entities.

The reorganization of native plants and animals into agroecosystems began long before the modern age. Often it started with a fire deliberately set and fanned into a raging blaze, clearing a patch of open soil; in the ashes of that opening farmers planted their own favored species, maintaining them against the successional pressures of the surrounding vegetation for a few years until the soil fertility was depleted and the agriculturist moved on to new lands.[13] This primitive method of clearance, found among North American Indians, white Kentucky pioneers, and New Guinea tribesmen, is still practiced in many parts of the world today, wherever land is plentiful and there is little pressure to maximize production; it is variously labeled shifting, swidden, slash-and-burn, or milpa faming.[14] In almost every case these early-style farmers introduced plants that were not part of the native ecosystem, that may even have been brought in from remote parts of the planet. Wheat, corn, and rice, the most widely cultivated cereals, have all been carried far from their points of origin and have replaced native vegetation over vast expanses of the earth's surface. As outsiders, they have in many cases thrived exceptionally well in their new

[12] Eugene P. Odum, "Properties of Agroecosystems," in *Agricultural Ecosystems: Unifying Concepts*, ed. Richard Lowrance, Benjamin R. Stinner, and Garfield J. House (New York, 1986), 5–11. See also George Cox and Michael Atkins, *Agricultural Ecology* (San Francisco, 1979). The scientific pioneers in applying ecology to agriculture were Karl H. W. Klages, *Ecological Crop Geography* (New York, 1942); and Wolfgang Tischler, *Agrookologie* (Jena, 1965).

[13] Omer C. Stewart, "Fire as the First Great Force Employed by Man," in *Man's Role in Changing the Face of the Earth*, ed. William L. Thomas, Jr. (2 vols., Chicago, 1956), I, 115–33; Stephen Pyne, *Fire in America: A Cultural History of Wildland and Rural Fire* (Princeton, 1982); and Emily W. B. Russell, "Indian-Set Fires in the Forests of the Northeastern United States," *Ecology*, 64 (Feb. 1983), 78–88.

[14] Harold C. Conklin, "The Study of Shifting Cultivation," *Current Anthropology*, 2 (Feb. 1961), 27–61; John W. Bennett, "Ecosystemic Effects of Extensive Cultivation," *Annual Review of Anthropology*, 2 (1973), 36–45; Robert McC. Netting, "Agrarian Ecology," *ibid.*, 3 (1974), 24–28.

settings, freed as they have been from the animal grazers and nibblers and the plant competitors that once kept them in check. In other cases, however, the newcomers have not been so well adapted to their new environment, or at least not so well adapted as the native plants; hence a great deal of effort must be given to securing them against destructive forces, adapting them as well as human ingenuity can, trying to replicate in mere decades or centuries of breeding what it may have taken nature millions of years to evolve, never letting one's vigilance rest. Likewise, the native fauna have been radically diminished, even in many cases exterminated, on every continent by clearance for agriculture, and new fauna—including a plague of insect pests—have appeared over time to thrive in those contrived agroecosystems. Tracing such ecological transformations ought to be the first and most essential step in writing the history of the planet.

Anthropologists and archaeologists are still debating the causes of the Neolithic revolution, which took place some ten thousand years ago in the Middle East (later in other areas), and conclusive support for any theory as to why humans gave up a hunting and gathering life for shifting, or later more settled, farming may always be hard to come by. One of the standard hypotheses starts with a shortage in food supplies brought on by population growth, a situation that may have happened in many places and at different times in prehistory but supposedly always had that same demographic pressure behind it. The hypothesis has plenty of critics, and it is not a matter that historians can pretend to settle, though it may be that historical studies of agricultural change in developing countries in recent centuries can be suggestive. One of the most influential agricultural theorists, the Danish economist Ester Boserup, has followed precisely that strategy and has concluded that population pressure has always been the key force behind land-use intensification, compelling groups to cultivate crops in the first place and then, as the pressure continues, to work harder and harder at the task, developing new skills as they go along and organizing themselves into larger work units. Sheer necessity, in other words, has been the mother of ecological innovation in preindustrial conditions.[15]

All the while they are rearranging the native flora and fauna to produce more food, people are forced to adapt to local conditions of soil, climate, and water. One might even call such conditions the soft determinants of human existence, for they significantly influence how and where prople get their living and what kind of living it is.

No people can do without a little soil. Before people began farming on it, topsoil may have required thousands of years to develop, accumulating at the rate of a mere

[15] Mark Nathan Cohen, *The Food Crisis in Prehistory: Overpopulation and the Origins of Agriculture* (New Haven, 1977), 18–70; D. C. Darlington, "The Origins of Agriculture," *Natural History*, 79 (May 1970), 46–57; Stuart Struever, ed., *Prehistoric Agriculture* (Garden City, 1971); Kent V. Flannery, "The Origins of Agriculture," *Annual Review of Anthropology*, 2 (1973), 271–310; Ester Boserup, *The Conditions of Agricultural Growth: The Economics of Agrarian Change under Population Pressure* (Chicago, 1965); Ester Boserup, "The Impact of Scarcity and Plenty on Development," in *Hunger and History: The Impact of Changing Food Production and Consumption Patterns of Society*, ed. Robert I. Rotberg and Theodore K. Rabb (Cambridge, Eng., 1983), 185–209. Boserup denies that there are any ultimate environmental limits on population growth; scarcity, in her view, always generates greater innovation and abundance.

fraction of an inch per century. One of the greatest challenges posed any community is to maintain that fertility under its contrived food system, and the historian must study the techniques by which the community does so, whether through fallowing, green-manuring, legume planting, or plowing human and animal excrement back into the soil, as well as the consequences that follow when it is not done. The second critical factor, climate, has until recently been well beyond human control; therefore the vulnerability of the agroecosystem to natural forces has been greatest here. Water has been less sovereign. It was one of the earliest forces of nature to come under human management, though here too a scarcity or an excess has, at many times and places, put severe constraints on social development.[16]

Unquestionably, all agriculture has brought revolutionary changes to the planet's ecosystems; and, most agroecologists would agree, those changes have often been destructive to the natural order and imperfect in design and execution. Yet as they have gained understanding of how agricultural systems have interacted with nature, scientists have discovered plenty of reasons to respect the long historical achievement of billions of anonymous traditional farmers. As Miguel A. Altieri writes, "Many farming practices once regarded as primitive or misguided are being recognized as sophisticated and appropriate. Confronted with specific problems of slope, flooding, droughts, pests, diseases and low soil fertility, small farmers throughout the world have developed unique management systems to overcome these constraints." One of the most impressive and yet common of such managerial techniques is to diversify the crops under cultivation; traditional Filipino farmers, for example, raise as many as forty separate crops in a single swidden at the same time. The advantages of such diversification include making more efficient use of light, water, and nutrients by cultivating plants of different height, canopy structure, and nutrient requirements, thus harvesting greater total yields per hectare; leaving more nitrogen in the soil from intercropped legumes; and achieving more effective soil cover, pest control, and weed suppression.[17]

The landscapes that resulted from such traditional practices were carefully integrated, functional mosaics that retained much of the wisdom of nature; they were based on close observation and imitation of the natural order. Here a field was selected and cleared for intensive crop production; there a forest was preserved as supply of fuel and mast; over there a patch of marginal land was used for pasturing livestock. What may have appeared scattered and happenstance in the premodern agricultural landscape always had a structure behind it—a structure that was at once

[16] According to Norman Hudson, soil may be formed under natural conditions at the rate of one inch in three hundred to one thousand years; good farming techniques can speed up this process considerably. See Norman Hudson, *Soil Conservation* (Ithaca, 1971), 38. See also M. Witkamp, "Soils as Components of Ecosystems," *Annual Review of Ecology and Systematics*, 2 (1971), 85–110. On the role of climate in history see, for example, Reid Bryson and Thomas J. Murray, *Climates of Hunger: Mankind and the World's Changing Weather* (Madison, 1977); and Robert I. Rotberg and Theodore K. Rabb, eds., *Climate and History: Studies in Interdisciplinary History* (Princeton, 1981). On the major types of water control in history, see Donald Worster, *Rivers of Empire: Water, Aridity, and the American West* (New York, 1985), 17–60.

[17] Miguel A. Altieri, *Agroecology: The Scientific Basis of Alternative Agriculture* (Boulder, 1987), 69–71; Harold C. Conklin, "An Ethnological Approach to Shifting Agriculture," in *Environment and Cultural Behavior*, ed. A. P. Vayda (New York, 1979), 228.

the product of nonhuman factors and of human intelligence, working toward a mutual accommodation. In many parts of the world that agroecosystem took thousands of years to achieve, and even then it never reached any perfect resting point.[18] Rises and falls in human numbers, vagaries of weather and disease, external pressures of wars and taxes, tragedies of depletion and collapse, all kept the world's food systems in a constant state of change. Yet, examined over the long duration, they had two remarkably persistent, widely shared characteristics, whether they were in medieval Sweden or ancient Sumer, in the Ohio River valley or the Valley of Mexico, whether the systems were based on maize or wheat or cassava. First, traditional agroecosystems were based on a predominately subsistence strategy in which most people raised what they themselves consumed, though now and then they may have sent some of their surplus off to cities for the sake of trade or tribute. Second, subsistence-oriented agroecosystems, despite making major changes in nature, nonetheless preserved much of its diversity and complexity, and that achievement was a source of social stability, generation following generation.

So it was, that is, until the modern era and the rise of the capitalist mode of production. Beginning in the fifteenth century and accelerating in the eighteenth and nineteenth centuries, the structure and dynamics of agroecosystems began to change radically. I believe the capitalist reorganization carried out in those years and beyond into our own time brought as sweeping and revolutionary a set of land-use changes as did the Neolithic revolution. Despite its importance, we have not yet fully understood why this second revolution occurred nor asked what its effect has been on the natural environment. I submit that the single most important task for scholars in the history of modern agroecology is to trace what Karl Polanyi has called "the great transformation," both in general planetary terms and in all its permutations from place to place.[19]

We do not yet have a thoroughly researched picture of just how and where ecological factors may have played a causative role in the great transformation. Since almost all studies of the rise of capitalism have been written by social and economic historians, those factors have not received much attention. Did the old medieval peasant life, we want to know, break down because it was degrading the environment? Was it falling hopelessly behind the pressing demands of population growth? Was it stretched to the point of collapse, until people were ready to heed the solutions offered by a new generation of rising capitalistic entrepreneurs? Or, quite the contrary, was the new capitalist mode of production forced on peasants who had been living in equilibrium with their environment and were reluctant to change? The questions are admittedly overly broad and need refinement, while the evidence

[18] One of the best descriptions of the mosaic in traditional agriculture can be found in Georges Bertrand, "Pour une histoire ecologique de la France rurale," in *Histoire de la France rurale*, ed. Georges Duby (3 vols., Paris, 1975), I, 96–102. See also E. Estyn Evans, "The Ecology of Peasant Life in Western Europe," in *Man's Role in Changing the Face of the Earth*, ed. Thomas, 217–39. The incredibly long-lived agricultural systems of East Asia, as they existed before the twentieth century forced decisive changes on them, are described in Franklin H. King, *Farmers of Forty Centuries* (Madison, 1911).

[19] Karl Polanyi, *The Great Transformation: The Political and Economic Origins of Our Time* (New York, 1944).

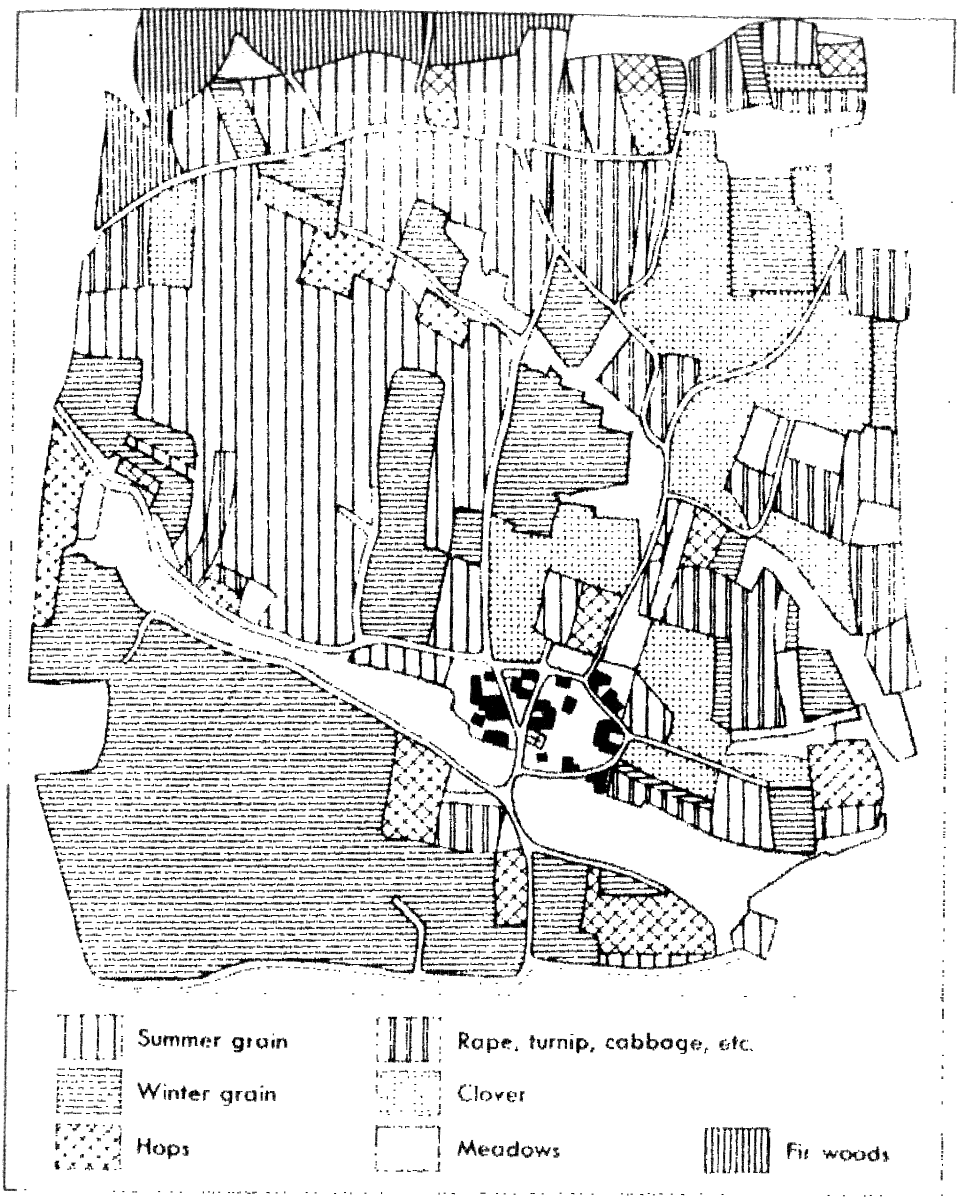
Rice and many other crops grow in an ecologically diverse farming patch in a planned agricultural community along the Transamazon Highway in Brazil. *Courtesy Emilio Moran.*

collected so far is too spotty to suggest which explanation is right. We may be in a position to ask better questions and form a coherent response when we have gained a clearer understanding of how the transformation is proceeding in Third World countries today, undermining traditional farming just as it was once undermined in England, France, and Germany.[20]

When I speak of the capitalist mode of production in agriculture I mean something broader than Marxists do when they use the phrase. For them, the crucial distinguishing feature of the new mode has been the restructuring of *human* relations: the buying of labor as a commodity in the marketplace and the organizing of it to produce more commodities for sale.[21] In my view, the buying of labor is too narrow a feature to cover so broad, multifaceted, and changing a mode as capitalism, even considered in merely human terms. It would leave out the slave-owning cotton planters of the American South, who bought people, not merely their labor; it would not include the agribusiness wheat farmers of the Great Plains, who have

[20] One of the few scholars to grapple with this transformation on the local level is Victor Skipp, *Crisis and Development: An Ecological Case Study of the Forest of Arden, 1570–1674* (Cambridge, Eng., 1978). For background to the period, see Phyllis Deane, *The First Industrial Revolution* (Cambridge, Eng., 1979), 20–52. On the transition to capitalism in the rural United States, see Steven Hahn and Jonathan Prude, eds., *The Countryside in the Age of Capitalist Transformation: Essays in the Social History of Rural America* (Chapel Hill, 1985). Unfortunately, this collection of essays includes no discussion of the ecological changes that accompanied, and may have contributed to, the social changes.

[21] A good recent discussion is Eric Wolf, *Europe and the People without History* (Berkeley, 1982), 73–100.



This schematic diagram of a peasant settlement, based on a small, closed hamlet in Lower Bavaria, shows diverse crops and intricate field patterns, including some open fields. Reproduced from William L. Thomas, Jr., ed., *Man's Role in Changing the Face of the Earth* (Chicago, 1956), 261. *Courtesy University of Chicago Press.*

seldom had access to hired hands and have invested in technology instead; and today it would have to omit from the realm of capitalism the California grower who has just bought a mechanical tomato harvester to replace all his migrant workers. In order to define capitalism more adequately, some have extended it to any organization of labor, technology, or technique for producing commodities for sale in the marketplace. If few agricultural producers have been capitalists in the strict Marxist sense, it is said, more and more of them have become "capitalistic" over the past four centuries, and nowhere more so than in the United States.

But this looser definition will not quite do either, for it is so imprecise that it could describe agriculture in ancient as well as modern times, in Africa, Central America, and Asia as well as Europe—wherever men and women have set up markets to trade their produce for goods and coin. Most important here, it does not incorporate the perspective of the environmental historian: it does not acknowledge that the capitalist era in production introduced a new, distinctive relation of people to the natural world. The *reorganization of nature*, not merely of society, is what we must uncover.

An adequate definition of the capitalist transformation of nature is a larger order than I can here undertake to fill, but a few preliminary thoughts may clarify what is meant. In the first place, a distinction must be made between markets and the market system or economy. The new order was not a matter of the existence of isolated markets here and there, but of an entire economy designed according to a simplified, idealized model of human behavior: the meeting of a buyer and a seller for the purpose of freely maximizing personal wealth. The most satisfactory definition of that market economy, one that captures its underlying moral essence, is Polanyi's:

> The transformation implies a change in the motive of action on the part of members of society: for the motive of subsistence that of gain must be substituted. All transactions are turned into money transactions, and these in turn require that a medium of exchange be introduced into articulation of industrial life. All incomes must derive from the sale of something or other, and whatever the actual source of a person's income, it must be regarded as resulting from sale. . . . But the most startling peculiarity of the system lies in the fact that, once it is established, it must be allowed to function without outside interference.

As Polanyi explains, capitalism was distinctive in that it was unabashedly based "on a motive only rarely acknowledged as valid in the history of human societies, and certainly never before raised to the level of a justification of action and behavior in everyday life, namely, gain."[22]

Capitalism introduced still another innovation, one that would change profoundly the way people related to nature in general: It created for the first time in history a general market in land. All the complex forces and interactions, beings and processes, that we term "nature" (sometimes even elevate to the honorific status

[22] Polanyi, *Great Transformation*, 30, 41.

of a capitalized "Nature") were compressed into the simplified abstraction, "land." Though not truly a commodity in the ordinary sense, that is, something produced by human labor for sale on the market, land became "commodified"; it came to be regarded as though it were a commodity and by that manner of thinking was made available to be traded without restraint. Whatever emotional meanings that land had held for the self and its identity, whatever moral regard it had engendered, now was suppressed so that the market economy could function freely. The environmental implications in such a mental change are beyond easy reckoning.[23]

What actually happened to the world of nature, once it had been reduced to the abstraction "land," is one of the most interesting historical problems presented by the capitalist transformation and will require a great deal more research by environmental historians. There are many possible lines for that research to take, but among the most promising is an inquiry into the restructuring of agroecosystems that capitalism promoted. First in England and then in every part of the planet, agroecosystems were rationally and systematically reshaped in order to intensify, not merely the production of food and fiber, but the accumulation of personal wealth.

Despite many variations in time and place, the capitalistic agroecosystem shows one clear tendency over the span of modern history: a movement toward the radical simplification of the natural ecological order in the number of species found in an area and the intricacy of their interconnections. As markets developed and transportation improved, farmers increasingly concentrated their energies on producing a smaller and smaller number of crops to sell for profit. They became, in short, specialists in production, even to the point of producing virtually nothing for their own direct personal consumption. But that is not all: the land itself evolved into a set of specialized instruments of production. What had once been a biological community of plants and animals so complex that scientists can hardly comprehend it, what had been changed by traditional agriculturists into a still highly diversified system for growing local foodstuffs and other materials, now increasingly became a rigidly contrived apparatus competing in widespread markets for economic success. In today's parlance we call this new kind of agroecosystem a *monoculture*, meaning a part of nature that has been reconstituted to the point that it yields a single species, which is growing on the land only because somewhere there is strong market demand for it. Although farmers in isolated rural neighborhoods may have continued to plant a broad, multispecies spectrum of crops, the trend over the past two hundred years or so has been toward the establishment of monocultures on every continent. As Adam Smith realized back in the eighteenth century, specialization is at the very heart of the capitalist mode of production. It should not be surprising then that it would eventually become the rule in agriculture and land use as it is in manufacturing.[24]

[23] For an insightful discussion of the new market in land, see William Cronon, *Changes in the Land: Indians, Colonists, and the Ecology of New England* (New York, 1983), 54–81.

[24] On monocultures, see Lech Ryszkowski, ed., *Ecological Effects of Intensive Agriculture* (Warsaw, 1974). This authority observes that Soviet bloc nations have followed the West in adopting monocultural farming, with many of the same environmental ill effects. See also Tim P. Bayliss-Smith, *The Ecology of Agricultural Systems* (Cam-

Combines at work in Washington wheat fields, c. 1900, an example of American monocultural farming techniques. *Courtesy Washington State Historical Society.*

In Smith's day, however, the trend in the new agriculture toward a massive loss of ecological complexity was not easy to foresee. On the contrary, it was obscured for a long while by the discovery and colonization of the Americas by the European nations, which suddenly made available to farmers a dazzling array of new plant species to try out in their fields: maize, potatoes, tobacco, to name some of the more valuable among them. On both sides of the Atlantic, agroecosystems might now contain more kinds of plants than ever before. That outcome was part of a more general process of global biological exchange, migration, and mixing that occurred with the great discoveries and the subsequent migration of Europeans all over the globe, reversing, as Alfred Crosby has written, the effects of continental drift and geographical isolation that had obtained for millions of years.[25] Thomas Jefferson's enthusiasm for introducing mulberry trees and silkworm cultivation from China into Virginia was only one example of what seemed, in the early days of modern farming, to be the possibility of a new plentitude in production. There was more variety in the modern agricultural market economy, considered as a whole, than in each of the scattered traditional economies of the past—a broader base for consumers than even the Philippine farmer enjoyed with his dozens of varieties growing in the forest clearings. Ironically, however, the individual producer had less biotic complexity to deal with on a given acre than before; his fenced and deeded lands became, in ecological terms, depauperate environments.

Another reason for the long obscurity in capitalistic agriculture's trend toward radical simplification was the near-simultaneous rise of modern science, both practical and theoretical, and its application to the problems of agriculture. The "agricultural revolution" that began in England during the eighteenth century was a double-sided phenomenon: one half of it was capitalistic, the other scientific, and the two halves have never been altogether compatible. In the early years of their relationship, scientifically inclined reformers taught traditional English farmers, faced with declining soil fertility and low output, to rotate their fields between arable and grass to improve livestock husbandry and augment their manure supplies, and to cultivate root crops such as turnips to feed their cattle and legumes such as clover to add nitrogen to the soil.[26] Today those innovations would be viewed as sound ecological practices—real improvements over archaic methods. Unquestionably, they also improved productivity and added to England's economic growth. For a while, they held considerable appeal for profit-seeking entrepreneurs, who preached the

bridge, 1982), 83–97, which deals with a Russian collective farm. Since Marxists accede to the view that capitalism achieves the final technological domination of nature and argue that communism is simply a rearrangement of the ownership of the technology, it is hardly surprising that they have not represented any real alternative from an ecological standpoint. On specialization in the pinmaker's trade as a model of capitalist development, as perceived in 1776, see Adam Smith, *An Inquiry into the Nature and Causes of the Wealth of Nations* (New York, 1937), 4–5.

[25] Alfred Crosby, Jr., "The British Empire as a Product of Continental Drift," in *Environmental History: Critical Issues in Comparative Perspective*, ed. Kendall E. Bailes (Lanham, 1985), 553–76.

[26] Sources for this discussion include J. D. Chambers and G. E. Mingay, *The Agricultural Revolution, 1750–1880* (New York, 1966), 54–76; Eric Kerridge, *The Agricultural Revolution* (London, 1967), 181–348; G. E. Fussell, "Science and Practice in Eighteenth-Century British Agriculture," *Agricultural History*, 43 (Jan. 1969), 7–18; and D. B. Grigg, *The Agricultural Systems of the World: An Evolutionary Approach* (London, 1974), 152–86.

gospel of turnips and clover across the English countryside. But in later periods most farmers in England and North America drifted away from those reforms, for example, replacing nitrogen-building root crops with chemical fertilizers. A biology-inspired system of farming, based on careful field rotations and striving for a better balance between plants and animals, failed to establish a secure, lasting, dependable hold on the imagination of capitalist landowners. The reason was that, over the long run, such farming too often interfered with the more compelling system of the market economy. There have been, in other words, two kinds of logic in modern agriculture—that of the scientist and that of the capitalist—and they have not agreed much of the time.[27]

My own research into the restructuring of ecosystems by capitalistic farming has dealt mainly with the raising of wheat on the western plains of North America in the twentieth century. Like any single case, it can afford only a partial understanding of ecological tendencies in the capitalist mode; but wheat provides much of the world's basic nutrition, and patterns of growing and consuming it may be taken as symptomatic of the whole modern mode of food and fiber production. The history of the Great Plains region followed a familiar line of development: It began with a rapid and drastic destruction of ecological complexity and the substitution of a single marketable species (indeed, a single variety of that single species in many instances) over a wide acreage. In their preagricultural state the Plains, though seeming bare and monotonous to many travelers, were in reality a highly diversified environment, containing hundreds of grasses, forbs, and sedges, some of them annuals, some perennials, together with large and small herbivores, and further up the trophic ladder, populations of carnivores and decomposers, which consume the herbivores and return their matter to the soil. From Texas northward into Canada that ecosystem, or more accurately, that series of ecosystems, gave way to wheat and a scattering of other crops. Not everything of the older order disappeared, but a large portion of it did, and some of it may have disappeared forever.[28]

The process of rigorous environmental simplification began among the sodbusters who first appeared on the Plains in the 1870s, looking for a crop they could raise and ship back east on the railroads. The process took a great leap forward during World War I when markets in wheat boomed, and it continued into the late 1920s. Most striking was the fact that livestock—the principal remaining fauna in most agroecosystems—were from the outset a minor, and diminishing, part of the Plains farmstead. Cattle, pigs, sheep, and chickens were seldom found in more than token numbers on those farms or soon disappeared if they were. They were a distrac-

[27] I do not deny that science has become, in many places and ways, a handmaiden of modern market agriculture; see, for example, the criticisms of two scientists: Richard Levins and Richard Lewontin, *The Dialectical Biologist* (Cambridge, Mass., 1985).

[28] Donald Worster, *Dust Bowl: The Southern Plains in the 1930s* (New York, 1979). The literature on the ecology and human settlement of the Great Plains is voluminous. Good introductions include Walter Prescott Webb, *The Great Plains* (Boston, 1931); James C. Malin, *The Grassland of North America: Prolegomena to Its History* (Lawrence, 1947); and Brian W. Blouet and Frederick C. Luebke, eds., *The Great Plains: Environment and Culture* (Lincoln, 1979). About the adjoining corn belt, which has much in common with the Plains, see Allan N. Auclair, "Ecological Factors in the Development of Intensive Management Ecosystems in the Midwestern United States," *Ecology*, 57 (Late Spring 1976), 431–44.

tion from the main business of raising grain. Of course, they did show up in other places, including livestock ranches in the region, but in spectacularly large numbers, in gatherings of thousands of animals, all one species again. The most important result of that severing of agroecosystems by the sharp knife of economic specialization was to make the maintenance of soil fertility and stability harder. Plains and prairie topsoils are deep—one to two feet on average—and they could grow a lot of crops before productivity began to decline. Eventually, though, the farmer must put back in what he took out; if there were no bison or cattle or prairie dogs to do that for him, he must buy some other sort of fertilizer on the national or world market; in effect, he must buy fossil fuels, for modern synthetic fertilizer is made from natural gas.[29] When the Plains farmer was forced to do that, he came to depend on an often remote, impersonal network of credit suppliers, manufacturers, and trading corporations, and he could only hope that what he could buy from them would be as good for the soil as the bison's great splats of dung had been.

The vulnerabilities inherent in modern monoculture now have a long history to be studied and understood. They include an unprecedented degree of susceptibility to disease, predation, and pest population explosions; a heightened overall instability in the system; a constant tendency of the human manager to take risks for short-term profit, including mining the soil (and in the American West mining a limited underground water resource); an increasing reliance on technological substitutes for natural plant and animal services; a reliance on chemical inputs that have often been highly toxic to humans and other organisms; a dependence on imports from distant regions to keep the local system functioning; and finally, a demand for capital and expertise that fewer and fewer individual farmers could meet.[30] This last characteristic is one of the earliest to show up and has been widely studied in rural history, though seldom from an ecological point of view. Farming communities reflect the biological systems they rest on. A society cannot radically diminish the diversity of natural ecosystems for the sake of maximum crop production, nor keep the land regimented for profit, nor augment the flow of energy through the system by introducing fossil fuels without changing the rhythms and diversity and structure of power within its various communities. An ecological approach helps explain why capitalistic agriculture has had its peculiar social effects as well as its managerial problems.

I have not yet mentioned what turned out to be the most serious vulnerability of all in Great Plains farming: its susceptibility to wind erosion and dust storms of the kind that wracked the region in the 1930s, storms that followed hard on the

[29] John S. Steinhart and Carol E. Steinhart, "Energy Use in the U.S. Food System," *Science*, April 19, 1974, pp. 307–16; William Lockeretz, ed., *Agriculture and Energy* (New York, 1977); David Pimentel, "Energy Flow in Agroecosystems," in *Agricultural Ecosystems*, ed. Lowrance, Stinner, and House, 121–32.

[30] David Pimentel et al., "Land Degradation: Effects on Food and Energy Resources," *Science*, Oct. 8, 1976, pp. 149–55. These authors argue that due to intensive, continuous cultivation, annual sediment loss via surface runoff increased from about 3 billion tons nationally in the 1930s to 4 billion tons in recent years. Other scientific critiques of modern agriculture appear in Miguel A. Altieri, Deborah K. Letourneau, and James R. Davis, "Developing Sustainable Agroecosystems," *Bioscience*, 33 (Jan. 1983), 45–49; and Stephen R. Gliessman, "An Agroecological Approach to Sustainable Agriculture," in *Meeting the Expectations of the Land: Essays in Sustainable Agriculture and Stewardship*, ed. Wes Jackson, Wendell Berry, and Bruce Colman (San Francisco, 1984), 160–71.

extension of wheat farming into high-risk areas in the preceding decades. The dirty thirties were an unmitigated ecological disaster for the Plains; in fact they were one of the worst environmental catastrophes in recorded human experience. In part, of course, the disaster was due to drought, the most severe drought in some two hundred years of the region's climate. But it was also the result of the radically simplified agroecosystem the Plains farmers had tried to create. What they demonstrated in the 1930s was that reducing the land to the single species of wheat did not provide an adequate buffer between themselves and drought. Wheat was a splendid species for making money, but taken alone, planted on immense expanses of plowed acres from which so many other, better-adapted forms of life had been eliminated, it proved to be a poor defense when the rains failed.[31] And therein lies one of the most important lessons we can find in the history of the new mode of production: it had the capability of making the earth yield beans or corn or wheat in quantities never before seen, and of creating more wealth and better nutrition for more people than any traditional agroecosystem could boast. But the other side of that impressive success was (and is) a tendency to bet high against nature, to raise the stakes constantly in a feverish effort to keep from folding—and sometimes to lose the bet and lose big.

Neither ecology nor history, nor the two working together, can reveal unequivocally whether modern capitalistic land use has been a success or a failure; the question is too large for an easy answer and the criteria for judgment too numerous. But they can make the point that scholars ought to begin to address the issue and also that the conventional answers, which have generally been laudatory and narrowly focused on economic or technological efficiency, need to be supplemented by an ecological perspective. From that vantage the historical interpretation of the past few centuries is likely to be a darker, less complacent one than we have known.

This blooming, buzzing, howling world of nature that surrounds us has always been a force in human life. It is so today, despite all our efforts to free ourselves from that dependency, and despite our frequent unwillingness to acknowledge our dependency until it is too late and a crisis is upon us. Environmental history aims to bring back into our awareness that significance of nature and, with the aid of modern science, to discover some fresh truths about ourselves and our past. We need that understanding in a great many places: for instance, in little Haiti, which has been undergoing a long, tragic spiral into poverty, disease, and land degradation, and in the rain forests of Borneo as they have passed from traditional tribal to modern corporate ownership and management. In both of those cases, the fortunes of people and land have been as inseparably connected as they have been on the Great Plains, and in both the world market economy has created or intensified an ecological problem. Whatever terrain the environmental historian chooses to investigate, he has to address the age-old predicament of how humankind can feed itself without degrading the primal source of life. Today as ever, that problem is the fundamental challenge in human ecology, and meeting it will require knowing the earth well—knowing its history and knowing its limits.

[31] See Paul Sears, *Deserts on the March* (Norman, 1980), 170–86.