Late Quaternary megafaunal extinctions in Europe and Northern Asia: new radiocarbon evidence

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The cause or causes of Late Quaternary megafaunal extinction continue to be debated. Establishing a reliable radiocarbon chronology for the extinct megafauna of each continent is essential for testing the hypotheses of environmental change *versus* human hunting ('overkill'). In North America, megafaunal extinctions, Late Glacial environmental changes, and the arrival of humans with advanced Upper Palaeolithic (Clovis) technology, all occurred at about the same time, making it difficult to disentangle the possible causes (Stuart 1991; Martin & Stuart 1995). However, in Northern Eurasia nearly all extinctions occurred well after the appearance of modern humans with Upper Palaeolithic technologies, so that here there is a clear potential for testing chronological correlations between extinctions, the archaeological record, and environmental changes.

The results of a recent UK Natural Environmental Research Council funded project (A.M. Lister, A.J. Stuart) include about 250 new ^{14}C AMS dates (Oxford) made directly on material of extinct megafauna, from Europe and North Asia. Together with previous direct ^{14}C dates from the literature and unpublished sources, these have been used to reconstruct chronologies for several megafaunal species, including: *Mammuthus primigenius* (woolly mammoth), *Megaloceros giganteus* (giant deer), *Coelodonta antiquitatis* (woolly rhinoceros), *Crocuta crocuta* (spotted hyaena) and *Panthera leo* (lion). Woolly mammoth has by far the largest number of radiocarbon dates (Sulerzhitsky 1997; Stuart et al. 2002).

The patterns of dates strongly indicate a close relationship between vegetational changes (in response to climatic changes) and major shifts in distribution of megafaunal species. For example, the Last Glacial Maximum (LGM) had a profound effect on most species, as is shown by major range shrinkages in most species ca. 20-16 ka (uncalibrated ^{14}C chronology). However, ca. 12 ka woolly mammoth withdrew rather suddenly from most of its formerly extensive range (Sher 1997; Stuart et al. 2002), at about the same time as giant deer was recolonising North-West Europe. Both events can be correlated with the major spread of trees at the expense of open 'steppe-tundra' environments, which occurred at the onset of the Allerød phase of the Late Glacial Interstadial, and each species appears to have responded differently, according to its ecological requirements. Giant deer responded to the renewed cold and return to open environments at the onset of the Younger Dryas by withdrawing entirely from North-West Europe, whereas at the same time woolly mammoth underwent a limited re-expansion and briefly recolonised part of North-East Europe from North Siberia (Stuart et al. 2002; Stuart in press.). Both species survived into the Holocene in restricted areas. A marked range shrinkage prior to extinction can be seen for more than one species, and each appears to have made its 'last stand' at different times and in different regions. This ragged pattern of extinction in North Eurasia contrasts with North America, where many megafaunal species may have disappeared at approximately the same time (Martin & Stuart 1995).

The possible role of humans remains unclear. So far no clear correlations can be demonstrated between the archaeological record and the extinction chronology for any species.

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