THE MONTEREY LIST

Growing toward a sustainable future

For ourselves and for the planet

By

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Introduction

This book is an attempt to reframe the discussion of environmental issues in a way that will fit them more successfully to the world we inhabit in the 21st century.

We face an immense array of problems - global climate change, water and energy shortages, mass extinctions, and the general decay caused by carrying capacity overshoot, to name just a few. Anxieties brought on by these problems have been exploited by politicians who have used them to consolidate power and wealth within a tiny fraction of the population. Many of the protections won in the last century are being rolled back; ideologies have taken hold that threaten, not only our existing environmental regulations, but the very idea of regulation itself.

Arrayed against these forces is an environmental movement whose philosophical underpinnings have not changed much since the 1890s. It is based primarily on the concept of preservation. Early leaders such as John Muir and Aldo Leopold originally fought to preserve wildlands. In the 1960s, Rachel Carson's *Silent Spring* expanded the idea of preservation to include animal and plant species, while the widely-reported "death" of Lake Erie ignited a campaign to restore and preserve clean surface waters. Writers such as Edward Abbey and photographers such as Ansel Adams and Eliot Porter kept us aware of the need to preserve the beauty of natural landscapes and the experience of solitude.

It seemed too simple. It was.

I do not wish to downplay the successes of the preservation movement. The world is a much better place as a result of its efforts. I have no regrets about my own lengthy participation in it. *But it is not adequate to deal with the problems that challenge us today.* Those of us who care for the environment need to switch our emphasis, from preservation to sustainability.

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Sustainability is not a new concept; it has been a thread in the environmental movement since at least the turn of the last century. Gifford Pinchot - the creator, along with Teddy Roosevelt, of the National Forest System - was a prominent advocate: the slogan he adopted, "The greatest good for the greatest number over the longest time," still serves well as a succinct explanation of what a sustainable lifestyle really means. A flurry of books at mid-century, including Barry Commoner's *The Closing Circle*, Paul Ehrlich's *The Population Bomb*, and especially Donella and Dennis Meadows's *The Limits to Growth*, briefly brought sustainability to the forefront of our national conversation.

But interest waned. Partly this was the result of a flurry of major challenges - the extension of the Wilderness System, the need for action on clean water, the love affair of Congress with big dams - that required a preservationist response; partly it was because preservation is considerably sexier than sustainability. Mostly, though, it was because of our familiarity with the concepts involved. The environmental movement fell back into doing what we knew how to do. We had evolved a large body of techniques for making

preservation happen, and a complete set of philosophical rationales for using them. In times of mounting environmental crises, it was natural to turn to these old and trusted friends.

When all you have is a hammer, every problem looks like a nail.

But we can no longer afford the luxury of the familiar. Preservation is of little use against mass extinction; it is of even less use against water or food shortages. And it is of no use at all against climate change and carrying capacity overshoot. It is time to switch gears. The book you are reading is one small attempt to encourage that process.

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The name "The Monterey List" comes from an actual list that I made in a Monterey, California hotel room in November 1997. The list had its genesis a few years earlier, in an incident - described fully in my book *The Left Hand of Eden*[1] - that had caused me to question the continuing validity of preservation as a tool for environmental protection. Each entry on the list was a short aphorism that expressed in as succinct a form as possible one of the principals I thought the environmental movement would have to adopt in order to switch from preservation to sustainability. Some of them were borrowed, but most were made up on the spot. There were more than one hundred of them. The present book consists of a reordering of those aphorisms into a coherent form, a division of them into chapters, and an expansion of each aphorism into a short essay that explains what the aphorism means and why it is necessary. The aphorisms themselves are present as numbered statements, in italics, at the head of each essay.

The original Monterey List, in the order it was written down in that hotel room, may be found in the Appendix.

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[1] William Ashworth, *The Left Hand of Eden: Meditations on Nature and Human Nature* (Corvallis, Oregon: Oregon State University Press, 1999), pp. 162ff.

I. On Nature

1. *There never was a war against nature. The war was against ourselves*.

For hundreds of generations - for thousands of years - the human race has seen itself locked in an epic struggle with the elements. The story of civilization has been told as a tale of gradual triumph over the brute forces of nature - rain, cold, famine, flood, drought, dangerous animals. We domesticated fire and the dog, spread seed and pulled weeds, built houses and clothed ourselves against the weather. The wheel and the horse shrank distance. Eventually we found gasoline and electricity. Today we routinely board aircraft for four-hour trips across a continent it took our ancestors a full season to span, reading magazines in air-conditioned comfort while flying at heights birds rarely reach and speeds they never do. We build and drain lakes. Telephones, television, and the Internet give us instant access to the entire planet. The natural world shrinks while the made world expands - irrigation, clearcuts, urban sprawl, omnipresent smog. We relish tales like *The Perfect Storm*, not because they relate to our own experiences, but because the incidents they describe - where nature, ever so briefly, regains the upper hand - are now so very, very rare.

But this tale of progressive conquest contains one major flaw: it doesn't exist. Battles require two sides, and this has had only one. Nature has been a noncombatant. She has been present, but she has ignored our taunts and continued to do as she damn well pleased. Everything she has always done, she still does today. Not one force, not one process, not one natural relationship has been changed. All we have done is to channel their effects.

Which is not to say that a war has not been going on. There has been one, but it has been between a somewhat different set of combatants. Every technological change we have made has had consequences - some good, some bad. The good are those we want; the bad are those we have been unable to avoid. The war has been between these two sets of consequences. And although the bad consequences have certainly been felt widely among all living things, the primary victims have been ourselves.

Yes, I am aware of extinctions. I am aware of the clearing of forests and the silting of streams with topsoil that has taken millenia to build. I am aware of global climate change. There is little elegance, and much brutality, in our relationship with the Earth. The point is not that these things are not happening, but that *they are not unnatural*. They are, in fact, the natural consequences of our actions, and we are the ones who will ultimately suffer the most from them. When a man crawls out on a tree limb and proceeds to saw it off between himself and the trunk, the tree is hurt. But the man is hurt more.

So I propose that we declare a truce - not with nature, but with ourselves. I propose that we agree to stop threatening our own future. I propose that we pay attention to those things we do in which the bad consequences outweigh the good, and stop doing them. To continue on our present course is not anti-nature or environmental rape or earth destruction, it is simply stupid. In order to win this war, we will have to die at our own hand. When you fight yourself, there is no victor; there are only self-inflicted wounds.

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2. *We view nature in largely mythical terms*.

Nature is the Other, a lurking presence outside our cities, by turns benign, ominous, suffering, giving, or fighting back. Nature, in this view, is damaged where we have tinkered with it and whole only where we have never trod; we can tame it or leave it alone, ignore it or embrace it, protect it or exploit it, but we cannot be part of it. Nature is nature and humans are humans, as thoroughly cloven from each other as God and Adam after the Fall, and whether we are developers or environmentalists depends less on our different attitudes toward the natural world than it does on the different conclusions we manage to draw from our shared mythology. The debate has never been about the presence of the Beast, only about its characteristics - and we agree to a surprising extent even on those.

Take, for example, the question of balance. If nature is an Other, it follows that it should function as a unit, and to do that, it is necessary for its various parts to exist and move in balance with one another. Both developers and environmentalists accept this. Where they differ is the extent to which they assume that this balance will be affected by human activities. Environmentalists believe it is delicate and easily disrupted; developers believe it is robust and self-healing. This is not a clash of opposing gods, it is a theological debate over whether we should treat the same god as an invalid or a weight-lifter. Deity itself has never been in doubt.

Or take the question of purpose. Environmentalists believe that nature should serve its own purposes; developers believe that it should serve the purposes of humans. Again, this difference is not so fundamental as it appears. The gap between wolf and dog is mostly a matter of training, not of genetics. One person may hang a Persian carpet on the wall to be admired while another spreads it on the floor to be walked on, but both of them are likely to recognize it both as a carpet and as a work of art: the difference in treatment comes, not from speaking different languages, but from emphasizing different parts of the same sentence. Purpose, like balance, is assumed as a given; only its characteristics change.

People who work directly with the land and the biota - farmers, natural scientists, tree fellers, the field staffs of land management agencies - tend to buy into the mythology of nature less completely than do those who remain disconnected from it. Mythology thrives on unfamiliarity. Unfortunately, these are rarely the people who make the decisions. In our increasingly manager-dominated world, the managers are usually disassociated from the actual work: farmers from the agribusinesses that own them, scientists from the corporations and universities that employ them, timber fellers from the "pinstripe loggers" at corporate headquarters, and field staff from the politicians and political appointees who make the laws and regulations that the staff persons must abide by. Lacking direct knowledge, managers are easy prey for mythology.

So are activists, of all stripes. Weekend recreation is of little help. The property-rights promoter who spends the weekend clearing brush around his lakeside cottage and

the preservationist who spends the same weekend backpacking through the wilderness each get a taste of the integration of humans and nature which tantalizes but does not satisfy. Each tries to preserve the opportunity for the activity; neither fully understands that it is the integration, not the activity, that has moved them. The mythology is wrong. There is no Other; life is all of a piece. It is gloriously off-balance and gloriously heedless, and we are just another part of it, one of the bumper cars, setting our direction partly by steering and partly by bouncing off the others. If we can get a feel for that, then maybe - just maybe - we can survive.

Mythologies are substitutes for understanding. They help us make sense of the world before the facts are known. As a predominantly intellectual species, we require things to make sense, so mythologies are a necessary part of our cultural growth. But we should have the good sense to discard them when the facts arrive. The myth of nature-as-Other is beautiful, easy to grasp, and wrong. We should stop arguing over the niceties of its theology and begin looking beyond it, into reality.

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3. *Our job is neither to preserve nature nor to conquer it, but to reintegrate with it.*

The developers and the preservationists are both wrong. Nature is neither an endless cornucopia of resources, nor a sacred precinct. It is not a playground, either for bulldozers or for hiking boots. It is our world. It gave shape to us, and we remain part of it. We really have no choice in the matter: all we can choose is whether or not to recognize the relationship.

For millenia, now, humans have been trying to separate ourselves from the Earth. It began with shelter-building, a trait we share with some of the other animals but which nevertheless represents an attempt to improve upon nature. Agriculture came next, a practice so ancient that we have long since forgotten what a radical alteration of natural conditions it represents. Modern agribusiness, often derided as "unnatural," differs from traditional practices only in degree, not in kind; unless they are actually gathered from the wild, so-called "natural" foods are no more truly natural than those raised with liberal doses of pesticides and fertilizers.

After agriculture came cities, and after cities came technology. The first brought, not only modification of the natural world, but physical separation from it; the second extended our presumed control over nature from the growing habits of plants and the social habits of animals to more basic forces such as wind, sunlight, gravity, oxygenation, and electrical potential. With each step came a greater sense of superiority and self-importance. We proclaimed ourselves no longer members of the natural order but masters of it, dwelling apart from it and pressing it into service for our own ends.

There was, of course, dissent. Movements arose for the protection of nature. These date back at least to Biblical times; the Book of Job is, among other things, the earliest known environmental treatise. Contemporary nature protectors have grown more strident, but their basic position is in fact no different from the developers. They want to coddle the baby rather than putting her to work, but they still maintain a sense of

superiority and separation. To preserve or to exploit are both actions done *to* something. They keep intact the long cleavage that began when our prehuman ancestors first wove leaves together to fend off the rain.

I do not suggest that we rid ourselves of our clothing and umbrellas and stand naked to the weather. We should continue to live in heated houses and eat agriculturally-raised food. I do think, though, that seeing nature as a separate entity should stop. It is not them and us, it is us and us. The connections have never been severed, they have just been obscured. We need to clear away centuries of attitude problems. It is time to rediscover our links to the Earth, to refurbish them, and to put them to good use.

What this means, in a practical sense, is that we must stop trying to dictate terms to nature and begin to listen to it, instead. This is true whether the terms we have been dictating are meant to squeeze profit out of it or to lock it up for its own protection. If we cooperate with nature, we will accomplish much more than if we try to force it to cooperate with us. It is not actually wrong to build houses in the wilderness - Thoreau did exactly that. The question is not whether or not to have technology, but how well that technology integrates into the rest of the living world.

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4. *Any definition of nature that does not include humans is necessarily false.*

We are as much a part of the natural world as are the birds of the air, the beasts of the field, the flowers, the whales, and the wilderness. The same forces have shaped us all; the same forces control our lives today. Any action taken on behalf of wild nature must be taken on behalf of humanity as well.

This will not be a popular stance. The Right will read to me from Genesis about how humans were created to have dominion over nature; the Left will cite a bill of particulars against humanity that includes dams, clearcuts, extinctions, nuclear power plants, and the gasoline engine. I will be attacked from one side as unGodly and from the other side as an apologist for destruction. The myth of separatism dies very hard.

But we all know the truth. Each time we eat, drink, defecate, dance, piss, bleed, sleep, or screw, we know it. We are kin to every other creature that does the same thing. The structure of our DNA is revealing: roughly one-third of it is the same as that of the simplest bacterium. Life is all of a piece. The Krebs cycle does its work in every cell, ours as well as the ant's, the redwood's, or the paramecium's.

This leads to several conclusions.

The first conclusion is that we cannot protect nature by excluding humans from it. That is like trying to protect a forest by excluding the trees. You cannot take a big piece of what you are trying to take care of, wall it off from the rest, and call the result "protection." Whatever else it may be, it is not that. We may indeed be called to be guardians of nature, but in order to do so we must be guardians of ourselves as well. The world is a self-inclusive set, and all the paradoxes apply. Remember that tricky bit about the barber who shaves every man in the village who doesn't shave himself? Who, then,

shaves the barber? If humans protect every creature that cannot protect itself from the effects of human actions, who protects the humans? We are all in this thing together.

The second conclusion is that humans need regular contact with the rest of the natural world. We need to know our bloodline. The things that we share are greater than the things that divide us, a statement that is as true across species as it is across cultures. We crave that sharing. That is what drives people to sprawl houses through the woods, to crowd into National Parks, to share our homes with pets, and to plant wet gardens in dry places. It is as much a part of our passion for outdoor sports as it is of our fondness for scenery. We need to feel fully alive. Our shared bonds with the whole of the living world are our best, and possibly our only, means of answering that need.

The third conclusion - and it will be the last for now, though there are others - is that all lives are meant to be lived together. On this particular planet, circling this particular sun, every creature is part of a single journey. We love our fellow journeyers; we also eat them (plants are living things, so being a vegetarian does not get you out of this). The story of life is also the story of death. It all works together. The cogs mesh and the engine spins, levering us toward the stars. Pulling ourselves out of the machinery is not an option. Jamming the works is easy but stupid. Our best choice - our only choice, really - is to take our place in the gear train, fitting into it as smoothly as possible. File the teeth, oil the axle. Let go. Live.

II. On Environmental Damage

5. *Environmental damage is real*.

My disagreements with the goals and tactics of the environmental movement do not extend to its concerns. We have pillaged the Earth without regard to the effects of our actions on its inhabitants, including ourselves. Our housekeeping is dismal. Wastes are strewn everywhere: we live among them, drink them, breathe them. Short-term interests are consistently allowed to override planetary health. We are riding the thin skin of a technological bubble which could burst at any time, leaving us crawling among the ruins, an impoverished species on an impoverished planet.

Literally thousands of books - including several of my own - have written down the rancid details of our biocidal spree through history, so it seems unnecessary to repeat the litany here. What I would like to do, instead, is to stress the irrefutable nature of the data. We are not dealing with hand-wringing, but with established connections and verifiable trends and, often, with blatantly obvious results. You don't need to be a scientist to understand these things. Anyone can go to what was once the Aral Sea and see the desert-stranded fishing villages, their boats still tied to their dried-up wharves, as much as ninety miles from the nearest water. Anyone can also visit the irrigation canals that suck away the rivers which once kept this sea and its large fishing industry - now derelict - alive. Statistics here merely restate the obvious. Anyone can also go to Lake Erie and view the encrustations of zebra mussels on wharves and ships and water intakes and listen to the waves tinkle onto beaches knee-deep in tiny striped shells. Or fly a small plane for hours at a time over a patchwork of clearcuts that gives the forest below you the look of an animal with a severe case of mange. These are not just warning signs of a disaster to come; these are the disaster itself. Continuing to live our lives as we lived them fifty years ago, as if nothing had changed in the meantime, is both criminal and stupid.

As we acknowledge the extent and severity of the damage, though, we must also remain clear about what exactly it is that is being damaged. Primarily, it is habitat. Not just any habitat, but vertebrate habitat. Mammalian habitat. *Our* habitat.

Global warming is a form of habitat change ("weather," after all, is one of the four factors ecologists ascribe to habitat.) So is extinction ("other animals"). Forest clearing ("shelter") is an obvious case, as are fisheries decline and the worldwide overpumping of aquifers for irrigation ("food"). Of the many and varied forms of environmental damage, only the destruction of scenic beauty is not directly expressible in terms of habitat loss, and one could probably make a case for that one, even, under the heading of shelter.

Habitat changes create complexes of effects, some helpful, some harmful. Those we have brought about are mostly harmful, to ourselves and to other vertebrate species, but it is worth remembering that some changes are positive and that almost always there are some creatures who benefit from others' misfortunes. When we introduced zebra mussels into Lake Erie, we dramatically changed its ecology. Several species of native mussels rapidly plummeted to near-extinction. Water clarity improved (a plus), allowing

rampant macrophyte growth (a minus). Small plankton-eating fish, which competed with the mussels for food, declined in numbers, affecting the populations of the larger fish which ate the plankton-eaters - a change reflected not only in the lake's ecology but in the habits of sport fishermen throughout the Midwest. In the midst of all this were the zebra mussels themselves - thriving. One might even say they were taking over. Zebra mussel habitat - as distinct from native mussel habitat, from fish habitat, and from human habitat - had never been healthier.

Environmental damage is real, and severe. But it is damage to *our* environment, not to the planet's. We need to hold that in perspective. The steps we take to counter the problems we have caused will be much more effective if we do not view them as saving the Earth, but as restoring our own habitat. The Earth will survive. The threat is to ourselves.

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6. *The current speed of extinctions is unprecedented*.

The word "unprecedented" has been deliberately chosen here, even though I am aware that larger mass extinctions have taken place in the past. Geologists have long calibrated the Earth's clock by these events, which bring about abrupt and easily verifiable changes in the fossil record. The famous extinction that wiped out the dinosaurs at the close of the Cenozoic era, 65 million years ago, was not even the largest: that would be the one which took place roughly 185 million years earlier, ringing down the Paleozoic era in dramatic fashion with the loss of between 70 and 90 per cent of all life forms on the planet. But notice that I said "speed." For a geologist, an "abrupt" mass extinction is one that lasts less than one hundred millenia. This one is taking place in only a few decades.

We don't actually know how fast creatures are disappearing, or how many will be gone before the situation stabilizes. We have, however, some educated guesses - and all of them are alarming. Working from rates of habitat loss and from estimates of the numbers of individual species found in various habitats - this includes microbes and fungi as well as plants, invertebrate animals, and vertebrates - biologists generally come up with loss rates in excess of 100 species per day, although no two biologists seem to agree on the exactly the same number. Working from actual rates of decline, the World Conservation Union finds twenty per cent of all vertebrates - and 34 per cent of fishes - threatened with extinction over the next several years to several decades. These are, of course, estimates, and thus open to debate. No such quibbling is possible with actual extinctions, of which there have been many. Birds are a particularly well-documented group. Since 1600, when reasonably accurate record-keeping may be said to have begun, more than eighty bird species have disappeared. Most of those losses have taken place in just the last century.

It can be argued that these numbers are irrelevant. So one in every eight bird species is currently on Birdlife International's threatened list. So what? If a species is threatened, it generally indicates that its numbers have already been severely reduced.

This means that we are, in effect, already getting by without it. We seem to be doing just fine. Why all the commotion?

There are two possible answers to this question.

The first answer argues from moral and aesthetic grounds. Human activities are causing by far the largest number of current extinctions. *Who gave us that right?* Even if we have it, why would we want to exercise it? Each time a species disappears, our lives are diminished by one more small amount. The effect is cumulative. Why are we deliberately impoverishing ourselves? The dinosaurs and the trilobites disappeared eons ago; few of us encounter this information without wishing that we could see one. If we have the ability to stop the Spix's macaw from following the same course, why aren't we using it?

That is the first answer. The second answer reminds us that the passengers in a car doing ninety-five miles per hour are still doing just fine in the fraction of a second before that car hits the side of a building.

The majority of species we have lost, or that are now on the endangered list, will not affect us by their disappearance. But a small minority will. And we have no reliable means of guaranteeing which is which. Several decades ago, alligators were nearly extirpated from the bayous of the American South, and the whole ecology of the Gulf Coast began to unravel. It turned out that these large, dangerous handbags on legs are necessary for the survival of many other creatures. This is not because of their predation patterns, but because of what they do to relax. Alligators dig holes. In the dry season, they dig them to reach water. In the wet season, they apparently dig them just for the hell of it. Whatever the reason, the holes appear, and other species take advantage of them. In the dry season especially, they are critical reservoirs of moisture and coolness and plant life. Take the alligators away, and untold numbers of other species suddenly become homeless.

Scientists call creatures like this, which provide services to numerous others, *keystone species*. When extinction removes a keystone species, the entire ecosystem to which it belonged suddenly becomes endangered. And at the current speed of human-caused extinction, we have only a limited time frame within which to work as we try to predict which threatened species are keystone - and an even shorter time frame to attempt to save them.

Consider what might happen if bees suddenly went extinct. (And don't be too sure that they cannot. There are millions of bees in the world at the moment, but there were also millions of passenger pigeons a decade or so before they disappeared forever.) Bees, as nearly everyone knows, are pollinators. In particular, they are pollinators of members of the rose family. This family contains the brier and bush roses beloved of gardeners and of lovers on Valentine's Day, but it also contains most of our favorite fruits, including apples, plums, cherries, apricots, pears, peaches, almonds, blackberries, raspberries, and strawberries. If bees disappeared, these plants would have a very hard time indeed. They would almost certainly go extinct in the wild. A few might survive on the efforts of lesser

pollinators such as moths, but they would have to change character to attract their new assistants, and what is attractive to a moth might not be at all attractive to a human. Rose-family plants could be saved in cultivation, but the effort would require hand-pollination and other expensive and difficult techniques. Apples would go from a grocery-store staple to a gourmet-store specialty.

Bees and alligators are, of course, extreme cases. Most extinctions do not cause anywhere close to that kind of waves. To judge from contemporary accounts, passenger pigeons were primarily nuisances - like starlings today, but worse. John James Audubon, caught beneath a passing flock in Ohio in 1812, complained that "the dung fell in spots not unlike melting flakes of snow," and that where the pigeons landed, food disappeared so thoroughly that "the gleaner who might follow in the rear of the flock would find his labor completely lost."[2] The birds were good for the pot, but otherwise had little to recommend them - as far as we know. We cannot be sure. Did their extinction help cause the disappearance of the wolf in the eastern United States soon after? Bounty hunters are usually blamed for that, but loss of the wolves' natural prey certainly would have contributed, if in no other way than to make them more dependent on livestock and thus increase the resolve of humans who wished to wipe them out. Which they - or something - did. Which, in turn, allowed the population of deer to explode, causing at least as much damage to crops as the wolves had caused to livestock. And so it goes, round and round, like the proverbial snake that eats its own tail. Extinction is forever, and so are the changes it brings with it. Where is the Carolina parakeet? Gone. Where is the great auk? Gone. Where is the Tasmanian wolf? Gone. And so are many that depended upon these creatures, and others. You cannot cut one strand without weakening those nearby.

It should not be implied from this that all extinctions are necessarily bad. Extinction is a natural process. It is what has encouraged the complexity of life to develop to the level that has allowed the birth of the human race. Niches must empty in order to make room for new creatures. Evolution depends on this. Dinosaurs turn into birds, and though small children may mourn, the world is probably better off.

So the point is not to save all species. The point is to save the ones that matter. And the problem with that is that we have no sure way of knowing just which ones these are.

Policies to prevent extinction must thus, of necessity, sift wide and fine. In the process they catch certain creatures, such as slugs and obscure plants, that cause us to scratch our heads and complain to our congressmen. In truth, many of these could probably be let go. But there is no surer way than this to find the one out of a thousand that should have been kept. And there is no bringing it back at that point.

When we contribute to extinctions, we play a massive game of Russian roulette with our own lives. In a world tied intimately together, the loss of one species can lead rapidly to the loss of others. A small rent in the fabric can spread. The sentimentality that

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[2] Adams, Alexander, *John James Audubon: A Biography* (Capricorn Books, 1966), pp. 149-150.

surrounds the protection of endangered animals can easily obscure this important fact: *extinctions are dangerous*. The speed at which they are currently taking place is equivalent to spinning the cartridge chamber in a gun we have pointed at our heads. Under the circumstances, attempting to push the gun away seems the only responsible thing to do.

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7. *Humans have simplified natural systems*.

Nearly everything we have thought of as "progress," through all of human history, has resulted in some form of ecological simplification. The first great simplification was the agricultural revolution. During this sweeping technological change, which took place in at least three separate places - in Arabia, in Mesoamerica, and in China - diverse natural plant communities were replaced by single-crop fields. Animal diversity dropped as well, as insects tied to particular plants disappeared with the plants, and as domestic mammals and birds were given a selective advantage over their wild relatives. Crop pests and predators were "controlled," which usually meant eradication to the extent possible. Other agricultural models exist - most hunting and gathering societies alter the landscape to improve game habitat, and they plant the seeds of favorite food plants near their regular encampments to ensure a steady supply, two complexity-retaining practices which clearly qualify as agriculture - but the simplification model has become overwhelmingly dominant. Each "improvement" to this model has simplified things a little further. Today's agribusiness is the epitome of ecological simplification: giant monocultured fields, aggressive pest and weed eradication programs, and artificially fed livestock and poultry confined to small areas in such great densities that there is no room for any other living thing. The diverse mix of life one finds in the wild has been replaced by what may be thought of as individual biological boxes, each containing a single species.

The simplifications brought by the agricultural revolution have paved the way for others. Forestry, for example, has traditionally followed the agricultural model, with monocultured tree plantations and aggressive pest control. In this "individual boxes" concept of the forest landscape, wilderness preservation is not so much a revolution as it is a logical extension. Conceptually, a wilderness preserve is just one more box, filled with "nature" instead of with crops or with livestock and kept that way in the same manner: by aggressively patrolling the bounds and keeping out everything that doesn't belong inside.

The built environment - cities, freeways, farmsteads - is an overwhelming simplification, pared down to fake rock, dead wood, and a single species (us) plus a few plants and animals (pets; birds) which we permit to share our realm. The suburban lawn is a simplification, reduced to a few varieties of grass and kept on a single water regimen year-round. The internal combustion engine is not a simplification - it interrupts the natural sequestering of carbon, and it puts gases into the atmosphere which are rare or absent under natural conditions - but its overall effect is to simplify, by allowing or encouraging such practices as suburban sprawl, agribusiness, and the concentration of

industry into areas which then become ecological dead zones due to pollution, paving, large buildings, and heavy machinery.

All this is important because nature does not ordinarily simplify. Overall, over astronomical time, it is true that the universe is running down and is therefore simplifying: the Second Law of Thermodynamics guarantees this result. The tendency of living things, however, is toward *more* complexity, not less. Biologists refer to this process as *negentropy*, the negation of entropy - "entropy" being the disorder introduced into systems by the Second Law. Life is negentropic because living systems are niche-driven. Niches - an ecological term which refers to what animals do for a living as well as to where they live - proliferate as life proliferates. There could be no predators, for example, until there were creatures to prey upon. Intestinal parasites could not develop until animals developed intestines. Bark beetles could not exist without bark for them to drill into.

Human simplifications reverse negentropy. This makes them profoundly anti-life. Note, however, that it is the *simplifications* - not the technologies - which are referred to here. To state that agribusiness (or forestry, or markets, or urban sprawl) is anti-life is itself a simplification. It is possible, for instance, to conceive of large-scale agribusiness based on sound ecological principals. Though nothing like that exists today, there is no compelling reason why it could not. It is *the way we do agribusiness* that has been creating problems, not the concept of agribusiness itself. As we seek to dig ourselves out of the hole we have dug ourselves into, it is important to keep the true character of the hole clearly in mind.

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8. *The first rule of intelligent tinkering is to keep all the parts*.[3]

No one who has dismantled a wristwatch or a car engine would expect it to run right again if, before reassembly, they threw a few random parts out of the window. Why should we be surprised when the biosphere acts the same way? The machinery of life is resilient, robust, and redundant in the good sense of that word: there are usually alternate pathways for accomplishing its necessary work. But the statement at the head of this paragraph, which I have intentionally misquoted from Aldo Leopold (the "cogs and wheels" he wrote of in his essay on "The Round River" no longer have much meaning in a microchipped society), continues to be fundamentally true.

Since the dawn of agriculture, the human race has been engaged in an aggressive makeover of biotic systems. Most of this makeover has involved simplification: the diversity of natural systems has been replaced by monocultures, the natural fluctuations of streamflow and rainfall have been smoothed out, and predator/prey relationships have

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[3] Paraphrased from Aldo Leopold, *A Sand County Almanac: With Essays on Conservation from Round River* (Oxford University Press, 1966), p. 190. The original quote reads, “To keep every cog and wheel is the first precaution of intelligent tinkering.”

been thrown out of balance. Even the sequestering of carbon in stone - a fundamental geological process - has been interrupted through the mining of coal and the pumping of oil and the quarrying of limestone. Until recently, this vast, uncoordinated, and largely unregulated experiment has at least been operating in the presence of control areas - large portions of essentially unaltered and unsimplified landscape within which the old, evolved patterns continued to operate. That is no longer the case. Human-caused ecological oversimplification is now found almost everywhere on the planet. One can hardly blame the preservation movement for wanting to build walls around the few small samples that still exist.

But this approach is fundamentally wrong, at least from the standpoint of biotic health. What are needed are not controls in the scientific sense, but controls in the governing sense. We already know that the experiment is a failure. We can read the results in the thinning ozone layer, in the collapse of the world's fisheries, in the exploding numbers of deer in suburbia. The machinery is out of kilter. We have rearranged the parts and thrown a fair number of them out the window. It is time to call a halt to the simplification process and begin the slow, difficult task of recomplicating.

Wilderness can help teach us the patterns for this, but it is no substitute for it. The work is most desperately needed, not in the wild, but in cities and on farms and in managed forests. Science has a fair idea of what is needed to get the machinery running smoothly again in these places. What is missing is the will - and that is true both of those who see nothing wrong with the current shape of the built environment and those who would have us abandon it.

Pure preservationism is a dead end. We cannot stop human tinkering, and there is nothing really wrong with tinkering, anyway. But Leopold was right. We need to make certain, as we tinker, that we don't lose anything. The object of intelligent tinkering, after all, is not just to mess around with machinery. The object is to keep the machinery running properly. And for that, we really are going to need all the parts.

III. On Natural Law

9. *The natural world does not pay attention to human rules*.

The natural world follows its own path, governed only by natural law. Human laws, human ethics and morals, and human desires have no more relevance to nature than a daisy has to an advancing bulldozer.

Preservation preserves nothing if it is not done in accord with natural law. Progress cannot progress except in accord with natural law. Human laws that are out of step with natural law are merely mischief; no matter how well-intentioned, they will always end up doing more harm than good.

When predator pressure is relaxed, prey populations grow. When a population exceeds the carrying capacity of its environment, the environment is degraded and the death rate of individuals within the population increases via starvation and disease until the size of the population drops back into balance with its degraded environment. To ban all deer hunting, therefore, is to condemn more deer to death than would die in a well-regulated hunt. But what is true of hunters and deer is also true of deer and browse plants: when browsing pressure is relaxed, plant populations grow. These can also exceed the carrying capacity of their environment, crowding out nonbrowse plant species and depriving the soil of nutrients. Such results follow implacably and inexorably: the natural laws that cause them cannot be overridden by the human laws that we pass. Anti-hunting laws are the biological equivalent of laws allowing unrestricted hunting: both lead to higher death rates, a depressed population, and a damaged environment.

Too much human activity - road-building, fire suppression, clearcuts - creates changes that damage the landscape. But it does not follow that eliminating all human activity leaves a landscape unchanged - or undamaged. Change always occurs, and it always follows the laws of nature. The changes that occur when humans withdraw completely from a piece of forest land are seldom as dramatic or damaging as those that occur where human presence lies too heavy, but they are not negligible. Underbrush increases; trees crowd each other; tree growth is depressed. Scenic beauty disappears, and catastrophic fires become more likely. The laws of nature are not there for our benefit only, and they do not always act on our behalf.

When King Canute tired of fawning courtiers telling him that his rule should be absolute, he commanded the tide to stop rising. Its failure to do so showed - as Canute meant it to - that certain things were beyond his control. Modern-day rulers can no more stop natural processes or suspend natural law than Canute could, but that has rarely stopped their courtiers from demanding that they try. The laws that result from these demands are unsuccessful in direct proportion to the extent that they ignore natural law. If they do not simply ignore it, but attempt to countermand it, they will not only be unsuccessful, but counterproductive, often leading - directly or indirectly - to the precise results that they claim to seek to avoid.

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10. *Natural law does not change*.

The rules the universe operates by today are the same as those that were active when the universe was young. The rules are the same in the city as in the deep wilderness; the same in the desert as at the bottom of the ocean. They are independent of what we think and of what we do.

This principal, known as *uniformitarianism*, is usually associated with geology - specifically, with James Hutton and Charles Lyell, whose work at the close of the 18th century and the beginning of the 19th demonstrated that the shape and structure of the earth could not be adequately explained without the consistent application of natural laws through long periods of time - but it is equally valid in other fields. It appears to be violated at the scales of the very large and the very small, but this variation is probably due to the presence of other, equally consistent laws whose actions have so far gone undetected, not because they do not exist, but because their effects on everyday-sized objects are immeasurably tiny.

Uniformitarianism precludes magic, whether it be of the occult, New Age, or Biblically miraculous variety. Effects must be consistent with causes. It precludes anthropocentrism: the laws of nature do not operate differently for the human race, nor adjust themselves conveniently to what we want them to do. It does not preclude religion, but it does preclude idolatry, orthodoxy, fundamentalism, or any other form of religious belief that limits inquiry or that claims to nullify or transcend the discoveries of science. It extends across disciplines. The rules of physics and faith and economics and population biology must be fully consistent with one another. Different viewpoints do not create different realities, and any delusions we have to that effect can only lead to more delusions.

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11. *Nature is fundamentally fractal*.

It is also fundamentally chaotic. It follows a mathematics we were totally unaware of as recently as 1963, and much of what we thought we knew has had to be looked at all over again in the light of our new understanding. The old theories are not necessarily wrong, but they are right for what have often proved to be the wrong reasons. As a result, predictions based on them are often faulty. The future we see today is a much more complicated and uncertain place than the one we saw before 1963, and is likely to remain so. It is, in fact, *inherently* unpredictable - a result that follows from the mathematics of fractals and chaos, which we now know come closer than any other mathematics yet developed to properly describing reality.

Fractals and chaos are closely related concepts, and cannot adequately be understood apart from each other. Though the mathematics can get quite complicated, the basics are not hard to grasp. A fractal is a figure whose structure is similar at any level of magnification. Think of a cherry tree, for example: it may appear to branch in a very complicated manner, but all the branchings arise in the same way. The trunk splits into main branches, which split into sub-branches, which split into branchlets, which split into

twigs. Examine any of those splits, and - apart from size - you will find it virtually identical to any other. Even the angles which they form are the same (and are characteristic for each species). Or think of the braided delta of a river. Its overall shape follows the same pattern as the shape of each small portion - so much so that, on seeing a photograph, it is often difficult to tell whether you are looking at rivulets in a delta sandbar, or the entire delta, seen from space.

Chaos is the mathematics that governs the overall shape a fractal will take. But it is also much more than that. It can be used, for example, to describe patterns in time as well as in space. Weather is a chaotic system. So are population growth, national economies, and the flow of water through channels. The equations that describe these systems, when graphed, form mathematical objects called "strange attractors." Strange attractors fall into several different classes, but one thing they all have in common is *nonlinearity*, a term used by mathematicians to describe equations in which the results are not always proportional to the inputs. Nonlinearity is dealt with at length in the next section; here, the important thing to note is its *lack of predictability.* Predictability is based on proportionality. If I know the diameter of a circle I can predict its area, because area is proportional to diameter. If I know the weather all over the planet today, I cannot predict it for this time next week, because the weather next week is not proportional to the weather today. It is not simply that weather equations are complex, but that they are nonlinear. Modern computers can deal with complexity. They cannot produce proportional outputs from nonproportional equations.

The implications of this for environmental management are profound. If nature is fundamentally fractal and fundamentally chaotic, it means that the results of any changes we introduce into natural systems are fundamentally unpredictable. All of our acts will have unintended consequences. These may be benign, or they may be disastrous; there is no way of predicting which. We may spot trends; we cannot tell where the trends are taking us. Therefore we should proceed with great caution. We should not suspend change - in fact, we cannot; to live at all means to change something - but we should always watch what changes concurrently with the changes we introduce, and we should always be prepared to adjust what we are doing in order to mitigate the effects of changes that we cannot predict. Unintended consequences are often larger than the changes we intend. We can learn where they will occur; the shapes of strange attractors are, after all, groupable by type, and are closely similar within type. What we cannot predict is their magnitude, and the magnitude of the changes that they will cause elsewhere. Therefore we should move slowly and deliberately, in small, preferably reversible stages. Change both purrs and bites. Understanding chaos will help us prepare us for either one.

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12. *Nature is nonlinear.*

Nature’s music moves to an irregular beat. Changes in the outputs of natural systems are not necessarily proportional to the inputs that caused them, nor are they necessarily predictable. They are not random: they remain bound by the laws of cause

and effect. But the scale of an effect is not necessarily the same as the scale of the event that caused it.

This is not a refutation of uniformitarianism. Given exactly the same initial conditions and exactly the same inputs, a system will always produce exactly the same results. This principle remains true. The trouble is that the initial conditions and inputs of natural systems are never exactly the same. The temperature may be a tenth of a degree off, or the time may be a day later in the season, or the yellow flowers laced through the grass may be birdsfoot buttercups instead of western buttercups. The squirrel may choose acorns one day and hazelnuts the next. None of these differences is significant in itself. Their importance is dynamic, not static; it lies in their roles as parts of a nonlinear system. Whether the number of deer mice in a meadow is twenty or twenty-one may not seem a question of earth-shaking importance. But if all the descendants of that one extra mouse were to survive, there would be 200,000 extra mice by this same time next year.

The nonlinearity of natural systems is a recent discovery. Until the last third of the twentieth century, linearity was treated as a given. The earth moved majestically - and steadily - around the sun. Temperature was proportional to the tilt of the planet, evaporation was proportional to temperature, rainfall was proportional to evaporation, plant growth was proportional to temperature and evaporation and rainfall. Everything was proportional to something. Nature was a neat, orderly system, as tidy as a deacon's parlor. To gain control of the results, it was sufficient to gain control of the major variables. Small errors in input could be ignored: if output was proportional to input, errors in output and input would be proportional as well. The only important exceptions to this, in theory, were threshold cases. These were epitomized by the straw that broke the camel's back: the load gradually increasing in small increments until the final increment pushed it above the camel's weight-bearing capacity. Such cases were only nonlinear if you looked at the wrong thing. It wasn't the weight of the final straw that drove the camel to its knees, but the accumulated weight of the entire load. Effect was still proportional to cause. A kingdom could be lost for want of a horseshoe nail, but each loss along the way - nail, shoe, horse, rider, battle, kingdom - was proportional to the earlier loss that gave rise to it.

One of the first cracks in this comfortable system came in the study of weather. Early meteorologists believed that if they gained a complete enough understanding of atmospheric cause and effect, they would be able to confidently predict the weather weeks, or even months, in advance. That was before they worked out the equations which appear to best describe atmospheric dynamics, and discovered that a fair number of them were nonlinear. Tiny variations in the values of the variables would lead to wild gyrations in the value of the results. Predictability was a chimera. You could refine the range of probabilities, but you could not eliminate the possibility of the improbable.

Another early casualty was population biology. The basic equations governing population size had been known for a long time, but it hadn't been understood that they were nonlinear. As the study of nonlinear systems advanced, though, the characteristics of population equations became more clear. These equations are, in fact, l*ogistical humps* - a

specific type of strange attractor, the odd mathematical objects described in the previous section. While numbers remain small, logistical humps function in a linear manner. As inputs grow large, though - as they must, in large populations - chaotic conditions come into play. A very small change in the variable describing average fecundity may cause the population to swing from rapid growth to precipitous decline. Biologists used to puzzle over animals such as lemmings and voles, whose populations bloom and crash in roughly three-year cycles. They looked, in vain, for matching cycles in predator numbers or weather or sunspots or nutrient levels in the animals' food. They found nothing, because there was nothing to find. The bloom and crash were inherent in the animals' numbers and reproductive rates.

As the lack of predictability in weather and population size was factored into equations in related fields, these related fields became unpredictable as well. Other areas of unpredictability were also discovered, in areas as seemingly distant from one another as fluid dynamics and the growth patterns of limbs on trees. It is now suspected that nature is *comprehensively* nonlinear. Its behavior is predictable only over short periods of time. We inhabit a universe of fractals and strange attractors, and though we may guess what our lives may be like ten years hence, it is impossible to know, with any certainty, the outcome of even the next five minutes.

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13. *Natural boundaries are always blurred.*

Nature's map is drawn with broad brushstrokes: it is impossible to discover where one type of landscape stops and the next one begins. Desert grades imperceptibly to grassland, grassland to woodland, oak forest to mixed conifer/maple to taiga. Even the water/land interface is imprecise: waves roll up and down beaches, beaches move, rivers alter their courses or overflow their banks or fade to a warm trickle in the summer sun. And the wind blows over all, carrying dust, water vapor, plant spores, pollutants, insects and birds everywhere it goes. Living things cross such indefinite boundaries as exist with near-complete impunity. Animals roam at will wherever they can find footholds; plants cast their seeds across entire landscapes via wind or water or fur. If conditions are even marginally adequate where a seed finally settles, it will sprout; if a group of such wayward plants provides a proper habitat, animals that like it will find it. In this manner, biomes crawl across the face of the planet. All landscapes are constantly in danger of becoming something else.

In the high desert landscape of southeastern Oregon, amidst millions of dessicated acres of sagebrush and sand, there is a small, anomalous woodland known as the Lost Forest. Big Ponderosas raise their orange-plated trunks to the sky over a typical pine-forest understory of wiry grasses and wildflowers, oblivious to the sands that blow in from the large dune field just to the west. Though scientists have studied them, no one yet knows precisely how these trees got here, or what keeps them defiantly alive. Some trick of the water table; some microclimatic shift; some magic of questing root or drifting vapor. Some blurring of boundaries. Is this a desert? Yes. Is it a forest? Yes. It is both of these things at once. It is not always possible to look at the world through one lens only.

Because natural boundaries are blurred, human-made boundaries are porous. A line drawn around the Lost Forest must necessarily include some sand and exclude some trees - if not when it is drawn, then certainly a few years later. Wilderness boundaries can ban loggers and restrict human visitors, but they cannot ban fire or restrict bears. Factory smokestacks in Ohio can poison zealously protected lakes in Vermont. We cannot stop these things by drawing boundaries. If we wish to protect wild places - and by all means, let us do so - then we had better abandon our present boundary-dependent tools, because they are an ill match to the task at hand.

Let us stop fooling ourselves on this point. Boundaries are useful for helping to determine where problems and opportunities lie, but they are next to useless for actually solving the problems or taking advantage of the opportunities. You cannot protect nature with tools that ignore or run counter to the principles by which nature operates. As long as we insist that the rules can be changed by a line we draw in the dirt, environmentalists will share the same self-deceiving worldview as the property-rights advocates - and will run the risk of doing every bit as much mischief to the environment we are trying to protect.

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14. *Change is inevitable in natural systems*.

Life is defined by process: the inhalation and exhalation of the breath, the pulse of blood through the veins, the constant motoric rhythm of the Krebs cycle. Organisms are born, grow, and die; rivers and winds shift course; the seasons sweep past. The long dance of the continents continues in imperceptible steps to unimaginably slow music. The planet constantly reinvents itself; each breath you take fills your lungs with a new atmosphere bathing a new and different world.

We know we are alive by the changes we see. The sun rises and sets; leaves spring forth in April and fall again in October; orchards bear, flowers bloom and die, friends and loved ones move in and out of our lives. Life cannot be separated from change. Metabolism churns away within each cell; hair grows; flowers bloom and fall. The organism ages. When change stops, the organism dies. A stuffed owl in a taxidermist's shop may look alive at first glance. We know it is dead because we never see its eyes move.

The same truth holds for ecosystems. Biomes expand, contract, and shift their composition; species radiate into new species. Each organism, like each cell in the body, runs through its own metabolic cycle, separate but tuned to the rest. Ecosystems expand in youth and contract in old age. They jostle one another for space. It was once believed that ecosystems tended toward stability; that they worked from bare earth through pioneer and sere to a climax condition that, once established, could maintain itself for millenia. We know now that this model is false. There is no climax: there are only seres. The system is constantly in flux. A tree toppling over, or a year of less than normal rainfall, will start small changes which elaborate themselves rapidly over the landscape. Nature seizes every opportunity for change. The god of preservation is a false god: there is

nothing to preserve. Draw the boundaries, walk away, and within months - even within hours - the thing you thought you had saved is gone. Wild tied down by bounds is no longer wild. As with a stuffed owl, we never see its eyes move.

But development is a false god, too. It is, in fact, the same false god as preservation; it is only the form of worship that has changed. Like preservation, development postulates a static universe. In the developer's world, as in the preservationist's, effects stop at borders: once the surveyors have done their job, what is done to one plot of ground has no bearing on what is done to the plot next door. Few will argue that there should be no wilderness, only that the wilderness which already exists is "enough." Enough for what? Not enough for recreation: our overcrowded wildlands give the lie to that. Not enough for wildlife, whose populations bulge, shrink and shift in total disregard of lines on the map. Not even enough for development, which depends - far more than most developers realize - on the services provided by wild nature. Clean air; clean, adequate water supplies; protection from erosion, and from wildfire, and from flood: all of these things depend upon an adequate supply of undamaged landscape. Even economic stability depends, to a very large degree, on the availability of wildlands. Thoreau was correct: *A town is saved, not more by the righteous men in it than by the woods and swamps that surround it*.[4]

Pinning down the land does much ill to Thoreau's vision, whether the pinning is done by concrete or by boundary lines. The changing lives of woods, swamps and towns alike demand the protection of all three but the preservation of none. The test of new conditions, whether imposed by nature or by humans, should be the same: *is the land no worse?* Improvement is a change; so is deterioration. The question is not whether or not we should prevent change from occurring, but on which side of the semicolon in that last sentence the change predominantly lies.

Much of this may seem self-evident, but we are in constant denial of it just the same. We cling to the myth of permanence. In this myth, we are the only ones who change: everything else stays the same. The same trees line the same streets as in our childhood; the paint remains fresh on the fences; taxes and salaries hold steady, the snow still falls in winter, the same summer trails lead through the same forests to the same lakes. In our hearts we know it for a myth, but such is its hold on us that it shapes our actions and our vision even when we know better.

And so we react to change by trying to change it back. Or, knowing this for the failed strategy that it is, we try to freeze all further change, drawing a line in the tide and pinning our boats to it even as the rising sea threatens to engulf them. The line we draw depends on what we value. Those who value wild places draw it there, "preserving" wilderness which nevertheless, in obedience to time and natural processes, continues to alter irrevocably with every moment. Others may value the axe their fathers swung, and

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[4] Henry David Thoreau, “Walking” (Atlantic Monthly, June 1862); excerpted in Chris Anderson and Lex Runciman, A Forest of Voices: Reading and Writing the Environment (Mountain View, California: Mayfield Publishing Co., 1995), p. 346.

the line they draw is an arc within which to swing, even though the space for swinging has shrunk into minuscule irrelevance. Still others may hold to taxation levels which have not kept pace with population density, or to egalitarian ideals hung up on the shoals of human differences. In all cases, the principle is the same. Change is an ogre to be slain, no matter what the consequences may be. Down goes the gauntlet, out come the banners, and your idea of permanence battles mine in an orgy of mutual self-denial.

At what cost? Change happens anyway; we cannot prevent it. The only thing our efforts accomplish is to put us out of step with the rhythm of the planet. Life goes on, and we wonder why we are less comfortable. We may feel that time has run over us, and in fact it has; but that is not time's fault. If we are steamrolled by change, it is not because the world is moving, but because we are standing still.

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15. *All species are exotic in the beginning*.

Every creature - every animal, every plant, and every microorganism - arrives first as an interloper. The organisms that we call "native species" are merely those which happen to have been there the longest.

New lands are blank slates. They rise from the sea or appear from beneath the ice or emerge from the bowels of the earth as raw, sterile rock. Life comes later. It arrives first as pioneer species - those which can endure the unshaded sun and take advantage of tiny inblown pockets of soil, or do without soil altogether. As these rugged, individualistic creatures adjust to each others' presences, communities develop. Communities imply niches; in pioneer communities, many of the niches are empty. Niche-occupiers appear to take advantage of these opportunities. Soil is built up. In remarkably short order, lands born naked are clothed with complex, mature ecosystems. The ecosystems are well fitted to the lands that grew them, and they may be unique, but they are not composed of unique organisms. With the rare exception of the species which still lives only where it evolved, each family line in any local community originally arrived from someplace else.

The process is not generally a smooth one. Each species, as it arrives, must find its own niche. This requires adjustment on the part of the other species present. They must move over to make room. A bumping process ensues. The new species may take advantage of the unrest it has caused and attempt to grab extra niches. Its population may swell to quite astounding numbers. But variety always prevails in the end. If it did not, the rich complexity of living systems the Earth enjoys could never have developed.

What has been just outlined is taught in ecology courses as "natural succession." It moves through recognizable stages of steadily-increasing complexity, called *seres*, toward a final, stable stage called the *climax*. Ecologists once believed that climaxes were the norm unless humans interrupted them. This would require much more stability than actually exists anywhere on the planet. Climates grow hotter or colder, fire sweeps through, winds lay forests flat, floods cover whole landscapes with fresh, bare soil.

Change, not stability, is the norm. New arrivals and the adjustments they require are a regular, steady occurrence.

This does not mean that we should remain unconcerned about exotic species, but it should enlighten our attitude toward them. Exotic species which invade an area are only doing what every species present in that area has already done. They are not evil interlopers. They may wreak havoc for a while, but the havoc will eventually settle down. Our best approach is not to eradicate the invaders (which is rarely successful, anyway); our best approach is to help the adjustment process along. We may wish to protect some of the more vulnerable earlier arrivals by establishing refugia for them, but this is usually only a temporary necessity. After the new arrival is acclimated into the system and the checks and balances for it have been established, the old species can emerge from their sanctuaries and regain some of their old turf.

As I write this, Lake Erie is being overrun by zebra mussels. They arrived from the Baltic Sea in ship ballast water in the late 1980s and rapidly made themselves at home, covering vast areas of the lake's bottom by the mid-1990s. The lake's native mussels have been largely unable to compete, and most of them have disappeared. The zebras have thrived. I have seen their shells on the shore, thumb-sized and thin-walled but in such numbers that they cover whole beaches two feet deep. They tinkle when the surf rolls in. I can understand the desperate desire on the part of Lake Erie residents to *do something!*

But zebras are not the first new species in Lake Erie's waters. In fact, every species there has arrived within the last twelve thousand years - *because the lake didn't exist before that time*. The ecosystem is young. That means it is subject to severe swings. But it also means that the swings will damp out rapidly.

Forty years ago, the species of concern was the alewife. These small fish also came in with human assistance - through navigation canals - and they also made themselves at home. Alewife populations then became as high as zebra mussel populations are now, not just in Lake Erie but throughout the Great Lakes system: at one point, over 90 per cent of the fish biomass in Lake Michigan was estimated to be alewives. I saw those on the beaches, too - small black carcasses piled along the surf line, so numerous that most dried before they could decompose or be eaten by scavenging animals.

Alewives are still present in the Great Lakes today, but the windrows on the beaches are gone. Another introduced species, Chinook salmon, prefers alewives as prey and avidly hunts them. Sportsmen avidly hunt the Chinook. The concern, today, is not too many alewives, but too few. Without them, the salmon fishery would fade away. In some areas of the Great Lakes, managing habitat to increase alewife numbers is now an established practice. Like other, earlier invaders which have survived, it now has a new name. It is called a resident.

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16. *Nature abhors zero.*

This proposition is more commonly stated as "nature abhors a vacuum," but "zero" is a better characterization. Emptinesses of any kind - physical, biological, ecological, sociological - always tend to fill.

In the physical world, the filling process usually takes place through *leveling*. Gases flow from greater to lesser density; water flows downhill; the walls of wells collapse. Mountains become hills and then plains. Non-physical holes may fill through leveling, as well - that is what causes forests to spread into grasslands, or populations of blackbirds to distribute themselves relatively evenly through a field of cattails - but when holes are non-physical, *creation* also becomes important. New species may evolve to fill empty ecological niches. New ideas may take root in ideologically empty societies. It is unimportant to nature what form the new species or the new ideas take. The important thing is that the holes get filled.

It is this seek-and-destroy attitude toward zero which is behind the explosive growth of exotic species in new environments. The frightening speed at which zebra mussels have colonized the Great Lakes, or star thistle has spread through pastures in the West, can only have taken place because there was a zero to be filled. Competition is part of the picture, but not in the way that is usually thought. It is not so much species competing for niches as it is niches competing for species. When species compete for niches, the result tends to be a slow dance of give-and-take across the landscape. When niches compete for species, the result can be a surge.

Niche competition (as opposed to species competition) takes place because of zeros. One niche has an empty space in it: an otherwise similar niche does not. The invading species exploits that empty space, and as a result it gets a competitive edge. Zebra mussels have thrived in the Great Lakes partly because of our success at cleaning them up. The changes in chemical balance and water clarity that resulted from this cleanup, especially in Lake Erie, brought with them changes in the types of plankton that inhabit the water. This created a niche for a new type of plankton-eater. What *could have* happened was the invasion of a specialist in the new types of plankton, or an extension of the diets of the plankton-eaters already in the Lakes. What *did* happen was the invasion of a generalist which could thrive on both the new and old plankton species. The generalist niche outcompeted the specialist niches. There were human hands involved - that is how the plankton changed, and how the zebras got into the Lakes. But it was the existence of a zero - an empty space in the niche structure - that created the frighteningly rapid turnover from the native uniotid mussels to the encrustations of zebras that have taken their place.

It is also, however, what will eventually save us. There is a new zero in the Lakes - the absence of a predator on zebra mussels. That hole will eventually fill. We may not wish to wait for it, nor may we wish to risk the extinction of native mussel species while we wait; but the hole *will* fill. Something will find it. As long as nature abhors zero, it is merely a matter of time.

Environmental management is best thought of as techniques for managing zeros. We should try to keep them from cropping up, and when they crop up anyway, we should find the most benign way possible to fill them. If we choose the wrong way, we may

inadvertently create new zeros, and something always comes along to take advantage of that. In the battle of competing factors, the only thing that we can be sure will always prevail is nature's abhorrence of zero.

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17. *Life is interdependent*.

We inhabit a system, not a random collection of parts. Our dependence on other living things begins with the air we breathe, a remarkably stable mixture of gases whose oxygen content is determined largely by the exhalations of plants and microorganisms. It extends to the water we drink - which all creatures must share - and to the food we eat, which is almost entirely the product of life. Whether steak-lovers or strict vegans, we are kept alive by the lives and deaths of others. Until and unless our bodies manufacture their own chlorophyll and grow roots to the soil, that is the way it is going to have to be.

But plants, too, depend on other living things, and the web of dependencies of which we are a part is much more complex than simple production and predation. It is a structure of enormous subtlety and variety whose links weave around constantly in unexpected directions. There is no such thing as independence in nature. Everything connects to everything else.

A simple example pointed to long ago by Charles Darwin is the dependence of English clover on cats. Clover is pollinated primarily by bumblebees. Bumblebees live in individual burrows, not hives, and the mother bee must care for her own eggs and larvae if they are to survive. But the mother must also forage for food, and while she is away from the nest the eggs and larvae are easy prey for mice, which relish them. Cats keep mouse numbers down, which keeps bee numbers up, which allows clover to be pollinated. Having pointed this out, Darwin proceeded to take the chain one link further. Clover, he pointed out, was a primary food of dairy cattle. Thus, in the England of Darwin's day, a dairy farmer who wished to stay in business would make certain that bowls of milk were left out to attract stray cats. The milk, of course, came from the cows. The links led around in a circle; break it at any point - remove cows, or clover, or bees, or mice, or cats - and all the rest would suffer as well.

Of course, it wouldn't have to be cats. Weasels would work just as well, or owls. Or even mousetraps, if lethal enough. This is not beside the point, but part of it. Stable systems are redundant: there is always more than one way to accomplish any given task. A richly interconnected system can survive when individual links are broken, because pathways can be found or created around the breaks. Simplify the system, and you reduce the number of alternate pathways. That is why biodiversity is so important. When a species goes extinct, it is not the loss of the species itself that is critical: it is the reduction of complexity. The web of life connects us all. Every part lost is a threat to every other part. If you protect spotted owl habitat, you do not merely save the spotted owl; you also save yourself.

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18. *When we try to pick out anything by itself, we find it hitched to everything else in the Universe*.[5]

This statement by John Muir is still the best one-sentence definition of ecology every written. Nothing is separate; everything is part of the web. Connections are as important as the objects they connect. Another John, John Donne, had written famously a quarter of a millennium earlier: *No man is an island, entire of itself; every man is a piece of the continent, a part of the main; if a clod be washed away by the sea, Europe is the less, as well as if a promontory were, as well as if a manor of thy friend's or of thine own were*.[6] Muir extended that vision to all of life.

Taking Muir's statement seriously - or Donne's - doesn't mean refusing to do anything that would affect the web. That would paralyze us into inaction: *everything* affects the web. Clods are washed away by the sea all the time. Damage should be avoided, but we have to be careful about how we define "damage" so that our attempts to avoid it don't create more problems than they solve.

Our experience with wildfire should be instructive in that regard. Protecting forest damage through fire suppression leads inevitably to more damage later, as fuel buildup creates hotter fires that become impossible to suppress. A forest that has not burned in its proper cycle is also brush-choked, ugly, and unhealthy. The "damage" caused by natural wildfire turns out not to be damage at all, but a necessary link in the web.

A deeper understanding of what Muir and Donne said leads, not to inaction, but to a broader view of the consequences of action. If everything is hitched to everything else, random prodding of things close at hand is probably not a good idea. Neither is a narrowly linear view of action/reaction chains. The tunnel vision of those engineers who see only that, if they block a river, water will rise behind the blockade, must be replaced by a vision that sees *all* the consequences of blocking a river: the reduction of downstream silting and scouring, the loss of riparian habitat above the dam and the alteration of it below, the tectonic effect of the water's weight, the chemical and ecological differences between running and still water, and a thousand other things, big and small, which will inevitably begin to flow when the water stops flowing. Knowing these results in advance does not necessarily mean we will not block the river. It does mean that we will have the opportunity to put the decision regarding whether or not to block it on a sound ecological basis. That is what we really need: not human actions stopped entirely, but human actions taken on a sound ecological basis.

If everything is hitched to everything else in the Universe, everything we do affects everything else in the Universe. That applies to not-doing as well as to doing. Inaction can have as serious consequences as action. Donne, who was a theologian as well as a poet, would have muttered something here about sins of omission being as

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[5] John Muir, *My First Summer in the Sierra* (San Francisco: Sierra Club Books, 1988), p. 110

[6] John Donne, "Meditation," 1623

dangerous as sins of commission. Good ecological understanding helps us avoid both. We do not necessarily keep either the clod or the promontory from washing away, but we do come to understand that, of the two, the clod is sometimes the more important.

IV. On Humans and Natural Law

19. *Humans remain subject to natural law.*

It is a foolish delusion to state that our comfortable modern civilizations have "conquered" nature; it is equally foolish to state that loggers, dam builders, capitalists, and the rest of the pantheon of environmental devils have "destroyed" it. Nature can neither be conquered nor destroyed. Living systems can be modified, thrown off balance, even wiped out: but these results stem from the *operation* of natural law, not its suspension or eradication. If we define "nature" as those areas where natural law is allowed to operate unfettered, then nature is everywhere. We may not like the form nature takes in a clearcut or a drained wetland or a housing development, but to call these places "unnatural" is to seriously miss the point.

I am not suggesting that we should rush to preserve clearcuts and subdivisions as legitimate expressions of nature. But we ought to recognize that nature is not banished from these places; it is merely proceeding, implacably and single-mindedly, in a direction we don't like. When we clearcut a hillside, it is natural forces - gravity, erosion, saltation, hydraulics - that muddy the streams and flood the downstream communities. When we destroy habitat, it is natural forces - niche competition, predation, environmental resistance, food-web dynamics - that simplify the remaining ecosystems and drive some creatures to extinction. The problem is not that we have eradicated nature; the problem is that we have proceeded as if we could.

Assuming that some natures are more natural than others is one of the great overriding delusions of our time. The laws of physics do not overrule the laws of biology - as dearly as some engineers might wish this - nor do the laws of ecology trump the laws of economics, despite the fervent attempts of some environmentalists to convince us that this is so. The laws of physics and biology and ecology and economics - and chemistry and sociology and astrophysics and all the rest - all describe the same central reality, and if laws from two of these disciplines appear to be in conflict with each other, either the conflict is illusory or at least one of the laws is. Truths are not true if they cannot coexist.

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20. *Nature's beneficence toward us is not a given*.

There is nothing in nature’s rule book which states that one species must be favored over all others simply because its brain is larger. We have thrived because we fit a broad niche very well. But the fit will last only as long as the niche does.

For ten thousand years, nature has been treating us with extraordinary kindness. The ice that once covered much of the Earth's surface has melted back, and the climate has moderated: this has given us both room to expand and a temperature range that favors expansion. At the same time, winter snows have continued to accumulate in the higher mountains, assuring steady summer streamflow in most of the rivers we depend upon. Grains and animals that we like to eat have proved amenable to domestication, increasing both the stability and the total size of our food supply. We have had willing draft animals

and, more recently, a vast supply of fossil fuels available to augment the strength of our own muscles. The crust of the planet has given us large amounts of copper for electrical conduction; iron, wood and stone for structural strength; chrome for durability; silica for transparency; and much else that we have needed in order to create a complex technology. Water stored in aquifers has waited, sometimes for millions of years, for the wells and pumps which make the desert bloom. The thick, dark miracle of the soil has accumulated, grain by grain, over the long eons since life began. We have been granted Eden without the expulsion. The flaming sword has been quenched, and the Gardener has given us free access, to cultivate and enjoy as we will.

But this bounty has not come with a guarantee. It is neither infinite nor permanent: it has limits. The window of friendly climate will someday shut; the Earth's storehouse of materials will come up empty. This is not a doomsday prediction, only a recognition of reality. No age lasts forever. The conditions that have so favored our species have not been present for most of the Earth's long past, and cannot be expected for much more of its future. No angel will chase us from the Garden; the Garden itself will do that. Other niches will expand, and ours will shrink. That is the way Nature operates.

Against this insecure and certain future, we have three choices. We can hoard; we can squander; or we can husband. None of these approaches is inherently wrong. They will, however, lead us in three very different directions.

Squandering will allow us to continue to enjoy the Earth's bounty to the full, but only for a very short time. Nature will continue to seem extremely kind to us until her bounty runs out; then she will be perceived to have suddenly turned cruel. The race will rapidly die back with its niche. Its remnants will hang on in an impoverished state by crowding into niches our species is less well adapted to. This is the world the developers among us are leading us toward.

Hoarding will preserve the Earth's bounty as long as possible, but at the expense of current generations. Our niche will remain, but we will have removed ourselves from it insofar as possible. Hoarding will make the hoarders comfortable, but they are always in the minority. For the rest of the population, the results will be the same as though the planet's resources had been squandered. This scenario, which has Nature trying to remain kind to a race which refuses her kindness, lies at the end of the path the preservationists among us would prefer to choose.

Husbanding lies between squandering and hoarding. It cuts down the flow of resources, but does not cut them off; it enjoys the Earth's bounty, but takes care not to enjoy it too much. It is not a perfect solution; it still depends heavily on the kindness which Nature is in the process of withdrawing. But it neither destroys our niche nor leaves it unused; instead, it strives to use that niche carefully as long as it remains.

We cannot assume that Nature will continue to provide, nor can we decide whom it should provide for. Nature is not ours. Our best course is to watch the changing

boundaries of our niche, and make certain that we do not try to live too far outside them - or pull back too far within.

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21. *The climate we currently live in is a historical accident*.

The Earth has been both much warmer and much cooler in the estimated 4-1/2 billion years of its existence. During parts of that time, ice has covered much of the planet; during other parts, flowers have bloomed in Antarctica. Over the limited span of historic time, the climate has been relatively stable and relatively benign, and it is easy to assume that it will be stable and benign forever. This assumption is false. Any century - any decade - could see it change.

The annular layers of the Greenland ice sheet can be opened like a book, one page per layer; and from the ratio of oxygen isotopes to each other in the small bubbles of air trapped in the lower strata, it has proved possible to reconstruct the temperatures of earlier times. What has astounded the scientists involved in these investigations is not the range of temperatures discovered in their samples but the speed at which they change. The temperature drops which bring on ice ages, and the temperature rises which end them, can happen in as little as fifty years. Lands once green can quickly turn to desert; living forests can disappear beneath advancing ice. There are no guarantees. In such a world, agriculture must be a shifting phenomenon. Crops are highly climate-dependent; what works well in Texas today may be more appropriate for Nebraska twenty years hence.

Actually, even the "stable" climate since the last ice age has seen significant shifts. Several advances and retreats of alpine glaciers in Europe have been documented during historic times. Five thousand years ago, large lakes surrounded by forests and grasslands occupied what is now desert in much of western North America; geologists call these "pluvial lakes," a term reflecting their origin in periods of higher rainfall. From roughly 1430 to 1850, the northern hemisphere was caught in the grip of what has been termed the "Little Ice Age." Glaciers overran villages in the Alps; crops failed in North America. Norse settlers who had gained a toehold in Greenland perished when supply ships could no longer reach them. Early in this period, the culture of Mesa Verde went under. Ice clogged the Great Lakes: as late as 1820, when the cold was beginning to lessen, geologist Henry Schoolcraft recorded that the expedition he was accompanying to Lake Superior could not leave Buffalo until the ice had broken on Lake Erie, an event which did not occur until May 3.

Media and politicians today are locked in an argument over global warming. This argument has shifted in recent years: it is no longer about whether warming is occurring (with the ten warmest years in recorded history all coming in the last two decades, and with ice-free navigation now possible at the North Pole for at least a few days in some years, rising temperatures are no longer in serious doubt), but whether the overwhelming majority of scientists are right in saying that human activities have something to do with it. I am pretty sure the scientists are right, but I am also pretty sure that the argument is

beside the point. The important question before us is not who (or what) has caused temperatures to creep up. The question is how we adapt.

Among the many points raised for and against industrial agriculture, one issue you seldom hear raised is that it is not very movable. It requires an immense investment in time and money to put a typical American factory-farming operation together. Only a small portion of this goes into transportable equipment: the rest is in things like wells and canals and buried pipelines and fields carefully leveled to maximize irrigation and harvest efficiency. It is in the intricate infrastructure of railroads and grain elevators and banks and farm-implement dealers that interfinger with the farms, both supporting them and depending upon them. Above all, it is in the land. The average size of a corporate farm in America is approximately three square miles, and many are much larger than that. (In Arizona, for instance, the average size is nearly fourteen square miles). At current land prices, those three square miles are worth roughly $1.5 million. You cannot walk away from an investment like that, and you cannot take it along. If you are forced out by global warming, you can't sell it, either: since no one can make a living from it, no one will want to buy. Those who state that global warming will be fine because the farmers on the American Great Plains can just pack up and move to Alberta have somehow missed this very basic point.

Our ability to feed the teeming populations of the Earth is dependent upon agriculture molded to fit current temperature and rainfall conditions. Those conditions are changing. What on Earth happens now?

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22. *Human law is always subordinate to natural law.*

Always. There is no time - none - when the decrees of humans can change the means by which nature operates.

This seems self-evident, and to a degree it is. No one expects to be able to fly by declaring the law of gravity null and void, or to end a drought by means of a legal instrument compelling rain to appear. When state lawmakers, in an effort to simplify the lives of schoolchildren, pass a law stating that the value of *pi* shall henceforth be 3.0 - this actually happened in one Midwestern state a century ago - we laugh at their ignorance and continue to base our engineering calculations on the inconvenient but accurate value of 3.14159… followed by an infinite number of nonrepeating decimal places. Galileo, forced by the Inquisition to recant his heretical statements that the Earth moves around the Sun, is said to have muttered as he got off his knees, "nevertheless, it does move." Few people today would side with the Inquisitors in that particular debate.

Unfortunately, not every conflict between law and reality is quite that obvious, and all of us - not just the Creationists - are entirely capable of selective acceptance of the findings of science. We filter our thoughts through our belief systems - religious, ideological, or just plain idiosyncratic - and ignore, downplay, or dispute those facts and principles which fail to match up.

And so environmentalists and social reformers, buoyed by the best of intentions - humanitarianism, egalitarianism, an end to pollution and resource rape - attempt to outlaw the profit motive and the dynamics of supply and demand, which continue to operate anyway, with unanticipated but often disastrous results. On the other side of the table sit the free-marketers, who resolutely oppose on principle any controls over economic activity at all, including those such as trust-busting, advertising controls, and the regulation of natural monopolies - all of which are designed to hold human institutions accountable to the laws of economics, not to attempt to evade them. Monopolies damage markets, whether in the hands of the state (communism) or private individuals (capitalism). Misleading advertising distorts consumers' motives and therefore skews market outcomes, whether the advertisers' sins are of omission (suppression of competitor's views) or commission (outright lies). Free-marketers blithely ignore these truths because they run counter to the body of law which treats corporations as if they were individuals, a legal fiction every bit as contrary to reality as is a belief that markets don't find their own levels or that the Sun moves around the Earth.

Similarly ideologically-purified stands drive both sides of the debate between preservation and development, but in this case the ideological error is the same: a belief that humans stand aloof from natural systems. One side calls human interactions with the environment improvements and the other side calls them meddling, but both see them as an interaction between two dissimilar realities. The folly of acting on this belief was brought home to me succinctly by a wildlife preserve manager in Texas in the early 1990s, who noted laconically that he had "never seen a raccoon who could read the boundary signs." Animals, winds, smoke, seeds, and tectonic forces all flow across the earth in obedience to *their* laws, not ours. They pay no attention to the way we have divided up the planet, and their interaction with technology depends on what it does to them, not how we feel about it. A dam created by a landslide is more "natural" than one built by the Army Corps of Engineers, but both back up water in the same way. Whether they are good or ill, environmentally, depends on what that backed-up water does, not how it came to be there.

I do not mean to imply that the results of our actions are always fore-ordained. There are always multiple pathways in front of us, and nature does not demand that we pick any particular one of them. The choices are ours. The outcomes of those choices, however, will always unfold according to natural law, not in compliance with government dictates. If we wish to solve the problems of war, environmental degradation, economic justice, and human rights, that is the principle we must learn to play by.

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23. *Nature always has the last word*.

Law, technology, and other human factors are never more than brief digressions from the conversations the Earth has been holding with itself for billions of years; and if disagreements arise, the Earth is the final arbiter.

Yes, we can damage the environment. We have in fact done so - often, and at times severely. The physical scale of this damage may be immense. The time scale, however, is always human. Nature measures time in eons, and there is always plenty of opportunity to erase whatever we create. The Rockies will erode and bury Denver. Los Angeles will peel off of California and slide up the coast to Oregon. Nevada will slowly sink and become seafloor: the Sea of Cortez will finger northward and claim Las Vegas. None of this is idle speculation. These things *will happen*. The trends are already in motion. They may take millions of years, but mere millions mean little to a planet still young at 4.5 billion. We will follow the dinosaurs and the trilobites into oblivion, and our works will vanish, the terrible along with the great.

The long view of geologic time does not allow us to make light of human-caused ecological damage, but it does provide a change of perspective that may help us sort out what to do about it. Invasive species may be the best example. There are more than 100 species of animals and plants in the Great Lakes today which were not there when Europeans first arrived. Most are invaders from Europe, and we are right to be concerned about them. But this concern should be tempered by the realization that everything in the Lakes is an invader from somewhere. 10,000 years ago, there were no Great Lakes. Every fish, every invertebrate, and every plant in Great Lakes waters has arrived from someplace else some time since they were born at the end of the last ice age. All have eventually adapted to each other. It may be that we should spend less effort trying to prevent invasions (and to eradicate new species that have managed to slip through), and more time trying to encourage adaptations. Preventing change is always ultimately futile. Keeping change livable is a much more obtainable goal.

There are vast ruins in Yucatan, hidden in jungle. There are vast ruins in Egypt, hidden in sand. Both of these should give us pause. All human endeavors are temporary. Dams bury themselves in silt; cutover land regenerates, either as forest or as something else; climate changes whether or not we have a hand in it. Our job is not to deny change, but to anticipate it and to attempt to guide what we do so that both the changes we cause and the changes we cannot avoid have the least possible impact on our culture and on the planet.

Nature's last word is both a threat and a promise. It is a threat because, if we do not mind what we do, nature's reaction to it may well wipe our species out altogether, along with numberless others. It is a promise because, no matter how badly we act, the effects will eventually be erased. We cannot cause permanent damage. We may warm the climate; we may trash the oceans; we may create millions of acres of new desert. Much may suffer. It is in our best interest to prevent this suffering. But do not look on this as saving the Earth. The repairs are no more permanent than the damage. The Earth's only savior is itself.

V. On Carrying Capacity

24. *There is a maximum carrying capacity for the planet*.

Our world is finite, and therefore has a finite capacity to support life. We may argue about where the limit lies, but not about whether or not the limit exists. Limitless growth simply cannot physically take place in a limited space; and the Earth, though very large, is a limited space. There are only so many square feet of land, only so many cubic miles of water, only so much oxygen and hydrogen and carbon. When these are all in use, there will be no place to go for more.

Carrying capacity may be defined as *the maximum number of organisms a given ecosystem is able to support in a sustainable manner.* ("Sustainable," here, means exactly what it sounds like: able to be sustained indefinitely at the current level.) It depends largely on three factors. The first is *primary productivity* - the amount of biomass the ecosystem can produce in a single day through photosynthesis. Technically, this is equivalent to the amount of carbon transferred from inorganic compounds to organic compounds through the action of chlorophyll. It is limited by the number of available carbon molecules, the number of chlorophyll molecules, and the amount of sunlight.

The second factor affecting carrying capacity is *land capability*, which is the amount of biomass the system can produce in a year from a given level of primary productivity. Capability is affected by climate, aspect (the direction a slope faces), soil fertility and drainage, and a host of other local conditions, in addition to the strictly chemical conditions governing productivity.

The third factor is *assimilative capacity.* Think of this as the ability to recycle garbage. All living systems produce waste. Assimilative capacity is the rate at which an ecosystem can absorb these wastes and convert them into useful materials again.

The limits imposed by carrying capacity are not inflexible. It is possible, for example, to increase the primary productivity of a body of water by cutting off overhanging branches (increasing its exposure to sunlight), adding more aquatic plants (increasing photosynthesis) or bubbling carbon dioxide through it (increasing available inorganic carbon). Similarly, one can increase land capability by fertilizing soils, improving drainage, adding irrigation, or regrading a slope to optimize its aspect. Assimilative capacity can be improved by culturing decomposers (organisms such as bacteria and fungi, which recycle the nutrients in dead organic matter), by aerating water or soil, or by building pollution-control devices. If all these things are done, carrying capacity may be significantly improved. But there is always an upper limit on how far such processes may be taken.

Look, for example, at the carbon cycle. This is the path by which carbon wheels through the environment, from inorganic to organic and back again. Primary productivity forms one side of the cycle; decomposition and respiration take care of the other side. The process is always ongoing, and is as close to perfect as anything in nature ("perfect," in this context, means the efficiency with which the conversions take place, without wastage or long-term side tracks into unavailable forms). There is, however, only so

much carbon on the planet. Even if we were to throw it all into the cycle - grind up all limestone, decompose all diamonds, do away with pencil leads and plastics - we would eventually reach a point at which no further carbon was available. No further gain would therefore be possible. Since the chlorophyll molecule contains carbon, chlorophyll would stop increasing at that point, too. That leaves sunlight - and the amount of sunlight falling on the planet's face on a daily basis is also finite, limited by the strength of the sun and the surface area of the globe. Primary productivity simply cannot grow beyond the limits which the Earth's carbon content, its size, and its position in relationship to the sun impose. Even if land capability and assimilative capacity could be made infinite - and they cannot - carrying capacity could not outgrow the carbon cycle. That is a real, and unavoidable, limit.

There is one more thing to note about carrying capacity, and that is what happens when you overshoot it. It is possible to do this for short periods. Such overshoots, however, *always have the effect of degrading the environment and thus decreasing carrying capacity in the long run*. You can only live beyond your means by going into debt - and the bill always comes due. Living high on the ecological hog today means scrimping by on a depleted resource base tomorrow in order to pay the ecosystem back for the excess materials and services it has provided for you. Poverty is the inescapable consequence of overshoot. The only way to avoid it - the *only* way - is to avoid going into overshoot mode in the first place.

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25. *More is merrier only up to a point*.

There is safety in numbers, but there is danger in too many numbers. There's always room for one more, but only as long as the harvest holds out and the water keeps flowing. Go forth and multiply, but know when and how to stop.

Most of our adages about human numbers come down to us from a time when women often died in childbirth and death stalked children in their cradles. Scripture, too, was set down by people still living precariously: the great cities of Old Testament times - Babylon, Jericho, Ur - had populations of perhaps 25,000 each. Humanity was a very small race in a very large world. Promoting population growth was necessary to keep the candle of civilization flickering safely in a dark sea of surrounding uncertainties and unknowns.

We no longer inhabit such a world. Humanity is now rampant throughout the globe: we have inhabited all continents and most islands, and have even placed a permanent settlement at the South Pole. Our species increases at the rate of roughly 170 mouths per minute. "Think of a million lives lost in a famine or war," suggests author Diane Raines Ward. "Those numbers are replaced in four days."[7]

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[7] Ward, Diane Raines. *Water Wars: drought, flood, folly, and the politics of thirst*. New York: Riverhead Books, 2002, p. 3

Encouragement to expand is no longer necessary. Unfortunately, it has proved exceedingly hard to silence. Cities proudly post their populations at their outskirts like scores in a contest. Committees are formed to help local economies grow. Each dollar of increase in GDP is hailed as a blessing. Even as services break down, crime increases, and individual lives become poorer, we continue to look on growth as a good thing. The drive to procreate is probably hard-wired into us. By that I do not mean the sexual drive; I mean the urge to see the offspring of our species thrive. Think of the fierce protectiveness engendered by the sight of an endangered child. Think of the smiles of strangers over the sight of a baby carriage. These were highly appropriate responses in the world of our ancestors. I don't wish to deny their appropriateness today, but I do want to point out what this portends. Each individual child is a treasure and a blessing. As a whole, they have become a curse.

Our attitudes toward growth were formed in a day when we could not dream about limits. Now we have reached them. The patterns of thought that kept us alive as recently as 200 years ago will kill us today. It is time to recognize that more is merrier only until you reach the right size. After that, less is lovelier.

And though our reactions may be based on innate emotions, our actions need not be. It is not appropriate to wish for children's deaths, but it is surely appropriate to stop encouraging more births. The old adages require revision. The growth of new cells is healthy when it is creating new human bodies or replacing damaged tissues. In most other circumstances, it is called cancer.

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26. *If we don't control our numbers, nature will.*

The human race is not immune from natural checks and balances. Our population cannot grow indefinitely: like any other species, we face environmental limits. If we exceed those limits, we will eventually be forced back into them. The methods used will not be pretty.

I do not postulate nature, here, as some form of mystical sentient being who will take conscious action against human populations. This is neither likely nor required. No decisions will be made in cosmic boardrooms. What will happen - what is already happening - is simple feedback. Growth will cause its own collapse. Like a balloon filled with too much air, the systems within which human population growth is taking place will eventually stretch so far that they rupture. There will be an abrupt population decline. A number of possible causes may contribute to that decline, but they will all come down to one thing: people will die. At that point, further growth will become the moral equivalent of murder.

The forces which control growth in nature are known collectively as *environmental resistance*. They operate in four broad areas. *Predation* may skim off some individual members of the species for use as food by other species. *Competition* may drive individuals into marginal habitats where survival becomes more difficult. *Starvation* may kill individuals who cannot find adequate food. And *Disease* may cause

individuals to simply stop working right. Any of these may increase the effects of any of the others. Disease is more likely to be fatal in a starving individual; animals outcompeted for good habitats are more likely to starve; predators tend to prey more heavily on individuals who have already been weakened by disease or starvation, or who have been driven into the open because all the good shelters have already been taken.

The impacts of all of these factors are increased by population growth. Dense gatherings of a single species attract that species's predators, who find the pickings rich and easy. Competition climbs as necessary resources such as food and shelter become more scarce relative to the number of individuals who are trying to use them. (There is also a psychological factor which heightens the sense of competitiveness as population densities increase. This has been demonstrated in a number of species, including humans.) Starvation increases with population growth, not simply because there is less food to go around, but also because it becomes more and more difficult to distribute what food there is among all of the individuals present. And diseases spread much more rapidly in dense populations than in sparse ones. The vectors which carry disease germs - primarily, insects and moisture droplets - almost always require close proximity. Proximity goes up, not just by the number of individuals present, but by the square of that number. In ariel species, it increases by the cube.

As a top-of-the-food-chain species, humans have never had many predators, and we have managed to wipe out most of those we once had; so predation is not a problem for us. The other three parts of environmental resistance, however, continue pretty much unchecked. Competition, in the form of war, is an ever-present threat. So is disease, as the various pandemics that fill our newspapers make abundantly clear. As for starvation, a look at places such as Somalia and Bangladesh should effectively quash any optimism brought on by the so-called Green Revolution. Do not be lulled by hopeful statements that these are "merely" distribution problems. Problems in food distribution are not an aberration which can be cured with a little more attention and a little more money: they are a normal part of the effect of population pressure on food supplies.

There are no technological fixes for environmental resistance. Its operation is physical, but its causes are statistical: too many individuals sharing too few resources. Individuals and resources must eventually be brought into balance, and if we successfully head off one means of doing this, another will immediately rise in its place. The Zika virus will not be the last pandemic we fight, nor will Somalia be the last place in the world where children starve. Massive warfare, with an overwhelming number of civilian casualties, is a dismal but increasingly likely possibility. Like it or not, human population growth will be terminated. We can do it ourselves, through birth control, or we can sit back and let environmental resistance do it for us. Ease off on the gas, or run into the wall. Those are the only choices we have.

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27. *We cannot evade carrying capacity, only postpone its effects*.

We may ignore environmental limits for a time, but we cannot do so forever: a reckoning will always take place. Like an aircraft, which appears to evade gravity, we must always eventually come to ground.

The aircraft analogy is a good one, because - like our current attempts to evade carrying capacity - it uses technology to create the illusion of conquest. Wings, engines and jet fuel lift us off the ground and defy gravity's hold on us. We climb high above the limits nature has set for our species. But when the fuel runs out - and it always runs out - the limits re-exert themselves. If we are prudent, we will land the plane before that happens. If not, we will simply fall out of the sky.

An interest-bearing bank account is an even better analogy. Carrying capacity, like interest, represents a flow of resources whose rate is constant but whose actual amount depends on the accumulation of capital - money in the case of the bank account, primary productivity in the case of carrying capacity. As long as you live within the limits of the flow, capital is protected and may even build up. If you try to live outside the flow, though, the story changes. If you cannot cover your spending from the interest on your account, your only choice is to dip into the capital. When capital begins shrinking, interest also shrinks. Drawdown accelerates. And when the account reaches zero, all spending suddenly stops. Period. One day, caviar; the next, not even tuna. If you have been squandering money, a rich uncle may step forward to bail you out. If you have been squandering primary productivity, though, you are simply out of luck. There are no rich uncles for the Earth. There is only the income from existing capital - and that income falls as the capital falls. It may seem difficult to live within our means today. It will become much more difficult after excess spending has caused those means to shrink.

Living above carrying capacity, like spending above income, carries the seeds of its own destruction. Each day of living high on the hog means that there is less hog available. Exceeding carrying capacity for this generation shrinks carrying capacity for future generations. We are leaving our descendants with more mouths to feed and an impoverished bank account to feed them from. They will be lifting off the runway with fuel tanks that are already half empty. Crash and bankruptcy are both very real possibilities. If present trends continue, these will someday become actualities. Technology has brought forth a bountiful harvest, which we are currently enjoying. But care must be exercised not to enjoy too much of it. If we fail to separate the seeds from the crop, the bounty will last for only a single planting.

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28. *Appropriate technology helps us live better within carrying capacity. It does not help us evade it.*

Developing forms of technology with less impact on the planet is a worthwhile goal, but we are still going to have to limit our numbers and alter our consumption patterns. There are no technological fixes for overshoot.

The term "overshoot" in that last sentence, and earlier in this book, is used in the sense that population biologists use it: the growth of a population beyond the ability of its

environment to support it. It is inevitably followed by two things: first, habitat degradation; second, population collapse. The three phenomena are intertwined and inseparable. When overshoot occurs, by definition, the demand on the resource base has exceeded the supply. When demand exceeds supply, supply shrinks. Marginal resources are pressed into use in an attempt to stretch supply; since they are marginal, it takes more of them to provide the same amount of support, and they decline even faster than the optimal resources. With both the optimal and the marginal resource bases depressed, the number of individuals the habitat can support plunges. The population eventually adjusts to this new, lower support level. The adjustment process is not a pretty one.

Technology has effectively moved the goalposts. By squeezing more use out of each unit of resource, it has raised the level at which demand will exceed supply; by increasing the efficiencies of marginal resources, it has reduced the speed at which we use them up. It has bought us much time. But there is a limit beyond which it cannot take us. That limit is the carrying capacity of the planet. It is determined by primary productivity - the rate at which carbon can be converted from its inorganic to its organic form - and it is fixed. Even if we could discover a way to speed up or circumvent photosynthesis - the principal (almost the only) current method of carbon conversion - it would still be fixed. There is only so much carbon on the planet, and only so much energy. Infinite growth cannot occur in a finite world.

Appropriate technology attempts to do technological tasks with less impact on the environment. It uses fewer resources and smaller amounts of energy. Much of it is human-powered. The bicycle is an obvious example; so is the hand-powered coffee grinder I use in place of electricity to grind up coffee beans each morning. Some of it is passive (planting trees around the house to reduce air conditioning load; using solar-heated thermal mass to reduce heating requirements). The rest either utilizes renewable energy sources or does the same task with less energy. Buckminster Fuller liked to use the example of the sailing ship: it is made of a renewable resource (wood), uses a renewable energy source (wind), and leaves no trace of its passage through the water.

All of these things are good, and we should be promoting them. At the same time, though, we should recognize their limitations. They are really just another level of efficiency, and their effectiveness at staving off ecological collapse depends upon how we use them. If we use them to adjust our current lifestyle to the earth, we may succeed in continuing it indefinitely. If we just move the goalposts again, we will only make the collapse worse when it - inevitably - arrives.

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29. *Carrying capacity rules*.

Carrying capacity is always the ultimate arbiter for how large a population may grow. It may be surpassed temporarily, but only at a cost. Balance must ultimately be achieved; and the balance for an excess of organisms is a dearth of them. Exceeding carrying capacity always - *always* - leads to habitat degradation and a reduction in the

total number of animals of a given species the land can support. There are no exceptions to this rule. There are only postponements of its application.

This rule holds because carrying capacity is a physical limit. It is determined by fixed rates and measurable quantities. How fast can phosphorus cycle through an ecosystem? How much dissolved oxygen is present in a body of water? How rapidly is soil being made? All of these, and all of the other factors that go into determining carrying capacity, are real, finite amounts. Even sunlight is finite. Plants compete for it: that is why all the trees in a forest are likely to be the same height over a broad area, and why the flowers of the forest floor have such large, dark-green leaves. The height restriction, called canopy height, is self-policing: any tree which exceeds it will elicit furious growth from its neighbors as they attempt to avoid being shaded. The large, dark-green leaves are an adaptation to dim light. They are large to present more surface area for light to strike, and dark green because they are stuffed full of as much chlorophyll as the plant's chloroplasts can manufacture. Adjustments such as these are attempts to squeeze every last bit of carrying capacity out of a given environment, not a means to evade it - or even to expand it. They assure that none of the planet's capacity to support life goes to waste. But they cannot actually increase that capacity. Whenever they appear to be doing so, all they are really doing is borrowing excess capacity from someplace else, or stealing it from their own future.

Because of the many variables involved in determining carrying capacity, it can appear to be elastic. To a degree, it is. But this elasticity comes from adjustments among the variables, not from pushing them beyond their envelopes. All of the variables have real upper limits: none is infinitely expandable. Like a balloon, the carrying capacity of a piece of land can flex to accommodate growth. But we all know what the results will be if too much growth flexes a balloon too far.

VI. On Death

30. *Life lives off other life*.

Predation is a necessity. Producer organisms - those which can construct organic molecules from inorganic molecules and energy - create all the lifestuff on the planet. The rest of us live off their leavings. Always this requires damage to other organisms. Usually it requires killing them.

It is necessary to be brutally honest with ourselves about this point. We are all murderers. Meat-eaters kill other animals. Vegans kill only plants, but the principle is the same and the killing is still killing. It is best to be humane about it: I prefer, whenever possible, to buy free-range chicken, or beef that has grazed on grass rather than existed in a cage too small to turn around in in order to marble its meat to epicurean perfection. Slaughtering should be done quickly and painlessly. But I see no bright moral line between preying on animals and preying on plants. Who is to say that the cabbage does not scream silently when we rip its leaves off, or the apple cringe when bitten into? Flayed oranges do not writhe in agony, but perhaps that is because they have no muscles. We know that plants are aware of their environments, and that they communicate: studies have demonstrated conclusively that trees attacked by insects warn other trees nearby of the danger, by releasing pheromes that the other trees can sense. Plants that bloom at sunrise or fold their flowers at sunset clearly can tell light from dark. Surely they know when the knife slices into them, or the fire slowly roasts the life force out of their helpless seeds.

Are you ready, now, to stop eating your vegetables? Please don't. Mother was right: vegetables are *good* for you. I have no wish to condemn vegetarians or vegans, either - only to point out that the moral high ground upon which they claim to stand is not quite so high as they think it is. All human diets, vegetarian and vegan included, are dependent upon predation. That is the price we pay for being consumers, a word I use here in its ecological rather than economic sense. Consumers are those organisms that cannot produce their own food through either photosynthesis or chemosynthesis (there are very few of the latter; most of them are bacteria living in hot sulfur springs). All animals belong in the consumer camp. All of us. Therefore, we must consume. And to do that, we must first kill.

Actually, most plants are not pure producers either. A carrot which sinks its thick taproot into the soil must first have soil to sink it into, and that soil is full of dead organic matter and millions of living bacteria and fungi. The carrot absorbs nutrients from the organic matter, and probably from the bacteria and fungi as well: most plants do not do a very good job of converting all of their required nutrients into usable forms on their own, but must depend on microorganisms to do part of the job for them. In particularly nitrogen-poor environments, such as bogs, plants develop a hunger for larger prey than microorganisms. Take a look at a Venus's fly-trap or a California pitcher plant someday. Carnivorous plants such as these may seem the stuff of nightmares or of musical comedies (is that Audrey II waiting in the wings?), but they are less remarkable - and less sinister - than they seem at first glance. All life lives off other life. Death keeps life alive.

And I haven't said a word, yet, about parasitism - the other manner, besides murder, through which life lives off other life. It turns out that we are all victims of this. In your cells, you carry tiny organelles called mitochondria: they each have their own DNA and live at their own pace, and most biologists today believe they are the descendants of once separately-living bacteria which coexisted with the first eukaryotic cells (that is, cells with nucleii) in the primeval seas, and which were eventually surrounded and enslaved by them. We depend on mitochondria for energy production. Similar organelles, called chloroplasts, inhabit the cells of plants, where they are the custodians of all the chlorophyll and thus do all the photosynthesis. These were almost certainly once free-living cyanobacteria ("blue-green algae"). Today, they produce nutrients for their host cells, which can produce none by themselves. Bacteria, in other words, are the only true producers on the planet. The rest of us all ride piggyback on their abilities - a swarming host of so-called "higher" organisms, all absolutely dependent upon killing or enslaving other living things.

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31. *All creatures wish to protect their young*.

Protecting the young is a necessary part of the urge to reproduce. Living systems are fragile and easily disrupted. Life wears out. Genes depend on the next generation to carry them forward; so our genes ensure, through a variety of mechanisms, that the next generation will be as well-provided for as possible.

Means of promoting reproductive success clump around two poles, which biologists refer to as the "K" strategy and the "r" strategy. K-selected species depend on their ability to exploit the entire carrying capacity of the environment (indicated by the letter "K" in the equations that describe population growth); r-selected species depend on their ability to reproduce rapidly (the letter "r" stands for net reproductive potential, which is births minus deaths). K-selected species have few young, but train them carefully and protect them fiercely to make certain that as many get through to adulthood as possible; r-selected species have numerous young and simply absorb the necessary losses. K-selected species tend to respond to environmental crises by lowering their birth rates; r-selected species tend to respond to the same crises by increasing theirs.

It is important to understand, however, that these two strategies are (a) relative, and (b) part of a continuum. K-selected species put more energy into protection of the young, and r-selected species put more energy into sheer, raw reproduction, but all species put at least some energy into each. Nor is protection of the young limited to animals only. All plants are by necessity r-selected, but they are not powerless. Seed coatings protect the life within; roots alter the chemistry and physical structure of the earth to encourage seedling establishment. Fallen trees become nurseries for their own young and those of others. Edible fruits are actually a protective mechanism. The seeds of these fruits are designed to survive the digestive tract. The animal that eats them will eventually defecate - and the seed will be back on the ground, surrounded by a hot, steaming pile of plant nutrients. Seeds which make this journey are optimally positioned to grow. Small wonder that so many plants have adopted this strategy.

Humans are K-selected, so we place our emphasis on protection. There is an r element - women in cultures where childhood deaths are common have more children than those in cultures where health care and good nutrition reduce that risk - but by and large we expect our kids to grow up, and we spend much of our lives and our incomes making certain that they will grow up safely. The urge to make our children better off than we were is old and deeply ingrained, residing quite literally in each cell of our bodies. It is not a rational thing, and does not respond to reason. We share it with all living things. Even bacteria, which reproduce by fission and do not contain a complete cell nucleus, let alone a nervous system, will not normally divide unless conditions around them indicate that both new organisms can survive.

That is the depth of instinct that we face when promoting environmental-protection measures. If what we suggest is perceived as child-unfriendly, it is dead before it starts. Population-control measures are particularly suspect, because they deal directly with reproductivity. In cultures such as ours, where income directly affects child health and safety, the argument that jobs will be lost is a potent one; in cultures where money is less important, laws cannot prevent the poaching of animals from game reserves, or food plants and firewood from protected forests, in order that children may eat and stay warm. These things are not correctable through education; they begin at a depth below the level that education can reach. They are not addressable through enforcement. They can be overcome only through design. Environmental measures will succeed when people can see that they are the best possible thing for the children - and through no other way.

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32. *Populations are healthier when they are being culled.*

The premature deaths of individual members of a population, up to a point, make the population as a whole stronger. It is thus necessary for some creatures to die "before their time" in order that their populations - and therefore, their species - may remain healthy.

Note that the principle expressed here is *not* eugenics, and has nothing whatsoever to do with the so-called “survival of the fittest.” Though the weakest members of a population are those most likely to die prematurely, they are not necessarily those who should die; they are not necessarily genetically unfit for survival; and it is not the removal of their weaknesses which makes those who remain stronger. It is, rather, the removal of their demands on the resource base on which the population depends. Populations are always healthiest when there is plenty to go around. As population density in a given habitat increases, each individual within the population must make do with less, and the population as a whole suffers. It is the old story: some members of a population must die in order to make room for the rest to live.

Death from old age is not adequate to solve this problem. The death rate of individuals within a population is determined by a whole host of factors, of which old age - the time at which the organism simply runs down - is only one. The rest are found in the category we have already discussed called environmental resistance. Many things play a

part in environmental resistance - weather, food supply, and competition for available living space among them - but predation is the one that has the most direct impact on the death rate. It is important enough that the reproductive rates of prey species tend to be geared to it. The number of offspring normally produced by a herd of deer, for example, is enough to keep the herd size stable even as a fair number of deer disappear down the gullets of mountain lions or wolves. Or onto the plates of hunters.

What happens to a population when predator pressure is reduced is the same thing that happens when the resistance to any expanding substance is reduced. The rate of expansion accelerates, and the population grows until something else stops it. The problem is that this "something else" usually affects a higher percentage of the population than predation does. It may be starvation; it may be disease; it may be exposure to severe weather (this is related to population size because the number of places to get out of the weather is finite and limited). Individuals are still dying of something besides old age, and those they leave behind are weaker and more miserable than they would be under normal levels of predation.

Several lessons can be drawn from this. The most obvious is that predation is a necessary part of any ecosystem. This includes hunting by humans in those areas - such as rural landscapes - where the presence of other predators has been reduced or eliminated. Vegetarianism is only appropriate where a full component of non-human predators still exists.

A second lesson concerns logging. Populations of trees in forests are as susceptible to the problems caused by relaxation of predator pressure as are populations of any other organism. This knowledge does not sanction clearcuts. It does mean that a ban on all logging is potentially as dangerous to forest health as is logging itself. The optimum level of logging is not no logging at all; it is that level of logging which leaves the remaining populations of the logged species in the healthiest possible state.

Perhaps the most important lesson of all, though, has to do with human numbers. There is nothing special about our relationship to environmental resistance. Like all creatures, we expand our numbers when resistance relaxes. And resistance has been relaxing - big time - as we have conquered disease, eliminated our own predators and competitors, and increased our food supply. Our expanding numbers now threaten the health and well-being of our own population, worldwide, and will continue to do so until environmental resistance increases again. And because our numbers cannot go on expanding infinitely, that increase in resistance will necessarily occur.

I say this not to encourage the culling of humans, but to try to avoid it. We have the capability of reducing our numbers without culling. It is called birth control. It is a lot safer than environmental resistance, and a lot more comfortable, and a lot better for the species as a whole. Left to its own devices, environmental resistance will control our numbers by killing us, through disease, or starvation, or war. A population decrease *will happen*. The only questions are how, where, and when - and whether the individuals removed from the population are those already living, or those who have simply never been born.

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33. *Life wants to live, but all things die*.

Our genes demand life; nature demands death. Self-perpetuation has been the primary rule of DNA since the molecule first assembled itself out of the primordial soup. But if all the DNA ever created were still in existence, there would be room for nothing else, and the earth would have become, roughly, a large celestial ball of slimy ooze. Death is therefore necessary.

Death is really the solution to a problem raised by the solution to another problem. The original problem was that DNA is fragile. Those long double-helix ladders of atoms break easily. The early, primitive genetic material couldn't count on mere physical survival: something had to be devised to make sure that, even if the original molecules broke, the distinct organizational pattern each one represented would still be perpetuated. The answer was reproduction.

I don't mean by this that the early DNA molecules called a conference in the Precambrian seas, and someone said *Aha!* and reproduction was born. Consciousness was still a long way in the future. Life, in fact, was still in the future: DNA is the basis of life, but it is not itself living. It does, however, self-replicate. With the assistance of another chemical called RNA, DNA assembles copies of itself. The copies then assemble copies. Some of the copies break, but enough always remain to keep the process going.

DNA's self-replication has never been perfect. Inevitably, some of the copies have been subtly different from the originals. This was all that was needed to begin evolution. Those differences that made it harder to break the new DNA molecules apart gave the molecules that carried them a competitive edge, and their numbers expanded in relation to the more breakable ones - and then shrank again as their own offspring stumbled upon even sturdier methods of self-protection. DNA molecules combined with others to form chromosomes. Some sections of the chromosomes, the genes, developed the ability to create protein coatings, and the DNA molecules in those chromosomes surrounded themselves with protein sheathes, then cell-like structures, then living cells. The cells made copies of themselves, using the patterns encoded in the genes of each chromosome. Self-replication was now full-fledged reproduction.

And that meant that death was necessary. Protected inside the cells, the DNA was no longer breaking, but it was still replicating. In order to prevent life from overwhelming the universe, the cells themselves would have to die.

That pattern continues to rule us today. Organisms are still born; they still reproduce; and they still die to make room for their offspring. Humans are as subject to these necessities as any other creature. Death is our birthright. Without the deaths of individuals, the species itself could not survive.

But self-preservation is our birthright, too. It is encoded into us right down at the level of the DNA. It drives reproduction. Without the perpetuation of the genes in which its characteristics are encoded, a species cannot survive. The conflict between self-

preservation and death is thus innate, fundamental, and inescapable. Each tries to thwart the other, but each also makes the other necessary. We protect ourselves; we protect our offspring (our own DNA's future); we protect our species. We do the first by living and the last by dying, and somewhere in the middle there is a switch from one necessity to the other occur. We may fight the switch to the end, on an individual level, but it takes place anyhow. In our own deaths lie our descendants' futures. We fear death; we run from it; but we all ultimately embrace it, the "necessary end," as Shakespeare wrote, “that comes when it will come."[8]

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34. *Extinction is life's way of adjusting to changing circumstances*.

The Earth is not static, and never has been. Climates change; continents drift; mountains rise and fall. Niches open and close. Life adapts to this slow dance of conditions by continually fine-tuning its species mix. Evolution and extinction are necessary partners.

The function of extinction is similar to the function of death. The death of a species, like the death of an individual, makes space for another. The fall of dinosaurs clears the way for the rise of mammals; the passing of our ancestors gives us the gift of our children. The analogy cannot be taken too far: all individuals eventually die, while some particularly adaptable species may remain viable essentially forever. The living stromatalites of western Australia are remarkably similar to those found in rocks more than three billion years old. Individuals die because their machinery wears out, a biological problem that has been solved by reproduction, which is precisely the mechanism that keeps species going. Species die because their niches disappear or are taken over by others. The processes are not strictly comparable. The results, however, are ultimately the same, and carry the same sense of finality. A last breath is drawn, and something unique passes from the planet, never to be seen again. A hole opens. And somebody else, or something else, fills it.

Humans are remarkably efficient niche-emptiers and niche-destroyers. As a result, we are also efficient species-killers. Estimates of the rate of loss range up to 140 species per day. That is roughly one species - one unique, irreplaceable life form - every ten minutes. It has rightfully been called carnage. The last time something comparable happened, 65 million years ago, it took the impact of a meteor the size of a small moon to bring it about.

But there is an important piece of information in that last statement that is often overlooked. *There was a last time*. We are not living through the first Great Extinction, or even the second, but at least the fourth (some paleontologists chart as many as twelve). The greatest of these, at the close of the Permian - 248 million years ago - wiped out between 70 and 90 per cent of all marine species living at that time. Among these were the last remaining trilobites, although their kind had been in decline since a previous

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[8] William Shakespeare, *Julius Caesar*, Act 2, Scene 2.

Great Extinction at the close of the Ordovician, 190 million years earlier. The Ordovician event also eliminated at least one-third of all brachiopod species - a group even more numerous than the trilobites were at that time - and cut similar swaths through the graptolites, the conodonts, and the bryozoans.

And extinctions do not occur only during Great Extinctions. There is in fact a steady background noise of them throughout geologic time. Literally millions of species of living things have come and gone, most of them quietly, in the intervening years. Massive changes in conditions - the meteorite at the close of the Mesozoic, widespread glaciation at the ends of the Ordovician and the Permian - cause massive extinctions. Small, everyday changes cause small, everyday extinctions. Each time a change occurs, life must adapt. Each time conditions shift, there are some species that cannot shift with them.

Should we be concerned about the extinctions we are causing? Of course. It is never good form to murder your companions on a journey. And along with that ethical dilemma there are practical considerations. We do not know, among the many species we are destroying, which ones might be critical to our own survival. Along with causing this particular Great Extinction, we may easily become one of the numerous species which do not make it through to the other side.

But there is an upside, too, which must be kept in mind. Every Great Extinction is followed by a Great Flowering. The empty niches will not remain empty. The remaining life forms will radiate into them, in shapes yet unfolded and beauties yet undreamed of. None of us will see these things, but they will happen. They always have. Individuals and species die. Life adapts.

If you wish to see the marvelous forms such adaptations can take, look out the window. There is probably one out there right now. It may be fluttering by, or soaring overhead, or sitting on a branch and singing. It is beaked and feathered and a direct descendant of the dinosaurs - those which were able to adapt. The Great Extinction of the Mesozoic destroyed the tyrannosaurs and the velociraptors and the triceretops and all the other saurians, lithe and lumbering, so beloved by school children and movie makers. It also gave us birds.

VII. On Wilderness

35. *There is no such thing as wilderness any more*.

Those areas that we call "wilderness," and that we have set aside by law, are as artificial as city parks and asphalt sidewalks. They are cultural creations. "Preservation" doesn't preserve anything; it creates artificial ecosystems instead, ecosystems from which an important keystone species, *Homo sapiens*, has been removed. The results are unnatural, by most reasonable definitions of the term.

These statements should not be read as giving *carte blanche* to large-scale human modifications of the landscape. Urban sprawl and clearcuts and the drying of the Aral Sea do not represent a healthy human relationship to the planet. But the opposite extreme - a complete absence of human impacts - is not healthy, either. It is akin to removing grizzlies, or elephants, or alligators, or any other keystone species. The land suffers as much from too few of these creatures as it does from too many.

In Old English, *wildeornes* was the domain of shaggy beasts. It was the place one found *wildeors* ("wild animals"), a word derived from the Latin *villus*, which meant "wool." *Wold* ("woodland") and *welt* ("wound") may be related terms. The understanding held by our ancestors was that places which contained such things were literally "out of bounds" - outside the boundaries, beyond the borders of cities and farms. This meaning persisted through the Renaissance. When the Pilgrims looked upon Massachusetts and saw a "wildernes," they did not mean that the land was uninhabited, only that it was unbounded. The tidy fields and teeming streets of England were nowhere visible.

Today we have turned this definition on its head. We have drawn bounds about the wilderness and left everything else to farms and cities. We have comforted ourselves with the notion that we have "preserved" these little bits of bounded landscape, and unfortunately that is precisely what we have done. We have pickled nature so that we can go and look at it on holidays. The exhibits in our nature museums are beautiful, well-tended, physically challenging, emotionally satisfying, and on occasion moderately uncomfortable and dangerous. They allow those of us who visit them a few hours' communion with our old wild natures. I am by no means advocating that we simply go out and dismantle them. But they are not wilderness, and the bounded and tended "natural environment" which they preserve should never be mistaken for the real thing.

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36. *Like it or not, we are now managing the entire planet*.

There is not an acre of ground that does not feel our influence, not an animal or plant whose life is unaffected, not a drop of water that runs through the hydrologic cycle unimpeded by human activities. Decisions currently being made in corporate boardrooms and legislative chambers will have profound effects on the future shape of the biosphere. Our choice is not whether or not to practice large-scale environmental manipulation, but what shape that environmental manipulation should take.

We are currently managing piecemeal and by default. Some areas and some functions are tightly controlled; others are managed sporadically; still others are merely watched. There is little coordination. Management boundaries rarely make biological sense: different parts of the same resource are made to serve different and often contradictory goals. Decisions are made on grounds entirely unrelated to easily predictable effects. Long-term trends are ignored. The result is a laissez-faire planetary governance system in which decisions of world-wide consequence are made by local whim. The preservation community and the development community are equally guilty of this. It matters very little whether the call is for hands off the resource, or hands off the resource abuser. "Hands off" is no longer an acceptable policy option.

The biosphere is a comprehensively integrated system within which even small changes have broad impacts, and the changes we are introducing into it are no longer small. Air-pollution events carry through entire hemispheres. Forested, deforested and reforested areas make a patchwork pattern over the whole globe. Water resources are diverted, polluted, manipulated, and used and used again; most of the world's fresh water flows through some form of management structure between rainfall and the sea. The sea itself is overfished, polluted, and heating up. Global climate change has already begun to happen: causes, consequences and continued trends are still under some dispute, but average planetary temperatures, which are measurable, are not. These temperatures have climbed more than a full degree Fahrenheit since 1970.

Since the results of our management practices are now felt system-wide, the management itself now needs to be done on a system-wide basis. Politics and national pride being what they are, I have no illusions that this will happen soon; but it ought to be the goal we set ourselves. It will conflict to some degree with the locally-based decision-making processes I also believe are necessary, but the two are not fundamentally opposed: it is the management *framework* that needs to be global in scope, not the choices made within that framework. Local communities should make the final decisions about what happens to local resources. They also should be held responsible for the impacts those decisions have on the rest of the planet.

An international environmental management framework is, in fact, beginning to develop. The Montreal Protocol, which controls the emission of ozone-layer damaging gases, is part of that framework. So are the environmental rules of the WTO and the World Bank; although these last two are muddled, often wrongheaded, and far from adequate, they are global in scope and thus have made at least a baby step along the path that needs to be taken. The destination needs to be changed. That should not be allowed to detract us from the importance of the fact that the journey has begun.

Meanwhile, as we work on changing the destination, there are a couple of facts that should be kept in mind.

The first fact is that *a decision not to manage something is still a management decision*. Wilderness is a land-management category. Dumping untreated wastes into rivers is a form of waste management. The management direction can be challenged in

either case, but that should not be allowed to obfuscate the fact that management has occurred.

The second fact is that *no environmental management decision can be final*. The natural world is dynamic, and cannot be managed in a static manner. What is best for a resource at one moment in history may not remain best in the next moment. Some lands now in wilderness may one day serve us better under timber management; some lands now in timber harvest may function better after a time as wilderness. Groundwater mining is a problem only if we lock ourselves into dependence on the mined water. Change is inevitable. Flexibility is therefore required.

Planetary management, like all management, can succeed only if it allows itself to continually redefine success.

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37. *There are no ancient forests*.

The term is a misnomer. Like most slogans coined for political advantage, it has little bearing in reality. It is strong on emotion but short on fact, and its widespread adoption has damaged the credibility of the environmental movement.

Though forests have been described as "ancient" for about as long as people have been talking about trees, it was not until the late 1980s that the word was used to describe a forest *type*. Before that time, it described an impression. Wandering through deep shade among huge-boled, hoary old trees, heavy with moss, it is easy to gain a sense of green antiquity. You feel the continuity of life, stretching back past the Ice Age and the dinosaurs and the trilobites to the first self-reproducing molecules in the first seas. Used in this way, the term has meaning. It is personal, immediate, and strongly descriptive, and it kindles a kinship of experience with other forest users. We all recognize that feeling of mingled awe and respect and connection with deep time. We have been there ourselves.

Beginning about 1986, though, there was a tectonic shift in the way the term was used. The wilderness movement had entered a new phase: most of the prime scenic areas were either already protected or already ruined, and what was left was attractive primarily because it was wild. Clearcuts were advancing on it. There was a need to act, but there was no constituency to act with. Whales had a constituency; scenery had a constituency; rivers had a constituency; but trees were just trees, and the general public was having trouble getting excited about them.

Until someone had a bright idea. There was (and is) a widely accepted but pedestrian term, "old growth," used to describe forests that show no signs of previous harvest. Foresters have a precise definition for it. Old growth has a mature overstory; a complex and multilayered understory; and a healthy number of snags and downed, rotting trees. It is at least ten acres in size (anything smaller cannot maintain all the attributes of a forest), and it shows few or no signs of human intrusion. This was the complex of characteristics environmentalists were trying to protect, so we were talking a lot about old

growth. The conversation was dry, academic, and distinctly unsexy. Suppose we were to juice it up a bit?

And so "old" became "ancient," and "growth" became "forest." The new name was specifically packaged for emotional appeal. Growth is just a process, but a forest is a place; ancient gets revered, but old just gets thrown away. "Old growth" is a technical term, and sounds like it. "Ancient forest" is a hallowed landscape. I remember being specifically discouraged from using the older language. I remember being told why. We were trying to compete in an arena where "jobs" had become "livelihood" and "clearcuts" had become "harvest units." It seemed necessary to fight back with emotional euphemisms of our own.

The problem with fighting back with the same tools that your enemy uses, however, is that you tend to become indistinguishable from your enemy. By creating our own euphemisms, we tacitly accepted the euphemisms of the other side. That moved the battle from facts to emotions. It became easier to win, but we lost control of what we were winning. How could we fight for the right thing if we couldn't even describe it accurately?

And as a factual description, "ancient forests" is bloody inaccurate. Forests are not living organisms, but living systems. They contain some trees that might reasonably be described as ancient, but they also contain saplings, trees of intermediate age, annual herbs, animals who are old at the age of ten and birds who are old at three, and a great many creatures (insects; microorganisms) whose lifespans are best described as ephemeral. The past states of forests are often discontinuous with their present. They move at the whim of climate. They are always changing, and thus are always new. They are more akin to children than to archaeological digs. They need protection. They do not need preservation.

Battle has been joined over a nonexistent entity. We pursue laudable goals, but with the wrong techniques and for the wrong reasons. We have shifted from dependence on fact to dependence on rhetoric, and though that may gain us an early advantage, we are likely to pay dearly for it down the road - when the forests, managed as "ancient," proceed to act that way. And die.

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38. *Protection and preservation are not identical*.

To protect something is to keep it from harm; to preserve something is to keep it from change. A protected species has a chance to live in safety and recover its numbers; a preserved species resides in a jar of alcohol in a laboratory. There is a place for each, but they should never be confused with each other.

In general, natural areas require protection, not preservation. I say "in general" because there are some exceptions to this. Certain groves, certain waterfalls, certain mountains of unusual aesthetic or spiritual importance may be worthy of preservation, unchanged, for the benefit of generations to come. There is nothing wrong with wanting

to keep Yosemite Falls and Crater Lake and Old Faithful Geyser just as they are. The problems come when we try to extend the preservation concept to entire living systems. Life is dependent upon change - the rhythm of growth, death and reproduction, the spread of forest into grassland and grassland into forest, the slow dance of evolution, the momentary pulsing of the blood. These things can and should be protected, but they cannot and should not be preserved. Preservation stops change. It is fine for museums. It is inappropriate for life.

This is more than a matter of semantics. Names have power. What we call something influences how we treat it. We protect our children and preserve our food. Try reversing those terms and see how you feel about the result. In the upper part of Michigan's Lower Peninsula, efforts went on for years to preserve habitat for the Kirtland's warbler. Warbler populations continued to decline. Someone finally figured out that the preservation was the problem. Kirtland's warblers breed only in young stands of jack pine; in the preserved state of the forests, all the young stands had grown up. Wildlife managers shifted to habitat protection, which meant prescribed burns (and, in some cases, clearcuts) to allow young pine stands to develop. Warbler populations immediately began rebounding. The key to this success was the shift in thinking from preservation to protection.

Our special places - the ones we preserve - often need intervention to keep them that way. The rim of Niagara Falls has been reinforced with concrete to keep it from eroding backwards; the Old Man of the Mountains, the famous rock formation in Franconia Notch that has become a symbol of New Hampshire, is today held together with cables. Big Spring, in the town of the same name in Texas, now flows with the assistance of pumps. These artificial assists allow people today to see what our ancestors saw. They are appropriate for these small places - and others like them - but it is inappropriate to extend them further than that. The places we wish to keep natural require protection, not preservation. They need to change. We need to accommodate to their natural changes; we also need to allow ourselves to initiate some changes. As long as these are kept to an appropriate level, within the capacity of the protected system to absorb them, we need not worry that we are interfering with natural processes. We may, in fact, be helping them, as we did with the Kirtland's warbler. Cutting down a tree is not necessarily an environmentally damaging act, and leaving it standing is not necessarily an environmentally beneficial one. We don't need one or the other; we need the perception to see which is appropriate at a given time for a given stand, and the courage to act on that perception. That is environmental protection. Neither dedicated preservation nor dedicated commodity production can do it, no matter how well-intentioned and enlightened they may be.

Preserves are for humans. They are, in their own way, as artificial as shopping malls. We may be called to create them, but we should be under no illusion that doing so is less exploitive than logging. If we wish to preserve our scenic wonders, by all means let us do so. If we wish to protect our environment, we will have to take a different approach.

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39. *The concept of wilderness separates us from nature*.

Wilderness boundaries are, by definition, lines which separate the natural from the artificial. On one side lie dams and roads and clearcuts and other human adaptations and modifications of the landscape; on the other side lies an unadapted and unmodified world in which, in the words of the Wilderness Act, "man is a visitor who does not remain."[9] It is Eden before the Fall, into which corrupted humans cannot venture without causing corruption.

The unavoidable message sent by wilderness designation is that the lands so designated are somehow "different." This attitude endangers wilderness as thoroughly as clearcuts do. In a world aching for wholeness, wilderness boundaries are yet another division. We ought to be seeking reintegration; instead, we champion separation. Wilderness preservation springs from a desire to protect nature *somewhere*, but its overall effect is to lessen the protection of nature *everywhere*.

Each time we create a preserve, we also create its opposite: an unpreserve. Within the preserves, our attention to environmental damage is heightened: within the unpreserves, it is slackened. Because we have the purity of wilderness to escape to, we are more likely to overlook the impurities in our daily lives.

I do not mean to suggest that we undesignate our already-designated wilderness areas, or even that we stop designating new ones: only that we should think very hard about what designating a wilderness really means. It does not mean the integration and wholeness of the natural world that the environmental community says it seeks. It means separation. It creates a little package full of nature, but the clutter from wrapping it lies everywhere around.

I am not sure that there is an answer to the dilemma that this particular set of unintended consequences raises. I know there are places which merit protection; I know there are humans who are insensitive to the values these places hold and who will run right over them if they are not stopped, and I know that boundaries are a necessary tool in our efforts to stop them. The problem is that the boundaries themselves help create the insensitivity that we find it necessary to protect the places within the boundaries against. Aldo Leopold once remarked (at the end of his essay, "Conservation Esthetic") that recreational development was a job "not of building roads into lovely country, but of building receptivity into the still unlovely human mind."[10] I doubt that Leopold would object if we were to substitute "drawing boundaries around" in place of "building roads into." The central task remains building the receptivity.

And in order to do that, we will have to work on lessening the separation. One necessary step in this direction is to abandon the "purity" doctrine. Not every tree cut

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[9] *The Wilderness Act* (Public Law 88-577), Sec. (2)(c)

[10] Aldo Leopold, *op. cit.*, p. 295.

down, inside or outside of a wilderness area, is a disaster; not every wheel on a wilderness trail is a portent of freeways and parking garages. We may not be able to do away with boundaries, but blurring them a little is at least a step in the right direction. To protect nature anywhere, it is necessary to care about it everywhere. It will help build this attitude if there are no longer any clearly marked lines telling us where it is OK for the caring to stop.

So I think that we should begin to look at converting our wilderness *areas* into wilderness *zones*. I think the tools of land use planning - the variance, the conditional use permit, the setback - might be as usefully applied to natural areas as they are to urban neighborhoods. I think a continuum of use, in which the wilderness border marks a stage rather than an abrupt reversal, would help integrate wilderness into our lives - and would thus advance the necessary reintegration of our lives into wilderness. The true task before us is not to protect nature apart from ourselves. It is to protect nature as a part of ourselves.

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40. *Wilderness is an idea, not a place*.

Wilderness is a concept and a notion, not a specific plot of ground. Its terrain is emotional, not physical. Wilderness is that-land-which-is-not-yet-conquered; it is by turns hostile and inviting, raw and whole, evil and spiritually pure. Wallace Stegner called it the "geography of hope."[11]

It has not always been liked. Lying off the coast of what is now Massachusetts, William Bradford gazed fearfully on the "hidious & desolate wildernes, full of wild beasts & willd men"[12] into which the *Mayflower* passengers would soon disembark. Bradford and his fellows wished to tame the wilderness, not save it, and for a long time that was the only official American wildlands policy. The less wilderness, the better. We surveyed it (the Cadastral Survey Act), enclosed it (the Louisiana Purchase), stripped it of its resources (the Timber and Stone Act) and gave it away (the Homestead Act; railroad land grants). Wilderness was the far side of the frontier, and the sooner it was brought inside, the better.

And then, suddenly, there *was* no frontier. As the 19th century ended, historian Frederick Jackson Turner pronounced the frontier closed. There were islands of still-wild land, but there was no longer an ocean of wilderness that could be pointed to beyond the nation's civilized shore. As this strange new state of affairs sank in, Americans began to remember that the wilderness was good as well as bad. Henry David Thoreau had already

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[11] Wallace Stegner, "Wilderness Letter," December 3, 1960

[12] William Bradford, *Of Plimouth Plantation*, Chapter 9. This account of the settlement of the Massachusetts Bay Colony in 1620 was written between 1630 and 1651 but remained in manuscript form until 1856. It has been published numerous times since. I have retained the original spelling.

told us bluntly that "in wildness is the preservation of the world;"[13] George Perkins Marsh had pointed to serious disruptions in the "ocean of organic being."[14] Now here was Turner, telling them that an America shaped by the frontier had lost its shaping force. Perhaps something should be done to stop what was left of our wilderness from disappearing. The Forest Service was created in 1897, the National Park Service in 1916; the giveaway of wildlands was officially stopped by the Taylor Grazing Act in 1937. By that time, Forest Service employees Arthur Carhart and Aldo Leopold had convinced their superiors to set aside the first two wilderness areas, Carhart's in Colorado and Leopold's (the second in time, although it was the first to actually carry the name) in Arizona. Wilderness spread quickly through the National Forest system, declared by administrative fiat. With the passage of the Wilderness Act of 1964, Congress engraved the notion into law and extended it to other public lands.

But then a funny thing began to happen: once pinned down, wilderness began to disappear. Defined by maps and recorded by photographs, it was no longer unknown; overrun by visitors, it was no longer unpeopled. The necessary rule-making for its management demonstrated that it was no longer unmanaged. It was still wild, but "wild" meant different things to different people. As Carhart himself pointed out, in a book published in 1961, a city-dweller could easily get too much wilderness for comfort in the hundred yards of woodland path between cabins at a lakeside resort.[15]

So now we come down to modern times, and a preservation movement which measures wilderness by how large a boundary it can draw around unlogged and unroaded forest. The wilderness concept has undergone some changes along the way: hideous has become beautiful, desolation has become sanctuary, and untouched has become untouchable. Empty spots on the map have been replaced by the *idea* of empty spots on the map. I have no quarrel with the need for connecting with nature, nor with the drive to protect places where this can happen. I abhor the thought that all places on the planet might be fed into the voracious maw of industry. But when protection becomes preservation, we have lost a good part of what we thought we were protecting. The idea of wilderness has always included the idea of latent possibility. Possibility implies change. And if something is changed, it is, by definition, no longer preserved.

The idea of wilderness is worth keeping. To do this, we need places where the idea can thrive. It is open to question whether or not our modern Wilderness Areas are such places.

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[13] Henry David Thoreau, *op. Cit.*, p. 344.

[14] George Perkins Marsh, *Man and Nature: The Earth as Modified by Human Action*, 2d edition (New York: Scribner, Armstrong, 1874), p. 144.

[15] Arthur H. Carhart, *Planning for America's Wildlands* (Harrisburg, PA: National Audubon society *et. al.*), p. 18. One is also reminded of the urban-based dentist Bill Ray mistaking a lawn chair for a bear in the wonderful 1981 movie *On Golden Pond*.

VIII. On Environmental Protection

41. *All environmental protection is really human protection*.

We may fool ourselves into believing that we are saving the gray wolf or the grizzly for their sake, but the deep-down truth is that we don't wish to live in a world that has no gray wolves or grizzlies in it. And even if we did wish to live in such a world, we are not at all certain that we could. We watch the fabric of the biosphere unraveling, and we carry a constant, nagging fear that our own species may be the next torn thread.

I don't mean to belittle the need for environmental protection. There is good reason for our fears. We are what ecologists refer to as a "keystone species," meaning one which stands at the apex of an interlocked structure of mutually dependent living things, and we have been blindly ripping stones out of the pillars for a long time. The symptoms of imminent collapse are so well known by now that a recitation of only a few of them should suffice to make the point. The world's fisheries are collapsing. The Aral Sea is drying up. The ozone layer is in tatters; the Amazon rain forests are shrinking. Urban sprawl oozes outward from our cities like the pseudopods of a giant amoeba, swallowing everything it touches. I stand with those who believe that these things are wrong, stupid, and extraordinarily risky. The human race seems bent on committing spectacular mass suicide, and Lord knows how many other species we will take with us when we go.

But that is precisely the point. It is "when we go" that we are worried about. The Universe is immense: even if we blow up the entire planet, we will cause no more than a barely detectable ripple in space-time, and that will happen eventually anyway when the Sun goes nova. Our fate is simply not important to Alpha Centauri. But it is overwhelmingly important to us.

So what I plead for, here, is not the abandonment of environmental activism but the restructuring of it. We need to be concerned less with details than with overall patterns. The fate of individual trees, of individual woodlands, or even of individual nonhuman species is not nearly so important as is assuring that there will still be trees and woodlands and nonhuman species. Our task is *continuity.* It is not necessary to freeze change to accomplish this, only to be certain that the changes which occur pose no threat to the future livability of the only Earth we have.

All of us have landscapes we love. It is natural to want to protect them, and in many cases that protection may be the best thing for all of us. It should never be automatically assumed that anything is expendable. Protecting the past can be a useful tool for ensuring the future. But let us make certain that this is what we are doing. The test is not whether or not we can go back to where we have been, but whether or not we can continue to go anywhere at all.

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42. *We need nature, but nature doesn't need us*.

Nature is our support system: if and when it stops supporting us, our species will die. Nature, however, will not die with us: it will merely shift its species mix to accommodate to the planet's new condition.

It is important to grasp the second half of this truth, as well as the first. Whether or not humanity survives is not of the least interest to the natural world. Gravity and centrifugal force will continue serenely on, with or without us; light will not change its spectrum; water will still freeze at 0º C and boil at 100º C, and it will still expand slightly at just above freezing. Life itself will continue. We may destroy whole biomes: if so, nature will simply replace them with new ones. These new biomes will be well-adapted to the new conditions imposed on the planet by the destruction of the old ones. They may or may not have room in them for human beings.

Irrelevancy being the worst fate of all - worse, even, than death - all of us deny its hold on us. This denial takes different forms, but all of them hold as common ground a demand to be considered relevant. Some proclaim mastery over the powers of nature: to these people, human acts are always improvements over the natural condition and human-caused damage is a side effect that can be either overlooked or, if too prominent to be ignored, fixed through more human acts. Others recoil at the abuse of nature: to these, the biosphere is a house of cards and humanity is a hurricane, and the only way to save nature is to put up a windbreak. Most of us see ourselves fitting somewhere on the continuum between these two extremes, but the fact is that it is not really a continuum. It is a single viewpoint. It assumes that we stand outside of nature and manipulate it. Whether the manipulation is for good or ill is of secondary importance: the primary fact is the manipulation.

And what if this manipulation doesn't exist? What if all we do is mess with the details while nature plows ahead irregardless of our presence? If this is our condition - and I believe it is - then we cannot harm nature, but we can bloody well sure harm ourselves. From this standpoint, environmental protection becomes human protection. It is not nature we need to protect: it is the peculiar natural conditions which make the earth friendly to our species. There is a whole flock of ecological niches within which our niche fits, and we need to keep enough of those other niches alive that ours remains safe. Thus we must protect endangered species - not for them, but for us. We must prevent pollution - not because of the damage it does to the environment, but because of the effect that environmental damage will have on us. We must protect wild places, not for the creatures who now live there, but for a creature who once lived there and who still, deep in its civilized heart, depends on wilderness to define it and make it whole.

This sounds selfish, and it is: but at least it avoids the hubris of assuming the starring role in the Universe for ourselves. In truth we are bit players only, irrelevant to the main plot, and if we don't say our lines well our part will be written out. Self-preservation demands that we get along with the other actors. Living in harmony with the natural world is not a necessary condition for the natural world's survival, only for our own.

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43. *The Earth does not require our presence*.

If we were to disappear overnight, some other species would rapidly arise to take our place. Despite our sense of self-importance, we are completely expendable. "Nature is trying very hard to make us succeed," remarked Buckminster Fuller to an interviewer from the *Minneapolis Tribune* in 1978, "but nature does not depend on us. We are not the only experiment."[16]

The technological course we set ourselves irrevocably upon with the invention of agriculture makes us unusual, but it does not make us immortal. All of the forces that operate on other creatures continue to operate on us, and we will survive or fail on the basis of those forces, not through our own will. Nature is a work continually in progress. The pieces which do not fit are the ones most likely to be discarded.

One need not choose sides over technology to understand this point. There is, in fact, much good to be said about the technological experiment. Technology keeps us warm and dry in cold and damp climates. It allows rapid travel, and instantaneous communication, to and from any place on the planet. It has increased lifespan and decreased infant mortality, allowing our species to proliferate widely, even in marginal habitat. By many of the measures used by population biologists - reproductivity, longevity, distribution, percentage of offspring reaching the age of recruitment (i.e., sexual maturity) - *Homo sapiens* is thriving. Through these lenses, technology appears to be a very successful adaptation.

There are, however, other, more worrisome views. Perhaps the darkest comes from the study of irruptions, which may be defined as the sudden growth of living populations under optimal conditions. In all known cases, irruptions have been followed by population crashes. The irruptive species becomes a victim of its own success. Irrupting populations outstrip their food supplies, leading to starvation. They reach densities beyond the level of individual tolerance, leading to psychological disorders, infighting, and deaths. They are easy pickings for predators; they are vulnerable to the rapid spread of disease. These things always bring about a precipitous drop in individual numbers. In the right (or wrong) combination, they can drive a species into extinction. The passenger-pigeon experiment ended in exactly this manner. The human experiment may very well follow.

If so, we can predict with some confidence what will happen. Those species for which we have provided support - domestic animals and plants, rats, cockroaches, star thistle - will undergo population declines; those which our presence has suppressed will recover. Some environments will improve; others will deteriorate. Scars will heal. Habitats will alter. The biosphere will adjust to our absence, as it once adjusted to our presence. The machinery of the Universe will move implacably onward. Dogs, cats, horses, and perhaps a few other species - assuming they survive - will miss us. Others will not even notice. The failure of one experiment does not mark the end of the project.

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[16] *Minneapolis Tribune*, April 30, 1978

Our lifestyle affects many other species, but it matters only to ourselves. The success of the human experiment will not be measured by how much of the planet we have conquered, or how much technology we have created, or how many other species we have subjugated or eliminated or saved. It will be measured by how long we are able to sustain ourselves.

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44. *Life can survive the disruptions caused by humans. Humans may not*.

Two million years from now, living species will still inhabit this planet. There is no guarantee that our species will be one of them.

Life is a resilient, adaptable, and extremely tenacious force. It has survived meteorite impacts and ice ages. It does not depend on a narrow range of conditions. Its only absolute requirement is the presence of liquid water; beyond that, just about anything goes. Algae inhabit both high-mountain snowbanks - where liquid water is an ephemeral presence dependent on the daily warmth of the sun - and scalding hot springs in the depths of the ocean. Emperor penguins breed in the bleak darkness of Antarctic winters, melting ice into water by the heat of their own metabolism; creosote plants survive the scorching sun of the Mojave Desert, sending questing roots downward as much as 150 feet to buried aquifers. Life extends high into the air as birds and insects and deep into the earth as worms and bacteria. Soil is quite literally alive; a single shovelful contains billions of microscopic creatures eating, excreting, breeding, and going about all the other business of their small existence. Life is everywhere.

There is no question that we are fouling the air and water, altering or eliminating habitats, and generally making life difficult for numerous other species, many of which are dying. But life has met this challenge before. We are not the first species to pour poisons into the environment on a massive scale. Anaerobic bacteria did it in the early days of the Earth. Anaerobes not only do not breath oxygen, they are poisoned by it. But some of them excrete it as a metabolic waste product. Several billion years ago, enough of them did that to shift the composition of the Earth's atmosphere, flooding it with toxic oxygen. Many species of anaerobes undoubtedly died out at that time. Those which survived followed one of two strategies. They went deep, where oxygen could not find them; or they adapted to oxygen. Those who went deep are still there, in the ocean abyss and in pond muck and in closed wounds and any place else that the air cannot reach. Those who adapted became our ancestors.

Individual species are often fragile. They operate within narrow tolerances of heat and moisture and nutrient balance, and they will perish if conditions exceed these fixed limits. But the limits vary, often dramatically, for different species. If you introduce an Arctic lemming into the desert, it will die of either thirst or heat exhaustion; if you introduce a desert kangaroo rat into the arctic, it will freeze to death. Birds thrive on mistletoe berries, which kill humans. Phosphate pollution of watercourses causes blooms of algae, which make the water distasteful or toxic for mammals, reptiles and birds but is quite pleasant, thank you very much, for the algae. The alterations we are bringing to the

planet change conditions, press tolerances, and make it impossible for many species to survive. We may well be among those who do not make it.

But the fates of individual species should not be confused with the fate of life. Species are, well, specific: they are an adaptation to a particular set of parameters. Change the parameters, and the adaptations will change to match them. Life will go on. We may not be there to see it, but that is our loss, not life's. *One generation passeth away, and another generation cometh; but the Earth abideth forever.* The dodo and the great auk may need our tears: the planet does not. The Preacher of Ecclesiastes was right.

IX On Science and Faith.

45. *If faith conflicts with truth, then faith is not true*.

Faith cannot take the place of evidence. God does not indulge in fakery: we are not required to override the facts in order to believe. Even miracles must be consistent with the laws of the Universe.

It is the nature of humans to seek reasons for things we do not understand. We want things to make sense. Faith can help with this task. It can provide a pattern for the seemingly patternless world. Gravity, sunlight, rain, winter, death - all of these are great mysteries to the infant, or to the infant race. We crave explanations. As bodies of explanations develop, we strive to connect them to each other, and to keep them coherent. Internally consistent worldviews are postulated within which the phenomena we observe can be categorized and understood. These are not yet theologies. They become theologies when we move from asking *how* to asking *why*. Faith provides a purpose for the Universe and helps us accept our place in it. It ties the things we observe together and gives them meaning. Any faith which does this consistently for everything a culture knows about the world is true for that culture.

But as soon as a fact doesn't fit, the situation changes. Faced with evidence it cannot explain, faith has two choices. It can alter what it believes, or it can deny the evidence. The first is harder, but it keeps the faith true. Truth cannot coexist with denial. A faith which teaches that all animals must remain earthbound cannot be true for those who have seen birds.

Faith must be continually tested, but the test is not whether or not one can believe in spite of the evidence; it is whether or not one can believe in both the faith *and* the evidence. If not, then it is faith which must be altered. The Inquisitors who forced Galileo to repudiate his evidence that the Earth moves around the Sun did not preserve their faith so much as they made it irrelevant. That is the fate of faiths which can be shown not to be true.

Accepting the evidence - celestial mechanics, the hydrologic circle, evolution, supply and demand - is not a defeat for faith, but an affirmation. It sorts out the inaccurate and unnecessary and helps locate the faith's truth. Those who really keep the faith are not those who stubbornly hang on to disproved notions, but those who let go of those notions - and still believe.

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46. *Science and religion conflict only in the minds of those who understand neither science nor religion*.

There is no reason not to have both faith and curiosity. Studying the workings of creation does not automatically preclude belief in a Creator, nor does finding purpose in our lives require us to abandon the scientific method. Dogmatic religion is suspect, but so is dogmatic science; the problem in either case is not the religion or the science, but the dogma.

Science is epistemological. It constantly attempts to validate its knowledge of the world. The big questions it attempts to answer are *what* and *how.* Much of its work is descriptive. Scientists look at the structures of things and try to determine the ways in which the structures they discover might operate. They seek functional relationships. The theories they postulate about these relationships are testable; they can be checked for fit against known or discoverable facts. Verification can be mechanically cumbersome, but it is always intellectually straightforward: do observable, measurable phenomena act in the way the theory predicts, or do they not? What is termed "scientific method" has little to do with laboratory technique or field methods or note-taking or mathematical accuracy - although all those things are important. What it has to do with is *repeatability.* At its heart lie the twin requirements of duplicable results and peer review: duplicable results to make sure the answer is the same every time, peer review to make sure that everybody gets the same answer. The point is not to prove you are right, but to obtain as objective a view as possible of what "right" is.

Religion is teleological. It seeks to find the purposes behind things: the big question it asks are *which* and *why.* Though it often strives for objectivity, much of it is necessarily subjective. Tests of faith do not follow the same process as tests of facts. They are not externally verifiable. Many people may come to the same conclusion - that is how we get organized religions - but the conclusion itself cannot be conclusively validated. We cannot prove the soul exists by measuring it, nor can we definitively describe the purpose of the Universe based on the small fraction of it that we can actually see. We cannot photograph the face of God. We can reach a fair degree of unanimity on what is wrong - greed, hatred, murder - but we cannot find the same level of agreement about what is right. We can experience Divine Love, but the only way we can show it to others is by practicing it.

Science and religion really exist in different spheres. One deals with the knowable; the other, with the unknowable. One can be proved; the other can only be practiced. Comparing one to the other is not only useless but dangerous. You cannot make such a comparison without disregarding important parts of one or both disciplines. To define one as true, but not the other, is to misuse the word "true." Truth and falsehood are only valid terms within areas of knowledge, not across them. In physics or art, one can have a "true red" - a color that consists of only the red rays of the spectrum. But red is not true in comparison to green.

The mathematics of infinity provide a useful way to look at the relationship between science and religion. Infinity is not simply enormous, it is unending. If you try to count to infinity you will never get there, because no matter how high you count, an infinite array of numbers will continue to stretch out before you. Thus, science - which is necessarily finite - cannot expand at the expense of religion, which is the study of the Infinite. No matter how much science learns about the world, there will always be an infinite amount it *does not know.* That is the realm in which religion properly operates.

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47. *Neither science nor religion can save us; all they can do is help us find the truth.*

Each in its separate sphere is important. Each can teach us things the other cannot. Neither is a substitute for the other, neither can stand alone, and neither has all the answers. They are companions, not opponents. Together, they can help us understand where truth lies. Acting on that understanding is up to us.

Truth is elusive; it hides beneath layer upon layer of preconception, illusion, bias, pride, ideology, smugness, and downright deceit. It looks different from different angles. As in the famous tale of the blind men trying to describe the elephant, we argue constantly over whether it is wall, hose, rope, tree, parchment, or sharp rock. A coherent description will not emerge until we pool our knowledge, insights, and efforts. We must be wise enough to let go of things we think we know when evidence is presented to the contrary. Skepticism is of great value, but it must be directed against our own ideas as well as those of others. We should always be prepared to be wrong.

Science and religion are two of the best tools we have for ferreting out the truth. Each has the capability of delving below the shiny surface of the world, down into the complicated darkness where the machinery ticks. They come at that machinery from different angles; this is an advantage, not a hindrance. Each can offer insights that the other cannot. Conflict arises, not from any inherent deficiency in either, but from attempting to use one to do the other's job.

Science deals with the physical realm - prions to galaxies and everything in between, plus the forces which move and shape them. Its tools are designed for investigating physical phenomena, and they are remarkably good at it. Its results are trustworthy. They are also, of necessity, incomplete. Good scientists understand that there is always more to learn about any phenomenon, and that we should always be prepared to allow cherished conclusions to be disproved. That is the way in which our overall understanding of the Universe advances and a clearer picture of truth continues to emerge.

Religion deals with the spiritual realm. Its subjects can neither be weighed nor measured. They can be experienced and described, but they cannot be shown to others. Their existence cannot be objectively proved. Like the tools and methods of science, the tools and methods of religion - meditation, prayer, ritual, love - can be used to gain a clearer picture of truth. The picture that emerges will necessarily be different from the picture provided by science, but that does not mean that either is wrong. It simply means that they are holding different parts of the elephant.

Religion cannot do the work of science. When it tries, we get the Earth-centered Universe, Creation science, and dependence upon abstinence as a tool to prevent overpopulation, which is like depending on a fishing net to stop a flood. Religion should yield the physical realm to science. We have always made up stories to explain that which we do not understand. To hold onto these stories after we *do* understand is to substitute dogma for truth. It is religiosity, but it is not religion.

But science cannot do the work of religion, either. When that is tried, we get eugenics. We get ethics based on supply and demand; we get love described as chemistry.

These things do not bring us closer to truth, but further away. Science can only deal successfully with what it can touch, either directly or through instruments. It must look to religion for the rest.

Both science and religion should therefore avoid the language of salvation. We are both physical and spiritual beings, and we cannot be saved by ignoring either aspect of our existence. Truth can save us, but only if we understand it, and then only if we act on our understanding but do not attempt to act beyond it. If truth is true, it is also coherent, whether or not it seems so. Our job is not to coerce other blind seekers into believing that an elephant is a rope, but to work with them to put together a description, not just of the tail, but of the whole elephant.

X. On Economics

48. *Supply and demand are natural laws*.

Supply and demand operate, not just in capitalist human societies, but among all living things. We can no more escape their influence on us than we can stop breathing or nullify gravity.

It is extremely important to understand this point, if we wish to make progress toward a healthy and sustainable planet. If the environmental community continues to propose solutions which treat supply and demand as an ideological baggage of capitalism which needs either to be overcome or ignored, then the solutions they propose will continue to fail. Natural laws cannot be selectively applied. Those who attempt to do so are doomed to failure, whether they are developers who ignore carrying capacity, farmers who ignore environmental resistance, or environmentalists who ignore supply and demand. Means to protect the environment have to meet the test of conforming to the principles through which the environment operates. We do not get a bye simply because our intentions are good.

The law of demand merely states that, as things get cheaper, more of them will be consumed. The law of supply is its opposite: as things get cheaper, fewer will be provided. The price at which the amount consumers are willing to purchase exactly balances the amount suppliers are willing to sell is known as "market equilibrium," and it is the point an economy will always tend to gravitate toward, whether or not that economy is capitalist - or even human.

Consider a non-human example, first. Trees which grow close together tend to be self-pruning: their lower branches die and fall off, leaving their trunks clear all the way up to the forest canopy. Why? Because it is difficult for sunlight to penetrate beneath the canopy, and it is not worth the tree's metabolic effort to maintain leaves down there. The purpose of branches is to spread leaves out to the sun, so when there is no longer a market for leaves, there is also no longer a market for branches, and the tree stops maintaining them as well. If you define price as the amount of sunlight available per square inch of leaf, then the lower branches are the victims of supply and demand. Looked at from the supply side, the price is dropping (less sunlight per square inch), so the tree has become less willing to produce the leaves necessary to obtain the supply. Looked at from the demand side, the price is rising (more square inches per unit of sunlight), so the tree begins to shift its sunlight purchases to cheaper suppliers (the leaves further up in the canopy). At some measurable point - some specific ratio of sunlight to leaf surface - the dropping price from the supply standpoint will fall below the rising price from the consumer standpoint. That is when self-pruning will take place.

Humans react in the same predictable manner that trees do. As suppliers, we will continue to bring goods to market as long as the price we obtain remains high enough to encourage the journey; as consumers, we will continue to purchase as long as the price remains low enough that the good is worth more to us than the money we will lay out for it. If these conditions are not met, we will self-prune. Many factors besides price may

enter into our decisions, but these have the effect of shifting our personal points of equilibrium, not of overriding them. On a society-wide level, the shifts average out, and we are left at market equilibrium. Period. A legally-mandated price above or below market equilibrium merely becomes the new equilibrium, and the supply and demand curves will shift until the amount produced reflects this - not necessarily in the way that we wish it to. A legally-mandated amount to be sold will also shift supply and demand to a new equilibrium that we may or may not want, but this time it is price that will climb or sink to undesirable levels. Legally mandating both amount to be sold and price to be sold at will fix the equilibrium in law but not in fact: either a black market will develop to take care of excess demand, or goods will rot unpurchased to take care of excess supply.

The lesson here is very clear. We will never defeat the law of supply and demand; therefore, we should learn to use it. The market will always find its way to equilibrium. The challenge we face is not how to override that equilibrium-seeking, but how to create the conditions under which the equilibrium, when found, will be at a level which society and the planet can continue to successfully sustain.

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49. *Money isn't value*.

Money is a means of measuring one particular type of value, and it does that very well. But we should never mistake the measuring stick for the real thing.

Economists recognize two distinct types of value that are only tenuously related to each other. *Value in use* is the value we get out of something when we put it to its designed purpose; *value in exchange* is the price that is put on something by the market. Price is conveniently stated in monetary terms, and that is where the confusion arises. But putting down a dollar and picking up a donut does not mean that the dollar and the donut are equal in value. What it means is that society in general values a donut about the same as it does a cup of coffee, or a bagel, or anything else you can buy for the same price.

Money also serves as a medium of exchange, which further confuses the issue. I accept money for writing a book; I give the money to the grocery store or the gasoline station or the dentist. The real exchange, here, is the book for the food or the gas or the tooth repair. Money makes it possible for that exchange to happen even when the grocer or the gasoline attendant or the dentist doesn't want the book. It is much more easily transferable - an economist would say *fungible* - than the goods we exchange it for. But even when it is acting as a medium of exchange, money is still really only a measuring stick. When I want to compare the width of my kitchen with the width of my bedroom, I don't carry the kitchen into the bedroom; I just carry the tape measure. The VISA card in my pocket serves the same purpose: it keeps me from having to carry my kitchen around.

All of this is important, in the context of this book, because of the difference between value in use and value in exchange. Adam Smith explained that difference, back in the 18th century, through what has become known as the "diamonds and water paradox." Diamonds, which are largely useless, are costly; water, which is necessary for our existence, is essentially free. Why? The paradox evaporates as soon as you realize

that "costly" and "free" refer to value in exchange, while "useless" and "necessary" refer to value in use. Costly vs. free is set by the supply and demand curves, and the supply of water is much much, much higher than that of diamonds. Useless vs. necessary is set in actual practice. If you pay a lot for a diamond, you can lock it up in a safe. If you pay a lot for a glass of water, you still have to drink it.

And now, perhaps, you can begin to see where this is going. Environmental values - the values that sustain all of us on this small blue planet - are primarily values in use. Developmental values are primarily values in exchange. The two are not normally comparable - and money measures only one of them. When we confuse money with value, we equate "value" with value in exchange, and that will give the edge to development every time.

And the danger in that is not simply that development will expand too far. There is added peril in the hidden connection that actually does exist between value in use and value in exchange. That connection depends on the relative positions of the supply and demand curves in classical market analysis. If supply is high relative to demand, prices will be low, and value in use can dominate in decision-making. But if demand becomes high relative to supply, prices will rise, and value in exchange will dominate. This is precisely what happens when scarcity of natural resources becomes an issue. The danger is real that, with money equated to value, the diamonds and water paradox will be resolved, not by recognizing the difference between value in use and value in exchange, but by raising the price of water until it approaches that of diamonds. Water will still have an essentially infinite value in use. But only the rich will be able to afford to use it.

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50. *The future tends to be discounted far below the present*.

What will happen twenty years from now - or even five years from now - is far less important to us than this present moment. We have taken the old advice about a bird in the hand too much to heart; even if the two in the bush are guaranteed, they are unlikely to be pursued if it means letting go of what we already have. What is true of future gains is even more true of future losses. If our lifestyles are squandering resources, what of it? The bill will not come due for several decades, so it can safely be ignored. We paste a bumper sticker to the planet: "I'm spending my children's inheritance." And then we do just that.

Economists have a process for quantifying this problem. What it involves, in essence, is taking the concept of accumulating interest and turning it on its head. How much money would you forego spending today in order to have a dollar to spend next year? Let us choose an amount - say, ninety-five cents. Now let us take you at your word. You hand me ninety-five cents, and I'll hand you a certificate entitling you to receive one dollar a year from today. You have just purchased a future dollar for ninety-five cents. If price represents value - and since this is an exchange, it is at least a reasonable approximation - then next year's dollars are worth only ninety-five per cent of today's.

That five per cent difference is known as the *discount rate*. It is handled just like compound interest: a dollar that can't be spent for two years is worth ninety-five per cent of ninety-five per cent, or a shade over ninety cents. Five years out, it is worth seventy-seven cents; ten years out, sixty cents; and twenty-five years out, just twenty-eight cents. And now you can begin to see the problem. A project that will save three times its cost over the next twenty-five years still looks like a bad deal to us - because it will cost us thirty-three cents per present dollar of future output, but deliver only twenty-eight cents per present dollar of future value.

It is beside the point, by the way, to argue: *but it is still saving money.* Of course it is: but it is saving *future* money, and the savings are therefore irrelevant. When we make decisions, we compare things in the present. And we will be getting only twenty-eight cents of present value for thirty-three cents of present cost.

It is the psychological ledgermaine practiced by discount rates that makes stewardship such a hard thing to sell. By definition, stewardship takes care of the present for the benefit of the future. But future benefits are worth less to us, today, than present benefits are. The further out the benefits run, the less their perceived value to us, and the more likely we are to put our resources into things which offer more immediate returns. Intellectually, we may understand clearly that a nation of SUV owners will run out of petroleum much faster than a nation that rides bicycles; but the petroleum will give out in the future, and the joys of SUV ownership are now. The value to us of extending the lives of the planet's oil fields is discounted far below the value to us of hurtling a big hunk of metal down the freeway at seventy-five miles an hour in four wheel drive. It makes no sense, from a long-term standpoint. But humans are not wired to think long-term.

This morning, while taking my usual constitutional around the neighborhood, I happened upon a bumper sticker that said *Question consumerism*. Right and good: we should all do that. But this bumper sticker was attached to a BMW. Perhaps it is easier to question consumerism after you have already consumed. Certainly it is easier to question *future* consumerism while you go ahead and consume today. The further out you look, after all, the cheaper the questioning becomes. At a discount rate of five per cent, questioning a BMW twenty-five years from now will only cost you a used Hyundai today.

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51. *All value is figured at the margin.*

The worth of a purchase or the worthiness of an action is determined, not by the costs and benefits of previous purchases or actions, but by the costs and benefits of the next one. This proposition is well known to economists, who use it to help establish price curves. For any commodity, the price consumers are willing to pay falls with each additional unit on the market. If the commodity is homogeneous (each unit is like every other), the price will be homogeneous, too: you can't charge $20 for an item that the store next door is selling for $10 and still expect to make sales. So the price of each additional unit determines, not only its own price, but the price of all previous units as well.

Price is a stand-in, here, for value: the price falls because people value each additional unit less. This is most clearly shown using money. Hand a homeless person a twenty-dollar bill. Hand another twenty-dollar bill to a millionaire. To the first, the gift may make the difference between life and death; to the second, the gift is essentially irrelevant. If you already own the equivalent of 50,000 twenties, one more or one less is not going to make a great deal of difference.

But talking about price and using money as an example - as economists usually do - obscures the broader truth inherent in this proposition. *All* value is determined at the margin, not just monetary value. The statement holds everywhere. It also works, importantly, in reverse: as the stock of an item shrinks, the value of each remaining item rises. The value of a shrinking forest is determined by the value of the next tree to be removed from it. This is as true for loggers who value the opportunity to cut the tree as it is for wilderness enthusiasts who value the opportunity to let it keep growing. Thus the increasing rancor of the logs-versus-wilderness debate as logged-over lands grow and forests fall. It has been said that loggers and environmentalists are each defending a vanishing way of life, and this is partly true. But what is often missed in that statement is the fact that both ways of life are vanishing along with the same resource. The increasing desperation felt by each side in this debate can be measured by the value of the next tree made ready for the axe.

Generally speaking, the marginal-value proposition works in favor of environmentalists. It is hard to argue against the increased value of vanishing wildlands, or of vanishing species. As pollution grows, the importance of clean water grows right along with it. There are, however, some caveats. If all value is determined at the margin, then all our successes are self-limiting. Each acre of wilderness we manage to add devalues all previously-established wilderness areas. Each incremental improvement in water quality makes it more likely that clean water will again be taken for granted. Pairing this trend with the rising costs associated with shrinking stocks - each additional acre of forest costs more to protect; each additional increment of pollution removal costs more to attain - creates a boundary beyond which further efforts no longer make sense. That is what is wrong with the goal of zero discharge of toxic pollutants and with the campaign to end logging entirely on the public lands. Each of these is not just politically inexpedient, but fundamentally flawed. They violate a law as basic and universal as gravity. All value is determined at the margin. This is not a capitalist proposition: markets don't determine it, they are determined by it. It is not a political proposition: it operates independently of the presence or absence of government action. It can be used to justify development, but it can also be used to justify preservation. It is not a human law at all, but a law of nature, and, like all such laws, cannot be violated. Any time we appear to be doing so, we are merely delaying the results, and they will ultimately hit much harder when they finally come around.

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52. *The last old-growth is valuable, not because it is old-growth, but because it is the last.*

The more our forests shrink and fragment, the more we treasure each acre. This is as true of those who value the trees as commodities as it is for those who value them as cathedrals. The supply of commodities and cathedrals shrinks together, and both sides battle over the same dregs. The stakes, though high, are really irrelevant; the quarrel has little to do with them. Beneath the rhetorical facade of jobs and ecosystems and economic welfare and endangered species lies the primal dynamic of a pack of dogs snarling over the last bone.

There will always be a fight over the last remnants of anything we want. Scarcity breeds value: the rarer the jewel, the more the king craves it for his crown. Whether or not the jewel is of any use is beside the point. The diamonds and water paradox holds here: value in exchange is not determined by utility, but by provenance. The more common the source, the less the value. It may be true, as the timber industry claims, that properly-managed second-growth forests will serve environmental values as well as old-growth; it may also be true, as the environmental community claims, that properly-managed second-growth forests can supply the timber we need without cutting any more of the old-growth. It may even be true - and I suspect it is - that "properly-managed" means essentially the same thing in both of these cases. None of these truths matter, because what is at issue is not value in use but value in exchange. We are not quarreling over the texts of Shakespeare's plays, but over ownership of the last copy of the First Folio.

The situation is further complicated by the fact that value is determined at the margin. Assuming reasonable uniformity, the value of all goods of a given type is equivalent to the price of the next one to be sold. Thus the mystifying (to some) dilemma of small towns surrounded by hundreds of square miles of untouched forest. The residents of these towns are often alarmed at restrictions on the harvest of what they see as an abundant resource, and they tend to grumble about environmental wackos and government meddlers. Neither of these is to blame. The problem is the margin. Local abundance notwithstanding, untouched forest is a scarce good, and the value of all acres everywhere is determined by the value of the next acre sold anywhere. The value of old-growth in Montana is determined by the amount remaining in Michigan (not an arbitrary example: Michigan was once the leading timber-producing state in the country). This is a rule of nature - human nature - and it cannot be changed by voting Republican in the next election. The role of scarcity in determining value is not a matter of politics, but of life.

None of this should be seen as belittling the passions stirred either by working in the woods or hiking through them. Forests have very high value in use, and these values are generally enhanced by the characteristics we think of as belonging to old-growth - big trees, intact canopies, a broad range of species, plenty of wildlife. (The "plenty of wildlife" part used to be disputed by those who called old-growth forests "green deserts," but what they were actually pointing to was the lack of forest-edge species, something that would naturally be noticed by a forest-edge species such as ourselves: there is a lot more wildlife in old growth than we once thought.) These values are crucial to our survival. They are also not the issue. What has triggered the current preservation battles is not value in use but value in exchange, and the more the forest disappears - the more it is

either logged over or locked up in preserves - the fiercer the war is certain to become. A rational look at value in use would cause both logging and preserving to slow down. But rational looks at scarce resources are few and far between.

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53. *Wealth is not past-oriented, but future-oriented*.

Wealth has little to do with accumulation. Merely owning things is inadequate: one must own things that will help. A woman with a gallon of water is wealthier than a woman with a gallon of diamonds, if both are in the middle of the desert. A man who owns his own home and car, but lives off his social security pension, is wealthier than a billionaire with a mansion and a fleet of limousines purchased on credit: if the billionaire suddenly loses his fortune, he will still owe his creditors, but the pensioner owes nobody. The pensioner's life is sustainable indefinitely, the billionaire's is not. True wealth is sustainable. It does not look at what has been done with resources in the past, or what is being done with them now, but what can be done with them in the future. How many jobs a logging operation provided yesterday, or provides today, tells us nothing about the wealth of the forest. That wealth can only be determined by measuring how many jobs the forest can continue to provide, without diminution, as far forward as we can see. To quote Buckminster Fuller: "Wealth has nothing to do with yesterday, but only with forward days. How many forward days, for how many lives are we now technically organized to cope? The numerical answer is the present state of our true wealth."[17]

Note that this definition of wealth calls into question not only massive clearcuts but massive preserves. It does not preclude either clearcutting or preservation, but it requires them to fit into context. Their value must be judged on the basis of the wealth they will continue to provide for society on a *sustained* - not a *present* - basis. It may well be that the best use of a particular piece of land is to feed the soul, through scenery, through contemplation, through a connection to wild nature, or simply through the knowledge that not all of the planet belongs to us. A wealthy society requires a sustainable supply of these things. But it also requires a sustainable supply of food and water and shelter, and if it preserves too much landscape, it cannot have these. Wealth, in Fuller's terms, is measured by the number of days forward that we are prepared to cope. A society surrounded by resources it cannot legally touch is no better prepared to cope than one that has used its resources up.

Economists tend to assess the wealth of nations through such measures as gross domestic product, gross national product, balance of trade, and per capita income. These are present-oriented and past-oriented values, and they are largely useless. Environmentalists are closer to the mark when they emphasize that a nation's true wealth lies in the resources it has not used; but if they demand that these resources never be used, they fall into the same trap as the economists. A resource that cannot be used is a

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[17] Fuller, Buckminster, "Technology and the Human Environment," in Disch, Robert, ed., *The Ecological Conscience: Values for Survival* (Englewood Cliffs, NJ: Prentice-Hall, Inc., 1970), p. 177.

resource that might as well not exist. The point isn't not to use it; the point is not to use it up.

Wealth is a flow. Our problem - and it is a human problem, not an American problem or an environmentalist problem or a developer problem - is that we tend to see it as a fund. We judge our wealth by what we own. Some of us want to own material goods and some want to own untouched landscapes, and when we argue over that difference we think we are debating something profound. We are not. We are distinguishing black and white phases of the same animal and trying to place them in different biological kingdoms. It doesn't matter what you want to own; it doesn't even matter that you want to own it. Ownership is irrelevant. It is not the size, shape, construction materials, motive power, purchase price, or registered owner of an aircraft that determines its value to us as passengers. It is whether or not it is going to stay in the air.