Chapter One

Global Environmental History: The First 150,000 Years

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If, as scholars of human evolution suppose, our species emerged about 150,000 years ago, then roughly 97% of human history took place before the first cities and civilization. This chapter will briefly explore global environmental history over that very *longue durée*. It will sketch some of the ways in which the changing earthly environment affected human affairs, including almost ending them entirely about 73,000 years ago, and will outline some of the ways in which human actions changed the environment. By and large, in the 140 millennia before farming, environmental change affected human affairs more than human affairs affected the environment. But with the transition to agriculture beginning about 10,000 years ago, that began to change fundamentally: our numbers and technologies attained new levels so that, when combined with our long-standing heedlessness, we became an increasingly important force in shaping the global environment.

The Environment Shapes Paleolithic Humans and Human Affairs

About 7 million years ago our ancestors diverged, genetically speaking, from other apes. After another couple of million years, later ancestors began to walk upright (bipedalism) and develop big brains all out of proportion to their bodies. Climate change, according to prevailing interpretations, likely played a role in these fateful departures. In East Africa, where it all happened, drier conditions some 6 to 8 million years ago reduced the domain of forest and encouraged the spread of grassy savanna. This new environment rewarded upright posture and bipedalism, which allowed hominins (now the preferred term for humans plus their ancestors) to see longer distances and to move faster in open terrain. Standing upright also made it easier to dissipate heat under the tropical sun, an important task if one is obliged to keep moving to stay away from predators. East African climate also apparently became more unstable, with

A Companion to Global Environmental History, First Edition. Edited by J. R. McNeill and Erin Stewart Mauldin.

rapidly alternating wet and dry phases. This instability, the thinking goes, rewarded flexible behavior and thereby big brains. So, if this line of reasoning is correct, climate change helped shape the human animal in basic ways.[1]

Climate change continued to influence human affairs in subsequent millennia. Beginning about 3 million years ago, the Earth entered a period – in which we still live – of alternating glacial and interglacial phases. In our African homeland, this oscillating climate rhythm appeared as wetter and drier phases, because it was never so cold as to encourage glaciation (outside of the highest mountains). When hominins left Africa, which some did more than a million years ago, they had to adjust to ice ages that in Eurasia involved much colder temperatures, as well as a drier, windier, and more unstable climate.

Migration

Our own species, *Homo sapiens sapiens*, evolved within Africa and by perhaps 150,000 years ago had emerged as a distinct species. A few intrepid populations walked out of Africa, perhaps 100,000 years ago. As they crossed to Arabia and Southwest Asia, they too encountered colder climate. Their migrations coincided with the early millennia of a new cold phase, an ice age that lasted from about 110,000 to 12,000 years ago. This latest ice age was not only much colder and dryer than modern climate, but in most parts of the world far more unstable. For decades or centuries comparatively sudden cooling or warming might occur, in swings of average temperatures of 5 to 10 degrees Celsius (9 to 18 degrees Fahrenheit). The slender evidence suggests these swings were smaller in Africa than on other continents. Elsewhere, the incentives to migrate, either to avoid the worst of the cold and drought or to take advantage of warming and moisture, were often strong. Staying put for centuries was usually a poor gamble because climate was too unstable.

The best aspect of ice-age conditions (for humans) was lower sea levels. This gave terrestrial species about 25 million more square kilometers to work with – the equivalent of an additional continent the size of North America. It was possible to walk across most of Indonesia, and from Australia to New Guinea, from Korea to Japan, and from Britain to France. The unfortunate part of this for historians and archeologists is that probably most people lived most of their lives in these zones, helping themselves to seafood found along the ancient shores, and all archeological remains of their existence vanished beneath the waves when sea levels rose sharply around 22,000 to 8,000 years ago.

The most challenging moment of the last ice age came around 74,000 to 70,000 years ago when a giant volcanic eruption (of Mt. Toba, on the island of Sumatra in what is now Indonesia) spewed enough dust and ash into the skies to block sunlight and lower temperatures by 5 to 15 degrees Celsius for 6 to 10 years. It may have tipped climate into another regime; the next thousand years were especially cold on average. Toba was the biggest volcanic eruption in the last 2 million years, 280 times the size of Krakatoa (1883) and about 5,000 times larger than Mt. St. Helens (1980), as measured by the quantity of tephra – rock, magma, and other material – thrown heavenward. Ash fell from the sky as far away as Arabia and the east coast of Africa. In some places in India the resulting tephra layer was, and is, six meters thick!

The Toba catastrophe played havoc with plant and animal life. The fossil pollen record shows collapses of vegetation in many parts of Asia, leaving animal species with

little to munch on. DNA evidence suggests that several animals, including tigers and orangutans, suffered dramatic reductions in populations at about this time. Toba's impacts probably brought the human species close to extinction: it is possible to interpret the DNA evidence to mean that at around this time our ancestors' numbers were reduced to 10,000 or so – our closest brush with extinction so far. Quite plausibly all humans outside favorable locations in Africa were wiped out by Toba's effects. This is also the time, incidentally, when (inferred from DNA evidence in lice) humans began to wear clothing.[2]

The Toba event was of unique intensity in human experience, but the ice age contained numerous cold spells and severe droughts. Over the past 150,000 years, modern humans evolved in a time of generally cool and highly erratic global climate, and they colonized Eurasia during the colder phases of the last ice age, a circumstance that surely rewarded innovation, learning, and communication in any species. Adverse climate may well have contributed to cultural dexterity.

From their African refugia, post-Toba human populations soon migrated once more into Eurasia. Once again, lower sea levels, thanks to the buildup of ice, helped. Humans reached Australia and New Guinea, at the time united as a single continent, perhaps as early as 60,000 years ago and no later than 40,000 BP (= before the present). Getting there required a sea journey of at least 100 kilometers (60 miles). This voyage implies a considerable technological and logistical competence, as well as high tolerance for risk: the first Australians were surely a plucky lot. Other modern humans headed north into what is now China and Japan by about 30,000 BP. Distant cousins entered Europe around 40,000 years ago, to the misfortune of the indigenous Neanderthals. These new Europeans, according to genetic evidence, are the ancestors of 75–85% of contemporary Europeans. They soon encountered the depths of the last ice age and – not unlike their more affluent descendants today – headed for Spain and the south of France in search of balmier climes. Meanwhile other humans walked into the chilly expanses of Siberia, attracted by the abundance of large, tasty, naive mammals. At this time, some 40,000 to 30,000 years ago, the global population was probably only a few hundred thousand, roughly as many people as live today in Des Moines, Lubbock, or Boise (or Nottingham, Coventry, Canberra, or Christchurch). It was an uncrowded world.

Nevertheless, some people moved further afield. The last chapter in these epic migrations brought people to the Americas, possibly as early as 20,000 years ago, certainly by 13,000 BP. They crossed from Siberia to Alaska, at that time a broad land corridor because of lower sea levels. They could have come by boat or they might have walked. Once in the Americas they apparently spread out quickly, reaching Chile no later than 12,000 years ago. The archeological, linguistic, and DNA evidence concerning this discovery of America is not consistent, so arguments rage about its timing, about the size of the founding population, and about whether or not it came all at once or in two or three separate waves. It does seem that the first Americans are most closely related to peoples of southern Siberia, although rival interpretations maintain their cousins were from what is now Korea and North China.

These long, slow migrations out of Africa and throughout the world no doubt contained many setbacks. Groups guessed wrong and found themselves in deserts from time to time. Others attempted what they thought was a short sea voyage and never saw land again. The Mt. Toba deep freeze might have killed off everyone not living in warm places. But slowly, in fits and starts, humankind colonized the globe.[3]

Domestication and Farming

The deep cold of Siberia in these millennia contributed to another momentous development: the first domestication. Man's first friend was the dog. Dogs evolved from wolves over thousands of years. Just how, when, and where this first happened is unclear, but the latest (genetic) evidence suggests it occurred in Southwest Asia around 30,000 BP.

The dog–human symbiosis was a mutually profitable partnership. Dogs provided people with hunting help (compensating for our poor sense of smell), with an early-warning system against attackers, and with loyal companionship including furry warmth on cold nights. In dire circumstances, people could also eat their dogs. People provided dogs with food (or hunting help, as the dogs might see it), and sometimes protection and shelter. People with cooperative dogs enjoyed great advantages in hunting and in self-protection. People living with barking dogs would not easily fall victim to surprise attack. Dogs with cooperative people got a more reliable food supply, including access to big game such as mammoths, which dogs could scarcely bag by themselves. So, over time, a genetic selection occurred for dogs that worked well with humans – dogs that showed loyalty, barked at the appearance of strangers, accepted human commands, and could read human gestures and expressions. Meanwhile, a cultural selection took place for human groups that worked well with dogs, training them, breeding them, protecting them, and eating them only in extreme need. The Ainu, a people in Japan's northernmost island of Hokkaido, even taught their dogs to catch salmon for them. The dog–human symbiosis spread rapidly and became well-nigh universal.

The domestication of dogs was the first of many such in the human career. Dozens of animals and hundreds of plants proved susceptible to domestication. Almost all of these domestications took place in remote times before written records. But archeologists can often tell the difference between wild and domesticated species from remains of seeds and bones.

Few things in human history have mattered as much as domestication. Raising one's food as opposed to collecting or hunting it implied broad changes in the human way of life. It required people to submit to laborious routines, but allowed enormous expansions in terms of cultural richness and diversity. Mobile hunters and foragers around the world had only a few tools (often very similar ones), the same social structures just about everywhere, and – as far as we know, which is not terribly far – roughly the same sorts of ideas about nature and spirits. In the late Paleolithic some people settled down in a few choice spots, becoming at least semi-sedentary if not fully so, and a notable elaboration of culture, especially in tools and art, took place. But, by later standards, there wasn't much cultural diversity in the Paleolithic, because most people remained mobile and had to carry their culture with them.[4]

With farming, all that would change. As the ice-age cold gave way to warmer temperatures and damper conditions, plant life flourished. Forests replaced steppe and scrubland, deserts retreated, and rivers rose. In many locations, these were favorable trends for people, allowing some groups to settle down and live off newly abundant local plants and animals. In many spots in Southwest Asia, for example, there were plenty of acorns, almonds, and grasses with edible and storable seeds. Some evidence suggests people were storing seeds as long ago as 23,000 BP. Gazelles and other tasty herbivores provided meat. The scant evidence suggests that population rose across Eurasia in the millennia from 16,000 to 12,000 years ago as climate warmed and foraging became

easier. In a few favored locations, it became so much easier that more people could settle down, at least for most months of the year, living off locally abundant food.

Settled populations tended to grow far faster than mobile ones, because they did not have to lug children long distances and were less inclined to try to prevent their birth, or to abandon newborns. Where people collected the seeds of wild grasses, they could mash the seeds into gruel and feed it to babies, weaning infants from their mother's milk sooner. Early weaning made mothers fertile again sooner (lactating women are much less likely to conceive). So intervals between births tended to be much shorter among settled people than among mobile ones, which meant higher fertility rates and faster population growth.

Population growth among the settled folk gradually caused difficulties. Big animals grew rare due to additional hunting. In the Levant, for example, archeologists have found that people were hunting smaller and smaller animals as time went on – fewer gazelles and more rabbits. In many parts of the world, the traditional solution for food shortage remained viable: walk somewhere else. But for settled folk with accumulated possessions, lots of small children, and perhaps spiritual and emotional commitments to preferred places, this approach was less practical. Instead, in a few circumscribed locations, such as the Levant (between a rising sea and a desert), in the Nile valley (a ribbon of oasis surrounded by desert), and in China's Yangzi valley (surrounded by hills), people intensified their quest for food. Rather than walk elsewhere, they foraged for a wider variety of plants, hunted a broader spectrum of animals, and began to work spreading the seeds of preferred plants such as wild wheat and rice. Such efforts probably took place elsewhere as well, but the archeological record is so spotty that no one knows.[5]

Not long ago scholars used to wonder why everyone did not take up farming. Now they wonder why anyone did so in the first place. Farming turns out to be more work than foraging and hunting, and usually results in worse nutrition and worse health. So why did people do it? No one knows. The archeological and, lately, genetic evidence goes some way toward illuminating where and when transitions to farming occurred. But explaining why is still a matter of ingenious guesswork.

After more than 100,000 years without bothering to farm, in the 7,000 years following the end of the ice age humans undertook at least seven transitions to farming on four continents. This seems most unlikely to be a random turn of events. It is good to bear in mind that conceivably dozens of earlier such transitions took place in environments where no archeological traces remain, either in warm humid conditions where things biodegrade quickly, or in locations now beneath the sea. So there might have been, in effect, dozens of "false starts" in agriculture. But even if so, the question merely becomes: why did at least seven *lasting* transitions take place only after the end of the ice age? Two important factors may help bring us closer to an understanding: intelligence and climate.

While turning to a way of life that brings poorer nutrition and health while requiring more work may not seem a hallmark of intelligence, it surely did take intelligence to notice which plants grow best in which sorts of places, which ones yield easily edible seeds, which seeds store well, and so forth. Developing this sort of knowledge required communication – language – as well as powers of observation, memory, and reason. So it could not have happened before modern, intelligent, language-wielding humans were on the scene. Depending on when it was that language emerged, there were either zero or very few such humans around before the last ice age. And during the ice age, conditions were too dry or too cold for agriculture outside tropical locations, sharply reducing the

chances that people would make the transition successfully. Ice age conditions were too inhospitable for sedentary life, except perhaps for a few mammoth hunters in Ukraine and fisherfolk here and there, and it is hard to imagine mobile people transitioning to agriculture. Intelligent, language-bearing humans enjoying interglacial conditions, then, seem a likely prerequisite for transitions to agriculture.

But we still do not know what triggered these transitions. As usual when evidence is sparse, hypotheses abound. Some scholars think that population growth led some human groups to the brink of Malthusian crisis, so they had to engage in risky experiments including agriculture; necessity was the mother of invention. Others think that adverse climate change had the same effect. Still others prefer explanations anchored in social pressures. Perhaps there were societies that practiced competitive feast-giving, like the famous potlatches among the Amerindians of the Pacific Northwest, and so strong incentives existed to produce more food in order to achieve greater renown. Maybe there were religious reasons to try agriculture, perhaps as an effort to appease gods irritated by heavy harvesting of certain plants. There is absolutely no evidence for these social explanations, but that does not mean they must be wrong. While there is some evidence for population growth, and good evidence for climate change, that does not mean these explanations are necessarily correct. In any case, it could well be that some combination of these (and other) factors led to agriculture, and indeed the relevant combination could well have been different in each transition to agriculture – in which case no general theory would be correct.

Enduring transitions to farming took place between 11,000 and 4,000 years ago in Southwest Asia, China, Southeast Asia, Sahelian Africa, South America, Mesoamerica, and the woodlands of eastern North America. Perhaps there were others too for which we at present lack convincing evidence. From its several points of origin, agriculture slowly extended its tendrils far and wide. The cereal culture of the Levant, the rice culture of China, and the maize and beans culture of Mesoamerica diffused furthest and gave rise to the world's most influential and widespread farming systems. The Levant farming system spread fairly quickly along the northern shores of the Mediterranean, but more slowly up the Danube and into cooler climates. But between about 7000 BCE and 4000 BCE generations of farmers carried it from Anatolia to the British Isles. Others carried it eastward too, into northwestern India by perhaps 7000 BCE, but much more slowly southward toward the southern tip of India. The rice-based farming system of the Yangzi meanwhile apparently spread westward into northeastern India, into the Ganges valley, by about 6000 or 5000 BCE, although some scholars maintain rice was independently domesticated there. Much later it spread to Southeast Asia, and later still to Korea and Japan. Maize culture spread from its Mesoamerican home both north and south, and became the staple food of most of the Americas by 1000 BCE.

Wherever and whenever it happened, farming spread in two main ways. First, farmers sometimes displaced foragers, pushed them off fertile lands, and extended their own domain. Second, sometimes the *idea* of agriculture spread: people who had not formerly practiced it learned about it, and imitated the practice of others.

Farmers could often displace foragers through violence. Food production allowed greater densities of population. Bigger groups normally prevailed over smaller ones in contests of violence. Moreover, the bigger social groups became, the more likely they could support specialists in weapon-making and in the arts of violence. Foraging bands, even those that included skilled hunters, could not consistently withstand the military pressure farming peoples could bring to bear.

Farmers could achieve much the same thing without even trying, through accidental biological warfare. Farming folk lived cheek-by-jowl with herd animals. Herd animals provide suitable environments for microbes that cause diseases, trigger immune-system responses, and therefore need to get from animal to animal. Gradually, farmers' bodies came to host microbes that routinely lived in sheep, goats, cattle, or dogs. Some of these microbes caused deadly diseases among humans. Measles and tuberculosis come from cattle diseases. Influenza is a gift from pigs and ducks. Smallpox may derive from camel pox. Over many generations, the immune systems of farming folk became increasingly resistant to these microbes. Indeed, when infectious diseases were constantly present, only people with robust immune systems survived childhood. Their own children, in turn, would be likelier to have robust immune systems, or at least immune systems attuned to the risks posed by sedentary life among herd animals and animal-derived diseases. In effect, a new selection process was at work among farming peoples, for disease resistance.

But hunters and foragers did not normally face this pressure. As long as they kept their distance from farmers, they remained healthier than sons and daughters of the soil, free from the infections hosted by crowded and sedentary peoples. But if hunters and foragers came into prolonged contact with farmers, disaster routinely followed. Their immune systems lacked all resistance to the infections now becoming common among farmers, and they sickened and died in droves. This process has happened again and again in more recent times, and it is extremely likely it happened early in the history of the expansion of farming too, although the archeological evidence for it is slender. In any case, while not perhaps certain, it remains most probable that greater vulnerability to new human infections cost foragers and hunters terribly, clearing the way for further expansion of farming.[6]

In some environments farming may also have spread because it indirectly ruined landscapes for foraging. Wherever dense populations developed due to agriculture, their activities depleted nearby wild herds. Farmers' own herds and flocks munched and trampled their way over the countryside, reducing the availability of forage plants for wild animals. And farmers often set fire to vegetation, to prepare the ground for their own plantings. Burning easily got out of hand, reducing woods and scrubland to ashes, and thereby made gathering wild plants and hunting wild animals less feasible. In these ways farmers and herders by pursuing their own subsistence often made it harder for anyone to make a living without farming.

Nonetheless, not everyone took up farming. Some people either already lived in or retreated to environments too dry, too cold, or too infertile for farming. Others, like the Jomon in Japan, found farming unattractive compared to the rewards of foraging and hunting, and they persisted in their way of life for several thousand years although in contact with farmers. They learned to cultivate plants, but did so only sparingly. But such cases remained exceptional.[7]

Over the last 10,000 years the spread of farming has almost matched the earlier spread of the use of fire and of language. In all three cases, at one point in time no people had the new technology. Then some people used it, while others did not, and those who had it enjoyed great advantages against those without it. Eventually in the cases of fire and language, all people used it. This point may yet come with respect to agriculture, although to this day in the Arctic, and in several moist tropical forests, people survive who neither practice agriculture themselves nor eat its products. They now account for less than 1% of humankind – and less every day.

Paleolithic Humans Shape the Environment

People had a notable impact on their immediate environs from the time they harnessed fire. Natural fires had shaped vegetation and ecosystems long prior, probably from soon after the initial appearance of plants on Earth. Human – or, more likely, hominin – fire made cooking possible, which broadened the range of foods our ancestors could eat. It also made successful migration out of Africa into cooler climes much more likely, expanding the geographical range over which humans had environmental impacts. Humans and fire co-colonized the Earth.

Everywhere they went Paleolithic people used fire to alter landscapes to their liking. Observant humans noticed that fresh shoots of plant life attracted big herbivores that people could hunt. Hunters set fires to drive game animals into ambushes. No doubt they also caused accidental fires countless times. Specialists have reached no consensus about the scale and scope of landscape burning in the distant past, but it seems that over recent decades the weight of opinion has moved in the direction of more and more widespread burning. Scholars of the Australian Paleolithic, for example, credit the early populations there with "firestick-farming," deliberate burning that improved the browsing for kangaroos and other marsupials that could be hunted.[8] Wetter continents than Australia burned less readily, and the twists and turns in climate history, mainly precipitation history, would have affected the degree to which early humans could successfully burn vegetation. Where and when moist tropical forests prevailed, they normally resisted sparks and flame. True deserts, although dry enough for fire, lacked fuel. But, by and large, where people lived they could burn the landscape, and where the landscape could be burned, people lived. Since it is usually impossible to tell the difference between a natural fire and a human fire of tens of thousands of years ago, scholars may always remain uncertain about the pervasiveness and frequency of human fire in the Paleolithic. It does seem, however, that in most instances when humans arrived suddenly on the scene – as in the Americas around 14,000 years ago or Australia 50,000 years ago – the frequency of fire increased.[9]

A more decisive impact on the environment came with the so-called late Pleistocene extinctions, in which humans almost certainly had a hand. Some 50,000 years ago the Earth hosted at least 150 genera (families) of megafauna, defined as animals with an average body weight of more than 44 kilograms. As of 10,000 years ago, at most 43 genera remained. North America, for example, lost mastodons and mammoths, condors with 5-meter wingspans, sloths the size of hippos, horses, camels, several sorts of elephant, big cats, giant beavers, and armadillos. South America lost its entire menagerie of megafauna larger than llamas. Australia lost wombats the size of grizzly bears and indeed all its species larger than 100 kilograms. Eurasia and Africa lost smaller proportions of their megafauna.

Since the 1960s, arguments have raged concerning the relative role of human hunting and climate changes in bringing about these waves of extinctions. Other hypotheses, such as new animal diseases or storms of comets, have very few supporters. By and large, the arguments for human hunting, dubbed the "overkill hypothesis," have gained ground. For one thing, all the creatures that became extinct between 50,000 and 10,000 years ago had survived prior bouts of climate change no less severe than that of the late Pleistocene. For another, this flurry of extinctions affected big animals far more than smaller ones (and humans, when given a choice, hunt big animals first and smaller ones later). Moreover, several species of megafauna, such as woolly mammoths, held out

for a few thousand years on islands without human presence. In addition, flightless birds suffered much higher rates of extinction than those able to fly.

Even the lower likelihood of extinction among African and Eurasian species suggests human agency: animals there had many millennia to grow accustomed to life amid intelligent fire- and spear-wielding bipeds and learned to be wary of humans. Or, put another way, African and Eurasian wildlife was subjected to selection pressure for wariness of humans at a time when humans were not so dangerous. By the time humans had become more dangerous, thanks to advances in weaponry and the evolution of language and complex cooperation, most species in Africa and Eurasia instinctively kept their distance from people. In the Americas and Australia, on the other hand, humans arrived suddenly and in full possession of language and of cooperative hunting techniques. Thus they could blitz their way through the big, nutritious, and naive megafauna. This blitz left too little for other big predators to eat, so some of them also became extinct.[10]

While climate change may also have helped, and conceivably other factors did too, it seems certain now that human hunting, and burning, played the largest role in bringing about the late Pleistocene extinctions. These changes in wildlife not only affected ecosystems everywhere, but in the fullness of time they proved portentous for human history. Continents with few big animals had fewer potential candidates for domestication, leaving human societies there with less to work with. The absence of horses in post-Pleistocene America, for example, meant no warhorses. When, after 1492, Europeans arrived in America, they brought cavalry. Native Americans had none.[11]

Paleolithic humans probably brought about one additional important extinction that altered the environment: that of the Neanderthals. They flourished in Europe and western Asia from roughly 500,000 years ago until 50,000 BP. They lived mainly as carnivores, hunting the deer, horses, gazelles, bison, and other wildlife that dotted western Eurasia. At their most numerous, there were perhaps 75,000 of them. But by 50,000 BP they were gone from Asia, by 30,000 BP from everywhere in Europe but its southwesternmost corner, and by 24,000 BP they were extinct.

Perhaps climate change had something to do with it. After 50,000 BP, colder and much more unstable weather set in the Neanderthal domain, so that vegetation regimes changed within a matter of decades, and therefore animal habitat and migration routes also. Perhaps the Neanderthals could not adjust to such instability. After 40,000 BP several volcanic eruptions affected the northern hemisphere, especially between Italy and the Caucasus mountains, bringing volcanic winters that were no doubt hard on vegetation, wildlife, and therefore even the cold-resistant Neanderthals.

Few specialists, however, believe that climate change alone could have wiped out a cold-resistant species that had lasted through previous glacials and interglacials. More likely, it seems, the advent of homo sapiens into western Asia and Europe spelled doom for Neanderthals. Disease might have played a role. So might violence. Or merely superior hunting skills that left the Neanderthals with less and less to eat. Modern humans were much more mobile than Neanderthals, better constructed for walking and running, which might have helped them both in military contests and in hunting. Neanderthals, stocky and powerfully built, needed more energy (more food) than modern humans. The fact that Neanderthals vanished first in western Asia and later in Europe supports the notion that modern humans had something to do with it: homo sapiens entered Europe from Southwest Asia. Probably, as with the other megafauna extinctions of the late Pleistocene, we will never know just how the extinction of the Neanderthals happened and what role in it to assign to human agency.

Unlike the other megafauna that became extinct in the Pleistocene, something of the Neanderthals apparently lives on. Recent genetic research suggests that people who are neither African nor of recent African descent derive approximately 1–4% of their DNA from Neanderthals. This strongly implies that, whether or not modern humans spread diseases to them, out-hunted them, or killed them, they definitely had sex with Neanderthals.[12]

With fire, with mobility, and with hunting prowess Paleolithic people altered environments everywhere except Antarctica. Their impacts were probably greater on continents such as Australia and the Americas where they arrived late and suddenly. In those cases they came with a full arsenal of intelligence, language, and tools and, as it were, took ecosystems by surprise. Paradoxically, their impacts on Africa were probably more modest, as African species and humans coevolved over very long spans of time. From the viewpoint of subsequent human history, the most important of these impacts was the extinction of megafauna – probably including Neanderthals.

Neolithic Farmers Shape Themselves and Their Environments

With the transitions to farming beginning about 11,000 years ago, people increasingly changed the environment around them. Human impacts manifested themselves on the smallest scales, from the microbial environment, to, perhaps, the largest, in the form of the global climate.

Health Impacts

Farming had a powerful effect on human health. Farmers ate a narrower diet than their foraging and hunting ancestors, depending heavily on a few staples, which left them at greater risk of poor nutrition due to lack of key vitamins or minerals. They ate less meat and got less protein than their ancestors. The evidence of surviving skeletons tells us that farming people were smaller than their pre-farming predecessors. Skeletal remains from various sites between Ukraine and North Africa indicate that late Paleolithic men on average stood 177 centimeters tall, and women 166 centimeters. In the last thousand years before agriculture, their average stature shrank by 5 centimeters – this was the time when game was growing scarce and climate colder and dryer. Then, in the first millennium after the origins of farming, they shrank by another 5 to 10 centimeters.[13]

Farmers were sicker as well as smaller. Hunting and foraging peoples of the Paleolithic suffered from several infections, and because they had a food-sharing ethos they shared a lot of infections with their kinfolk too. They caught diseases from eating diseased meat, and picked up plenty of bacterial infections by rooting around in the soil. In health terms, the shift to agriculture was a gigantic stride backwards for human beings.[14]

First of all, like all sedentary people, farming folk lived in the midst of their own garbage and waste. Moreover, they probably deliberately handled human feces to use it as fertilizer. It is likely, therefore, that they suffered heavily from gastrointestinal diseases carried by worms and other parasites, which one might collectively call "diseases of sedentism."

They also suffered from what one could call "diseases of domestication." Over 300 human diseases derive from domesticated animal diseases. Half of these come from dogs, cattle, sheep, and goats. Even chickens and cats have donated some of their infections to their human masters. As these infections evolved into human diseases, farmers in Eurasia

(not in the Americas) increasingly were born into hazardous microbial environments, aswirl with measles, influenza, smallpox, mumps, tuberculosis, tetanus, whooping cough (pertussis), and a host of other killing diseases.

If that wasn't bad enough, farming folk also had to face what might be termed "diseases of storage." By storing grain, farmers attracted rats, mice, and other disease vectors, and put themselves at enhanced risk of bubonic plague, hemorrhagic fevers, and other nasty things. There are about 35 human diseases derived from rats or from the fleas and ticks that live on rats.

To top if off, where farmers cleared forest and especially where they allowed water to accumulate, they created new habitat for malarial mosquitoes. Malaria, which has a good claim to being one of humankind's worst scourges, seems powerfully correlated with farming environments in Africa and Asia, and seems to have taken hold among humans soon after they took up farming.[15]

What with these diseases of sedentism, of domestication, and of storage, life for farming folk – especially children – became far more hazardous than for hunting and foraging peoples – provided they could stay away from disease-bearing farmers. A large proportion of infants and toddlers in farming villages died of disease, often abetted by malnutrition. Farmers had far more babies than did hunters and foragers, but their environments also killed them much faster.

Even in the Americas, where there were almost no domesticated animals, early farming folk were far less healthy than their hunting and foraging neighbors. Careful study of some 1,500 skeletons from 22 sites in Ecuador, for example, leaves no doubt that in general farmers suffered a more severe burden of disease. If anyone had known these facts of paleopathology before adopting farming, whether in Eurasia, Africa, or the Americas, they would have avoided agriculture like the plague. But they did not know.[16]

Among the Natufians of the Levant, who left more skeletons than most pioneers of farming, life expectancy of men grew with agriculture, but that of women shortened. Two likely reasons for this are that death by violence (more likely to befall men) decreased as people took up farming, but death in the act of giving birth (much, much more likely to befall women) became more common due to higher fertility. The routines of work among farmers also left telling marks on female skeletons. They show signs of stresses from the kneeling and bending required for grinding grain and cooking: deformations of their knees, wrists, and lower backs. In general, the transition to agriculture made people shorter, sicker, and more likely to suffer from acute malnutrition.[17]

Landscape Impacts

Agriculture changed landscapes more obviously than it changed human health. In the first instance, it required the creation of new species. Wheat did not grow in the wild: it is descended from a wild progenitor, einkorn, that grew (and still grows) in southeastern Turkey and northern Syria. Maize (corn) is derived from a Mexican wild plant called teosinte. Just as dogs are not wolves, maize and wheat are different from teosinte and einkorn. Cattle, sheep, goats, camels, water buffalo, pigs, chickens, and a dozen other beasts of the field are new creations, derived from wild ancestors. In the first few millennia of farming, people created thousands of new species through patient domestication.

Beyond creating new species, early farmers created new landscapes. They used fire and ax to clear wood and scrublands to make way for their digging sticks and plows. In rice

regions of East, South, and Southeast Asia, they learned to build paddies, dikes, and berms to control the flow of water for the benefit of rice. In hilly country they learned to sculpt terraces into slopes (although it is possible this skill had not developed before the first cities and civilization). They built villages. They burned woodlands to create pasture for their own flocks and herds, as their forebears had done to favor game animals. Even before the rise of cities and civilization they began to experiment with irrigation. In dozens of ways, large and small, early farmers changed their landscapes.

The scale on which early farmers wrought their changes was governed by their numbers. Prior to 3500 BCE (a reasonable date for the advent of cities and civilization), the Earth hosted only a few million people.[18] Average population density globally was only about one-thousandth of what it is today. In fact, farmers were huddled in a few choice locations as late as the fourth millennium BCE and left the greater part of the world untouched. But they had established the practices by which humankind would, over the millennia to come, alter environments almost everywhere.

Agriculture created new species through domestication. It changed landscapes, through clearing and cultivating. It changed human health. It may also have changed climate.

Possible Climate Impacts

According to a controversial hypothesis, as early as 8,000 years ago, deforestation undertaken to clear land for agriculture began to raise the concentration of carbon dioxide in the atmosphere. With the spread of agriculture, deforestation and carbon-dioxide emissions reached a scale sufficient to warm the planet. The ice cores from which scientists infer past carbon-dioxide concentrations do show modest increases beginning around that time that are not easily explicable in natural terms. Subsequently, beginning around 5,000 years ago, levels of methane in the atmosphere began to rise. Methane is an even more powerful greenhouse gas than carbon dioxide. Its emission into the atmosphere came mainly from wet rice cultivation and secondarily from livestock. The spread of rice farming from its origin in the lower Yangzi valley – perhaps – accounts for the observed upturn in methane concentrations.

Specialists remain divided about this exciting new hypothesis. Some are content to accept it and argue that human activity prevented an otherwise likely return to glacial conditions 8,000 years ago. Others, while not disputing the ice core evidence, think that the scale of early farming was too small to have the requisite effects on the atmosphere. Some embrace a rival possibility: that rising sea levels created new coastal swamps and bogs which account for the rising presence of methane in the atmosphere. If it is valid, the new hypothesis means that human action affected climate not just in the industrial era, but from the dawn (or at least the early morning) of agriculture.[19]

Conclusion

For most of the human career, our ancestors lived precariously in environments that must often have seemed hostile. They struggled to survive amid predators eager to make them into their next meal. They were at the mercy of shifts in climate that brought drought, flood, or frosts for which they were ill-prepared. When the Toba eruption blocked out the sun for years on end, the human career almost came to a sudden halt. Nonetheless, humans managed to walk all over the world and find ways to survive in Siberian forests and Australian deserts. Fire was their best tool in the Paleolithic, and

with it they could alter landscapes to their advantage and roam where they could not have prospered without fire. They turned wolves into dogs.

Scholars now have strong evidence in favor of the proposition that Paleolithic people had major impacts on their environments. Archeology shows us the remains of human fire. Paleontology reveals the vast array of megafauna swept into the dustbin of prehistory with human help. Palynology indicates changes to vegetation resulting from megafauna extinctions and human burning. No one can suppose any longer that preagricultural humans lived in gentle harmony with a nature primeval.

That said, the environmental change people wrought after they developed agriculture eventually dwarfed what Paleolithic people could do. That took time, and farmers of the early Neolithic and their livestock probably had only local effects. But – despite their burden of disease – their numbers grew faster than those of hunters and foragers. Gradually their technologies became more powerful – plows and dams for example. Perhaps they even influenced climate. These two trends, of population growth and technological advance, over several millennia made Neolithic peoples shapers of their environment. The emergence of states, war, and long-distance trade combined with further growth in population and advance in technology would bestow even greater environment-shaping power upon the human race, as the remaining chapters of this book will show.

Notes

1 These ideas are reviewed on the Smithsonian Institution's Web page, accessed from http://humanorigins.si.edu/research/climate-research/effects on September 3, 2011. Bear in mind both the climate reconstruction and the interpretation of hominid evolution are based on very few data.

2 A summary of current views appears in: M. A. J. Williams, S. H. Ambrose, S. van der Kaars, et al., "Environmental Impact of the 73 ka Toba Super-Eruption in South Asia," *Palaeogeography, Palaeoclimatology, Palaeoecology* 284/3–4, 2009, pp. 295–314.

3 A useful summary is P. Manning, "*Homo sapiens* Populates the Earth: A Provisional Synthesis, Privileging Linguistic Data," *Journal of World History* 17, 2006, pp. 115–58. A recent example of the use of genetic date is H. Zhong, H. Shi, X. B. Qi, et al., "Global Distribution of Y-Chromosome Haplogroup C Reveals the Prehistoric Migration Route of African Exodus and Early Settlement in East Asia," *Journal of Human Genetics* 55, 2010, pp. 428–35.

4 S. Mithen, *After the Ice: A Global Human History, 20,000–5,000 BC*, Cambridge, MA, Harvard University Press, 2003.

5 Works that address the role of climate in transitions to agriculture include: G. Barker, *The Agricultural Revolution in Prehistory: Why Did Foragers Become Farmers?*, Oxford, Oxford University Press, 2006; P. Bellwood, *First Farmers: The Origins of Agricultural Societies*, Oxford, Blackwell, 2005; J. L. Brooke, *A Rough Journey: Human History and a Volatile Earth*, New York, Cambridge University Press, 2012; W. J. Burroughs, *Climate Change in Prehistory: The End of the Reign of Chaos*, Cambridge, Cambridge University Press, 2005.

6 These matters are well explained in J. Diamond, *Guns, Germs and Steel*, New York, Norton, 1997.

7 J. Habu, *The Ancient Jomon of Japan*, New York, Cambridge University Press, 2004.

8 The term was coined by R. Jones: "Fire Stick Farming," *Australian Natural History* 16, 1969, pp. 224–8; a recent challenge to the idea of pervasive firestick-farming appears in S. D. Mooney, S. P. Harrison, P. J. Bartlein, et al., "Late Quaternary Fire Regimes of Australasia," *Quaternary Science Reviews* 30, 2011, pp. 28–46.

9 A helpful synopsis is S. J. Pyne, *Fire: A Brief History*, Seattle, University of Washington Press, 2001, pp. 27–64.

10 A recent survey of the evidence is A. D. Barnosky, P. L. Koch, R. S. Feranec, et al., "Assessing the Causes of Late Pleistocene Extinctions on the Continents," *Science* 306, 2004, pp. 70–5.
11 This theme is elaborated in Diamond, *Guns, Germs and Steel.*
12 R. E. Green, J. Krause, A. W. Briggs, et al., "A Draft Sequence of the Neandertal Genome," *Science* 328, 2010, pp. 710–22.
13 B. Bogin, *The Growth of Humanity*, New York, Wiley, 2001.
14 The classic on this subject is M. N. Cohen, *Health and the Rise of Civilization*, New Haven, CT, Yale University Press, 1991. See also: M. N. Cohen and G. M. M. Crane-Kramer, *Ancient Health: Skeletal Indicators of Agricultural and Economic Intensification*, Gainesville, FL, University Press of Florida, 2007; J.-P. Bocquet-Appel and O. Bar-Yosef (eds.), *The Neolithic Demographic Transition and Its Consequences*, Dordrecht, Springer, 2008.
15 J. L. A. Webb, *Humanity's Burden: A Global History*, New York, Cambridge University Press, 2009, pp. 1–58.
16 On populations of the Americas, see R. Steckel and J. C. Rose (eds.), *The Backbone of History: Health and Nutrition in the Western Hemisphere*, New York, Cambridge University Press, 2002.
17 An overview is A. Mummert, E. Esche, J. Robinson, and G. J. Armelagos, "Stature and Robusticity during the Agricultural Transition: Evidence from the Bioarcheological Record," *Economics and Human Biology* 9, 2011, pp. 284–301.
18 M. Livi-Bacci (*A Concise History of World Population*, 5th ed., Oxford, Wiley-Blackwell, 2012, p. 2) says 10 million.
19 Its originator is W. F. Ruddiman, *Plows, Plagues and Petroleum: How Humans Took Control of Climate*, Princeton, NJ, Princeton University Press, 2005.

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