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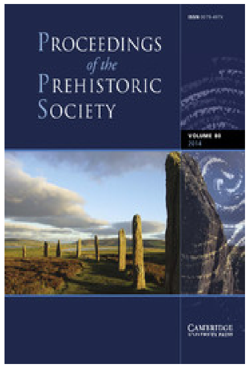

Plant Use in the Mesolithic and its Role in the Transition to Farming.

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Proceedings of the Prehistoric Society / Volume 60 / January 1994, pp 35 - 74
DOI: 10.1017/S0079497X00003388, Published online: 18 February 2014

Link to this article: http://journals.cambridge.org/abstract_S0079497X00003388

How to cite this article:
Marek Zvelebil (1994). Plant Use in the Mesolithic and its Role in the Transition to Farming. . Proceedings of the Prehistoric Society, 60, pp 35-74 doi:10.1017/S0079497X00003388

Proceedings of the Prehistoric Society 60, 1994, pp. 35–74

Plant Use in the Mesolithic and its Role in the Transition to Farming

By MAREK ZVELEBIL[1]

Leif set sail when he was ready; he ran into prolonged difficulties at sea, and finally came upon lands whose existence he had never suspected. There were fields of self-sown wheat growing there, and vines, and among the trees there were maples.
(Erik's saga).

The purpose of this paper is to review the current evidence for plant use in Mesolithic Europe and to summarize its implications. In order to do so, four sources of data are examined: macrobotanical remains, palynological data, artefactual evidence, and the human biological record.

A prelimary survey of palaeobotanical evidence for plant use in the Mesolithic indicates that the evidence is far more extensive than expected hitherto and that accumulations of plant food, especially of nuts, point to their regular and extensive use. In those areas such as Britain, where a large number of fine-resolution palynological studies have been carried out, the incidence of clearance and burning phases seems to be too high to be explained by acts of nature alone. A good case can be made for deliberate forest clearance and the maintenance of a more open landscape by Late Mesolithic groups as part of a promotional strategy to increase the productivity of nut and fruit trees and shrubs, wetland plants, and possibly native grasses.

Artefactual evidence points to a widespread distribution of soil-working tools (hoes and antler mattocks), especially in temperate Europe, and to a greater than expected presence of reaping and grinding equipment, lending conditional support for the existence of a specialized plant processing tool kit for digging, reaping, and plant processing.

Palaeopathological evidence indicates the existence of a dietary pattern in the west Mediterranean making extensive use of starchy and carbohydrate foods which resulted in a high caries rate among the Mesolithic population of that area.

In discussing the significanse of these four lines of evidence, it is argued that, by the Late Mesolithic, the patterns of plant use support the notion of wild plant food husbandry instead of the incidental and opportunistic use of plants for food which has implicitly been accepted as a norm for the Mesolithic in Europe. Three geographical areas can be identified with their specific pattern of plant use: temperate Europe, Mediterranean Europe, and the south-eastern Balkans/Pontic Steppe. The patterns of plant use suggested in this paper emphasize the additive nature of the adoption of the agro-pastoral Neolithic farming practices in Europe.

INTRODUCTION

In a seminal essay 18 years ago, David Clarke (1976) made a case for plant husbandry in Mesolithic Europe. Despite emphasizing the wide availability of potential plant food in temperate and Mediterranean Europe, Clarke was deterred by the fragility of palaeobotanical evidence to undertake a review. Consequently, his model attracted little support because of the lack of supporting evidence (Bonsall 1981; Rowley-Conwy 1986; Price 1987; Rozoy 1989). Recent research, however, has put Clarke's model into a new perspective. The purpose of this paper is to review the current evidence for plant use in Mesolithic Europe and to summarize its implications. In order to do so, I wish to examine four

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sources of data: macrobotanical remains, palynological data, artefactual evidence, and the human biological record.

In my review, I am adopting a broad frame of reference, a period covering some 5000 years from about 7000 to 2000 bc, a time coeval with the expansion of the temperate deciduous forest. During the Climatic Optimum, *c.* 6000–3000 bc temperate forest reached well beyond its present southern and northern limits. Mediterranean vegetation, confined at first to the southern and eastern Mediterranean, expanded west and north in the 8th–6th millennia bc, partly as a result of human interference. In the north, the recolonization by conifers in the 3rd and 2nd millennia bc replaced broad-leaved woodland in peninsular Scandinavia, the east Baltic, and northern Russia. Bearing in mind the high concentration of wild plant food in temperate woodlands and undegraded Mediterranean habitats (Clarke 1976), the availability of wild plant foods during the Climatic Optimum would have been greater in most parts of Europe than in the more recent past or at present.

MESOLITHIC PLANT USE — GATHERING, HUSBANDRY OR CULTIVATION?

During the last 30 years, an increasing number of papers, books, and edited volumes have been published with the aim of explaining the processes of domestication and the origins of agriculture (e.g. Ucko and Dimbleby 1969; Higgs 1972; Higgs 1975; Reid 1977; Rindos 1984; Harris & Hillman 1989, etc.). The main corpus of this research has been marked by the growing awareness of three aspects of the process of domestication:

1. Since biologically domesticated plants evolve as a result of cultural selection brought about by prior cultivation of undomesticated species (Harris 1977; Hillman & Davies 1992), cultivation must have occurred some time before it can be recognized on morphological grounds in the archaeological record (Helbaek 1960; Higgs & Jarman 1972; Jarman *et al.* 1982, etc.).

2. The domestication of plants and animals was a long-term process, reaching, perhaps, as far back as the Upper Palaeolithic (Higgs & Jarman 1972) and marked by an evolutionary continuum of interaction between people and plants (Rindos 1984; Harris 1989; *but see* Hillman & Davies 1992) and animals (Higgs & Jarman 1972).

3. Highly sophisticated systems of wild plant use, not neccessarily leading to domestication, existed both in the archaeological and ethno-historical past among hunter-gatherers outside Europe especially in North America (Harris 1977; 1984; Lewis 1982; William & Hunn 1982; Munson 1984; Shipek 1989; Watson 1989; Fritz 1990) and Australia (e.g. Lourandos 1985; Yen 1989; Chase 1989).

The implications for the Mesolithic communities in Britain are obvious. In theory, at least, they may have been engaged in similarly intensive forms of plant management. Clarke (1976) has made an eloquent case for both the availability of suitable wild plant foods in Europe (*see also* Price 1989; Nunez 1990) and for Mesolithic people to have possessed the technological capacity to utilize them effectively. The problem now rests in using the various strands of evidence to infer the patterns of behaviour responsible for plant use.

The problem is really two-fold. First, depending on the type of research, scholars differ in their behavioural definitions of what constitutes wild plant gathering, husbandry, cultivation, and agriculture. On the one hand there are those who stress the social, ideological, and symbolic aspects of human domesticatory behaviour (i.e. Ingold 1980; Rindos 1984; Chase 1989; Yen 1989; Ford 1985; Higgs & Jarman 1972; Hodder 1990). For those workers, agricultural domestication — one involving botanical changes in cultigens and domesticates — is by and large preceded by other forms of management, such as plant husbandry of wild species. Others, more concerned with the biological changes attendant on domestication, adopt a more cautious approach (i.e. Zohary & Hopf 1988; Hillman & Davies 1992), where plant husbandry is characterized by cultivation and where domesticated plant remains are crucial, if not the only, means of identifying cultivation in the archaeological record.

Second, there is no consensus as to what archaeological signatures can be linked to each type of behaviour. For example, while Harris (1989) links clearly different plant-managing practices to different food-yielding systems and emphasizes their social and demographic implications, (Fig. 1), no archaeological signatures are given. The reason is that nothing in the archaeological record can be linked to a single type of behaviour and we have to rely on the interpretation of several strands of evidence.

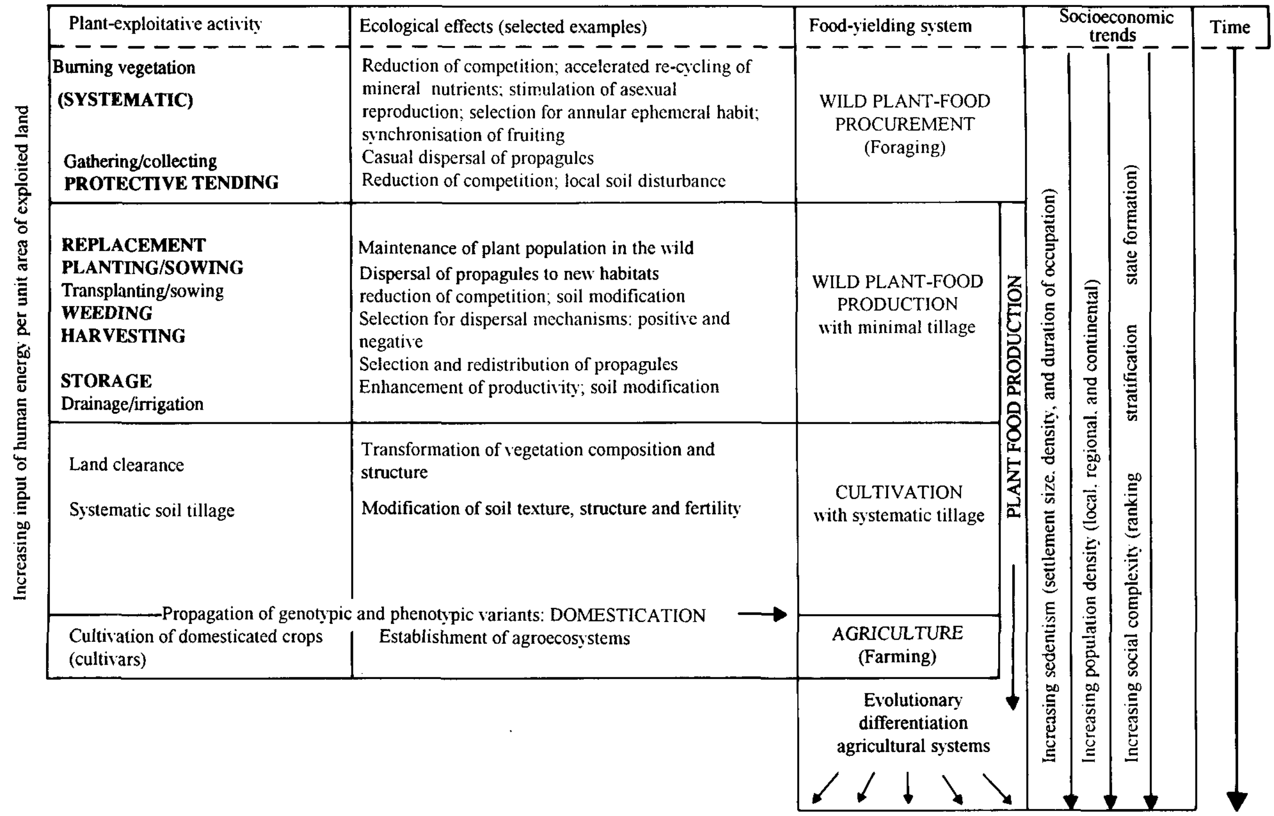

Fig. 1

Propagation of wild crops (after Harris 1989)
Capitalized activities in the 'Plant Exploitive Activity' column
characterize plant management as defined in this paper

Bearing this in mind, I would like to outline five plant using traditions, three of which have relevance to the plant use in the Mesolithic:

1. Opportunistic and incidental use of plant food. This would not cause any adjustments in the overall organization of procurement activities, would proceed without technological specialization, and would also leave little trace in the archaeological record. It corresponds to 'casual gathering' as defined by Jarman *et al.* (1982). Mesolithic plant use has been regarded in this light by many archaeologists, either explicitly (Rozoy 1989; Bonsall 1989; Rowley-Conwy 1986; *see also* Nunez 1990 for a regional review of Finnish literature) or implicitly in that wild plant use was not accorded a role to play in settlement-subsistence modelling or in the social organization of Mesolithic communities (Price 1987; Clark 1975; 1980; Morrison 1980, etc.).

2. Systematic and intensive plant use, suggesting that wild plants played a major role in the subsistence of Mesolithic communities. If such was the case, plant use should have been an important factor in the location of Mesolithic settlement, in their food-getting strategies and in the social organization of labour. Within such a tradition, people can be expected to engage in the conservation of their food resources, in the development of specialized tool kits for plant processing, and in the storage of plant foods. In terms of previous frameworks, such tradition would correspond to the systematic gathering of Jarman *et al.* (1982), incidental domestication of Rindos (1984), and to some aspects of wild plant procurement of Harris (1989; Fig. 1). Archaeologically, this would be discernable by the existence of tool-kits for plant use, stored plant food, and by the evidence for increased plant use in the skeletal remains. A number of scholars have already

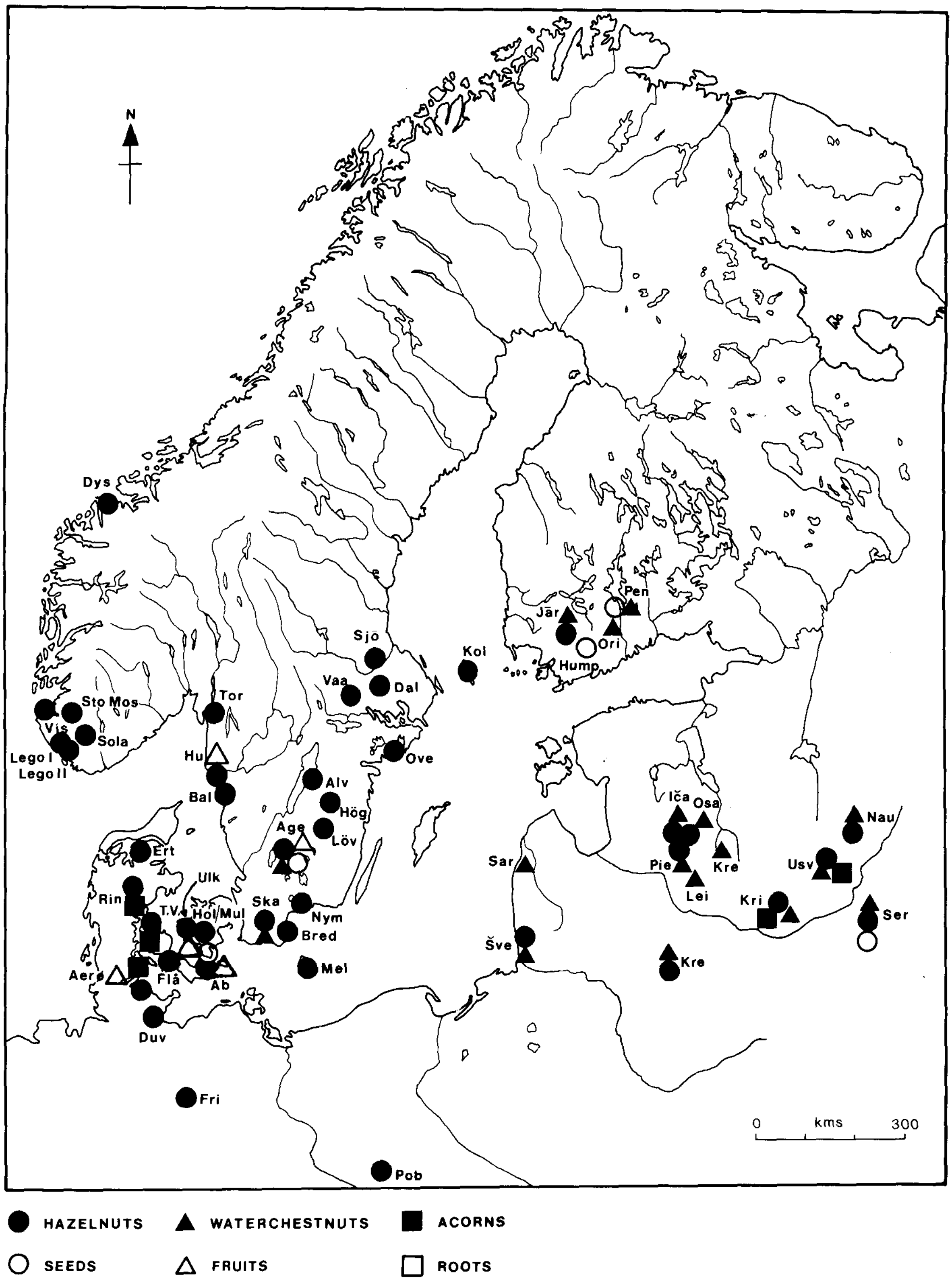

Fig. 2

Sites with edible plant remains in northern Europe (figure and table)

TABLE 1: SITES WITH EDIBLE PLANT REMAINS IN NORTHERN EUROPE SHOWN IN FIG. 2. UNLESS OTHERWISE STATED ALL DATES ARE RADIOCARBON DATES bc FOR THE SITES

Site	*Date bc*	*Plant remains*	*References*
NORWAY			
Dvsvijka	6100–5600	Hazel nuts	Kaland 1972; Indrelid 1975
Torkop	*6590–6180*	Hazel nuts	Mikkelsen 1975; Gulliksen *et al.* 1978
Viste	6000–3000	Hazel nuts	Mikkelsen 1975; Lund 1951
Hå	6480–6000	Hazel nuts	Bang-Andersen pers. comm.
Stora Mosvatnet	3090±100	Hazel nuts	Bang-Andersen 1979
Sola	6420±120	Hazel nuts	Haraldsen 1984
Lego 1	5640±120	Hazel nuts	Bang-Andersen pers. comm.
Lego 2	5730±150	Hazel nuts	Bang-Andersen pers. comm.
SWEDEN			
Bredasten	4500–4000	Hazel nuts	Larsson 1986
Ageröd 5	4910–4500	Hazel nuts, water-chestnuts, goosefoot, sorrel, waterlily, raspberry meadowsweet	Larsson 1983; Goransson 1983
Skateholm		Hazel nuts, water-chestnuts	Gaillard & Lemdahl 1988
Ageröd 1 B/D	6200–4500	Hazel nut	Larsson 1978
Nymölla 3	Meso/TRB transition *c.* 3000 bc	Hazel nut	Wyszomirska 1986; 1988
Sjövreten	4600–4200	Hazel nut	Welinder 1977
Vaalby	4200	Hazel nut	Welinder 1977
Darlarlstorp	4500	Hazel nut	Welinder 1977
Overäda	2250–2085	Hazel nut	Welinder 1977; Lofstrand 1974
Högby (Räa)	7020–5150 5900–4600	Hazel nuts	M Larsson pers. comm.
Lovas	*6020–6280*	Hazel nuts	M Larsson pers. comm.
Huseby Klev	6400–6650	Hazel nuts, apple	Nordquist pers. comm.
Ball Torp	6400–700	Hazel nuts	Wigforss 1993
FINLAND			
Kolvidja	Säter III ceramics: 2350–2200 bc	Hazel nuts	Lindquist 1988
Järvensuo	Combed Ware	Hazel nuts, water-chestnuts	Aalto *et al.* 1985; Meindander 1971
Orimattila	3420	Water-chestnuts	Vuorela & Aalto 1982
Pennala	3360	Water-chestnut	Vuorela & Aalto 1982
Humpilanjärvi	3000–2500	Polygonum seeds	Nunez 1990; Aalto 1983
DENMARK			
Ertebølle	3810–3160	Hazel nuts	Andersen & Johansen 1986
Ringkloster	3600–3200	Hazel nuts, acorns	Andersen 1975
Tybrind Vig	4500–3200	Hazel nuts, acorns	Andersen 1987
Holmegaard	4500–6450	Yellow waterlily	Bronholm 1931
Ulkestrup	6030–6370	Hazel nuts	Clark 1975
Fladet	Pre-boreal		Fredskild 1975
Melsted	6240	Hazel nuts	Clark 1975
Aerø Mollegabet I and II	3960±75	Hazel nuts, acorns Hawthorn	Grøn & Skaarup 1992
Angus Bank Småland Bight	4900	Hazel nuts, black- or raspberry	Fisher 1993
Muldbjerg		Raspberries	Troels-Smith 1959; Renfrew 1973
NORTH GERMANY			
Duvensee	Late Mesolithic	Hazel nuts	Clark 1975
Friesack	6200–2450	Hazel nuts	Gramsch & Kloss 1989

TABLE 1: SITES WITH EDIBLE PLANT REMAINS IN NORTHERN EUROPE SHOWN IN FIG. 2. UNLESS OTHERWISE STATED ALL DATES ARE RADIOCARBON DATES bc FOR THE SITES — *continued*

Site	*Date bc*	*Plant remains*	*References*
LITHUANIA			
Šventoji 1 & 2	2690–2450	Hazel nuts, water-chestnut	Rimantienė 1992; 1979
Kreutonas	2470–1620	Hazel nuts, water-chestnut	Girininkas 1990
LATVIA			
Sarnarte	2700–2490	Water-chestnut	Vankina 1970
Ica	Late Neolithic	Hazel nuts, water-chestnuts	Loze & Yakubovskaya 1984; Vankina 1970
Piestina	2510	Hazel nuts, water-chestnuts	Loze & Yakubovskaya 1984; Vankina 1970
Kreichi	2250–2070	Water-chestnuts	Loze & Yakubovskaya 1984; Vankina 1970
Leimaniski	1879	Water-chestnuts	Loze & Yakubovskaya 1984; Vankina 1970
Osa	3800–3700	Hazel nuts, water-chestnuts	Loze & Yakubovskaya 1984;
NORTH-WEST RUSSIA			
Naumovo	2050	Hazel nuts, water-chestnut	Dolukhanov & Aniklyayev 1986; 1992
Usvyaty	2360–2100	Hazel nuts, water-chestnuts	Dolukhanov 1979; 1992 Aniklyayev 1986
Krivina	2000–1600	Hazel nuts, water-chestnuts, acorns	Dolukhanov 1979
Serteya	4250–4050	Hazel nuts, water-chestnuts, waterlily, Ceratophyllum	Dolukhanov & Aniklyayev 1986; Dolukhanov 1992
NORTHERN POLAND			
Pobiel	6370	Hazel nuts	Bagniewski 1985; Kosina 1991.

argued for heavy plant use in the Mesolithic (e.g. Clarke 1976; Woodman 1985; Simmons & Innes 1985; 1987, Simmons *et al.* 1981; Bogucki 1988; C. Smith 1992).

3. Plant food management or husbandry, marked by deliberate and planned promotional strategies designed to increase the control over plant resources and the conditions of habitat favourable to the propogation of targeted plants. Such practices would include protective plant tending, selective burning of woodland, weeding, and soil modification. It does not necessarily include sowing or planting although occasionally it may. It is with these promotional practices that, in my view, the change in social relations towards investment, delayed returns, and towards the appropriation of resources and landscape takes place: well in advance of actual cultivation (Testart 1982; Hynes and Chase 1982; Yen 1989; for contrary view, see Ingold 1980; 1983). In terms of established frameworks, this tradition would fall between wild plant procurement and production as defined by Harris (1989) and, in its emphasis on social practice and control of the landscape, it conforms to the notion of husbandry as outlined by Chase (1989) and Yen (1989). It corresponds to the specialized domestication defined by Rindos (1984) and subsumes the definition of husbandry by Higgs and Jarman, based on plant relationships 'where some form of intentional conservation was practiced' (1972, 8; see also Jarman *et al.* 1982). In the archaeological record, such practices, though difficult to identify, should be reflected in the repeated episodes of burning, maintainance of open landscapes, rise in the incidence of targeted species, and in specialized tool-kits for plant tending and soil-working.

4. Cultivation of wild species denotes husbandry with systematic sowing/planting added: practices which may lead to domestication. Archaeologically, it would be difficult to recognize such practices, unless the presence of sown/planted wild plants could be attested (*see* Hillman & Davies 1992). In the Mesolithic of Europe, Dennell (1983) suggested that such cultivation may

have occurred in the Balkans and in Britain, while Clarke spoke of 'asexual horticulture and arboriculture' in temperate Europe (1976).

5. Cultivation of domesticated species is predicated on 'intentional selective purposeful breeding' of cultigens and domesticates (Higgs & Jarman 1972). While the process of plant domestication is well attested in the Near East (i.e. Reed 1977; Zohary & Hopf 1988; *see* Hillman & Davies 1992 for a recent summary), no evidence so far has been advanced for the indigenous domestication of plants in Mesolithic Europe.

It needs to be stressed that these types of human–plant relationships are not mutually exclusive. Indeed it can be expected that several traditions were practiced simultaneously, making the recognition of each practice all the more difficult. Nor is it neccessary to regard these traditions as a cultural evolutionary advance towards civilization, a view which would have hunter-gatherers redeemed only be their 'progress' towards agriculture. There was nothing inevitable about the adoption of farming. On the contrary as I am about to argue, the adoption of agro-pastoral farming must have been a considered decision made at different times by different groups in response to local or regional conditions and with the benefit of prior knowledge of wild plant husbandry (as here defined) within indigenous systems of plant management.

PALAEOBOTANICAL EVIDENCE

Clarke noted the high productivity and the large number of edible plants — between 200 and 450 species — in European temperate and Mediterranean regions (1976, but see Bonsall 1981). This included green leafy plants, seaweed, roots and rhizomes, nuts, grass seeds, and fruits. Many of these plants were concentrated in wetland habitats, along coastal, lacustrine, and riparian shores, and their greatest availability coincided with the eutrophic stage in the development of lakes, attracting settlement (Clark 1952; Welinder 1978; Zvelebil 1981). Mediterranean Europe offered a greater range of seeds, pulses, and nuts, while in temperate Europe, plant food was concentrated along the forest edge or in wetland areas in the form of fruit (both nuts and berries), roots, tubers, and green plants. Despite the problems of plant preservation and the lack of effective recovery techniques, evidence is continually increasing for plant use in the Mesolithic. In temperate Europe, this includes nuts, fruit, and grasses. (Figs 2 and 3).

Remains of hazelnut, sometimes in large quantities, have been found ubiquitously throughout temperate Europe (Woodman 1985; Price 1987; 1989; Mellars 1976; Edwards 1989b; Jacobi 1978; Bakels 1991; Blouet *et al.* 1984; Lauwers & Vermeersch 1982; Huyge & Vermeersch 1982; Ziesaire 1986; Thévenin, pers. comm.). Remains of water-chestnut were reported from the Netherlands (Newell 1973), Sweden, Finland, and especially the east Baltic (Vankina 1970; Dolukhanov 1979; Zvelebil 1987; Kozłowski 1989). Among fruit, remains of pear were found at Téviec, Brittany, (Clark 1952) and Mount Sandel, Ireland (Woodman 1985), of *Prunus* in the Netherlands and Belgium (Bakkels 1991; Veermeersch *et al.* 1974), and of raspberries at Muldbjerg (Troels-Smith 1959; Renfrew 1973) and Argus Bank in Denmark (Fischer 1972). Concerning seed and root plants, many sites with good preservation and/or careful recovery techniques, such as Mount Sandel; Morton, Fife; Holmegaard, Denmark; Star Carr, Yorkshire; or Zvidze, Latvia contained edible species, such as *Chenopodium*, or wetland plants, such as waterlily, reed, and bog bean, even though the use of all these plants as food cannot be proven beyond doubt (Clark 1972; 1975; Woodman 1985; Coles 1971; Loze & Yakubovskaya 1984). At Vlasac, Serbia and other sites in the Iron Gorge, coprolites (*presumed* human) contained large quantities of pollen of Chenopodicea and Cerealia (Carcuimaru 1973; Printz 1987). Since no sieving was applied, only hazelnut shells were reported from the archaeological contexts.

Contextual information indicates an intensive use of plant food on some sites: at Sarnate in Latvia, layers of water-chestnut shells, covering several square metres and reaching 40 cm in thickness, were deposited around hearths inside dwellings. Burnt remains of water-chestnut have been also found among the ashes. These remains were associated with plant processing equipment (see below). Abundant finds of hazelnut at sites such as Tybrind Vig, Denmark (Andersen 1987; Price 1989) or Mt Sandel (Woodman 1985) or Oakhanger VII, Hampshire (Jacobi 1978) also point to their intensive use.

Along the rim of the Mediterranean, the greater range of fruit and nut trees and of small seeded grasses might be expected to increase the visibility of plant use in the archaeological record. This is, in fact, the case. Mediterranean sites, such as Franchthi cave, Greece; Uzzo, Italy; Aberadou, Montclus, and Fontbregua, France; Balma Margineda and Cingle Vermell, Spain; and also coastal Atlantic sites in Portugal, show that a wide

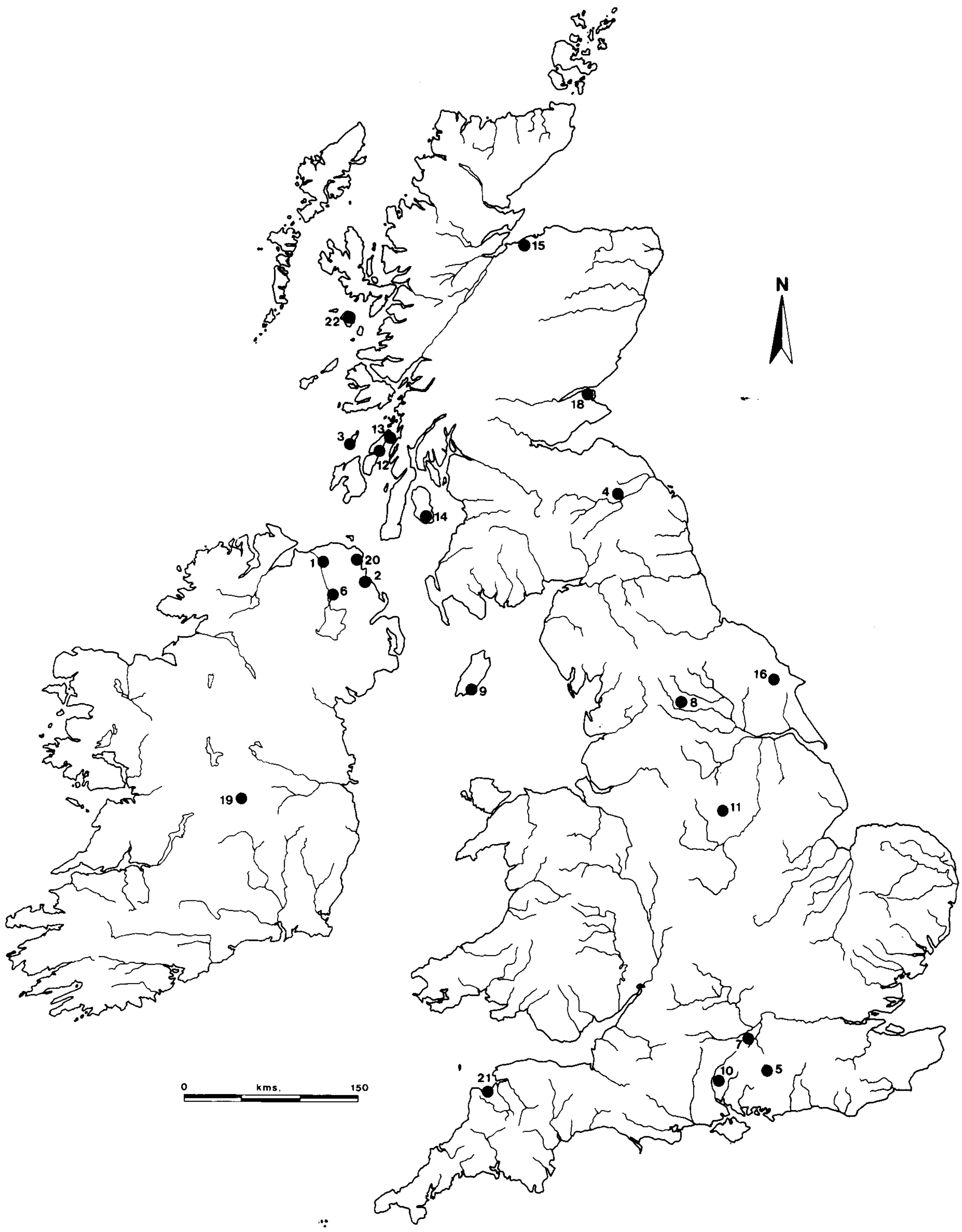

Fig. 3
Sites with edible plant remains in Britain and Ireland (figure and table)

TABLE 2: SITES WITH EDIBLE PLANT REMAINS IN BRITAIN AND IRELAND SHOWN IN FIG. 3. DATES DERIVED FROM CHARRED HAZEL NUTS IN ITALIC

Number	*Site*	*Type of organic matter*	*Date bc*	*Reference*
1	Mount Sandel	Hazel nuts	*7010±70* *6840±185* *6775±115* *6605±70* *6490±60*	Woodman 1985
		Vetches, goosegrass seed, wild pear/apple, white waterlily	*6845±135* *6270±100*	Monk & Pals 1985
2	Carnlough	Hazel nuts	Late Mesolithic	Monk & Pals 1985
3	Cnoc Coig	Hazel nuts	*3345±75* *3585±140*	Mellars 1978
4	Derravaragh	Hazel nuts & yellow waterlily seeds	3410	Morrison 1980; Mitchell 1972
5	Oakhanger	Hazel nuts	*4350–4430*	Rankine & Dimbleby 1960
6	Newferry	Raspberry seeds	5500–3500	Woodman 1978
7	Thatcham	Hazel nuts	*7150±80*	Healy *et al.* 1992
8	Blubberhouses Moor	Hazel nuts		Davies 1963
9	Cass Ny Hawin	Hazel nuts	7660±100	Woodman 1987
10	Broom Hill	Hazel nuts	*5270±120*	Morrison 1980
11	Thorpe Common	Hazel nuts	4500–3700	Morrison 1980
12a	Lussa Wood	Hazel nuts	6013	Morrison 1980
12b	Lussa River	Hazel nuts, acorn husks barren strawberry, chickweed, lead shot fungus, bog myrtle,	3450–2980	Mercer 1970
13	Carn Southern	Pear fruit pip, hazel nut shells	3000	Searight 1990
14	Auchareoch	Hazel nuts	*5350±90* *6110±90*	Affleck *et al.* 1988
15	Kingsteps Quarry	Hazel nuts		Edwards & Ralston 1984
16	Star Carr	Reeds, bog bean, hazel nuts		Clark 1972
17	Poldowrian	Hazel nuts	*4500±110*	Berridge & Roberts 1986
18	Morton A	Hazel nuts	5350±200	Coles 1971
18	Morton B	Iron root, fat hen, knottgrass, annual knavel, corn spurrey, chickweed, silver birch	4197±90 4432±120	Coles 1971
19	Lough Boora	Hazel nuts	6400±70 6525±75	Ryan 1984
20	Cushendun	Microbotanical remains of edible plants: *Eurhynchium Hylcomium*, *Nechara complanata*, *Thamnobryum alopercurum*, *Thuidium tamariscinum*	5720±140	Morrison 1980; Jessen 1949
21	Westward Ho!	Hazel nuts, fruits, seeds, prickle, thorn	4860±140 5005±140 4635±130	Vaughan 1987; Churchill 1965 Berridge & Roberts 1986
22	Kinloch Rhum	Hazel nuts	6640±95	Wickham-Jones 1989

range of nuts (walnut, almond, pistachio, pine nut, hazel, acorn), grains, and pulses (wild cereals and legumes at Franchthi, pulses at west Mediterranean sites), and fruits (cherry, plum, strawberry tree, hawthorn, blackthorn, blackberry, wild grape, olive, pear) have been collected (Turbon 1989; Geddes *et al.* 1989; Constantini 1989; Hansen & Renfrew 1978; Vaquer *et al.* 1986; Lubell & Jackes 1985). Conspicuous by their absence are small-seeded plants, such as Chenopods, but in the absence of fine-mesh water screening, their chances of retrieval would be minimal: a point reinforced by the abundance of such seed foods in the Near

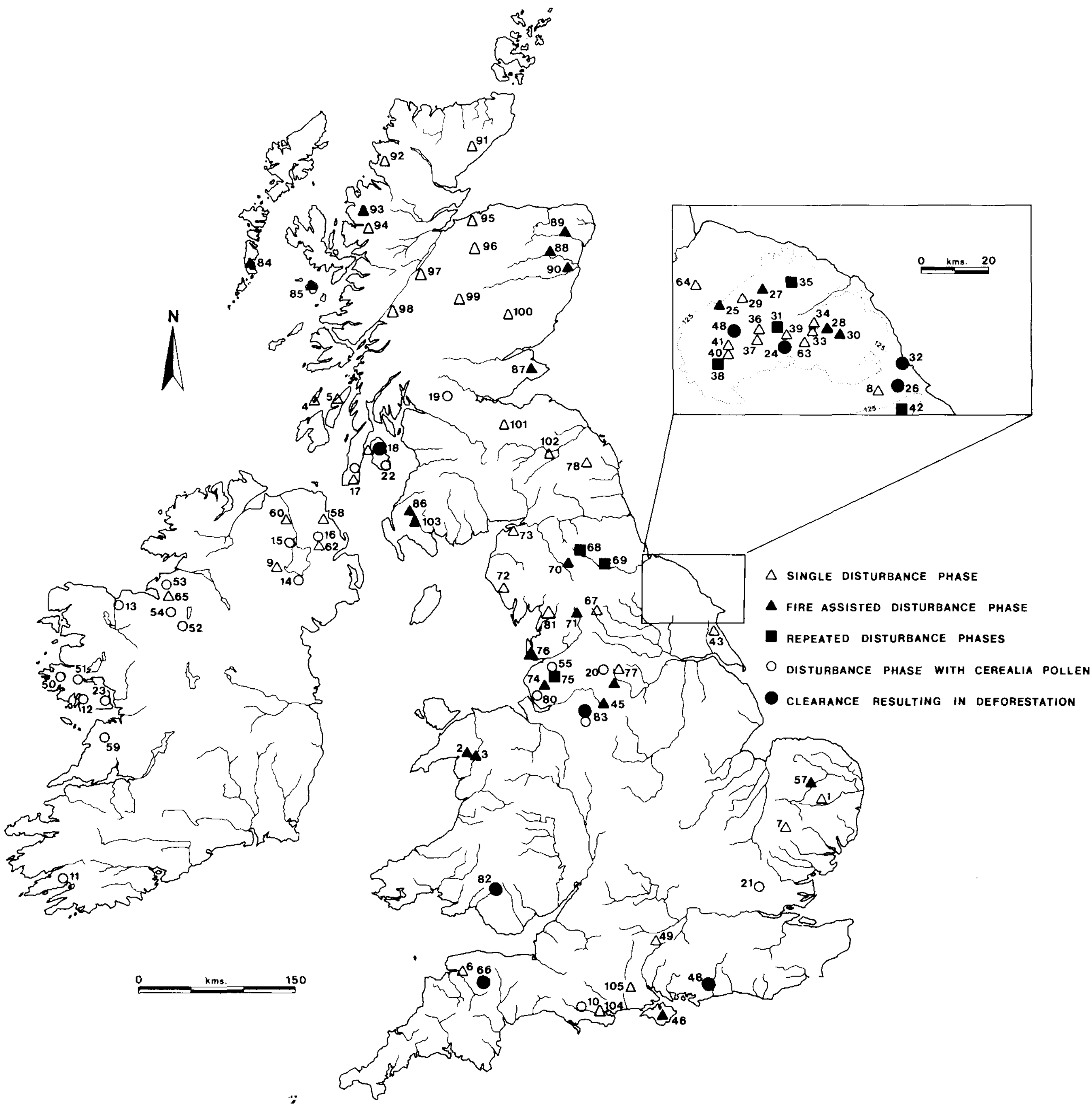

Fig. 4
Sites in Britain and Ireland with disturbance phases recorded in pollen diagrams (figure and table)

TABLE 3:
SITES IN BRITAIN AND IRELAND WITH DISTURBANCE PHASES RECORDED IN POLLEN DIAGRAMS SHOWN IN FIG. 4

Number	*Site*	*Type of clearance*	*Date bc*	*Reference*
1	Diss Mere	Single disturbance phase	5000	Birks *et al.* 1988
2	Ardudwy	Fire aided disturbance phase	6500	Chambers *et al.* 1988
3	Oronsay	Possible clearance phase	6400–5600	Bohncke 1988
4	Meinonnydd	Fire aided disturbance phase with periodic burning	6500	Chambers *et al.* 1988
5	Jura Lealt Bay	Single phase disturbance	6400–5500	Mercer 1968
6	Westward Ho!	Single phase disturbance	3790–3250	Vaughan 1987
7	Peacock's Farm	Single phase disturbance	6300	Smith *et al.* 1989
8	Star Carr	Single phase disturbance	760	Cloutmann 1988
9	Killymaddy Lough	Single phase disturbance	Pre-elm decline	Edwards 1988
10	Rinsmoor	Pre-elm decline cerealia type pollen	Pre-elm decline	Edwards 1988
11	Cashelkeelty	Disturbance phase with cereal type pollen	3895±100	Lynch 1981
12	Dolan	Disturbance phase with cereal type pollen	Pre-elm decline	Edwards 1988
13	Lough Doo	Disturbance phase with cereal type pollen	Pre-elm decline	Edwards 1988; O'Connell *et al.* 1987
14	Weirs Lough	Disturbance phase with cereal type pollen	Pre-elm decline	Edwards 1988
15	Ballynagilly	Disturbance phase with cereal type pollen	3795–3550	Apsimon 1976; Pilcher & Smith 1979
16	Newferry	Disturbance phase with cereal type pollen	Pre-elm decline	Edwards 1988
17	Rhein Farm Aros Moss	Disturbance phase with cereal type pollen some evidence of fire	Pre-elm decline	Edwards 1988
18	Machrie Moor	Disturbance phase with cereal type pollen fire open landscape	Pre-elm decline	Edwards 1988
19	North Mains	Disturbance phase with cereal type pollen	Pre-elm decline	Edwards 1988
20	Soyland Moor	Disturbance phase with cereal type pollen	3870±95	Williams 1985
21	West Health Spa	Disturbance with cereal type pollen	Pre-elm decline	Edwards 1988
22	Dan I Isle of Arran	Disturbance with cereal type pollen	Pre-elm decline	Edwards 1988
23	Lough Namackanbeg	Disturbance with cereal type pollen	3650	O'Connell *et al.* 1988
24	North Gill/Glaidsale Moor Profiles	Fire aided disturbance phase with cereal type pollen deforestation	4366±55	Innes & Simmons 1988; Edwards 1993
25	Kildale Hall	Fire aided disturbance	Flandrian I	Innes & Simmons 1988
26	Flixton II	Disturbance phase resulting in the establishment of open landscape	Flandrian I	Innes & Simmons 1988
27	Ewe Crag Slack	Fire aided disturbance charcoal	Flandrian I	Innes & Simmons 1988
28	Fen Bogs	Fire aided disturbance with charcoal present	Flandrian I	Innes & Simmons 1988
29	West House Moss	Single phase disturbance	Late Fland. I	Innes & Simmons 1988
30	May Moss	Fire aided disturbance with charcoal present	Mid Fland. I	Innes & Simmons 1988
31	Glaisdale Moor	Repeated clearances	Mid Fland. I	Innes & Simmons 1988
32	Seamer Carrs	Clearance resulting in the establishement of open landscape and evidence of burning	Flandrian II	Innes & Simmons 1988
33	Lady Bridge Slack	Single phase disturbance	Flandrian II	Innes & Simmons 1988
34	Moss Swang	Single phase disturbance	Flandrian II	Innes & Simmons 1988
35	Tranmire Slack	Repeated clearances	Mid Fland. II	Innes & Simmons 1988
36	Trough House	Single phase disturbance	Flandrian II	Innes & Simmons 1988
37	Loose Howe	Single phase disturbance	Flandrian II	Innes & Simmons 1988

TABLE 3:
SITES IN BRITAIN AND IRELAND WITH DISTURBANCE PHASES RECORDED IN POLLEN DIAGRAMS SHOWN IN FIG. 4 — *continued*

Number	*Site*	*Type of clearance*	*Date bc*	*Reference*
38	Bonfield Gill Head	Repeated clearances	Flandrian II	Innes & Simmons 1988
39	Blue Wath Beck Head	Single phase disturbance	Flandrian II	Innes & Simmons 1988
40	Botany Bay	Single phase disturbance	Flandrian II	Innes & Simmons 1988
41	Small Howe	Single phase disturbance	Flandrian II	Innes & Simmons 1988
42	Willow Garth	Two phases of disturbance with cereal type pollen	6850–6650 6450–6300	Bush 1989
43	Sproathy in Holderness	Single phase disturbance	4350	Ellis & Crowther 1990
44	White Gill	Clearance resulting in the establishment of open landscape	Flandrian II	Innes & Simmons 1988; Dimbleby 1962
45	Bleaklow S. Pennines	Fire aided disturbances	Mesolithic	Jacobi *et al.* 1976
46	Mumsley Bay	Fire aided disturbances	Mesolithic	Scaife 1982
47	Gatcombe Wilty Bed	Fire aided disturbance	Mesolithic	Scaife 1982
48	Iping Common	Disturbance resulting in heath formation	Mesolithic	Scaife 1982; Keef *et al.* 1965
49	Oakhanger VII	Single phase disturbance	Mesolithic	Scaife 1982
50	Lough Sheeaun	Disturbance phase with cereal type pollen	Pre-elm decline	Edwards 1989a
51	Connemara	Disturbance phase with cereal type pollen	Pre-elm decline	Edwards 1989a
52	Carrowkeel	Disturbance phase with cereal type pollen	Pre-elm decline	Edwards 1989a
53	Strandhill	Disturbance phase with cereal type pollen	Pre-elm decline	Edwards 1989a
54	Ballygawley	Disturbance phase with cereal type pollen	Pre-elm decline	Edwards 1989a
55	Martin Mere	Disturbance phase with cereal type pollen	Pre-elm decline	Edwards 1989a
56	Flea Moss Wood	Disturbance phase with cereal type pollen	Pre-elm decline	Edwards 1989a
57	Hockham Mere	Fire aided disturbances	Pre-elm decline	Bennett 1983; Bennet *et al.* 1990
58	Parkmore	Single phase disturbance	Pre-elm decline	Groenman van Waateringe 1983
59	Carron	Disturbance phase with cereal type pollen	Pre-elm decline	Groenman van Waateringe 1983
60	Fallahogy	Single phase disturbance	Pre-elm decline	Groenman van Waateringe 1983
61	Ben Eighe	Fire aided disturbances with repeated clearances	Mesolithic	Simmons *et al.* 1981
62	Ballyscullion	Single phase disturbance	Pre-elm decline	Groenman van Waateringe 1983
63	Collier Gill	Single phase disturbance	Pre-elm decline	Innes & Simmons 1988
64	Seamer Cars Stokesly	Single phase disturbances	Pre-elm decline	Innes & Simmons 1988
65	Lough Gill	Single phase disturbance	*c.* 3450	Dodson & Bradshaw 1987
66	Dartmoor: Pinswell & Black Ridge Brook	Fire aided disturbances resulting in peatland open landscape	5750–5350	Simmons 1964; Caseldine & Hatton 1993
67	Stump Cross	Single phase disturbance	Flandrian II	Simmons & Innes 1987; Walker 1956
68	Quick Moss	Repeated clearances	Flandrian II	Simmons & Innes 1987; Rowell & Turner 1985

TABLE 3:
SITES IN BRITAIN AND IRELAND WITH DISTURBANCE PHASES RECORDED IN POLLEN DIAGRAMS SHOWN IN FIG. 4 — *continued*

Number	*Site*	*Type of clearance*	*Date bc*	*Reference*
69	Pawlaw Mire	Repeated clearances	Flandrian II	Simmons & Innes 1987; Sturludottir & Turner 1985
70	Valley bog	Field aided disturbances	Flandrian II	Simmons & Innes 1987; Chambers 1978
71	Malham Tarn Moss	Fire aided disturbances	Flandrian II	Simmons & Innes 1987; Piggott & Piggott 1963
72	Williamson's Moss	Single phase disturbance	Flandrian II	Simmons & Innes 1987; Pennington 1975
73	Bownes Common	Single phase disturbance	Flandrian II	Simmons & Innes 1987; Walker 1966
74	Simonswood Moss	Fire aided disturbance	Flandrian II	Simmons & Innes 1987; Innes & Tomlinson 1983
75	Hoscar Moss	Repeated clearances	Flandrian II	Simmons & Innes 1987; Radley *et al.* 1974
76	Starr Hills	Fire aided disturbances	644±105	Simmons & Innes 1987; Tooley 1978
77	Broomhead Moor 5	Fire aided disturbances	6620±110	Simmons & Innes 1987; Radley *et al.* 1974
78	Black Lough	Single phase disturbance	Flandrian I–II transition	Simmons & Innes 1987
79	Dunford Bridge	Single phase disturbance	Flandrian II	Simmons & Innes 1987; Radley *et al.* 1974
80	Flea Moss Wood	Disturbance phase with cereal pollen type	Flandrian II	Simmons & Innes 1987
81	Storrs Moss	Single phase disturbance	Flandrian II	Simmons & Innes 1987; Powell *et al.* 1971
82	Waun-Fingen-Felen	Disturbance resulting in heathland	Prior to 6000 bc	Cloutman & Smith 1988
83	Lismore Fields	Repeated disturbances resulting in deforestation *cerealia* pollen from 4000 bc	5265–5180 4140–3790	Wiltshire & Edwards 1993
84	Loch Eynort	Disturbance with burning	5330	Edwards 1990
85	Kinlock Rhum	Disturbance with burning	5850–3350	Edwards 1990
86	Loch Doon	Disturbance with burning	4969–2920	Edwards 1990
87	Black Loch	Disturbance phase with burning	5650–2830	Edwards 1990
88	Loch Davan	Disturbance phase with burning	5035–2283	Edwards 1990
89	Burreldale Moss	Disturbance phase with burning	Flandrian II	Edwards 1990
90	Lock of Park Nethermills	Disturbance phase with burning	Flandrian II	Edwards 1990
91	Loch na Moine	Disturbance phase	Flandrian I–II	Durno 1958; Edwards & Ralston 1984
92	Loch Borralan	Disturbance phase	Flandrian I–II	Pennington *et al.* 1972; Edwards & Ralston 1984
93	Beinn Eigh	Disturbance phase	Flandrian I–II	Durno & Mcvean 1959; Edwards & Ralston 1984
94	Loch Clair	Disturbance phase	Flandrian I–II	Pennington *et al.* 1972 Edwards & Ralston 1984
95	Kingsteps Quarry	Disturbance with burning	Possible association with Mesolithic artefacts	Knox 1954; Edwards & Ralston 1984
96	Alt na Feithe Sheilich	Disturbance phase	Flandrian I–II	Birks 1975; Edwards & Ralston 1984
97	Loch Tarff	Disturbance phase	Flandrian I–II	Pennington *et al.* 1972; Edwards & Ralston 1984

TABLE 3:
SITES IN BRITAIN AND IRELAND WITH DISTURBANCE PHASES RECORDED IN POLLEN DIAGRAMS SHOWN IN FIG. 4 — *continued*

Number	*Site*	*Type of clearance*	*Date bc*	*Reference*
98	Kings House	Disturbance phase	Flandrian I–II	Walker & Lowe 1977; Edwards & Ralston 1984
99	Drumochter	Disturbance phase	Flandrian I–II	Walker 1975; Edwards & Ralston 1984
100	Dalnaglar	Disturbance phase	Flandrian I–II	Durno 1965; Edwards & Ralston 1984
101	Upper Eddleston Valley	Disturbance phase	Flandrian I–II	Newey 1967; Edwards & Ralston 1984
102	Linton Loch	Disturbance phase	Flandrian I–II	Manion 1978; Edwarads & Ralston 1984
103	Cooran Lane	Disturbance phase with burning	Flandrian I–II	Birks 1972; Edwards & Ralston 1984
104	Wareham	Disturbance phase	Zone VII A	Seagrief 1959
105	Lithe Bog Crane's Moor	Disturbance phase	Zone VII A	Seagrief 1960

East on sites such as Abu Hureyra, Syria, where fine-mesh water sieving has been carried out (Hillman *et al.* 1989)

What does this tell us about plant use in the Mesolithic? The above is not an exhaustive list of plant remains on Mesolithic sites. Yet the evidence is far more extensive than one would have suspected (Fig. 2, 3): it suggests that plant food was used extensively in Mesolithic diet and it emphasizes the crucial importance of recovery techniques in discovering plant remains.

Recovery of plant remains depends on harvest methods, methods of processing, preservation conditions, and the method of retrieval. (*See* Dennell 1976; Hastorf & Popper 1988; Hillman 1981; 1984; 1991 for further discussion). Plants are mostly preserved in a carbonized or anaerobic state. Given the absence of a consistent policy of fine-mesh water sieving (300 microns), small seeds of uncultivated grasses, even if carbonized, will remain undetected (Jones 1983). Until very recently remains of fruits, tubers, and leafy plants, would not have been detected in carbonized contexts, although recent advances in the micro-morphological identification of charred fruit and tuber remains have shown that such foods were used already in the Upper Palaeolithic of Europe (Mason *et al.* 1994) and in North Africa (Hillman 1989). Such techniques have not yet made an impact on the Mesolithic in Europe. Given this situation, the 'absence of evidence cannot be taken as evidence of absence' as Gregg pointed out (1988), and the only way to improve on this situation is to carry out 'careful and controlled searches for vegetal remains (Price 1987, 288), including fine-meshed water sieving, which, *contra* Price (1987), have not been carried out on a regular basis. The only plant remains that preserve relatively well are nuts: and their occurrence in considerable quantities on many sites is significant and may indicate the degree of bias affecting other plant food. In estimating the intensity of plant food use, palaeobotanical data offers only one source of evidence: we are faced with a question which can not be resolved on botanical grounds alone, and have to turn to other information.

PALYNOLOGICAL EVIDENCE

Here we are dealing with an enormous amount of information, spread unevenly across Europe. While many detailed pollen diagrams are available in northwest and northern Europe, pollen analyses in other areas have been rarely carried out at a level of resolution fine enough to allow for more than broad regional reconstruction. In here, the discussion will concentrate on Britain and Ireland as a case study.

Traditionally, Mesolithic communities were not expected to clear forests, the clearances visible in pollen diagrams being taken as evidence for the arrival of farming (e.g. Iversen 1941). More recently, this view was modified by an increasing number of sites in Britain (Fig. 4) and Scandinavia with evidence of a forest disturbance dated to the Late Mesolithic period, well in advance of the establishment of farming communities (Dimbleby 1962; Simmons 1969; Smith 1970). Simmons (1979) mentions that over 100 pre-elm decline

clearances are known in Britain, and there are cases of pre-Neolithic disturbances also in Ireland (Smith 1981; Hirons 1983), southern Scandinavia (e.g. Göransson 1988; Welinder 1983a; 1983b; 1989), the North European Plain (Bogucki 1988), Poland (Tobolski 1986, 2), and Finland (e.g. Huttunen 1980; Vuorela 1986). Many of these disturbance phases are associated with evidence of burning (Mellars 1976; Jacobi *et al.* 1976; Scaife 1982; Simmons & Innes 1985; 1987; Simmons *et al.* 1981; 1989; Welinder 1983a; 1983b; Huttunen *et al.* 1980; Göransson 1988), and with extended episodes of clearance activity delaying forest regeneration (Simmons & Innes 1987; Buckland & Edwards 1984; Simmons *et al.* 1981; Edwards 1989b; Göransson 1988). In some areas, especially in upland Britain, such early interventions have initiated a continuous change in the landscape, resulting in deforestation, development of successional growth, more open conditions, and increased erosion (Mellars 1975; 1976; Simmons 1969; 1975; Simmons *et al.* 1989; Simmons & Innes 1987; Thomas 1989; Simmons *et al.* 1981). Jacobi *et al.* (1976) and Mellars and Reinhardt (1978) have noted concentrations of Mesolithic sites in areas with reduced forest cover which they see as a result of habitat modification by fire.

Such evidence lends support to suggestions that Mesolithic people deliberately manipulated their environment as a part of an organized land use strategy (Mellars 1975; 1976; Jacobi *et al.* 1976; Jacobi 1978; Simmons 1975; Simmons *et al.* 1989; Simmons & Innes 1987; Simmons *et al.* 1981; Bogucki 1988; Welinder 1989; Göransson 1988). As many authors have noted, forest clearance would have many advantages for Mesolithic communities: Mellars (1976) estimated that plant and animal productivity could be almost doubled by a strategy of controlled burning. Forest clearance and maintenance of clearings would have particular advantages for the propagation of edible plants, both in the shrub layer (hazel, hawthorn, etc.) and in the forbaceous and herbaceous layers where it would aid the reproduction of ruderals (plantain, sorrel), grasses, tubers, and wetland plants. Hazel in particular would have profited from burning (Smith 1970; Salmi 1963; Jacobi 1978). It is worth noting that the development of hazel woodland, in some regions beyond the area of natural distribution is thought to have been brought about by human clearance in Ireland, Britain (Smith 1970; Jacobi 1978; Edwards 1982), Holland (Smith 1970), Poland (Bogucki 1988), and Finland (Salmi 1963). If indeed such extensive manipulation of the vegetational cover as suggested above did take place, then it would support Clarke's view of 'fire-controlled asexual horticulture and arboriculture, based on vegetatively reproducing root staples, forest perenials (and) controlled nut and fruit trees' (1976, 260).

Such an anthropogenic view of vegetational changes has not gone uncontested, however. There are factors other than human agency, which can be responsible for a disturbance phase. These include natural fires, windthrows, paludification, and geological changes, prompting Edwards (1982, 17) to warn against 'anthropogenic orthodoxies' in palynology. We are faced with the problem of differentiation between man-made clearances and natural disturbances. Presence of plants out of their natural context, introduced species, disproportionate representation of anthropogenic indicators, duration of disturbance phases, and repeated burning episodes have all been used to argue the case for human interference (Vuorela 1975; 1986, Simmons & Innes 1987; Göransson 1988; Huttunen 1980, etc.). None of these features seem able to demonstrate the anthropogenic origin of disturbances on their own. Given the wide range of factors bearing upon the composition and meaning of pollen spectra, some authorities argue that only the presence of cereal pollen can show beyond doubt the anthropogenic cause of disturbance phases (Groenman van Waateringe 1983; Bergelund 1985; Hoeg 1988; Simmons & Innes 1987; Edwards 1982; 1989a; 1989b). This would rule out any forest clearances not associated with cereal cultivation. Moreover, cereal pollen (except rye) is strongly selected against, due to its low dispersal rates, the forest edge effect, and location of pollen sites away from cultivated fields (Vuorela 1975; 1986; Edwards & Hirons 1984; Edwards 1989a). Even modern samples reflecting the contemporaneous situation in some of the most agricultural areas of Europe reveal very low cereal pollen values, never more than 10% (Huntley & Birks 1983).

On the other hand, Göransson (1986) introduced a model of forest utilization which allows for the role of the Mesolithic hunter-gatherers in forest management. During the early, pre-Neolithic stage, foragers generated copiced woodland by ring-barking, thus creating browse for wild animals and assisting shrubs and grasses to flourish under a more open canopy. Significantly, Göransson argues that coppiced and girdled woodland would produce a pollen rain undistinguishable from that of virgin forest: a position endorsed by Edwards (1993, 143). If this is the case, then it could be argued that multi-faceted forest disturbances recorded

in Britain (*see above*) represent human interference which went beyond mere coppicing and involved more extensive clearance activities.

The appearance of pre-Neolithic cereal-type pollen adds a new dimension to this issue. There is now growing evidence for cereal-type pollen occurring in central, northern and western Europe *before* the emergence of Neolithic communities (i.e. those with pottery, new lithic traditions, cultigens, and domesticates). This includes pollen which corresponds to Cerealia in size (ie, Carciumaru 1973; Bush 1988; Huttunen 1980), morphology (i.e. Edwards & Hirons 1984), or both, in which case it is regarded as derived from cultivars (Groenman van Waateringe 1983; Vuorela 1975; 1986; Simmons & Innes 1987; Simmons *et al.* 1989; Edwards & Hirons 1984; Edwards 1989a; Kuster 1989; Williams 1989). The point is that this evidence is coeval with the existence of Late Mesolithic societies, tradionally regarded as hunting and gathering.

Cereal-type pollen, however, cannot always be distinguished from cultivated Cerealia pollen. Pollen of a number of large grass species, *Agropyron repens* for example, cannot always be distinguished from cereal pollen on criteria of size or shape, making it possible that much of the Cerealia-type pollen does not belong to cultivated cereals at all (Andersen 1979; Edwards 1989a). This has led some palynologists to discriminate between Cerealia and non-Cerealia pollen on the grounds of chronology and associated archaeological materials, thus introducing circularity into the whole question of cultivation in the Mesolithic (e.g. Edwards & Hirons 1984).

Given this situation, several explanations regarding cereal-type pollen are possible:

1. Cereal-type pollen is an advance marker of cultivation by Neolithic groups, denoting small-scale cultivation in a farmed forest environment, not necessarily marked by widespread arboreal clearance (Bradley 1978; Edwards & Ralston 1984). It is only a matter of time before more careful examination of cultural layers will lead to the discovery of macrobotanical cereal remains (Kuster 1989; Groenman van Waateringe 1983). Although there is some evidence in support of this view (Kunster 1989; Lindquist 1988), this does not explain the appearance of early cereal-type pollen which pre-dates the conventional appearance of Neolithic societies by centuries or even millennia (Simmons & Innes 1987; Simmons 1989; Bush 1988; Kuster 1989; Edwards 1989a; 1989b; Williams 1989).

2. Cereal-type pollen in early spectra is a result of mis-identification or contamination. Although this may occasionally be the case, there is too much evidence now for this explanation to be acceptable. On the contrary, the existence of cereal-type pollen may have been ignored in earlier studies as a result of paradigmatic bias (Edwards & Hirons 1984; Simmons & Innes 1987; Edwards 1989a).

3. Cereal-type pollen belongs to large pollen grains of wild grasses with no implications for plant husbandry. But if this is the case, why should their incidence increase in the Late Mesolithic? The increase in the incidence of large pollen grained grasses reflects a shift in species composition of grassland habitats in which the large pollen grained grasses such as *Hordeum* spp. played a greater role. Such changes in composition could reflect human impact on woodland and water-edge habitats (Hillman, pers. comm.; Smith 1975; Caseldine & Hatton 1993). In particular, if the Late Mesolithic forest management resulted in local shifts from closed canopy forest to mosaic woodland with increasingly open ground, the blocking 'curtain effect' of closed forest would be removed, increasing the capacity of large-grained grass pollen to reach pollen-receiving sites (Edwards 1993).

4. The increasing incidence of cereal-type pollen is a result of the increase in the size of pollen grains arising from the cultivation of indigenous wild grasses in temperate Europe from *c.* 6000 bc. Although native grasses are known to have been cultivated in historical times (Renfrew 1973; Edwards 1982; Gregg 1988), the prehistoric distribution of suitable species in Europe has been questioned. Even so, cultivation of any of the nine species of oats, six of barley, and one of wheat (einkorn), as well as of Lyme grass (*Elymus arenarius*) and Couch grass (*Agropyron repens)* which appear to be native to Europe, especially the Balkans (Renfrew 1973; Hopf & Zohary 1988; Huntley & Birks 1983; Edwards 1982), remain a possibility. Cultivation based on harvest by uprooting or by sickle, and followed by reseeding could lead to selection for domesticated characteristics (such as a non-shattering rachis or size of grains) by a process described for the Near East by Harris (1977), Zohary & Hopf (1988), and Hillman & Davies (1992). The cultivation of native grasses would then be replaced by more productive Near Eastern strains in the 5th and 4th millennia bc.

Even though theoretically possible, there is little support for last explanation as present because the

TABLE 4: SITES WITH ANTLER MATTOCKS SHOWN IN FIG. 5
Unless otherwise stated the antler mattock is of perforated antler beam type, types A, B, C, & D belong to this category

Number	*Site*	*Type*	*Date bc*	*Reference*
1	Earls Barton		8370±150	Bonsall & Smith 1990
2	Thatcham		7810±120	Bonsall & Smith 1990
3	Kew Bridge	B	6870±100	Bonsall & Smith 1990
4	Kew 1	B		Smith 1989; Wymer 1977; Bonsal & Smith 1990
	Kew 2	B	1350±80	Smith 1989; Wymer 1977
	Kew 3	D		
	Kew 4	D		
5	Risga	–	4050±90	Bonsall & Smith 1990
			4050±90	
6	Meiklewood	C	3970±80	Bonsall & Smith 1990
7	Staines	D	3400±100	Bonsall & Smith 1990
8	Finsbury Circus	A	2190±70	Bonsall & Smith 1990
9	Willington Quay	A	1930±80	Bonsall & Smith 1990
10	County Hall 1	A	1900±70	Bonsall & Smith 1990
	2	A	1750±80	
11	Splash Point	D	4610±80	Bonsall & Smith 1990
12	Star Carr 1	E	7538±210	
	2	–	7607±210	
13	Druimvargie	C/D	5860±90	Bonsall & Smith 1990
14	Caisteal nan Gillean	C?	4240±80	Bonsall & Smith 1990
			4170±80	
			4085±70	
			3895±50	
	Priory Midden	C	3920±50	Bonsall & Smith 1990
		C	3875±50	
		C	3767±50	
		C	3560±50	
		C	3520±50	
16	Cnoc Coig		3695±80	Bonsall & Smith 1990
			3585±140	
17	Cnoc Sligeach		3676±159	Bonsall & Smith 1990
18	Bankside Power Station	A		Smith 1989; Lacaille 1966
19	Barn Elms	D		Smith 1989; Wymer 1977
20	Battersea Reach	D		Smith 1989; Wymer 1977
21	Boveney Lock	D		Smith 1989; Wymer 1977
22	Brentford	B		Smith 1989; Wymer 1977
23	Brentford Eyot	A		Smith 1989; Wymer 1977
24	Chelsea Reach	D		Smith 1989; Wymer 1977
25	Cliff Creek 1	A		Smith 1989; Wymer 1977
	2	D		
26	Eel Pie Island	D		Smith 1989; Lacaille 1961
27	Feltwell	B		Smith 1989; Wymer 1977
28	Grangemouth			Smith 1989; Lacaille 1954
29	Hammersmith	B		Smith 1989; Wymer 1977
		B		Smith 1989
		B		Smith 1989
		D		Smith 1989
		D		Smith 1989
		D		Smith 1989; Wymer 1977
		D		Smith 1989; Wymer 1977
		D		Smith 1989; Wymer 1977
30	Manchester Ship Canal	D		Smith 1989
31	Moorfields	B		Smith 1989

TABLE 4: SITES WITH ANTLER MATTOCKS SHOWN IN FIG. 5 — *continued*
Unless otherwise stated the antler mattock is of perforated antler beam type, types A, B, C, & D belong to this category

Number	*Site*	*Type*	*Date bc*	*Reference*
32	Mortlake	B		Smith 1989; Wymer 1977
		D		Smith 1989; Wymer 1977
		D		Smith 1989; Wymer 1977
		D		Smith 1989; Lacaille 1966
33	New Scotland Yard	A		Smith 1989; Lacaille 1966
34	Old England 1	A		Smith 1989
		B		Smith 1989
35	Peterborough 1	B		Smith 1989
	2	B		Smith 1989
36	Putney 1	B		Smith 1989
	2	B		Smith 1989
37	Richmond	D		Smith 1989; Wymer 1977
38	Sunbury Lock	B		Smith 1989; Wymer 1977
39	Syon Reach	D		Smith 1989; Wymer 1977
40	Teddington	B		Smith 1989; Wymer 1977
41	Twickenham	D		Smith 1989
		D		Smith 1989; Lacaille 1961
42	Wandsworth	D		Smith 1989; Wymer 1977
43	Windmill Lane	B		Smith 1989; Wymer 1977
		B		
		A		
		A		
		D		
44	Windsor	B		Smith 1989
45	Wormingford Bridge	D		Smith 1989; Smith 1989
46	Airthney Castle	–		Smith 1989; Lacaille 1954
47	Blair Drummond Moss	–		Smith 1989; Lacaille 1954
48	Grays	–		Smith 1989; Wymer 1977
49	London Area	–		Smith 1989; Wymer 1977
50	Richmond Lock and Weir			Smith 1989; Wymer 1977
51	Strand on the Green	–		Smith 1989; Wymer 1977
52	Walthomstow	–		Smith 1989; Wymer 1977
53	West Row	–		Smith 1989; Wymer 1977
54	Ulrome	–		Louwe Kooijmans 1971
HOLLAND				
55	Wichelen			Louwe Kooijmans 1971
56	Brown Bank			Louwe Kooijmans 1971
57	Herrickerberg			Louwe Kooijmans 1971
58	Koerhuisbeek			Louwe Kooijmans 1971
59	Eurospoort			Louwe Kooijmans 1971
60	Kuinre			Louwe Kooijmans 1971
61	Aschbroeken			Louwe Kooijmans 1971
62	De Gaaste			Clason 1983
63	Noordoostpolder			Clason 1983
64	Oostelijk			Clason 1983
65	Züidelijk			Clason 1983
66	Urk			Clason 1983
67	Schokland			Clason 1983
68	Kampen			Clason 1983
69	Swifterbant		5425–3280	Clason 1983
70	Spoolde		6050±30	Clason 1983
CENTRAL & EASTERN EUROPE				
71	Friesack	–	7750±5050	Gramsch & Kloss 1989
72	Henauhof Federsee	–	6270±70	Jochim 1988

TABLE 4: SITES WITH ANTLER MATTOCKS SHOWN IN FIG. 5 — *continued*
Unless otherwise stated the antler mattock is of perforated antler beam type, types A, B, C, & D belong to this category

Number	*Site*	*Type*	*Date bc*	*Reference*
73	Schoetz			Wyss 1980
74	Lepenski Vir; Vlasac and Schela Cladovei	T shaped axes	5980–5490 5615	Letica 1969; Srejovic 1969; Classon 1983; Boroneant 1989
128	Obre	T shaped axe	4225–3820	Gimbutas 1974; Benac 1973
75	Soroki II	T shaped axes	5470–5265	Markevitch 1971
76	Dereivkaa		3565–2950	Telegin 1986
77	Dudka		7760–7660	Guminski & Fiedorczuk 1989
78	Šventoji	wooden & antler mattocks	2690–2460	Rimantiene 1979 1992
79	Lake Krautonas sites	non-perforated antler mattocks	*c.* 3000–2500	Girininkas 1990
80	Krivina	non-perforated antler mattocks		Girininkas 1990
81	Naumovo	non-perforated antler mattocks		Girininkas 1990
82	Lake Lubans sites Abora Zveisalas Zvidze Piestina Lagazha	wooden & non-perforated antler mattocks	*c.* 4500–1700	Loze 1979; 1988
83	Zedmar	T shaped non-perforated & wooden mattocks	3450–2970	Timofeev 1981
84	Sarnate	wooden mattocks	2750–2540	Vankina 1970
85	Zvejnieki		7000–6000	Zagorska & Zagorskis 1989
86	Lammasmägi			Zagorska & Zagorskis 1989
87	Siimusaare Umbusi Moksi			Zagorska & Zagorskis 1989
88	Pernau			Clark 1975
89	Kääpa	non-perforated antler mattocks	*c.* 2000	Girininkas 1990
90	Nizneye Veretye	antler bone shovels and antler axes	7000–6000	Oshibkina 1989
NORWAY				
91	Vattabakkjen			Clark 1975
92	Tingelstad			Clark 1975
93	Hurum			Clark 1975
SWEDEN				
94	Halla			Clark 1975
95	Gorvik			Clark 1975

TABLE 4: SITES WITH ANTLER MATTOCKS SHOWN IN FIG. 5 — *continued*
Unless otherwise stated the antler mattock is of perforated antler beam type, types A, B, C, & D belong to this category

Number	*Site*	*Type*	*Date bc*	*Reference*
96	Singsan			Clark 1975
97	Hacksås			Clark 1975
98	Atervall			Clark 1975
99	Sittesta and Korsnas			Clark 1975
100	Rorvik			Clark 1975
101	Holmangen			Clark 1975
102	Borre Bog			Clark 1975
103	Maglekarr			Clark 1975
104	Harlosa			Clark 1975
105	Sjorup			Clark 1975
106	Mossby			Clark 1975
107	Ageröd I			Larsson 1978
108	Segebro		6500–5500	Larsson 1978
DENMARK				
109	Hillerod			Clark 1975
110	Verup and Amosen			Clark 1975
111	Skellingsted			Clark 1975
112	Gogsmore			Clark 1975
113	Svaerdborg			Clark 1975; Brinch-Petersen 1971
114	Nisted			Clark 1975
115	Gjersbol			Clark 1975
116	Ertebølle			Mattiassen *et al.* 1942 Childe 1950
117	Norsminde	perforated beam and T shaped antler mattocks	3820–3090	Andersen 1989
118	Tybrind Vig	perf beam & T shaped axes	4600–3200	Andersen 1987
119	Møllegabet II			Grøn & Skaarup 1992
120	Satruper Moor	Wooden matts & perforated antler mattocks		Schwabedissen 1981
BELGIUM FRANCE AND LUXEMBOURG				
121	Antwerp			Rozoy 1978
122	Lochsboor			Newell *et al.* 1979
123	Birsmattet		Late Mesolithic	Rozoy 1978
124	Hoédic/Téviec		Late Mesolithic	Rozoy 1978
125	Couzol Le Gramat		Late Mesolithic	Rozoy 1978
126	Poyemau		Late Mesolithic	Newell *et al.* 1979
PORTUGAL				
127	Cabeço Da Arruda Cabeço Da Amoreira		Late Mesolithic	Newell *et al.* 1979

cultivation status of wild grasses remains to be established, and because no causal or genetic link appears to exist between the selection active in the process of domestication and the larger pollen grains evident in the palynological record.

What conclusions can we draw from palynological evidence? In some areas such as Britain, where palynological evidence of appropriate resolution is available, the incidence of burning and clearance phases seems to be too coincidental to be explained by acts of nature

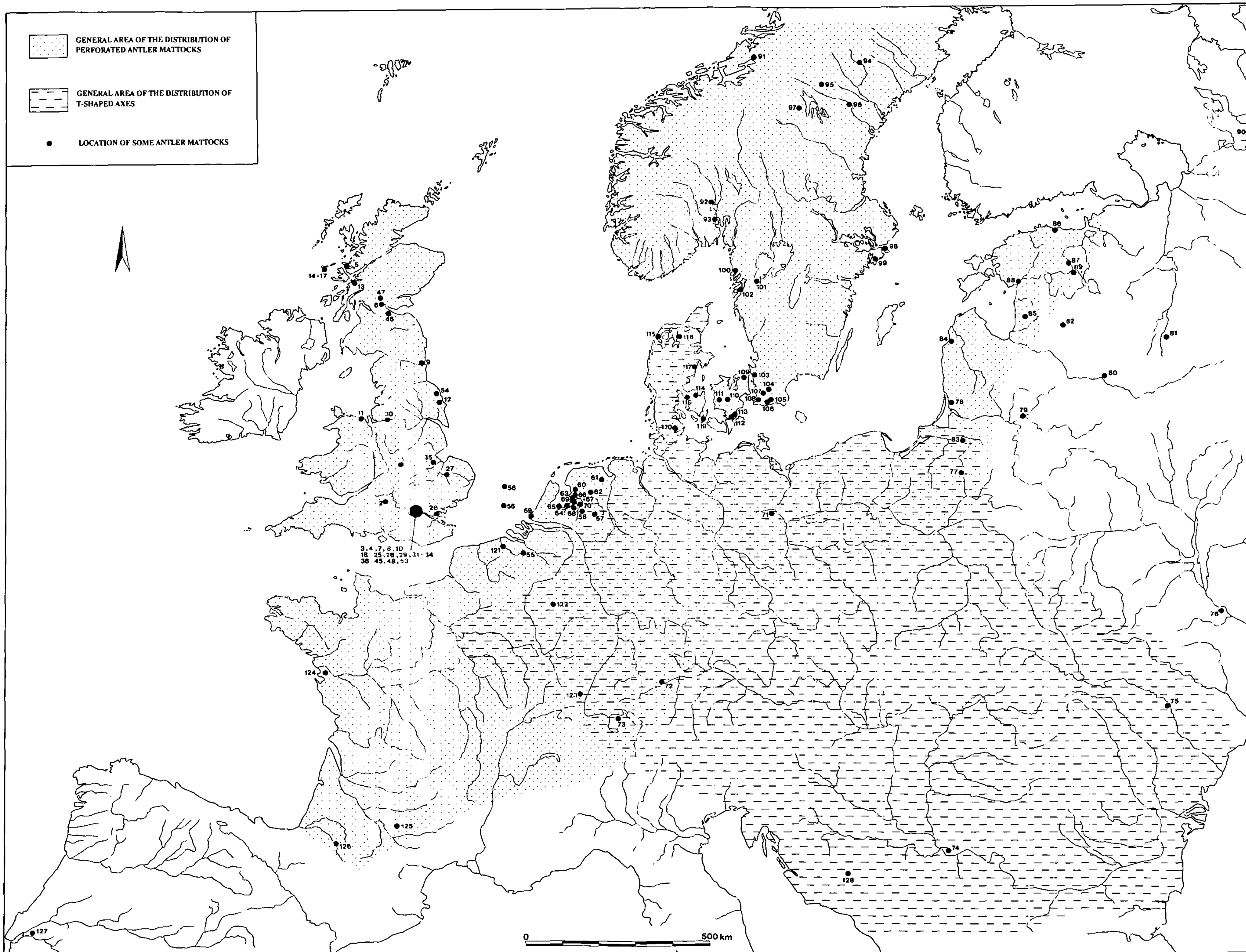

Fig. 5
Distribution of perforated antler beams tools in the Mesolithic and Neolithic of temperate Europe

alone. Vegetation disturbances are now known to occur from the early post-glacial onwards (Bush 1988) and increase markedly in the later Mesolithic (Simmons & Innes 1987). Some of these disturbances are associated with Mesolithic artefacts (Jacobi *et al.* 1976; Cloutman 1988).

On the other hand, most of this palynological evidence is circumstantial. Natural factors cannot be excluded as a cause of many disturbance episodes. Pollen samples taken from several major Mesolithic sites, such as Star Carr, or Addington, Yorkshire, failed to provide significant signs of anthropogenic disturbance (Bush 1989). It is beyond the capacity of the pollen diagram to reveal whether the human groups were deliberately clearing forests or perhaps making an opportunistic use of natural clearances.

However, bearing in mind the associated artefactual and paleobotanical data, palynological evidence lends tentative support for human manipulation of the landscape in a pattern which would benefit plant husbandry. Human interference appears to have been long-lasting and widespread in some regions, particularly uplands (Simmons 1975; Caseldine & Hatton 1993). This anthropogenic influence increases in the Late Mesolithic (Simmons 1975), and this is co-eval with the appearance of large pollen-grained grasses.

ARTEFACTUAL EVIDENCE

The artefactural evidence of plant use should include basic tools for soil-working, reaping, and processing. Soil-working equipment might include digging sticks, hoes, mattocks, and similar gardening tools, the purpose of which would be to procure roots and tubers, clear undergrowth, and possibly prepare soil for the planting of seed and seedlings.

In the archaeological record of hunter-gatherer Europe, we can find tools which have clearly been used for digging the soil. These include wooden hoes and mattocks from Nizhnie Veretie, northern Russia (Oshibkina 1989), from Sarnate (Vankina 1970)and the Lake Lubans sites, Latvia (Loze 1988), and Sventoji, Lithuania (Rimantene 1979) in the east Baltic. Made of wood, such finds are rare, however, and can only suggest that soil-digging occurred among Late Mesolithic hunter-gatherers, in advance of the adoption of agro-pastoral (i.e. Neolithic) farming.

Much more common are antler implements conventionally perceived as axes, adzes, or picks (Fig. 5). These tools can be divided into several different categories, including T–shaped axes, perforated axes, browtine axes, base axes, picks, etc (Classon 1983; Smith 1989; Clark 1975). The working edge can be either perpendicular, parallel to the shaft, or pointed. These antler tools seem to have reached their greatest popularity in the Late Mesolithic and the Neolithic, between *c.* 6000 and 2000 bc (Classon 1983), although Clark (1975) and Smith (1989) have shown that perforated antler base mattocks date back to the Early Mesolithic. Perforated antler beam tools are commonly found associated with hunter-gatherer settlement in temperate Europe from Britain to Russia (Smith 1989; Classon 1983; Dolukhanov 1979; Clark 1936; 1975; Zagorska & Zagorskis 1989; Letica 1969; Boroneant 1989; Printz 1987; Dergachev 1989). On the other hand, they are far less common in the Mediterranean zone (Rozoy 1978).

Generally, these implements are interpreted as woodworking tools. Recently Smith (1989) argued convincingly that the perforated and bladed types were in fact mattocks, used as digging tools. Such tools would have been poorly balanced and awkward to use for chopping purposes, and the patterns of wear found on them suggest digging in gritty soil rather than wood-work. A digging, as opposed to wood-working, function for some antler tools has also been suggested by others (i.e. Clark 1975; Jochim 1988; Timofeev 1981; Tringham 1971). Rimantiené (1979) describes 'antler shovels' at Šventoji. At the sites of the Lepenski Vir culture, Chapman (1989) notes the presence of a large number of antler hoes and mattocks interpreted by some as the evidence of the planting of wild cereals (Boroneant 1970; 1989) and of plant use in general (Letica 1969). Antler mattocks appear on pre-Neolithic Bug-Dniester sites, where their presence together with microliths with sickle gloss may suggest harvesting of local wild grasses (Markevitch 1971; Dergachev 1989; Dolukhanov 1979). If reflecting more than just preservation bias, the coastal lake-shore and riverine distribution of mattocks — in areas, where intensive plant use might be expected (Smith 1989) — adds further support to their function as digging tools. In summary, while antler mattocks as a tool-type were probably used for a range of activities, the evidence presented above suggests that digging or breaking soil must have been one of them. The determination of more specific chronological or regional patterns in their use is currently under study (Buckler 1993).

Reaping would have included the collection of berries, nuts, and fruits, harvesting of seeds, and gather-

ing of leafy plants. The reaping equipment would have included knives, sickles and containers.

Admittedly, there is as yet little evidence for reaping activity in Mesolithic Europe. Basketry is preserved only exceptionally and its presence does not necessarily demonstrate gathering of plants. Clarke's (1976) suggestion that microliths in Europe were used as insets for composite sickles or reaping knives has gone largely untested; where microwear analysis has been applied, the results as yet appear inconclusive. While Dumont (1987) failed to identify any traces of plant use on microliths from Mount Sandel and Star Carr, Jensen's (1987) study of blades and microblades from Denmark shows the same traces of plant wear present in the Late Mesolithic as in the Neolithic, suggesting the same harvesting function.

Interestingly, Domanska (1989) and Neisiołowska-Sreniowska (1990) also report traces of wear, similar to those found on Neolithic sickles, on blades from Late Mesolithic sites in Poland. Sickle gloss has also been reported on microlith insets in the first phase of the Bug-Dniester culture (Markevitch 1971).

The presence of sickle gloss, however, is not conclusive proof for or against the harvesting of food plants: it could have been formed by cutting reeds or other plant materials. Ungarn-Hamilton (1989) has shown that the formation of gloss is due to several factors, including moisture, thickness of stem, frequency of use, and of course the method of harvesting. Grains could have been shaken into containers or by uprooting, neither of which would have required sickles.

Processing equipment would include chopping, grating, and grinding tools. Although there appears to be little evidence for the presence of such equipment in Mesolithic Europe, the problem again is one of non-recognition or neglect. This is well illustrated by the case of the Iron Gates sites on the Serbian–Romanian border. Although Printz (1987) notes the absence of any clear seed-grinding equipment there, Voytek and Tringham (1989) argue that pounders and mortars with suggestive traces of wear, found at Lepenski Vir and Padina, could have been used for grinding or pounding of seeds and nuts. The presence of pounding stones and of similar ground stone equipment is widely reported from Mesolithic sites in Europe (e.g. Valoch 1989; Clark 1975; Dergachev 1989; Indrelid 1975; L. Larsson 1982; 1978; Loze 1979; Timofeev 1981; Vankina 1970; Anderson 1975; 1989; Girininkas 1991; Rozoy 1978), but rarely are they interpreted as plant processing equipment.

On a number of sites in north-east Europe, remains of water-chestnut (*Trapa natans*), sometimes in large quantities, were found in association with wooden mallets, which had fragments of water-nut shells imbedded in their working surfaces (Vankina 1970; Rimantiené 1979; Loze 1979; 1988; Dolukhanov & Miklyayev 1986). In this area, processing of water-chestnut seems to have been a common activity, requiring the development of specialized equipment. No similar wooden tools were found in other areas of Mesolithic Europe, but preservation bias makes it difficult to judge how widespread such plant processing practices were.

The tool types discussed here could be used in activities other than plant husbandry. Bone shovels, grinding equipment, flint knives, and microlith insets all occur already in the Upper Palaeolithic (Klima 1963; Kraybill 1977). In the Mesolithic however, their incidence and co-occurence increases, while antler beam tools and stone and polished axes, the latter an index of forest clearance (Clark 1975; Toth *et al.* 1992), are added at the onset of the Holocene. Together they formed a viable toolkit for forest clearance, soil-working, plant harvesting and processing.

PALAEOPATHOLOGICAL EVIDENCE

Human skeletal evidence can reveal dietary patterns through pathological conditions and chemical composition of bone. As regards Mesolithic Europe, both pathological and chemical analysis of bone are at an early stage (Price 1989; Meiklejohn *et al.* 1984), and both suffer from unresolved problems of methodology and sampling. Here I wish to report briefly on an overview of palaeopathological conditions prepared by Christopher Meiklejohn and myself (Meiklejohn & Zvelebil 1991).

Our survey of pathological conditions of Mesolithic populations revealed an unexpected variability in their health status, which we believe to be related to their diet and lifestyle. A dual pattern of variability seems to be emerging: a 'west Mediterranean' one, marked by high incidence of caries and the relative absence of other pathologies, and a 'north-east' European one, marked by the occurrence of indicators of nutrient deficiency and by the absence of caries (Fig. 6).

The west Mediterranean pattern, observed on sites in Portugal, Spain, and Italy is coeval with an increased intake of starchy foods (see above), raising the question of intensive plant use in the Late Mesolithic of this area.

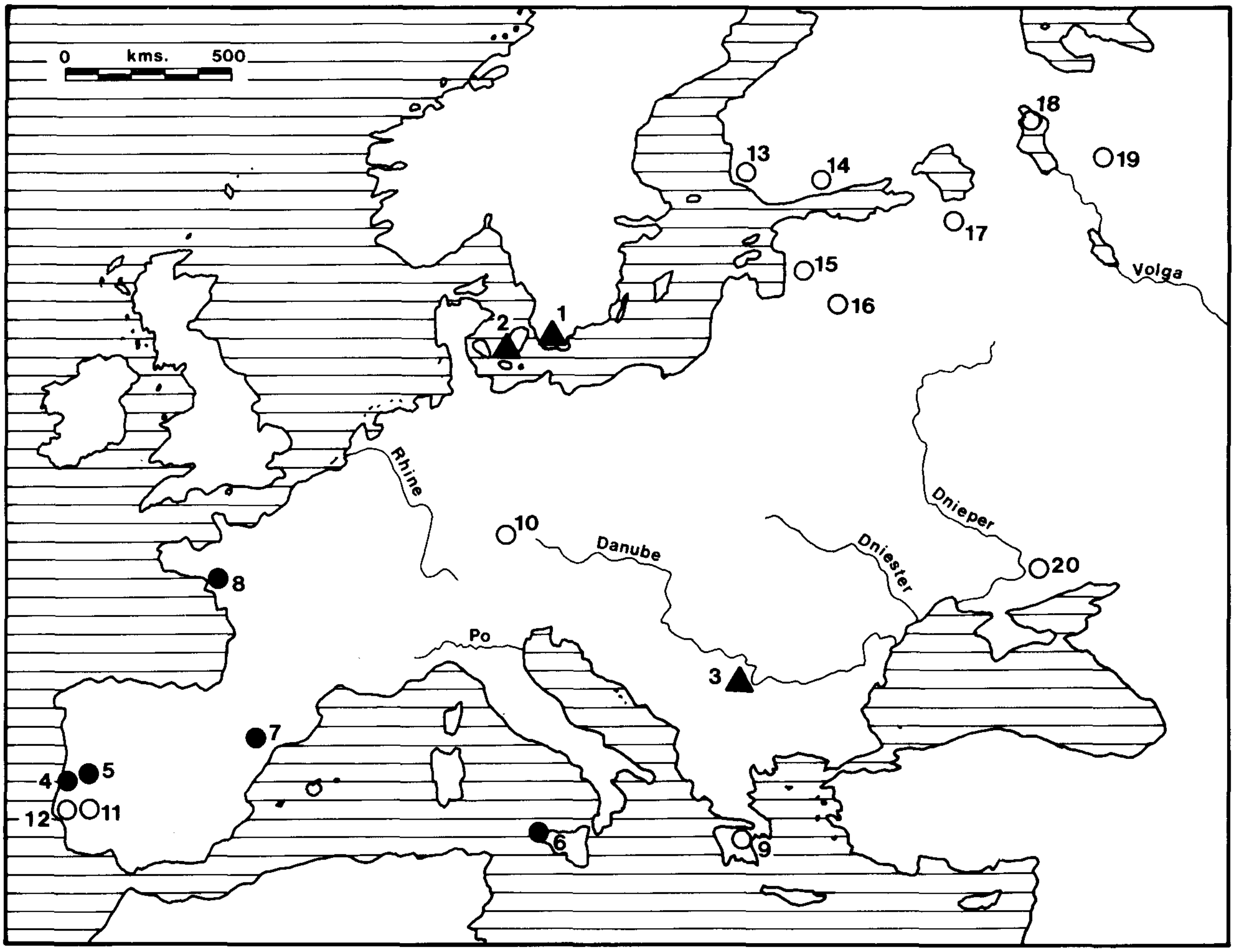

Fig. 6

Patterning of pathologies in the mortuary remains in the Mesolithic Sites characteristic of the north-east European pattern: 1. Skateholm, Sweden 2. Vedbaek, Denmark 3. Iron Gates Sites (Vlasac, Padina), Serbian–Romanian border

Sites characteristic of the West Mediterranean pattern: 4. Moita de Sebestião, Portugal 5. Cabeço da Arruda, Portugal 6. Uzzo and Molara, Italy 7. El Cingle Vermell, Spain 8. Hoedic and Teviec, France

Other burial sites: 9. Franchthi Cave, Greece 10. Ofnet, Germany 11. Cabeço do Pez, Portugal 12. Cabeço das Amoreisaas, Portugal 13. Komhaara, Finland 14. Jonsas, Finland 15. Zveinieki, Latvia 16. Abora, Latvia 17. Sandermokha, Russia 18. Oleneostrovskii Mogilnik, Karelia 19. Popova, Russia 20. Vasilevka 1–3, Ukraine (Meiklejohn & Zvelebil 1991)

Yet, comparative data from known farming contexts do not replicate the west Mediterannean pattern. The Levantine situation shows a lesser incidence of caries in the Natufian and the Neolithic, but a greater incidence of stress-related conditions, such as cribra orbitalia, porotic hyperostosis, enamel hypoplasia, and osteoporosis (Angel 1984; Smith *et al.* 1984), showing that on the whole the Levantine populations were less healthy than the west Mediterranean ones. The west Mediterranean pattern suggests an early stage in the intensive use of plant foods, as yet not attended by the markers of stress and reduced health which are common among many prehistoric agriculturists (e.g. Cohen & Armelagos 1984). Bone chemical analysis from Uzzo cave in Sicily and from Portuguese shell middens would seem to suggest that meat and marine foods remained

the major component of the diet (Tarli *et al.* 1989; Lubell *et al.* 1989).

The 'north-east' European pattern, observed in the south Baltic and in the Iron Gorge on the Danube, is marked by the absence of caries and by a higher incidence of porotic hyperostosis, enamel hypoplasia, and, in the case of Vlasac, Serbia, of rickets and osteomalacia. All these sites are associated strongly with fishing and increased sedentism, leading to the suggestion that increased residential permanence and dependence on a fish diet have caused parasitic infestations and infections which prejudiced the health of hunter-fisher populations and resulted in the observed range of pathological conditions. Evidence from a number of wide-ranging contexts outside Europe supports this hypothesis, as do the results of bone chemical analysis from the south Baltic sites, showing heavy dependence on marine diet (Tauber 1981; Price 1989).

Bone chemical analysis failed to show any decisive shift from meat-based to plant-based diet. Yet the high incidence of caries on west Mediterranean sites shows that starchy and carbohydrate foods were an important element of the diet *before* the adoption of agro-pastoral farming.

THE INTENSITY OF PLANT USE IN THE MESOLITHIC

What does all this information tell us about the extent, intensity, and significance of plant use in the Mesolithic?

Although perhaps not as great as David Clarke argued, the potential for the use of plants as food in the Mesolithic must have been considerable (i.e. Price 1989). The question is, of course, whether this potential was exploited to anything approaching its capacity. The estimates for the contribution of plants to diet in the Mesolithic vary from 5% (Rozoy 1978, for France and Belgium) to 80% (Clarke 1976), with 15–20% being the most commonly occurring estimate (i.e. Jochim 1976, for southern Germany; Price 1978, for the Netherlands; Zvelebil 1981, for southern Finland). These are very approximate figures, and there is, of course, bound to be variation between individual regions. At present, we simply do not know what the actual plant food intake was. But it could be argued that the contribution was greater than the 15–20% commonly quoted. First, the evidence presented above indicates a more regular and intensive use of plant foods than hitherto postulated. Second, the estimates quoted above do not take into account the potential for, and the practice of storage of some of the plant foods, but assume that plant food was consumed only in the summer months (i.e. Price 1978; Jochim 1976). Third, in recent articles, Speth (1989; 1990; 1991) has highlighted human intolerance of a lean meat-based diet, showing that meat protein can supply only up to 50% of human energy needs, the rest having to come from fat or plant food. This is especially important for inland Mesolithic communities, where fatty aquatic resources, such as seal, anadromous fish, and waterfowl, would have been non-existent or rare. With the exception of waterfowl and sea mammals, the fat content of terrestrial mammals, game birds, and fish range between 1% and 20%. For instance, taking into account seasonal variation, the typical ranges for deer are 1–6 %, for wild pig 10–20%, while the maximum fat content of salmon and eel is 15% and 18% respectively (Zvelebil 1981; Speth & Spielman 1983). Depending on whether one chooses the average or maximum figures for the fat content of these resources, we are led to the conclusion that plants must have contributed between 30% and 40% to the Mesolithic diet in order to satisfy human protein and energy requirements which had to be obtained from plant food.

The need for plant food may also explain why people engage in gathering even when game is readily available. Collection and processing of plant food is often held to be less efficient and more labour-demanding than hunting. Quoting Ache as an example, Bettinger (1991, 98) states that, excluding search time, hunters net between 65,000 and 6000 calories per foraging hour, while the gatherers seldom exceed 5000. Among the mongongo nut gathering !Kung and the seed processing Alyawara, these activities will net 700 and 500 calories per hour respectively (Bettinger 1991). Similarly, among the Hiwi in Venezuela, men obtained on average three times as many calories per hour hunting (search time included) than men and women did gathering, prompting Hurtado and Hill to ask 'Why should a man sacrifice almost 2000 calories per hour to collect mangos rather than hunt?' (1990, 335).

The notion of low gathering efficiency has been contradicted by other studies, showing that a low density of game, its unpredictability and an increased search time dramatically reduce the efficiency of hunting (Lee 1979; Kent 1989), in some cases below that of gathering (Ehrenberg 1989).

None of the case studies noted above come from temperate woodlands akin to Mesolithic Europe. They show, however, that we cannot automatically assume that plant gathering was less efficient than hunting. The

lowest rates of return for gathering come from nut and seed harvests and are due to processing costs (Wright 1991); the efficiency would have been higher for starchy root crops, whose processing costs are lower (Clark & Haswell 1964). In the European woodlands and wetlands, roots and rhizomes are widely available (Clarke 1976), while the efficiency of hunting must have been reduced by the dispersed, solitary, and territorial habits of major game taken during the Mesolithic (such as roe and red deer, wild pig, elk, and beaver). Even where the plant gathering was significantly less efficient, the ethnographic data show that people are willing to sacrifice higher caloric returns for a balanced protein–carbohydrate diet, as among the Hiwi (Hurtado & Hill 1990). Arguments advanced by Speth (1989; 1990) give sound biological basis to such preferences. In addition to being a desirable source of energy, plant foods contain vitamins (especially B and C) and minerals (magnesium, manganese, sodium) not commonly found in meat, but which are indispensable for survival. In summary, irrespective of the relative energy costs of its procurement, plant food must have been a major component of the Mesolithic diet.

Bone chemical analysis may eventually provide a reliable means of estimating the dependence on plant food in Mesolithic diet (Price 1989). Both, the elemental and isotopic analyses applied to human remains from the Mesolithic period so far show dependence on marine foods in some coastal areas, such as in Denmark, but the evidence for the plant component within the terrestrial diet has been, to date, inconclusive. For the time being, the problems of diagenesis, variation in the trace element content of potential food resources, and sample bias (all the Mesolithic samples come from coastal regions) cast some doubt on the absolute value of the results (Hancock *et al.* 1989, Sillen *et al.* 1989).

Moreover, in evaluating the role of plant food, we must also consider its social and strategic importance. If stored, plant food could have played a crucial role in the overall subsistence strategy as a stop-gap resource during the winter months. Nuts, grains, and possibly tubers, once gathered, have a 'shelf life' of about six months, just long enough to cover the period from harvest through the winter. Ethnographically, we know that nuts, fruits, and grains were parched, dried, ground into flour, and pickled in fat among recent hunter-gatherers of northern Europe and Asia to prolong their storage life (Eidlitz 1969). Archaeologically, circumstantial evidence for storage, parching, and processing into flour comes from Mesolithic sites with caches of burned or unburned nuts (e.g. Mount Sandel, Sarnate, Oakhanger, etc.), and from sites with processing equipment (Rowley-Conwy & Zvelebil 1989).

Regardless of biasing factors affecting the ethnographic evidence, ethnographic studies indicate that women were principally responsible for plant gathering (Kent 1989; Ehrenberg 1989). If this was the case in the Mesolithic, the heavy reliance on plant food can be expected to increase the economic and possibly the social status of women, provide them with relative independence of men's foraging activities, and invest them with the responsibility and the rights associated with the distribution of plant food in the community. Assuming that grave-goods reflect the status of the individual during lifetime, the variation in the furnishing of Mesolithic graves at Oleneostrovski Mogilnik, northern Russia, and elsewhere in northern Europe suggests that women attained the same range of social positions as men, even though they were less likely to attain the highest ranking status (O'Shea & Zvelebil 1984, Meiklejohn & Zvelebil 1991). Speculatively, the more equal status of women and the economic importance of female labour may have led to the reduction in female infanticide, thereby enhancing the reproductive capabilities of Mesolithic communities and leading to population growth (Vincent 1979; Bettinger 1991; Ehrenberg 1991).

Recent ethnographic research and re-evaluation of ethnographic sources show that hunter-gatherers employ a wide range of strategies designed to exercise control over their resources and to either increase or maintain their productivity and reliability (Williams & Hunn 1982; Harris & Hillman 1989). These strategies can be broadly grouped into conservational policies and promotional policies:

Conservation

Conservation involves culturally sanctioned restrictions on resource use. It also involves practices the effect of which is to avoid the over-use of resources. Conservation can be achieved through spatial, social, and economic strategies.

Movement between food collecting grounds as a part of the annual pattern is the most obvious example of spatial conservation strategy. In planning their seasonal movements, hunter-gatherers select some foraging grounds, leaving others to recover from hunting and

gathering. Such alternative use of foraging territories is widespread, for example, among the North American (the Cree, Nunamiuit) and the Siberian (the Kets) groups.

Ownership of territories and/or resources often impose restrictions on their use, or at least provides a way of assessing the level of resources and the number of users. Despite earlier misconceptions, most hunter-gatherer groups claim ownership *as a group* over territories they habitually use and outsiders must be given permission to use them (e.g. Australian Aborigines, Indians of north-west Coast, Columbia Plateau, and California; Williams & Hunn 1982; G/wi, Silberbauer 1981). In some societies which exploit more intensively aggregated resources, it is households or families, rather than a group, claiming ownership over key fishing and gathering locations, as for example, among the Ainu in Hokkaido and Sakhalin, the Nivkhi on the river Amur, the Sahaptin, the Tolowa, or the Yurok of north-west America.

Social strategies include sharing of food to minimize waste and equalize distribution among some, but not all, groups. They also include a flexible membership of bands with individuals having residence rights in several bands and moving between them in response to the perceived availability of resources (!Kung, Tiwi, Nunamiuit: Williams & Hunn 1982; Lee 1979; Binford 1983).

Conservation strategies can be applied directly to the plant and animal resources themselves. In the 1970s the work of Higgs and the palaeoeconomy school (1972; 1975) pointed to the existence of increasingly complex man–animal relations before domestication, which involved conservational practices, such as predation controlled by the selective cull of males, and by variable predation designed to maintain yields and to ensure resource regeneration.

Similarly, recent work by Rindos (1984), Harris and Hillman (1989), and others has illustrated the wide range of plant tending practices employed by pre-agricultural societies. These include harvesting practices allowing for regeneration (and incidental dispersal) of crops.

Promotional

Promotional policies involve the manipulation of non-domesticated resources or of their environment to increase their productivity or reliability of supply, such as coppicing, pollarding, and selective cropping.

Controlled burning of the land has been used to increase the productivity of both selected plants and animals. Different burning regimes are illustrated in Figure 7. Note that:

1. Even though the extent and frequency of burning is predicated on local conditions, there are discrete burning cycles, reflecting the different goals of burning.

2. Natural fires, especially in deciduous woodlands, are usually less frequent than anthropogenic burning episodes (*see also* Simmons 1993, 118).

3. Assuming that different burning cycles were used simultaneously within a region, the effect would be the development of a vegetational mosaic and a steady deposit of thin charcoal horizons within a sediment.

Propagation of undomesticated crops, summarized by Harris (1989; Fig. 1) includes replacement planting and transplanting, sowing, protective tending by weeding and removal of competitors, physical soil modification, manuring, drainage and irrigation, and land clearance activities usually associated with farming, but now shown to have been practised also by hunting and gathering groups using undomesticated resources (Harris & Hillman 1989).

The recognition of such a wide range of interventionist practices in pre-agricultural contexts has wide ranging ramifications. As ethno-historical data accumulate about plant husbandry from Australia, Africa, and North America, the concept of domestication has recently been extended from its orthodox biological definition to embrace wider aspects of relationships between people and plants. Such range of practices gave rise to the notion of incidental, specialized, and agricultural domestication described by Rindos (1984), domiculture, by Hynes and Chase (1982), cultivation and domestication stages of food production (Ford 1985), and a four-fold scheme presented by Harris (1989), where a distinction is made between foraging, wild plant food production, cultivation, and agriculture. Of relevance to the Mesolithic is that all these schemes recognize a stage which involves practices more intensive than gathering. These practices are described in terms of social relationship of humans to plants, extractive technology used, plant use practices and the way they affect different plant communities, and the environment in general.

What evidence do we have in the Mesolithic for plant use that goes beyond gathering? Many of the key behaviours associated with incipient plant husbandry

LAND CLEARANCE BY FIRE AMONG HUNTER-GATHERERS AND FOREST FARMERS

BURNING PRACTICE AND INTERVAL	OBJECTIVE	TYPE OF ENVIRONMENT	EFFECT ON ENVIRONMENT	SOURCE
Initial burning, repeat burning of mature forests and of windfall forests Interval greater than 40 years	To renew and re-establish plant and animal communities To reduce risks of uncontrolled fire	Boreal and Temperate forest in North America Boreal forest - North-East Europe	Major charcoal horizon Major (?) erosion	Lewis 1982 Zvelebil 1981
Repeat burning 1 - 5 years	To maintain grassland and herbaceous environment, to raise deer population and to improve nesting habitat for waterfowl, to create yarding habitat for deer	Mediterranean and semi-arid env. in California and Australia Temperate grasslands, forests and wateredge habitats, boreal forests and wateredge habitats	Limited but continuous charcoal dusts within sediment	Shipek 1989 Hallam 1989 Lewis 1982 Jones 1989 Gould 1971 Hallam 1975
Repeat burning 8 - 12 years	To allow regeneration and raise productivity	Mediterranean coniferous forests in California	Limited erosion Thin charcoal horizons	Lewis 1982
Repeat burning 15 - 30 years	To bring vegetation to sub-climax, successional stage, to allow regeneration of fruit and nut trees (i.e. hazel), to exploit the herbaceous undergrowth	Temperate and boreal woodland in NE Europe and North America	Limited erosion Thin charcoal horizons	Zvelebil 1981 Petrov 1968
Natural forest fires 25 - 50 years or greater intervals		Temperate and boreal forests of North America and Europe	Major charcoal horizon Major erosion	Lewis 1982 many other authors

Fig. 7
Woodland burning regimes

are difficult to recognize archaeologically, but the following points could be made:

1. The widespread use of burning, to the point of creating a permanent change in the landscape, had, as we have seen, a protective and promotional effect on food plants, such as hazel, forbs, and grasses. Such a symbiotic relationship would correspond to 'specialized domestication', which is 'mediated by the environmental impact of humans, especially in the local areas in which they reside' (Rindos 1984). If the use of fire was indeed anthropogenic and intentional in most cases, then such a practice would reflect 'spatially focused, labour-demanding and ecologically interventionist activities' which characterize the wild plant food production system of Harris (1989, 20), and correspond to the plant food management as defined in this paper.

2. The use of mattocks (wooden and antler), hoes, and picks on the scale suggested by the distribution of the antler mattocks, indicates interference with the soil which *may* indicate either soil preparation for planting and/or harvesting of root crops on regular basis. The correspondence between the distribution of antler mattocks and the temperate forest, where roots and tubers occur in profusion (Clarke 1976), makes the latter a stronger possibility. Harvesting, processing, and storage are also demonstrated in the case of water-chestnut in the east Baltic. Harvesting, storing of undomesticated crops, and minimal tillage are the key activities which characterize plant food management.

3. The presence of large-grained cereal-type pollen in the pollen diagrams dating to the Late Mesolithic period may indicate either anthropogenic selection of certain species of native grasses (even though there is no evidence for their domestication as in the Near East), or more likely, is the result of fire-assisted forest clearance by Mesolithic groups. Again, this suggests implementation of promotional strategies which characterize plant food management or husbandry as defined here.

All these suggestions are to some extent speculative. The evidence does not amount to indicating domestication, but it raises the question of cultivation. It shows, to my mind, the manipulation of the environment to raise the productivity and predictability of the plant resources, and supports the notion of deliberate management of the ecosystem (Simmons & Innes 1987; Clarke 1976; Mellars 1975).

REGIONAL PATTERNS AT THE MESOLITHIC–NEOLITHIC TRANSITION

Most of the information about plant use dates at present to the Late Mesolithic or a period preceeding the adoption of agro-pastoral farming. Two ways of seeing much of the above data can be adopted: in terms of indigenous or derived plant use traditions. In the former case, plant use strategies would be developing indigenously throughout the Mesolithic; in the latter case, they developed at the end of the Mesolithic in replication of agricultural practice of Neolithic farmers. In either case, it was the local, indigenous populations, defined by their Mesolithic material culture, who were responsible for the putative husbandry of indigenous plants.

At the Mesolithic–Neolithic transition we can envisage a number of different plant use strategies or in a broader sense, social traditions (i.e. Chase 1989) operating in the temperate, (west) Mediterranean and south-east Europe (Fig. 8). These would have acted as filters through which agro-pastoral (Neolithic) farming was adopted.

Temperate Europe

From the late Boreal, temperate Europe was dominated by deciduous or mixed broad-leaved–coniferous forests. Given the potential distribution of plant foods within this zone (Clarke 1976), Mesolithic communities could be expected to exploit the arboreal and shrub vegetation bearing nuts and fruits, and also roots, with seeds assuming a secondary role. The palaeobotanical evidence, particularly for hazelnut and water-chestnut, and the distribution of antler mattocks as digging tools, provides some support for the use of these two major elements in plant diet.

Harvesting of small-seeded grasses would have been of lesser importance, unless clearances were maintained to increase their productivity. That this may have been the case from the later Mesolithic onwards is suggested by the pollen evidence.

Such plant use strategies focused on the exploitation of the forest ecosystem, within an economy which could be characterized by the specialist use of several animal resources (Zvelebil 1989). Such patterns of plant and animal management would not necessarily lead to domestication, either for reasons of animal and plant biology (Higgs 1972; 1975; Harris 1977; Hillman & Davies 1992), or because of scheduling conflicts within the complex Mesolithic economy (Zvelebil 1986). Tending of nut, tuber, and seed plants in the summer and

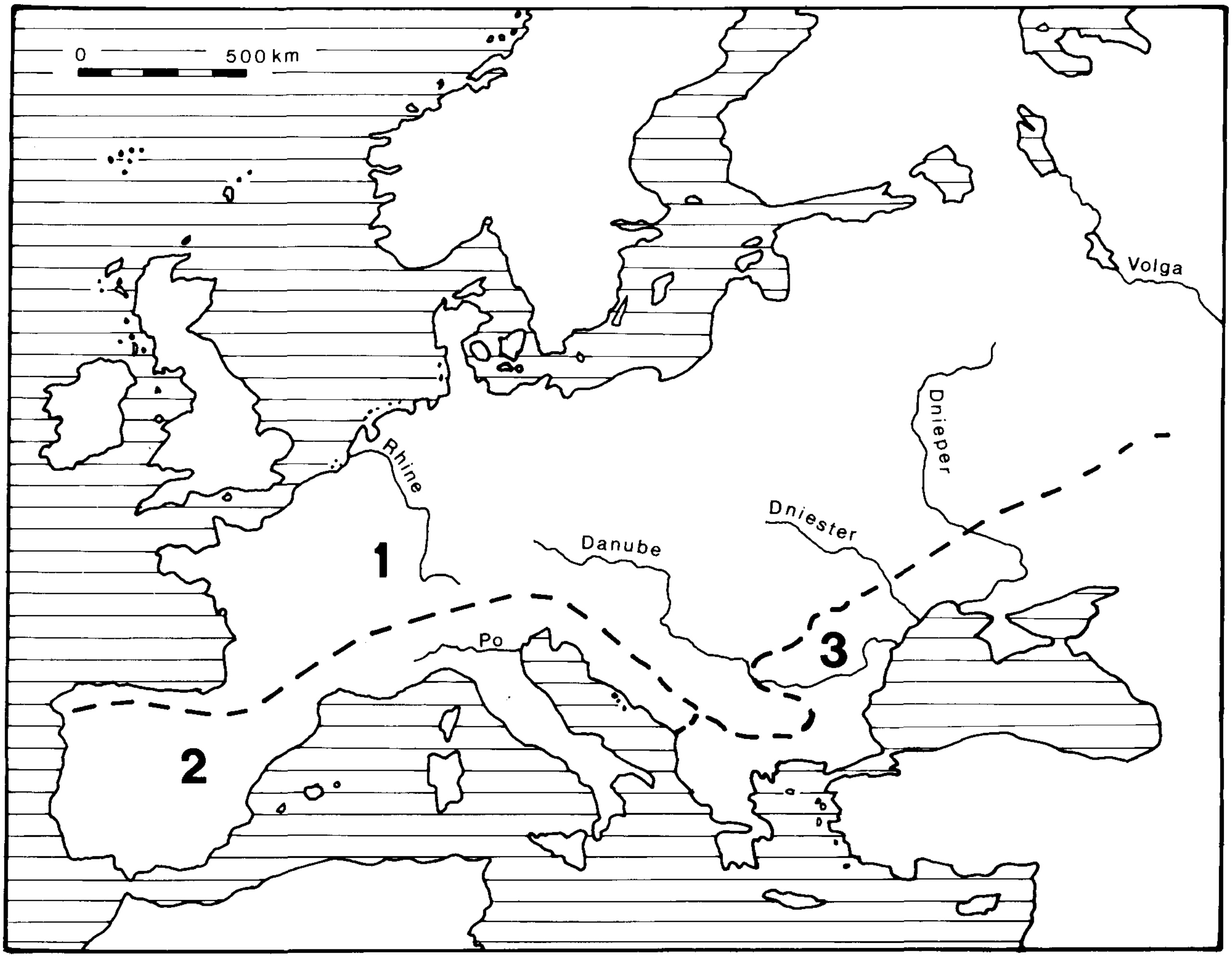

Fig. 8
Regional traditions in plant use during the late Mesolithic in Europe: 1: Temperate Europe 2: Mediterranean Europe 3: Southern Balkans and the Pontic Steppe.

their harvest in the autumn would have conflicted with the main fishing and hunting seasons respectively. On the other hand, the value of plant food as a storable investment for winter may have placed a premium on plant use activities. The intensification of plant use, and the adoption of agriculture, may have taken place as a replacement for other storable food resources.

Mediterranean Europe

A mosaic of vegetational zones covered Mediterranean Europe, including temperate forest, pine, and juniper dominated woodland and open grassland environments (Vernet & Thiebault 1987; Huntley & Birks 1983). These associations included stands of wild cereal grasses and Mediterranean fruit and nut trees, such as olive, fig, grape, pistachio, almond, and pine nut. Mesolithic groups could be expected to exploit the seed, nut, and fruit elements, with root crops playing a secondary role. Two points need stressing here: the forest, whether evergreen or temperate, never became ubiquitous, allowing grasslands to survive from the late glacial through Holocene; and from the late 7th millennium BC, Mediterranean vegetation spread from restricted areas in southern Italy, southern France, and Greece to other regions, increasing the availability of fruit and nut resources. It has become increasingly clear that pulses, wild cereals, and other grasses were exploited from the Early Mesolithic onwards: a notion

increasingly supported by finds of pulses and plants such as *Chenopodium* in Mesolithic layers in southern France, Spain, Italy, Yugoslavia, and Greece (see above), while the increased importance of fruit and nut elements is shown not only by the macrofossil remains from sites such Uzzo, Italy, Cingle Vermell, Spain, or Balma Margineda, but also by the high incidence of dental caries among the west Mediterranean Mesolithic populations. Taken together, this amounts to a significant exploitation of vegetal foods prior to the adoption of Neolithic economy. In the Mediterranean region, then, the adoption of agro-pastoral farming could be seen as an addition of domesticated crops (Hansen & Renfrew 1978; Dennell 1983), to an established socio-economic tradition, of wild food husbandry.

Southern Balkans and the Pontic steppe

These areas are characterized by deciduous or evergreen woodland and by open grassland steppe extending from eastern Greece around the northern coast of the Black Sea. It is cut by gallery forests and wetland vegetation along the valleys of large rivers. It may be useful to consider this area as an extension of grassland habitats of the Near East (Irano-Turanian steppe), which share in common the abundance of wild seed grasses, including wild barley and einkorn. The gallery forests and riparian environments supported root crops, while Mediterranean fruit and nut trees were less abundant. Such an environment would suggest a reliance on cereals, roots, and tubers. Little is known about plant use from Mesolithic sites in this region at present, but the occurrence of antler mattocks in the Dnieper Valley and in the Bug-Dniester Mesolithic may indicate the importance of root crops, while the presence of grinders, reaping tools, and of wild cereals and other seed plants at Franchthi, the Iron Gates, and Soroki suggests that in this area, the introduction of Neolithic economy is preceded by the exploitation of wild cereals, not excluding the possibility that local domestication may have taken place (Dennell 1983; Markevitch 1971). Indeed, the recent analysis of skeletal remains from Vasilevka 2 and 3 in the Middle Dnieper valley, Ukraine, by Jacobs (1993) suggests just such a shift to greater use of plant foods, possibly seeds, from the 6th millennium onwards.

CONCLUSIONS

The patterns of plant use suggested above add further evidence for continuity across the Mesolithic–Neolithic transition which has already been observed in material culture in many parts of Europe (*see* Bonsall 1989; Zvelebil 1986; Barker 1985; Printz 1987; Bogucki 1988, for regional reviews) and emphasize the additive nature of agro-pastoral farming. As among the prehistoric hunter-gatherers in parts of North America and Australia, the Mesolithic communities in Europe appear to have developed a form of plant husbandry of their own based on indigenous resources. The agro-pastoral farming was then added to the existing traditions of undomesticated plant and animal management (Dennell 1983, 189; Simmons & Innes 1987, 399; Rindos 1989; Clarke 1976). Conversely, traditional resources continued to be utilized in the Neolithic, often very extensively (i.e. Moffett *et al.* 1989; Coles & Coles 1989; Barker 1985; Tringham 1971; Bogucki 1988).

At the broadest level, the existence of intensive plant use strategies in the Mesolithic casts further doubt on the Neolithic as an integrated package of new resources, new technology, and new traditions. Recent evidence suggests that differences seen earlier between the two periods in terms of material culture (chipped stone, polished stone, antler tools, pottery), economic practices (plant and animal resource use), and patterns of residence (sedentism and logistic mobility occurs in both periods: see e.g. Price 1987; Rowley-Conwy 1983; Woodman 1985; Zvelebil 1986, for the Mesolithic; Whittle 1985; Bogucki 1988, for the Neolithic) have been exaggerated. Indeed, the presence in the Mesolithic of so many traits conventionally regarded as 'Neolithic' calls into the question meaning of those terms.

In evaluating the evidence for plant use in the Mesolithic, I have combined a number of archaeological and ethno-historical sources, and adopted a very broad perspective with little regard for finer chronological and regional differences. On its own, most of the evidence presented here can have alternative explanations, unrelated to the intensity of plant use, leaving a lingering suspicion that the whole I am seeing may be greater than the sum of its parts.

I share these doubts. Yet the four lines of evidence I considered here point in the same direction: towards controlled, regular, and intensive use of plant resources on a scale which left an imprint on the landscape and which must have had an impact on the social and economic organization of Mesolithic communities. What we need now are integrated strategies designed to test the accuracy of this pattern and to improve its resolution. This will have to include regular use of

fine-meshed water sieving techniques, horizontal pollen sampling of archaeological sites, development of phytolith studies, microwear and organic trace analysis of artefacts implicated in plant use, and, of course, further development of bone chemical analysis. Various approaches are already being implemented (i.e. Hillman 1989; Edwards 1990). But we also need to link more consistently archaeological patterning to human behaviour. Above all, we have to be prepared to accept the likelihood that, in addition to being 'carefree families of bowmen' (Rozoy 1978), Mesolithic people were also careful forest farmers, who may already have been domesticating their landscape and its resources.

Acknowledgements: The original version of this paper was presented at the Fourth International Symposium on the Mesolithic in Europe at Leuven in September 1990. Since then a number of people have provided information which has been included in this paper. I am very grateful to Phillippa Tomlinson for providing details of paleobotanical remains in Britain from her database, and to Sveinung Bang-Anderson, Ole Grøn, Bjorn Nordquist, Grigoriy Burov, Corrie Bakels, Eva Niesietowska, André Thévenin, Pierre Ziesaire, Richard Willis, Pierre Vermeersch, Jean Rozoy, Erwin Cziesla, Mats Larsson, and Stig Welinder for information about paleobotanical remains on the continent.

I would like to thank Gordon Hillman, Robin Dennell, Christina Rushe, Sheila Boardman, Glynis Jones, Paul Halstead, Andrew Garrard, Paul Buckland, and Kevin Edwards for reading and commenting upon earlier versions of this paper and for relocating the definite articles where they should be. I am much obliged to Vanessa Toulmin for the production of the final manuscript. Any errors and omissions are my own.

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