

cut the way off back to Asia. It is therefore not entirely surprising that the main expansion of human population in the Americas did not take place until the terminal Pleistocene 14 000–13 000 years ago. On the other hand, there is an active debate as to whether the hunters of this Clovis culture were home grown from pre-existing, pioneering groups, for which there is some fragmentary archaeological evidence, or whether they were of exogenous origin, descending from Alaska via an ice-free corridor that opened up during deglaciation (West, 1983).

The third and final stage in the colonization of the Earth took place in the Holocene and involved the inhospitable terrain around the ice sheets of Greenland and northern Canada, and many of the world's islands. It is curious that despite the existence of water-borne craft, virtually no Mediterranean islands were settled until early in the Holocene (Cherry, 1981; Schule, 1993). More easily understood is the late arrival of humans in the geographically isolated islands of the eastern Pacific (c.3000 Cal. yr BP), Madagascar (c.2000 Cal. yr BP) and New Zealand (c.1000 Cal. yr BP).

The Pleistocene colonization of the Earth by humans was an extraordinary achievement (Cavalli-Sforza and Cavalli-Sforza, 1995). What is more, it was achieved with subsistence economies entirely based on hunting of wild animals, fishing, and gathering of wild plants. Hunter-fisher-gatherer (h-f-g) peoples need to have an intimate knowledge of their natural environment upon which they depend for food and other resources. 'Man the hunter' must be familiar with the movement and behaviour of his quarry, whether stag or seal, just as 'woman the gatherer' must know of the location and uses of different plants, whether hemlock or hazelnuts. Ethnographic studies of modern h-f-g groups suggest that plant foods are normally a more important component of the diet than meat, although both this and the gender-based division of labour may not have been true of all Pleistocene populations. Establishing the relative importance of the hunted/scavenged versus the gathered food component at archaeological sites is not easy, because plant remains are much less well preserved than animal bones. However, it is likely that meat provided the bulk of the food supply to later Pleistocene populations in mid-latitude Eurasia (Klein, 1980). This is because the open steppe-tundra glacial vegetation would have supported large numbers of game, but provided little in the way of edible plants. Hunting groups were able to follow animal herds across the open landscape, relying on them to provide protein, fat, hide, bone, and all the other material necessities for life. By contrast, the forest environments of the tropics and of the Holocene possessed a wide

age of potential food plants which may have shifted the dietary emphasis away from meat.

H-f-g bands move camp throughout the year following game, water or other resources, and need a relatively large territory to support them, at least 75 km² for a band of only 25 persons. The resulting low population densities mean that even at the end of the Pleistocene, world population is unlikely to have risen above 10 million. Because this level was maintained for many thousands of years, however, 90 per cent of all humans ever to have been alive were hunters, fishers or gatherers.

Simple stone-age technology and low population numbers limited the extent of human impact upon the natural environment. Plant resources were manipulated by agencies such as fire, and burning to clear vegetation or encourage regrowth is certainly one of our oldest tools of environmental management (Lewis, 1972). Although forest or grassland fires only take hold where there is abundant dry plant matter, the spark to light them could be caused by lightning strikes as well as by deliberate human action. It is therefore difficult to know how far former fire frequencies were naturally, and how far culturally, determined. Interestingly, in a long pollen record from northern Australia, charcoal frequencies are many times higher during the Holocene than during the last interglacial, when Australia's aboriginal population had probably not yet arrived (Kershaw, 1986). However, more clearly evident than the effect on vegetation was that on other parts of ecosystems, notably upon large mammals who were the prey or competitors of *Homo sapiens*.

Megafaunal extinctions

Towards the end of the Pleistocene there occurred a devastating wave of animal extinctions. The most obvious victims were mammals with body weights over 44 kg, such as the mastodont (*Mammot americanum*), the woolly rhino (*Coleodonta antiquitatis*), the giant deer (*Megaloceros*) and the native American horse (*Equus occidentalis*) (see plate 3.4), but birds and smaller mammals were not entirely unaffected either (Grayson, 1977). The extinctions varied in their timing and severity across the globe, but the most widespread phase took place during the terminal Pleistocene (16 000–11 500 Cal. yr BP) and affected the Americas and northern Eurasia (see table 3.5). This was of course a period of rapid climatic change, and it has been suggested that many large mammals were unable to adapt to the new environmental conditions (Reed, 1970). For example, a family of mammoths (*Mammuthus primigenius*) whose remains have been found at Conover in England have been ¹⁴C dated to precisely the period of most rapid warming just after 15 000

Table 3.5 Late Pleistocene extinct and living genera of large terrestrial mammals (>44 kg adult body weight)

Continent	Extinct	Living ^a	Total	Extinct (%)	Major period of extinction (Cal. yr BP)
Australia	13	3	16	81	30–17 000
South America	46	12	58	80	15–9000
North America	33	12	45	73	16–11 500
Europe ^b	9	14	23	39	16–10 000
Africa	7	42	49	14	14–10 500

^a or extinct in historical times
^b excluding Mediterranean islands
 Source: Martin and Klein (1984)

one of the terminal Pleistocene butchered, in vast numbers, animals that were quite unused to human predation (Martin and Klein, 1984). Archaeological support for this overkill hypothesis comes from 'kill' sites at which a great many animal bones are present, although perversely such associations are much more common in the Old World than the New. At Solutré in France, for instance, the bones of over 100 000 horses (*Equus przewalskii*) have been found at the base of a cliff over which they appear to have been driven by Late-glacial hunters. Later Holocene island extinctions, such as that of the giant flightless moa bird (*Dinornis*) (plate 6.3), similarly followed within a few centuries of the arrival of humans, in this case the Maori peoples of New Zealand (Cassels, 1984). Evolution in isolation meant that prior to the Holocene the Mediterranean islands were home to creatures almost as bizarre as those found in Dr Doollittle's zoo, including flightless swans, dwarf 'antelopes' (*Myotragus*) and pygmy hippos. With the arrival of the first permanent human populations at the beginning of the Holocene, all of these rapidly became extinct (Lewthwaite, 1989; Simmons, 1991; Schule, 1993). Not a single one of the 'wild' animals on islands such as Mallorca and Cyprus is therefore truly native; all have been introduced by people.

Although there are good grounds for believing that human agency was involved in most cases of faunal extinction, overkill seems no more satisfactory a universal explanation than does climatic change. Mammalian extinctions may have followed soon after the appearance of the Clovis hunters in America, but in Europe and Australia hunting populations co-existed with megafauna for many thousands of years before the latter declined at the end of the Pleistocene. At Lancefield Swamp in Australia, a bone bed contains the remains of some 10 000 giant extinct animals (Gillespie et al., 1978). ¹⁴C dating indicates that humans and fauna lived together in Australia for at least 8000 years, and therefore rules out any possibility



Plate 3.4 Skeleton of a woolly mammoth, one of many species of megafauna made extinct during the last glacial-to-interglacial climatic transition. This specimen, found on the banks of the River Shandra in eastern Siberia, is the largest complete skeleton so far found (the distance between the tusk ends is 3 m). In addition to the skeleton, this mammoth's heart, liver, stomach and intestines were also preserved as a frozen mass weighing 700 kg

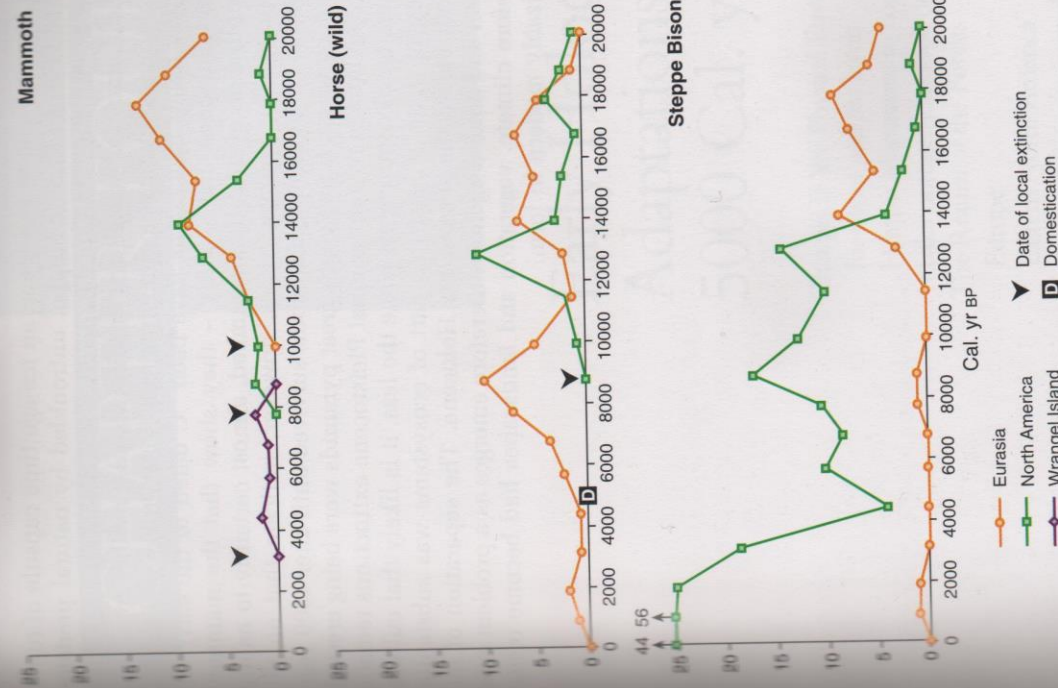
Cal. yr BP (Coope and Lister, 1987). Herbivores such as these found their tundra-steppe environment being displaced northwards and reduced in extent by the invasion of woodland. In turn, carnivores like the sabre-tooth tiger (*Smilodon*), who preyed upon grazing mammals, found their food resources diminishing. In some cases, movement to new areas was hampered by mountain ranges, rising sea levels or other natural barriers. This combination of climatically caused environmental stresses could, it has been suggested, have led to the more specialized and less adaptable species being exterminated.

Unfortunately, this hypothesis has some manifold weaknesses. Most obvious of these is the fact that no comparable extinctions took place at other times of rapid climatic change during the Pleistocene; for instance, at the beginning of the last interglacial c.130 000 years ago. Researchers such as Paul Martin have instead been struck by the coincidence between cultural changes and the timing of megafaunal extinctions. This is most clearly the case in North America, where the appearance of the Clovis culture at 13 500 Cal. yr BP was followed within less than a thousand years by the demise of many large mammals. It has been argued that big game hunt-

of rapid, first-contact overkill in this continent. With animals such as the giant deer (*Megaloceros*), which was abundant in Ireland during the Late-glacial period, extinction seems to have occurred before humans had even arrived.

Another feature inconsistent with overkill is that many of the animals which are most numerous at archaeological sites in fact avoided extinction, for instance the bison (*Bison bison*) in North America and the reindeer (*Rangifer tarandus*) in Europe. These lines of evidence suggest that indirect human action may have been as important as direct kill-off (Krantz, 1970). As hunters, late Pleistocene humans would have partly replaced the ecological niche of carnivores, and may also have threatened non-favoured herbivores such as the American Shasta ground sloth (*Nothrotheriops shastense*). In contrast, favoured game species would have been preserved, probably by laws and taboos similar to those recorded historically for hunter-gatherer groups. This would have applied especially to herd ungulates like the bison and the reindeer, with whom human populations were able to develop a symbiotic relationship (see figure 3.8).

Having modified the structure and stability of ecosystems, human populations would have made other large mammals more vulnerable to environmental stress. In particular, the changing and, from the faunal point of view, deteriorating climate towards the end of the last glaciation would have forced animals to compete with each other and with humans for increasingly scarce resources. In Australia, climatic desiccation from about 30 000 to 18 000 Cal. yr BP forced aboriginal and animal populations into competition for food and water resources, with the latter suffering in consequence. In western North America, a similar contraction of water resources occurred at around the time of the Younger Dryas, with Clovis culture artifacts and mammoth tracks being found together around spring sites (Haynes, 1991). Indirect human disturbance of ecological balances is consistent with the loss of birds and small mammals, and also with the differing severities of late Pleistocene extinctions across the world. In Africa, where hominids had formed part of savanna ecosystems for millions of years, a phase of extinctions can hardly be recognized at all. Nearly all of that continent's megafauna has remained intact until the present day, to fill the game parks and cages of modern zoos. In northern Eurasia some eight genera disappeared at the end of the Pleistocene, all of them adapted to steppe-tundra environments and most exploited by stone-age hunters through the last glaciation. In the Americas, where human antiquity is shorter and ecosystems were almost pristine until the terminal Pleistocene, mammalian extinctions were devastating in their effects. They involved 39 genera of large mam-



mals in North America alone, a greater number of extinctions than during the preceding 4 million years (Martin and Klein, 1984), and have left New World megafaunas impoverished ever since.

Perhaps the most remarkable discovery of all has been the fossil remains of dwarf mammoths of Holocene age on Wrangel Island in the Siberian Arctic (Vartanyan et al., 1993). During the late Pleistocene, Wrangel Island was joined to the mainland by the land bridge of Beringia, but, as sea levels rose, so it became isolated, and its mammoth population was trapped. Elsewhere, the mammoths quickly became extinct, but here

they were able to survive in an ice-age time capsule of tundra meadows and arctic steppe, untroubled by natural predators or by humans. As often happens with isolated populations, the mammoths started to 'shrink' in size, possibly to around half their previous height. Numerous bones, tusks and teeth of these dwarf mammoths have been ^{14}C dated to the early and mid-Holocene, but – sadly – they show that the mammoth population eventually succumbed, almost certainly to natural causes. The youngest dates, however, indicate that on this remote Arctic island, mammoths survived until after 4500 years ago, by which time Egypt's great pyramids were being erected!

The human role in terminal Pleistocene extinctions remains a matter of controversy. None the less, it is likely that cultural impact upon at least this part of ecosystems was substantial even before the start of the Holocene. The separation of human and natural agencies therefore emerges as a problem even before climate, vegetation and landscapes had become recognizably modern in form.

CHAPTER FOUR

Early Holocene Adaptations (11 500 5000 Cal. yr BP)

Changes in the Physical Environment

Ice sheets and sea levels

Human adaptations to coastal environment

Lake ontogeny and soil development

The Return of the Forests

Europe

Eastern North America

Dry mediterranean woodland

Tropical forests

Factors affecting forest re-advance

The Ecology of Mesolithic Europe

The Early Holocene in the Tropics

Saharan palaeoecology

Early Holocene Climates: Pattern and Process

Conclusion