

# WOODLAND CONTINUITY AND CHANGE IN EPPING FOREST

By COLIN A. BAKER

*Department of Geography, King's College, London\**

PAUL A. MOXEY

*Epping Forest Conservation Centre, High Beach, Loughton, Essex*

and

PATRICIA M. OXFORD

*Department of Geography, King's College, London†*

## ABSTRACT

The application of pollen analysis and radiocarbon dating to a shallow valley bog in Epping Forest has indicated the continuity of woodland cover and the changes in its species composition over the past 4,000 years. From the Neolithic until the early Saxon period lime-dominated woodland persisted; lime underwent a dramatic decline between A.D. 600 and 840 and this is interpreted to reflect selective forest clearance during the middle Saxon period. The familiar beech-birch and oak-hornbeam associations of the Forest of today developed only after this Saxon phase. The evidence is considered in the context of the known archaeology and history of the Forest, with particular reference to the Neolithic, Iron Age and Saxon periods. The hydrosere succession is also discussed.

## INTRODUCTION

THE modern Epping Forest consists of some 2,430 hectares of woodland and grass, together with a small amount of heath, extending in a crescent from Wanstead, in the London Borough of Redbridge, at its southern end, to a little beyond Epping in the north, a distance of approximately 19 km (Fig. 1). Of the total area, approximately 1,620 hectares are woodland, the principal tree species being beech (*Fagus sylvatica*), hornbeam (*Carpinus betulus*), common oak (*Quercus robur*) and silver birch (*Betula pendula*).

The present character of the area has been strongly influenced by its past management, and the Forest is rich in historical associations. The Epping Forest of today is a remnant of the Royal Forest of Essex, established shortly after the Norman Conquest and managed for centuries by the lords of the manors as wood-pasture (Rackham, 1976). Under this system, it was possible for the interests of the Crown and those of the manorial lords to be compatible with the commoners' rights to graze cattle, turn out swine, lop wood and dig gravel. Medieval records of outbreaks of disease amongst the deer in the Forest (Fisher, 1887) fit a pattern that is known to have existed in other parts of the country (Chapman and Chapman, 1975) and probably reflect the high stocking rates that existed in the past and which would have seriously impeded natural regeneration of the trees.

\* Present address, St Lawrence College, Ramsgate, Kent.

† Now Mrs A. Gillespie, 1 Stanley Crescent, London W11.

The practice of lopping or pollarding (i.e. regularly cropping the trees for wood at a height of about 1.5 metres above the ground) ensured that new growth was out of the reach of browsing deer and cattle, whilst at the same time creating an open canopy which encouraged the growth of herbage on the woodland floor. The influence of social and economic change upon the Forest, with the declining importance of both the Crown's interests and those of the commoners, as well as the gradual diminution of the Forest area by enclosure, has been recorded by a number of authors, notably Fisher (1887) and Addison (1977). Since 1878, Epping Forest has been under the jurisdiction of the Corporation of the City of London, and managed as a place of public recreation. Although it is still grazed by cattle, their numbers have steadily declined; deer are virtually non-existent in the Forest itself, though a herd of fallow deer (*Dama dama*) is maintained in a fenced sanctuary adjacent to Forest land at Theydon Bois. With the arrival of myxomatosis in 1956, the fall in the rabbit (*Oryctolagus cuniculus*) population has reduced the grazing pressure still further, thus accelerating the advance of scrub into the former grazing areas. At the same time, with the cessation of pollarding, the rights to which were terminated in 1878, not only has the canopy closed to reduce the shrub and field layers in the older woodlands, but there is also clear evidence that the species composition of the tree population has shifted. Birch now covers many of the previously open areas on the lighter soils, and beech has begun to out-top and kill both oak and hornbeam. Whilst the influence of past management within the Forest is still obvious, the major ecological trend of the past 100 years has been towards uniformity.

Even so, Epping Forest has many of the characteristics of ancient woodland (Peterken, 1974), including such species as wild service (*Sorbus torminalis*), butcher's-broom (*Ruscus aculeatus*) and pendulous sedge (*Carex pendula*) that are considered to indicate a long continuity of woodland. At least two similar indicators of old woodland, *Enterographa crassa* and *Pyrenula nitida*, are constituents of the present impoverished lichen flora, although historical records show that until the middle of the nineteenth century the Forest supported such ancient woodland species as *Lobaria pulmonaria* (Rose, 1976). The loss of many species of lichen from the Forest is to be attributed to increasing levels of atmospheric pollution as a result of the industrial development of north London (Laundon, 1967).

Buxton (1884) provided what must still be considered an excellent general account of the Forest vegetation, and Qvist (1958) and Leutscher (1974) have more recently written in a broad descriptive manner. Jermyn (1974) has considered the Forest vegetation within the general framework of the flora of Essex, whilst Lloyd (1977) has recently examined in depth the status of one species—the wild service—and Paulson (1926) and Moxey (1977) have looked at aspects of the Forest vegetation within a regional context. Only Rutter (1949) has viewed the woodland associations from an ecological viewpoint, and his study covers only a limited part of the area.

There is a considerable historical documentation for the Forest, the bulk of it relating to the nineteenth and early twentieth centuries. Understandably, little is known of the period before the Norman Conquest, although there are relevant passages in both Caesar's *Gallic Wars* and the *Anglo-Saxon Chronicle*.

There is, however, sufficient archaeological evidence to indicate the nature and extent of the human occupation of the area before the Roman period. There have

been a number of Palaeolithic finds at various locations as well as evidence for at least temporary occupation during the Mesolithic period (Warren, 1913, 1926; Marshall, 1959). The first major settlement, however, appears to have been in the Iron Age, and the impact of these communities is critical in an evaluation of the Forest's vegetation history.

The existence of at least two Iron Age camps on the Forest ridge, at Ambresbury Banks and Loughton Camp (Pitt-Rivers, 1881; Cotton, 1957) has been taken by some to suggest extensive woodland clearances at that time. It should be noted that one of the camps, Ambresbury Banks, lies no more than 700 metres from the site of the present study, and is a univallate camp dated by its pottery to the late Bronze or early Iron Age (800–300 B.C.), with evidence of Belgic or late Iron Age re-occupation (Huggins and Huggins, 1971). It appears that Belgic re-occupation of sites established during the early Iron Age was a feature of the late Iron Age. Julius Caesar refers to the Belgae maintaining such fortified camps within woodland (Carrington, 1939) and recent archaeological evidence and pollen analysis of buried soil horizons appears to confirm this suggestion that Iron Age forts were built and maintained in woodland conditions (Dimbleby, pers. comm.).

Gillam (1973) has drawn attention to increased activity along the River Lea and its tributaries in the Iron Age, and Wheeler (1933) earlier pointed out the importance of river-systems in the Belgic economy. It seems unlikely, however, that a sensible interpretation of the role of Iron Age man on the Forest ridge can be made without reference to activity along the adjoining river valleys or considering the relationship between the Catevellauni, occupying Hertfordshire, and the Trinovantes, in Essex, whom they conquered in A.D. 10 (Munby, 1977).

It has been suggested (Dunnett, 1975) that the Forest ridge hill-forts were originally established in a troubled frontier zone between the two Iron Age groups and that, with political unification under the Catevellauni, they became, at least from a military or strategic standpoint, obsolete. What is certain is that the pollen profile which is the basis of the present study shows no significant decline in tree species during the Iron Age, thus indicating that neither the Belgae nor their predecessors made any significant impact on the Forest vegetation.

The influence of Iron Age man has been only one of the unresolved problems when considering the vegetation history of the Forest. That the area has had a long history of woodland cover has never been doubted, but the length of that history and the possibility of changes in the tree composition were questions that had not been considered in detail before the present study. Paulson (1926) had speculated that the beech represented survivals of the original "climax" vegetation, but this hypothesis was not based on the detailed kind of evidence that is now available.

The present study is based upon the examination of the pollen deposits contained in a valley bog close to the watershed of the Forest ridge, about 700 metres from Ambresbury Banks and 3.5 kilometres south-west of Epping. The site is significant in a number of respects. Not only does it provide the first detailed picture of changes in the Forest vegetation, but it is unique in being the first site from which such data have been obtained from within a surviving ancient woodland in Britain. It also contributes to a growing body of information about the status of the lime (*Tilia* sp.) in southern England during the prehistoric and early historic periods (Moore, 1977).

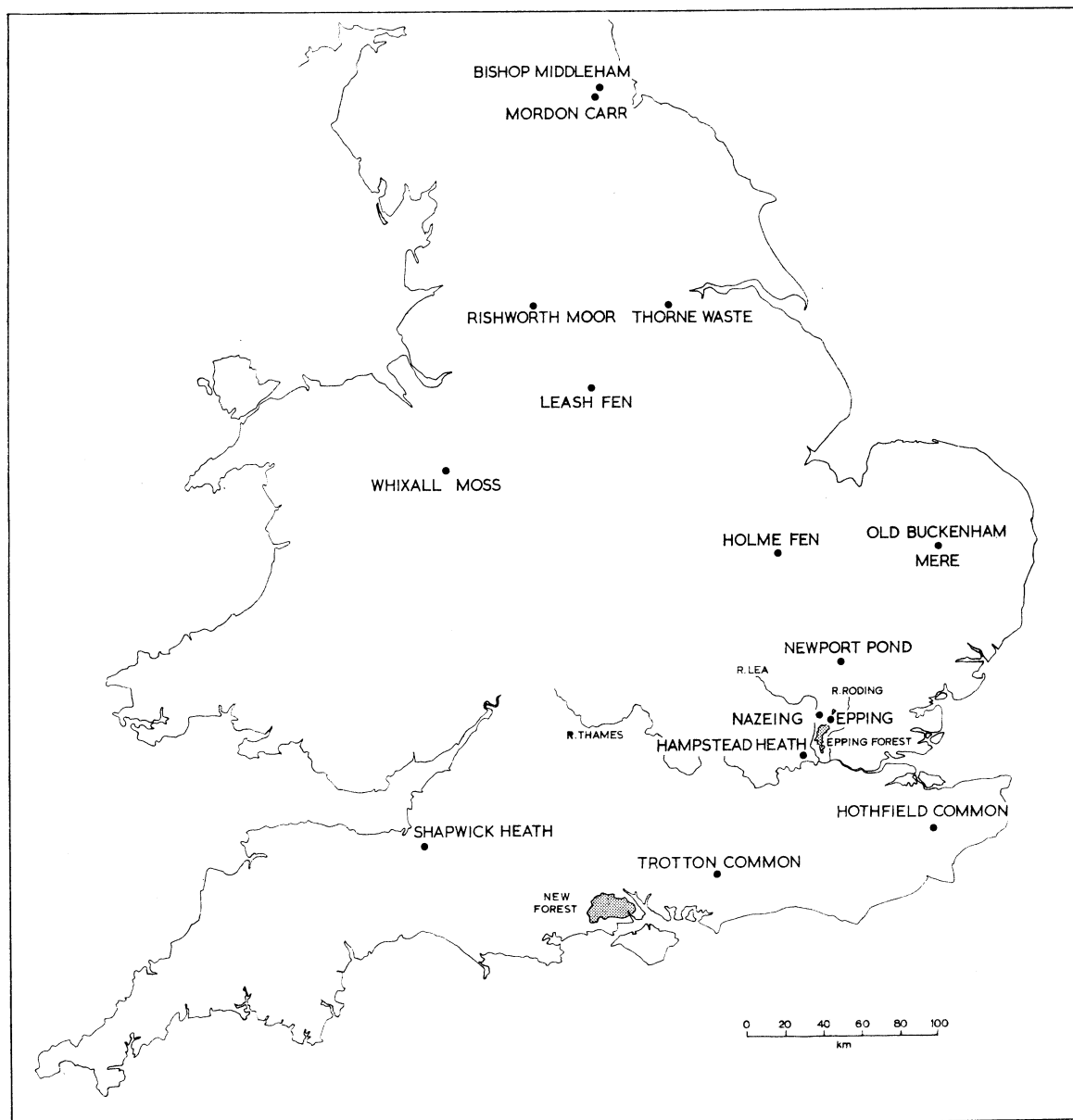


FIG. 1.  
Location of British sites mentioned in the text.

## THE STUDY AREA

Epping Forest occupies a ridge, of up to 117 metres O.D. in height, between the valleys of the River Lea and River Roding, both north-bank tributaries of the Thames (Fig. 1). In the northern part of this ridge the geology consists principally of London Clay (100 metres thick at Epping) overlain conformably in the higher areas (above 76 metres O.D.) by up to 8.5 metres of laminated sandy clays (Claygate Beds) and 4.0 metres of bedded and current-bedded sands (Bagshot Beds) (Dines and Edmunds, 1925; Baker, 1971). These strata are shown in distribution and cross-section in Fig. 2. The Tertiary deposits are overlain unconformably by coarse fluvial gravels (Pebble Gravel) up to 4.6 metres thick in the highest ridge sites (Wells and Wooldridge, 1923; Baker, 1971), and by irregular shallow spreads of glacial till and outwash gravels, probably of Anglian age (approximately 250,000 years Before Present). There is considerable solifluxion and ground-ice disturbance of the surface layers (Warren, 1945), probably dating from the late Devensian period (30,000–10,000 years B.P.). Situated within the Forest are a number of Postglacial *Sphagnum* bogs containing organic deposits up to 2.5 metres thick.

The majority of *Sphagnum* bogs in Essex is considered by Adams (*in* Jermyn, 1974, p. 233) to be man-made habitats (either shallow gravel workings on open heath, or valley bogs ponded back by ancient trackways), although some may occur at natural spring or seepage points. The deposits in these bogs form a valuable palaeobotanical record of the area's vegetation history.

Several valley bogs in Epping Forest were initially examined, of which two, adjacent to Lodge Road (TQ 432999), were found to be particularly well-developed (Fig. 2). Of these, the one nearest to the Epping New Road (All), Bog "B", appeared to be the older and was chosen for detailed investigation.

The bog is located on sandy Claygate Beds (Fig. 2) and is maintained by surface flow from a small stream that is fed by seepage from the junction between the highly permeable Bagshot Beds and the less permeable underlying Claygate Beds. Pebble Gravel outcrops at a short distance to the east and south-east (Fig. 2). The surrounding strata are generally low in nutrients and yield a base-deficient water supply. The bog is thus both soligenous (i.e. maintained by mineral ground-water) and oligotrophic (i.e. poor in nutrient supply). It is an example of stagnant woodland-type bogs characterized by much *Sphagnum flexuosum* (syn. *S. recurvum*) and *S. palustre* (Rose, 1953).

## THE HYDROSERE

*Surface Vegetation*

The surface vegetation of the site was mapped in July 1974 by plane-table survey, and described in terms of approximate zones according to relative species abundance (Fig. 3). The surrounding woodland (part of St Thomas's Quarters) is composed principally of beech with oak and occasional hornbeam (Qvist, 1958). Six vegetation zones are recognizable in the bog (Fig. 3); these form a pattern broadly comparable to the classification of lowland bogs proposed by Rose (1953). In detail, however, the Lodge Road site deviates from Rose's scheme and this is probably due to its small size, densely wooded surroundings, and to recent human disturbance.

The surface dimensions of the site, taken as the extent of the open dry heath community, are 60 metres by 29 metres; the wet area, characterized by rushes

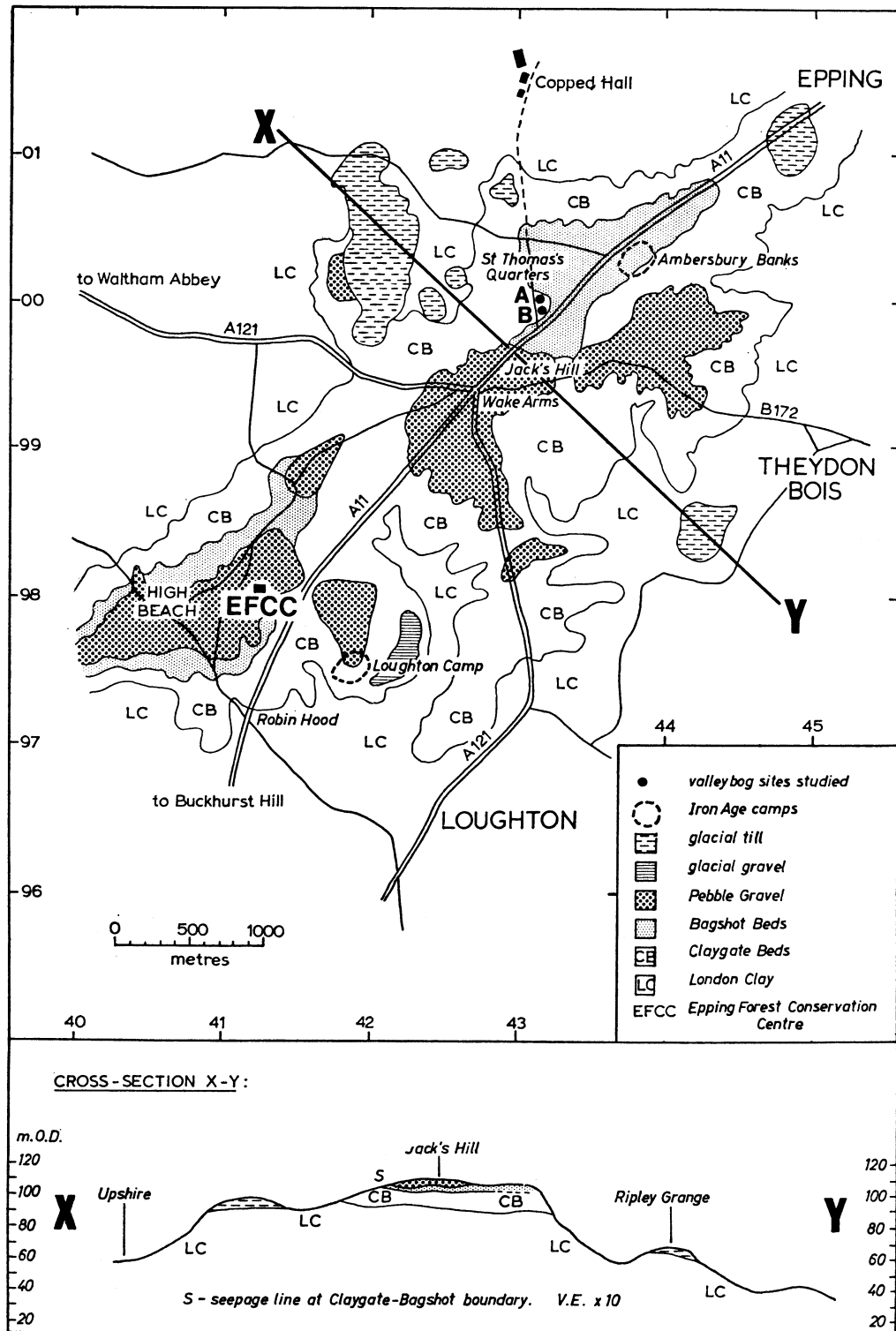


FIG. 2.  
Geology of the area around Lodge Road, Epping Forest.

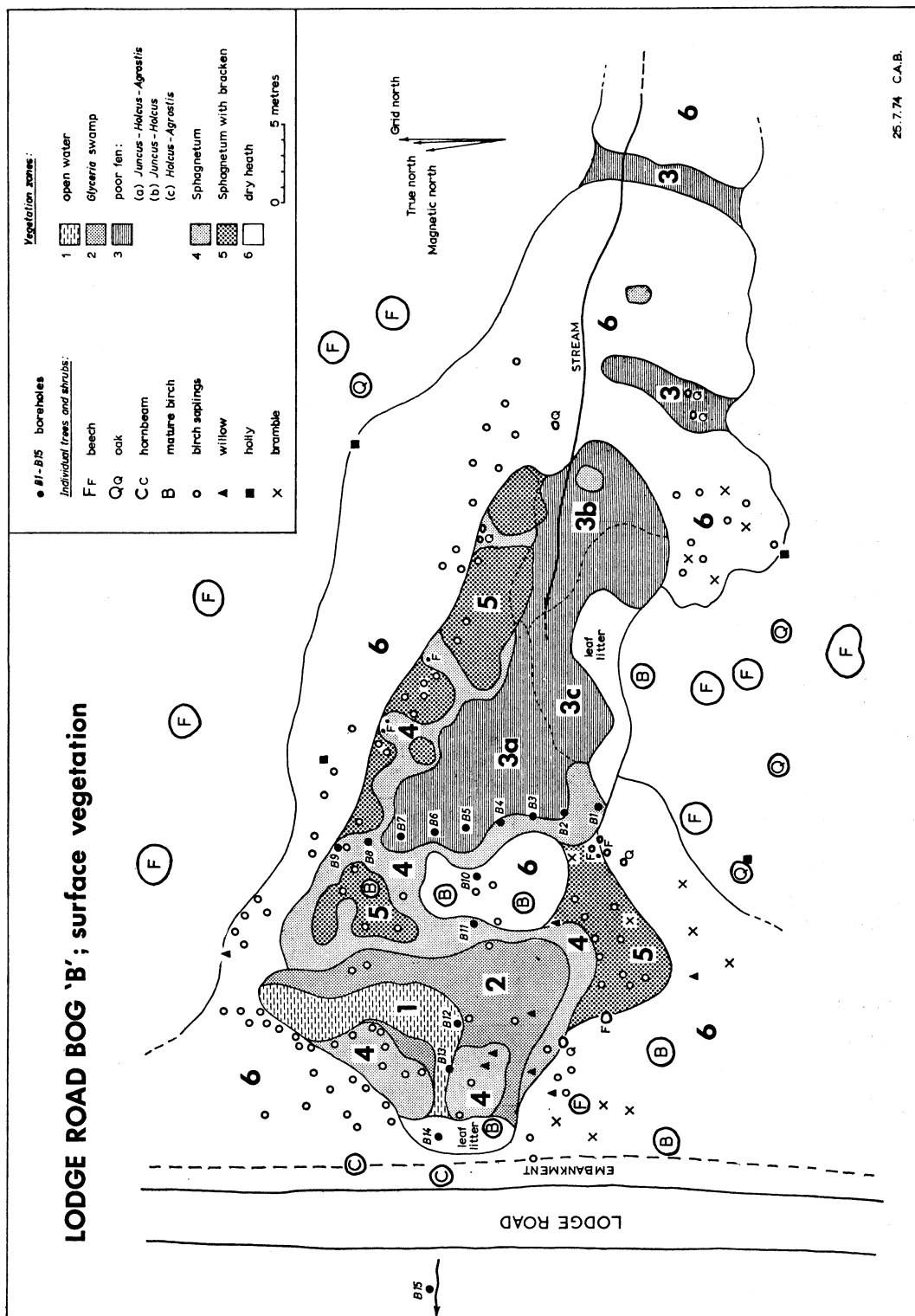


FIG. 3.  
Lodge Road; Bog B; Present surface vegetation and location of the boreholes.

(*Juncus* spp.), measures 45 metres by 15 metres, tapering upstream. At the lower end of the bog (Fig. 3), adjacent to the road, there is an area of open water (pH 4.0) which coincides with the line of an anti-tank ditch constructed during the 1939–1945 war along the east side of the road (Warren, 1945; Qvist, 1958). This contains a thin, submerged mat of *Sphagnum cuspidatum* (Adams, in Jermyn, 1974) which was penetrated by bore B12 (Fig. 4). To the east of the ditch there is a slight mound (bore B10, Fig. 4), which was probably thrown up during the construction of the ditch itself. This made ground is elevated above the waterlogged *Sphagnum* level, and carries a line of bracken (*Pteridium aquilinum*) and mature birch across the bog (Fig. 3, zones 5 and 6).

Surrounding the open water area is a zone of *Glyceria* swamp (Fig. 3, zone 2). This is characterized by floating sweet-grass (*Glyceria fluitans*), jointed rush (*Juncus articulatus*) and *Sphagnum flexuosum* with patches of marsh pennywort (*Hydrocotyle vulgaris*), water horsetail (*Equisetum fluviatile*) and *Polytrichum commune*. Incipient willow carr development can be seen in the sporadic invasion of the lower end of the swamp zone by willow (*Salix* sp.) (Fig. 3). The “poor fen” zone (Rose, 1953) is found in the permanently waterlogged central area upstream of the mound (Fig. 3, zone 3) and is typified by jointed rush, soft rush (*Juncus effusus*), creeping soft-grass (*Holcus mollis*) and creeping bent-grass (*Agrostis stolonifera*). *Sphagnum* is conspicuously absent from this zone.

A fringing carpet of *Sphagnum* (Fig. 3, zones 4 and 5) is found on the bog margins and is between one and four metres in width; both *Sphagnum palustre* and *S. flexuosum* are present, together with the zone 3 species outlined above. Where the carpet is most mature, small birch saplings, bracken and purple moor-grass (*Molinia caerulea*) are invading in spur-like areas (Fig. 3, zone 5).

“Wet-heath” and “damp-heath” zones (Rose, 1953) are absent, zone 5 giving way abruptly at the change of gradient to a dry heath community (Fig. 3, zone 6). This is dominated by birch, bracken and purple moor-grass with traces of wavy hair-grass (*Deschampsia flexuosa*) and heather (*Calluna vulgaris*) on the more open north side. This zone is underlain by a podsol soil profile developed on Claygate Beds.

The hydrosereal succession at the Lodge Road site therefore appears to take the following form: (1) base-deficient open water; (2) *Glyceria* swamp; (3) grass and rush fen; (4) Sphagnetum; (5) birch-*Molinia* dry heath.

### Organic sediments

The lithology of the bog was investigated in a number of closely-spaced boreholes at points indicated in Fig. 3. The maximum depth of infill (bore B14) appears to be 240 cm. Typical stratigraphy is encountered in bore B5 (Table 1).

Cross-sections illustrating the stratigraphy are presented in Fig. 4. Three bores (B10, B12 and B14) show the considerable degree of human disturbance of the bog. B14 shows inorganic sandy clays at the distal margin, associated with the road; B10 and B12 show made ground and open water respectively, related to anti-tank ditch construction. Bog sediments clearly terminate at the road (Fig. 4) and Claygate Beds are detected immediately west of the road (bore B15).

Table 1 shows a sequence of partially-organic lake clays (Bed E) passing up into increasingly organic detritus muds (Bed D) and highly organic peats (Beds C and A).



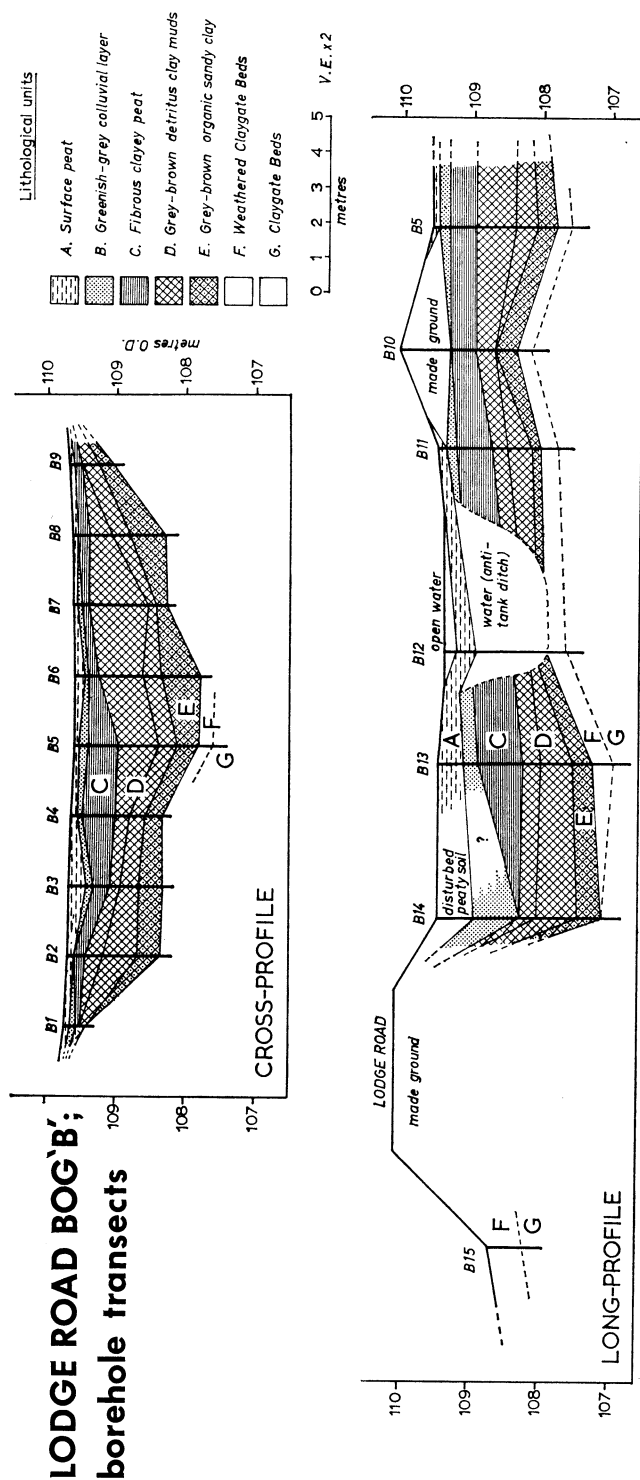


FIG. 4.  
Lodge Road; Bog B; Borehole transects.

Table 1. *Stratigraphy of organic sediments in bore B5*

Depth to (cm)	Stratum	Lithology
10	A	Surface peat layer
16	B	Greenish-grey gleyed inorganic sandy clay
61	C	Fluid, fibrous, unhumified clayey peat
150	D	Firm, grey-brown detritus clay mud with variable organic and colluvial layers. Charcoal fragments occur between 95 cm and 110 cm. Below 135 cm stratum D develops into firm dark grey-brown sandy detritus clay mud with occasional layers of light grey sand and fine subangular gravel
177	E	Very firm dark grey-brown silty sandy organic clay with a basal gravel layer
207	F	Stiff mottled dark grey-brown and blue-grey sandy clay (weathered Claygate Beds)
>215	G	Very stiff blue-grey to greenish-grey sandy clay (Claygate Beds)

This sequence is taken to indicate a primary hydrosere developed over a small ponded lake. At a number of levels, coarser mineral influxes denote temporary phases of local soil erosion and hillwash. The basal stone layer (Bed E), inclusions of sand and fine gravel (Bed D) and the persistent colluvial layer (Bed B) are examples of such phases (Fig. 4). Godwin and Vishnu-Mittre (1975) have described clay bands similar to Bed B in Holme Fen where they are interpreted as evidence of the erosion of woodland soils following exposure by clearances.

Sediment analyses of the organic beds are given in Table 2. Samples were taken from bore B5 at 10-cm intervals. Fine fractions ( $>2$  mm) were analysed for organic content (by loss on ignition at  $850^{\circ}\text{C}$ ), for pH status (measured by meter with a soil : water ratio of 1 : 2.5), for total exchangeable bases (by exchange in 1 N acetic acid), for natural water content (by loss of moisture at  $50^{\circ}\text{C}$ ), and for particle size distribution (by hydrometer method and wet sieving).

Organic content (Table 2, column 3) is shown to remain at levels between 8% and 12% up to 125 cm. Thereafter there is a rapid increase in organic production from 15% to 44.6%. The inorganic colluvial layer (Bed B) is indicated at 15 cm (4.8%). pH values (column 4) confirm an acid status throughout, but with increasing acidity upwards from pH 5.4 at the base to pH 4.0 in the surface layers. Exchangeable bases (column 5) are low throughout, confirming base deficiency, though a slight increase upwards possibly reflects increasing nutrient production with hydrosere progression. Natural water content (column 6) decreases with depth, reflecting increasing compaction of sediments; there is, however, a marked change at around 115 cm, at the same level as organic content and particle size both alter. Mechanical composition (columns 7–9) very largely reflects the character of the underlying Claygate Beds which are thus presumed to have contributed the bulk of the inorganic fraction. High sand content, however, is evident below 115 cm and in Bed B; this coarser material may have had its origin in local Bagshot Beds or Pebble Gravel.

On the whole, therefore, the analytical data show a generally consistent lithology, and this is taken to confirm continuous progression towards hydrosere climax.

Table 2. *Sediment analyses of organic sediments from bore B5*

Depth (cm)	Stratum	Organic content (%)	pH	Total exchangeable bases (meq/100 gm)	Natural water content (%)	Particle size distribution		
						Clay (%)	Silt (%)	Sand (%)
5	A		4.0	8				
15	B	4.8	3.8	2	53.8	15.0	27.5	57.5
25	C	44.6	4.6	11	355.0			
40		25.6	4.3	9	351.3	86.9		13.1
55		23.5	4.9	9	320.0			
65	D	20.6	4.9	9	338.5			
75		14.4	5.0	9	245.4	89.5		10.5
85		24.1	5.1	9	206.4			
95		21.3	5.4	9	170.9	90.1		9.9
105		24.4	5.2	8	250.3			
115		15.0	5.5	10	109.7	69.7		30.3
125		9.6	5.5	5	52.6			
135		8.0	5.8	5	42.9	67.6		32.4
145		10.4	5.7	7	49.2			
155	E	12.0	5.6	8	64.9			
165		8.8	5.5	6	47.0	69.3		30.7
175		8.4	5.4	6	45.9			
185	F	5.8	5.3	4	34.3			
195		4.8	5.0	3	24.9			
205		2.8	5.5	4	27.4			
215	G	3.8	5.8	4	22.0	17.0	63.0	20.0

However, the slight discontinuity at about 115 cm (noted in organic content, water content and particle size) is a feature which coincides with a marked change in sedimentation rate following large-scale lime (*Tilia* sp.) clearance (see below). Likewise, the colluvial layer Bed B is another discontinuity in the lithology which probably reflects a late and temporary reversion of the hydrosere, probably also related to human interference and soil erosion.

#### POLLEN ANALYSIS

##### Methods

Following Faegri and Iversen (1964), who suggest that in very small lakes or bogs a single profile point is sufficient to represent the pollen spectra at the site, only one borehole (B5) was sampled for pollen. Using a Hiller auger (1.5 m with a 4-cm chamber), samples were taken at 10-cm intervals, and at 5-cm and 2.5-cm intervals in the critical 100–130-cm horizon. Laboratory procedure, following Faegri and Iversen (1964), was one of successive treatments with potassium hydroxide, hydrofluoric acid and acetolysis solution for the removal of humus, silicates and cellulose respectively. Pollen concentrates were then stained in safranin and mounted in glycerol jelly. Slides were examined at  $\times 400$  magnification, identification being made with reference to Erdtman *et al.* (1961), Faegri and Iversen (1964), and the pollen slide collection at the Department of Geography, King's College, University of London. A minimum arboreal pollen count of 150 was stipulated, and results were expressed as percentages of total tree pollen (excluding *Corylus*\*). Arboreal pollen (trees and shrubs) is represented in Fig. 5;

\* It is conventional to exclude *Corylus* because of the ease with which its pollen may be confused with that of *Myrica*.

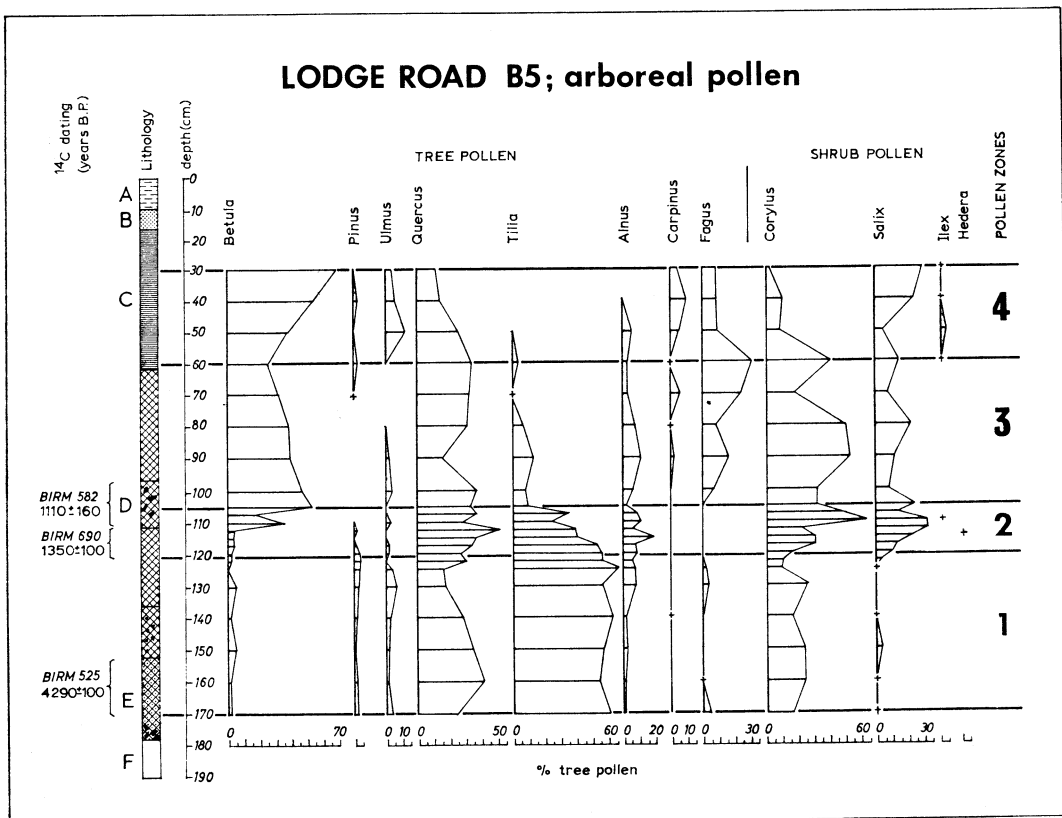


FIG. 5.

Lodge Road; Borehole B5; Uncorrected arboreal pollen diagram.

non-arboreal pollen (grasses, sedges, herbs, aquatics) and fern spores is represented in Fig. 6.

### Results

The arboreal component of the pollen spectra (Fig. 5) is thought to be most diagnostic of vegetational changes in the woodland surrounding Lodge Road, while the non-arboreal component (Fig. 6), together with the *Alnus* (alder) and *Salix* (willow) curves (Fig. 5), is taken to denote more localized hydroserral changes. Results may be conveniently described in four zones which are annotated on the pollen diagrams. These are:

4. 60– 30 cm *Betula-Quercus-Fagus-Carpinus* zone.
3. 105– 60 cm *Betula-Quercus-Corylus-Fagus-Carpinus* zone.
2. 120–105 cm *Tilia-Betula-Quercus-Corylus* zone.
1. 170–120 cm *Tilia-Quercus-Corylus* zone.

### Zone 1 (170–120 cm)

This zone, which corresponds with the detritus muds of Bed E and lower Bed D, shows a consistent lime-oak-hazel association, with traces of other tree species

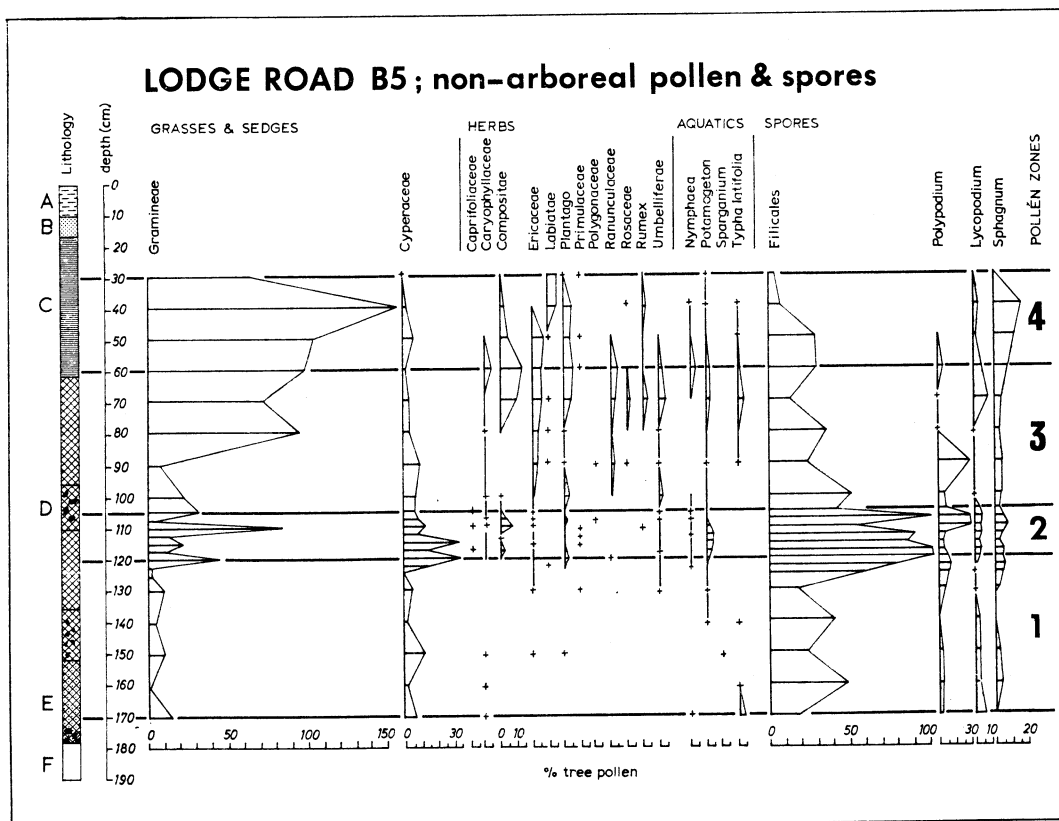


FIG. 6.

Lodge Road; Borehole B5; Non-arboreal pollen and spore diagram.

(birch, pine (*Pinus* sp.), elm (*Ulmus* sp.), alder and beech). There is very little willow pollen, so that carr development of the hydrosere may be discounted at this stage. Bed E (between 150 cm and 170 cm) is dated at  $4,290 \pm 100$  B.P. (2340 B.C.) (Birm. 525) indicating commencement of sedimentation in the late Neolithic and early Bronze Age period. There are many similarities between this part of the diagram and that described by Girling and Greig (1977) from Hampstead Heath. There, a similar soligenous bog yielded pollen spectra probably covering the same period as that described here.

*Tilia* (lime) dominates the tree pollen (Fig. 5) with frequencies between 55% and 65% of arboreal pollen. *Quercus* (oak) reaches a maximum of 41% but declines to 18%, while *Corylus* (hazel) maintains levels between 18% and 26%. Non-arboreal genera (Fig. 6) are poorly represented, though there are abundant fern spores. The basal layers thus denote the initial hydrosereal stage of a valley flooding within a closed lime-dominated forest.

The dominance of lime is reinforced by the fact that the genus is zoogamous (insect-pollinated) and is often under-represented in the pollen rain (Godwin, 1975a). Other tree species may also be misrepresented in pollen diagrams because of differential pollen production and dispersal. Accordingly, certain authors (Faegri and Iversen, 1964; Andersen, 1970) have advised correction factors to be applied

to the absolute pollen frequencies. The arboreal diagram from Lodge Road has been corrected in this manner (Fig. 7), using Andersen's factors (Andersen, 1970, 1973). The correction factors are: *Betula*  $\times \frac{1}{4}$ ; *Pinus*  $\times \frac{1}{4}$ ; *Ulmus*  $\times \frac{1}{2}$ ; *Quercus*  $\times \frac{1}{4}$ ; *Tilia*  $\times 2$ ; *Alnus*  $\times \frac{1}{4}$ ; *Carpinus*  $\times \frac{1}{3}$ ; *Fagus*  $\times 1$ . The corrected diagram highlights the overwhelming dominance of *Tilia* in Epping Forest in the early Bronze Age period; figures commence at 86% and increase to a remarkable 96% at 125 cm (Fig. 7). Other woodland species (oak, birch, elm and beech) are shown to be virtually eclipsed by lime, so much so that the term *Tilia* consociation (i.e. a climatic climax community dominated by a single species) may not be inappropriate.

### Zone 2 (120–105 cm)

At about 120 cm fundamental changes in woodland composition appear to take place (Fig. 5). *Tilia* levels decline dramatically from 58% to 10% and this is accompanied by a corresponding rise in *Betula* (birch) from 5% to 52%. *Quercus* achieves a temporary peak of 42%, and *Corylus* a temporary peak of 63%. Corrected pollen frequencies (Fig. 7) show that the drop in lime is the first of two stages of lime decline, and that lime is replaced initially by oak (20%) and birch (30%), only later to be replaced by beech (see below). *Salix* and *Alnus* curves (Fig. 5) expand in zone 2, and these disturbed conditions are accompanied by significant changes in non-arboreal pollen (Fig. 6). Grasses and sedges fluctuate widely, herbs become more varied, and fern spores achieve maximum values of over 100%.

Two changes of vegetation are thus discernible in zone 2. Firstly, there was a rapid decrease in overall *Tilia* stands (similar to those described by Turner (1962, 1965), Andersen (1973), Godwin and Vishnu-Mittre (1975) and Girling and Greig (1977)) and their rapid replacement by pioneer birch with expansion of oak and hazel. Secondly, there were internal hydrosereal changes from open water to fen and carr as indicated by the expansion of the alder, willow and sedge curves, continuous curves of *Sphagnum* (above 130 cm) and Ericaceae (above 110 cm) suggest development of Sphagnetum and heath communities too.

Two radiocarbon dates within Bed D provide chronological limits for the *Tilia* decline. At the commencement of the decline (120–110 cm) a date of  $1,350 \pm 100$  B.P. (A.D. 600) was obtained (Birm. 690). During the decline (110–95 cm) a second date of  $1,110 \pm 160$  B.P. (A.D. 840) was obtained (Birm. 582). These dates indicate that *Tilia* disappearance was essentially a Saxon phenomenon.

### Zone 3 (105–60 cm)

Zone 3 is characterized by a second fall in *Tilia* frequencies, and the emergence of the familiar *Fagus* (beech)–*Carpinus* (hornbeam) association which, with oak and birch, typifies the existing Forest. Woodland composition in zone 3 is the most varied in the diagram; *Betula* is apparently dominant (54% declining to 27%), *Quercus* is generally steady at 35%, and *Corylus* varies from 20% to 52%. The most important feature of zone 3 is the first appearance of *Carpinus*, and the rational limit\* of *Fagus*. Hornbeam reaches 7% while beech expands rapidly to a maximum of 32% (Fig. 5). Corrected figures (Fig. 7), in which the proportions of both *Tilia*

\* Rational limit is the point at which the pollen curve begins to rise to sustained high levels, as opposed to the empirical limit, which is the point at which the pollen curve becomes continuous (Smith and Pilcher, 1973).

and *Fagus* are increased relative to other species (Andersen, 1970), show beech to be the major colonizer of areas cleared of lime; after the first lime decline, beech expands to 26%, and this increases further to 62% after the second lime decline (at 80 cm) (Fig. 7). The magnitude of the lime declines is also clarified in the corrected diagram (Fig. 7); the first decline is a reduction from 96% to 45%, followed by a plateau at about 40% until 80 cm, where the second rapid decline sets in, falling to 3%.

Non-arboreal elements show impressive gains during zone 3 (Fig. 6), particularly grasses, composites and plantains together with a greater variety of other herbs. This suggests the most open woodland conditions in the whole period covered by the complete pollen diagram. In terms of hydroseral succession, zone 3 shows continuous curves of heather and *Sphagnum*, an expansion of grasses and a persistence of sedges with some representation of aquatics (*Potamogeton*, *Nymphaea*, *Typha latifolia*); this suggests a stabilization of the hydrosere to fen, heath and *Sphagnetum* communities, although open water and swamp conditions probably persisted.

#### Zone 4 (60–30 cm)

This final zone, from the fibrous peat layer, Bed C, corresponds most closely with the woodland composition of the existing Forest. Pollen is strongly dominated by *Betula* (up to 65%) with substantial though decreasing values for *Quercus*

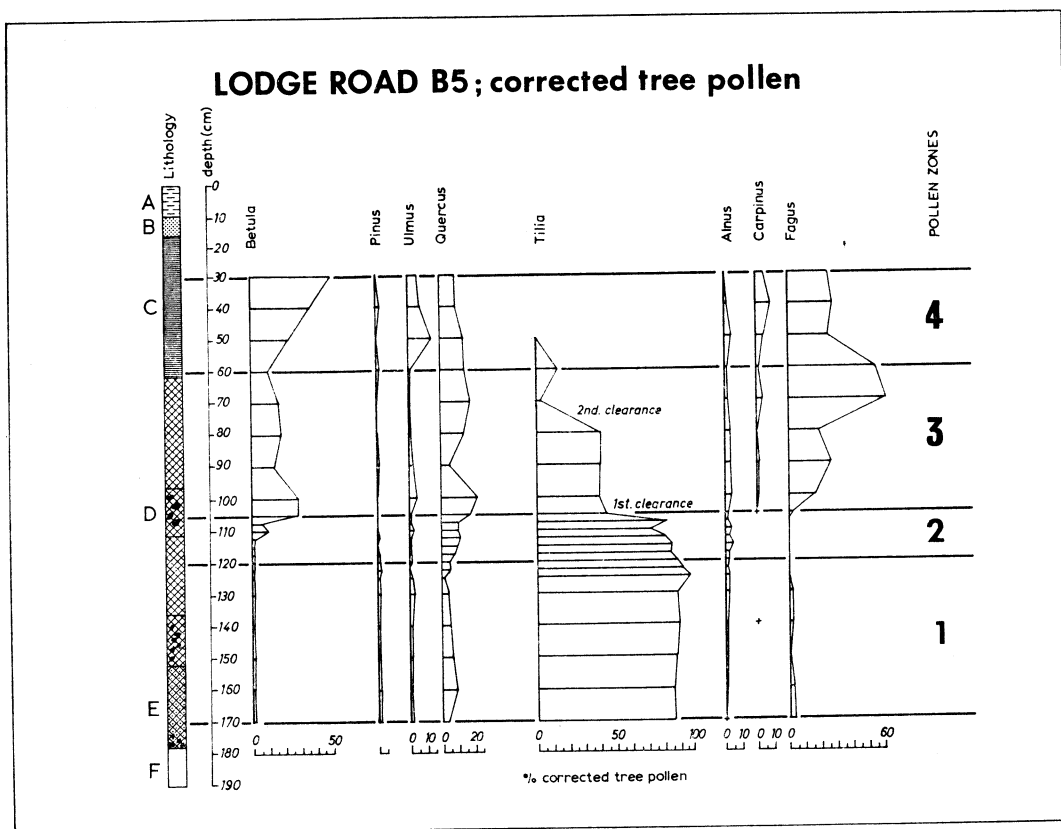


FIG. 7.

Lodge Road; Borehole B5; Corrected arboreal pollen diagram.

(35% declining to 12%). *Corylus* also declines, though more dramatically (43% to 4%). *Carpinus* and *Fagus* together account for about 20% of arboreal pollen. *Tilia* is completely phased out by 50 cm; *Alnus* too drops to negligible proportions, while *Salix* conversely expands to 30%. An interesting development in zone 4 is a temporary recovery of *Ulmus* (elm), rising to 12% at 50 cm. A similar pattern of woodland change is revealed in the corrected pollen frequencies (Fig. 7), though *Fagus* is proportionately better represented (25%).

By the end of zone 4, therefore, the present woodland association appears to be well established: lime has completely disappeared, hazel is declining, and the familiar beech-hornbeam-oak-birch association is established. Minor differences appear, however, when the existing woodland composition is compared with the highest available pollen spectrum (30 cm). These are examined in Table 3, where

Table 3. *Present-day woodland composition and pollen rain compared with the highest available pollen spectrum (B5, 30 cm)*

Tree species	B 5 (30 cm) pollen (% corrected tree pollen frequencies)	Present-day pollen (moss cushion sample; % tree pollen frequencies)	Woodland composition (% mature trees in 200 m radii estimate)
<i>Betula</i>	52	31	20
<i>Quercus</i>	10	14	11
<i>Fagus</i>	25	47	67
<i>Carpinus</i>	6	5	2
<i>Ulmus</i>	6	0	0
<i>Pinus</i>	0	3	0

the local woodland composition is estimated by 200-m transects radiating from the bog, and contemporary pollen rain is estimated by pollen recovered from a moss cushion sample located 10 m from the bog edge.

Table 3 allows the following tentative conclusions to be drawn concerning recent woodland change. (a) Birch has probably decreased in importance. (b) Oak has remained stable. (c) Beech has greatly expanded. (d) Hornbeam shows little evidence of change. (e) Elm has locally disappeared, though it is still found in small areas of the Forest. (f) Pine is largely absent from the Forest; the presence of its pollen in the Lodge Road deposits may be due to long-distance transport, as suggested by Faegri and Iversen (1964) for sites where pine values are less than 10%. This interpretation may well be applicable to all pine pollen grains identified in the diagram.

Differences may also be observed between the pollen spectra of zone 4 (Fig. 6) and the existing bog vegetation (Fig. 3). Amongst the non-arboreal pollen, grasses achieve exceptionally high levels, though sedges, herbs and ferns appear to decline (Fig. 6). Both *Sphagnum* (17%) and *Salix* (30%) are well represented. Within zone 4, therefore, we may assume that open water and swamp species have gone, and that sedge fen, *Sphagnetum*, heath and willow carr communities are well-established. Since that time, we may infer the local extinction of sedges, a reduction in willow carr, and a partial reversion to open water and swamp (Fig. 3). This hydrosereal reversion may be accounted for by a recent history of considerable disturbance, including a temporary phase of soil erosion (denoted by Bed B), the reconstruction of Lodge Road in the eighteenth century (see below), the possible diversion of



drainage water into the bog from the Epping New Road in the early nineteenth century, and anti-tank ditch construction during the 1939–1945 war.

### DISCUSSION

The radiocarbon-dated pollen sequence outlined above points to a continuity of woodland cover within Epping Forest from the late Neolithic period to the present day. Changes in species composition appear to be related on the one hand to a major disturbance of former *Tilia*-climax woodland, and, on the other, to local hydrosere succession. Since the diagram covers the late Postglacial period only, the observed variations in the vegetation are unlikely to be due to climatic change alone (Godwin, 1975*b*), but must rather be seen as a response to other factors such as forest clearance, burning, or soil deterioration.

#### (a) *Tilia*-dominated woodland

Pollen evidence from zone 1 (Figs. 5 and 7) supports a growing body of opinion that *Tilia* was abundant over much of southern and eastern England in early Neolithic times (5,000 years ago), before human interference with woodland became a major factor (Godwin, 1975*b*; Moore, 1977). Furthermore, the present data are significant in yielding the largest recorded *Tilia* frequencies of all known Postglacial sites. The uncorrected figure of 65% of arboreal pollen (Fig. 5) and the corrected figure of 96% (Fig. 7) are greatly in excess of other figures reported from Holme Fen (50%) (Godwin and Vishnu-Mittre, 1975), Hothfield Common (40%) (Webb, quoted in Moore, 1977), Old Buckenham Mere (30%) (Godwin, 1968), and Hampstead Heath (30%) (Girling and Greig, 1977). Overall lime pollen frequencies for south-eastern England at 5,000 B.P. (3050 B.C.) are assumed to have been in the order of 11–15% (Birks, Deacon and Peglar, 1975), and lime-dominated woodland in Denmark (Eldrup Forest, East Jutland) shows sustained levels of 20% at about the same time (Andersen, 1973).

In comparison with the Hampstead Heath site (Girling and Greig, 1977), the uncorrected figures for Lodge Road (Fig. 5) show a remarkably similar woodland composition, dominated by lime, oak and hazel. Consequently, we have no reason to believe that the two sites, which are only 21 km apart, differ greatly in age. Girling and Greig claim an Atlantic age (zone VIIa, between 5100 and 3050 B.C.) for the base of their diagram. This chronology, however, was based on an apparent elm decline (assumed to mark the Atlantic-Sub-Boreal transition) and not on any  $^{14}\text{C}$  dates. Both the Epping and Hampstead Heath diagrams are believed by us to be Sub-Boreal in age; both postdate the early Postglacial and mid-Postglacial sequences recorded in mere and peat deposits of the Lea valley at Nazeing (Allison, Godwin and Warren, 1952). The highly localized dominance of *Tilia* in Epping Forest can be gauged from comparative pollen frequencies recorded at Nazeing (18%) and Hampstead (30%). The *Tilia*-dominated forest, with or without correction, demonstrates how small basins give a different picture of woodland composition compared with larger basins which tend to have low levels of poorly dispersed lime pollen (Iversen, 1960). Evidence from soil pollen examined by T. Keatinge at Trotton Common, Sussex, indicates considerable local variation in *Tilia* pollen levels, suggesting that peaks may be very local, i.e. in the order of 20 m or so. It is

therefore possible that one might have very local accumulations of *Tilia* pollen in the vicinity of lime trees in mixed woodland (P. Moore, pers. comm.).

### (b) Cause of *Tilia* decline

The *Tilia* decline is a widely recognized phenomenon in late Postglacial pollen diagrams. Godwin's original hypothesis of climatic deterioration affecting this thermophilous tree (Godwin, 1956) has now been superseded by an anthropogenic hypothesis (Turner, 1962, 1965; Pigott, 1969; Godwin, 1975*a*, 1975*b*; Moore, 1977). Turner (1962) first showed that the decline was not synchronous with any one cultural period and attributed it to clearances that took place during the Neolithic, Bronze and Iron Age periods. Godwin (1975*b*) remarks that lime "was a numerous component of undisturbed mixed oak forests of zones VIIa and VIIb" and that "the value of the tree for leaf-fodder and bast fibre . . . induced strongly selective felling and suppression of it". Also, both native species of lime (*Tilia cordata* and *T. platyphyllos*) are generally associated with base-rich soils of mull humus type (Moore, 1977), so that cleared areas were well suited to cultivation. Iversen (1952), Dimbleby (1962) and Andersen (1973), however, have shown that lime formed a large part of the original forest on sandy soils that are today podzolic: this would accord with the evidence from Epping and Hampstead where acidic soils are developed on the Bagshot and Claygate strata.

Turner (1962) clearly demonstrated the close relationship between areas of *Tilia* clearance and subsequent expansion of grass, plantains, bracken and ruderal species indicative of human interference and cultivation. In the Epping Forest environment, the greater proportion of grasses, plantains and bracken (Fig. 6) over arable weeds of cultivation (*Artemisia*, *Rumex*, *Chenopodium*, etc.) points to a pastoral rather than arable economy at the time of woodland clearance (Turner, 1965). The nature of the clearance was probably selective felling with burning, as suggested by the charcoal remains at the clearance level (Fig. 5). Similar charcoal fragments are evident at Hampstead Heath (Girling and Greig, 1977).

The exposure of woodland soils by these clearances would have initiated soil erosion and a certain degree of podsolization, as well as encouraging alluviation of sediment in the lower valley sites. Thin clay bands in Holme Fen were interpreted by Godwin and Vishnu-Mittre (1975) in terms of alluviation following selective clearance of *Tilia*. In the Lodge Road sediments, however (Tables 1 and 2), there is no obvious indication of accelerated soil erosion in the lithology at either the first or second phase of lime clearance. There is a marked increase in organic content, though, and an increase in clay/silt content above 115 cm (Table 2), which is accompanied by a significant change in the sedimentation rate of the hydrosere. Up to 115 cm, a sedimentation rate of 15.3 cm/1,000 years applies: this is a very slow rate of accumulation in comparison with average rates of 48 cm/1,000 years for fine detritus muds estimated by Walker (1970). Above 115 cm, the sedimentation rate accelerates to 94.6 cm/1,000 years, a figure more in line with deposition in Holme Fen (87–91 cm/1,000 years) (Godwin and Vishnu-Mittre, 1975) and in Newport Pond (116 cm/1,000 years) (Baker, 1977). This marked change in the sedimentation rate is believed to reflect an increase in sediment yield consequent upon the temporary lime clearances in Epping Forest. The high rate of sedimentation may have been maintained in the historic period by the

practice of pollarding. By creating a more open canopy and reducing overall evapotranspiration levels, pollarding and grazing in recent times may well have increased the likelihood of woodland soil erosion. Evidence of this erosion may be seen in increased alluviation in the Lea valley since the Atlantic period. Alison *et al.* (1952), in describing the stratigraphy at Nazeing, comment that "At some undetermined date the exposure of the upland forest soils to erosion led to the sealing in of all the organic muds and peats by a fresh-water clay laid down by flood-water."

### (c) Date of *Tilia* decline

The *Tilia* decline was not a synchronous event. Turner (1962, 1965) attributed lime clearance at seven widely dispersed sites to the influence of late Neolithic, Bronze Age and early Iron Age man. More recent work on radiocarbon-dated sites largely corroborates this chronology (Table 4).

Table 4. Radiocarbon-dated *Tilia* clearances

Date	Period	Location	Author
<3390 B.C.	Neolithic	Eldrup Forest, East Jutland	Andersen, 1973
2593 B.C.	Neolithic	Mordon Carr, Durham	Bartley <i>et al.</i> , 1976
2060 B.C.	Late Neolithic	Rishworth Moor, Yorkshire	Bartley, 1975
2015-			
1920 B.C.	Late Neolithic	Shapwick Heath, Somerset	Turner, 1962
1790 B.C.	Early Bronze Age	Leash Fen, Derbyshire	Hicks, 1971
1710 B.C.	Early Bronze Age	Bishop Middleham, Durham	Bartley <i>et al.</i> , 1976
1445-			
1400 B.C.	Middle Bronze Age	Holme Fen, Huntingdon	Godwin and Vishnu-Mittre, 1975
1277 B.C.	Late Bronze Age	Whixall Moss, Shropshire	Turner, 1962
1210-			
971 B.C.	Late Bronze Age	Thorne Waste, Yorkshire	Turner, 1962
368 B.C.	Early Iron Age	Thorne Waste, Yorkshire	Turner, 1962
600 A.D.	Anglo-Saxon	Epping Forest, Essex	Present study

In view of the concentration of dates within the Neolithic, Bronze and Iron Age periods (Table 4), the Saxon date for *Tilia* decline in Epping Forest is unusually late and constitutes the latest known lime clearance of all available Postglacial sites. The possibility of contamination of samples by modern organic material (Shotton, 1967) must, however, be considered. The first date (A.D. 840 $\pm$ 160) (Birm. 582) was secured from fine organic debris from Bed D by multiple auger shots; contamination may thus have been a possible source of error. The second sample (Birm. 690), however, was obtained from larger wood fragments washed from 10 kg of sediment secured directly from an open pit face. A valid and consistent date (A.D. 600 $\pm$ 100) was obtained. Neither date carries a large standard error, and the degree of modern contamination necessary to give a date of A.D. 840 on, say, Bronze Age material (1,000 B.C.) would be in the order of 57% (Shotton, pers. comm.). Consequently, we are confident that the  $^{14}\text{C}$  dates are authentic, and not the result of contamination.

This being so, the question remains as to why the lime decline was so inordinately late in Epping Forest. Any explanation must be sought within the context of both

the local topography and our knowledge of the history of the area during the time that the clearance occurred.

Various writers have commented on the frequency of Saxon place-names in the area around Epping Forest, and have inferred a major Anglo-Saxon incursion into the district, probably via the Thames, Roding and Lea (Wooldridge and Smetham, 1931; Reaney, 1935; Munby, 1977).

The Lodge Road pollen data suggest that the main period of lime decline coincides with the middle Saxon period (A.D. 600–850). This was a time of major settlement and cultural change, analagous to the nineteenth-century settlement of the U.S.A. With the increase in population, the new settlers would have been obliged to make greater use of the marginal lands on the poorer soils of the Forest ridge. It is significant that this was the period that saw the origins of the manorial system, and probably the formal recognition of the status of the watershed as an inter-commoning area for pasture and as a source of timber and wood (Stamp and Hoskins, 1963). The pattern of the manorial boundaries, stretching from the main lines of communication and foci of settlement in the valleys, up to the grazing lands and wood resources of the ridge, reflect the adjustment of political organization to economic need (Huggins, pers. comm.).

This social pattern was sufficiently well established in the middle Saxon period for it to survive the more troubled times that followed when Danish raiding parties disrupted settlements in the Lea valley (*Anglo-Saxon Chronicle*, trans. Garmonsway, 1954) and the river became the boundary between Wessex and Danelaw (Munby, 1977). It is possible that the second fall in the *Tilia* frequency, seen in zone 3, may reflect an intensification of the use of the ridge, which offered relatively secluded grazing areas away from the main river valleys that appear to have been the major scene of conflict between the Saxons and Danes.

Pigott (1969) considers that woodlands containing lime species have often remained undisturbed over long periods of time. It therefore seems reasonable to infer from the late persistence of lime on the Epping Forest ridge that the area was relatively undisturbed until the middle Saxon period and that the use of the ridge during earlier cultural phases was extensive rather than intensive. Only with the middle Saxon settlement did the Forest ridge become used in any organized way and, by the thirteenth century, historical records show that large areas were being systematically cleared of trees (Buxton, 1884).

#### (d) Woodland succession following *Tilia* decline

The vegetation succession following lime clearance, in Britain and elsewhere, has been examined by various authors (see Table 4; also Iversen (1952) and Pigott (1969)). The present data reveal that during the first lime clearance (zone 2) the *Tilia* was replaced initially by hazel and birch, with some expansion of oak. Only after this stage did beech and hornbeam become established (zone 3), and of these two species beech appears to have been the more successful (Fig. 7). Both zones 2 and 3 are accompanied by an increase in *Salix* (Fig. 5) and herb species (Fig. 6), reflecting the opening of the Forest canopy. All these changes in the vegetation, it must be emphasized, occurred quite rapidly within the last 1,350 years. After clearance, *Tilia* never again plays an important part in woodlands (Turner, 1962; Godwin, 1975a), and this seems to be true of Epping Forest. Lime is not

recorded in historical time as a native to the Forest, and the small number of *Tilia cordata* that are found in the area today are the result of nineteenth-century plantings. Although *Tilia* was probably widely distributed throughout Essex in Atlantic and Sub-Boreal times (Allison *et al.*, 1952; Birks *et al.*, 1975; Baker, 1977), it is now considered to be native in only a relatively small number of woodland sites in the north of the County (Jermyn, 1974), where it is found associated with sandy loams (Moxey, 1976). At Hayley Wood, Cambridgeshire, Rackham (1975) suggests the species has survived because it has been accepted into coppice cycles.

Turner (1962, 1965) and Godwin and Vishnu-Mittre (1975) observed grass-plantain maxima associated with lime clearance, together with other ruderal species from which strong human influence was inferred. The tree species that replaced lime were, however, variable from site to site. In most sites, replacement was by hazel and birch, with only temporary alterations in oak and elm (Turner, 1962, 1965), but at Holme Fen the tree genera were not differentially affected (Godwin and Vishnu-Mittre, 1975). Pigott (1969) considers ash, elm and sycamore to be replacers of disturbed lime woodland, but this succession is probably typical only on limestone soils. At Hampstead, lime is replaced principally by alder and open ground herbs, with only minor fluctuations in birch, oak and hazel (Girling and Greig, 1977). The site that shows the closest similarity to Epping Forest is that at Eldrup Forest (Andersen, 1973), where "stage II" is characterized by *Tilia* forest; a dramatic lime decline is observed shortly after 3390 B.C., and oak and birch become initially dominant with moderate increases in hazel ("stage III"). There are distinct maxima also in *Salix* pollen and wild grass pollen (mainly *Glyceria* and *Molinia*) at the same time. Only after this clearance phase does *Fagus* become dominant ("stage IV"). This is remarkably similar to the succession observed in Epping Forest. Iversen (1964) also notes the same succession—lime-oak-beech—developed on what are now podsolic soils in Denmark.

The behaviour of *Fagus* itself, greatly expanding within the Sub-Atlantic, is not due to increased oceanity, but to the manner in which beech massively invaded areas of former oak forest cleared by man and subsequently released for re-colonization (Godwin, 1975*b*). This fact emphasizes that lime clearance in Epping Forest by Saxon settlers was, for all its severity, a temporary phenomenon, the cleared areas being later abandoned as oak and beech invaded them. This abandonment was probably due in part to the nature of beech as a heavy shade-casting species (Andersen, 1973), and as a soil degenerator, an effect observed by Dumbleby and Gill (1955) in the New Forest. Thus, although earlier writers (Paulson, 1926) considered beech to have been the natural climax of Sub-Atlantic climatic conditions in Epping Forest, its prominence must be attributed largely to human activity.

The temporary regeneration of elm in zone 4 (Figs. 5 and 7) is an interesting feature, particularly in view of its rather exacting soil requirements, favouring base-rich loams. It is possible that it could have been introduced artificially in the manner discussed by Richens (1956) and used as a forage tree.

#### (e) Neolithic influence

Lodge Road impounds two valley bogs, one of which is the subject of this study. It is therefore reasonable to assume that it was the construction of the road that was responsible for initiating the formation of the bogs, and that they would date

from the time that the road was built. However, radiocarbon dating shows the commencement of sedimentation at *c.* 2340 B.C. (late Neolithic), whilst the earliest written reference to the existence of the road gives a date of 1707, when a licence was granted to make a road and avenue from the Epping highway to Copt Hall Park (Fisher, 1887).

Documentary evidence, however, exists to show there was a track on the line of Lodge Road before the eighteenth century. A map of Waltham Abbey and its surroundings, dated to *c.* 1590 and in the possession of the Marquis of Salisbury at Hatfield House, clearly shows a road on the line of the present one, but extending to the east to join the Theydon Road about half a kilometre east of the Wake Arms, where it joins the manorial boundary between Theydon Bois and Loughton. The tithe map for Theydon Bois, dated 1848, and the first edition of the Ordnance Survey, six-inch scale, surveyed between 1870 and 1872, clearly indicate a trackway following on this line to cross the River Roding between Abridge and Debden and continuing in a south-easterly direction towards Romford. Field survey in the late summer of 1977 revealed that parts of this line may still be traced on the ground.

This documentary and field evidence suggests that Lodge Road lies on an earlier trackway; in light of the radiocarbon date for the origin of the bog, that trackway may have been Neolithic in origin.

Archaeological evidence from other parts of Britain (Godwin, 1960; *Somerset Levels Papers*, 1975, 1976) has shown that prehistoric tracks across marshy sites were constructed on wooden causeways; such a causeway carrying an early track on the line of Lodge Road could have initiated the formation of the bogs. Much of this is of course, hypothetical and the evidence circumstantial, but certain critical facts remain. The radiocarbon dates from the base of the bog at Lodge Road indicate a Neolithic origin; both documentary and field evidence suggest that the present Lodge Road is on the line of a route of much greater age than the 1707 reference indicates; finally, the apparent reversal of the hydrosere noted at 30 cm in the pollen diagram could approximately coincide with the "construction" of Lodge Road in the early eighteenth century and the consequent flooding of the site. In the absence of other evidence, the existence of a Neolithic trackway must be considered at least a possibility.

#### SUMMARY AND CONCLUSIONS

The pollen profile and radiocarbon dates from the Lodge Road site provide a valuable insight into the vegetation history of the Epping Forest ridge. Whilst it has for long been assumed that the area is one of ancient woodland, the Lodge Road site points to a continuity of tree cover from the Neolithic period until the present time. Contrary to the opinion that is sometimes expressed, there is no evidence to support the view that Iron Age man was responsible for extensive woodland clearances; whilst it is clear that both the Belgae and earlier Iron Age peoples made use of the Forest, the modern evidence supports the contemporary witness of Julius Caesar in suggesting that their activities were carried out in a woodland environment.

The pollen data do, however, indicate a change in the composition of the woodland, with a remarkably late survival of *Tilia* until the middle Saxon period. Whilst this suggests that the *Tilia* decline in Epping Forest was considerably later than

in any other known site, it is compatible with the historical and archaeological evidence. It also indicates that the familiar woodland associations of the modern Forest—beech-birch and oak-hornbeam—are a relatively late development.

Whilst the Lodge Road data are of considerable value in interpreting the history of the Forest, the evidence assumes a wider significance in being from the only site of its kind to have been examined within a surviving ancient woodland in Britain; it is also one of the relatively small number of localities within south-east England from which such data has been published. As such it suggests that the history of *Tilia* decline and the general pattern of vegetational change may be more complicated than hitherto suspected.

#### ACKNOWLEDGEMENTS

The original basis for this work was an undergraduate dissertation carried out by one of the authors (Oxford, 1974) at King's College, University of London. Since then, it has been considerably expanded, and the nature of its multi-disciplinary approach has, inevitably, meant consultation with many people in many areas of study. In particular we would like to thank: The Conservators of Epping Forest, for permission to work on the site; the Departments of Geography and Geology at King's College, London, for financial assistance to meet the cost of radiocarbon dating; Judy Smith, Dr Ann Thorley and Dr Judith Turner for their comments on the pollen profile; Dr Ken Adams for botanical advice; Professor F. W. Shotton for providing the facilities for radiocarbon dating and discussion of its interpretation; Dr John Alexander and Professor G. W. Dimbleby for archaeological advice; Hazel Faulkner for discussions of the Forest hydrology; Rhona and Peter Huggins for their advice on the Anglo-Saxon period; Paul Moreland for his assistance in tracing sources of Classical scholarship; Dr Ken Bascombe and the Essex Record Office for access to documentary sources and assistance in their interpretation; Tricia Moxey for assistance in field survey; Bill Liddell, Dr Peter Moore and Dr Francis Rose for their encouragement and helpful discussion of the manuscript.

We are grateful to them all for the courtesy of their time and trouble, without which our task would have been immeasurably more difficult. Any errors are, of course, our own.

#### REFERENCES

- ADDISON, Sir William. (1977). *Portrait of Epping Forest*. Robert Hale, London.
- ALLISON, J., GODWIN, H., and WARREN, S. H. (1952). Late-Glacial deposits at Nazeing in the Lea valley, north London. *Phil. Trans. Roy. Soc., B* **236**, 169.
- ANDERSEN, S. T. (1970). The relative pollen productivity and pollen representation of North European trees and correction factors for tree pollen spectra. *Danm. geol. Unders., Ser. II*, **96**, 99p.
- ANDERSEN, S. T. (1973). The differential pollen productivity of trees and its significance for the interpretation of a pollen diagram from a forested region. Pp. 109–115 in *Quaternary Plant Ecology*, ed. H. J. Birks and R. G. West. Blackwell Scientific Publications, Oxford.
- THE ANGLO-SAXON CHRONICLE, trans. G. N. Garmonsway. (1953). Dent, London.
- BAKER, C. A. (1971). A contribution to the glacial stratigraphy of west Essex. *Essex Nat.*, **32**, 317–330.
- BAKER, C. A. (1977). Quaternary stratigraphy and environments in the upper Cam valley, north Essex. Unpub. Ph.D. thesis, University of London.
- BARTLEY, D. D. (1975). Pollen analytical evidence for prehistoric forest clearance in the upland area west of Rishworth, West Yorkshire. *New Phytol.*, **74**, 375–381.
- BARTLEY, D. D., CHAMBERS, C., and HART-JONES, B. (1976). The vegetational history of parts of south and east Durham. *New Phytol.*, **77**, 437–468.

- BIRKS, H. J. B., DEACON, J., and PEGLAR, S. (1975). Pollen maps for the British Isles 5,000 years ago. *Proc. Roy. Soc. Lond. B*, **189**, 87–105.
- BUXTON, E. N. (1884). *Epping Forest*. Edward Stanford, London.
- CARRINGTON, R. C. (Ed.) (1939). *Caesar's Gallic War*, Book V, 9: 21.
- CHAPMAN, D., and CHAPMAN, N. (1975). *Fallow Deer: their history, distribution and biology*. Terence Dalton, Lavenham.
- COLES, J. M., ORME, B. J., HIBBERT, F. A., and WAINWRIGHT, G. J. (Eds.). (1975: 1976). *Somerset Levels Papers*, Nos. 1 and 2. Joint publication of the Universities of Cambridge and Exeter.
- COTTON, M. A. (1975). Excavations at Ambresbury Banks, 1956. *Essex Nat.*, **30**, 43–44.
- DIMBLEBY, G. W. (1962). *The development of British heathlands and their soils*. Oxford Univ. Press, Oxford.
- DIMBLEBY, G. W., and GILL, J. M. (1955). The occurrence of podzols under deciduous woodland in the New Forest. *Forestry*, **28**, 95–106.
- DINES, H. G., and EDMUNDS, F. H. (1925). The geology of the country around Romford. *Mem. Geol. Surv.*, New Series **257**.
- DUNNETT, R. (1975). *The Trinovantes*. Duckworth, London.
- ERDTMAN, G., PRAGLOWSKI, J., and NILSSON, S. (1963). *An introduction to the Scandinavian pollen flora*. Vols. I and II. Almqvist Wiksell, Stockholm.
- FAEGRI, K., and IVERSEN, J. (1964). *Textbook of pollen analysis*. 2nd. edn. Blackwell, Oxford.
- FISHER, W. R. (1887). *The Forest of Essex*. Butterworths, London.
- GILLAM, G. R. (1973). Prehistoric and Roman Enfield. *Enfield Arch. Soc. Research Report*, No. 3.
- GIRLING, M., and GREIG, J. (1977). Palaeoecological investigations of a site at Hampstead Heath, London. *Nature*, **268**, 45–47.
- GODWIN, H. (1956). *The History of the British Flora*. Cambridge Univ. Press, Cambridge.
- GODWIN, H. (1960). Prehistoric Wooden Trackways of the Somerset Levels: their construction, age and relation to climatic change. *Proc. Prehistoric Society*, **XXVI**, 1–36.
- GODWIN, H. (1968). Studies of the Postglacial history of the British vegetation, XV: Organic deposits of Old Buckenham Mere, Norfolk. *New Phytol.*, **67**, 95.
- GODWIN, H. (1975a). *The History of the British Flora*. 2nd. edn. Cambridge University Press, Cambridge.
- GODWIN, H. (1975b). History of natural forests of Britain: establishment, dominance and destruction. *Phil. Trans. Roy. Soc. B* **271**, 47–67.
- GODWIN, H., and VISHNU-MITRE. (1975). Studies of the Postglacial history of the British vegetation, XVI: Flandrian deposits of the Fenland margin at Holme Fen and Whittlesey Mere, Hunts. *Phil. Trans. Roy. Soc. B* **270**, 561–608.
- HICKS, S. P. (1971). Pollen analytical evidence for the effect of prehistoric agriculture on the vegetation of north Derbyshire. *New Phytol.*, **70**, 647.
- HUGGINS, P., and HUGGINS, R. (1971). Waltham Abbey. *The London Archaeologist*. Vol. I, No. 11.
- IVERSEN, J. (1952). Retrogressive vegetational succession in the Postglacial. *J. Ecol.*, **52** (Suppl.), 59–70.
- IVERSEN, J. (1960). Problems of the Early Postglacial forest development in Denmark. *Danm. geol. Unders.*, Ser. IV, **4** (3), 32 pp.
- JERMYN, S. T. (1974). *Flora of Essex*. Essex Naturalists' Trust, Colchester.
- LAUNDON, J. R. (1967). A study of the lichen flora of London. *The Lichenologist*. Vol. 3, Pt. 3, pp. 277–327.
- LEUTSCHER, A. (1974). *Epping Forest: its history and wildlife*. David and Charles, Newton Abbot.
- LLOYD, ERNEST G. (1977). The Wild Service Tree *Sorbus torminalis* is Epping Forest. *Lond. Nat.*, **56**, pp. 22–28.
- MARSHALL, K. (1959). Excavations at a Mesolithic site near High Beach, Epping Forest. *Essex Nat.*, **30**, 163.
- MOORE, P. D. (1977). Ancient distribution of lime trees in Britain. *Nature*, **268**, 13.
- MOXEY, P. (1976). "Woodland in Essex", in *Essex—A Guide to the Countryside*. County Guide Publications, Letchworth.
- MOXEY, PAUL A. (1977). "Oak-hornbeam woodland: perspective and possibilities", in *Research and Management in Wildlife Conservation*, Nos. 3 and 4. Hertfordshire and Middlesex Trust for Nature Conservation, Hertford.
- MUNBY, LIONEL M. (1977). *The Hertfordshire Landscape*. Hodder and Stoughton, London.



- OXFORD, P. M. (1974). A Pollen Analytical Investigation into the Vegetational History of Epping Forest. Unpublished B.A. dissertation, Dept. Geography, King's College, London.
- PAULSON, R. (1926). The Beechwood: its canopy and carpet. *The South Eastern Naturalist*, **31**, 24–37.
- PETERKEN, G. F. (1974). A Method for Assessing Woodland Flora for Conservation Using Indicator Species. *Biological Conservation*, **6**, 239–245.
- PIGOTT, C. D. (1969). The status of *Tilia cordata* and *T. platyphyllos* on the Derbyshire limestone. *J. Ecol.*, **57**, 491–504.
- PITT-RIVERS, A. (1881). Report on the Excavations of the Earthwork known as Ambresbury Banks, Epping Forest. *Trans. Epping Forest and County of Essex Field Club*, **II**, 55–68.
- QVIST, A. (1958). *Epping Forest*. Corporation of London.
- RACKHAM, OLIVER (1975). *Hayley Wood: its History and Ecology*. Cambridgeshire and Isle of Ely Naturalists' Trust, Cambridge.
- RACKHAM, OLIVER (1976). *Trees and Woodland in the British Landscape*. Dent, London.
- REANEY, P. H. (1935). *The Place-Names of Essex*. Cambridge University Press, Cambridge.
- RICHENS, R. H. (1956). Elms. *New Biology*, **20**, 7.
- ROSE, F. (1953). A survey of the ecology of the British lowland bogs. *Proc. Linn. Soc.*, **164**, 186–211.
- ROSE, F. (1976). Lichenological indicators of age and environmental continuity in woodlands. Systematics Assoc. Special Vol. No. **8** “*Lichenology: Progress and Problems*”, Ed. Brown, D. H. Hawksworth, D. L., and Bailey, R. H., pp. 279–307. Academic Press, London and New York.
- RUTTER, F. (1949). *Vegetation of Epping Forest*. Unpub. report of the Nature Conservancy.
- SHOTTON, F. W. (1967). The problems and contributions of methods of absolute dating within the Pleistocene period. *Q. Jl. geol. Soc. Lond.*, **122**, 357.
- SMITH, A. G., and PILCHER, J. R. (1973). Radiocarbon dates and vegetational history of the British Isles. *New Phytol.*, **72**, 903–914.
- STAMP, L. D., and HOSKINS, W. G. (1963). *The Common Lands of England and Wales*. Collins, London.
- TURNER, J. (1962). The *Tilia* decline: an anthropogenic interpretation. *New Phytol.*, **61**, 328–341.
- TURNER, J. (1965). A contribution to the history of forest clearance. *Proc. Roy. Soc. B* **161**, 343–354.
- TURNER, J. (1970). “Post Neolithic disturbance of the British vegetation” in *Studies in the Vegetational History of the British Isles*, ed. Walker, D., and West, R. G. Cambridge University Press, Cambridge.
- WALKER, D. (1970). “Direction and Rate in some British Post-Glacial Hydroseres”, in *Studies in the Vegetational History of the British Isles*, ed. Walker, D., and West, R. G. Cambridge University Press, Cambridge.
- WARREN, S. H. (1913). Pygmy (Mesolithic) Flints in Epping Forest. *Essex Nat.*, **17**, 292.
- WARREN, S. H. (1926). Excavation in Pillow Mounds, High Beach. *Essex Nat.*, **21**, 214–226.
- WARREN, S. H. (1945). The drifts of south-western Essex. *Essex Nat.*, **27**, 173.
- WELLS, A. K., and WOOLDRIDGE, S. W. (1923). Notes on the geology of Epping Forest. *Proc. Geol. Ass. Lond.*, **34**, 244–252.
- WHEELER, R. M. (1933). Belgic cities in Britain. *Antiquity*, **3**, 21–35.
- WOOLDRIDGE, S. W., and SMETHAM, D. J. (1931). The Glacial Drifts of Essex and Hertfordshire and their Bearing upon the Agricultural and Historical Geography of the Region. *Geog. Journ.*, **LXXVIII**, 260.

**THE EPPING FOREST CONSERVATION CENTRE** is the youngest of the ten Centres managed by the Field Studies Council, having been established by the Corporation of the City of London in 1970, to mark European Conservation Year.

The Corporation of London has been responsible for the management of Epping Forest since 1878, a period of rapid and far-reaching economic and social changes. Amongst the consequences of those changes have been a greater access to the countryside for an increasingly urban population, the development of field studies as an element in formal education, and a growth of public interest in natural history and the environment. It was in response to these developments that the Epping Forest Conservation Centre was established to meet the needs of visitors to the Forest, both through formal education and public information services.

Situated in the heart of the Forest at High Beach, but only twelve miles from St. Paul's Cathedral, the Centre is within easy reach of the densely populated areas of Greater London and the adjoining parts of Essex and Hertfordshire. It consists of a group of modern buildings which include, in addition to the teaching facilities, an exhibition area, lecture theatre, library, research laboratory, and information desk. Approximately 12,000 students a year visit the Centre, ranging in age from Primary Schools to University parties; there are no residential facilities and all courses are on a day basis.

The Centre's interpretative services include, as well as the information desk and exhibition, weekend courses for adults, guided walks for the general public, holiday activities for young children, and a newsletter.

Research into, and the collection of information concerning the Forest environment is an important part of the Centre's work and is undertaken by Centre staff in collaboration with the Nature Conservancy Council, Universities, Polytechnics and other interested organizations and individuals. Such research and the building up of records is important, both for its relevance to the teaching and information services and as valuable background for those concerned with Forest management.

The Centre publishes a *Teachers' Guide*, outlining the range of course available at High Beach. Copies of this and further information about the Centre's other services are available from The Warden, Epping Forest Conservation Centre, High Beach, Loughton, Essex IG10 4AF.