THE THIRD CHIMPANZEE

The Evolution and Future OF THE *Human Animal*

JARED DIAMOND

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The Golden Age That Never Was

Every part of the earth is sacred to my people. Every shining pine needle, every sandy shore, every mist in the dark woods, every clearing and humming insect is holy in the memory and experience of my people.... The white man... is a stranger who comes in the night and takes from the land whatever he needs. The earth is not his brother but his enemy.... Continue to contaminate your bed, and you will one night suffocate in your own waste.

—From a letter written in 1855 to President Franklin Pierce by Chief Seattle of the Duwanish tribe of American Indians.

ENVIRONMENTALISTS SICKENED BY THE DAMAGE THAT INDUSTRIAL societies are wreaking on the world often look to the past as a Golden Age. When Europeans began to settle America, the air and rivers were pure, the landscape green, the Great Plains teeming with bison. Today we breathe smog, worry about toxic chemicals in our drinking water, pave over the landscape, and rarely see any large wild animal. Worse is surely to come. By the time my infant sons reach retirement

age, half of the world's species will be extinct, the air radioactive, and the seas polluted with oil.

Undoubtedly, two simple reasons go a long way toward explaining our worsening mess: modern technology has far more power to cause havoc than did the stone axes of the past, and far more people are alive now than ever before. But a third factor may also have contributed: a change in attitudes. Unlike modern city dwellers, at least some preindustrial peoples—like the Duwanish, whose chief I quoted—depend on and revere their local environment. Stories abound of how such peoples are in effect practicing conservationists. As a New Guinea tribesman once explained to me, "It's our custom that if a hunter one day kills a pigeon in one direction from the village, he waits a week before hunting for pigeons again, and then goes in the opposite direction." We're only beginning to realize how sophisticated the conservationist policies of so-called primitive peoples actually are. For instance, well-intentioned foreign experts have made deserts out of large areas of Africa. In those same areas, local herders had thrived for uncounted millennia by making annual nomadic migrations, which ensured that land never became overgrazed.

The nostalgic outlook shared till recently by most of my environmentalist colleagues and me is part of a human tendency to view the past as a Golden Age in many other respects. A famous exponent of this outlook was the eighteenth-century French philosopher Jean-Jacques Rousseau, whose *Discourse on the Origin of Inequality* traced our degeneration from the Golden Age to the human misery that Rousseau saw around him. When eighteenth-century European explorers encountered preindustrial peoples like Polynesians and American Indians, those peoples became idealized in European salons as "noble savages" living in a continued Golden Age, untouched by such curses of civilization as religious intolerance, political tyranny, and social inequality.

Even now, the days of classical Greece and Rome are widely considered to be the Golden Age of western civilization. Ironically, the Greeks and Romans also saw themselves as degenerates from a past Golden Age. I can still recite half-conscious those lines of the Roman poet Ovid that I memorized in tenth-grade Latin, "Aurea prima sata est aetas, quae vindice nullo. . . .": "First came the Golden Age, when men were honest and righteous of their own free will." Ovid went on to contrast those virtues with the rampant treachery

and warfare of his own times. I have no doubt that any humans still alive in the radioactive soup of the twenty-second century will write equally nostalgically about our own era, which will then seem untroubled by comparison.

Given this widespread belief in a Golden Age, some recent discoveries by archaeologists and paleontologists have come as a shock. It's now clear that preindustrial societies have been exterminating species, destroying habitats and undermining their own existence for thousands of years. Some of the best-documented examples involve Polynesians and American Indians, the very peoples most often cited as exemplars of environmentalism. Needless to say, this revisionist view is hotly contested, not only in the halls of academia but also among lay people in Hawaii, New Zealand, and other areas with large Polynesian or Indian minorities. Are the new "discoveries" just one more piece of racist pseudo-science by which white settlers seek to justify dispossessing indigenous peoples? How can the discoveries be reconciled with all the evidence for conservationist practices by modern preindustrial peoples? If the discoveries are correct, can we use them as case histories to help us predict the fate that our own environmental policies may bring upon us? Can the recent findings explain some otherwise mysterious collapses of ancient civilizations, like those of Easter Island or the Maya Indians?

Before we can answer these controversial questions, we need to understand the new evidence belying the assumed past Golden Age of environmentalism. Let's first consider evidence for past waves of exterminations, then evidence for past destruction of habitats.

WHEN BRITISH COLONISTS began to settle New Zealand in the 1800s, they found no native land mammals except bats. That wasn't surprising: New Zealand is a remote island lying much too far from the continents for flightless mammals to reach. However, the colonists' plows uncovered the bones and eggshells of large birds that were then already extinct but that the Maori (the earlier Polynesian settlers of New Zealand) remembered by the name "moa." From complete skeletons, some of them evidently recent and still retaining skin and feathers, we have a good idea how moas must have looked alive: ostrichlike birds comprising a dozen species, and ranging from little ones "only" three feet high and forty pounds in weight up to giants

of five hundred pounds and ten feet tall. Their food habits can be inferred from preserved gizzards containing twigs and leaves of dozens of plant species, showing them to have been herbivores. They used to be New Zealand's equivalents of big mammalian herbivores like deer and antelope.

While the moas are New Zealand's most famous extinct birds, many others have been described from fossil bones, totaling at least twenty-eight species that disappeared before Europeans arrived. Quite a few besides the moas were big and flightless, including a big duck, a giant coot, and an enormous goose. These flightless birds were descended from normal birds that had flown to New Zealand and that had then evolved to lose their expensive wing muscles in a land free of mammalian predators. Others of the vanished birds, such as a pelican, a swan, a giant raven, and a colossal eagle, were perfectly capable of flight.

Weighing up to thirty pounds, the eagle was by far the biggest and most powerful bird of prey in the world when it was alive. It dwarfed even the largest hawk now in existence, tropical America's harpy eagle. The New Zealand eagle would have been the sole predator capable of attacking adult moas. Although some moas were nearly twenty times heavier than the eagle, it still could have killed them by taking advantage of the moas' erect two-legged posture, crippling them with an attack on the long legs, then killing them with an attack on the head and long neck, and finally remaining for many days to consume the carcasses, just as lions take their time at consuming a giraffe. The eagle's habits may explain the many headless moa skeletons that have been found.

Up to this point I've discussed New Zealand's big extinct animals. But fossil hunters have also discovered the bones of small animals the size of mice and rats. Scampering or crawling on the ground were at least three species of flightless or weak-flying songbirds, several frogs, giant snails, many giant cricketlike insects up to double the weight of a mouse, and strange mouselike bats that rolled up their wings and ran. Some of these little animals were completely extinct by the time that Europeans arrived. Others still survived on small offshore islands near New Zealand, but their fossil bones show that they were formerly abundant on the New Zealand mainland. Collectively, all these now-extinct species that had evolved in isolation would have provided New Zealand with the ecological equivalents of the continents'

flightless mammals that had never arrived: moas instead of deer, flightless geese and coots instead of rabbits, big crickets and little songbirds and bats instead of mice, and colossal eagles instead of leopards.

Fossils and biochemical evidence indicate that the moas' ancestors had reached New Zealand millions of years ago. When and why, after surviving for so long, did the moas finally become extinct? What disaster could have struck so many species as different as crickets, eagles, ducks, and moas? Specifically, were all these strange creatures still alive when the ancestors of the Maoris arrived around A.D. 1000?

At the time that I first visited New Zealand in 1966, the received wisdom was that moas had died out because of a change in climate, and that any moa species surviving to greet the Maoris were on their figurative last legs. New Zealanders took it as dogma that Maoris were conservationists and didn't exterminate the moas. There is still no doubt that Maoris, like other Polynesians, used stone tools, lived mainly by farming and fishing, and lacked the destructive power of modern industrial societies. At most, it was assumed, Maoris might have given the coup de grace to populations already on the verge of extinction. But three sets of discoveries have demolished this conviction.

First, much of New Zealand was covered with glaciers or cold tundra during the last Ice Age, ending about ten thousand years ago. Since then, the New Zealand climate has become much more favorable, with warmer temperatures and the spread of magnificent forests. The last moas died with their gizzards full of food, and enjoying the best climate that they had seen for tens of thousands of years.

Second, radiocarbon-dated bird bones from dated Maori archaeological sites prove that all known moa species were still present in abundance when the first Maoris stepped ashore. So were the extinct geese, ducks, swan, eagle, and other birds now known only from fossil bones. Within a few centuries, the moas and most of those other birds were extinct. It would have been an incredible coincidence if individuals of dozens of species that had occupied New Zealand for millions of years selected the precise geological moment of human arrival as the occasion to expire in synchrony.

Finally, more than a hundred large archaeological sites are

known—some of them covering dozens of acres—where Maoris cut up prodigious numbers of moas, cooked them in earth ovens, and discarded the remains. They ate the meat, used the skins for clothing, fashioned bones into fishhooks and jewelry, and blew out the eggs for use as water containers. During the nineteenth century moa bones were carted away from these sites by the wagonload. The number of moa skeletons in known Maori moa-hunter sites is estimated to be between 100,000 and 500,000, about ten times the number of moas likely to have been alive in New Zealand at any instant. Maoris must have been slaughtering moas for many generations.

Hence it is now clear that Maoris exterminated moas, at least partly by killing them, partly by robbing their nests of eggs, and probably partly as well by clearing some of the forests in which moas lived. Anyone who has hiked in New Zealand's rugged mountains will initially be incredulous at this thought. Just picture those travel posters of New Zealand's Fiordland, with its steep-walled gorges ten thousand feet deep, its four hundred inches of annual rainfall, and its cold winters. Even today, full-time professional hunters armed with telescopic rifles and operating from helicopters can't control the numbers of deer in those mountains. How could the few thousand Maoris living on New Zealand's South Island and Stewart Island, armed only with stone axes and clubs and operating on foot, have hunted down the last moas?

But there would have been a crucial difference between deer and moas. Deer have been selected for tens of thousands of generations to flee from human hunters, while moas had never seen humans until Maoris arrived. Like the naïve animals of the Galápagos Islands today, moas were probably tame enough for a hunter to walk up to one and club it. Unlike deer, moas may have had sufficiently low reproductive rates for a few hunters visiting a valley only once every couple of years to kill moas faster than they could breed. That's precisely what's happening today to New Guinea's largest surviving native mammal, a tree kangaroo in the remote Bewani Mountains. In areas settled by people, tree kangaroos are nocturnal, incredibly shy, live in trees, and are thus far harder to hunt than moas would have been. Despite all that, and despite the very small human population of the Bewanis, the cumulative effects of occasional hunting parties—literally one visit per valley per several years—have sufficed to bring this kangaroo to the verge of extinction. Having seen it happen to

tree kangaroos, I now have no difficulty understanding how it happened to moas.

Not just moas but also all of New Zealand's other extinct bird species were still alive when Maoris landed. Most were gone a few centuries later. The larger ones—the swan and pelican, the flightless goose and coot—were surely hunted for food. The giant eagle, however, may have been killed by Maoris in self-defense. What do *you* think happened when that eagle, specialized at crippling and killing two-legged prey between three and ten feet tall, did when it saw its first six-foot-tall Maoris? Even today, Manchurian eagles trained for hunting occasionally kill their human handlers, but the Manchurian birds were mere dwarfs beside New Zealand's giant, which was preadapted to become a man killer.

Surely, though, neither self-defense nor hunting for food explains the rapid disappearance of New Zealand's peculiar crickets, snails, wrens, and bats. Why were so many of those species exterminated, either throughout their range or else everywhere except on some offshore islands? Deforestation may be part of the answer, but the major reason was the other hunters that Maoris intentionally or accidentally brought with them: rats! Just as moas that evolved in the absence of humans were defenseless against humans, so, too, small insular animals that evolved in the absence of rats were defenseless against rats. We know that the rat species spread by Europeans played a major role in modern exterminations of many bird species on Hawaii and other previously rat-free oceanic islands. For example, when rats finally reached Big South Cape Island off New Zealand in 1962, within three years they exterminated or decimated the populations of eight bird species and a bat. That's why so many New Zealand species are restricted today to rat-free islands, the sole places where they could survive when the rat tide accompanying the Maoris swept over the New Zealand mainland.

Thus, when the Maoris landed, they found an intact New Zealand biota of creatures so strange that we would dismiss them as science-fiction fantasies if we did not have their fossilized bones to convince us of their former existence. The scene was as close as we shall ever get to what we might see if we could reach another fertile planet on which life had evolved. Within a short time, much of that community had collapsed in a biological holocaust, and some of the remaining community collapsed in a second holocaust following the arrival of

Europeans. The end result is that New Zealand today has about half of the bird species that greeted the Maoris, and many of the survivors are either now at risk of extinction or else confined to islands with few introduced mammalian pests. A few centuries of hunting had sufficed to end millions of years of moa history.

NOT ONLY ON NEW ZEALAND but on all other remote Pacific islands where archaeologists have looked recently, bones of many now-extinct bird species have been found at sites of the first settlers, proving there too that the bird extinctions and human colonizations were somehow related. From all the main islands of Hawaii, paleontologists Storrs Olson and Helen James of the Smithsonian Institution have identified fossil bird species that disappeared during the Polynesian settlement that began around A.D. 500. The fossils include not only small honey creepers related to species still present but also bizarre flightless geese and ibises with no living close relatives at all. While Hawaii is notorious for its bird extinctions following European settlement, this earlier extinction wave had been unknown until Olson and James began publishing their discoveries in 1982. The known extinctions of Hawaiian birds before Captain Cook's arrival now total the incredible number of at least fifty species, nearly one-tenth the number of bird species breeding on mainland North America.

That's not to say that all these Hawaiian birds were hunted out of existence. Although geese probably were indeed exterminated by overhunting, like the moas, small songbirds are more likely to have been eliminated by rats that arrived with the first Hawaiians, or else by destruction of forests that Hawaiians cleared for agriculture. Similar discoveries of extinct birds at archaeological sites of early Polynesians have also been made on Tahiti, Fiji, Tonga, New Caledonia, the Marquesas Islands, Chatham Islands, Cook Islands, Solomon Islands, and Bismarck Archipelago.

An especially intriguing collision of birds and Polynesians took place on Henderson Island, an extremely remote speck of land lying in the tropical Pacific Ocean 125 miles east of Pitcairn Island, which is famous for its own isolation. (Recall that Pitcairn is so remote that the mutineers who wrested the H.M.S. *Bounty* from Captain Bligh lived undetected on Pitcairn for eighteen years until the island was

rediscovered.) Henderson consists of jungle-covered coral riddled with crevices and totally unsuited for agriculture. Naturally, the island is now uninhabited and has been ever since Europeans first saw it in 1606. Henderson has often been cited as one of the world's most pristine habitats, totally unaffected by humans.

It was therefore a big surprise when Olson and fellow paleontologist David Steadman recently identified bones of two large species of pigeons, one smaller pigeon, and three seabirds that had gone extinct on Henderson some time between five hundred and eight hundred years ago. The same six species or close relatives had already been found in archaeological sites on several inhabited Polynesian islands, where it was clear how they could have been exterminated by people. The apparent contradiction of birds' also being exterminated by humans on uninhabited, seemingly uninhabitable Henderson was solved by the discovery there of former Polynesian sites with hundreds of cultural artifacts, proving that the island had actually been occupied by Polynesians for several centuries. At those same sites, along with the bones of the six bird species that were exterminated on Henderson, were the bones of other bird species that survived, plus many fish.

Thus, those early Polynesian colonists of Henderson evidently subsisted mainly on pigeons, seabirds, and fish until they had decimated the bird populations, at which point they had destroyed their food supply and either starved or else abandoned the island. The Pacific contains at least eleven other "mystery" islands besides Henderson, islands that were uninhabited on European discovery but that showed archaeological evidence of former occupation by Polynesians. Some of those islands had been settled for hundreds of years before their human population finally died out or left. All were small or in other respects marginally suitable for agriculture, leaving human settlers heavily dependent on birds and other animals for food. Given the widespread evidence for overexploitation of wild animals by early Polynesians, not only Henderson but the other mystery islands as well may represent the graveyards of human populations that ruined their own resource base.

LEST I LEAVE the impression that Polynesians were in any way unique as preindustrial exterminators, let's now jump nearly halfway around

the globe to the world's fourth-largest island, Madagascar, lying in the Indian Ocean off the coast of Africa. When Portuguese explorers arrived around 1500, they found Madagascar already occupied by people now called the Malagasy. On geographic grounds, you might have expected their language to be related to African languages spoken a mere two hundred miles to the west, on the coast of Mozambique. Astonishingly, though, it actually proved to belong to a group of languages spoken on the Indonesian island of Borneo, on the opposite side of the Indian Ocean thousands of miles to the northeast. Physically, the Malagasy range in appearance from typical Indonesians to typical blacks of East Africa. These paradoxes are due to the Malagasy's having arrived between one thousand and two thousand years ago, as a result of Indonesian traders' voyaging around the Indian Ocean coastline to India and eventually to East Africa. In Madagascar they proceeded to build a society based on herding cattle, goats, and pigs, farming, and fishing, and linked to the East African coast by Muslim traders.

As interesting as Madagascar's people are the wild animals that it has—and those that it lacks. Living in enormous abundance on the nearby African mainland are many species of large and conspicuous beasts that run on the ground and are active by day—the antelopes, ostriches, zebras, baboons, and lions that draw modern tourists to East Africa. None of these animals, and no animals remotely equivalent to them, have occurred on Madagascar in modern times. They were kept out by the two hundred miles of sea separating Madagascar from Africa, just as the sea also kept Australia's marsupials from reaching New Zealand. Instead, Madagascar supports two dozen species of small, monkeylike primates called lemurs, weighing only up to twenty pounds and mostly active at night and living in trees. Various species of rodents, bats, insectivores, and relatives of mongooses also occur, yet the largest still weighs only about twenty-five pounds.

However, littering Madagascar's beaches are proofs of vanished giant birds, in the form of countless eggshells the size of a soccer ball. Eventually, bones turned up not only of the birds that laid those eggs but also of a remarkable suite of vanished large mammals and reptiles. The egg makers were half-a-dozen species of flightless birds up to ten feet tall and weighing up to one thousand pounds, like moas and ostriches but more massively built and hence now termed ele-

phant birds. The reptiles were two species of giant land tortoises with shells about a yard long, and formerly very common, as indicated by the abundance of their bones. More diverse than either these large birds or reptiles were a dozen species of lemurs up to the size of a gorilla, and all larger than or at least as large as the largest surviving lemur species. To judge from the small size of the eye orbits in their skulls, all or most of the extinct lemurs were probably diurnal rather than nocturnal. Some of them evidently lived on the ground like baboons, while others climbed in trees like orangutans and koala bears.

As if all this were not enough, Madagascar also yielded the bones of an extinct "pygmy" hippopotamus ("only" the size of a cow), an aardvark, and a big mongoose-related carnivore built like a short-legged puma. Taken together, these extinct large animals formerly gave Madagascar the functional equivalents of the surviving large beasts for which tourists still flock to African game parks—just as did New Zealand's moas and other strange birds. The tortoises, elephant birds, and pygmy hippos would have been the herbivores in place of antelope and zebras; the lemurs would have replaced the baboons and great apes; and the mongoose-related carnivore made do for a leopard or scaled-down lion.

What happened to all these big extinct mammals, reptiles, and birds? We can be confident that at least some of them were alive to delight the eyes of the first arriving Malagasy, who used elephant-bird eggshells as water containers and discarded butchered bones of the pygmy hippo and some of the other species in their garbage heaps. In addition, the bones of all the other extinct species are known from fossil sites only a few thousand years old. Since they must have evolved and survived for millions of years until then, it is unlikely that all those animals had the foresight to give up the ghost just in those last few moments before hungry humans showed up. In fact, a few may still have been holding out in remote parts of Madagascar when Europeans arrived, since the seventeenth-century French governor Flacourt was given descriptions of an animal suggestive of the gorilla-sized lemur. The elephant birds may have survived long enough to become known to Arab traders in the Indian Ocean, and to give rise to the account of the rok (a giant bird) in the tale of Sindbad the Sailor.

Certainly some and probably all of Madagascar's vanished giants

were somehow exterminated by the activities of the early Malagasy. It's not hard to understand why the elephant birds went extinct, since their eggshells made such convenient two-gallon jerrycans. While the Malagasy were herders and fishermen rather than big-game hunters, the other big animals would have been as easy prey as New Zealand's moas, since they had never seen humans before. That's presumably why the easy-to-see, easy-to-catch lemurs big enough to be worth the effort of butchering them—the large, diurnal, terrestrial species—all went extinct, while the small, nocturnal, tree-living ones all survived.

However, unintended by-products of Malagasy activities probably killed more big animals than did hunting. Fires lit to clear forest for pasture and to stimulate growth of new grass each year would have destroyed habitats on which the beasts depended. Grazing cattle and goats also transformed habitats, as well as competing directly with grazing tortoises and elephant birds for food. Introduced dogs and pigs would have preyed on ground-dwelling animals, their young, and their eggs. By the time the Portuguese arrived, Madagascar's once-abundant elephant birds had all been reduced to eggshells covering the beaches, skeletons in the ground, and vague memories of roks.

MADAGASCAR AND POLYNESIA merely provide well-documented examples of the extinction waves that probably unfolded on all large oceanic islands colonized by people before the European expansion of the last five hundred years. All such islands where life had evolved in the absence of humans used to have unique species of big animals that modern zoologists never saw alive. Mediterranean islands like Crete and Cyprus had pygmy hippos and giant tortoises (just as did Madagascar), as well as dwarf elephants and dwarf deer. The West Indies lost monkeys, ground sloths, a bear-sized rodent, and owls of several sizes: normal, giant, colossal, and titanic. It seems likely that these big birds, mammals, and tortoises too somehow succumbed to the first Mediterranean peoples or American Indians to reach their islands. Nor were birds, mammals, and tortoises the only victims: lizards, frogs, snails, and even large insects disappeared as well, comprising thousands of species when one adds up all oceanic islands. Olson describes these insular extinctions as "one of the swiftest and most

profound biological catastrophes in the history of the world." However, we won't be sure that humans were responsible until the bones of the last animals and the remains of the first people have been dated more exactly for other islands, as has already been done for Polynesia and Madagascar.

In addition to these preindustrial extermination waves on islands, other species may have fallen victim to extermination waves on continents in the more distant past. About eleven thousand years ago, around the probable time that the first ancestors of American Indians reached the New World, most large species of mammals became extinct throughout all of North and South America. A long-standing debate has raged over whether these big mammals were done in by Indian hunters, or whether they just happened to succumb to climate changes around the same time. I'll explain in the next chapter why I personally think that hunters did it. However, it's much harder to pinpoint dates and causes of events that happened around eleven thousand years ago than it is for recent events like the Maori versus moa collision within the past one thousand years. Similarly, within the past fifty thousand years Australia was colonized by the ancestors of today's Aboriginal Australians *and* lost most of its species of big animals. Those animals included giant kangaroos, the "marsupial lion," and "marsupial rhinos" (known as diprotodonts), plus giant lizards, snakes, crocodiles, and birds. However, we still don't know whether the arrival of Australia's humans somehow caused the disappearance of Australia's big animals. Although it's now reasonably certain that the first preindustrial peoples to reach islands wrought havoc among island species, the jury is still out on the question whether this also happened on continents.

FROM ALL THIS EVIDENCE that the Golden Age was tarnished by exterminations of species, let's now turn to evidence for destruction of habitats. Three dramatic examples involve famous archaeological puzzles: the giant stone statues of Easter Island, the abandoned pueblos of the U.S. Southwest, and the ruins of Petra.

An aura of mystery has clung to Easter Island ever since it and its Polynesian inhabitants were "discovered" by the Dutch explorer Jakob Roggeveen in 1722. Lying in the Pacific Ocean 2,300 miles west of Chile, Easter surpasses even Henderson as one of the world's most

isolated scraps of land. Hundreds of statues, weighing up to eighty-five tons and up to thirty-seven feet tall, were carved from volcanic quarries, somehow transported several miles, and raised to an upright position on platforms by people without metal or wheels and with no power source other than human muscle. Even more statues remain unfinished in the quarries, or lie finished but abandoned between the quarries and platforms. The scene today is as if the carvers and movers had suddenly walked off the job, leaving an eerily silent landscape.

When Roggeveen arrived, many statues were still standing, though new ones were no longer being carved. By 1840 all the erected statues had been deliberately toppled by the Easter Islanders themselves. How were such huge statues transported and erected, why were they eventually toppled, and why had carving ceased?

The first of those questions was answered when living Easter Islanders showed Thor Heyerdahl how their ancestors had used logs as rollers to transport the statues and then as levers to erect them. The other questions were solved by subsequent archaeological and paleontological studies that revealed Easter's gruesome history. When Polynesians settled Easter around A.D. 400, the island was covered by forest that they gradually proceeded to clear, in order to plant gardens and to obtain logs for canoes and for erecting statues. By around 1500 the human population had built up to about 7,000 (over 150 per square mile), about 1,000 statues had been carved, and at least 324 of those statues had been erected. But—the forest had been destroyed so thoroughly that not a single tree survived.

An immediate result of this self-inflicted ecological disaster was that the islanders no longer had the logs needed to transport and erect statues, so carving ceased. But deforestation also had two indirect consequences that brought starvation: soil erosion, hence lower crop yields, plus lack of timber to build canoes, hence less protein available from fishing. As a result, the population was now greater than Easter could support, and island society collapsed in a holocaust of internecine warfare and cannibalism. A warrior class took over; spear points manufactured in huge quantities came to litter the landscape; the defeated were eaten or enslaved; rival clans pulled down each other's statues; and people took to living in caves for self-protection. What had once been a lush island supporting one of the world's most remarkable civilizations deteriorated into the Easter Island of today:

a barren grassland littered with fallen statues, and supporting less than one-third of its former population.

OUR SECOND CASE STUDY of preindustrial habitat destruction involves the collapse of one of the most advanced Indian civilizations of North America. When Spanish explorers reached the U.S. Southwest, they found gigantic multistory dwellings (pueblos) standing uninhabited in the middle of treeless desert. For example, the 650-room dwelling at Chaco Canyon National Monument in New Mexico was 5 stories high, 670 feet long, and 315 feet wide, making it the largest building ever erected in North America until topped by steel skyscrapers in the late nineteenth century. Navajo Indians in the region knew of the vanished builders only as "Anasazi," meaning "the Ancient Ones."

Archaeologists subsequently established that construction of the Chaco pueblos began shortly after A.D. 900, and that occupation ceased in the twelfth century. Why did the Anasazi erect a city in a barren wasteland, of all unpromising places? Where did they obtain their firewood, or the sixteen-foot-long wooden beams (200,000 of them!), that supported the roofs? Why did they then abandon the city that they had built at such enormous effort?

The conventional view, analogous to the claim that Madagascar's elephant birds and New Zealand's moas died out from natural changes in climate, attributes the abandonment of Chaco Canyon to a drought. However, a different interpretation emerges from the work of paleobotanists Julio Betancourt, Thomas Van Devender, and their colleagues, who used an ingenious technique to decipher changes in Chaco vegetation through time. Their method relied on the little rodents called packrats, which gather plants and other materials into shelters (termed middens) that they eventually abandon after fifty to one hundred years but that remain well preserved under desert conditions. The plants can be identified centuries later, and the midden can be dated by radiocarbon techniques. Thus, each midden is virtually a time capsule of the local vegetation.

By this method, Betancourt and Van Devender were able to reconstruct the following course of events. At the time that the Chaco pueblos were erected, they were not surrounded by barren desert but by pinyon-juniper woodland, with ponderosa pine forest nearby. This

discovery at once solves the mystery of where the firewood and timber came from, and disposes of the apparent paradox of an advanced civilization rising from barren desert. As occupation continued at Chaco, however, the woodland and forest were cleared until the environment became the treeless wasteland that it remains today. The Indians were then having to go over ten miles to get firewood, and over twenty-five miles to get pine logs. When the pine forest had been felled, they built an elaborate road system to haul spruce and fir logs from mountain slopes over fifty miles away, relying on nothing more than their own muscle power. In addition, the Anasazi had solved the problems of agriculture in a dry environment by building irrigation systems to concentrate available water into valley bottoms. As deforestation caused progressively increasing erosion and water runoff, and as irrigation channels gradually dug gullies into the ground, the water table may finally have dropped below the level of the Anasazi fields, making irrigation without pumps impossible. Thus, while drought may have made some contribution to the Anasazi abandonment of Chaco Canyon, a self-inflicted ecological disaster was also a major factor.

OUR REMAINING EXAMPLE of preindustrial habitat destruction illuminates the gradual geographic shift in the power center of ancient western civilizations. Recall that the first center of power and innovation was the Mideast, where so many crucial developments arose—agriculture, animal domestication, writing, imperial states, battle chariots, and others. Ascendancy shifted between Assyria, Babylon, Persia, and occasionally Egypt or Turkey, but remained in or near the Mideast. With the overthrow of the Persian Empire by Alexander the Great, ascendancy moved finally westward, at first to Greece, then to Rome, and later to western and northern Europe. Why did the Mideast, Greece, and Rome in turn lose their primacy? (The transient current importance of the Mideast, resting as it does on the single resource of oil, merely emphasizes by contrast the region's modern weakness in other respects.) Why do modern superpowers include the United States and the USSR, Germany and England, Japan and China, but no longer Greece and Persia?

This geographic shift in power is too big and lasting a pattern to have arisen by accident. A plausible hypothesis attributes it to each

ancient center of civilization in turn ruining its resource base. The Mideast and Mediterranean were not always the degraded landscape that they appear today. In ancient times much of this area was a lush mosaic of wooded hills and fertile valleys. Thousands of years of deforestation, overgrazing, erosion, and valley siltation converted this heartland of western civilization into the relatively dry, barren, infertile landscape that predominates today. Archaeological surveys of ancient Greece have revealed several cycles of population growth alternating with population crashes and local abandonment of human settlement. In the growth phases, terracing and dams initially protected the landscape until felling of forests, clearing of steep slopes for agriculture, overgrazing by too many livestock, and planting of crops at too short intervals overwhelmed the system. The result each time was massive erosion of the hills, flooding of the valleys, and the collapse of local human society. One such event coincided with (and may have caused) the otherwise mysterious collapse of Greece's glorious Mycenean civilization, after which Greece fell back for several centuries into a dark age of illiteracy.

The support for this view of ancient environmental destruction comes from sources such as contemporary accounts and archaeological evidence. Yet a few sequences of photographs would constitute more decisive tests than all that anecdotal evidence combined. If we had snapshots of the same Greek hillside taken at thousand-year intervals, we could identify the plants, measure the ground cover, and calculate the shift from forest to goat-proof shrubs. We could thereby put numbers on the extent of environmental degradation.

Enter middens to the rescue again. While the Mideast doesn't have packrats, it does have rabbit-sized, marmotlike animals called hyraxes that build packrat-like middens. (Surprisingly, the closest living relatives of hyraxes may be elephants.) Three Arizona scientists—Patricia Fall, Cynthia Lindquist, and Steven Falconer—studied hyrax middens at Jordan's famous lost city of Petra, which typifies the paradox of ancient western civilization. Petra is now especially familiar to moviegoing aficionados of Steven Spielberg and George Lucas, whose film *Indiana Jones and the Last Crusade* shows Sean Connery and Harrison Ford searching for the Holy Grail in Petra's magnificent rock tombs and temples amidst the desert sand. Anyone who sees those scenes of Petra must wonder how such a wealthy city

could have arisen and supported itself in such a bleak landscape. In fact, there was already a Neolithic village near the site of Petra before 7000 B.C., and farming and herding appeared there soon after. Under the Nabataean kingdom, of which it was the capital, Petra thrived as a commercial center controlling trade between Europe, Arabia, and the Orient. The city grew ever larger and richer under Roman, then Byzantine, control. But it was subsequently abandoned and so completely forgotten that its ruins were not rediscovered until 1812. What caused Petra's collapse?

Each hyrax midden at Petra yielded remains of up to one hundred plant species, and the habitat prevailing when each midden's owner was alive could be calibrated by comparing pollen proportions in the midden with those in modern habitats. From the middens, the following trajectory was reconstructed for the degradation of Petra's environment:

Petra lies in an area of dry Mediterranean climate not unlike that of the wooded mountains behind my home in Los Angeles. The original vegetation would have been a woodland dominated by oak and pistachio trees. By Roman and Byzantine times, most of the trees had been felled, and the surroundings had been degraded to an open steppe, as expressed in the fact that only 18 percent of midden pollen came from trees, the rest from low plants. (For comparison, trees contribute 40–85 percent of the pollen in modern Mediterranean forests, 18 percent in forest-steppe.) By A.D. 900, a few centuries after Byzantine control of the Petra area ended, two-thirds of the remaining trees had disappeared. Even shrubs, herbs, and grasses had declined, converting the environment into the desert that we see now. Surviving trees today have their lower branches pruned off by goats and are scattered on goat-proof cliffs or in groves protected from goats.

Juxtaposing these data from hyrax middens with archaeological and literary data yields the following interpretation. Deforestation from Neolithic to imperial times was driven by the clearing of land for agriculture, browsing by sheep and goats, gathering of firewood, and wood needs for house construction. Even Neolithic houses not only were supported by massive timbers but also consumed up to thirteen tons of firewood per house to make the plaster for the walls and floor. The imperial population explosion quickened the pace of forest destruction and overgrazing. Elaborate systems of channels,

pipes, and cisterns were needed to collect and store water for the orchards and city.

After Byzantine authority collapsed, orchards were abandoned and the population crashed, but land degradation continued as the remaining inhabitants became dependent on intensive grazing. The insatiable goats began to eat their way through the shrubs, herbs, and grasses. The Ottoman government decimated surviving woodlands before the First World War, to obtain the wood needed for the Hejaz Railway. I and many other moviegoers thrilled at the sight of Arab guerrillas led by Lawrence of Arabia (a.k.a. Peter O'Toole) blowing up that railway in wide-screen Technicolor, without realizing that we were watching the last act in the destruction of Petra's forests.

Petra's ravaged landscape today is a metaphor for what happened to the rest of the cradle of western civilization. The modern surrounds of Petra could no more feed a city that commanded the world's main trade routes than the modern surrounds of Persepolis could feed the capital of a superpower such as the Persian Empire once was. The ruins of those cities, and of Athens and Rome, are monuments to states that destroyed their means of survival. Nor are Mediterranean civilizations the only literate societies that committed ecological suicide. The collapse of Classic Maya civilization in Central America, and of Harappan civilization in India's Indus Valley, are other obvious candidates for ecodisasters due to an expanding human population overwhelming its environment. While courses in the history of civilization often dwell on kings and barbarian invasions, deforestation and erosion may in the long run have been more important shapers of human history.

THESE ARE SOME of the recent discoveries making the supposed past Golden Age of environmentalism look increasingly mythical. Let's now go back to the larger issues I raised at the outset. First, how can these discoveries of past environmental damage be reconciled with accounts of conservationist practices by so many modern preindustrial peoples? Obviously, not all species have been exterminated, and not all habitats have been destroyed, so the Golden Age couldn't have been all black.

I suggest the following answer to this paradox. It's still true that small, long-established, egalitarian societies tend to evolve conserva-

tionist practices, because they've had plenty of time to get to know their local environment and to perceive their own self-interest. Instead, damage is likely to occur when people suddenly colonize an unfamiliar environment (like the first Maoris and Easter Islanders); or when people advance along a new frontier (like the first Indians to reach America), so that they can just move beyond the frontier when they've damaged the region behind; or when people acquire a new technology whose destructive power they haven't had time to appreciate (like modern New Guineans, now devastating pigeon populations with shotguns). Damage is also likely in centralized states that concentrate wealth in the hands of rulers, who are out of touch with their environment. And some species and habitats are more susceptible to damage than others—such as flightless birds that never had seen humans (like moas and elephant birds), or the dry, fragile, unforgiving environments in which both Mediterranean civilization and Anasazi civilization arose.

Second, are there any practical lessons that we can learn from these recent archaeological discoveries? Archaeology is often viewed as a socially irrelevant academic discipline that becomes a prime target for budget cuts whenever money gets tight. In fact, archaeological research is one of the best bargains available to government planners. All over the world, we're launching developments that have great potential for doing irreversible damage, and that are really just more powerful versions of ideas put into operation by past societies. We can't afford the experiment of developing five counties in five different ways and seeing which four counties get ruined. Instead, it will cost us much less in the long run if we hire archaeologists to find out what happened the last time than if we go making the same mistakes again.

Here's just one example. The American Southwest has over 100,000 square miles of pinyon-juniper woodland that we are exploiting more and more for firewood. Unfortunately, the U.S. Forest Service has little data available to help it calculate sustainable yields and recovery rates in that woodland. Yet the Anasazi already tried the experiment and miscalculated, with the result that the woodland still hasn't recovered in Chaco Canyon after over eight hundred years. Paying some archaeologists to reconstruct Anasazi firewood consumption would be cheaper than committing the same mistake and ruining 100,000 square miles of the United States, as we may now be doing.

Finally, let's face the touchiest question. Today, environmentalists view people who exterminate species and destroy habitats as morally bad. Industrial societies have jumped at any excuse to denigrate preindustrial peoples, in order to justify killing them and appropriating their land. Are the purported new finds about moas and Chaco Canyon vegetation just pseudo-scientific racism that in effect is saying, Maoris and Indians don't deserve fair treatment because they were bad?

What has to be remembered is that it's always been hard for humans to know the rate at which they can safely harvest biological resources indefinitely, without depleting them. A significant decline in resources may not be easy to distinguish from a normal year-to-year fluctuation. It's even harder to assess the rate at which new resources are being produced. By the time that the signs of decline are clear enough to convince everybody, it may be too late to save the species or habitat. Thus, preindustrial peoples who couldn't sustain their resources were guilty not of moral sins, but of failures to solve a really difficult ecological problem. Those failures were tragic, because they caused a collapse in life-style for the people themselves.

Tragic failures become moral sins only if one should have known better from the outset. In that regard there are two big differences between us and eleventh-century Anasazi Indians: scientific understanding, and literacy. We know, and they didn't know, how to draw graphs that plot sustainable resource population size as a function of resource harvesting rate. We can read about all the ecological disasters of the past; the Anasazi couldn't. Yet our generation continues to hunt whales and clear tropical rain forest as if no one had ever hunted moas or cleared pinyon-juniper woodland. The past was still a Golden Age, of ignorance, while the present is an Iron Age of willful blindness.

From this point of view it's beyond understanding to see modern societies repeating the past's suicidal ecological mismanagement, with much more powerful tools of destruction in the hands of far more people. It's as if we hadn't already run that particular film many times before in human history, and as if we didn't know the inevitable outcome. Shelley's sonnet "Ozymandias" evokes Persepolis, Tikal, and Easter Island equally well; perhaps it will someday evoke to others the ruins of our own civilization:

I met a traveller from an antique land
Who said: "Two vast and trunkless legs of stone
Stand in the desert. Near them, on the sand,
Half sunk, a shattered visage lies, whose frown,
And wrinkled lip, and sneer of cold command,
Tell that its sculptor well those passions read
Which yet survive, stamped on these lifeless things,
The hand that mocked them and the heart that fed;
And on the pedestal these words appear—
'My name is Ozymandias, king of kings:
Look on my works, ye Mighty, and despair!'
Nothing beside remains. Round the decay
Of that colossal wreck, boundless and bare
The lone and level sands stretch far away."