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Contents

7. The Case for Climatic Stress Forcing Choice in the Adoption of Agriculture in the British Isles

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Many recently obtained high-temporal-resolution palaeoclimatic records are assembled which demonstrate that the change from a Mesolithic to a Neolithic economy in the British Isles coincided with a period of rapid and significant climatic change. A series of processes, physical, ecological and conceptual, are suggested, some of which are demonstrable, by which the change to agriculture became the preferred choice for hunter-gatherer-fishers.

Introduction: climate change and human decision-making

A recently recognized and unavoidable factor in the relation between humans and their environments is large-scale rapid climate change (Mayewski *et al.* 2004). The astonishing growth of data on Holocene climate change since the 1980s has led to a new paradigm with three key properties (Chambers and Brain 2002). First, some climatic changes were very major events, global in extent though regional in effect. Secondly, some were rapid, even abrupt, meaning that the climate system crossed thresholds over only decades. Third, climate extremes exceeded anything within normal human experience (de Menocal 2001).

The last two properties of the paradigm in particular have led to new speculations on the impacts of climate on human societies because there is a temporal association between periods of rapid climatic and cultural change (Berglund 2003). Mayewski *et al.* (2004) identify six such periods in the Holocene, broadly defined at 7000–6000, 5000–4000, 2200–1800 and 1500–500 BC, and 800–1000 and 1400–1850 AD. This paper develops this idea by a restatement of the 'food crisis' hypothesis at the Mesolithic–Neolithic transition in Northwest Europe, emphasizing that people worry about food more than about other things (Fernandez-Armesto 2000; Schulting 2004). The definition here of the Neolithic is that of Fischer (2002, 344): the introduction of cereal cultivation and/or stock raising.

Some analyses of the role of climatic change in human experience are 'catastrophist' in postulating that climate change was sometimes so rapid, large or extreme that adaptation was impossible (e.g. Weiss and Bradley 2001), but the more catastrophist claims are undoubtedly over-simplistic and unremittingly deterministic (Whittle 2003a). Other interpretations have been concerned to emphasize that people always had choices in how they coped with climatic stress. Most well-explored case studies of climatic impacts have considered scenarios in which the carrying capacity of the environment was lowered and a complex agrarian society fragmented or 'shifted to lower subsistence levels by reducing social complexity … and reorganizing systems of supply and production' (de Menocal 2001, 572). The change from foraging to farming is ostensibly in the opposite direction, from apparent simplicity to greater complexity in social and economic structure, though we should not assume that early agriculture required a substantially more complex society. One of the most successful applications of a climate stress model to increasing socio-economic complexity is the introduction of agriculture in the Near East (Bar-Yosef and Belfer-Cohen 1992). Brooks (2004) has applied a similar 'oasis' model in explaining climatic forcing in the near-synchronous rise of complex societies in low-latitude, monsoon-affected regions around 4000 BC, and Sandweiss *et al.* (1999) have argued that global climate dislocations at this time impacted on several human societies.

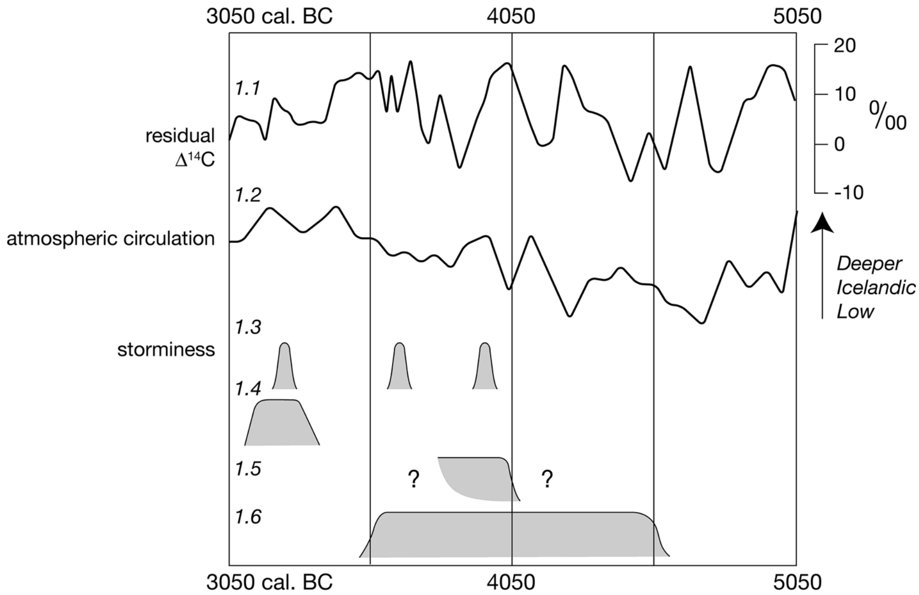

Fig. 7.1. Changes from 5050 to 3050 BC in indicators of change in atmospheric and ocean circulation from major data-sets relating to north-west Europe. Some records have been modified from the original publications to allow comparability: 1.1. residual Δ14C activity (modified from Stuiver and Braziunas 1993) which may represent the global impact of fluctuations in solar activity; 1.2. intensity of North Atlantic atmospheric circulation estimated from the inverse abundance of Na+ (sea salt) in the GISP2 ice core, Greenland, interpreted (Mayewski et al. *2004) as a proxy for the depth/intensity of the Iceland Low atmospheric pressure zone. Deeper periods mean stronger and more zonal winds across the North Atlantic Ocean; 1.3. aeolian sand-blowing events across coastal raised mosses in south-west Sweden (Bjorck and Clemmensen 2004; de Jong* et al. *2006); 1.4. sand-blowing event across peat in north-west Ireland (Caseldine* et al. *2005); 1.5. summary of dune mobilization phases in the UK (Keatinge and Dickson 1979; Mellars 1987; Tooley 1990; Cowie 1996; Gilbertson* et al. *1999); 1.6. sand dune mobilization on the northern Irish coast (Wilson* et al. *2004).*

Baillie (1995), Mayewski *et al.* (1996) and Berglund (2003) noted the temporal association between climatic deterioration at this time and the introduction of farming in the British Isles and Northern Europe respectively, but did not consider the physical, ecological, economic or social mechanisms involved. Bogucki (1998) suggested that agriculture was fully adopted on the Northern European plain to broaden the resource base in response to increased climatic variability. Bonsall *et al.* (2002) have argued that an abrupt change at c. 4000 BC to a drier, more continental climate in the British Isles encouraged the uptake of agricultural resources. Tipping and Tisdall (2004) developed a model, elaborated in this contribution, which examined reasons why resources used by foraging communities might have failed or become much less reliable with climatic deterioration, encouraging those communities to adopt, perhaps only in part, an agrarian 'package'. A new element developed in this paper considers how physical changes to the North Atlantic Ocean might actually have discouraged contact between islands such as the British Isles and the continent before c. 4000 BC.

The model presented here is intended only to explain the adoption of agriculture by hunter-gatherers in the British Isles. In all its details the model is arguably most applicable to the north and west of the British Isles. The model is not applicable to the introduction of agriculture to continental Europe because the timing of this was significantly earlier (Whittle 2003b), although the scale of the climate changes described can in general terms be used to examine the apparent instability of farming populations on the continent closest to Britain at around 4100 BC (Louwe-Kooijmans 1999; Sheridan, this volume). It is considered that the introduction of agriculture to the British Isles and southern Scandinavia was rapid, at 4000–3800 BC (Ashmore 2004; Rowley-Conwy 2004), that there is no evidence in the British Isles for an 'invisible' Neolithic (Tipping 1994; 2004) and that, in contrast to parts of Northwest Europe (Klassen 2002), there is no evidence for contacts between Mesolithic foragers and contemporaneous farmers on the continent (*contra* Thomas 2004). The introduction of agriculture in the British Isles was an event (Schulting and Richards 2002). Of key importance, then, is to explain why this event happened when it did.

Rapid climate change at the Mesolithic–Neolithic event in Northwest Europe

The major climate changes summarized in Figures 7.1 to 7.3 are from a wide range of datasets for Northwest Europe north and west of the Alps, which is modelled to have been for the most part a uniform climatic region (Cheddadi *et al.* 1997), for 5050–3050 BC. At c. 5000 BC extensive areas of intertidal marsh are modelled to have fringed East Anglia and the adjacent continent, including much of the Dogger

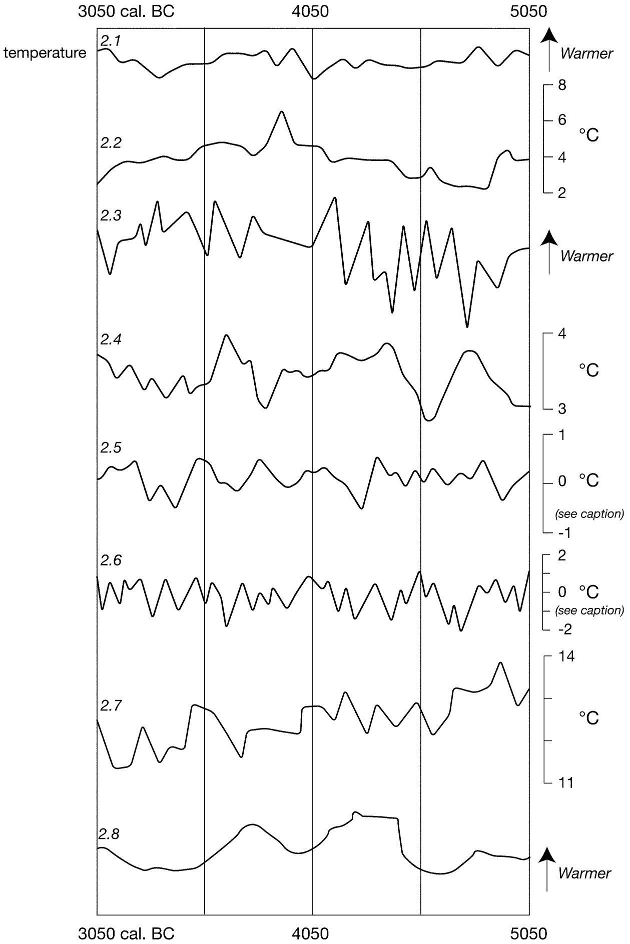

Fig. 7.2. Changes from 5050 to 3050 BC in different indicators of temperature change relating to north-west Europe. Some records have been modified from the original publications to allow comparability: 2.1. $\delta^{18}O$ values in the GRIP ice core, Greenland, from Mayewski et al. *(2004); 2.2. planktonic foraminiferal assemblages in the northern North Atlantic expressed as summer sea surface temperature (ºC), from Mayewski* et al. *(2004); 2.3. $\delta^{18}O$ values in a speleothem in western Ireland (McDermott* et al. *2001); 2.4. $\delta^{18}O$ values in a speleothem in western Norway expressed as mean annual air temperature (ºC), drawn from Lauritzen and Lundberg (1999); 2.5.* Pinus *tree ring widths in northern Finland expressed as differences in July mean temperature (ºC) from 0ºC, drawn from Helama* et al. *(2002); 2.6.* Pinus *tree ring widths in northern Finland expressed as July mean temperatures (ºC), drawn from Grudd* et al. *(2002); 2.7. pollen spectra in northern Finland expressed as July mean temperatures (ºC), drawn from Seppa and Birks (2001); 2.8. peat-stratigraphic analyses from blanket peats in northern Scotland interpreted as a record of relative desiccation, drawn from Tipping and Tisdall (2004).*

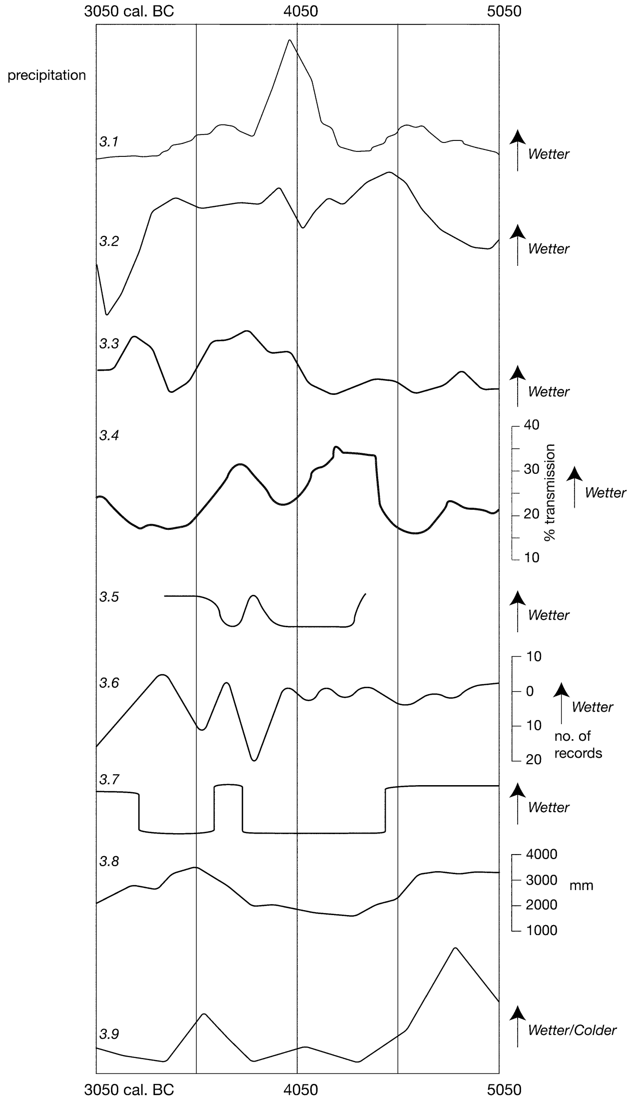

Fig. 7.3. Changes from 5050 to 3050 BC in different indicators of precipitation change relating to north-west Europe. Some records have been modified from the original publications to allow comparability: 3.1. relative deposition rate of oak trees in sediments of the River Main, Germany, suggested to be determined by soil dryness, drawn from Spurk et al. *(2002); 3.2. peat-stratigraphic analyses from a raised moss in north-west England, drawn from Hughes* et al. *(2000); 3.3. peat-stratigraphic analyses from a raised moss in south-east Scotland, drawn from Langdon* et al. *(2003); 3.4. peat-stratigraphic analyses from a fen peat in northern Scotland, drawn from Tipping and Tisdall (2004); 3.5. schematic summary of peat-stratigraphic analyses from a raised moss in the Netherlands (Blaauw* et al. *(2004); 3.6 lake-level fluctuations at several localities in the Alps (numbers of records of high and low lake level), redrawn from Magny (2004); 3.7. lake-level fluctuations at a site in northern Scotland, drawn from Tipping and Tisdall (2004); 3.8. winter precipitation derived from analysis of glacier fluctuations in western Norway, drawn from Nesje* et al. *(2001); 3.9. synthesis of glacier recessions in the Swiss Alps, redrawn from Joerin* et al. *(2006).*

Bank, but by 4000 BC the coastlines were close to those of the present day (Shennan *et al.* 2000).

Palaeoclimate datasets differ in their dating controls and temporal resolutions. This interpretation has tried to focus on the best-constrained and most clearly understood records. Ages are reported in these publications as cal. years BP (these should be referred to for calibration procedures) but are reported here as calibrated years BC. Evidence from datasets that use comparatively imprecise controls like ^{14}C are distinguished in the text by the term c. (circa): other datasets can be resolved to 10–25 years. There is developing in the literature a tendency to 'suck-in' events, to conflate different events into one (Baillie 1991). In addition, a search for cyclicity has meant that many high-resolution records are smoothed when published to 100- or 200-year resolutions.

Four aspects of climate change are explored: a) atmospheric and ocean circulation; b) storminess; c) temperature; and d) precipitation. All use proxy data, of course, and some data are ambiguous as to what they indicate. Tipping and Tisdall (2004) drew on analogies with changes in the most recent climatic excursions c. 1400–1850 AD or at present but this contribution focuses on events that took place at and around the Mesolithic–Neolithic transition. Nonetheless, because many details of climate change in this period are unclear, there is still a need to draw comparisons with possible modern analogues.

A decline in solar output is suggested to have been the most likely cause of the rapid climate change c. 3950 BC (Mayewski *et al.* 2004). Icebergs were transported from the Arctic Ocean after c. 4550 BC, most commonly between c. 4350 and c. 3650 BC. Sea-surface temperatures west of Ireland were sharply reduced (Keigwin and Boyle 2000) and thermohaline circulation in the North Atlantic Ocean was possibly weakened (Broecker 2000). Arctic Ocean currents are modelled to have altered at around 4000 BC because of increased river discharges (Prange and Lohmann 2003). Rates of sedimentation on the Irish Sea floor accelerated after c. 4700 BC (Scourse *et al.* 2002), a phenomenon attributed to a restructuring of continental shelf sea circulation. The same sediment sequence suggests strong seasonal contrasts of up to 15ºC in sea-surface temperatures (SST) with winter SST possibly lower than 5ºC after c. 4700 BC (Marret *et al.* 2004). After c. 4350 BC the South Jutland current flowing north past Denmark strengthened and outflow from the Baltic Sea was reduced (Gyllencreutz *et al.* 2006). Salinity within the Baltic Sea was rapidly halved at c. 4750 BC but had recovered by c. 4250 BC (Emeis *et al.* 2003).

Polar atmospheric circulation (Fig. 7.1.2) was increasingly strong between 4150 and 3400 BC and mid-latitude westerly storm tracks were more intense, persistent and more strongly meridional (east–west) between 4450 and 3050 BC. Storm events on the Atlantic coast recorded by dune mobilization are most frequent from c. 4000 BC (Figs 7.1.3–7.1.5), though in northern Ireland they are recorded from c. 4500 BC. Dune mobilization events are very poorly dated, however, and several systems in western Scotland were active in the Late Mesolithic period, continuing into the Early Neolithic period, contrasting with more ambiguous biological evidence for climatic quiescence (Andrews *et al.* 1987a; Andrews *et al.* 1987b; Russell *et al.* 1995).

Proxy terrestrial temperature records from Europe (Figs 7.2.1–7.2.8) are rather inconsistent, reflecting different data sources and temporal resolutions. Most reconstructions suggest falls of up to 2ºC from c. 4800 BC to c. 4600 BC with an erratic recovery to c. 4200–4000 BC (Figs 7.2.2, 7.2.3, 7.2.6, 7.2.7, 7.2.8). The Late Mesolithic period was generally colder than the Early Neolithic period, with several of the coldest winters in the last 7500 years (Grudd *et al.* 2002). Cheddadi *et al.* (1997) suggest the period around 4050 BC to have been up to 3K warmer than present. The period after c. 4000 BC appears in most reconstructions (except Figs 7.2.7 and 7.2.8) to have been more stable.

Different precipitation proxy data (Fig. 7.3: see also Magny *et al.* 2006) agree more closely (Barber *et al.* 2004). Most records suggest that the climate of Northwest Europe became wetter from c. 5050 to 4550 BC, but then became drier, probably much drier, after c. 4550 BC. Relative dryness may have been most intense or most widely recognized after c. 4250 BC. Seppa and Birks (2001, 535) argued that very dry soils between c. 4400 and 4250 BC should have had 'strong hydrological and ecological consequences'. Recovery had occurred by c. 3900 BC but a further phase of relative dryness occurred in the Early Neolithic period from c. 3850 BC, and in some reconstructions persisted beyond 3050 BC (Figs 7.3.1, 7.3.2, 7.3.4), although in others it is seen to have been interrupted after c. 3650 BC (Figs 7.3.5–7.3.8 inclusive).

Physical and ecological impacts of rapid climate change

Changes in ocean circulation, lower surface temperatures, increased storminess and salinity fluctuations in partly enclosed seas can be expected to have led to at least some of the following physical and ecological changes: changes in spawning and migratory patterns of fish populations; changes in species distributions of coastal faunas; reductions in population numbers or biomass of fish and animal populations; altered coastal geographies; greater wave strengths; increased threats to travel between islands. Few such changes have been demonstrated for this period or, more significantly, ascribed to climatic factors. Only recently have records of dune mobilization been considered to be a measure of storminess rather than relative sea-level change (Orford *et al.* 2000). Other substantial coastal changes in this period, such as the construction of beach ridges, are usually interpreted only in terms of relative sea-level change. Faunal changes signifying a shift from marine to brackish water environments at sites bordering the Baltic Sea, poorly dated but occurring around 4000 BC, have been ascribed to a reduction in tidal amplitude through the submergence of the North Sea (summarized in Fischer 2002, 369) but may be related more directly to atmospherically driven salinity change (Emeis *et al.* 2003).

Climatically induced landscape change away from the coast can be hard to distinguish from anthropogenic change, even within the later Mesolithic period (Tipping 2004). Regionally synchronous change is the most-used distinction. Precipitation is generally thought to have been the most effective climatic factor (Bonsall *et al.* 2002). Rivers in Northwest Europe appear to have flooded more frequently in brief peaks around 4850 BC, and in Central Europe again around 4300 BC and 3970 BC (Macklin *et al.* 2006). British rivers were again more active after c. 3780 BC (Macklin *et al.* 2005; Johnstone *et al.* 2006). Most events, though perhaps not all, relate to phases of increased precipitation (above: Fig. 7.3).

Palaeoecologists have tended to assume a causal relationship between woodland loss and agricultural expansion, but this need not be correct, particularly in periods of rapid climate change. In the boreal forests of Northern Europe many pine trees died between 4150 and 4000 BC, again between 3950 and 3650 BC and at 3600 BC (Zetterberg *et al.* 1996). Tipping *et al.* (2008) describe a collapse of the pine population in northeast Scotland between c. 4250 and 3750 BC associated with otherwise rather poorly defined event(s) between c. 4650 and 4150 BC and c. 3850 and 3650 BC (Bridge *et al.* 1990). Populations of oak trees growing on bog surfaces throughout Northern Europe collapsed for brief periods at 4450 BC and again at 3950 BC (Leuschner *et al.* 2002), events inferred to be related to rising groundwater tables. Few oak trees were preserved on flood plains in northern Germany between 4210 to 3920 BC, possibly because of increased dryness (Spurk *et al.* 2002). Populations of elm trees living alongside these oaks collapsed near-synchronously at 4393–4357 BC (Parker *et al.* 2002). These workers and Cayless and Tipping (2002) argued for a climatic cause for the primary elm decline.

Trees less stressed by climatic extremes, like hazel and birch, seem commonly to have filled gaps created by dying trees, so that the woodland canopy may have remained complete. Very rarely did woodland loss in the Late Mesolithic or Early Neolithic lead to the creation of extensive grasslands (Berglund *et al.* 1996; Richmond 1999; Tipping 1994). The chalk of southern England may be one region where grasslands emerged (Waton 1982), perhaps through precipitation starvation. O'Connell and Molloy (2001) also argued for extensive woodland clearances for pasture 400–500 years long in northwest Ireland from c. 3850 BC in a storm-sensitive region. The apparent completeness of the woodland cover on some exposed Hebridean islands is why Andrews *et al.* (1987a) argued for climatic stability, but other equally exposed localities on this seaboard show that woodland barely took hold in the Holocene (Birks and Madsen 1979; Carter *et al.* 2005; Walker 1984). Blanket peat in upland areas expanded or was established in the Late Mesolithic period to fill the spaces left by dying trees (Tallis 1991). Simmons (1996) argued for moorlands having been created by Late Mesolithic human pressures, but this is debated (Tipping 2004), and the frequency of fires at this time, implied as causal in peat spread, may have been determined by climatic factors (Froyd 2006; Tipping 1996; Tipping and Milburn 2000).

Choices and worldviews: human responses to climate change

Although Bogucki (1998) and Bonsall *et al.* (2002) argued that climate change made farming a more attractive proposition to forager populations by broadening the resource base, most reconstructions emphasize the already wide resource base of later Mesolithic communities (e.g. Mithen 2000), and it is more likely that climate change led to the failure of existing resource strategies or to the conviction among these communities that these were failing. The arguments presented by Sheridan (2007; this volume) for migration of farmers to the British Isles are accepted, but the widespread adoption of agrarian techniques (Jones 2000; Schulting and Richards 2002) is assumed here to have required acceptance and engagement by the native population (Thomas 2004). It is thus argued that the complexity and variability of climate made natural resources used by foraging communities unreliable and unpredictable.

Coastal resources may have become more abundant as a result of coastal erosion accelerating nutrient supply after c. 4700 BC (Andersen 2004, 397), leading to the development of a distinctive shell-midden economy. This may have been sustained after c. 4500 BC by increased storminess as sea-level change slowed. Mithen (2000) suggested major population shifts to these resources on Oronsay at c. 4500 BC, and Andersen (2004, 408) considered that most if not all Late Mesolithic foragers around the Baltic Sea lived on the coast. Deteriorating sea-surface temperature and salinity, increased seasonality and changing ocean currents (above) may, however, have led by c. 4000 BC to a widespread decline in the productivity of these resources (cf. Rowley-Conwy 1984) and the 'slighting of the sea' (Schulting 1998; Schulting and Richards 2002; Richards *et al.* 2003: but see also Milner *et al.* 2004). By denying environmental stress as an explanation of this event because it was so widespread, Thomas (2004, 119) underestimates the hemispheric scale of rapid climate change (Mayweski *et al.* 2004), as might Schulting *et al.* (2004) by assuming the 'gulf stream' to have been a constant ameliorating factor along the Atlantic coast in this period (Broecker 2000; Clark *et al.* 2002; Keigwin and Boyle 2000). The economic significance of the 'slighting of the sea' is uncertain (Fischer 2002, 370; Andersen 2004, 408), but few palaeoeconomic data exist. Middens might then be indicators of famine (Hardy and Wickham-Jones 2003, 375), the 'slighting of the sea' a final failure of the resource, and the development of social mechanisms expressions of concern over resource depletion (e.g. taboos: M. Richards 2003; 2004; Schulting 2004). Natural change in this environment may have been seen as malevolent by Late Mesolithic coastal communities, or at best quixotic and temperamental, and nature as undependable.

Away from the coast there is no evidence that resource strategies changed in the latest Mesolithic, but there is little evidence for resources at all (Warren 2004). We should not assume their constant abundance but the effects of climatic deterioration (above) may not have adversely impacted on these, with the possible exception of migratory fish caught inland (Warren 2005) but coming from the sea. The impact of climate change may have been to promote expansion of grasses beneath thinning woodland canopies (Bonsall *et al.* 2002; Davies *et al.* 2004; Tipping and Tisdall 2004). This may have encouraged the development of agro-pastoralism (Bonsall *et al.* 2002) but would equally have been beneficial to wild animal populations. Change would have allowed both hunters and early pastoralists to thrive, permitting choice. High-resolution faunal analyses in Central Europe suggest that farmers did continue to make choices through resource-switching (Huster-Plogmann *et al.* 1999; Schibler 2006). In these inland and upland landscapes, then, nature simply by changing would have appeared beneficent and generous in spirit. Might this be the context in which woodland glades became charged with special significance (Brown 1999)?

The observation of rapid natural change in their world may have encouraged among forager communities a more ready acceptance of new ideas (Tipping and Tisdall 2004). Mesolithic lives embedded in a world of seasons and ceaseless cycles (e.g. Pollard 1996; Jones 1996), seemingly changeless, were jarred and unsettled by the unavoidable but unexplained evidence of change (Larsson 2003, xxx). Even when resources were not actually threatened, landscape change raised questions and introduced uncertainty. Seasons changed in timing and character, things formerly predictable could no longer be predicted with assurance and were seen to be impermanent. The natural world, and so time, ceased to be perceived in cycles. Mesolithic foragers became more receptive to innovation simply because the natural world appeared differently, as when walking through oak, elm and pine woods that were now decaying; or watching in wonder as fodder for animals magically appeared; or fording rivers made dramatically deeper and more dangerous by frequent floods and in which until recently was reliably found food; or surveying shorelines that in living memory were welcoming and resource-rich; or eyeing islands that were now thought unsafe to reach. Change required no great emotional or philosophical restructuring (Thomas 1999) because it was part of the 'natural order', different only because it was no longer gradual but abrupt and transformative. These people could choose not to change, but increasingly they saw and chose new ways of doing things.

Climatic instability would have had effects on continental farming communities. The periods of crisis in these groups identified by Louwe Kooijmans (1999) may relate to these pressures. The general rise in temperatures after c. 4000 BC (Fig. 7.1.1) and the longer growing season (Cheddadi *et al.* 1997) may have promoted better growing conditions on the continent and in the British Isles, particularly for autumn-sown cereal crops (Bogaard 2004, 164) but the argument in this paper is that the preceding impacts of deteriorating climate did more to prepare the native forager population for an alternative way of life.

In his unease over Sheridan's (2004, 2007) migration hypothesis, Thomas (2004, 118) rightly asks why should 'groups of people … all have set sail simultaneously' for the British Isles: 'Why did they wait so long, and then all go at once?' Exaggeration apart, these are good questions. The movement of foragers to Oronsay around 4500 BC (Mithen 2000) and the arrival, if securely dated, at Ferriter's Cove in western Ireland of domesticated cattle at around this time (Woodman *et al.* 1999) indicate that sea journeys could be made, but these are separated in time from the second 'wave' of migration by a period which, at least in parts of western Britain, seems to have been one of heightened storminess. Movement in the Mesolithic period between Scottish islands is often assumed to have been routine (Warren 2000; Wickham-Jones 2005), but this may be overstated (Pickard and Bonsall 2004). Such journeys may have been high-risk adventures to collect high-prestige stone from islands (Saville 2003, 346) and we do not know how many such expeditions failed. Might sea travel have become too risky, or been perceived to be, with climatic deterioration? Tipping and Tisdall (2004) suggested that the timing of the introduction of agriculture to the British Isles, and so migration from the continent, was determined by the perception that sea voyages were becoming less climatically hazardous than they had been. The phase of increased storminess identified from the chronology of sand dune mobilization (above: Fig. 7.1) suggests that the earliest Neolithic period was more hostile than the later Mesolithic period, but this chronology is by far the least satisfactorily defined of the records presented in Figs 7.1–7.3. It is critical to define with high precision when storms were most active in this period on the Atlantic coast because the apparent absence of links between Ireland and Scotland in the Mesolithic (Saville 2003; Woodman 2004) can be contrasted with the clear movement between the two in the Early Neolithic (Cooney 2004; Noble 2006; Sheridan 2004). The apparent isolation of foragers on Oronsay at the end of the Mesolithic period can be compared with their return to Islay after c. 4000 BC (Mithen 2000). Raemakers (2003) has argued, for the exposed shorelines of the Netherlands, that our knowledge of settlement in the centuries before 3600 BC is distorted by the loss of sites through coastal erosion, assumed by him to be related to sea-level rise but more likely to have been through heightened storminess. Such phases of increased storminess may have had more than economic impacts.

Might they, for instance, have been memorialized? Portal dolmens look like natural rock formations (C. Richards 2004; Whittle 2004), like tors (Tilley and Bennett 2001), but tors are not found everywhere along the Atlantic coast. Portal dolmens also look like coastal rock formations termed megaclast deposits, enormous stones hurled high on cliff tops onto underlying rocks by truly prodigious storm waves (Williams and Hall 2004). People may have wanted to remember not only natural places (Bradley 2000) but natural events also.

Acknowledgements

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