Research in Philosophy and Technology **18(1999): 143-164.**

A MANAGED EARTH AMD THE END OF NATURE?

Holmes Rolston, III

Two keywords have become inseparably linked in the last decade: "development" and "environment." The four principal issues now facing humankind are war and peace, population, development, and environment; all four are so entwined that none is likely to be solved without solutions to the others as well. The United Nations Conference on Environment and Development fused its themes with their "sustainable development." Solutions will require help from all quarters: politicians, economists, lawyers, technicians, agriculturalists, planners, and environmentalists.

Philosophers come into the picture often as applied ethicists, importantly so. Soon, however, we further find that we get plunged into theoretical issues. The debate whether environmental ethics needs a foundation in intrinsic value in nature is an example. A related question asks whether and how far humans, in their development, can or ought to wish the *management* and/or the *end* of nature. To answer, one needs a metaphysics of nature and of human nature. Lest this be thought "too theoretical," or "just philosophical," notice how the non-philosophers involved (those economists, technicians, planners, and so on) are, more often than not, less than clear—not to say confused—about what they believe,

Research in Philosophy and Technology, Volume 18, pages 143-164.

ISBN: 0-7623-0439-1

desire, or ought to do about managing and ending nature. "Act now, think later," is doubtful advice when what one values is unsettled.

The end of nature, on the one hand, is lamented notably by Bill McKibben (1989). He worries that already "we live in a postnatural world," in "a world that is of our own making." "There's no such thing as nature anymore." "Changing nature means changing everything," and this "seems infinitely sad." "We live at the end of nature, the moment when the essential character of the world ... is suddenly changing" (pp. 60, 85, 89,78-79, and 175).

Emmanuel G. Mesthene (1967), however, speaking as director of a Harvard Program on Technology and Society, is glad, not sad. Because of our power and our conscious management, "our age is different from all previous ages. ...We are therefore the first age that can aspire to be free of the tyranny of physical nature that has plagued man since his beginnings." "Nature is coming increasingly under control as a result of restored human confidence and power" (pp. 482 and 491-492).

Before we can address what ought to be the case, we need an estimate of what is the case, both about technology and about nature. What kind of power do we have (and have in prospect), and what kind of nature do we have around (present, continuing from the past)?

THE PLANETARY MANAGERS

Editing a *Scientific American* issue on "Managing Planet Earth," William Clark (1989) writes that humans are moving toward consciously managing the Earth. Here "two central questions must be addressed? What kind of planet do we want? What kind of planet can we get?" (p. 48). Earth is now in a post-evolutionary phase. Culture is the principal determinant of Earth's future, more now than nature; we are passing into a century when this will be increasingly obvious. Indeed, some say, that will be the principal novelty of the new millennium; Earth will be a managed planet. This is possible because of our increasingly powerful technology. J. Barnet and C. Morse (1963) see no limit, in principle, to these managerial powers:

> Advances in fundamental science have made it possible to take advantage of the uniformity of energy matter—a uniformity that makes it feasible, without preassignable limit, to escape the quantitative constraints imposed by the character of the earth's crust. A limit may exist, but it can be neither defined nor specified in economic terms. Flexibility, not rigidity, characterizes the relationship of modern man to the physical universe in which he lives. Nature imposes particular scarcities, not an inescapable general scarcity. Man is therefore able, and free, to choose among an indefinitely large number of alternatives (p. 11).

The rapid development of contemporary technology opens the possibility that, in the next millennium, nature will be less and less constitutional, as it is more and more modified, in an increasingly technologically sophisticated world. Nature will

become not so much redundant as increasingly plastic. The technicians can get houses out of trees, clothing out of crude oil, a turkey with more white meat by gene-splicing. They can make this molecule out of that molecule, even this atom out of that one, whatever *x* out of whatever *y*. Human life will depend less and less on working with natural kinds (feldspar, turkeys, cellulose, or carbon) and more and more on artifacted kinds (vinyl, transgenic turkeys, fiberglass, or Teflon). How far might this go? Engineers are hard at work on artificial photosynthesis (Lewis 1995). Biochemists have already made artificial blood, where the hydrogen atoms are replaced by fluorine atoms (Hart 1991, pp. 189-190). Such blood is being tested in medical treatments because it is resistant to leukemia and to certain toxins. So we have in prospect people with artificial blood eating artificial food.

At the one extreme in range is microtechnology, already realized in computing and genetics, with nanotechnology in prospect (Drexler 1992). We can design our children, or make trans-uranic elements. At the other extreme is planetary engineering, for example, in weather manipulation. The U.S. Federal Weather Modification Advisory Board, established under the National Weather Modification Act of 1976, has reported that, with proper funding, the United States could, within 20 years, control rainfall in the Midwest, the amount of snow in the Rockies, the velocity of hurricanes on the Plains, and make the science and practice of weather modification a reality all over the nation (1978).

Henri Bergson (1911), writing early in this century, was prophetic. With the coming of the industrial age, when science joined with technology, we crossed the threshold of a new epoch:

> In thousands of years, when, seen from the distance, only the broad outlines of the present age will still be visible, our wars and our revolutions will count for little, even supposing they are remembered at all; but the steam-engine, and the procession of inventions of every kind that accompanied it, will perhaps be spoken of as we speak of the bronze or of the chipped stone of pre-historic time: it will serve to define an age (pp. 138-139).

The transition from muscle and blood, whether of humans or of horses, to engines and gears shift by many orders of magnitude the capacity of humans to transform their world. Even more recently, the capacity to produce has been augmented by the capacity for information transfer. Consider the transition from handwriting to printing, from communication by written mail to electronic communication, from information processing in books to information processing by computers. All this has occurred in a few hundred years, much of it in decades we ourselves recall.

In the course of human history, there have been epochal changes of state, such as the transition from hunter/gatherer cultures to agriculture, from oral to written cultures, the discovery of fire, the discovery of iron. In our epoch we have seen the coupling of science and technology. The next century will indeed launch a new millennium. The industrial age. The technological age. The postmodern world? The post-natural world?

Nature will be increasingly humanized. Activities on the planet will center on humans. "Dominate" remains a somewhat disliked word, since it has echoes of the abuse of power. But "manage" is still quite a positive term. Humans have, now and increasingly, the power to impose their will on nature, remaking it to their preferences. With so much human power already on hand, one does need to ask whether nature is already at an end.

NATURE AT AN END?

All culturally intended activity modifies spontaneous wild nature. The essence of culture is the deliberate rebuilding of nature. "Man is by nature a political animal," said Aristotle.[1] The human *genus* may be animal, but the human *differentia* or essence is to build a *polis,* a town. The human habitat is village, town, city, which is another way of saying that human life is political, social, or, as we have been saying, cultural. In agriculture the plowed field is symbolic—an artifact remade from nature. In that sense, culture is neither logically nor empirically possible without the alteration of nature. Ancient cultures, not less than modem ones, remade the landscapes they used for their villages, fields, and flocks.

The question is one of degree. Certainly, nature now bears the marks of human influence more widely than ever before. In one survey, using three categories, researchers find the proportions of Earth's terrestrial surface altered as follows:

1. Little disturbed by humans, 51.9%.
2. Partially disturbed, 24.2%.
3. Human dominated, 23.9%.

Factoring out the ice, rock, and barren land, which support little human or other life, the percentages become:

1. Little disturbed, 27.0%.
2. Partially disturbed, 36.7%.
3. Human dominated, 36.3%

(Hannah, Lohse, Hutchinson, Carr, and Lankerani 1994).

Most terrestrial nature is dominated or partially disturbed (73.0%). Still, nature that is little or only partially disturbed remains 63.7 percent of the habitable Earth. Also, of course, there is the sea, less affected than the land; and the oceans cover most of the Earth.

In another study researchers found that humans now control 40 percent of the planet's land-based primary net productivity, that is, the basic plant growth which captures the energy on which everything else depends (Vitousek, Ehrlich, Ehrlich, and Matson 1986). That is worrisome, but it does leave 60 percent still in the spontaneously wild. Possibly, with ever-increasing

transformation of nature, whatever residual nature remains may cease to be of interest or significance for what it is in itself, with value attached more and more to the artifacted characteristics now superimposed on what was once wild nature. There will typically be degrees of modification, of artifact, intermixed with degrees of the natural: the relatively natural, the relatively cultured—or agricultured—or manufactured.

Nature is mixed with human "labor" or "industry." A revealing word here is "resource." Where there is a natural "source" that has been or can be "re-directed" into channels of human interest and preference, nature is redone, "re-sourced," made over into an artifact that we can use. To use a more philosophical word, nature is "transformed," its form is transmuted into a more desirable humanized form. To use a scientific-engineering word, human values are "synthetic." Of course, some second-order cultural effects on nature are not intended. Escaped and spreading exotics like loosestrife and knapweed are accidental byproducts. But the first-order effects are intended. If nature means absolutely pristine nature, totally unaffected by human activities, past or present, there is relatively little remaining on Earth—if our detection instruments are keen enough. In another of those unintended effects, there is DDT in penguins in Antarctica. When the astronauts walked on the moon, they encountered absolutely pristine nature. Still, nature on Earth can be relatively pristine, as it is in Antarctica, despite the DDT in the penguins.

Sometimes one encounters the objection that the slightest human intervention has a sort of totalizing effect, and brings straightway the end of nature. This is like saying that the whole moon is pristine no more because the astronauts took a few steps on it, or that the sky is not natural because some jet planes have flown through it. It is true that certain human actions do have unintended consequences that spread everywhere; there are contagious effects that eventually interrupt everything, that seep into the nooks and crannies of all nature. This might be true of global warming, or perhaps of toxic chemicals that are nonbiodegradable and have cumulative effects, or maybe even of exotic weeds.

Most human activities, however, do not have such far-reaching effects. The world is too pluralist for that. Not everything is that tightly bound up to everything else. Is it the case, for instance, that, owing to human disturbances in the Yellowstone Park ecosystem, we have lost any possibility of letting the park be natural? In an absolute sense this is true, since there is no square foot of the park in which humans have not disturbed the predation pressures. There is no square foot of the park on which rain falls without detectable pollutants. But it does not follow that nature has absolutely ended, because it is not absolutely present. Answers come in degrees. Events in Yellowstone can remain 99.44 percent natural on many a square foot, indeed on hundreds of square miles, in the sense (recalling the language of the *Wilderness Act)* that they are substantially "untrammeled by man." We can put the wolves back and clean up the air, and we have recently done both.

Where the system was once disturbed by humans and subsequently restored or left to recover on its own, wildness can return.

This presumes that Yellowstone was wild before the Europeans arrived. But that, it may be protested, underestimates how much native Americans had already transformed the American landscape. How much they did so is an empirical question. In part, this is an ecological question whether ecosystems were thrown out of balance. And, in part, this is an anthropological question concerning the practices of the pre-Columbian peoples. Native American cultures altered the locales in which they resided, more so in Central America, less so in portions of North America, variously in South America. Did the Native Americans transform the pre-human landscapes (of 15,000 B.C.E., or whenever they arrived) on regional scales beyond the range of its spontaneous self-restoration? If so, Yellowstone is not wild, and has not been since the Pleistocene period.

Most of what we think of today in the United States as pristine nature, and have designated perhaps as wilderness areas or parks, was infrequently used by the aborigines, since such areas are often high, cold, arid, difficult to traverse on foot. In places such as Yellowstone, the native Americans were (again recalling the language of the *Wilderness Act)* "visitors who did not remain"—for the same reasons that the whites after them left those regions sparsely settled. We have little reason to think that in such areas the aboriginal modifications were irreversible. Just what did these Native Americans do to manage the Grand Canyon, or Mount Rainier? Or for that matter Yellowstone or the Great Smokies? Or regional wetlands such as the Everglades?

What about the more temperate regimes? Unlike the Europeans, Native Americans had no machinery; they had no iron, even for axes or plows. They had no horses (prior to the Spanish), nor cattle, nor wagons, nor wheels. There was limited agriculture in the North American Southwest, under the necessity of irrigation (Donkin 1979). One does not greatly alter semi-arid ecosystems on regional scales by terracing here and there with primitive implements. The most common crop was maize, which does not persist wild, but disappears as soon as humans cease to plant it.[2]

There was virtually no agriculture otherwise in the western United States, which includes the Great Plains, the Rocky Mountains, the Pacific Northwest, California, the interior deserts (see maps in Denevan 1992, p. 380; Donkin 1979, p. 23). On forested areas or grasslands, what agriculture there was tended to resent succession; and, when agriculture ceased, the subsequent regeneration was not particularly unnatural. Otherwise, they were hunters and gatherers whose activities were without irreversible adverse effects.

The Native American technologies for larger landscape modification were bow and arrow, spear, and fire. The only one of these that extensively modifies landscapes is fire.[3] Fire is—we have by now learned—also quite natural; Forests in the Americas have been fire-adapted for at least 13 million years, since the Miocene Epoch of the Tertiary Period, as evidenced by fossil charcoal deposits.

The fire process involves fuel build-up over decades, ignition, and subsequent burning for days or weeks; any or all of the three may be natural or unnatural. Fire suppression is unnatural, and can result in fuel build-up and catastrophic fires, but no one argues that the Native Americans used that as a management tool, nor did they have much capacity for suppression.

The argument is that they deliberately set fires (Pyne 1982, chap 2). Does this make their fires radically different from natural fires? It does in terms of the source of ignition; the one is a result of environmental policy deliberation, the other of a lightning bolt. But students of fire behavior realize that in dealing with forest ecosystems on regional scales the source of ignition is not a critical factor. Once the fire has burned a hundred square yards, the vegetation cannot tell what the source of ignition was. The question is whether the forest is ready to burn, whether there is sufficient ground fuel to sustain the fire, whether the trees are diseased, how much duff there is, and so on. If conditions are not right, it will be difficult to get a big fire going; it will soon burn out. If conditions are right, a human can start a regional fire this year. If not, lightning will start it next year, or the year after that. Natural ignition sources are available on an order of magnitude (a few years) that greatly exceeds the order of magnitude of fuel build-up for burning (several decades).[4]

In short, though the Native Americans lived on the landscape, the land was relatively untrammeled by them. Even the lands that they more actively managed were not managed outside their resilient capacity to return to natural landscapes, once the native American interventions were removed. It is difficult to cite, for example, a designated U.S. wilderness where the ecological processes today are substantially different from what they would have been had there never been any Native Americans living on this landscape.

ENDING BY TRANSFORMING

Not even the Europeans, much less the indigenous peoples, have brought nature to an end, not yet at least. But we do have to face that possibility in the future. Daniel Botkin (1990) quite agrees: "Nature in the twenty-first century will be a nature that we make." "We have the power to mold nature into what we want it to be." Of course he, like everybody else, urges us "to manage nature wisely and prudently," and, to that end, ecology can "instrument the cockpit of the biosphere," That sounds like high-tech engineering which brings wild nature under our control, remolding it into an airplane that we fly where we please. So it first seems, although Botkin—the ecologist in him returning—does go on to warn that it is important to recognize that "the guide to action is our knowledge of living systems and our willingness to observe them for what they are" and "to recognize the limits of our actions"(pp. 190-193 and 200-201).

"We can outdo evolution." So claims David Baltimore, a microbiologist at the Massachusetts Institute of Technology and a 1975 Nobel laureate, speaking of biotech genetics (Rogers 1977, p. 52). Edward Yoxen (1983) agrees:

> This is not just a change of technique, it is a new way of seeing. ...The limitations of species can be transcended by splicing organisms, combining functions, dovetailing abilities and linking together chains of properties. The living world can now be viewed as a vast organic Lego kit inviting combination, hybridisation and continual rebuilding. Life is manipulability. ...Thus our image of nature is coming more and more to emphasise human intervention through a process of design (pp. 2 and 15).

The technicians can transfer genetic material between plants and animals, or between diverse animal lines, or between animals and humans. Or make clones of species that naturally reproduce only sexually, or send genetic information on fiberoptic transmission lines, or make new amino acids, beyond the 20 naturally occurring ones, and incorporate them into proteins.

Perhaps evolution has been overtaken by human engineering, but is it not true that humans will always need an ecology? We have not gotten past the need for a life support system. Nevertheless, humans do not any longer have anything like an ecological relationship to any local ecosystem in which they have an evolved niche. We eat bananas from Central America; the average bite of food eaten in the United States has traveled 1,200 miles. Even the food we eat from closer to home has been grown in radically transformed ecosystems. We can re-engineer our ecosystems. Michael Soulé (1989) faces this prospect:

> In 2100, entire biotas will have been assembled from (1) remnant and reintroduced natives, (2) partly or completely engineered species, and (3) introduced (exotic) species. The term *natural* will disappear from our working vocabulary. The term is already meaningless in most parts of the world because anthropogenic [activities] have been changing the physical and biological environment for centuries, if not millennia (p. 301).

Humans have always had to rest their cultures upon a natural life support system. Their technosphere was constructed inside the biosphere. But in the future that could change: the technosphere could supersede the biosphere. The focus of science would no longer be the laws of nature and how we can use them. Classical science has been grouped into the natural and the social sciences, depending on the object of study, nature or culture. Interestingly, today we have a new domain of science: the sciences of the artificial. Computer science, for example, is a science of artifacts. Other scientists study Teflon, or the trans-uranic, superheavy elements (like plutonium), or the engineered biotas that Soulé envisions. These sciences do not, of course, violate any laws of nature, neither those of physics or chemistry; thermodynamics and gravity still reign. But they do bring into play forces hitherto unknown in nature; their constructions are not natural kinds, but artifacts. The processes that govern such artifacts are not those of wild nature, but those that scientists have elected to create. Scientists will sometimes need new

laws which did not operate and were only potentially there in old nature. Or, if you prefer, they were always there, but there were no empirical instantiations of such laws; they were empty sets.

So it does seem possible to end nature by transforming it into something humanized. This has already been taking place, and the future promises more, at an escalating pace. Over great stretches of Earth, wild nature has been already or likely will be diminished in favor of civilization. In some sense, that ought to be so. This ending may be always, in its own way, a sad thing; but it is an inevitable thing, and the culture that replaces nature can have compensating values. It would be sadder still, if culture had never appeared to grace the Earth, or if cultures had remained so modest that they had never substantially modified the landscape. We do not always lament our presence, even though we do want some lands where humans only visit. Humans too belong on the planet, and the epoch of evolutionary nature, and even of ecological nature, is over. That is what is right about the view that with the arrival of humans pristine nature vanishes. Nature does not vanish equally and everywhere, but there has been loosed on the planet such a power that wild nature will never again be the dominant determinant of what takes place on the inhabited landscapes.

ENDING BY BLENDING

Evolutionary natural history might be over, and ecosystems might be managed, but—it will be objected—-it does not follow that nature is ended. Rather, we need a gestalt change from the dualistic one that contrasts nature and culture to a new one in which culture is part of nature. That is really what ecology tries to do: envision humans as a part of nature and not apart from nature. When we look at it this way, nature is not ended, because everything that humans do is quite natural. There never has been, and never can be, any ending of nature.

We have to draw this conclusion, do we not, from Baird Callicott's (1992) exclamation: "La Nature est morte, vive la nature!" (pp, 16-23). That's a provocative aphorism. Something is dead, yet lives. We understand how the aphorism works in the original context. An elderly French king dies and, at once, his son succeeds him on the throne. The office of king passes from one generation to the next. The aphorism depends on continuity of kind over changing individuals. After a double-leveled analysis of identity—king-office identity versus king-person identity—the aphorism makes good sense. There is a double connotation and denotation of "king": person and office. The latter continues; the former does not.

The aphorism, applied to "nature," will make sense only if there is some comparable identity analysis. There is no nature-person who dies, succeeded by any offspring, in whom some nature-office continues with unbroken identity. But what about the nature-idea? Rather than there being some important continuing

identity, it seems that one nature idea is abandoned and a new one supplants it. In so doing, the identity of nature is radically transformed. Callicott puts it this way:

> Nature as Other is over. ...We are witnessing the shift to a new idea, in which nature is seen as an organic system that includes human beings as one of its components. ... A new dynamic and systemic postmodern concept of nature, which includes rather than excludes human beings, is presently taking shape. From the point of view of this new notion of nature, human technologies should be evaluated on their ecological merits (p. 16).

Spontaneous wild nature dies, and what lives on is not such nature *redivivus*, but a transformed, managed nature, a civilized nature, one also, hopefully, with ecological merits. The aphorism can be true only if we slip from "nature" as connoting and denoting wild spontaneous nature to "nature" as connoting and denoting some humans and their human-managed system. With the changing connotation comes a changed denotation: not wild but humanized nature.

Look at the results of this, with regard to Chicago, with its humans and their culture. Metaphysically speaking, all this is quite natural, both the persons and their effects, even though some of these effects are undesirable. Callicott continues: "We are animals ourselves, large omnivorous primates, very precocious to be sure, but just big monkeys, nevertheless. We are therefore a part of nature, not set apart from it. Chicago is no less a phenomenon of nature than is the Great Barrier Reef (p. 17). And Lake Michigan polluted with the effluents of Chicago (by some precocious monkeys) is as natural as the Great Barrier Reef too. Lake Michigan restored (by some conservationist monkeys) is natural too; anything that humans do is natural, no matter whether it is better or worse.

Pretty obviously, nature cannot be ended, if "nature" is given such a replacement meaning. Also pretty obviously, we are not going to get any guidance about whether we humans can or ought to end nature. The products of Chicago industries, such as Pampers and styrofoam cups, are natural just as much as coral reefs with their polyps and giant clams. Corporate executives deciding to break the standards of the Clean Water Act and pollute Lake Michigan, though they are doing something unwise, are behaving in accord with nature as much as those deciding to meet or exceed the standards, so as to preserve the integrity of the waters. CEO decisions are as natural as clams feeding underwater off Australia. Whatever pollutants these precocious monkeys discharge into Lake Michigan are as natural as any fishes already there. Pretty obviously, we can't address the question whether nature can and ought to end by our transforming it, if we have revised the meaning of "nature" so as to blend it with "culture," no matter how technologically advanced.

Instead of trying to claim that any culturally reconstructed environment, better or worse, is still wholly natural, why not speak, as we ordinarily do, with a contrast of the natural and the cultural? Here some environments are urban, and not natural. Some rural environments can remain more or less natural (portions of the Adirondacks of New York), although some agricultural environments (the wheat

fields of eastern Washington where every square inch of nature has been replaced with hybrid wheat), are neither natural nor even rural environments, owing to the drastic intervention and management. The more drastic the intervention and management, the more nature has ended. The question we need to address is how much nature has ended, not whether we can frame an answer in which every human action can be construed as natural.

Taking another tack with the same idea, blending humans and nature, David Rothenberg (1992) is unable to find any wilderness. We might first think that, like Bill McKibben, he would be sad about that. To the contrary, though (or perhaps because!) he is a deep ecologist; he is glad that wild nature is ending. It was a bad idea:

> The philosopher of ecology can only implore you to try to conceive of your self and your purpose not in opposition to an environment ... but through the surrounding world which may support us forever. .. It is the idea of nature independent of humanity which is fading, which needs to be replaced by a nature that includes us. ... There is no such thing as a pure, wild nature, empty of human conception. ... Wilderness is a consequence only of a civilization that sees itself as detached from nature. ... This is a romantic, exclusive and only-human concept of a nature pure and untrammeled by human presence. It is *this* idea of nature which is reaching the end of its useful life (pp. 1-3).

Deep ecologists, it seems, can identify with wild nature. That may be well and good up to a point, but Rothenberg has overdone this blending. It does not follow that, in wilderness areas, the idea of nature independent of humanity is fading. In the conservation of wilderness, for example, we do not want nature there too to include humans; sometimes we wish, as nearly as possible, to let wild nature be. Surely Rothenberg and Callicott believe that there was, long ago, such a thing as pure, wild nature, empty of human conception. Such a nature was on the planet for millennia before humans evolved. Why not realize that it yet remains, more or less, in wilderness areas yet today. Wilderness is not a consequence of our dualistic European civilization; there was wilderness before there was civilization at all.

It is true, of course, that there was no wilderness movement, a twentieth-century social and political effort to save wild nature, until some humans got the idea that saving some pristine nature (as nearly as possible) was a good thing. They wanted to designate some wilderness before it was all ended. But wilderness is and was there before and without people; the idea of preserving some of that spontaneous nature has not at all reached the end of its useful life. The death of that idea, as McKibben laments, would be sad indeed.

Rothenberg was hoping to say, I suppose, that humans belong on the planet, and that we have an entwined destiny with planetary nature, and ought to build our cultures in some harmony with nature on our local landscapes. But he confuses belonging *somewhere* on the planet with belonging *everywhere* on it. Rather than welcoming the end of nature, I prefer to argue that, though there is much nature still at work on Earth, both wild and rural, the end of nature is a serious threat. If,

for instance, global warming proves to introduce climatic changes so dramatic that natural environments cannot track these changes, nature will be further ended. Again, this is not absolute, for some natural processes will remain, but the system will be unrecognizably natural. The five hundred wilderness areas will be something like city weedlots, with tatterdemalion scraps of nature that have managed to survive catastrophic upsets. The epoch of spontaneously self-organizing systems, of wild nature with integrity, will be effectively over, and that will be a tragedy. Similarly, if other toxins or pollutants choke up the landscape ecology, or if the extinction rate reaches the projected disastrous levels, or if deforestation and soil loss reach levels that cause the system to crash. So the end of nature is not absolutely here, it is not absolutely possible, but it is relatively to be feared. Some end of nature is a good thing; but too much of any good thing is a bad thing.

Curiously, the view that humans ought to transform nature and the view that humans ought to blend with nature, opposite though they are, are nevertheless alike in that they wish to get rid of "the Other." But some of us do not want "Nature as Other" to be "over"—not entirely, anyway. We do not want "nature" homogenized with "culture," much less with "technology." This is arrogant of humans. More insidious than the hard anthropocentrism of dominion and conquest, this softer arrogance conquers by blending, by assimilation. Beware of those who wish to abolish all otherness. We need some spaces in our togetherness. Yes, the cultural story does end nature, and it ought to end nature; sad, but true. This is widely true on the surface of the planet. But it is not yet true, and it ought not to become true, that nature is everywhere at an end, either by humans transforming it into an artifact, or by humans blending themselves with it. Neither a humanized nature nor a naturalized humanity is an adequate replacement.

THE POSTMODERN ENDING

Richard Rorty (1982) tells us that the natural world, as humans have conceived of it over many centuries, is "the world well lost" (pp. 3-18). He too claims a postmodern ending of nature, though his is rather different from Callicott's. Nature is over for Rorty because nature cannot be known in itself; all the nature humans can know is the nature we have interacted with. We must not think that "Reason" offers "a transcultural human ability to correspond to reality"; the best that reason can do is ask "about what self-image society should have of itself' (1991, p. 28).[5] The big mistake is to "think that the point of language is to represent a hidden reality which lies outside us" (1989, p. 19). In fact, humans lack the epistemological faculty to know nature in itself.

Philosophers have perennially found themselves in an epistemic prison, as every freshman discovers early in the introductory course. There is no human knowing that is not looking out from where we are, using our senses and our brains, from an anthropocentric perspective. That is the lesson of Plato's myth of

the cave from ancient Greece, or the tale of the blind men and the elephant from India. These fables, all over again (so these postmodernists say), enshrine the deepest truth of all: All knowledge is relative; there is no "mirror of nature" (Rorty 1979). Viewing one's world, the realist hopes "to detach oneself from any particular community and look down at it from a more universal standpoint" (1991, p. 30). This can't be done.

Hilary Putnam (1983) explains to us "why there isn't a ready-made world." "There is a real world *but* we can only describe it in terms of our own conceptual schemes"(1978, p. 32). Everything has been "conceptually contaminated" (1981, p, 54) when we see it He continues, "'Objects' do not exist independently of conceptual schemes. *We* cut up the world into objects when we introduce one or another scheme of description" (1981, p. 52).[6] Is there then only some undifferentiated flux before we cut? No, Putnam backs off a bit, we should not describe the view of the anti-realist as one "in which the mind *makes up* the world. ... If one must use metaphorical language, then let the metaphor be this: the mind and the world jointly make up the mind and the world" (1981, p. xi).

But now what is getting contaminated conceptually is *epistemological* making up the world with *ontological* making up the world: the order of knowing with the order of being. True, we humans make up our categories as we know the world; that is epistemology. But it is also true that the world made up these natural kinds once upon a time; that is ontology. These are two very different make-ups; and it only confuses them to telescope them into a joint metaphor. The problem with the joint making-up aphorism is that the Earth-world was quite made up with objects in it long before we humans arrived with our minds.

The Earth-world made our minds over several billion years of evolutionary history, as it also made up our hands and our feet. True, our minds are unfinished, and we make up our metaphors in this construction, but joint make-up is another half truth, which becomes false in the whole. Our minds, with our words, are made to reach for objects as much as our hands and fingers. What the realist wishes to claim is that human-made epistemology can, and often does, track world-made natural kinds and structures. Ontologically, we should begin with an account of the world out there, and, following evolutionary history, at or near the end of this account, move inside to the mind "in here" and how it knows what is "out there." Epistemologically, we do have to start within and move out. We may find sometimes that objects in the world are conceptually illuminated as much as conceptually contaminated by our linguistic conceptions.

Still, replies Putnam, we can have only a limited objectivity, realism with a human face:

> Our conceptions of coherence and acceptability are ... deeply interwoven with our psychology. They depend on our biology and our culture; they are by no means "value free." But they *are* our conceptions, and they are conceptions of something real. They define a kind of objectivity, *objectivity for us*, even if it is not the metaphysical objectivity of the God's Eye view. Objectivity and rationality humanly speaking are what we have; they are better than nothing (1981, p, 55).

So we are back, in a different way, to Callicott's blending of humans and nature. All we can know is nature with a human face, and that is not to know any wild, spontaneous nature at all.

Linguists and cultural relativists will say that the very question of whether nature can or ought to end, in favor of a managed Earth, is a socially constructed question, depending as it does on a view of nature as different from culture, interpreting the principal mode of culture as reconstructing nature. This, they say, is not the universal worldview, indeed, not the view of most other cultures. This is only the modern European framework, a perspective adopted by Descartes, Newton, and others initiating the Enlightenment and the Scientific Revolution. The idea that nature is "out there"—something different from us, to be managed for human benefit—is just the perspective taken up by Western culture. Other cultures think more of humans as being within nature, something to which we submit. For them, entertaining the question of whether nature can or ought to end would be conceptually impossible.

Indeed—when this claim becomes even more specific—it is a Northern European construct, transplanted and intensified in white America. The nature-in-contrast-with-culture view is the epitome of social constructs, made in a self-consciously technological society. In reality, there is no nature-culture dualism; it is an artifact of the eyeglasses Westerners wear when they look at nature. Or, in a more agnostic account, humans cannot know what is there in reality; but, when other cultures take up their attitudes toward nature, nature need not be taken up with an other-than-culture appearance.

The human mind is capable of a great diversity of worldviews, and one hesitates to claim that any element of any worldview is pan-cultural. Nevertheless, every culture can, to some extent, see beyond itself to a spontaneous nature, unaffected by culture. The very idea of culture, in any form, has the sense of cultivation, of taking oversight, direction, and control of a found natural process to redirect it. That contrast is found wherever there are people with minds and hands who act on the world to alter it from the course of events it might otherwise have had. If such people have language, they are going to need words for such human actions.

Push the nature-as-social-construct view to the end of its logic, and one reaches, curiously, quite the opposite of the "nature is everything including culture" view. Now "culture is everything, including nature"; one cannot get past one's culture, which gives all form and shape to whatever world one can experience. Since any person, ourselves, or anyone with whom we converse, is a human, none of us humans can get outside of ourselves, so any viewpoint that can be had is a human point of view. Since no one can be human without a culture, any viewpoint is a cultural point of view. In this sense, once again, there is no contrast class. But if that is true, then those in other cultures who choose to integrate nature and culture, in contrast with the Northern European separation of them—those persons in their cultures are just someone else making up their alternative social constructs, and we have no reason to think that any of these views are either more true or more

preferable.[7] Even the nature-is-every thing view is one more social construct; in some other culture, nature might have not been so constructed.

NATURE AS AN **END IN ITSELF**

Nature neither is, nor ought to be, ended. Rather, humans can and ought to make nature an end in itself, complementary to their own human ends. We do not want to transform the natural into the cultural entirely, nor do we want to blend the cultural into the natural entirely. Neither realm ought to be reduced to, or homogenized with, the other. Critics will doubtless complain, using their pejorative word, that this is to fall back into a "dualism"; we reply that it is better to be discriminating about the real differences between nature and culture. Otherness is not, ipso facto, a bad thing. We ought not to eliminate such diversity, even though we ought to see unity, plurality in unity, community, where we can.

We do not want a humanized nature, shore to shore, ocean to ocean, pole to pole. Humanizing it all does not make us a part of it; rather, the dominant species becomes still more dominant by managing all. That, ipso facto, sets us apart—the one species that manages the place. Rather, we humans, dominant though we are, want to be a part of something bigger, and this we can only do by sometimes drawing back to let others be. This we do precisely by recognizing the otherness of wildness, by setting aside places as wilderness where we will not remain, which we will not trammel. Insisting on being part of everything, even wilderness, separates us out just because nothing else on earth so insists.

So perhaps either way, in the resolution to be apart from, or to be a part of, our difference is revealed. We have to choose either the nature of our apartness, or the nature of our partness. Roger DiSilvestro (1993) urges us to keep these partners sometimes separate:

> Territorial boundaries are ancient; they are artifacts dating from a primordial world. They are, in essence, established for the exploitation of the Earth. ... Only in the past century has humanity begun to set the protection of wildlands as a broad social goal, creating national parks, national forests, wildlife refuges, even protected wilderness areas. This is something truly new under the sun, and every protected wild place is a monument to humanity's uniqueness. The greatest qualitative difference between us and nonhuman animals is not that we can change and modify our environment Practically every living creature does that,.. ,But we are the first living things, as far as we know, to make a choice about the extent to which we will apply our abilities to influence the environment. We not only *can* do, but we can choose *not* to do. Thus, what is unique about the boundaries we place around parks and other sanctuaries is that these boundaries are created to protect a region from our own actions. ... No longer can we think of ourselves as masters of the natural world. Rather, we are partners with it (pp. xiv-xv).

Well, it may be replied, at least nature now needs for us to stay out of its way, and, paradoxically, even this is some sort of interdependence. Callicott (1994) puts it this way: "We depend on plants and animals for goods and services, and they

depend on us for their very existence—since without our respecting them ... many of them will be driven to extinction" (p. 131). In that latter sense, wilderness depends on an act of Congress. But here one is glossing over quite different senses of "depend." Wild plants and animals do not in any ecological sense depend on humans at all; all they need is our absence, a negative dependence. Every autonomous being depends on not having its integrity interrupted by invaders, but that is a nonfunctional sense of dependence.

Wilderness is the place where humanity is absent, perhaps not completely, but nearly enough to allow independence. Humans need to see their lives in a larger context, as embedded in, surrounded by, and evolved out of a sphere of natural creativity that is bigger than we are. Humans who cannot do this never know who they are and where they are; they live under some other and inadequate mythology. In that sense, it is important that this nature is independent of humans. Thinking of this as some more subtle form of dependence will miss seeing nature as an end in itself. Setting aside wild places—fauna and flora—as ends in themselves will do two good things. It will respect the intrinsic value in such pristine nature. It will conserve places on the planet where humans, when they visit there, can experience their lives in this larger context. Either of these benefits is sufficient reason for saving nature as an end in itself.

ONCE AND FUTURE NATURE

Management does require humanizing the landscapes on which we reside. What is true—but only half true—in the views I have been examining is that the future will be, over most of the landscape, inescapably, a synthetic world. We might as well be philosophical about this. The Hegelian dialectic may be useful. Nature is the thesis, culture the antithesis, and cultures harmonized with nature the synthesis. But, as usually formulated, the Hegelian dialectic suggests too strongly that original nature, the thesis, is entirely transformed in the synthesis, and passes over into something else.

We can better think of world events taking place within an ellipse with two foci. Some events are generated under the control of a focus that we label *culture*; such events are in the *urban* zone, where "urban" marks those arts and achievements where the contributions of spontaneous nature are no longer evident in the criteria of evaluation, though they remain among the precursor events. This is the *political* zone, recalling how "political" is derived from the Greek *polis,* or town. This is the *artifactual*, the *technological* domain.

At the other extreme, a *wild* region of events is generated by spontaneous *nature.* These events take place in the absence of humans; they are what they are in themselves—wildflowers, loons calling, or a storm at sea. Although humans come to understand such events through the mediation of their cultures, they are evaluating events generated under the natural focus of the ellipse. The constraint

of nature is maximal; the contribution of culture is minimal. Here nature is for real, not a social construction.

A domain of *hybrid* or *synthetic* events is generated under the simultaneous control of both foci, a resultant of integrated influences from nature and culture, under the sway, variously, of more or less nature and culture. Nature is redirected into cultural channels, pulled into the cultural orbit. This happens when human labor and craft put natural properties to use in culture, mixing the two to good effect in agricultural, industrial, scientific, medical, and technological applications, or to adverse effect by mistake and spillover. But always culture has to answer to what is objectively out there in nature.

In much of the arena of the ellipse, culture is pulling on the picture of nature, and there we find socially constructed nature: the legends of the American West, the landscape of the British countryside, or the Australian outback. Nature is encountered during the course of social construction. Cultures take up nature symbolically. This cultural symbolism appeals to geographers, anthropologists, sociologists, novelists, poets, humanist philosophers—all those interpreters who deal more with the human perceptions of the environment than with the environment per se. But it does not follow that others—natural scientists, conservation biologists, environmentalist philosophers—cannot take up nature as an end in itself. Nor does it follow that even the humanists, in their most sober moments, cannot do so as well.

"Symbiosis" is a parallel biological word, more positive than "synthetic" or "hybrid." René Dubos (1973, see also 1976) claimed that

> [t]he symbiotic interplay between man and nature can generate ecosystems more diversified and more interesting than those occurring in the state of wilderness. ... By using scientific knowledge and ecological wisdom we can manage the earth so as to create environments which are ecologically stable, economically profitable, and favorable to the continued growth of civilization.

The result is a humanized nature. In the symbiosis zone, we have both and neither (synthesis), but we do not forget that there remain event-zones in which the principal determinant is culture (antithesis), and other zones in which the principal determinant remains spontaneous nature (thesis). We do not want the ellipse to collapse into a circle, especially not one that is anthropocentric.

Nature as it once was, nature as an end in itself, is no longer the whole story. Nor is nature as contrasted with culture. One can dwell on the extremes in either direction. Much of life does take place in the symbiotic zone, and there we need an adequate theory lest our practices go astray. Wendell Berry (1995) raises this fear:

> The moral landscape of the conservation movement has tended to be a landscape of extremes. ... On the one hand we have the unspoiled wilderness, and on the other hand we have scenes of utter devastation—strip mines, clearcuts, industrially polluted wastelands, and so on.

> We wish, say the conservationists, to have more of the one, and less of the other. To which, of course, one must say amen. But it must be a qualified amen, for the conservationists' program has been embarrassingly incomplete. Its picture of the world as either deserted landscape or desertified landscape has misrepresented both the world and humanity. If we are to have an accurate picture of the world, even in its present diseased condition, we must interpose between the unused landscape and the misused landscape a landscape that humans have used well (p. 64).

The more perceptive environmentalists have always seen that it is a mistake, in their zeal for nature, to think of all culturally occupied lands as being "disturbed" or "trammeled." Managed they must be, and only semi-natural, but over much of the landscape, the goal is humans in a sustainable relationship (a dialogue, an equilibrium, a synthesis, a symbiosis) with nature. Here culture gardens nature. Nature is no longer wild.

Even there, nature does not end, but not so much because humans are natural in their management, and themselves a part of nature. Rather this is because nature remains the milieu of culture. Using a metaphor, nature is the womb of culture, but a womb that humans never entirely leave. Nature can do much without culture—the several billion years of evolutionary history are proof of that. Culture, appearing late in natural history, can do nothing without nature as its ground. To use a word in some disfavor, in this "foundational" sense, nature is the given. To take a favored word and turn it on its head, rather than culture "constituting" nature, nature here is constitutional for culture. No culture can ever be independent of nature, not unless some future society learns to produce matter *ex nihilo.* Culture will always have to be constructed (constituted) out of nature.

This remains true no matter what kind of exodus humans make from nature. Humans are going to remain male or female, with hearts and livers, and blood in their veins (partially artificial though it might be), walking on two feet, and eating energies that were originally captured in photosynthesis by chlorophyll (even if technology learns to mimic it). Culture remains tethered to the biosystem, and the options within built environments, however expanded, provide no release from nature, which remains as a life support system. Humans today depend on air flow, water cycles, sunshine, nitrogen-fixation, decomposition bacteria, fungi, the ozone layer, food chains, insect pollination, soils, earthworms, climates, oceans, and genetic materials. An ecology still lies in the background of culture, natural givens that underlie everything else. In any future that we can presently envision, some sort of inclusive environmental fitness is required of even the most advanced culture.

Here, we have a paradoxical turn of the argument. Those who insist on how much humans constitute nature likely also believe that nature is the foundation on which culture is constituted. In this case, here is a belief which Western civilization, particularly its science, has produced: humans evolved out of nature, and nature remains our life support system. Through our Western cultural lenses, we see nature making us and supporting us. But are we only constituting this belief

under the influence of some fashionable social ideology? Might others who came before us, animists perhaps, or others who come after us, super-technocrats perhaps, or sages and mystics in non-Western cultures—might such persons just as legitimately have different options about what they shall prefer to believe? Or have we, through Western science and its constructions, got it right about culture evolving out of nature and still today being supported by ecology? Is there not some transcultural truth in this discovery that nature once generated and now environs culture?

In conclusion, we should end with a sense in which nature has not ended and never will. Humans stave off natural forces, but the natural forces can and will return, if one takes away the humans. In that sense, nature is forever lingering around. Given a chance, which will come sooner or later, natural forces will flush out human effects, similar to the way in which natural effects themselves also are often washed out. Even if the original wildness does not return to nature, having been irreversibly knocked into some alternative condition, wildness will return to take what course it may.

To put this thermodynamically: Nature contains entropic forces that tear down high negentropic structures, unless these are constantly maintained by an informed energy input. Generally, the struggle for life is in countercurrent to entropy; metabolism directs the synthesis and repair of the highly ordered protein structures that compose the organs of the body. At death, the forces of entropy take over and the body decays. If the organism that dies happens to be a human, who also has made extrasomatic artifacts, not only does the body decay but the artifacts too begin to decay, once they are no longer maintained extrasomatically by the care of the embodied person. In time, entropy wipes out the remnants of culture, as it does the corpse of the body. Nature is indifferent to whether these high negentropic structures were constructed by genetic information or by cultural information. This also means that if we humans, while yet alive, withdraw from the maintenance of our cultural artifacts, the entropic forces will take over to flush out the ephemeral effects of cultural intervention.

Nor is it just the entropic forces of nature that return. The self-organizing (autopoietic) forces reappear as well. If you wonder whether nature has ended, watch what happens on a vacant lot when its former owners move away. One might first think that there is no nature left, since the lot is filled with the rubble of artifacts—pop cans and broken concrete blocks. But nature comes back, and soon there are weeds sprouting up, a lush growth of them, if there is rain and the soil is not too contaminated. We could almost say, in a more philosophical mood, that nature still knows how to value the place, or knows, as it flushes out the human disruptions, what values to put in place that can still be sustained there. In that sense, a vacant city lot, which might seem to be a place where nature has quite ended, is, if watched a little longer, a place that testifies eloquently to how nature, managed and mismanaged by humans though it may be,

does not and cannot end. In, with, and under culture, there is always this once and future nature.

NOTES

1. Aristotle, *Politics* 1,2. 1253.

2. In cultivation from its wild ancestor, maize has been bred for a characteristic that humans desire: the seeds stay in the ear. But this prevents dispersal in the wild, and the plants do not successfully propagate by themselves over longer periods of time.

3. For a summary of wilderness and native American fires, see *Proceedings—Symposium and Workshop on Wilderness Fire* (November 1983, Missoula, Montana), eds. James E. Lotan, Bruce M. Kilgore, William C. Fischer, and Robert W. Mutch (Ogden, UT: USDA Forest Service, Intermountain Forest and Range Experiment Station, General Technical Report INT-182,1985), especially section 3.

4. Some grasslands differ in that fuel becomes available annually. Fires can retain grasslands that, unburnt, would revert first to shrubland and then to forests. This happens naturally in the Midwest where the forests transpose to grasslands and lightning is frequent. In similar grassland situations, the Indians might have augmented ignition relative to fuel availability, and burned unnaturally often. However, the effect is mostly to shift succession toward earlier stages, and, released from Indian burning, such lands resume their natural succession. Meanwhile, there is no reason to think that the Indians, by deliberate fire policy, greatly modified the regional grassland ecology of the vast American West.

5. "Reason," in the upper case, is Rorty's emphasis for accentuating and mocking such aspirations.

6. Notice that "objects" is in quotes in the first half of the sentence but not the last.

7. The pragmatist may reply that we choose the nature-integrated-with-culture view because it has fewer undesirable consequences than the Western nature-separate-from-culture view, although we do not know which is objectively true. But of course what consequences we desire (wild nature ended and more sustainably used, or wilderness preserved as end in itself) depends significantly on what worldview we take up.

REFERENCES

Barnett, Harold J., and Chandler Morse. 1963. *Scarcity and Growth: The Economics of Natural Resource Availability.* Baltimore: Johns Hopkins University Press.

Bergson, Henri, 1911. *Creative Evolution,* trans. Arthur Mitchell. New York: Henry Holt.

Berry, Wendell. 1995. "The Obligation of Care," *Sierra,* vol. 80, no. 5 (September/October), pp. 62-67,101.

Botkin, Daniel B. 1990. *Discordant Harmonies: A New Ecology for the Twenty-first Century.* New York: Oxford University Press.

Callicott, J. Baird. 1992. "La Nature est morte, vive la nature!" *Hastings Center Report,* vol. 22, no. 5 (September/October), pp. 16-23.

Callicott, J. Baird. 1994. *Earth's Insights.* Berkeley, CA: University of California Press.

Clark, William C. 1989. "Managing Planet Earth," *Scientific American,* vol. 261, no. 3 (September), pp. 46-54.

Denevan, William M. 1992. "The Pristine Myth: The Landscape of the Americas in 1492," *Annals of the Association of American Geographers,* vol. 82, no. 3, pp. 369-385.

DiSilvestro, Roger L. 1993. *Reclaiming the Last Wild Places: A New Agenda for Biodiversity.* New York: John Wiley and Sons.

Donkin, R.A. 1979. *Agricultural Terracing in the Aboriginal New World.* Tucson, AZ: University of Arizona Press.

Drexler, K. Eric. 1992. *Nanosystems: Molecular Machinery, Manufacturing, and Computation.* New York: John Wiley and Sons.

Dubos, René J. 1973. "Humanizing the Earth," *Science,* vol. 179, no, 4075 (February 23), pp. 769-772,

Dubos, René J. 1976. "Symbiosis Between the Earth and Humankind," *Science,* vol. 193, no. 4252 (August 6), pp. 459-462.

Hannah, Lee, David Lohse, Charles Hutchinson, John L. Carr, and Ali Lankerani. 1994. "A Preliminary Inventory of Human Disturbance of World Ecosystems," *Ambio,* vol. 23, no. 4-5 (July), pp. 246-250.

Hart, Harold. 1991. *Organic Chemistry,* 8th ed. Boston: Houghton Mifflin Co.

Lewis, Nathan S. 1995. "Artificial Photosynthesis," *American Scientist,* vol. 83, no. 6 (November-December), pp. 534-541.

McKibben, Bill. 1989. *The End of Nature.* New York: Random House.

Mesthene, Emmanuel G. 1967. "Technology and Religion," *Theology Today,* vol. 23, no. 4 (January pp. 481-495).

Putnam, Hilary. 1978. *Meaning and the Moral Sciences.* London: Routledge and Kegan Paul.

Putnam, Hilary. 1981. *Reason, Truth, and History.* Cambridge: Cambridge University Press.

Putnam, Hilary. 1983. "Why There Isn't a Ready-Made World," *Realism and Reason,* Philosophical Papers, vol. 3 (Cambridge: Cambridge University Press), pp. 205-228.

Pyne, Stephen J. 1982. *Fire in America: A Cultural History of Wildland and Rural Fire.* Princeton, NJ: Princeton University Press.

Rogers, Michael. 1977. *Biohazard.* New York: Alfred A. Knopf.

Rorty, Richard. 1979. *Philosophy and the Mirror of Nature.* Princeton, NJ: Princeton University Press.

Rorty, Richard. 1982. "The World Well Lost," in *Consequences of Pragmatism* (Minneapolis, MN: University of Minnesota Press), pp. 3-18.

Rorty, Richard. 1989. *Contingency, Irony, and Solidarity.* New York: Cambridge University Press.

Rorty, Richard. 1991. *Objectivity, Relativism, and Truth.* Philosophical Papers, vol. 1. New York: Cambridge University Press.

Rothenberg, David. 1992. "The Greenhouse from Down Deep: What Can Philosophy Do for Ecology?" *Pan Ecology,* vol. 7, no. 2 (Spring), pp. 1-3.

Soulé, Michael E. 1989. "Conservation Biology in the Twenty-first Century: Summary and Outlook," in *Conservation for the Twenty-first Century,* David Western and Mary Pearl, eds. (Oxford: Oxford University Press), pp. 297-303.

Vitousek, Peter M., Paul R. Ehrlich, Anne H. Ehrlich, and Pamela A. Matson 1986. "Human Appropriation of the Products of Photosynthesis," *BioScience,* vol. 36, no. 6 (June), pp. 368-373.

Weather Modification Advisory Board. 1978. *The Management of Weather Resources,* vol. 1, *Proposals for a National Policy and Program,* Report to the Secretary of Commerce. Washington, DC: Government Printing Office.

Yoxen, Edward. 1983. *The Gene Business: Who Should Control Biotechnology?* New York: Harper and Row.