POST GLACIAL HISTORY OF THE NANT HELEN OPENCAST SITE SOUTH WALES: IMPLICATIONS FOR LAND RESTORATION

F.M. CHAMBERS, J.G.A. LAGEARD
L. ELLIOTT

Occasional Paper No. 15.

Frank Chambers, spent a year's research with the Gwynedd Archaeological Trust before his appointment in 1978 as Lecturer in Biogeography at the University of Keele. He is currently Director of Keele's Environmental Research Unit.

Jonathan Lageard was employed at Keele as a research assistant on the Nant Helen Environmental Project, with the Environmental Research Unit in 1987. In 1988 he commenced a Natural Environment Research Council Studentship, based in the Department of Geography.

Lorne Elliott spent a sandwich-year placement in 1986/7 as a research assistant in Physical Geography at Keele. After completing his studies at Coventry Polytechnic, he was appointed Assistant Map Curator in the Department of Geography, University of Keele.

Further details of the Keele Geography Department Occasional Papers will be found at the back of this publication.

Department of Geography
University of Keele
KEELE
Staffordshire
ST5 5BG

Telephone Newcastle Staffs 0782 621111

ISBN 0948943 05 X

ABSTRACT

A proposal to extend opencast mining at Nant Helen Colliery, South Wales, threatened both archaeological sites and a large expanse of upland mire on Mynydd y Drum. Excavations of two cairns and a length of post-Medieval trackway were conducted there by the Clwyd-Powys Archaeological Trust in the summer of 1987. These were accompanied by palaeoecological work to ascertain both the post-glacial environmental history of Mynydd y Drum and the contemporary environmental setting of the two cairns. The treeless, moorland landscape of the present and recent past contrasts starkly with macrofossil evidence for upland carr woods in prehistory. Pollen and charcoal records suggest local human impact from the Mesolithic, with notable impacts upon woodland in the Neolithic and Bronze Ages. Evidence suggests that the most dramatic impact upon local woodland was in the early Bronze Age. The evidence for former extensive deciduous woodlands on Mynydd y Drum now offers British Coal a wider range of land restoration goals, for consideration when the opencast mining ceases.

INTRODUCTION

For coal reserves at or near the present surface, open-cast methods of extraction have certain economic advantages over other methods. There are, however, attendant disadvantages. Amongst these are the environmental problems of noise and dust from the use of heavy plant, the sheer visual intrusion of the workings, plus the ecological and environmental damage caused both directly to the areas stripped of overburden and indirectly to neighbouring areas. Various methods have been devised to mitigate the effects of overburden removal and storage, and to secure the reclamation and restoration of open-cast sites (Bradshaw & Chadwick 1980).

The existing landscape and its attendant plant communities are inevitably destroyed by open-cast methods, but it is a legal requirement that the land-use capability class should be retained or enhanced when the land is restored. Nevertheless, in previous land restorations, little attempt has been made to re-create the semi-natural plant communities which preceded the coal extraction.

In recent instances, British Coal have been persuaded that where major, irreversible environmental impact will occur, some of their funds might be directed to 'rescuing' environmental and archaeological data from the threatened sites. This paper presents the results of one such study into the environmental history of an area of Mynydd y Drum, South Wales, part of British Coal's expanded Nant Helen (opencast) Colliery. New options for the restoration of the site are then considered in the light of the palaeoecological results.

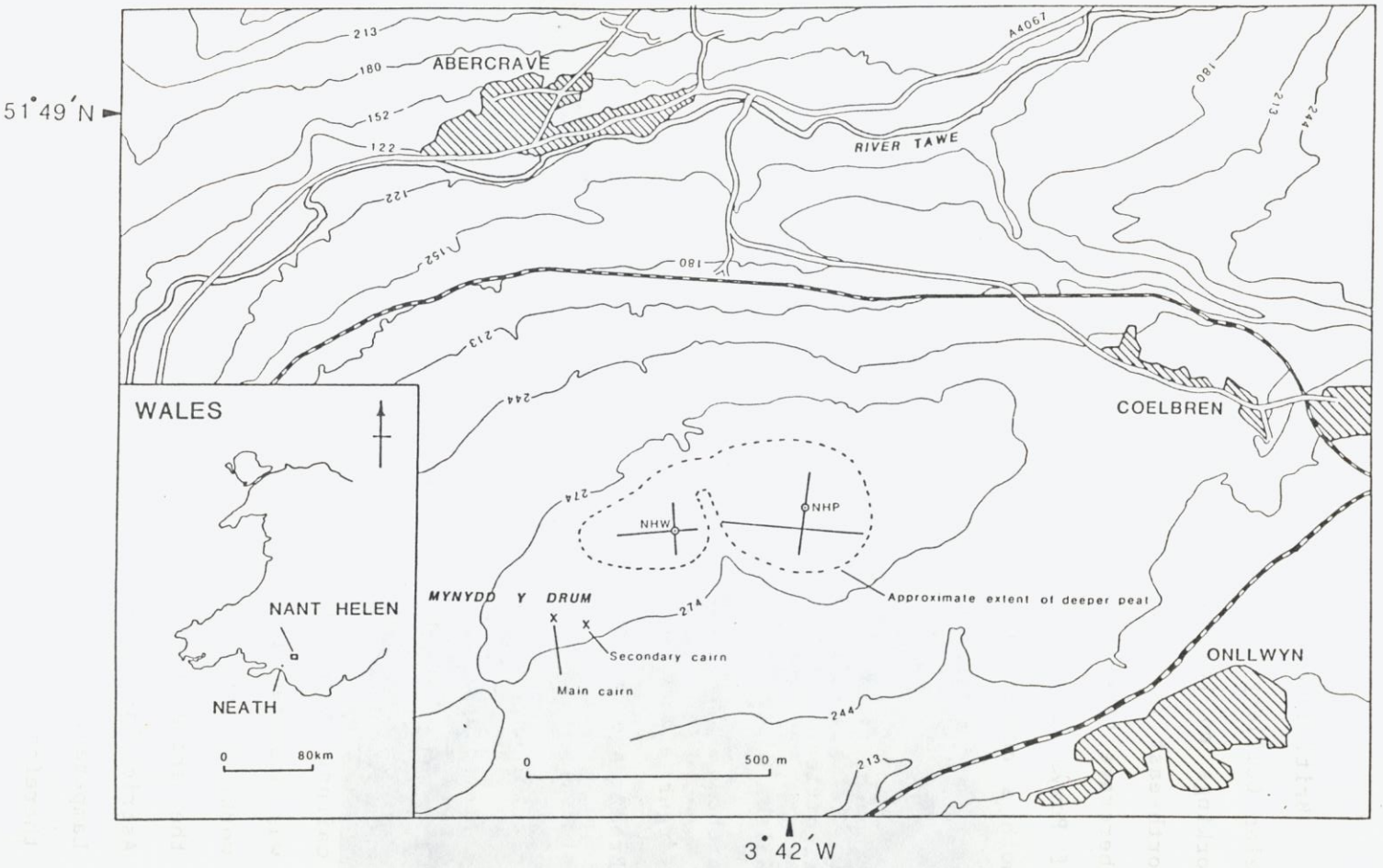


Figure 1. Map of the study area, showing location of transects and core sites NHP and NHW.

Background to and aims of the study

British Coal recently proposed an extension to their Nant Helen Colliery operations to include a large area of opencast workings on the eastern part of Mynydd y Drum, some 15 km north-east of Neath and approximately 1 km to the south of Abercrave (Abercraf), in the extreme south-west of the county of Powys (Fig. 1). These workings would inevitably destroy both a number of small archaeological sites in the proposed area, and a large expanse of upland mire on Mynydd y Drum.

There is a statutory obligation placed on the four Welsh Archaeological Trusts to conduct 'Rescue' watches on any significant threatened sites. Through the offices of Cadw/ Welsh Historic Monuments (Welsh Office), the Clwyd-Powys Archaeological Trust (C-PAT) was funded to excavate two of the larger archaeological sites in the proposed area - presumed Bronze Age cairns - and to commission a local palaeoecological study. This was designed both to provide a general post-glacial environmental history for the area and to ascertain the contemporary environmental setting of the archaeological sites. The study would be integrated with the archaeological excavations and include analysis of samples from beneath the cairns. A tender from Keele's new Environmental Research Unit was accepted for the pollen analytical and biostratigraphic work, whilst analyses of any charred macro-plant remains from the archaeological excavations were to be conducted by Dr Astrid Caseldine, based at St. David's University College, Lampeter. The palaeoecological work desribed in this study was therefore funded by a grant to Keele's Environmental Research

Plate 1:

The treeless environment on Mynydd y Drum, 1987.

Unit from C-PAT, from monies jointly subsribed by Cadw and British Coal.

The study area

Mynydd y Drum is an elongated rounded hill, trending south-west to north-east, straddling the border between West Glamorgan and Powys in South Wales. The hill separates the Tawe and Dulais (Dylais) valleys and is largely treeless (Plate 1) although conifer plantations have been established on its northern flanks in areas of former colliery activity. Quality coal deposits, at depths suitable for opencast working, are known from multiple borehole logs on the hill. The north-eastern, plateau area of the hill has superficial deposits of peat which have accumulated in two connected shallow depressions or basins. The approximate area of deeper peat is shown in Figure 1. These peats exceed 4 m in depth in the eastern-most basin. Peat deposits were also present in the southern part of the proposed opencast site, but have been largely destroyed by British Coal operations. Their original depth and extent are not reliably known.

The deeper peat areas are classified by the Soil Survey of England and Wales as the Crowdy series. These areas support an acidophilous flora, dominated by Molinia caerulea (purple moor grass) with abundant Eriophorum (cotton sedge), Erica tetralix (bog heather), frequent Sphagnum (bog moss) and occasional Drosera rotundifolia (round-leaved sundew). The area not only has no trees, but also lacks large shrubs. It is used in the spring by ground-nesting birds, but the whole habitat will

Plate 2:

Overburden encroaching on the western basin, October 1987.

Plate 3:

Southern boundary of the eastern basin - a roadway for dumper trucks.

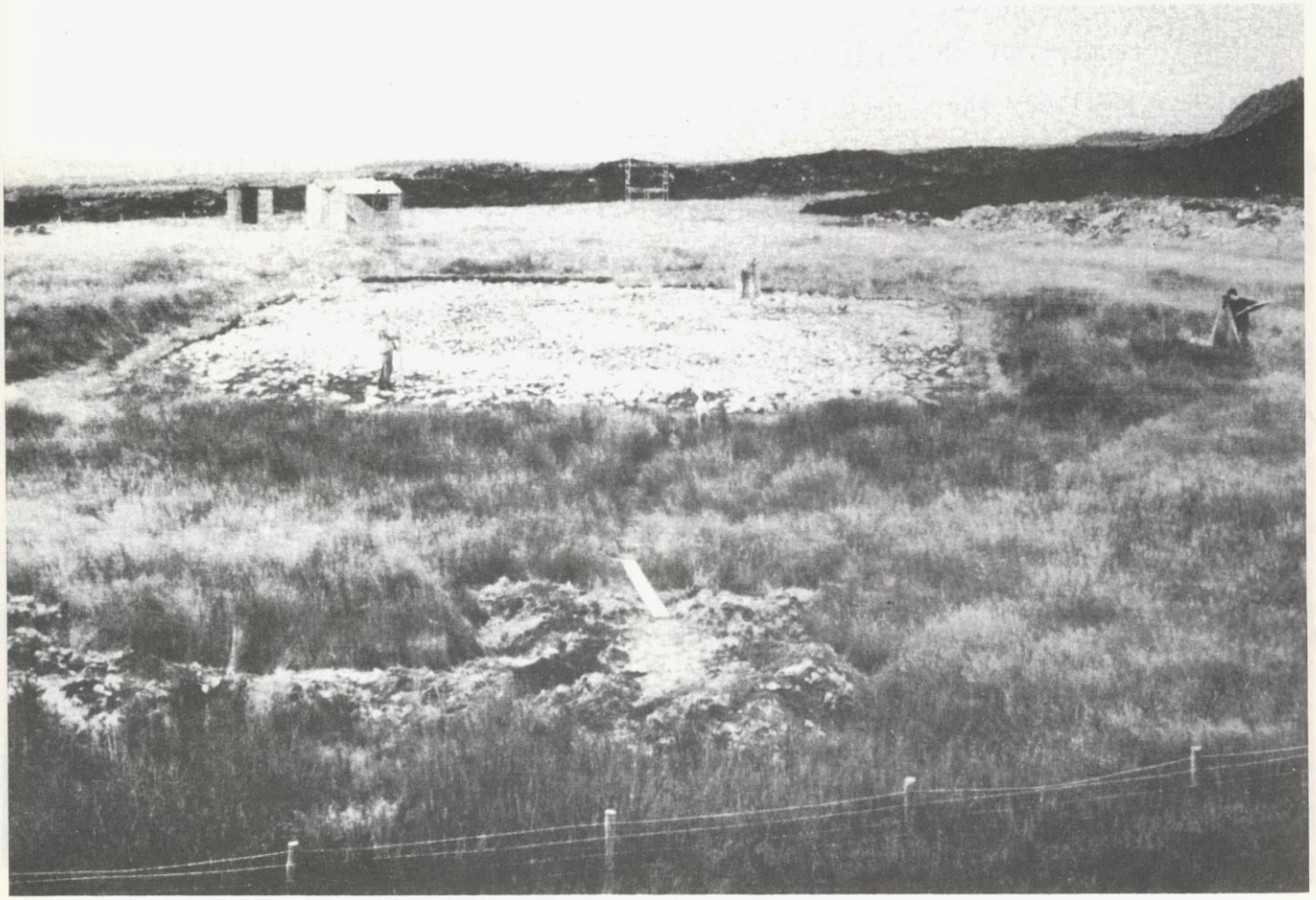
eventually be destroyed by the opencast operations.

At the time of sampling (1987), overburden was encroaching on the western basin (Plate 2), whilst the area immediately to the south had been transformed into a new roadway for 50-tonne dumper trucks (Plate 3). Archaeological excavations of two cairns were directed by Peter Dorling of C-PAT during the summer of 1987 and already by August they were surrounded by colliery spoil dumps (Plate 4). Excavation adjacent to cairn 1 also revealed possible evidence for former coal-mining activity in the form of a presumed late eighteenth or early nineteenth century stone trackway, whixh encroached onto the site of the cairn (Plate 5). Details of the excavations will be published separately (Dorling et al. forthcoming).

METHODS

The time-scale for fieldwork was originally expected to be very short as there was an imminent threat of deliberate drainage of the mire area. Whilst this might have been convenient in producing sections for sampling, it could not be guaranteed that clean and accessible sections would be available after the drainage operations. This threat prompted an urgent visit in April of 1987 to recover sufficient undisturbed material for pollen analysis and radiocarbon dating. A modified Jowsey sampler was employed, and duplicate cores were taken to a depth of over 4 m. Additional basal cores were taken for dating.

Plate 4:



Excavation of Carn Goch in progress, Summer 1987.

Plate 5:

Exhumation of the stone trackway

Field methods

A large-scale computer-drawn isopleth map of 'peat thickness' prepared from British Coal borehole data had been supplied to the Environmental Research Unit to assist in locating the deeper areas of peat. These deeper areas were expected to have accumulated before, during and after the construction of the cairns, and hence were expected to provide information on the environmental setting of the sites. The map was used to define the location of the original core (NHP), taken in April 1987 (Fig. 1). Subsequent biostratigraphic study showed that the NHP location was representative of the deeper areas of peat, but that the British Coal map had exaggerated the depth of peat in the eastern basin by up to 2 m (or 40% over-estimate). This may have been due to all unconsolidated superficial deposits, including lacustrine clays, being recorded in the British Coal borelogs as 'peat'.

During field visits for biostratigraphic study, orthogonal transects were laid out across the deeper areas of peat. The stratigraphy was recorded at borepoints made every 30 m with a Jowsey sampler. The eastern basin was surveyed in July 1987; the western basin was surveyed in October of the same year, from which duplicate cores were taken at location NHW (fig. 1). Employees of British Coal kindly supplied spot heights and grid references for all transect lines.

During core sampling, Jowsey core-sample lengths of 50 cm were each laid in plastic guttering, wrapped in polythene tubing and transported to Keele for subsequent laboratory analysis.

Laboratory sampling

The duplicate NHP cores were first examined for their mineral magnetic susceptibility in an attempt to match the cores. In practice, the susceptibilities generally proved to be too low, with too much 'noise' to match satisfactorily, with the exception of the basal 50 cm. Here, a reliable match was obtained for the duplicate cores and for two more basal lengths taken to ensure sufficient material for dating (Fig. 2).

Due to time constraints, a method of laboratory sampling was devised to optimise the availability of samples for pollen analysis, but without involving contiguous sampling of over 4 m of material. The sampling interval of the original NHP core was based on data on growth rates of peats elsewhere in Wales (Chambers 1984), to ensure that likely Bronze Age horizons - the anticipated age of the cairns - were sampled more closely than others. Samples of 0.5 cm vertical thickness were taken at intervals varying from 1 to 4 cm, and stored pending pollen preparation. The remaining core material was cut into 2 cm lengths and stored in sealed polythene bags for possible radiocarbon dating. Detailed stratigraphic notes were compiled during this sampling. The duplicate NHP core was sectioned for possible radiocarbon dating, using stratigraphic notes to match the two cores. The NHW cores were sampled in a similar way to those from NHP.

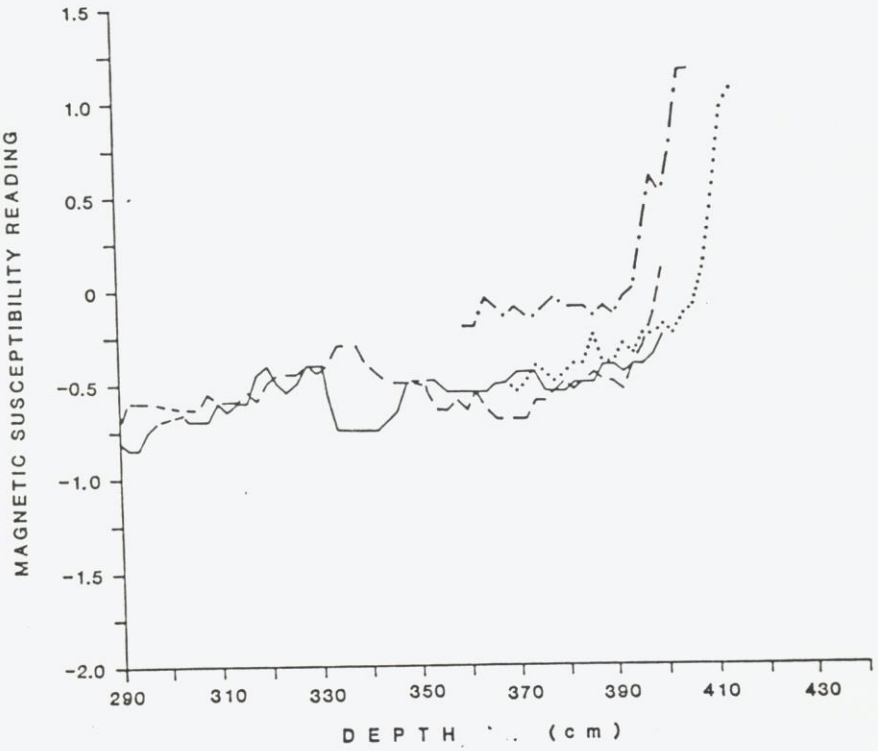


Figure 2. Core-loop magnetic susceptibility readings for basal core-lengths taken from the NHP location. Core sampling required adjustment of field depth measurements of the cores to ensure the transitions from sediment with more inorganic components (shown by positive values) were a good match.

Pollen analysis of the NHP and NHW cores

Samples were prepared for pollen analysis after Barber (1976), employing silicone fluid of 2000 cs as mountant (Andersen 1960). Lycopodium spore tablets were added to each sample to permit future calculation of pollen influx (Stockmarr 1971). A pollen sum of c. (circa) 500 total land pollen (TLP) was counted by from each sample. Spores were excluded from the pollen sum, but are expressed in the pollen diagrams as percentages of TLP. 'Cerealia' pollen represent Gramineae >40 um. The pollen diagrams were divided into local phases, a to h, based originally on the NHP relative pollen data.

Charcoal analysis

Charcoal fragments in the pollen preparation residues were counted on the pollen microslides using a modified version of the point-count method, developed by Clark (1982).

Soil pollen analysis

Samples of buried soils were also prepared for pollen analysis. These samples were taken during site excavations by Peter Dorling from contexts beneath the cairns. Duplicate samples were analysed from each context. A pollen sum of c. 500 TLP was the target, but due to very sparse pollen in some samples, this was only achieved in 4 of the 10 samples.

Radiocarbon dating

Samples were taken from selected horizons from sites NHP and NHW for radiocarbon dating. The sampled horizons were either to date phase boundaries or to date pollen and charcoal evidence of woodland clearance. Samples underwent pretreatment and dating at the Cardiff Radiocarbon Dating Laboratory. The ages of undated phase boundaries in Tables 1 and 2 were interpolated from peat accumulation rates between adjacent pairs of dates.

RESULTS

Peat stratigraphy

The stratigraphy of the deeper, eastern, basin is shown in Figure 3, whilst that of the western basin is depicted in Figure 4. The stratigraphical evidence suggested former Late-Devensian shallow lakes in the two basins. Early Flandrian sedimentation is missing, but the eastern basin seems to have been wet enough by 8000 bp to infill with fen and carr peat, succeeded finally by Sphagnum-sedge blanket peat. A similar sequence is indicated in the western basin; the base of the organics was dated here at 6240±60 bp (CAR-1155). Lenses of dark clay inwash in the western basin imply later disturbance of drier land to the west and east during the Post-glacial.

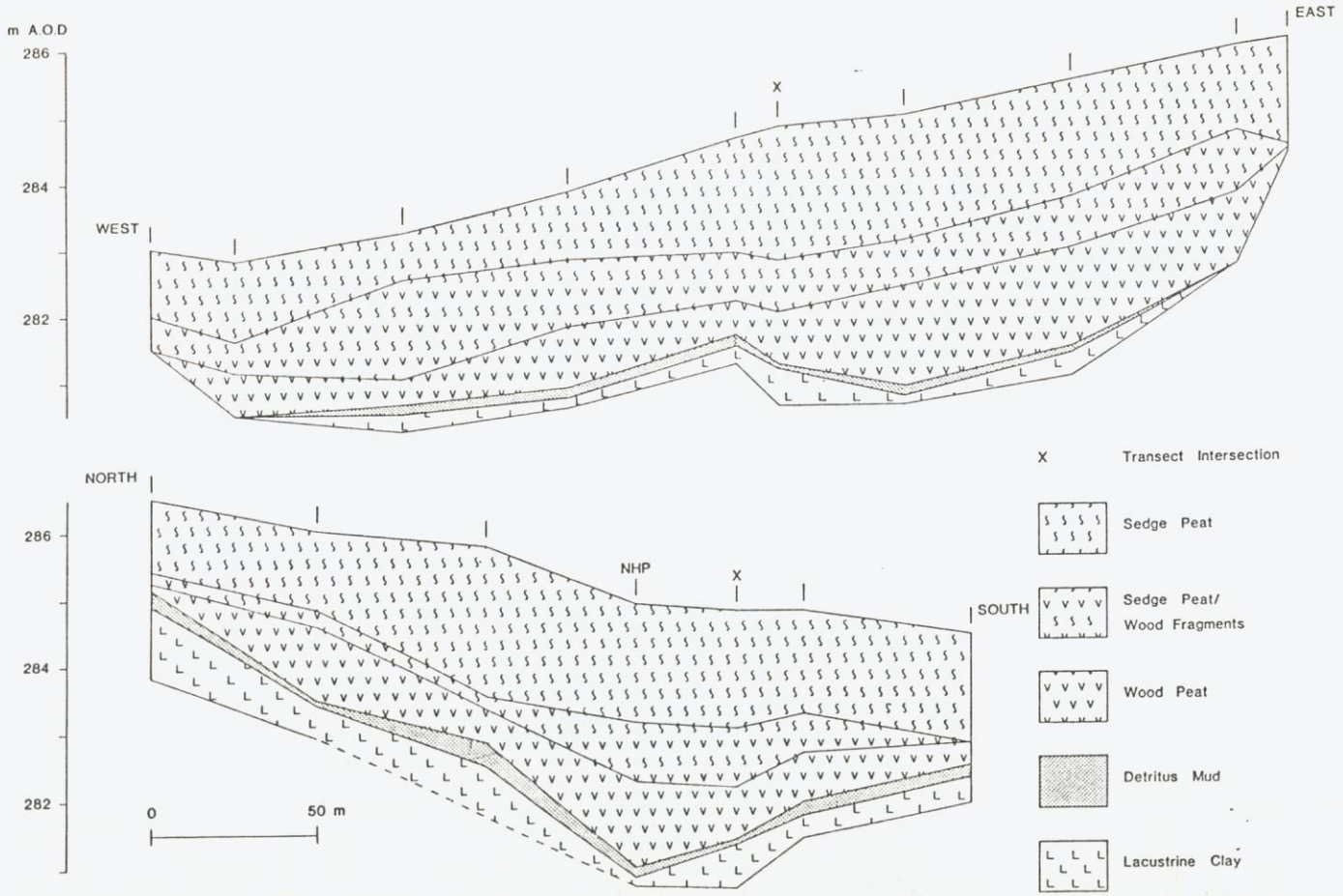


Figure 3. Stratigraphy of the eastern basin.

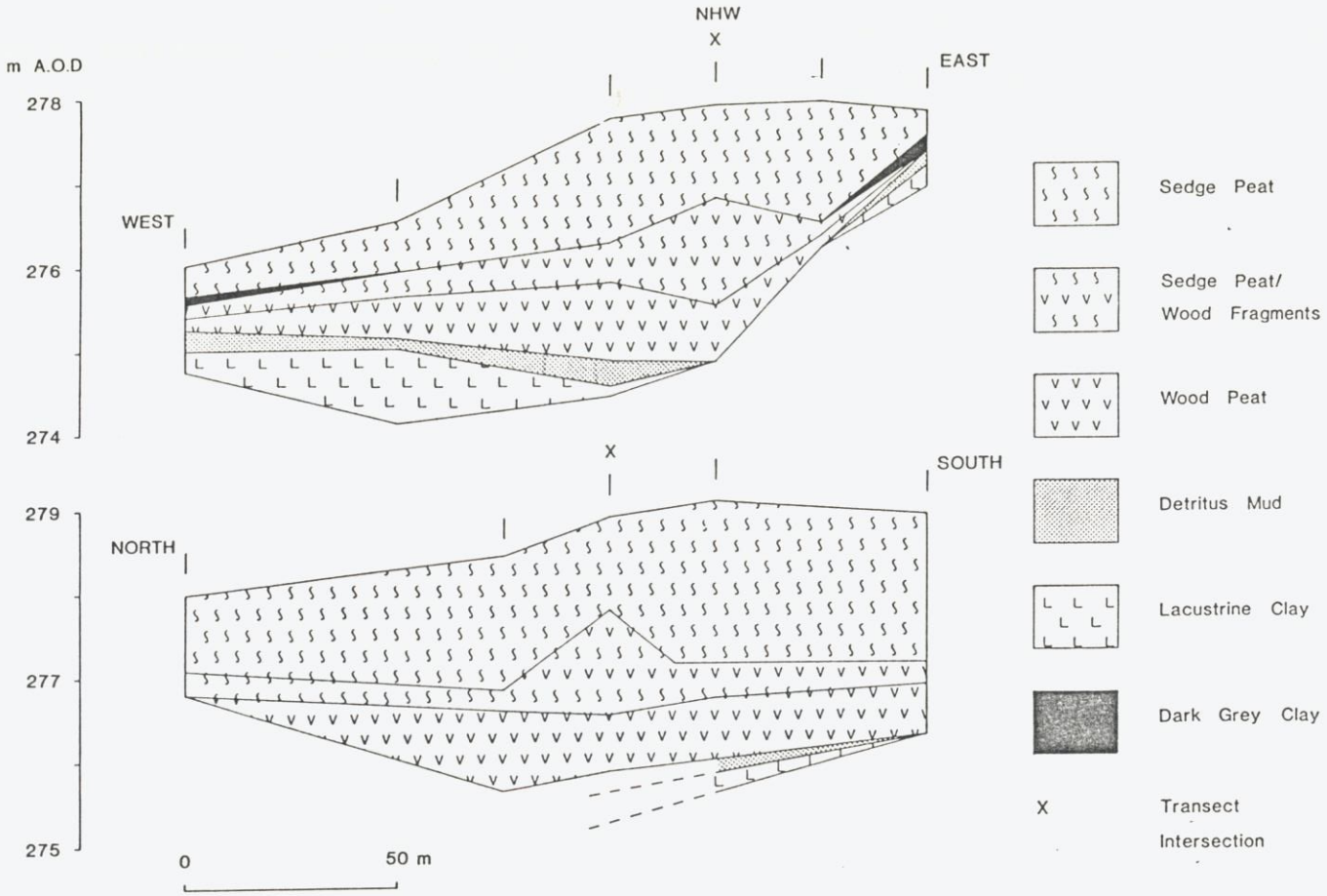


Figure 4. Stratigraphy of the western basin.

Pollen diagram from the eastern basin (NHP site)

The sampling point was at SN 826 112 on the north-south transect across the eastern basin, at 284.56 m altitude. The pollen diagram (Fig. 5) was divided into phases from changes in the pollen spectra and charcoal records. Characteristics and age ranges of each of the phases are listed in Table 1.

Pollen diagram from the western basin (NHW site)

The sampling point was at SN 824 111 at the intersection of the two transects across this part of the mire, at an altitude of 278.88 m. Samples taken for dating from this core yielded ages which were remarkably close to the presumed corresponding samples from the NHP site. The pollen diagram (Fig. 6) was therefore phased to match those in the NHP diagram. Characteristics and age ranges are listed in Table 2.

Soil pollen analyses

Results of pollen analysis on samples taken from selected contexts during the excavation of the two cairns are presented in Figure 7. With one exception, these pollen spectra are dominated either by Corylus (hazel) or by Ericaceae (heaths). Either a heath-dominated or hazel scrub-dominated landscape is indicated by the soil pollen samples. Of particular note is the difference in representation of these two taxa in samples taken from separate cairn quadrants. Very high spore counts of

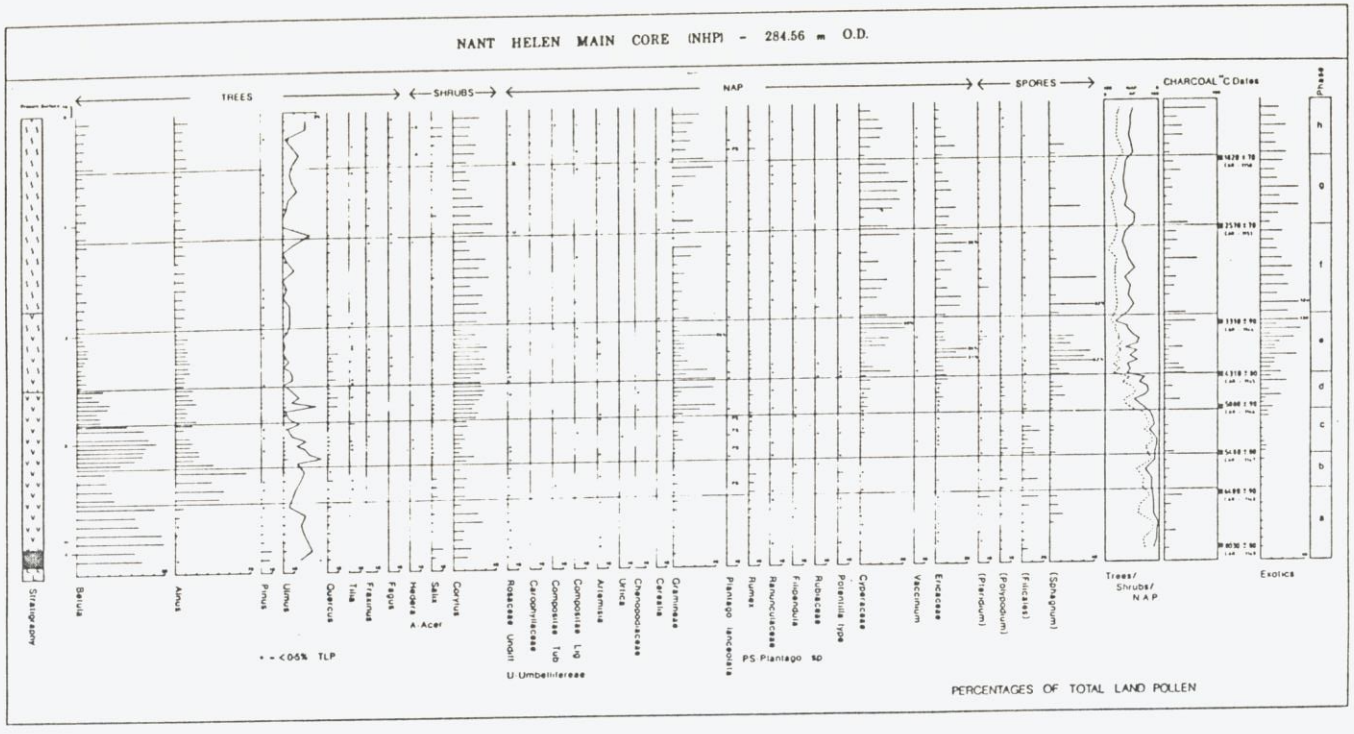


Figure 5. Pollen diagram from the eastern basin, NHP site.

Table 1: Characteristics and ages of phases in Fig. 5 (NHP)

Phase	Features	Age (yr bp)
	Top 10 cm not sampled	c. 150 - present
h	Lower Cyperaceae; fair Gramineae	c. 1445 - c. 150
g	High Cyperaceae	c. 2540 - c. 1445
f	Recovery of AP/NAP ratios	c. 3260 - c. 2540
e	Low *Betula*; high mire types	c. 4310 - c. 3260
d	Lower AP; higher NAP	c. 5100 - c. 4310
c	High *Betula*, lower *Alnus*	c. 5480 - c. 5100
b	Higher *Alnus*, lower *Betula*	c. 6350 - c. 5480
a	High *Betula*, low *Alnus*	>8000 - c. 6350

The ages of phase boundaries were interpolated from apparent deposition rates between pairs of radiocarbon dates, except for the conclusion of phase h, whose age is based on the appearance of soot particles towards the close.

Polypodium (polypody fern) in the 'buried soil' samples reflect mainly the low total pollen counts and selective preservation.

INTERPRETATION AND DISCUSSION

The sparser data from core NHW suggest broadly similar trends to the more detailed data from core NHP. Hence, interpretation of pollen, spore and charcoal data has largely been based on the Nant Helen Main Core (NHP).

Human influence on vegetation: the Mesolithic

The base of the organic material in the NHP core was dated to 8030±80 bp (CAR-1149). Pollen spectra in phase a are dominated by Betula (birch), indicating local birch carr in what then seems to have been a damp local environment. The stratigraphic profiles (Figs 3, 4) might imply lacustrine sedimentation at this time, but this is rather misleading. Although the organic material resembled fine, unstructured detritus, no aquatic micro-fossils were recorded, and given this absence, the material is better interpreted as basal fen-carr deposition.

Charcoal dust recorded in the pollen slides in phase a (NHP) implies the practice of burning by Mesolithic peoples. Upland Mesolithic activity elsewhere in South Wales has been referred to by Jacobi (1980) and confirmed through pollen analyses by Cloutman (1983) in the Black Mountain area, where flints were found stratified in peat. Recent discussion of Cloutman's data from Waun-Fignen-Felin has lent support to the

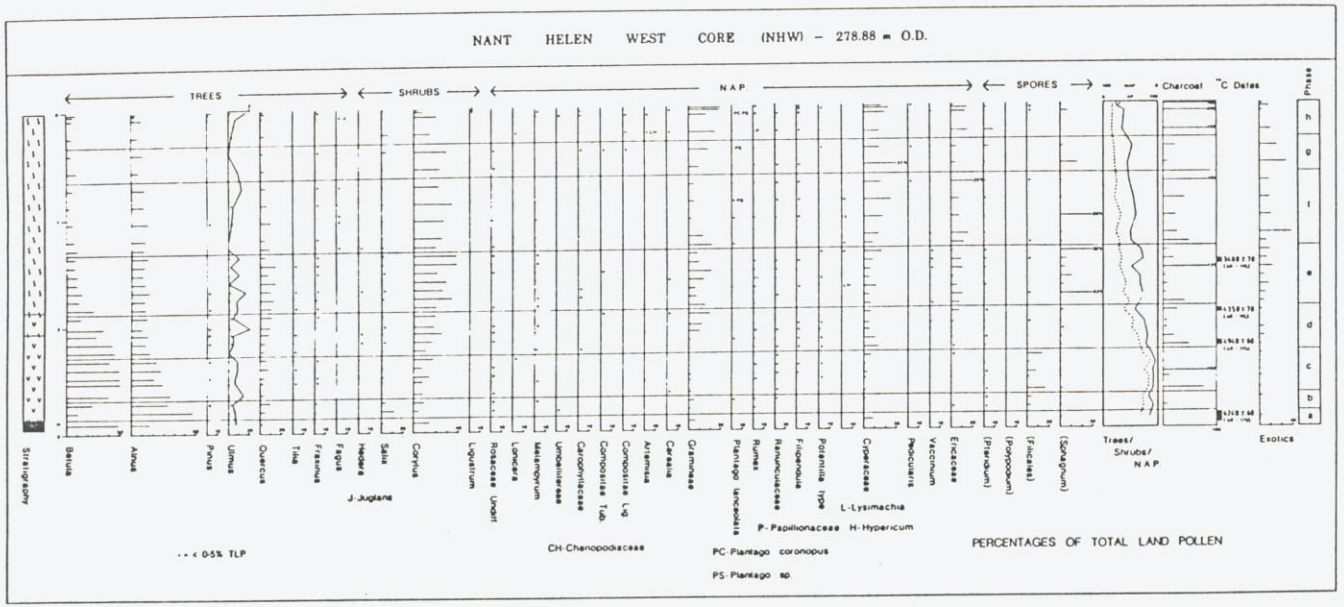


Figure 6. Pollen diagram from the western basin, NHW site.

Table 2: Characteristics and ages of phases in Fig. 6 (NHW)

Phase	Features	Age (yr bp)
h	Fair Gramineae	? - present
g	Rising Gramineae	? - ?
f	Fair *Corylus*	*c.* 3180 - ?
e	Low *Betula*; high mire types	*c.* 4300 - *c.* 3180
d	Lower AP; higher NAP	*c.* 5055 - *c.* 4300
c	High *Betula*	*c.* 5810 - *c.* 5055
b	Higher *Alnus*, lower *Betula*	*c.* 6155 - *c.* 5810
a	High *Betula*, low *Alnus*	>6155

The ages of phase boundaries were interpolated from apparent deposition rates between pairs of radiocarbon dates. There is a remarkable correspondence in age between equivalent phases d and e at NHP and NHW: these are the phases with the most marked evidence for human impact. The beginning and end of phase g are not reliably known due to the lack of dating evidence in the upper part of the diagram.

notion of Mesolithic activity creating a small woodland clearing c. 8000 bp in that locality and subsequently maintaining heath by burning (Smith & Cloutman 1988). A number of other Mesolithic sites are known from upland South Wales (Wymer 1977), which Jacobi (1980) has interpreted as indicating seasonal use of upland resources. The pollen and charcoal evidence from NHP and NHW may support these ideas of deliberate periodic upland burning in the Mesolithic.

The rational limit for Alnus (alder) was dated by sample CAR-1148 to 6400±90, indicating a late rise of alder in this upland locality. This late rise of alder has been a feature of some sites elsewhere in upland South Wales, compared with its apparent earlier arrival in the uplands of North-west Wales (Chambers & Price 1985). Alder appears to have invaded the carr successfully in the neighbourhood of NHP for the duration of phase b. Its invasion follows a period of disturbance in which charcoal levels are high and ferns (Filicales and Pteridium) flourished, perhaps in a temporary clearing.

Establishment of alder after local disturbance has been a feature of several pollen diagrams, noted by Smith (1984). Amongst these were Cloutman's diagrams from Waun-Fignen-Felin, 5 km to the north, where the establishment of alder was also late in some profiles, but followed evidence for burning. There, Mesolithic flints added to the circumstantial evidence linking burning with the establishment of alder. However, there are as yet no such records of flints from the Mynydd y Drum site.

Neolithic, Bronze Age and Iron Age Environments

Phase c (NHP) commences at 5480±80 bp (CAR-1147), which approximates the start of the early Neolithic in South Wales. The phase boundary marks a decline in alder and a resurgence of local birch. Continued charcoal records and the presence of *Plantago* pollen attest to human influence.

The exaggerated curve for *Ulmus* (elm) suggests that the primary elm decline occurs towards the close of phase c. A secondary *Ulmus* minimum occurs early in phase d (NHP). At NHP, the primary decline immediately precedes the date of 5080±80 bp (CAR-1146). At NHW, the elm decline is dated to 4940±80 bp (CAR-1154). These are within the age ranges to be expected for the primary elm decline in Britain (Smith *et al.* 1981). The regional details are rather masked by a substantial local decline in *Betula* (birch). The latter part of phase c also has increased representation of Gramineae (grasses) and of ruderal taxa, plus the start of rising representation from the fire-resistent *Corylus* (hazel). These lines of evidence might support an anthropogenic interpretation of the elm decline (Sturludottir & Turner 1985). It is not clear, however, whether the 'Cerealia' records in phase c at both sites really attest to pre-elm-decline cereal cultivation experiments (Edwards & Hirons 1984) or whether they might be better interpreted as representing the native herbaceous flora (O'Connell 1987).

Both the *Ulmus* and the summary AP/NAP curves suggest two clearance episodes for phase d, one at the start of the phase and one towards the close, separated by a period of woodland

regeneration. Whether the story is as simple as that is rather difficult to assess, for evidence among the NAP types implies a change also in local habitat conditions, with birch carr giving way in stages to a more open local environment, with increasing representation of heaths (Ericaceae) and sedges (Cyperaceae), in addition to grasses. These changes culminate at the phase d/e boundary, which is marked by a stratigraphic change, increased charcoal representation, and a dramatic fall in Betula values. Such evidence suggests marked human impact in the locality, dated to 4310±80 bp by sample CAR-1145 and to 4350±70 bp by sample CAR-1153 from site NHW.

Fluctuating AP/NAP ratios in phase e (NHP) apparently chronicle repeated human impacts, but also record hydrological changes in the mire, with successive peaks in Sphagnum, Ericaceae and Cyperaceae values. In retrospect, it might have been helpful to determine peat humification during this phase to clarify the hydrological changes, but contiguous samples were not available for this. The most dramatic subsequent change occurs towards the close of the phase when a peak in Gramineae representation is succeeded by high Cyperaceae values, whilst the AP curve falls to a minimum. This episode is dated to 3310±90 bp (CAR-1144) at NHP, and to 3480±70 bp at site NHW.

The absence of wood remains in peat from the early part of phase f, and the generally low AP values, indicate that all tree growth on the mire has terminated, and the upland landscape may by now be substantially disforested. However, relatively high Corylus values are indicative of regenerating

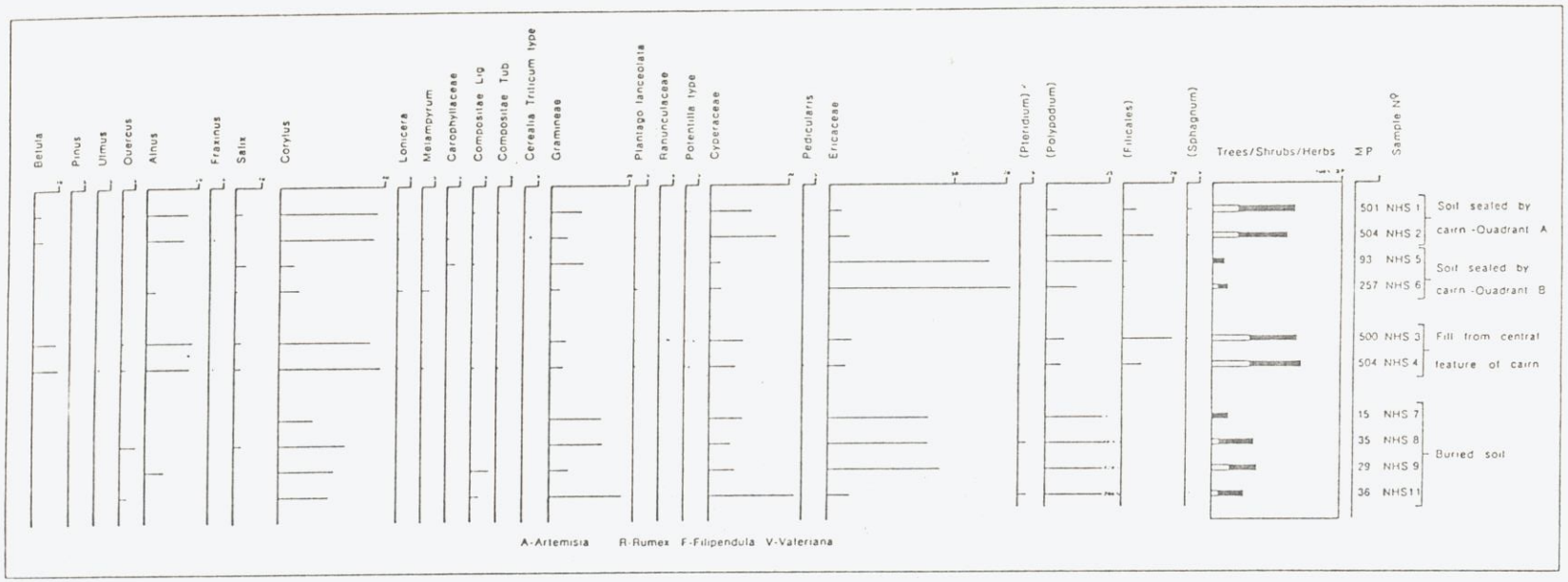


Figure 7. Pollen spectra from soil samples taken from the cairn excavations.

hazel scrub, presumably on the drier upland areas, but which seems to decline towards the close of the phase.

The environmental setting of the cairns

Three main lines of evidence allow an assessment of the contemporary environmental setting of the cairns. These are the pollen evidence from samples taken beneath the cairns, the pollen evidence from the mire cores and the radiocarbon dates.

Pollen evidence from beneath the cairns indicated either a heath-dominated or hazel scrub-dominated landscape (Fig. 7). This implies construction of the cairns in a landscape already substantially disforested through earlier human activities. There is a possibility that one of the cairns was constructed at a habitat boundary between heath and scrub woodland, though this depends upon the contemporaneity of pollen samples from separate cairn quadrants. Dorling collected charcoal fragments from features apparently sealed beneath cairn 1 for radiocarbon dating, but the dates obtained spanned some 500 years in the historical period. Contamination or disturbance must be suspected. Assuming the cairns date from the Bronze Age, pollen evidence from the mire cores suggests construction in a landscape already substantially altered by Neolithic activity.

The historical period

Apart from a resurgence of hazel scrub in the early part of phase g, the upland landscape remains largely disforested, whilst the mire vegetation varies between sedge and grass

domination. The rising Gramineae curve in late phase h suggests that the present dominance of Molinia caerulea (purple moor grass) may be a relatively recent feature, possibly post-dating the start of the industrial revolution. This is a feature which has been noticed elsewhere in blanket mire in South Wales, and might be attributed inter alia to fallout of atmospheric pollution (Chambers et al. 1979).

RESTORATION GOALS AFTER OPENCAST MINING ON MYNYDD Y DRUM

Earlier drift and opencast mining on the flanks of Mynydd y Drum has been followed by land restoration either for coniferous plantations or for sheep grazing. Modern methods of land restoration take better account of initial conditions and make provision for eventual restoration by ensuring that topsoil is scraped aside and stored. The problem with Mynydd y Drum is that the Crowdy soil series there has no real topsoil - rather there is a considerable depth of peat which, given the terrain, is regarded by British Coal as difficult to scrape aside and worthless for restoration purposes. An internal British Coal report stated: "Some 38% of the site area has no topsoil and a further 11% (Crowdy) is peat where no stripping will be practicable. There is therefore a grave shortage of topsoil for restoration. Of the remaining area, 36% (Wilcox [soil series]) is highly organic or peaty over clay loam and can be exceedingly difficult to strip, store and replace without severe compaction....Topsoil is not a necessity for restoration to forestry and thereby the available topsoil can be reserved for better restoration of the agricultural land

area." (Internal British Coal Report, supplied by C-PAT).

Pollen and biostratigraphic evidence from the deep peat areas has shown a range of habitat conditions on Mynydd y Drum in the last 12,000 years. The postulated Late-Devensian shallow lakes, the later Boreal carr woodlands, the Atlantic deciduous woods, the clearances to upland heath and hazel scrub, plus extensive mire development, all suggest the possibility of a wider range of restoration goals for the Nant Helen opencast site. By creating the appropriate habitat conditions, it may be possible to re-create a semblance of several of the Post-glacial plant communities on Mynydd y Drum.

To take an example: landscaping of the area after opencast workings could be engineered to leave a large, relatively shallow, upland plateau lake (thereby obviating the need for topsoil). The shorelines of this lake could be planted with pioneer native species such as Alnus glutinosa (black alder) and Betula pubescens (hairy birch), both of which formerly grew on Mynydd y Drum in abundance, and both of which can be regarded as soil improving species. In time (sooner, if inoculated by the introduction of native aquatic plants), the lake might be colonized by water fowl, and be reduced in size by the growth of marginal aquatic vegetation, providing a wider range of habitats. Attempts to re-establish oak-hazel woodland might follow the birch-alder plantings. The wildlife potential of such a scheme is perhaps of greater 'benefit' than restoration for plantations of non-native conifers or for upland sheep grazing. Indeed, experiments elsewhere in upland Britain have shown that native deciduous trees can be successfully re-established at altitudes greater than this

(Maltby, pers. comm.). Provided that British Coal is not constrained unduly by a strict application of land-use capability requirements, it is at least worthy of consideration.

CONCLUSIONS

The principal findings of this study may be summarised as follows.

During the period of Late-Devensian deglaciation, prior to 10,000 bp, shallow lakes were apparently left on Mynydd y Drum, possibly ice-dammed, in two connected basins. Flandrian sedimentation seems not to have commenced in these former lake basins until a little before 8000 bp. At that time, charcoal records implicate Mesolithic peoples in upland woodland disturbances. Local birch carr on Mynydd y Drum preceded a rather late rise of alder (c. 6400 bp) at the principal site (NHP) investigated. Establishment of alder followed evidence for disturbance by fire.

Neolithic disturbances are indicated both before and at the primary elm-decline horizon, dated by samples from the two sites (NHP and NHW) at c. 5000 bp. Evidence for pre-elm-decline cereal cultivation is tantalizing but inconclusive.

Major impacts upon woodland are indicated for the Bronze Age. There is a remarkable concordance between the two sites (NHP and NHW) in the dating of phases of marked human impact (Tables 1 and 2). Subsequent regeneration of upland hazel scrub is indicated, but this declines by the close of the Iron Age. A predominantly open upland landscape has prevailed since

then.

The excavated cairns appear to have been constructed in an environment already substantially disforested as a result of the activities of earlier cultures. Their age is not certainly known, but a Bronze Age date is suspected, and this would accord with pollen evidence from beneath the cairns.

Some parallels may be drawn between the environmental history of Mynydd y Drum and that inferred for Waun-Fignen-Felin (Smith & Cloutman 1988), 5 km to the north.

The changing Late- and Post-glacial environments on Mynydd y Drum suggest a wide range of options for land restoration goals, once opencast coal mining has ceased. Coniferous afforestation does not reflect past habitat conditions and is therefore not recommended. Rather, creative conservation, involving the planting of birch and alder around a specially created shallow lake, is suggested as a more imaginative scheme. The lake would obviate any need for topsoil, which is a major problem with land restoration on Mynydd y Drum, and would be in keeping with the environmental history of the area.

REFERENCES

ANDERSEN, S.T. (1960) Silicone oil as a mounting medium for pollen grains, Danm. Geol. Unders., 4, 5-17.

BARBER, K.E. (1976) History of vegetation, in: Methods in Plant Ecology (ed. Chapman, S.B.) Blackwell Scientific, Oxford, 5-83.

BRADSHAW, A.D. & CHADWICK, M.J. (1980) The Restoration of Land, Blackwell Scientific, Oxford.

CHAMBERS, F.M. (1984) Studies on the Initiation, Growth-rate and Humification of 'Blanket Peats' in South Wales, Dept. of Geography Occasional Paper 9, University of Keele.

CHAMBERS, F.M., DRESSER, P.Q. & SMITH, A.G. (1979) Radiocarbon dating evidence of the impact of atmospheric pollution on upland peats, Nature, 282, 829-831.

CHAMBERS, F.M. & PRICE, S.-M. (1985) Palaeoecology of Alnus (alder): early Post-glacial rise in a valley mire, north-west Wales, New Phytol., 101, 333-344.

CLARK, R.L. (1982) Point-count estimation of charcoal in pollen preparations and thin sections of sediment, Pollen et Spores, 24 (3/4), 523-535.

CLOUTMAN, E.W. (1983) A contribution to the vegetational history of Black Mountain, South Wales, Unpub. Ph.D. thesis, University of Wales.

DORLING, P. et al. (forthcoming) Field survey, excavation and pollen analysis at Mynydd y Drum, Ystradgynlais, Powys, 1983 and 1987 Bull. Board Celtic Stud.

EDWARDS, K.J. & HIRONS, K.R. (1984) Cereal pollen grains in pre- elm-decline deposits: implications for the earliest agriculture in Britain and Ireland, Jnl. Archaeol. Sci., 11, 71-80.

JACOBI, R.M. (1980) The early Holocene settlement of Wales. In: Culture and Environment in Prehistoric Wales (ed. Taylor, J.A.) British Archaeological Reports 76, Oxford, 131-206.

O'CONNELL, M. (1987) Early cereal-type pollen records from Connemara, western Ireland and their possible significance, Pollen et Spores, 29, 207-224.

SMITH, A.G. (1984) Newferry and the Boreal-Atlantic transition, New Phytol., 98, 35-55.

SMITH, A.G., HILLMAN, G.C. & GRIGSON, C. (1981) The Neolithic, in: The Environment in British Prehistory (ed. Simmons, I.G. & Tooley, M.J.) Duckworth, London, 125-209.

SMITH, A.G. & CLOUTMAN, E.W. (1988) Reconstruction of Holocene vegetation history in three dimensions at Waun-Fignen-Felin, an upland site in South Wales, Phil. Trans. Roy. Soc. **B** (in press).

STOCKMARR, J. (1971) Tablets with spores used in absolute pollen analysis, Pollen et Spores, 13, 615-621.

STURLUDOTTIR, S.A. & TURNER, J. (1985) The elm decline at Pawlaw Mire - an anthropogenic interpretation, New Phytol., 99, 323-329.

WYMER, J.J. (1977) Gazetteer of Mesolithic Sites in England and Wales, C.B.A. Research Report No. 22, Geo Abstracts/C.B.A., Norwich.

ACKNOWLEDGEMENTS

Thanks are due to J. Lloyd Jones (Site Manager) for site access, and to D.R. Williams (Site Engineer) and N. Thomas of British Coal for transect survey data. Unpublished data from British Coal and from the Plant Science Dept., U.C., Cardiff were made available by C-PAT. Additional field assistance in April 1987 was provided by I. Wilshaw and G.J. Morgan; in October 1987 by K. Ambridge, E.M. Botterill and T. Mighall. Dr Dresser supplied the radiocarbon dates. Additional data on Nant Helen were supplied by K. Brassil and P. Dorling of C-PAT. Liaison with P. Dorling (excavation supervisor, C-PAT) and with W. Britnell (Director, C-PAT) is gratefully acknowledged. Mrs M. Patrick drew Figure 2. The Nant Helen Environmental Project was funded by a grant from C-PAT, through joint funding by Cadw/Welsh Historic Monuments and British Coal.

UNIVERSITY OF KEELE

DEPARTMENT OF GEOGRAPHY

OCCASIONAL PAPERS

* 1.	P.T. KIVELL (1982)	Land Reclamation and Housing Development
* 2.	J. NAYLON (1982)	Politics and Urban Growth in Franco Spain: The Case of Barcelona
* 3.	M. BERNARD (1982)	Leisure Defined: a Review of the Literature
* 4.	D. WEATHERLEY (1982)	Tourism and Second Homes in the Sierra Morena (Spain): Problems and prospects for Rural Development
* 5.	S.W. WILLIAMS (1983)	The Concept of Culture and Human Geography: A Review and Reassessment
* 6.	D.J. DWYER and S.W. WILLIAMS (1983) (Editors)	Progress in Third World Urban Studies: The Contribution of British Geography
* 7.	D.W. DRAKAKIS-SMITH (1983)	Towns Like Alice: Race and Class in Aboriginal Australia
8.	R. WHITLOW (1984)	Environment, Land Utilisation and Development Prospects in the Peasant Farming Areas of Zimbabwe
9.	F.M. CHAMBERS (1984)	Studies on the Initiation, Growth-rate and Humification of 'Blanket Peats' in South Wales
10.	P.T. KIVELL (1986)	Applied Geography: its contribution to planning and public policy
11.	D.W. DRAKAKIS-SMITH (1986)	Housing Tenants in Darwin, Australia: An Investigation of the Private and Public Sectors
12.	B.J. TURTON (1987)	Touring Caravanning and the Changing Geography of Leisure in Britain: a Case Study of the Role of the Caravan Club
13.	D.W. DRAKAKIS-SMITH and P.T. KIVELL (1987)	Food Production and Purchasing in Harare, Zimbabwe: a Preliminary Report
14.	ABD. RAHIM (1988)	Public Transport Planning in Kuala Lumpur, Malaysia
15.	F.M. CHAMBERS, J.G.A. LAGEARD L. ELLIOTT (1988)	Post-glacial History of the Nant Helen Opencast Site, South Wales: Implications for Land Restoration

Enquiries should be addressed to Dr. P.T. Kivell (Managing Editor) and papers may be ordered from the Secretary, Department of Geography, at a price of £3.00 each including p.&p.(if resident in the U.K). Papers marked with an asterisk are out of print although photocopies may be available by special request.

Department of Geography,
University of Keele
Keele, Staffordshire ST5 5BG

Telephone Newcastle (Staffs) (0782) 621111 Telex 36133 UNKLIBG