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2 The First Hundred Thousand Years

J. R. McNEILL

I rush in where prudent angels fear to tread, to the realm of long-term global-scale history. As a rule, historians leave this treacherous terrain to others, to historical sociologists in particular. Historians have their reasons for this caution, preferring the surer ground of smaller-scale history that can be supported by written documentation. One way to reduce the impracticalities of long-term global-scale history is to privilege one variety of human experience. I confine my scope here to environmental history, and to a few turning points within it. Of all the possible candidates for the title of "turning point" in the long history of human habitation of the biosphere, I maintain that seven stand out. They are, in chronological order, (1) the harnessing of fire; (2) the emergence of spoken language; (3) the exodus from Africa and occupation of other lands; (4) the domestication of plants and animals; (5) the emergence of cities; (6) the Columbian Exchange; and (7) the development of fossil fuels.

For most of the human career, we lived in small bands and roamed large territories. It is difficult to know a lot about these millennia, but much of what little we know has to do with human involvement with the environment. It was surprisingly eventful. First, at some point our ancestors, whether human or hominid, learned how to harness fire and then to make it. This was one of the great turning points of human history, not merely environmental history, although we do not know when or where it happened. Informed guesses suggest this occurred maybe half a million years ago, which is before the appearance of *Homo sapiens*.[1] It almost certainly happened somewhere in Africa, where most hominids were and where *Homo sapiens* first emerged. The use of fire allowed our ancestors to shape landscapes to suit their purposes. For example, they could now turn a forest into grassland, a habitat better suited to their hunting skills and attractive to the big herbivores that were the most rewarding prey. Fire also proved useful in keeping large carnivores at bay, especially at night, improving our ancestors' survival chances. Cooking over fire enormously widened the range of possible foods they could digest, improving their nutrition. In short, fire changed our ancestors' place in nature and reduced the chances they might go extinct, as most branches—indeed *all* other branches—of our genus did.

The landscapes our ancestors helped to create in turn altered their genes and their bodies (and thus ours). They became, for example, excellent long-distance walkers, developed arms and shoulders capable of launching projectiles forcefully and accurately, and, because of cooking, stopped investing much scarce energy in building formidable teeth. They developed the capacity to sweat profusely and thereby keep their bodies from overheating during prolonged exercise, a trait shared only with horses.[2] It allowed hunters to run down far faster creatures—antelopes in Africa or kangaroos in Australia—by keeping the prey on the run until it wilted from heat exhaustion. Bodily adaptation to the grassland habitat began in all probability even before hominids harnessed fire, but the use of fire, both to expand grasslands and to cook meat, accelerated and confirmed the process.

A second skill that emerged long ago and influenced our place in nature was the development of complex language. The origins and early evolution of language remain obscure; it may have begun as recently as fifty thousand years ago, although most expert opinion places it much further back in the past. In any case the capacity to coordinate action as it happened, and to plan it in advance, through language, made hunting far more effective and far safer. Language allowed cumulative learning and improved the transmission of information across the generations, a great advantage in competition with other hominids who lacked language and an asset in the struggle for survival against hunger, thirst, and fierce animals. People with language could tell one another where to find water in time of drought or how to avoid certain poisonous plants. This was a great advance over trial and error. Presumably language, like fire, allowed our ancestors to survive longer, to reproduce more abundantly, to secure a larger role in the web of nature, and, once again, to reduce the odds of extinction.

About a hundred thousand years ago, some *Homo sapiens* walked out of Africa and began to spread to other continents. No doubt several groups made the trek at various times. In Africa our remote ancestors had co-evolved over many millennia with various microbes that fed upon them and with the animal prey

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upon which they fed. This checked hominid biological success. Many microbes eventually "learned" how to use our ancestors' bodies for their energy and sustenance, and to move from one body to the next efficiently, often provoking illness in humans (or hominids). Thus our remote African ancestors lived with a heavy load of parasites and pathogens. Moreover, the animals they hunted had plenty of time to "learn" our ancestors' tricks—more strictly speaking, to evolve adaptations that equipped them to survive in the presence of human (or hominid) hunting.

Once out of Africa, however, our ancestors stole a march on the rest of nature. They left some of their pathogens and parasites behind, bringing many millennia of comparatively good health for the migrants and their descendants. They also walked into landscapes brimming with naive animals that had never been stalked by projectile-throwing upright apes capable of running for hours on end and coordinating their hunting efforts through language. They were, in effect, an exotic invasive species in Asia, Europe, Australia (by perhaps sixty thousand years ago), and the Americas (at least fourteen thousand years ago). As invasive species often do, they flourished in these new landscapes, reproducing prolifically and causing havoc for other species. Thanks to the use of fire and language, and a few stone tools, our ancestors entered new continents as a rogue species, armed and dangerous.

Among the species most affected were the big mammals that provided hunters with the most food for their efforts. Soon after people arrived in Australia, many species of large mammals went extinct. The same thing happened in the Americas.[3] It also happened much later, when people first got to previously uninhabited islands such as Madagascar (about two thousand years ago) and those of New Zealand (about a thousand years ago). These extinctions may or may not have resulted from human hunting; the evidence is usually too slender to permit confident judgment, especially in the Paleolithic cases. Sometimes these waves of extinction are put down to such things as climate changes or epizootics. Climates, however, had changed many times before, sometimes quickly enough to affect species survival. Climate change had nothing to do with the recent extinctions on Madagascar or in New Zealand, but in the Americas the arrival of humans coincided with rapid warming at the end of the last ice age, which might well have helped usher many creatures off the stage. Probably the truth of the matter is that both human predation and climate change were often involved, in different proportions in different settings.

Whatever the constellations of causes may have been, these extinctions had important historical consequences that have reverberated down the millennia to the present. Australia lost all of its largest marsupials, including one the size of a rhinoceros. North America lost giant sloths, mastodons, camels, and horses. This impoverishment of the fauna left human populations in Australia and the Americas with very little to work with in terms of potentially domesticable animals. This situation meant that for millennia Australian aborigines and pre-Columbian Americans enjoyed somewhat better health than African and Eurasian peoples, who suffered from infectious diseases derived from domesticated animals. But it also meant that when strangers arrived on their shores accompanied by horses, cattle, pigs, and a host of unfamiliar infectious diseases, early Australians and Americans were at a profound disadvantage.

About eleven thousand to twelve thousand years ago, perhaps spurred by climate change, people began to produce food by domesticating plants and animals. This transition, long and justly regarded as another of the great turning points in human history (again, not merely environmental history), seems to have occurred first in the foothills of the Zagros and Taurus mountains in the Middle East.[4] However, we probably would not know had it happened earlier somewhere in the tropical rain forests or along coastlines now submerged (sea level was about a hundred meters lower ten thousand years ago because so much water was locked up on land in the form of glacial ice). Archeological remains last much better in dry conditions, such as those of the Middle East, and decay much faster in the humidity of the world's rain forests. So it remains quite possible that earlier transitions to agriculture, or at least to horticulture, took place perhaps in Southeast Asia or West Africa or northern South America. We will probably never know. Agricultural transitions that left some impression in the archeological record seem to have happened independently at least five or seven times, perhaps more, all between twelve thousand and four thousand years ago. These transitions seem to have spread from each point of origin.[5]

Food production allowed much denser human populations than did hunting and foraging. It required a more sedentary lifestyle, even if farmers packed up and moved to new fields every now and then (in a pattern known as "shifting agriculture"). Fields and gardens replaced forest and savanna. When people learned to irrigate crops, agriculture came to involve a new connection to fresh water. Almost everywhere it required dogged labor to carve out fields, to maintain them, to nurture crops, to pluck out weeds, to keep hungry animals from munching the harvest, and in some cases to keep water in the right places at the right times. Soon after people settled down to farming, they began to dot landscapes with villages—the first real "built environment." Of course hunters and foragers had built shelters for themselves from time to time. And probably

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some fishing communities enjoying especially rich waters built real villages. But only with farming did this become a widespread habit. For all these reasons—the creation of gardens and fields, the careful manipulation of water, and the emergence of the built environment—farming amounted to a thorough revolution in the human environment and the human relationship to nature.

On perhaps a more fundamental level, this transition involved the gradual creation of new breeds of plants and animals—a significant alteration to the biosphere. Over hundreds or thousands of generations, people selected certain plants and animals for preferred characteristics, such as the tameness of wolves (as they became dogs) or abundant seed in the ancient Middle Eastern grass einkorn (as it became wheat). They intervened not with the intent of producing genetic change and new species, but for their own practical purposes which, if sustained over time, inadvertently but inevitably yielded genetic change and new species. Thus thousands of years of more or less consistent human selection turned an unpromising Mesoamerican grass, teosinte, into maize, an amazingly efficient device for turning sunshine into edible calories. Ferocious razorback hogs were turned into docile pigs.

Similar things presumably happened quite accidentally at times. Humans inadvertently, and often counterproductively, selected for certain traits in other species by maintaining certain domestic environments. So, for example, the practice of storing food created new niches for mice, encouraging them to become in effect domesticated, dependent on human communities for their survival. Even insects could become fellow travelers, adapting to human environments. For example, the *Aedes aegypti,* a mosquito native to West and Central Africa, breeds almost exclusively in artificial water containers, pots, buckets, wells, cisterns, or calabashes, rather than puddles, ponds, or lakes like other mosquitoes. The *A. aegypti* also became one of the world's deadliest creatures, serving as the vector for the viruses of both yellow fever and dengue fever.

Viruses and bacteria too adjusted to the new ecological world brought forth by domestication. Most of these adjustments in the microbial world are unknown and inconsequential, but some of them announced themselves forcefully. Bacteria that cycle through our bodies and spread by the oral-fecal route, some of which cause gastrointestinal diseases, enjoyed new scope once people settled down to live in one place day after day and month after month. When farmers came to live cheek by jowl with their livestock (mainly in Eurasia), their health got worse still. Some of the diseases that infected livestock, especially herd animals, evolved into such human diseases as measles, tuberculosis, influenza, and smallpox. Somehow the influenza virus (or viruses, for there have been many) evolved so as to flourish within and among the bodies of pigs, domestic fowl, and humans, leaping from one to the other in the world's farmyards. Perhaps the world's worst human disease, in terms of total lives claimed, is smallpox, which seems to have jumped from camels to humans some time after camel domestication roughly five thousand years ago. Where human populations were dense enough, these diseases could circulate endlessly.[6] Happily, to some extent, the presence of livestock improved human diet, especially where dairy cattle could be raised (and adult human populations developed the capacity to digest milk).

The case of lactose tolerance is another instance of the connections between environmental, cultural, and genetic change, and a consequence of domestication. Lactose is a form of milk sugar. Today all human beings easily digest milk as small children, but most lose the capacity as they age. Before domestication, all people became lactose intolerant after childhood because their bodies stopped making the enzyme that allowed them (as children) to digest it. The domestication of cattle in particular, but sheep and goats as well, offered a tremendous expansion of the food supply—milk, cheese, yogurt—for people able to digest lactose. Sometime around eight thousand years ago a genetic mutation arose in the Middle East or Europe, whereby even adults could digest milk. This proved a tremendous advantage, and by three thousand years ago a quarter of the population in central Europe were milk drinkers.

Today in northern and central Europe 80 percent to 90 percent of the population carries the necessary allele that instructs their bodies to continue producing the necessary enzymes throughout their lives. A similar mutation took place in East Africa, rather later, so that some of the pastoralist peoples there (the Tutsi, for example) are today mostly (90 percent of them) capable of digesting dairy products. Many Fulani—pastoralists of the western and central Sudan—also carry this genetic trait. When and where these mutant milk-drinking human populations arose, which seems to be only twice, they had great incentives to reshape the landscape to make it suitable for cattle, sheep, and goats. In East Africa they tended to do this by fire, controlling the bush and extending pasture in ways practiced by their early human ancestors. In the Middle East and Europe they did this too but also developed agricultural systems in which cattle, sheep, and goats nibbled on stubble after harvests, browsed in forests and on hillsides, and in effect created human food from landscapes humans could not directly exploit for sustenance. In this example domestication led to genetic change within humans that in some parts of the world changed the logic behind land use.[7]

A second example, malaria in Africa, shows some of the negative connections between environmental and genetic change resulting from domestication.

Probably because humans have lived far longer in Africa than anywhere else, Africa evolved a species of anopheles mosquito that drinks only human blood. There are some four hundred species of anopheles in the world, of which about thirty or forty can transmit the plasmodia that cause the human disease of malaria. But most anopheles prefer nonhuman blood and are thus inefficient disease vectors. The *An. gambiae,* however, is the world's deadliest mosquito, because it only bites humans and thus could become a highly efficient malaria vector. Judging from genomic evidence, it did so somewhere around four thousand to eight thousand years ago. The most lethal form of malaria (called *Plasmodium falciparum*) seems to have developed in response to closer-packed human communities in Africa—farming communities—that supported *An. gambiae* in profusion. The disease was so deadly, it provided a rigorous selective pressure for resistance, which meant that genetic mutations that shielded individuals from malaria spread very rapidly through populations. Africans in malarial zones began to develop antimalaria mutations about twenty-five thousand years ago. In Southeast Asia, where malaria also became endemic, different kinds of genetic shields evolved starting around two thousand years ago.[8]

The whole gamut of life-forms, from bacteria to oxen, evolved in new directions as a result of the agricultural transitions, sometimes through enduring human efforts to select useful individuals but more often by chance. And humans themselves changed genetically as a result of new opportunities (the capacity to digest milk) and new risks (the devastating existence of malaria) associated with domestication and farming.

Although human populations grew in number when they shifted to agriculture, they shrank in stature. Skeletal remains show that on average early farmers were shorter than their hunting and foraging ancestors, perhaps by as much as ten centimeters. They ate less varied diets and generally ate less animal protein than did nonfarmers. They suffered more often from vitamin-deficiency diseases.[9] Living sedentary lives among their own wastes, they consequently suffered more from gastrointestinal diseases than did more mobile peoples. Their lives, like their bodies, were shorter than those of hunters and foragers. But they reproduced faster than any other human population.[10]

This exuberant fertility translated into large and dense populations. Combined in many cases with their growing mastery over useful animals—especially horses, camels, and elephants—this population density made agricultural peoples a redoubtable foe for hunters and foragers. Horses, camels, and elephants all became instruments of war. Agriculturalists, especially if they organized themselves into tribes or even states, became militarily formidable and routinely pushed hunters and foragers into the world's deserts, mountains, jungles, and other ecosystems that held no appeal for farmers. Even when their social organization remained modest, farmers reproduced so fast compared with foragers that their sheer demographic weight favored spatial expansion. Pastoralists, who combined mobility with high birth rates and mastery of useful animals, posed at least as strong a threat to hunters and foragers, and drove them from many of Asia's and Africa's steppe and prairie ecosystems (there were no pastoralists in the Americas before 1492 for want of suitable animals).[11]

Horses and war elephants became so valuable for military purposes that rulers tried to govern environments so as to ensure a ready supply of these strategic goods. With respect to horses, this meant expanding or preserving grasslands. In the case of elephants, it meant forest preservation. An ancient Indian author, Kautilya, an adviser to the throne in the Mauryan Empire, explained the importance of maintaining forests as elephant breeding grounds in the interest of the state.[12] Only Asian elephants were domesticated and trained to war; African elephants remained wild animals and from the farmer's point of view, a pest.

City life, which began about 5,500 years ago, marked a another stage in world environmental history. Urban populations generally were so unhealthy that they could not reproduce fast enough to offset their mortality; they were sustained only by constant influx from the surrounding countrysides. Cities were black holes for population until improvements in sanitation and disease control were developed, only about 100 to 120 years ago. The natural decrease (surplus of deaths over births) in London in 1750 was so great, it alone canceled half the natural increase of all of England.[13] Thus urban growth for most of human history was curtailed by the limited supply of potential in-migrants, and big cities could emerge only in the heart of rich agricultural zones or on rivers and coasts well served by cheap transport. Cities in colder climates also made heavy demands on their hinterlands for fuel. According to the calculations of Canadian geographer Vaclav Smil, in the temperate latitudes of Europe or China a city needed to have reliable access to woodlands for fuel amounting to fifty times its own area. In warmer climes this constraint on urban growth did not tell quite so much, because no fuel was needed for heating, but cooking and other uses still required fuel, usually in the form of biomass, often wood or charcoal.[14]

City life also created problems for agriculture. In village settings nutrients from the soil cycled through crops and then human or animal bodies, eventually returning to the soil as excrement, rich in nitrogen, phosphorus, and other elements critical for plant growth. With the rise of urban populations, nutrients often moved from the fields into cities, where they accumulated. Carrying human excrement ("night soil") from cities to the fields compensated somewhat for the long-term drawdown of soil nutrients. But the distance over which such measures were practical was much shorter than the distance over which it was practical to send food to cities. So over time cities reduced the fertility of the fields that supplied them, especially cities perched on riverbanks or seacoasts—usually the bigger cities—because their wastes were often dumped into the water and thus their nitrogen and phosphorus delivered to the oceans and forever lost to farmers' fields.[15] Until the age of chemical fertilizers, the only efficient way to counteract this nutrient loss was the use of manure from animals that grazed in forests or on meadows. They in effect imported nutrients from otherwise little-exploited ecosystems to farmers' fields. Hence, as a sixteenth-century Polish nobleman so pithily put it: "Manure is worth more than a man with a doctorate."[16]

Cities caused problems for agriculture, but they also encouraged its spread and its intensification. Cities became the loci of high-consumption lifestyles (by the standards of the distant past at least), where some people ate more than others, used more flax or cotton, and in general stimulated demand for agricultural goods above and beyond what they could have done as villagers. Greater demand for food and fiber stimulated more agricultural production, which required either bringing more land under cultivation or raising yields—or both. According to a new and controversial hypothesis, expanding agriculture may also have affected climate. Around eight thousand years ago, it seems, the concentration of carbon dioxide (the chief greenhouse gas) in Earth's atmosphere began to climb slowly. This came after about two thousand years of declining CO_2, and when, according to climate models based on earlier alternations of ice ages and interglacials, the CO_2 levels should have continued to fall.

How could this happen? William Ruddiman, an environmental scientist and climate historian, thinks it happened because agriculture spread far and wide. Farmers cut and burned enough forest to send about two hundred billion tons of CO_2 into the atmosphere. This may have forestalled the next ice age. Ruddiman thinks the advent of irrigated rice farming, around five thousand years ago, resulted in extra doses of methane in the atmosphere. Methane is also a greenhouse gas, and its rising concentrations over the past five millennia have helped warm Earth. Ruddiman's views are quite novel and have provoked mixed reactions. If they are correct, they mean that human behavior has been affecting climate in significant ways for eight thousand years, rather than merely in the past two centuries. The emergence of cities, although well after the start of the era of rising CO_2, helped hasten the spread of agriculture and especially its intensive formats, like paddy rice.[17]

For many millennia agriculture remained the most important way in which humankind affected the environment. Agrarian societies outcompeted all others for the most fertile and well-watered lands, continuing to push hunter-foragers, and eventually even pastoralists too, to the margins. Slowly, inexorably, human numbers grew, and more and more land became field, pasture, and garden. Agro-ecosystems spread. Domesticated animal populations flourished. Forest and other wild lands shrank back.[18]

This slow frontier process is the main theme of world environmental history between the emergence of cities (fifty-five hundred years ago) and modern times. John Iliffe, a leading Africanist, made it the central theme of African history in his survey, *Africans: The History of a Continent*, in which Africans are cast as world history's frontier farmers par excellence, struggling to carve their fields from the forests, to keep wild animals at bay, and to keep their populations up in the face of a fierce disease regime. In Africa these struggles often presented stern challenges. Wildlife there posed a more serious threat to human life than anywhere else. The disease climate did as well. This constrained human life directly, via a high human burden of disease, but indirectly as well, because animal diseases (such as nagana, which is spread by the tsetse fly) severely limited the use of domestic animals, especially horses, in Africa. Many parts of Africa had (and have) leached and infertile soils, so African farmers had to learn their soils with great care.

The Sinologist Mark Elvin sees Chinese history in a broadly similar light, as an epic of frontier expansion of the Chinese styles of agriculture, slowly taking over more and more land, assimilating or expelling other peoples, and all the while chiseling the earth into paddies and plots. Hunting and foraging people almost disappeared under this onslaught, driven to the southwestern fringes of China. Pastoral people on the steppelands to the north and west of China proper fared better, mounting a considerable challenge to China from the time of the Han dynasty (second century B.C.E. to second century C.E.) until the armies of the Qing Dynasty subdued the Dzunghar Mongols in the mid-eighteenth century, ending two millennia of competition between Chinese farmers and steppe pastoralists.[19] Elvin has assigned the Chinese state a key role in promoting this frontier process, which is quite different from the African story Iliffe tells. But as ecological phenomena the general patterns are broadly similar.[20]

SAGAS OF EPIC agricultural expansions have also characterized the history of the Indian and European subcontinents, and large parts of the Americas as well. Wherever human populations became large and dense, they did so because of successful agriculture. Large and dense populations (or at least the less well-off people within them) typically felt a need to migrate, to expand, or to set up new colonies. Wherever they had the power to drive off, kill off, or absorb hunter-foragers and pastoralists, they did so. And so, eventually, agriculture covered a third of the earth's land surface, arguably the largest environmental impact (such things cannot be reliably quantified) of the human race.

From the earliest times humans also affected environments by moving plants, animals, and microbes around, both intentionally and accidentally, a process that may be called ecological exchange. Wheat, for example, somehow got from the site of its original domestication, in southwestern Asia, to China by 1500 B.C.E. In times and places where conditions promoted travel and trade (for example, peace), the spread of crops, and presumably weeds and pests as well, accelerated. In the heyday of the Silk Road, for instance, China and the Mediterranean world exchanged numerous useful plants and animals. China acquired grapes, peas, alfalfa, sesame, camels, and donkeys in the era of the Han and Roman Empires (from about 200 B.C.E. to 200 C.E.). Sea routes made ecological exchange feasible over enormous distances. African millets that did well in dry environments were taken to India, expanding the potential of agriculture in the subcontinent; bananas from Southeast Asia came to East Africa, improving the prospects of farming in the moist forest regions around Africa's great lakes. Polynesian seafarers brought a suite of crops and a few animals throughout the South Pacific in their countless colonizing voyages. All this furthered the frontier epics of agricultural expansion; it also promoted a slow process of (partial) ecological homogenization, whereby humankind altered ecosystems so as to raise a handful of rewarding crops.[21]

A famous pulse of ecological exchange followed upon Columbus's voyage from Spain to the Americas in 1492. After the original human invasion of the Americas toward the end of the last ice age, very little interaction took place between the Americas and the rest of the world. The histories of the Western and Eastern Hemispheres, although showing some parallels (such as domestication, state-creation, and urbanism), remained separate. But after 1492, as the eminent environmental historian Alfred Crosby memorably showed, the flora and fauna of the two hemispheres mixed together with tumultuous results. Crosby coined the phrase "the Columbian Exchange" to refer to this ongoing human-assisted migration of plants, animals, and microbes across the Atlantic.[22]

The most disruptive component of the Columbian Exchange was disease. Eurasian and African infections ran rampant among Amerindian populations, reducing them by 50 percent to 90 percent between 1500 and 1650. Amerindians, with their scant experience of domesticated herd animals, had no prior experience of smallpox, mumps, measles, whooping cough, influenza, and several other lethal killers that had become routine endemic diseases in most of Eurasia and Africa. They had no acquired immunities to any of these infections. Moreover, because the entire population of the Americas was descended from a small number of forebears who had migrated across Beringia at the end of the last ice age, these people had minimal genetic diversity among them. This meant that any particular strain of smallpox or influenza that easily circumvented one Amerindian's immune system would likely circumvent everyone's. A more genetically diverse population—Africa's is the world champion in this regard—made the spread of infectious disease more difficult. The catastrophe that befell the Amerindians after 1492 was probably the greatest single demographic disaster in human history, rivaled only by the Black Death of the fourteenth century in Eurasia (and perhaps in Africa).[23]

At the same time as epidemics ravaged Amerindian populations, animals from Afro-Eurasia refashioned American ecosystems. Horses, cattle, pigs, sheep, and goats all crossed the Atlantic with Columbus and many of his successors, finding the Americas a welcoming environment. These animals all ran wild, forming feral herds so large as to amaze observers. They also continued to serve as domestic livestock, first for immigrant Europeans and (mainly enslaved) Africans, and then for Amerindians. These new creatures chewed and trampled their way through ecosystems—including farmers' fields and plots—that were ill adapted to the ways of large hoofed mammals. Their impacts encouraged the spread of immigrant grasses and other vegetation better adapted to life under the hoof. The imported animals also provided American populations, immigrant and Amerindian, with supplies of protein, wool, leather, tallow, and other useful products they otherwise could not have obtained except in tiny quantities (from llamas, deer, and other creatures). As with microbes, rather little of the indigenous American fauna successfully colonized Afro-Eurasia.

When it comes to the plants involved in the Columbian Exchange, however, traffic went both ways. The Americas gave maize, potatoes, cassava, tomatoes, peanuts, and dozens of other cultigens to Afro-Eurasia. Peanut production is so woven into the economy and culture of parts of West Africa that peanut farmers are certain that their crop is native to their part of the world. But it arrived only in the sixteenth century. The potato became at least as central to life in Ireland and the rest of cool and humid northern Europe. Maize became the staff of life in southern Africa, not to mention large parts of the Balkans. Meanwhile several food crops from Africa and Eurasia took root in the Americas. Spaniards and

Portuguese brought vines, olives, and wheat with them. Northern Europeans brought oats and rye. African rice crossed the Atlantic presumably with slave ships and did well in such places as Surinam and South Carolina. Transatlantic migrants brought dozens of other foodstuffs with them, enriching the food supply of the Americas just as American crops did for Afro-Eurasia.

A handful of other historically important plants crossed the Atlantic in the ships of Columbus and his successors. Most of these plants are best classified as drug crops. Sugar and coffee, which were new to the Americas, were the most important economically and socially. They formed a large part of the slave plantation economy so prominent in the history of the Americas from the sixteenth to the nineteenth century. Cacao, another drug crop, went from the Americas to West Africa, where it eventually became a major cash crop.[24]

The economic globalization that followed in the wake of Columbus and other mariners of the fifteenth and sixteenth centuries brought other effects beyond a flurry of ecological exchange. Commodity markets emerged with long-distance reach. The demand for silver in China drove a worldwide mining boom, most rewarding in Japan, Mexico, and the Andes. Mining everywhere changed the face of the earth, spurred deforestation, and, in the case of silver (which was most efficiently separated from its ores by the use of mercury), brought lethal pollution. Fur and hide markets animated a global hunt for beaver, seals, and deer, altering population dynamics and ecosystem balances in northern North America, for example, where beaver had before 1800 played a key role in shaping the landscape (and especially the waterscape). Markets for sugar inspired the creation of a plantation complex, first around Mediterranean shores, then on Atlantic islands, and on the largest scale in northeastern Brazil and the Caribbean lowlands. Sugar meant deforestation, rapid soil nutrient depletion, and biodiversity loss.[25]

THE PROCESS OF economic and ecological globalization lurched into a higher gear around 1500 and is still in motion today. Overlaid upon it, since about 1800, is the emergence of high-energy society based on fossil fuels. The Industrial Revolution is often regarded as a turning point in world history as seen from an economic and social point of view. It is even more clearly a turning point from the point of view of environmental history. Before the harnessing of fossil fuels, people had great difficulty deploying energy in anything but tiny amounts. The main way to do it was through human muscle power, supplemented in cases with animal muscle and in a few select locations, wind or waterpower. Most everything, from building pyramids to carrying freight, required muscle power. This was a great constraint on how much work could be done, and therefore how much wealth might be created. It also helped to account for the widespread practice of slavery in the preindustrial era, as there was no more efficient way to get big things done than to amass human muscle.

Fossil fuels changed all that. They represent a subsidy from the geologic past bestowed upon the past six or seven human generations (and probably the next several as well). Their ecological effects were, and remain, enormous. Fossil fuels made the big cities of the industrial era by snapping former constraints on urban growth. They allowed enough food to be brought in fast enough to keep millions of people alive. They eliminated the need to bring vast quantities of firewood into cities each day. They made the factory labor of the toiling masses so much more productive that factory owners, and eventually laborers, could afford to consume cotton, tea, sugar, flour, and other products brought from far continents, changing the landscapes of India, Egypt, the Caribbean, and Australia. Initially, in the first two generations, industrial laborers were more malnourished than their country cousins. Like the Neolithic Revolution before it, the Industrial Revolution at first made human beings shorter in stature.

Fossil fuels were a dirty innovation. The first industrial cities, in Britain, were horribly polluted as a result of the burning of coal.[26] Children living in these cities developed rickets, a result of vitamin D deficiency because so little sunshine reached their skins (where healthy children manufacture vitamin D). Everyone breathed quantities of particulate matter as well as chemical pollutants released in the combustion of coal. As a result, lung disease rates soared. Mining coal was a messy business itself. It filled local environments, and miners' lungs, with coal dust, which gave millions of them emphysema and other lung diseases. Mining also dotted landscapes with slag heaps. Eventually, by the late twentieth century, more technologically sophisticated coal-mining methods involved lopping the tops of mountains and filling valleys and streambeds with rubble and slag.

The use of coal had important indirect ecological effects, mainly through cheap transportation. Steamships and railroads opened up broad new landscapes to systematic economic use, changing landscapes and ecologies wherever they went. Refrigerated railroads and steamships by the 1880s made it practical to turn large swathes of the United States, Canada, Argentina, and Australia—a goodly portion of the world's grasslands—over to meat production. Coal also helped inspire vast increase in the mining of such useful metals as iron, tin, nickel, and copper, because metallurgy based on a cheap and abundant fuel was so much more profitable than metallurgy based on charcoal. Without the cheap energy coal embodied, Chile's copper, Malaya's tin, Ontario's nickel, and Australia's iron ore would still lie underground.

Oil made energy cheaper than ever before. The first major strikes occurred in the 1850s in Pennsylvania. Great gushers followed, in Baku, Austrian Galicia, Texas, California, Venezuela, Mexico, Iraq, and Sumatra—all before 1940. Then, in the late 1940s, petroleum engineers developed the great underground sea of oil around the Persian Gulf. The second-largest deposits in the world, in western Siberia, opened up in the 1960s. Drilling, transporting, refining, and burning oil were all dirty businesses with widespread consequences in the form of spills and pollution of air and water. But the largest environmental consequences of oil, as with coal, came not from its direct pollution effects, considerable though they were. Instead, they lay with the economic activities that oil made possible. In combination with new machinery, cheap oil made it economically practical to tear the top off of mountains in search of a few grams of gold. Cheap oil (and chain saws) made possible a sudden spurt of cutting and burning in the world's tropical rain forests after 1960, a major ecological change of our times, and one that could not have happened quickly without oil. Cheap oil also underlay the rise of the personal automobile, car culture, and the consequent changes in urban air pollution, land use, and city layouts.

The power of cheap energy to enable sweeping ecological changes, to make things happen faster and more broadly than they otherwise could, reached every corner of the globe. Cheap oil made the fertilizers and pesticides of modern agriculture feasible, as well as the agricultural machinery and transport networks that help bring food from fields to tables almost everywhere. Without it the yields of agriculture would be roughly half of what they are, and the quadrupling of human population since 1910 could not have occurred. Thus one can logically say that oil has doubled our food supply and population, and all the environmental consequences that flow from having six billion people on earth (rather than three billion) are owing to oil.

Fossil fuels, both coal and oil, may constitute a turning point in environmental history in yet another way. They currently account for upwards of three-fourths of the greenhouse gas loading of the atmosphere that is warming the planet. Historically and cumulatively, they probably account for somewhat less, but surely more than half of the greenhouse gas emissions. If global warming turns out to be a severe challenge to human habits, or to require major adjustments in patterns of life, then the advent of fossil fuels will qualify still more convincingly as a turning point.[27]

Over the past hundred thousand years seven turning points in world environmental history stand out: (1) the domestication of fire, (2) the emergence of language, (3) the exodus from Africa, (4) the domestication of plants and animals, (5) the rise of urbanism, (6) the Columbian Exchange, and (7) the adoption of fossil fuels. Most are widely recognized as turning points in history in general, and all should be. All represent basic renegotiations of the human place within the biosphere. They came at faster intervals in more recent millennia, a result of our species' growing power and numbers. In the fullness of time there will be other turning points, the nature of which we cannot yet guess.