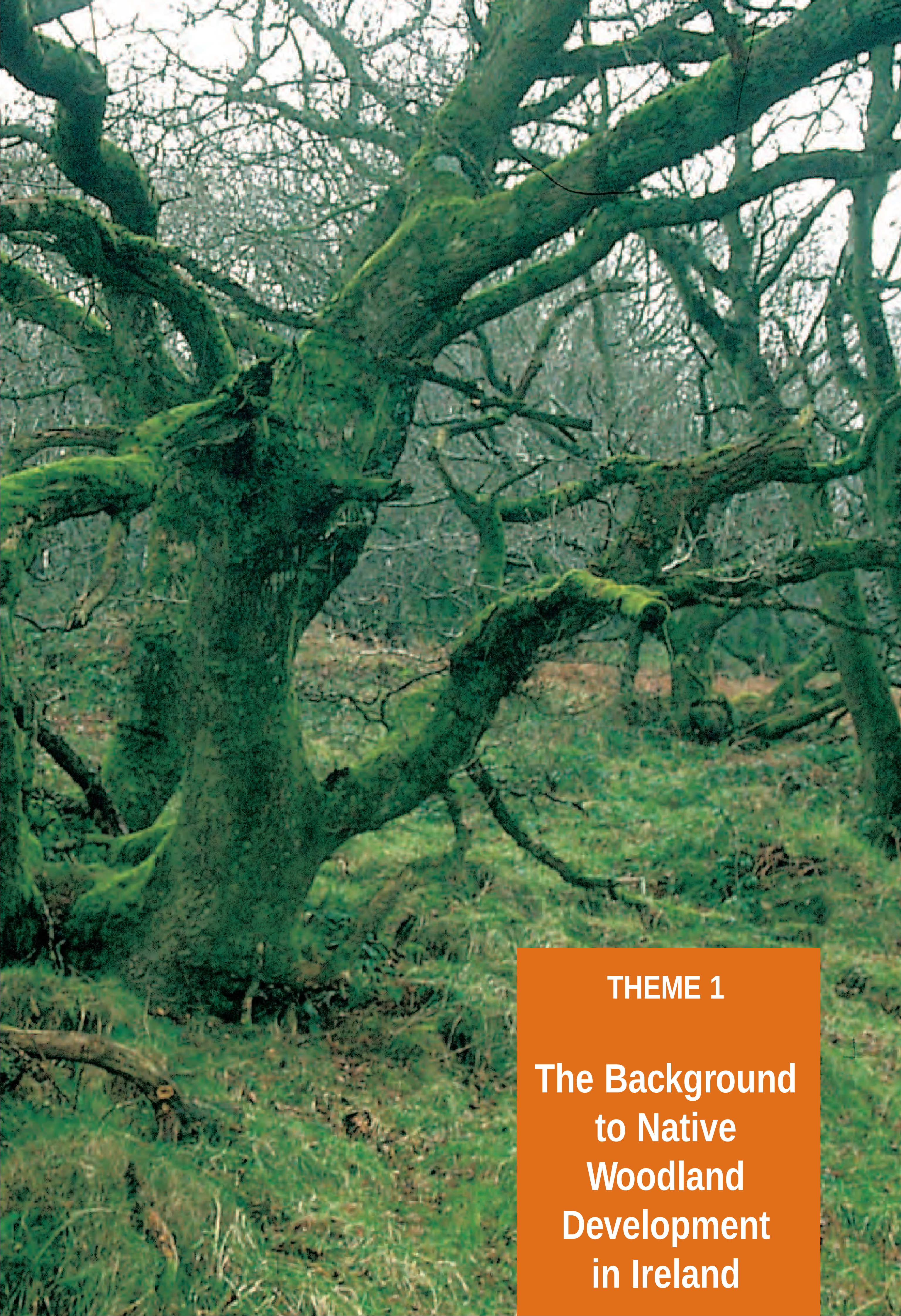

THEME 1

The Background to Native Woodland Development in Ireland

NATIVE WOODLAND COMPOSITION AND DYNAMICS: A LONG-TERM PERSPECTIVE BASED ON A HOLOCENE POLLEN PROFILE FROM INIS OÍRR, ARAN ISLANDS, WESTERN IRELAND

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Abstract

A detailed Holocene pollen record, elaborated in the project TIMECHS, is presented from An Loch Mór, a deep lake at the north-eastern end of Inis Oírr, Aran Islands, western Ireland. Close interval sampling, identification of a wide range of arboreal and non-arboreal palynomorphs and a well constrained chronology have enabled woodland development and land-use history to be reconstructed in considerable detail. The pollen data are supported by stomatal records for *Pinus*, *Taxus* and *Juniperus*, all three of which were exceptionally important on Inis Oírr at various times during the post-glacial. The early Holocene woodlands were dominated by hazel, pine, oak and elm and also contained tall shrubs that are seldom recorded in pollen diagrams such as *Viburnum opulus*, *Rhamnus catharticus* and *Sorbus* (probably includes not only *S. aucuparia* but also broad-leaved whitebeams such as *S. aria* and *S. hibernica*). Particularly noteworthy features include the rather open character of the early Holocene woodlands and the evidence for two major perturbations, P1 and P2, which are ascribed to climatic oscillations. The former is of similar age to the 8.2 ka event, a cooling event first described from the Greenland ice cores. The latter perturbation is shorter but the movement of the pollen curves suggests a more pronounced cooling event. In the upper part of the profile, human impact in the form of farming activity (mainly pastoral but with an important arable component from c. AD 800 onwards) is the main, though not the only, forcing factor influencing woodland composition and extent. The final demise of woodland is dated to the late fifteenth/early sixteenth century though occasional trees probably survived into the late eighteenth century. The present-day almost treeless landscape is thus of relatively recent origin.

Introduction

Long-term perspectives on vegetation and particularly woodland development are dependent largely on reconstructions based on evidence gleaned from macrofossil and particularly pollen analyses. The potential of pollen analysis for elucidating the history of Irish vegetation and flora was first seriously realised in Jessen's (1949) classic paper *Studies in the Late Quaternary deposits and flora-history of Ireland* (cf. also earlier publications such as Erdtman 1924; White 1931; Mitchell 1940). In the meantime, many pollen profiles have been constructed from Ireland that elucidate aspects of interglacial, Late-glacial and post-glacial (Holocene) vegetation development in various parts of the country. Beginning with the earliest investigations, trees received particular attention, which is not surprising given the importance of woodland during the Holocene as a whole and also interglacial periods. From a methodological viewpoint, this is also understandable in that arboreal pollen (AP) normally constitutes the bulk of Holocene fossil pollen assemblages and, furthermore, pollen identification of AP is relatively easy even with non-sophisticated microscopy. An obvious exception is Taxus (yew), which went unrecognised in Holocene profiles from Ireland prior to the 1980s. This, and also omissions such as *Fraxinus* in the earliest profiles (e.g. Jessen 1949), reduce the value of results from earlier investigations for reconstructions to modern standards. Furthermore, considerable attention has been paid to the identification of the non-arboreal pollen (NAP) component in more recent investigations (largely ignored in the earlier investigations). The NAP component is essential for reconstructing farming history (Behre 1981) and also documenting changes in limnic and bog environments.

In this paper, the results of pollen analytical investigations of thick Holocene deposits taken from An Loch Mór, Inis Oírr, are presented. While woodland dynamics in a karstic situation such as the Aran Islands can hardly be regarded as typical for Ireland or even the comparable nearby Burren region, the results are of more than usual interest because of the exceptional habitat, the floristic importance and the archaeological evidence for long-term human impact on the natural environment in the Aran Islands. The pollen profile, in itself, is also exceptional given the high temporal resolution (261 pollen spectra), the variety of pollen taxa identified (some 180 palynomorphs; these include non-pollen palynomorphs, i.e. fungal spores, animal microfossils, etc.) and also the high pollen counts (in most spectra >1000; less in uppermost spectra where the pollen concentration is low).

The investigations formed part of the EU 4th Framework project, TIMECHS. Publications to date from this project include a detailed description of Holocene vegetation and land-use dynamics with particular reference to land-use and the archaeological record (Molloy and O'Connell 2004) and an account of tephra investigations and the implications of twelve microtephra layers for the chronology of the profile (Chambers *et al*. 2004). The present paper draws on the information contained in these papers and also the investigations of other TIMECHS partners that are detailed in the Final Report of TIMECHS (TIMECHS 2001; publications in preparation).

Site description

An Loch Mór (the large lake), lies in a sheltered, north/south-running valley at the eastern end of Inis Oírr (grid ref. L 990 020; 9° 30.3'W, 53° 03.5'N; Fig. 1), known in the anglicised form as Inisheer. The lake is c. 460 m long (excluding the neck at the southern end) by c. 200 m wide and attains a maximum depth of almost 23 m. Today, it is slightly brackish (c. 5‰) due mainly to the twice daily incursion of saltwater through the jointed 250-m-wide band of limestone bedrock (narrowest point) that separates it from the Atlantic Ocean at its northern end (aerial photograph, Fig. 1).

The lake is bounded to the north and north-west by low-lying small fields enclosed by high stone walls that are typical for the Aran Islands as a whole (Fig. 1). Today, the fields carry mainly species-rich pastures and meadows but, until the recent past, many of these fields carried crops of potatoes, rye and oats (see below). The soils are largely, or even perhaps exclusively, plaggen soils, i.e. they have been artificially created by the transport of sand and seaweed by the local farming communities onto more or less drift-free, karstic limestone bedrock (Conry 1971). The relatively high ground to the east of An Loch Mór, which slopes steeply to the lake, consists mainly of jointed limestone pavement with a rather sparse vegetation cover. The higher ground on the western side that extends southwards from Formna – a small settlement on high ground overlooking the north-west corner of the lake – slopes down to the lake in a series of cliffs and rock terraces. The short cliff faces and the narrow terraces are covered, to a large extent, with low shrub vegetation. Much of this consists of *Hedera* but taller shrubs such as *Crataegus monogyna*, *Prunus spinosa*, *Euonymus europaeus* and *Cornus sanguinea* are also common (higher plant taxonomy follows Stace (1991)).

The island is virtually treeless. *Corylus avellana* is known only as a nineteenth century record, and *Alnus glutinosa*, *Quercus* and *Ulmus glabra* are not regarded, in descriptions of the present-day and recent flora, as native to the Aran Islands. *A. glutinosa*, *Quercus robur* and *U. glabra* are present on Inis Mór; it is generally presumed that they have been planted (Webb 1980; Webb and Scannell 1983; Roden 1994). *Juniperus communis*, which is common on the two larger islands, was reported in the last century from Inis Oírr but, in the meantime, has become extinct, possibly through use in religious ceremonies on Palm Sunday (Webb 1980).

Today, pastoral farming (mainly cattle and also sheep), some fishing and increasingly tourism are the economic mainstays of the islands. In the past, however, tillage was important. In the 1940s, for instance, the Aran Islands had 139, 28 and 10 ha under potatoes, rye and oats, respectively (average data over 7 years; Central Statistics Office). In addition, there was a small wheat acreage due to the exceptional circumstances associated with World

War II. In all, c. 4% of the total land surface was under tillage, which is relatively high given the highly karstic terrain that includes extensive areas of limestone pavement. At that time, mainly farming and fishing supported a population of c. 2000 (in 1946 the population was 1971). In 1821 Inis Oírr had a population of 417; in 1996 the population was only 274. Since the onset of farming in the Neolithic, Inis Oírr was probably always populated and especially during the Medieval (Christian) period to which most of the archaeological field monuments relate (at least three Church/monastic sites and a late medieval tower house/castle (Fig. 1). Monuments relating to earlier periods include a large stone fort (cf. mid to late Bronze Age and also used in later periods; age assignment relies mainly on the results from excavations of Dún Aonghasa and other forts on Inis Mór; cf. Cotter 1996).

Methods

Coring was carried out using an Usinger piston corer in August 1996 in water depth of c. 23 m, i.e. the deepest part of the lake (Fig. 1). Triplicate, parallel, 8-cm-diameter cores (MOR1, MOR2 and MOR3) were taken within c. 4 m of each other, in 2-m overlapping drives. Core MOR1, the most complete Holocene core (c. 11.55 m of Holocene sediments) was used as the primary sample source for the pollen analytical investigations. Additional samples were taken from the parallel core, MOR2, to fill gaps between the first and second (3 samples) and second and third (16 samples) drives in MOR1. Samples of 1-cm thickness were used, apart from the basal part of the sequence, which was continuously sampled by taking mainly 0.5-cm thick slices. Four samples were also analysed from a 1-m top core taken by a Mackereth corer in June 1999 (designated as subzone D28). High representation of *Potamogeton* sect. *Coleogeton* pollen in the Mackereth core and the uppermost spectrum from MOR1 (c. AD 1950/60) shows that these two records overlap.

Pollen have been identified to the lowest taxonomic unit that is compatible with secure identification. Cereal-type pollen (includes only those pollen ≥41 µm) were distinguished from other Poaceae pollen on the basis of size of grain, pore and annulus, and *Secale*-type were distinguished as a separate taxon (cf. Beug 2004).

Data presentation

The primary pollen data are presented in percentage pollen diagrams relating to the earlier, and mid and later parts of the Holocene (Figs. 2 and 3, respectively). These are supplemented by pie and bar charts (Figs. 4 and 5, respectively). The percentage curves are based on a total terrestrial pollen (TTP) sum, i.e. aquatics, etc. are excluded from the divisor used for calculating the percentage values. Pollen concentration values (curves not provided) are also referred to where appropriate.

The pollen diagrams have been zoned as follows to facilitate description and evaluation. Major biostratigraphical units are recognised as superzones A-D (Table 1). The superzones are defined on the basis of large movements in several pollen curves, and especially the relative contributions of arboreal (AP) and non-arboreal (NAP) pollen taxa. The superzones, in turn, are divided into local pollen assemblage zones (referred to as zones; in some instances, subzones are also distinguished; Table 1) on the basis of less pronounced but nonetheless important changes in pollen representation.

The chronology for the pollen profile relies on several lines of evidence including AMS 14C dates, tephra, pollen stratigraphy and varve analysis (TIMECHS 2001). While the chronology is regarded as sound, it is important not to underestimate the error ranges that are inevitably associated with a chronology based on connecting points that are not absolutely fixed (apart from tephra-based dates). Dates are cited as calibrated AD/BC years (indicated as AD or BC). Dates in calibrated BP years (cal. BP; obtained by the addition of 1950 to AD/BC dates) and non-calibrated 14C years (BP) are also occasionally cited.

The classical pollen zones, i.e. Preboreal, Boreal, Atlantic, Subboreal and Subatlantic, are sensu Mitchell (1956) (cf. also Table 1.7a, Mitchell *et al.* 1996). These are used mainly as reference points; they are not intended to have any climatic and chronological (apart from the Elm Decline at the Atlantic/Subboreal transition) significance.

Cultural periods are as generally recognised in the archaeological and historical literature relating to Ireland (cf. Molloy and O'Connell 2004; Waddell 1998). The Neolithic is regarded as beginning shortly before the Elm Decline which is usually regarded as dating to c. 5100 BP or 3800 BC. The Bronze Age is considered to begin at c. 2400 BC or 3900 BP. It is subdivided informally into early, middle and late Bronze Age, the transitions to middle and late Bronze Age being placed at c. 2000 BC (3700 BP) and 1200 BC (3100 BP), respectively. The Bronze Age/Iron Age transition, which is poorly defined in the archaeological record, is placed at c. 700 BC (2600 BP). The subdivision, late Iron Age (c. AD 100-500) is based on palynological criteria rather than the archaeological record. The subdivisions, early and middle Iron Age, are informal divisions though the latter equates approximately to the La Tène period. The beginning of the Medieval period is regarded as contemporary with the spread of Christianity, which also marks the beginning of the historical period. The mid-/later Medieval period includes historical developments such as the period of strong Viking influence (c. AD 830-1000) and the arrival of the Normans in Ireland (AD 1169) and their subsequent expansion.

Table 1. *Biostratigraphical zonation of profile MOR1, An Loch Mór, Inis Oírr.*

Superzone / Zones	Main features (pollen data, vegetation development and cultural period)	Depths (cm)* / Ages (approx.)
Superzone D / Zones D1-D2	Historical period characterised by strong human impact and final demise of woodland	2642-2226 / AD 500-1990
Superzone C / Zones C1-C9	Subboreal to early Subatlantic, i.e. from the Elm Decline to the end of the Late Iron Age Lull (prehistoric farming periods, i.e. Neolithic to Iron Age)	3210-2642 / 3650 BC-AD 500
Superzone B / Zones B1-B3	Boreal and Atlantic periods. Maximum woodland development. Spans the Mesolithic; probably includes the beginning of the Neolithic	3454.5-3210 / 8070-3650 BC
Superzone A / Zones A1-A2	Younger Dryas/Holocene transition and pre-Boreal (Corylus has not expanded)	3472-3454.5 / 9420-8070 BC

** Depths are with respect to the lake water surface; the water column is c. 23 m. Sediment depths have been adjusted to allow for expansion of the sediment after coring, etc.*

Description and interpretation of the fossil pollen record

Zone YD (end phase of Younger Dryas; 9500-9600 BC)

This zone relates to the final phase of the Late-glacial, i.e. the uppermost part of the Younger Dryas and is presented here for completeness and to give context to the Holocene part of the record. It includes two contiguous pollen spectra from the top of the Younger Dryas sediments. Non arboreal pollen (NAP) dominate (68%) with Poaceae, *Thalictrum* and Cyperaceae the main contributors. The vegetation was not only treeless but shrubs were also unimportant. For instance, *Juniperus* achieves only 1% and ericoids were not recorded. The sediments are highly minerogenic, which suggests active solifluxion, i.e. in-wash of raw, mineral-rich soils as a result of freeze-thaw action. The average air temperature in the warmest month may not have exceeded 6°C while the corresponding winter temperature may have been as low as -20°C (O'Connell *et al.* 1999; Atkinson *et al.* 1987). Such conditions are not conducive to the growth of tall shrubs and trees.

Zone A1 (Early pre-Boreal; 9500-8750 BC)

The Holocene record commences with zone A1, which consists of ten contiguous pollen spectra and so the record may be regarded as continuous.
Noteworthy features include:

- A gradual and sustained increase in *Betula*, fern spores (also fern annuli) and *Filipendula*.
- A sharp peak (28%) in *Juniperus*. The *Juniperus* stomata curve is almost continuous.
- Initial high values for Poaceae, *P. lanceolata* and *Campanula*-type. A single pollen of *Gypsophila fastigiata/repens*-type is recorded (subzone A1).
- Total terrestrial pollen concentration values increase steadily in this zone from an initial 17 300 to 61 400 grains cm^{-3}. This is accounted for mainly by an increase in the woody component (mainly *Betula* but also *Juniperus*).

Interpretation

The basal spectra record the transition from open grass-dominated to shrub-dominated plant communities, consisting mainly of juniper and also birch – presumably tree birch, *B. pubescens* – with a well-developed fern component. The continuous curve for *Juniperus* stomata, combined with substantial pollen representation, shows that juniper persisted locally while birch expanded. Herb communities were also important. These communities changed from being initially grass dominated with *P. lanceolata*, *Rumex* (possibly also *Oxyria*) and *Campanula* (may include *Phyteuma*; subzone A1) to communities where the relative importance of grasses and sedges declined and *Filipendula* (presumably *F. ulmaria*, the meadowsweet) flourished (subzone A1).

A mosaic of tall shrub and herb-dominated communities is envisaged for this time. As regards the presence of a thermophilous element, the evidence is not entirely unambiguous. *Pinus* and *Corylus* have values of 1% in several spectra. Overall pollen influx is low and so long-distance transported pollen, even if infrequent, is expected to be relatively well represented in percentage data. Rather significantly, *Pinus* stomata were not recorded.

At the base of the zone, the sediments change from highly minerogenic to lighter coloured, i.e. relatively marl-rich sediment with a noticeable silt component. The uppermost two samples are from dark, organic-rich fine sediments, i.e. sediments that are characteristic of the next zone. This probably signals a climate shift that was probably small, a conclusion based on the rather modest shift in composition of the pollen assemblage.

Succession involving expansion of thermophilous plants, such as hazel and tall canopy trees, might be expected, given the rather long time period represented (>700 years). It is assumed that climatic rather than edaphic conditions inhibited more rapid establishment and expansion of the full complement of thermophilous woodland species. Micropropagules were probably not available because plant migration, at a regional scale, was inhibited by unfavourable climate.

Zone A2 (Late pre-Boreal; 8750-8050 BC)

In this zone, a record based on fine resolution (mainly 0.5-cm thick samples; 15 spectra in all) continuous sampling is available. *Betula*, at c. 30%, dominates the pollen assemblage and *Corylus* begins to rise rather sharpy as the zone ends. *Juniperus* and also *Juniperus* stomata are well represented. In the upper part of the zone a substantial *Viburnum opulus* curve is initiated. This tall shrub is seldom recorded in Irish pollen diagrams (see below).

NAP continues to be well represented, especially *Filipendula*, Poaceae and *P. maritima*. There are minor but more or less continuous curves for other herbs such as *Helianthemum* and Asteraceae (cf. Liguliflorae and Tubuliflorae curves) as well as the ferns *Botrychium* and *Ophioglossum* that are associated with grassland. There are two records for *Gypsophila fastigiata/repens*. Today, *G. fastigiata* and *G. repens* have rather different distributions; the former is regarded as continental-type and the latter as strictly 'alpine' (cf. Webb and Moore 1982). Both species and also several of the other NAP curves (esp. *Helianthemum*, *Rumex*-type and *Caryophyllaceae taxa* (undifferentiated, i.e. excluding **Gypsophila**) suggest a continental-type climate in which winter temperatures were depressed. TTP concentration is higher than in zone A1 and interestingly *Juniperus* has similar concentration values to those in zone A1. This suggests that *Juniperus* percentage representation is depressed by the increased input of AP that consists mainly of *Betula*.

Interpretation

In this zone, birch (presumed to be tree birch, *B. pubescens*) achieved maximum development. Hazel was undoubtedly present at least towards the end of the zone (apart from the basal spectrum it is >1% and achieves 20% in the uppermost spectrum) when *V. opulus* (guelder rose) also achieved importance. Today, this tall shrub occurs sparingly on Inis Mór though it is common in the limestone areas of N. Clare and E. Galway. The pollen profile by Watts (1984) from Gortlecka, SE Burren, also shows a more or less continuous curve for *V. opulus* during the early Holocene. It was probably rather frequent on karstic terrain on the Aran Islands and in nearby Clare and Galway where limestone dominates (on-going investigations indicate that it was common in the Corrib lowlands (A. Bingham, unpublished data)).

Tall canopy trees were probably not yet locally present. *Pinus* achieves only c. 1%, *Quercus* is mainly <1% and only occasional pollen of *Ulmus* were recorded. Significantly, *Pinus* stomata were not recorded (points strongly to absence), which contrasts with the substantial record for *Juniperus* stomata.

Despite the strong development of birch-dominated woodland, open herb communities persisted. *Helianthemum* was relatively important throughout and also *Campanula* (probably *C. rotundifolia*) and possibly *Phyteuma* species, though this genus is not represented in the present-day Irish flora. *Empetrum* (crowberry; included in the curve for Ericoids) was also present (also in zone A1) but it was a minor element of the flora (<1%;), which is not surprising given the calcareous substrate.

Though climatic amelioration relative to conditions pertaining during zone A1 had occurred, the climate probably remained rather strongly continental with severe winters which would explain the poor development of thermophilous taxa. Lake levels appear to have been much shallower than today. This is suggested by a substantial *Littorella* curve (c. 2-3%; this semi-aquatic typically grows on gently sloping lake-shore where it is subject to more or less continuous immersion in rather shallow waters), consistent records for *Hydrocotyle vulgaris* (wet rather than submerged habitats) and the records for true aquatics such as *Myriophyllum spicatum* (main contributor to the *M. spicatum/verticillatum* curve). Precipitation was probably depressed and summer evapotranspiration levels were probably higher than today as a result of greater seasonality resulting from the orbital configuration of the earth *vis-à-vis* the sun at this time (Kutzbach and Ruddiman 1993).

As the zone ends, hazel had established itself locally (in uppermost spectrum it achieves 20%) and had begun to expand, mainly at the expense of birch. This was probably in response to climatic amelioration that also resulted in higher pollen productivity (pollen concentration has risen to 1.06×10^5 grains cm^{-3}).

Zone B1 (Boreal period; 8050-5310 BC)

In zone B1, arboreal pollen (AP) clearly dominates for the first time, with an average of 79%. The main contributors are *Corylus*, *Pinus*, *Quercus*, *Ulmus* and *Betula* in order of decreasing percentage pollen values. A high NAP diversity, however, persists though values are generally low. *Rhamnus catharticus* is represented by a continuous curve (no comparable records available for Ireland) and *V. opulus*, which expanded in zone A2, continues to be strongly represented. Alnus is consistently represented at low values (generally <0.5%) in the upper part of B1. Pollen concentrations are much higher than in zone A2. AP increase from c. 50 000 to c. 200 000 grains cm^{-3} mainly as a result of a large increase in *Corylus*.

Interpretation

Tall canopy woodland had developed though 100% closed cover was not achieved, which is most atypical for the Boreal period in Ireland and NW Europe generally.
Detailed palaeoenvironmental reconstruction is considered firstly in the context of three subzones (B1α, Bβ and B1γ) and, secondly, with respect to evidence for two perturbations in the woodland cover (P1 and P2). In subzone B1α, hazel expanded rapidly and became the dominant woodland species. It largely displaced birch. At the same time, pine expanded locally (cf. records of *Pinus* stomata) and presumably also at a regional level. Oak, and also elm, may have been present but as minor elements. Open areas persisted where herbaceous plants, such as Poaceae, *Filipendula*, Asteraceae (Liguliflorae and Tubuliflorae) and *P. lanceolata*, flourished.

In subzone B1β, pine expanded further, and oak and elm were almost certainly present but remained minor elements of the hazel (*Corylus* achieves highest overall representation at *c.* 50-60%) and pine-dominated woodlands. Juniper persisted but is greatly reduced in importance, especially near the lake (only one sample with stomata in zone B1). A slender curve for *R. catharticus* suggests local presence, presumably near the lake margin, i.e. the type of habitat that it frequently occupies in the Burren today and also on Inis Mór and Inis Meáin. Today, it is rare on both these islands and has not been recorded from Inis Oírr (Webb 1980). A rather substantial *Helianthemum* curve (continuous representation also in zone A2) and more or less continuous curves for several NAP (cf. *P. lanceolata, Filipendula* and Chenopodiaceae) indicate persistence of some open habitat devoid of woodland cover.

In subzone B1γ, oak expanded further (especially above P1) and became more important than pine. Elm also expanded but to a lesser degree. A continuous curve for *Hedera* (ivy) is initiated (7100 BC), NAP increases somewhat in importance and *P. coronopus,* which today is strictly limited to a narrow coastal strip (unlike *P. maritima* which in Ireland occurs far inland, e.g. it is common in grasslands in the upper reaches of turloughs in the eastern Burren), forms an almost unbroken curve throughout this subzone. The importance of pollen of shrubby species, e.g. ivy, and the persistence and diversity of the NAP component point to woodlands with a relatively open character and possibly limited areas more or less totally free of trees. Subzone B1γ includes features referred to as P1 and P2 that are now considered.

Evidence for perturbations in the Boreal woodlands

Two perturbations, P1 and P2, were detected at an early stage of the analyses and have been elaborated in some detail by close interval sampling.

P1 (6500-6250 BC; 8450-8200 cal. BP). P1 spans a 14-cm interval (nine pollen spectra between 3406-3393 cm). Palynologically, it is characterised as follows:

1. Increased *Corylus* and *Juniperus* (achieves 10%; *Juniperus* stomata are also recorded; concentration values also show a distinct increase).
2. *Pinus*, *Betula* and especially *Quercus* values are depressed.
3. NAP remain more or less unchanged but the fern *Ophioglossum* is consistently recorded and *Pteridium* expands.

4 TTP concentration remains high but *Pinus* and *Quercus* decline as in the percentage curves.

Tall canopy trees (especially oak, birch and pine; cf. few *Pinus* stomata) declined at the onset of P1. The expansion of *Juniperus* (particularly mid-way in the perturbation) suggests increase in juniper pollen productivity and presumably also the juniper population. This was presumably facilitated by increased openness in the woodland structure that probably also stimulated flowering of hazel. The overall changes suggest substantial woodland perturbation that persisted over a rather long period (c. 250 years). Its cause presumably lay in an external forcing factor such as climate change (e.g. increased storminess, lower precipitation levels, etc.) that operated over a considerable period rather than a catastrophic event of short duration (within the perturbation there may have been a particularly short-lived sharp downturn that is signalled by the *Juniperus* peak).

Changes in the limnic environment are suggested by increased representation in the alga *Botryococcus.* However, *Pediastrum*, which often responds positively to perturbations in a catchment that result in increased mineral input through soil inwash, shows no response.

P2 (5650-5530 BC; 7600-7480 cal. BP). P2 spans an 8-cm interval (continuous sampling between 3361-3354 cm). Palynologically, it is characterised as follows:

1 *Corylus* representation decreases from 50% to 30%, approximately.
2 *Betula* increases (c. 4% to 14%); also *V. opulus* and, to a much lesser degree, *Juniperus* (from <1% to *c.* 2%). *Pinus* increases in the upper part of the interval.
3 NAP are somewhat elevated, especially Poaceae, but the *P. coronopus* curve is interrupted.
4 TTP concentration values are lower and especially *Quercus* and *Corylus*.

These features suggest rather profound changes as birch, pine and to a small extent juniper were favoured at the expense mainly of hazel and also oak. Herbaceous communities showed only a weak response, expressed mainly as elevated Poaceae representation. The beginning of the perturbation is marked by an expansion of *Pteridium*, a fern normally favoured by woodland disturbance and opening-up of the canopy.

These vegetation changes suggest increased continentality (less precipitation; increase in seasonality) that shifted the competitive balance away from hazel and in favour of birch. The subsequent expansion of pine at the expense of birch is comparable to developments characteristic of the early part of interglacial cycles. As in these cycles, this development was probably the result of a recovery in the thermal environment as climatic conditions similar to those pertaining before the perturbation were restored.

Two additional features in zone B1 are worthy of note. Firstly, the course of the *Alnus* curve which, apart from being indicative of the spread of alder, also marks the transition from the Boreal to the Atlantic period. A more or less continuous curve for *Alnus* begins immediately after P1, but in P2 the *Alnus* record consists of usually two, rather than single, pollen as hitherto in each spectrum. Alder was probably present from the end of P1 (6200 BC), at least at a regional level.

The second feature relates to a pollen spectrum derived from the calcite layer, M1 (depth 3380 cm), at approximately mid-way between P1 and P2 (forms the lowermost of four well-defined layers, M1-M4, in the lower part of the core sequences). The precipitation of calcite is normally associated with a shift in the chemical equilibrium within a lake that involves uptake of CO_2 by aquatic plants, including algae. Conditions must also be such as to inhibit re-solution of calcite as it descends through the water column and enters the sediment. Layer M1 was *c.* 15 mm thick and had a particularly sharp lower boundary. When sampling this layer for pollen analysis, care was taken not to include any of the adjoining organic-rich sediment.

The pollen spectrum shows slightly elevated values for *Pinus* and ferns, and lower values for *Corylus* and *Ulmus*. This suggests that the layer was formed in late spring/summer, i.e. after hazel had finished flowering and pine was still flowering (late May). AP concentration values are substantially lower (*c.* 50%), which is as expected if the layer was deposited within a short time period – possibly over several days or weeks.

Zone B2 (Early Atlantic period; 5310-4500 BC)

The base of zone B2 is regarded as the Boreal/Atlantic transition (BAT), a key feature of which is the rise in *Alnus,* which began to increase near the top of zone B1 (see above). The zone boundary is placed where *Alnus* exceeds 1% for the first time. The zone is also characterised by a steady decline in *Corylus* (from *c.* 50% to 35%). There is a marked rise in the aquatic *Myriophyllum spicatum* near the base of the zone.
Near the base of this zone, the lithology changes from relatively dark to a light grey, relatively marl-rich sediment. Upwards in the sequence, the marl content increases and laminations, which are seasonal (varves), were recorded from near the base of zone B3 to mid-C2 (Fig. 3B). Laminations, though weaker and less regular, begin immediately below P1 in subzone B1(where the marl content increases (Fig. 2A).

Interpretation

Alder expanded in the context of oak-pine-hazel-elm woodlands, but population levels remained modest. *Alnus* averages 2.4% in zone B2, and 7.7% over zones C1-C5, i.e. the interval during which it is most strongly represented. These values are low, particularly in the context of a very high pollen producer with high pollen dispersal. That alder failed to expand substantially is hardly surprising given the general scarcity of suitable wet habitat in the karstic terrain. The base of the zone and the expansion of *Alnus* is dated to 5300 BC (c. 6700 BP) but alder may have been present locally for a century or more prior to this (see zone B1; also supported by macrofossil finds; J.N. Haas in TIMECHS 2001).

Another major change during zone B2 was the decline of hazel in favour of oak. Hazel pollen production may have been adversely affected by increased shade from oak and pine, but it is likely that the contribution of hazel to the woody vegetation as a whole also declined. *Fraxinus* is consistently recorded (in 12 of the 15 spectra), which suggests presence of ash as a minor component of the woodlands. Near the top of the zone, *Taxus* pollen is recorded so that yew may also have been present as the zone ends.

Shrubs Smaller woody taxa such as *R. catharticus, V. opulus* and *Hedera* continue to be important. These shrubs are probably under-represented in the pollen record because of low pollen production and dispersal capacities, particularly given the largely wooded landscape.

The relatively high *Myriophyllum spicatum* values (also leaf fragments noted by J.N. Haas; TIMECHS 2001) for most of the zone suggest lowering in lake levels, which in turn points to less precipitation and/or increased temperatures especially during summer months and hence increased evapotranspiration levels. Such a climatic scenario is the opposite to that traditionally associated with the Atlantic period.

Pollen spectrum 3298 cm is from the well defined calcite layer, M2. *Pinus* and *Myriophyllum* have increased representation that, as in the case of M1, points to deposition during the summer period.

Zone B3 (Late Atlantic period including possibly the earliest Neolithic; 4500-3650 BC)

The course of vegetation development during the past *c.* 6500 years has been considered in detail in an earlier publication (Molloy and O'Connell 2004). The present account is confined to detailing the main developments with particular emphasis on woodland dynamics and the interplay of human activity and climate on vegetation developments.

Zone B3 is differentiated from the preceding zone mainly by the initiation of a substantial curve for *P. lanceolata* with an average value of 4.1% and a range 1.5-7.5%. This contrasts with occasional records in zone B2. The trend towards declining *Corylus* values continues and *Pinus* (also *Pinus* stomata) and *Quercus* are more strongly represented. Other features include the initiation of an *Ilex* curve and consistent records for *Fraxinus* and to a lesser extent *Taxus*. Pollen concentration values remain stable.

Interpretation

Woodland with oak, pine and hazel as the main components continued to dominate. The pine stomatal record indicates that pine was important in the vicinity of the lake shore. Tall shrubs such as *R. catharticus* and *V. opulus* continued to flourish and holly was an important element in the flora for the first time (from *c.* 4100 BC).

A strong expansion of *P. lanceolata* prior to the Elm Decline is unknown in NW European pollen diagrams. However, recent detailed pollen diagrams from western Ireland show a slender curve for *P. lanceolata* that began before the Elm Decline, i.e. at *c.* 4000 BC (5300 BP) in the L. Sheeauns profile, NW Connemara, where an *Ilex* curve is initiated at about the same time (Molloy and O'Connell 1991, O'Connell and Molloy 2001). Clearly, the opening up of the mid-Holocene woodlands and the development of grassland communities occurred earlier, and to a greater extent, in parts of western Ireland than previously realised. Another aspect of note is the failure of Poaceae and NAP in general (also *Pteridium*) to expand. Conditions that favoured ribwort plantain but not grasses and herbs of open habitat over a relatively long period are difficult to envisage from a present day perspective.

Woodland cover on Inis Oírr was probably never as closed as on the mainland and so an environmental change that adversely affected trees and tall shrubs would almost inevitably lead to openings in the woodland cover into which herbaceous species, which were already well represented locally (cf. P1 and P2), could expand.

There is lack of evidence as to the nature of the environmental changes that resulted in opening up of the woodland cover. Neolithic farming is a possibility though unlikely. Cereal-type pollen are recorded but these probably arise from non-cultivated grasses rather than cereals (Molloy and O'Connell 2004). It is generally accepted that there was a Neolithic presence in Ireland as early as *c.* 4000 BC (5300 BP), but secure evidence is not yet available for a presence several centuries prior to this (cf. O'Connell and Molloy 2001).

Varve formation was initiated immediately above the B2/B3 boundary, continued throughout zones B3 and C1 and ceased mid-way through zone C2 (Fig. 3B; T. Saarinen in TIMECHS, 2001). Within-lake conditions, at least as regards sedimentation processes (e.g. absence of perturbations that might give rise to mixing, etc.) were probably relatively stable throughout this period. Lake levels possibly rose, which is suggested by the decline in *M. spicatum* (Fig. 3B).

It is concluded that the human factor was not responsible for the significant shift in vegetation composition and woodland cover. Likewise, changes in edaphic conditions were hardly responsible given that any soil parent material deposited in the course of the last glaciation was probably already lost by the end of the Younger Dryas, i.e. the beginning of the Holocene (G. Schettler, unpublished data). The best explanation probably lies in climate forcing, though again it is difficult to envisage the nature of a climatic shift that could have resulted in such profound changes in the terrestrial vegetation.

Zone C1 (Early Subboreal/Earlier Neolithic; 3650-3350 BC)

A sharp fall in *Ulmus* representation is recorded across the lower zone boundary (from *c.* 6 to 0.7%) which is followed by a recovery. *Pinus* declines and *Pinus* stomata are recorded only in the two lowermost spectra. *Corylus* falls to overall lower representation (c. 23% as against 30%) but *Alnus* and *Betula* increase. Curves for shrubs such as *R. catharticus, V. opulus* and *Ilex* are interrupted and *Hedera* has very low representation. On the other hand, NAP and especially Poaceae, *P. lanceolata,* Liguliflorae and Rubiaceae, have increased representation (the pastoral indicator component of the NAP increases from *c.* 10% to an average of 26%; cf. Fig. 4). The concentration curves follow a similar pattern.

Interpretation

The classic Elm Decline of NW European pollen diagrams, which is datable to *c.* 5800 cal. BP (5100 BP), is recorded at the base of the zone. A Landnam-type event (clearance for Neolithic farming) was probably involved but, given the pronounced decline in *Ulmus* representation, a disease, with effects similar to recent Dutch Elm epidemics, may also have played a key role. The substantial increase in NAP, and especially Poaceae and *P. lanceolata*, suggests rather extensive grassland that was created at the expense of elm, hazel and also pine and oak. The interruption in the *Pinus* stomatal record suggests that pine growing near the lake margins was also cleared. Algal growth was favoured (cf. *Pediastrum* and *Botryococcus)* probably as a response to increased inwash that followed woodland clearance.

Zone C2 (Early Subboreal (later part); mid-Neolithic; 3350-3150 BC)

Zone C2 is essentially a transitional zone between C1 and C3. It is characterised by steadily increasing *Pinus* and *Corylus* curves. *Pinus* achieves a maximum for the profile (33%; also stomata are frequent). Poaceae values decrease steadily, *P. lanceolata* declines sharply and NAP, in general, decline. AP concentration values are exceptionally high at the top of the zone, which suggests greatly increased input of arboreal pollen.

Interpretation

Strong regeneration of woodland took place in a post-Landnam context, which lead briefly to the dominance of pine, at least in the vicinity of the lake. Hazel was also important in these pine-dominated woodlands. It is interesting that, at this time, pine out-competed oak and elm, both of which had begun to regenerate strongly as zone C1 closed, but yet failed to become the dominant trees. The re-establishment of a curve for *Juniperus* suggests that the pine, oak and hazel-dominated woodlands were not totally closed.

An expansion of pine at about this time (mid-Neolithic) is unusual in Irish pollen diagrams. Where an expansion is recorded, it dates to a few centuries later and is normally attributable to a so-called flush of pine on blanket bog surfaces (O'Connell and Molloy 2001). On Inis Oírr, however, there is no bog or possibility for bog development, yet pine had the competitive edge over the tall canopy deciduous trees, presumably as a result of an unusual combination of edaphic and climatic conditions.

Other indicators of environmental change at this time include the cessation in varve formation at 3173 cm, i.e. as *Pinus* expanded sharply. Above this, the sediment is dark, organic-rich and massive, and has few or only faint laminations. The sedimentation process has changed and the seasonal pattern, whereby calcite-rich sediments were deposited in spring and summer followed by darker, more organic-rich sediments in autumn and winter, has broken down. What caused these changes at *c.* 3200 BC is unclear; given that farming activity had already declined, climatic factors probably played a critical role.

Zone C3 (mid-Subboreal; late Neolithic;3150-2950 BC)

Arboreal pollen peaks in the profile (94%; also maximum concentration values are recorded). This is achieved through a major expansion of *Taxus,* which peaks at 37% (3158 cm; 3050 BC).

Interpretation

There is a major change in woodland composition as yew expanded to become the dominant tree. This occurred at the expense of all trees (ash is an exception though it remains a minor component; *Fraxinus* maximum: 4.3%) and especially pine. *Pinus* stomata are frequent, which suggests that, though pine declined, it still persisted in the vicinity of the lake where it may have successfully competed with *Taxus* (*Taxus* stomata are poorly represented). A fruit of *B. pubescens* suggests local presence of birch (J.N. Haas in TIMECHS 2001).

Low NAP (minimum 0.9%) and low values for tall shrubs (*R. catharticus, V. opulus*, etc.), and greatly reduced pollen diversity serve to further emphasise the closed woodland cover with high shade due to dominance of yew. Woodland regeneration was facilitated by much reduced – and quite probably cessation – of human activity, though it is assumed that the population dynamics of the various woody species were modulated by factors such as edaphic and climatic conditions rather than changing levels of human activity.

Zone C4 (mid-Subboreal (later part); early and mid-Bronze Age; 2950-1750 BC)

At the base of the zone, *Taxus* falls initially sharply to *c.* 10% and then in a series of steps to 4%, 2% and, from 3050 cm onwards (shortly after 2200 BC), to usually less than 1%. On the other hand, NAP have high values and especially Poaceae and *P. lanceolata*, both of which average 10%. Three subzones are recognised based mainly on movement in the NAP curves.

Interpretation

At the base of the zone, a major clearance is recorded that affected mainly yew, the dominant tree. This facilitated the short-term expansion of willow (*Salix*) and *Osmunda*, the royal fern. The clearance occurred in the context of pastoral farming (cereal-type pollen are rare until the early medieval period when rye was introduced). Fire was important and may have had a role in woodland clearance (peak in micro-charcoal). In the upper part of the zone there is a shift in woodland composition that favoured hazel at the expense of pine.

As the period progresses there is a gradual shift in woodland composition so that by the middle of the zone (c. 2100 BC) yew, though still present, was a minor component and pine became increasingly less important though the stomatal record indicates continued local presence.

The high diversity of NAP suggests grasslands with high species diversity, e.g. Liguliflorae (dandelion-type), Tubuliflorae (daisy-type), Rubiaceae (probably includes *Galium*, *Rubia* and *Asperula*) and *Botrychium* (moonwort, a small grassland fern). In subzone C4β, lower *P. lanceolata* values (average: 7.5%) and an increase in *Corylus* suggest reduction in farming intensity over about two centuries centred on *c.* 2100 BC. This is followed by a particularly intensive farming phase during which *P. lanceolata* averages 12.8% (*P. coronopus* also frequent here; subzone C4γ, i.e. shortly after 2000 to 1750 BC).

Spectrum 3036 cm is from the calcite layer, M4. The pollen composition is comparable to that in adjacent spectra. Pollen concentration, however, is low, which suggests rapid deposition.

Zone C5 (Late-Subboreal; most of Mid-Bronze Age and early part of Late Bronze Age; 1750-1050 BC)

Quercus, *Corylus, Alnus* and *Fraxinus* are well represented (at least equivalent to, or exceeding, the representation in C4) while *Pinus* declines steadily to reach 2.4% at the end of the zone. NAP representation falls steadily; *P. lanceolata*, for instance, averages 7.1% compared with 10.2% in zone C4 and other NAP curves are interrupted (e.g. *Filipendula*).

Interpretation

There is a shift from woodland in favour of grassland, presumably as a result of reduced farming activity particularly towards the end of the zone. Oak, hazel and alder were the main woody plants, ash and yew (local presence confirmed by shoot fragments in a sample from middle of zone; J.N. Haas, TIMECHS 2001) were of minor importance. Pine declined steadily in importance so that by the end of the zone it was probably less frequent than ash. Since other trees do not decline and human activity wanes, the decline of pine is hardly attributable to anthropogenic factors. Conditions were such that pine seems to have lost its competitive ability *vis-à-vis* other trees. This was probably the result of a shift in climatic conditions.

The expansion of *R. catharticus* is noteworthy as well as the short-lived increase in juniper at the end of the zone. Juniper expansion was probably facilitated by removal of oak and hazel. Farming activity at this time may have been extensive rather than intensive, which could explain the delayed response in *P. lanceolata* (does not expand until zone C6).

Zone C6 (early Subatlantic; late Bronze Age (most of)/Early Iron Age; 1050-400 BC)

Pinus representation has again halved (<5%; stomata only sporadically recorded) and *Quercus* has also substantially lower values. A feature of the zone is the increased representation of shrubs including *Juniperus, Rhamnus*, *Viburnum, Hedera* and *Ilex*. NAP are well represented with Poaceae and *P. lanceolata* averaging 15.8% and 10.1%, respectively.

Interpretation

At the beginning the zone, substantial woodland clearance took place involving all tall trees including oak. Though woodland had lower representation than at any time since the Boreal, woodland communities with hazel, oak, ash and elm probably still provided substantial cover. Pine was a very minor element though pine trees were probably common beside the lake (cf. the consistent stomatal record). Tall shrubs such as *Rhamnus*, *Viburnum,* and *Ilex* flourished, which suggests that farming (mainly pastoral) was probably extensive rather than intensive. The expansion of *Sambucus* is particularly noteworthy. While *S. nigra* is recorded in the flora of all three islands, Webb (1980) regards it as probably introduced. The evidence provided here suggests native status.

Increased flowering and better pollen dispersal of shrubby species as a result of the reduction in tall canopy trees are probably as important as population increases. The exceptionally high *Hedera* representation suggests that ivy was more important than today, which is difficult to envisage since it is now the main shrubby species and covers much of the sloping ground on the sheltered western side of the lake.

Zone C7 (mid-Subatlantic (1); mid-Iron Age (1); 400-150 BC)

This pollen assemblage is similar to C6, but *P. lanceolata* and Poaceae have lower representation at the bottom and top of the zone where small peaks in *Juniperus* (8 and 9.5%, respectively) are recorded.

Interpretation

A reduction in pastoral farming, especially at the beginning and end of the zone, facilitated some regeneration of woody vegetation, mainly oak, elm, ash and juniper, and ivy at the base of the zone.

Zone C8 (mid-Subatlantic (2); mid-Iron Age (2); 150 BC-AD 100)

This pollen assemblage is broadly comparable to zone C6, but the main tall canopy trees (*Quercus*, *Ulmus* and *Fraxinus*) have lower representation and NAP values are higher (cf. *P. lanceolata*, Rubiaceae, *Filipendula*, Liguliflorae and Tubuliflorae).

Interpretation

Woody vegetation, including trees and tall shrubs, has reached its minimum since the expansion of yew in the later Neolithic. The small increase in *Pinus* may simply be the result of overall low input of AP pollen (stomata are, however, recorded suggesting local presence). Farming, which continues to be pastoral based, but perhaps with a minor arable component, was the major factor determining the overall vegetation, including the low woodland cover.

Zone C9 (mid-Subatlantic (3); late Iron Age; AD 100-500)

In this zone *Juniperus* expands to 20.6%, there are more subdued increases in AP (*Corylus*, *Ulmus, Fraxinus* and *Taxus* near the top of the zone) and low NAP values (*P. lanceolata* averages only 2.5% and falls as low as 0.3%). The concentration values show a similar pattern.

Interpretation

This is considered to be the late Iron Age lull (LIAL), a period of woodland regeneration in Ireland (especially in western Ireland) that was favoured by reduced farming activity. The expansion of juniper at this time is unique in Irish pollen records.

The extent of juniper expansion on Inis Oírr as a whole cannot be determined on the basis of a single pollen profile. It was almost certainly the main shrub in the vicinity of the lake, a view supported by the stomatal record (stomata recorded in five out of eleven spectra). It is reasonable to assume that it was the main species on the island as a whole. Why other fast regenerating shrubs, such as hazel, responded to a much lesser degree is difficult to explain. Shrubs such as *Rhamnus*, *Ilex* and *Hedera* were better represented, though they remain of minor overall importance.

The expansion in yew at the top of the zone is noteworthy (peaks at 13%). In the course of the zone, *Pinus* falls to consistently less than 2%, which suggests that it had become locally extinct (very few stomatal records). Interestingly, records for cf. *Ustilago* (rust fungus; TIMECHS 2001) are interrupted in this zone, which suggests that suitable hosts (probably mainly grasses) were scarce due to reversion of pasture to shrubby vegetation as a result of greatly reduced farming pressure. Indeed, short-term cessation of farming cannot be excluded.

Zone D1 (late-Subatlantic (1); Early Christian/Medieval (incl. Viking and Early Norman periods); AD 500-1230)

Zones D1 and D2 relate to the historical period in Ireland. These zones are characterised by more or less stepwise decline in AP interrupted occasionally by short-term minor recoveries, and the rise to dominance of NAP taxa. Subzones are indicated in both zones to highlight minor, yet significant shifts in AP and especially NAP curves.

Zone D1 is characterised by decreasing AP values (especially *Corylus*; *Quercus* representation is rather stable) and increased NAP diversity and percentage values equivalent to those pertaining prior to the LIAL (zone C8).

Interpretation

At the beginning of the zone there was substantial clearance (subzone D1). Scrubby vegetation was most affected, e.g. hazel, *R. catharticus*, holly, ivy, etc., while tall canopy trees such as oak seem to have been spared. Elm, ash and yew probably still survived locally, but in greatly reduced numbers (especially yew). Grasslands with high species diversity (cf. *P. lanceolata*, *P. maritima*, Liguliflorae, *Rumex*-type, *Filipendula*, Fabaceae, etc.) flourished in the context of increased farming activity associated with the beginning of the Christian period.

Subzone D1β is differentiated from D1α mainly by a continuous record for cereal-type (*sensu lato*, i.e. including *Secale*) pollen. *Secale* pollen was first recorded near the top of D1α (0.2% at 2597 cm, i.e. *c.* AD 770), but expands in D1β (5.4% at 2573 cm, i.e. *c.* AD 880). The rise in importance of an arable component in the farming economy, with rye as a main crop, is further emphasised by the increased representation of pollen of arable weeds (cf. Brassicaceae, *Artemisia* and Chenopodiaceae).

Zone D2 (late-Subatlantic (3); post Norman arrival to present; AD 1230-1990)

This pollen assemblage is characterised by the lowest AP (average 19.8%) and the highest NAP (57%) for the whole of the Holocene. The NAP component is also distinctive on account of the relatively large contribution by cereal-type pollen and especially *Secale* (average: 3.2%), and pollen of arable weeds (average: 9.6%). For the first time, *Sanguisorba minor* (salad burnet; a grassland herb, common today about the lake) is recorded and forms a continuous curve in the upper part of the sequence.

Note: subzone D2δ consists of the uppermost four spectra from a 1-m Mackereth core taken in August 1999; these spectra are regarded as spanning the interval *c.* AD 1960 and 1990.

Interpretation

Zone D2 reflects the final phases in the creation of a tree-free landscape. The trend towards a treeless landscape was already established by the end of subzone D1β (*c.* AD 1230; this date is constrained by dates derived from Hekla 1 tephra (AD 1104) and Veiδivötn tephra (AD 1477) at 2526 cm and 2416 cm, respectively; Chambers *et al.* 2004). Hazel, oak, alder and birch probably still had a considerable role in the island flora until at least mid-way in subzone D2β, i.e. prior to *c.* AD 1500. Persistence of hazel until at least 2336 cm (base of D2γ; *c.* AD 1750) is quite plausible (cf. Webb (1980) refers to an old but unconfirmed record for hazel on Inis Oírr). Written records show that juniper survived into the late nineteenth century (Colgan 1893), which is also suggested by pollen records in several spectra (top of D2β and D2γ). Oak probably also survived in small quantities until at least the eighteenth century (see also Molloy and O'Connell 2004). It is assumed that the rise in population associated with the late eighteenth century and which led to the Great Famine (1845-1847) was instrumental in the final demise of most woody species.
The NAP component of the pollen record of zone D2 is also of interest in that it provides insights into farming practice about the lake that are probably applicable to the Aran Islands as a whole. In subzone D2α, *Secale*-type representation is very low but Poaceae, *P. lanceolata* and other herbaceous taxa are well represented. These changes suggest a decline in cereal growing and perhaps farming activity generally. Apart from holly, however, there is no regeneration of woody species.

In subzone D2β cereal-type pollen (including *Secale*-type) is well represented. This indicates sustained arable farming with rye as the main crop. Brassicaceae are strongly represented. This family includes several species characteristic of arable and disturbed habitats, e.g. *Raphanus raphanistrum* and also *Sinapis arvensis* and *Capsella bursa-pastoris*. According to Webb (1980), however, these species may be introductions to the Aran Islands. *R. raphanistrum* subsp. *maritimus* is frequent today on Inis Oírr and subsp. *raphanistrum* was recorded in the mid-nineteenth century on all three islands (Webb 1980). It is quite likely that *Raphanus* was the main contributor to the Brassicaceae curve.

This period of considerable arable activity extended from the early fourteenth to the early nineteenth century with possibly a shift towards a more pastoral-based farming system from the late fifteenth century onwards (cf. higher Poaceae and *P. lanceolata,* and lower Brassicaceae representation).

In subzone D2γ, *P. lanceolata* has particularly high representation and Brassicaceae are poorly represented. This subzone spans much of the nineteenth and twentieth centuries when potatoes replaced rye as the main arable crop (see Introduction). The potato (*Solanum tuberosum)* is generally silent in pollen records because of low pollen productivity and dispersal and so is not normally recorded in pollen diagrams. The uppermost spectrum, which has greatly increased Poaceae representation, relates to *c.* 1950 and possibly reflects the beginning of the decline in farming activity associated with the later part of the twentieth century.

In the uppermost spectrum of subzone D2γ and continuing into subzone D2δ, there is a sharp rise in *Potamogeton* sect. *Coleogeton* (Fig. 2), which reflects the recent expansion of *Potamogeton pectinatus* in the shallow northern part of An Loch Mór. This aquatic has probably been favoured by higher nutrient/pollution inputs as well as brackish conditions.

Discussion and conclusions

Pie and bar charts are presented in Figs. 4 and 5, respectively, which summarise the main developments as regards woodland dynamics and farming history, and the population dynamics of the most important trees. In evaluating these data (also the pollen diagrams) it is important to bear in mind the differential pollen production and dispersal capacities of the various pollen taxa. In general, arboreal taxa (AP) have better pollen dispersal than non-arboreal taxa (NAP) in that most of the AP are wind pollinated and, furthermore, arboreal pollen are liberated much higher above ground level and so have a greater opportunity of becoming effectively airborne.

Trees that are known to be strongly over-represented in the pollen record include alder, pine, hazel and birch, oak and yew (listed in order of decreasing representation) while ash may be under-represented. On the other hand, holly and several other shrubby plants such as *R. catharticus*, *V. opulus, Sorbus* and *Hedera*, are under-represented often due to a combination of factors that may include low pollen production, poor pollen dispersal (many are insect pollinated) and location beneath tall canopy trees which in itself often inhibits flowering and diminishes dispersal capacity. Long-distance transport is also an important factor, particularly in the case of trees such as pine, which has pollen that are liberated in early summer (May) when warm convection air currents and low rainfall facilitate long-distance transport. In the present instance, however, long-distance transport is not regarded as a major factor given the island location in the Atlantic and downwind with respect to the main landmasses represented by Counties Clare and Galway. Furthermore, in the case of pine, yew and juniper, a stomatal record provides secure evidence for local presence insofar as the stomata are from leaves that presumably derive exclusively from within the catchment and most likely from close proximity to the lake.

Non-arboreal taxa with substantial to high pollen production and good dispersal (anemophilous species) include important indicator taxa such as Poaceae, *P. lanceolata*, *Rumex* and *Secale*. On the other hand, there are several indicative herbaceous plants such as cereals (excluding *Secale*), Fabaceae (clover family), Liguliflorae (dandelion-type) and Tubuliforae (daisy-type) that are under-represented mainly because of cleistogamous flowers that severely limit pollen dispersal. Low pollen representation of the latter may therefore be highly indicative of farming activity and human impact generally.

As regards changing patterns in woodland cover during the course of the Holocene, the pie charts serve to highlight the following features:

- The highly diverse vegetation cover during the Preboreal, i.e. the initial *c.* 700 years of the post-glacial (zones A1 and A2). The main woody plants were initially juniper and later birch (presumably the tree birch, *Betula pubescens*).
- The Boreal begins shortly before 8000 BC with the expansion of hazel (zone B1, Figs 2A and 4). From this until the end of the Neolithic (c. 3000 BC), AP was at *c.* 80% or more, with the exception of zon C1 when it fell to <70%. Zone C1 includes the Elm Decline – elm differentially affected by disease – and Neolithic Landnam, i.e. the first substantial woodland clearance by a farming culture. Grassland taxa expand to 26% of TTP; prior to this grassland taxa represented 10% or less (Fig. 3). Interestingly the Atlantic woodlands in the vicinity of An Loch Mór appear never to have been fully closed. The

densest woodlands (at least in terms of shade) developed towards the end of the Neolithic (zone C3) when yew became the dominant tree.

- The Bronze Age and the Iron Age are represented by zones C4 to C9. During C4 and C5, though there was considerable opening up of the woodland cover, woodland continued to be of major importance (AP averages 66%). During this time, woodland composition changed to the disadvantage of pine (see below). In zones C6-C8 (end of Bronze Age to mid-Iron Age), AP oscillates at about 50% which indicates further substantial inroads by farming into woodland cover. The impact was severest in zone C8 (150 BC-AD 100) when grassland indicators expanded to 42% at the expense of both AP and tall shrubs.

Zone C9 is distinctive in that both AP and tall shrubs (mainly *Juniperus*) expand and together constitute 73% of TTP.

In Zones D1 and D2 (the historical period), the final and most significant phases in the creation of the present-day open, treeless landscape is recorded. In the final zone (D1), AP averages 21%. Given the known scarcity of woody vegetation over recent centuries, it is assumed that much of this pollen represents long-distance transported pollen (e.g. *Corylus* from the Burren and *Pinus* from plantations in Clare and Galway). It should be borne in mind that the relative importance of this component in the percentage data is exaggerated because of overall low pollen input.

The increase in the arable/disturbed biotope is another distinctive feature of zones D1 and D2 (averages almost 10% in D2). The importance of the arable component in the farming economy is undoubtedly under-represented since widespread cultivation of the potato commenced in the late eighteenth century. Agricultural statistics for the period 1926-1950, for instance, give an average of 48 ha under cereals (mainly rye) and 215 ha under potatoes on the Aran Islands (total area: 4685 ha). Yet, *Solanum tuberosum* pollen is not recorded as it is silent in pollen records.

As regards the changing contribution of various woody species to overall woodland composition, the main highlights are as follows (cf. bars charts, Fig. 4; also pollen diagrams, Figs. 2A and 3A):

- Hazel was already present in the final phase of the Preboreal, i.e. at *c.* 8100 BC.
- Hazel achieved more or less full expansion within *c.* 150 years of the beginning of the Boreal period (7900 BC).

  Pine was locally present – based on pollen (3%) and stomatal records – from near the beginning of the Boreal (8000 BC).

  Pinpointing the arrival of oak and elm is difficult. Oak is consistently represented in zones A1 and A2 while elm is only consistently represented in the mid and upper part of zone A2, a pattern that continues into B1 (cf. subzone B1a). Oak may have been present from the beginning of the Boreal, i.e. as hazel began to expand rapidly, and elm was probably present as the maximum expansion of hazel was achieved. By 7200 BC (3429 cm), both trees were well established in the context of pine and hazel-dominated woodlands (Fig. 2A); subsequently oak became more important than pine, which, in turn, was more important than elm in the Boreal and Atlantic woodlands (cf. zones B1-B3).
- Two periods with woodland perturbation are recorded during the Boreal. In the first perturbation (P1; 6500-6250 BC), juniper and probably also hazel expanded at the expense of oak and pine; in the second (P2; 5650-5530 BC), which was shorter but more severe, birch expands mainly at the expense of hazel. P1 falls within the 8.2 ka event which was first highlighted in stable isotope records from Greenland (cf. O'Brien *et al.* 1995; Alley *et al.* 1997) and has, in the meantime, been detected in a wide variety of proxies (e.g. von Grafenstein *et al.* 1998; Tinner and Lotter 2001), including a .^{18}O and a high resolution trace element record from a speleothem from Crag Cave, Co. Kerry (McDermott *et al.* 2001; Baldini *et al.* 2002). The data from Crag Cave point to cold dry conditions that were initiated abruptly at c. 6400 BC (8350 cal. BP) and ended, also abruptly, at 6360 (8310 cal. BP). The P1 event at An Loch Mór lies within the same period as that recorded at Crag Cave, though P1 is clearly of much longer duration. In the case of woody vegetation, a lag between change in environmental conditions and species response can be expected, but a lag extending over many decades is unlikely. The P2 event, which is distinctly shorter and more severe, is also a possible correlative with the

8.2 ka event but, given the age that is ascribed to P2, such a correlation is unlikely. The information presented here clearly indicates that there is a distinct possibility of finding perturbations in the Boreal part of Holocene pollen records from western Ireland that are ascribable to climatic change. Further research is required to clarify the nature of these changes and their relationship to proxy records from other parts of the northern hemisphere.

- The Boreal and Atlantic woodlands probably never gave full cover (cf. in B3, *P. lanceolata* averages 4.2%). This is highly unusual. It is assumed that the highly karstic and uneven terrain in the vicinity of the lake resulted in woodlands with relatively open and fragile structure that were not well buffered (low inertia) to withstand environmental shifts such as those that gave the features P1 and P2.
- Alder expanded at *c.* 5300 BC (Boreal/Atlantic transition). Subsequently, it pollen representation remains mainly less than 5%, though it averages 10% in zone C5. Given that alder is normally strongly over-represented in pollen records, it is concluded that it was generally of minor importance. Alder was probably present locally from the beginning of P2 (upper part of B1) and may even have been present as a rare tree from immediately after P1, i.e. from shortly before 5500 BC.
- Woodland regeneration that followed a Neolithic Landnam phase (C1) involved rapid regeneration of secondary woodland, firstly of pine (in C2, *Pinus* achieves 33%, the maximum for the Holocene), which was then displaced by yew as the dominant (in C3, *Taxus* averages 26% and peaks at 37%). *Taxus* is recorded mainly as single pollen in the upper part of B3 and C1, which may indicate rare presence. It is assumed that a climatic change, rather than lack of competition from other trees resulting from clearances, favoured a rapid expansion of yew at *c.* 3150 BC. The period of yew-dominated woodland ended even more rapidly some 200 years later as a result of renewed farming activity in the late Neolithic/early Bronze Age.
- By the mid C5 (later Bronze Age; 1500 BC), *Pinus* had declined to generally <5%, i.e. it was a relatively minor tree with respect to oak (Figs. 3A and 4). This change occurred in the context of reduced farming. It is assumed that pine was not as competitive as previously, possibly due to a climatic shift.
- Considering the Holocene as a whole, the last *c.* 2200-year period (the uppermost zones, i.e. C8 to D2) is exceptional in that woody vegetation was greatly reduced and more or less ceased to contribute in any meaningful way by the end of the period. Within this interval, zone C9, i.e. the Late Iron Age Lull (LIAL), is exceptional. During this zone which extends from *c.* AD 100-500, *Juniperus* averages 12% and peaks at 24%, values only exceeded at the beginning of the Holocene (zone A1). Hazel, ash and yew (briefly only) also increased.
- The upper part of zone D1 records the expansion of arable farming based on rye cultivation (at/before AD 800). In D2 there is further farming expansion and the final demise of woodland communities begins (c. AD 1250). Hazel and oak probably survived in some numbers into the 1700s when increasing population saw the final demise of more or less all woody vegetation. In some spectra, *Corylus* – a high pollen producer and frequent in the nearby Burren – falls to <5%.
- The elevated values for *Pinus* throughout zone D2 and also the occasional stomatal record raises the possibility that pine became extinct only in very recent times on Inis Oírr. In this connection, AMS ^{14}C dating of pine charcoal collected from an eroding margin of the upper layer of debris (shell, animal bone and small charcoal fragments; charcoal identification by M. Dillon) from the midden at Teampall Chaomháin, a medieval church *c.* 1 km east of An Loch Mór yielded a date of 610.45 BP (GrA-24632), which corresponds to AD 1295-1409 (2s confidence level). This suggests local presence of pine as late as the 14th century and supports the view that at least some of the *Pinus* pollen recorded in zone D2 is of local origin (for further discussion on the late survival of pine in Ireland see Feehan (2000), Molloy and O'Connell (2004); Nicholls (2001)).

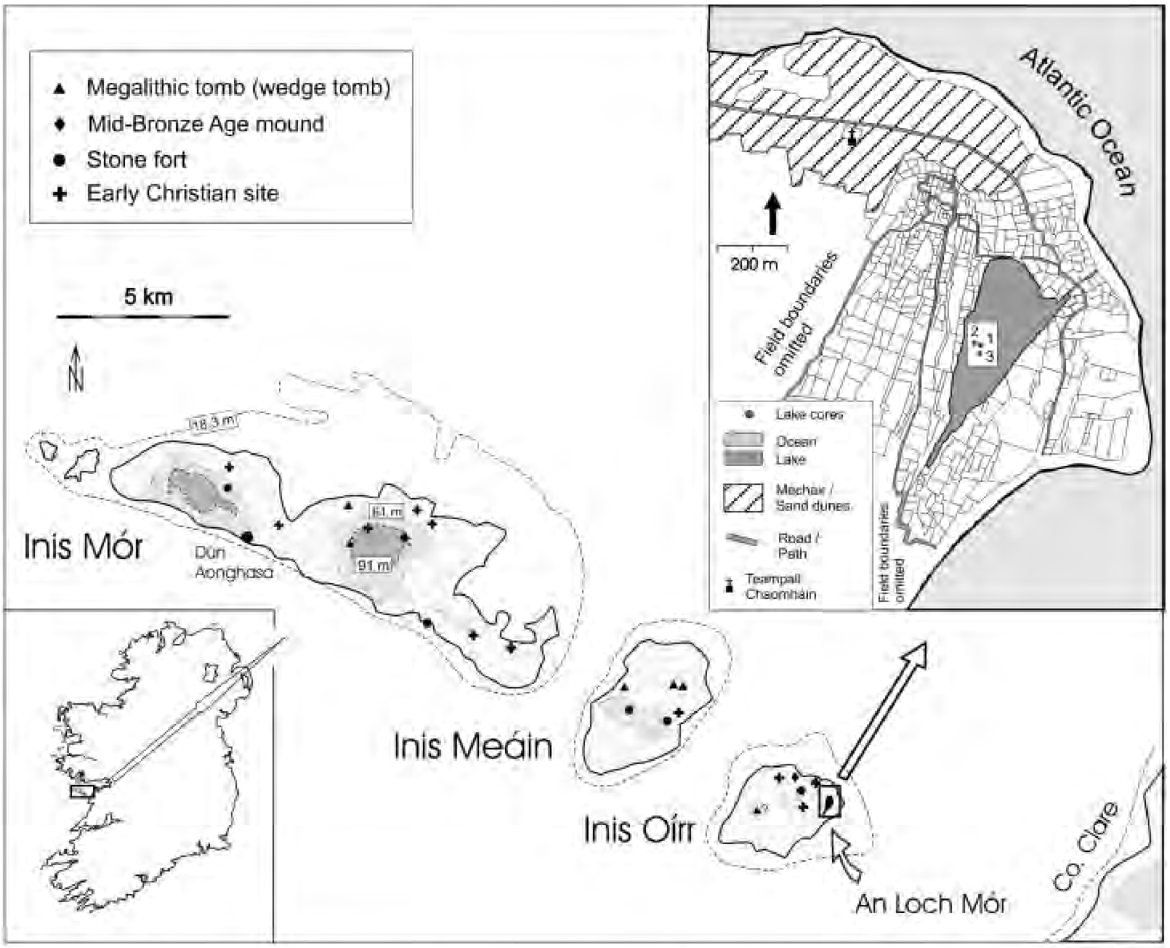


Fig. 1. Maps showing location of the Aran Islands off the west coast of Ireland, and detailed maps of (a) the Aran Islands and (b) the north-east corner of Inis Oírr including An Loch Mór. On the map of the Aran Islands contours at 100 ft (61 m) and 200 ft (91) OD, the 10-fathom (18.3 m) bathymetric line, and the main archaeological sites are indicated. In the detailed map showing An Loch Mór, the coring locations are indicated and also field boundaries as indicated on the OS 6-inch map (1:10 560 scale; revised 1899; little change in the meantime), machair and sand dunes and the main roads and paths.

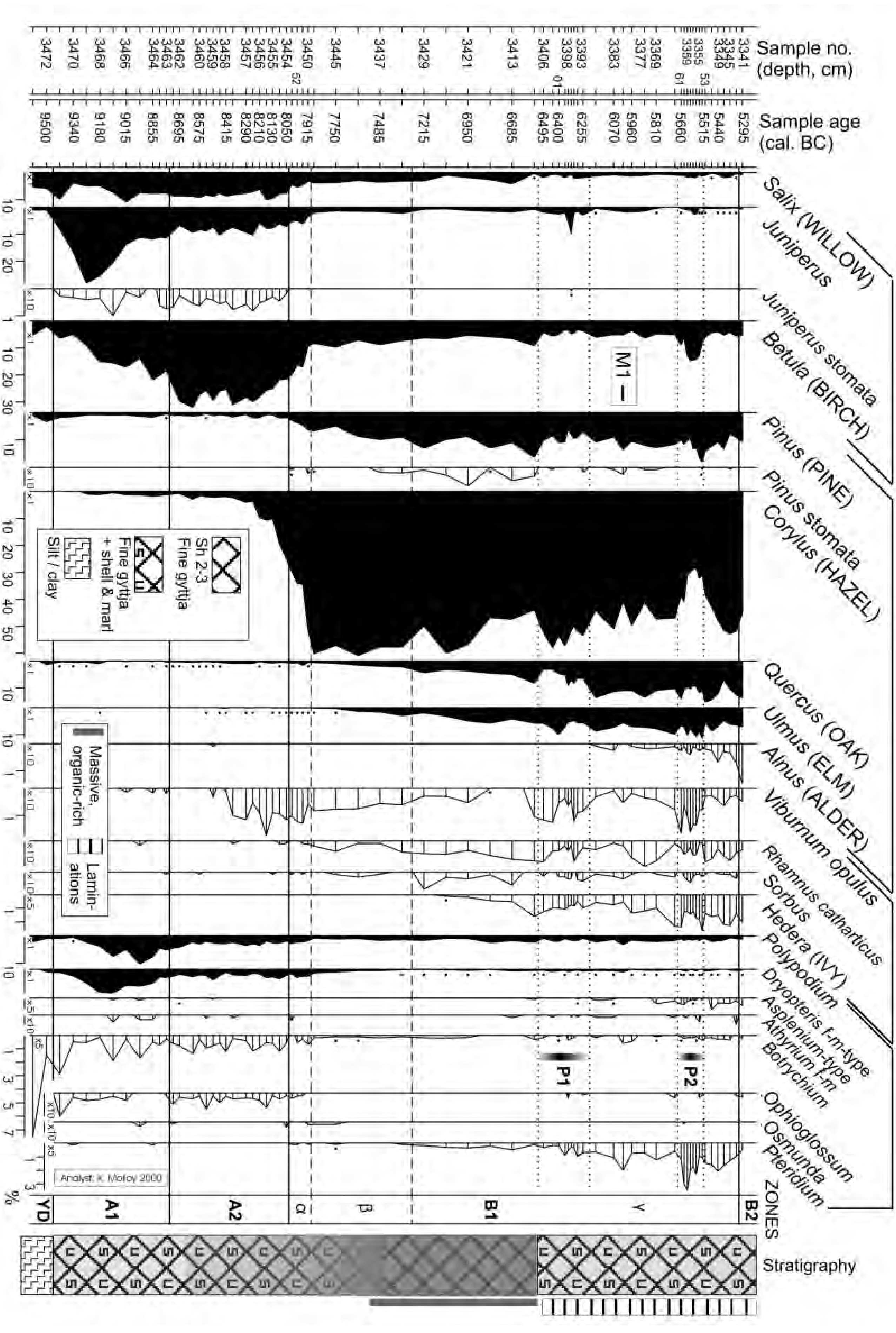


Figure 2A. *An Loch Mór, Inis Oírr MOR1, early Holocene (1)*

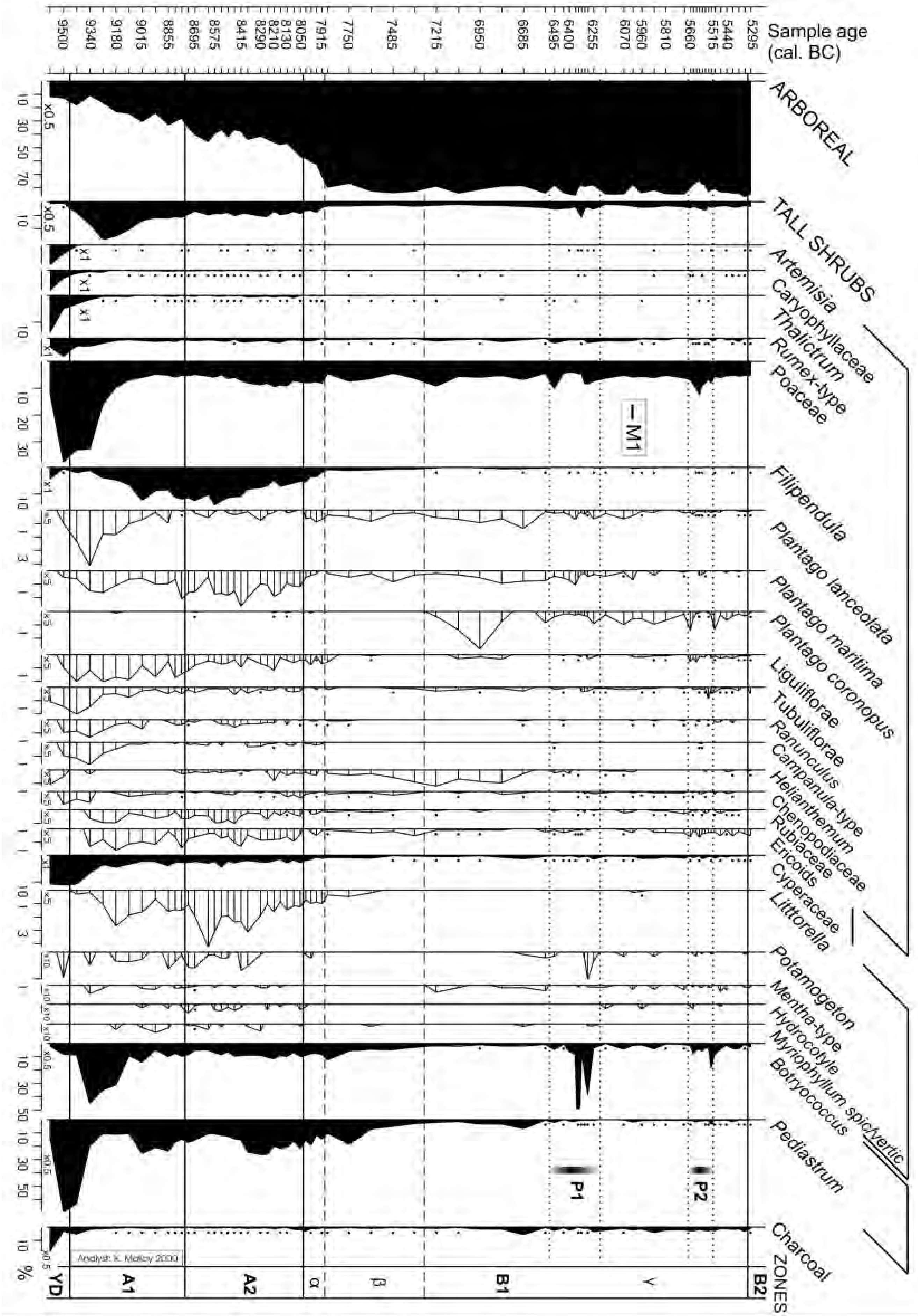


Figure 2B. *An Loch Mór, Inis Oírr MOR1, early Holocene (2)*

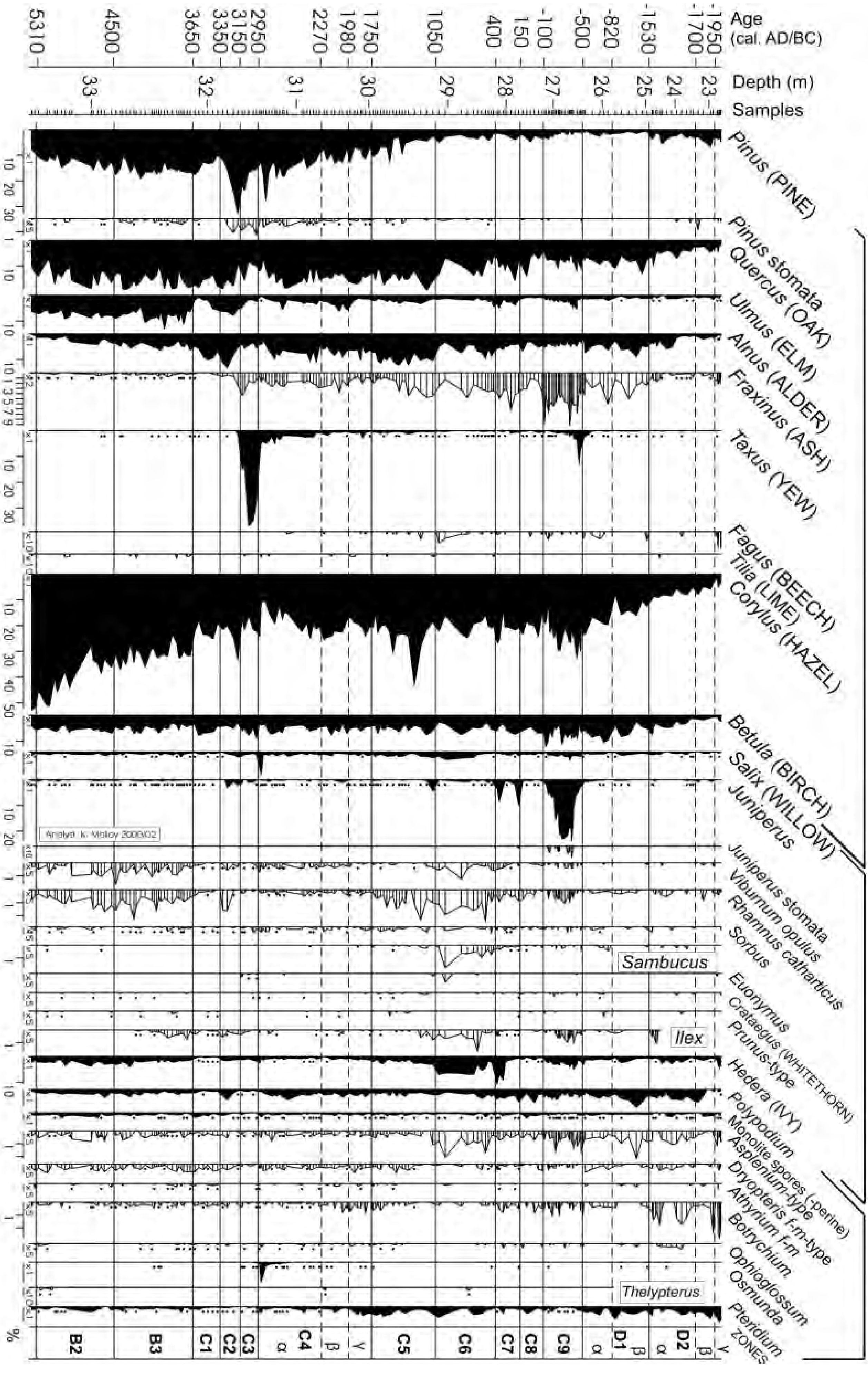


Figure 3A. *An Loch Mór, Inis Oírr MOR1, mid & late Holocene (1)*

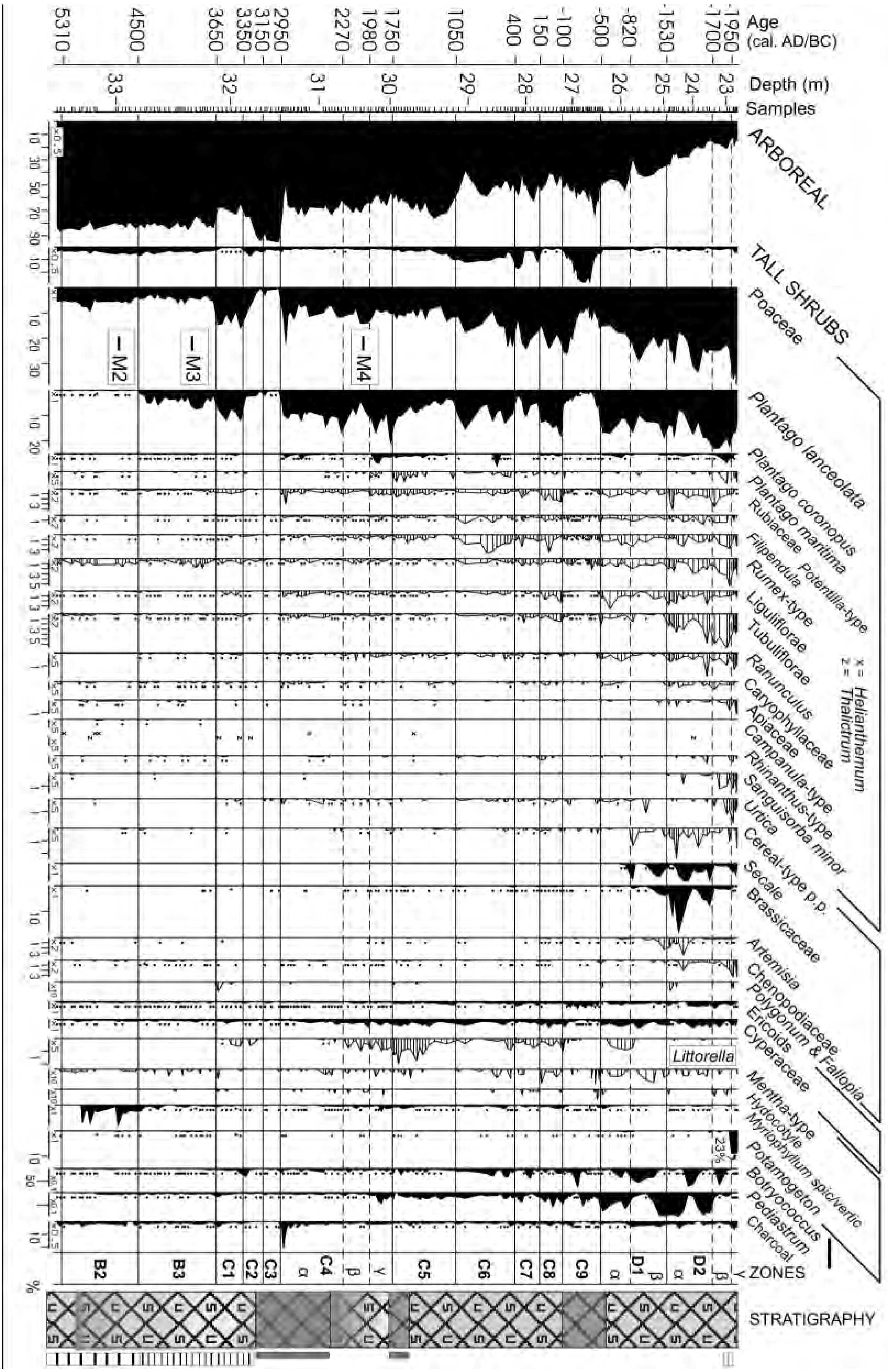
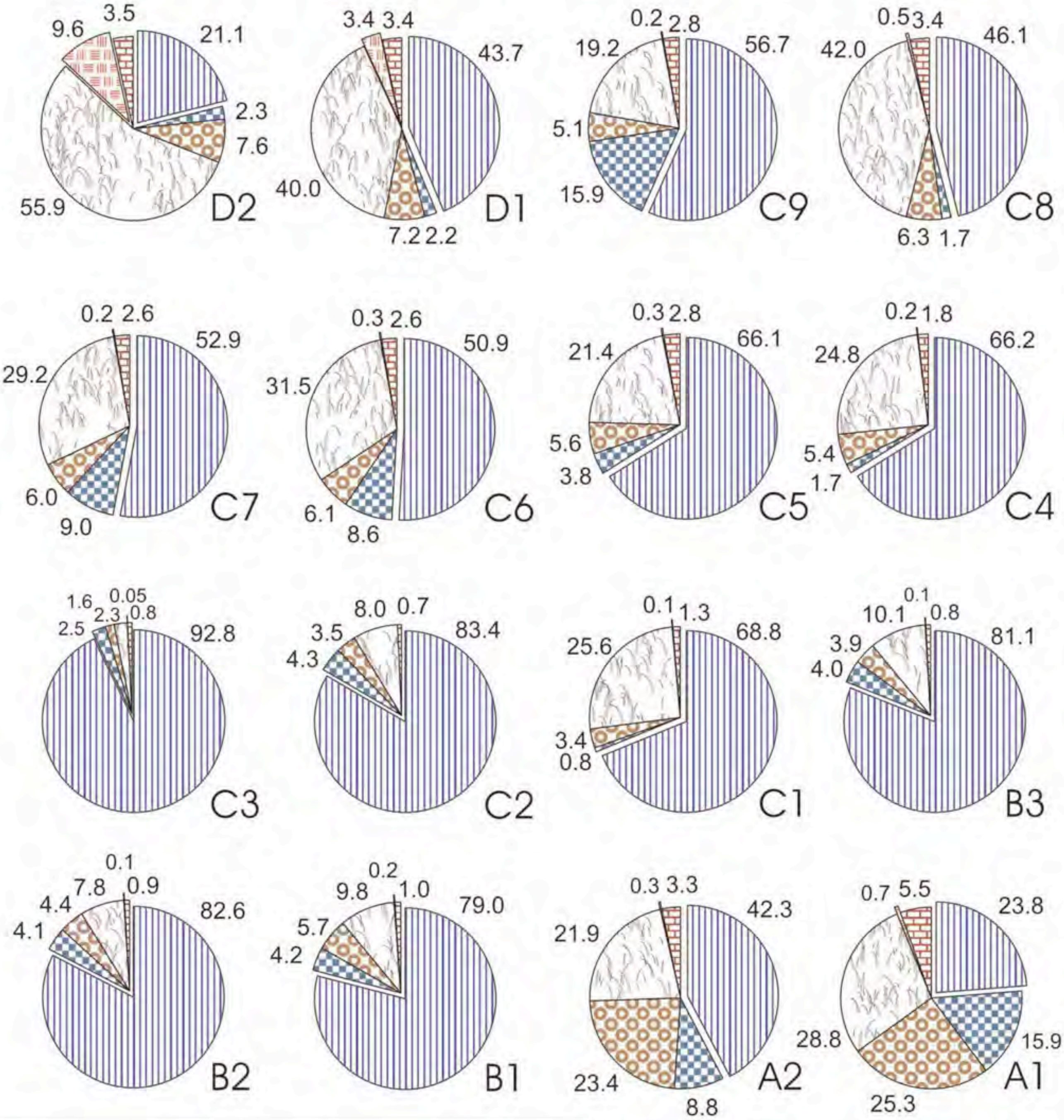


Figure 3B. *An Loch Mór, Inis Oírr MOR1, mid & late Holocene (2)*



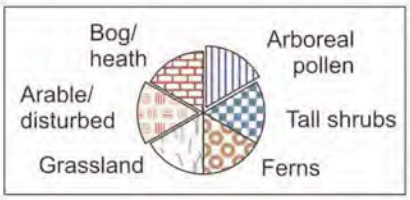


Fig. 4. Pie charts showing mean percentage representation of composite pollen groups (those included in the PS) in the Holocene PAZs from An Loch Mór. The mean values are also indicated beside the respective segments.

Zone	Cal AD / BC	Periods
D2	AD 1230-1990	Late Norman to present
D1	AD 500-1230	Early Medieval/Viking/Early Norman
C9	AD100-500	Late Iron Age Lull
C8	150-AD100	Mid-Iron Age (2)
C7	400-150	Mid-Iron Age (1)
C6	1050-400	Late BA/Early Iron Age; Subatlantic begins
C5	1750-1050	(Mid)/Late Bronze Age
C4	2950-1750	Early and Mid-Bronze Age
C3	3150-2950	Late-Neolithic
C2	3350-3150	Mid-Neolithic
C1	3650-3350	Earlier Neolithic; Subboreal begins
B3	4500-3650	Later Atlantic; earliest Neolithic?
B2	5310-4500	Atlantic period begins
B1	8050-5310	Boreal period begins
A2	8750-8050	Late pre-Boreal
A1	9450-8750	Early pre-Boreal

Note: ages are in calendar/calibrated years; AD years are indicated; otherwise years as BC.

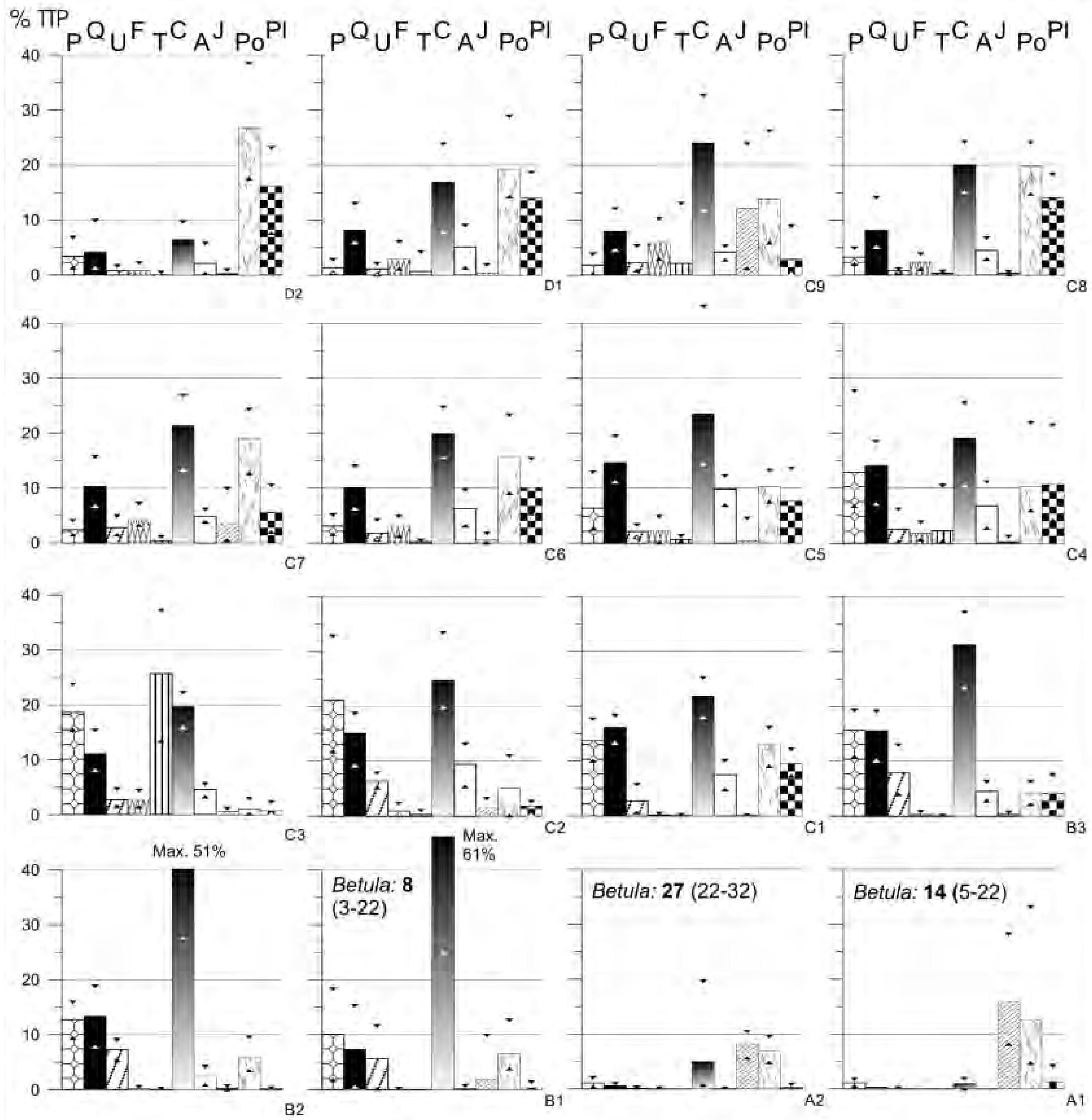


Fig. 5. Bar charts showing representation (mean, maximum and minimum percentage values) of selected taxa from An Loch Mór in the PAZs delineated in the pollen diagrams. *Betula* values are indicated in zones A1, A2 and B1 only where the early Holocene expansion and decline of birch are recorded (mean is in bold; max. and min. are within parentheses).

Pinus (P)
Quercus (Q)
Ulmus (U)
Fraxinus (F)
Taxus (T)
Corylus (C)
Alnus (A)
Juniperus (J)
Poaceae (Po)
Plantago lanceolata (Pl)
Maximum
Minimum

Legends to Figures

Fig. 1. Maps showing location of the Aran Islands off the west coast of Ireland, and detailed maps of (a) the Aran Islands and (b) the north-east corner of Inis Oírr including An Loch Mór. On the map of the Aran Islands contours at 100 ft (61 m) and 200 ft (91) OD, the 10-fathom (18.3 m) bathymetric line, and the main archaeological sites are indicated. In the detailed map showing An Loch Mór, the coring locations are indicated and also field boundaries as indicated on the OS 6-inch map (1:10 560 scale; revised 1899; little change in the meantime), machair and sand dunes and the main roads and paths.

Fig. 2. Percentage pollen profile, MÓR1, from An Loch Mór. Spectra from the lower part of the profile are shown, i.e. two spectra from the Younger Dryas, Preboreal, Boreal and a single spectrum from the base of the Atlantic period. The profile is drawn to a calibrated time scale.

The pollen curves are grouped to reflect the main physiognomical/ecological plant groups. Individual pollen curves that are not shaded have a magnified horizontal scale (scale indicated at the base of each curve). A closed circle is used where the value is low and the scale is such that the presence of a taxon may not otherwise be clearly shown.

The pollen taxa are presented as follows: in **2A** trees, tall shrubs and ferns and in **2B** composite curves for AP and tall shrubs and individual curves for NAP, aquatics, algae and charcoal (particles <37 μm). A TTP is used for calculating percentage representation, i.e. aquatics, algae and charcoal are excluded.

Fig. 3. Percentage pollen profile, MÓR1, from An Loch Mór. Spectra from the upper part of the profile are shown, i.e. two spectra from the end of the Boreal and the remainder of the profile. The profile is drawn to a calibrated time scale. In spectra from 2451, 2458, 2481 and 2497 cm, *Pediastrum* counts were entered as 9999, the maximum permitted by the plotting programme; the counts ranged between 10800 and 16700. For conventions and other details consult the legend to Fig. 2.

Fig. 4. Pie charts showing mean percentage representation of composite pollen groups (those included in the PS) in the Holocene PAZs from An Loch Mór. The mean values are also indicated beside the respective segments.

Fig. 5. Bar charts showing representation (mean, maximum and minimum percentage values) of selected taxa from An Loch Mór in the PAZs delineated in the pollen diagrams. *Betula* values are indicated in zones A1, A2 and B1 only where the early Holocene expansion and decline of birch are recorded (mean is in bold; maximum and minimum are within parentheses).

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FORESTS AND PEOPLE IN IRELAND'S STONE AGE

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KEYWORDS: Mesolithic, Neolithic, island, forest, landnam

Abstract

The impact of human activity as the dominant factor in explanations of woodland change is examined mainly in the prehistoric period. The human woodland experience is considered from an archaeological perspective from Mesolithic times onwards. The practical problems of the initial colonising of an island with an ecosystem unknown on the mainland from where the colonisers originated is examined and the impact of the forest on human settlement for the initial four thousand years of settlement is indicated. In the subsequent prehistoric periods the main issue considered is the anthropogenic impact put forward as the explanation for specific and general forest species decline and recovery. The fact that forest decline and recovery seen in many pollen diagrams coincides with clearly identified human settlement leads to the anthropogenic interpretation implicit in the term "landnam". The possibility that cause and effect may have to be reversed in some cases, i.e. that forest change led to human occupation rather than the explanation that human impact led to forest decline will be considered in the light of research in Co. Mayo.

Main text

The relationship of people to the forests of Ireland is one, which is well recorded, in our written history. For the prehistoric period the relationship is established in a more indirect way and often as a result of collaboration between a number of disciplines involved in studying the past. Indirectly, we can study the human connection with the forest by the surviving evidence for exploitation of the resources of the forest both faunal and floral. In the earliest prehistoric period in Ireland, as on other contemporary European sites the frequent survival of hazelnut shells as food debris is not necessarily an indicator of the dominant importance of this source of nutrition. It could be seen as an indicator of the likely exploitation of a whole range of forest food, which could not have survived in the same way as charred hazelnut shells can. While wood will not normally survive from this time, evidence for the use of wood in structures can be found in the survival of postholes. In the later Stone Age, tools used for woodworking, in particular the enormous quantity and sophisticated manufacture and trading enterprises associated with artefacts such as polished stone axes do show the importance of forests and wood in the Neolithic.

This paper raises some new questions about the human relationship with the forest during the Irish Stone Age covering the two periods, Mesolithic and Neolithic, a time span of about six thousand years ending at about 2500 BC. The main issue raised for the Mesolithic period is the likely problem faced by the earliest settlers to come to Ireland. The well recorded impoverished flora and fauna of Ireland is often contrasted with the greater range of species found on the adjacent island but which in turn is relatively impoverished compared to mainland Europe. But to view Ireland thus is to miss the much great differences between the two islands in both their natural and human histories.

The present island of Britain is less than nine thousand years old (Coles, 1998). Prior to that, on numerous occasions, the land mass was part of a peninsula of Europe joined along a broad front from Yorkshire to Denmark and form west of Dover to west of Calais (White & Schreeve, 2000). Towards the end of the last ice age as the ice retreated northwards, forests that had survived in the southern Europe expanded northwards and with them the forest animals and human populations of hunter-gatherers who exploited the resources of those forests. The man/animal relationship of predator/prey, which occurred on the pensinsula of 'Britain', was merely a continuation of the same relationship which would have existed for tens of thousands of years further south in Europe. Other than for those in the immediate vicinity of the south-eastern coast, the final severing of the land bridge, which created the island of Britain, would have had no observable significance. Slower colonising flora would continue to extend northwards and would now be blocked by the English Channel but in terms of forest colonising, the main tree species had expanded onto the peninsula of 'Britain' before the land bridge did have an unexpected impact in the way in which it seemed to sever connections between human populations on both sides of the Channel. We know from evidence from sites such as Star Carr (Clark, 1954) in Yorkshire and from the presence of Mesolithic remains on off-shore islands off Britain's west coast (Mithen, 1999) that communities of Mesolithic hunter/gatherers had a knowledge of navigation at his time, yet the newly formed Channel seems to have created an impassable barrier to human contact for well over a millennium (Jacobi, 1976).

The hunter/gatherers of the forests who expanded with the forests and their animals northwards onto the peninsula of 'Britain' would have encountered an indigenous population descended from Palaeolithic populations. Evidence of Palaeolithic population groups which spread onto the peninsula of 'Britain' extend back to Lower Palaeolithic times of over half a million years (White & Schreeve, 2000). At periods during the depths of the various glacial periods much of the peninsula of 'Britain' was covered by ice and would have been uninhabited. The tens of thousands of Palaeolithic artefacts found for example in the Thames gravels, give some idea of the great antiquity of intermittent human settlement on what at present is the recent and ephemeral island of Britain.

Archaeological excavations at sites such as Thatcham (Wymer, 1962) and Star Carr show that the full range of large forest herbivores found in Europe were hunted for food. The largest animal was the aurochs or wild bovine, much larger than our domesticated breeds and with a male weight approaching a tonne. The next largest was the elk, an animal of over a quarter of a tonne in weight, with a wide spread of antler. A solitary animal, more a browser than a grazier, it can bend light trunks of young trees to get at the leaves on the higher branches. The third large animal is the red deer, with males up to 300kg and with a high and wide spread of antler. Together with these three, two other animals, wild pig of 100 kg and the diminutive roe deer of about 25 kg made up the main source of meat for Mesolithic forest hunters throughout Europe including its north-western peninsula. As young juveniles, these animals may have been at risk from predators such as wolves but once they reached maturity until weakened by old age, sickness or injury, they had no other predator other than hunters.

Information on the composition of the ancient forests is largely reliant on the pollen record but while this can tell us much about proportions and content it can tell little about the physical make up of the actual forest. The archaeological evidence for the exploitation of the suite of large animals listed above does allow certain conclusions to be arrived at in relation to the nature of the forest environment. The presence of these large animals means that the forest had to be permeable. Grazing and browsing animals must have been able to move from one clearing to another. As forests closed in and animals were restricted to narrower paths the heavy animals must have poached the ground into well-trodden plant-free paths. The aurochs, elk, and red deer all stand taller and have greater body width than their human predators with the head room for the elk and red deer maintaining high open tunnel avenues even through the densest growth.

It has been suggested by Mellars (1976) that Mesolithic hunters deliberately fired the forest in places to increase its grazing capacity or to create grazing traps to lure the animals to, though one has to consider the probability that fires maintained on a permanent basis in a forest environment would inevitably lead to accidental firing of the forest on occasion. At any rate, clearings whether deliberate or otherwise and no matter how large would have to be accessed through forest if continuous forest covered the landscape. Because of the presence of these large animals within the forest, we can be certain that routes through the forest by open paths from one clearing to another had to be in existence.

From many points on the west coast of the peninsula of 'Britain', Mesolithic hunters looked across at the land to the west. From Scotland, the Antrim and Down coastline was less than 30 kilometres away. Further to the south in Wales, the Dublin and Wicklow mountains though a greater distance away, were clearly visible. But while mountains on the skyline may have looked not different to the skyline of the inner Hebrides to the north or the Pennines to the east, there the similarity ended. The single biggest influence on the very important flora and fauna of Ireland compared even to Britain is the fact that the land bridge between this terminal peninsula of 'Ireland' and 'Britain' was connected at the northernmost end. Because of this, flora and fauna that would have found Munster as fertile ground in which to thrive, had to migrate through the horseshoe peninsula of what is now the north of England and south of Scotland and enter 'Ireland' at its most northerly. During the depth of the last glacial period when sea level was more than one hundred metres lower than at present as a result of the quantity of water tied up in the ice caps, access to 'Ireland' would not have been as straightforward as access into the south of 'Britain'. The extending icecap, which was the cause of the lowering sea level, now covered Ulster and Scotland so that the ice-free parts of 'Ireland' to the south were still cut off from mainland Europe, a period which allowed many more species of plants and animals to migrate into the peninsula of 'Britain' with no possibility of reaching the island of Ireland.

The end result of the last glacial period is that Ireland has an impoverished flora and fauna relative to Britain and mainland Europe. In the forests, the absence of tilia meant that the composition of the forest was inevitably different. However, from a human perspective, the absence of forest animals was of much greater importance than was the absence of certain tree species. There is no evidence in Ireland that aurochs, elk or roe deer ever migrated onto this land. Red deer are recorded in Ireland in the late glacial period but appear to have died out and are not recorded again until the Neolithic (Woodman *et al*., 1997). If red deer was also absent from Ireland then the question must be asked; were the forests permeable for human movement? This would not have been a problem in the early stages of post glacial expansion of the trees but as stands in open terrain expanded and merged, the stage of full forest cover with open clearings would have made travel on land exceptionally difficult if not impossible. If red deer were not present in Ireland at this stage, then the tallest animals moving in the forest were pig and wolf.

Sometime around then thousand years ago the first humans came to the island of Ireland. Apart from the contrasting natural world which greeted them, as compared to their straying onto the peninsula of 'Britain', there was a major cultural difference between the two environments. The land of Britain onto which the forest hunters strayed, was a land inhabited for over half a million years. The marks of that habitation and of an existing indigenous people would be visible in many ways. Smoke from distant fires, the quenched embers of old fires, the butchered skeletal remains of prey, broken and transported branches for shelter, struck flint or fully formed artefacts, all of these clues to an existing human presence and past would have been obvious to the newcomers.

Contrast then the arrival of the first people to arrive in Ireland, coming as they did as recently as ten thousand years ago. They did not stumble into here by wandering further north than usual in their hunt. The first to set foot on the island of Ireland had to do so as a deliberate act of navigation, of getting into a boat and setting out for the land across a stretch of water. As they approached the shore it may have looked similar to the shore they had left but arrival would have immediately made them aware of a difference. They had left a peninsula with half a million years of human history and they had now landed on a desert island. There were no embers, no smoke, no cut branches and no artefacts. Nor was there a landscape of known and remembered and named places and remembered routes from one named place to another. The total absence of a human presence or past must have seemed strange. Equally so must have been the reaction of animals and birds. The wild animals such as pig, wolf, fox or hare would never have seen a human before. Presumably they would have approached out of curiosity and from never before have to fear anything which was not in direct physical contact with them.

Two factors would have kept the newcomers close to the water's edge. The absence of a range of forest animals to hunt would leave people having to rely on plant food and on shell fish and ultimately on other fish. The impermeable nature of the forest would force people to use water as the main route for travel. This is exactly where one finds Irish Mesolithic sites, on the coast or beside rivers and lakes. This is in contrast to

Britain where many hunting camps are found high in the Penines where for example many of the sites are located above 500 metres. The emphasis on water resources and fishing is evident at the earliest known Mesolithic sites such as Mount Sandel (Woodman,1985) and Boora (Ryan,1980). The same emphasis on a fisher-gatherer economy continued into the Late Mesolithic where a particularly insular form of stone technology developed. While the emphasis on water resources is there from the beginning of the Mesolithic in Ireland it is only in the later stages of the Mesolithic elsewhere in Europe that the major shift from land to marine resources takes place. The Irish Mesolithic ended as it had begun four to five thousand years before with a clear emphasis on water-based resources and with no evidence that anything other than the forest margins near the water's edge was exploited during this period.

Around 4000BC or possibly even before this, new developments can be observed in the Irish record. An emphasis on land use begins to emerge in the botanical record. Three phenomena, namely the identification in the paleobotanical record, of pollen similar to cereal pollen, the differential decline of the pollen of elm and the more general decline of the pollen of trees followed by recovery are identified as anthropogenic and as such taken to be an indication of the beginnings of farming.

The first of these, the occurrence of cereal type pollen, I do not propose to deal with in this paper other than to observe that all occurrences of such pollen in pre-farming contexts should be fully noted, otherwise archaeologists and other non-specialists may attribute too much archaeological significance to the occurrence in a non anomalous context.

The second phenomenon is the differential decline of pollen of elm shortly after 4000 BC. From the discovery of elm leaves used as fodder on archaeological sites on mainland Europe and anthropological evidence for the lopping of elm branches as fodder it has been assumed by palaeobotanists that elm decline (often written as Elm Decline) is an unambiguous sign of the beginnings of farming. The close synchroneity of dates for observed elm decline in different parts of north-western Europe, left many archaeologists sceptical about the certainty of the anthropogenic origin of the phenomenon. Shortly before his death in 1978 the late Professor De Valera in his preface to the revised edition of 'Antiquities of the Irish Countryside' (O Riordain, 1979) suggested that the phenomenon might best be explained as a rampant disease similar to Dutch elm disease. While the view received little support at the time, there is now a general consensus that disease rather than human activity can best explain the phenomenon though some palaeobotanists still attribute special significance to the decline by continuing to designate it with capital letters.

Professor W. Groenman van Waateringe (1983) has proposed an alternative link between elm decline and the beginnings of farming by suggesting that the death of stands of elm as a result of disease would have profound effect on forest floor and under-storey vegetation wherever it occurred. In an otherwise closed forest with limited open space, stands of dead elm would offer a labour saving opportunity to animal herders or early cultivators of crops. This could explain the synchronous occurrence of archaeological evidence of farming communities and the elm decline but with a reversal of cause and effect. Instead of farming practices bringing about the decline of elm, the death of elm stands would have provided the conditions for the establishment of farming without the labour of felling or ring-barking the trees.

The third anthropogenic indicator in the pollen record is the more general decline of forest pollen to be replaced for a period by herbaceous pollen often coinciding with low levels of cereal-type pollen but with a subsequent recovery of arboreal pollen. This evidence, interpreted as 'landnam' or land taking was first thought to indicate a slash and burn form of semi-nomadic farming with onward movement after a short interval and the resultant recovery of the trees and therefore the arboreal pollen. Radiocarbon dating has shown however that the episodes represented by classic landnam phenomena are of much longer duration than was originally thought and periods of half a millennium or more may be represented by the entire episode. When the time period of the so-called landnam coincides with the dates for archaeological artefacts or monuments in the vicinity, the understandable inference is drawn that the decline of arboreal pollen and the rise of herbaceous pollen has been caused by farming activity. By reviewing the archaeological, palaeobotanical and radiocarbon evidence from North Mayo, it will be suggested that the Groenman van Waateringe explanation for the link between early farming and elm decline may also be an appropriate explanation for the landnam phenomenon in certain cases.

Two major programmes of archaeological research in North Mayo, one on megalithic tombs (De Valera & O Nuallain, 1964) and the other on pre-bog filed systems have indicated intensive settlement during the fourth millennium BC. This intensive settlement does not extend over the whole area because to the west of Belderrig, which is situated in the middle of the North Mayo coast, there is a major void in the archaeological record. This low-lying flat area is covered by deep bog and Radiocarbon dates for pine stumps preserved by the basal peat indicate bog growth by the seventh millennium BC, long before the beginning of farming in Ireland (Caulfield, 1983).

Palaeobotanical research carried out by K. Molloy and M. O'Connell (1995) on a deep core within Céide Fields identified a clearly defined 'landnam' phase where arboreal pollen dropped to low levels and grasses and other herbaceous pollen dominated. This in turn gave way to heather and a brief return to forest pollen before reverting to bogland species. The dates for the initiation of the tree pollen decline are uncertain but precede 3700 BC. The end of the phase dominated by grass pollen, which gives way to heather pollen, is more clearly defined between 3300 BC and 3200 BC. This is similar in date to settlement evidence dated on the site but dates in the immediate vicinity of the Behy megalithic tomb, which is located within the fields are some centuries earlier than this. The correspondence of archaeological and palaeobotanical dates for the 'landnam' phenomenon suggests that the decline in tree pollen is a reflection of the activity of farming communities clearing extensive tracts of pine forest and by building field boundaries, converting them into the open organised grasslands of the Céide Fields.

The certainty of the anthropogenic nature of the decline of arboreal pollen which the term 'landnam' implies is somewhat weakened by some results from a dating programme of pine stumps in and under the bog within or in the vicinity of the pre-bog field boundaries in North Mayo (Caulfield *et al.,* 1998). The dates for pine stumps growing in bog within Céide Fields are somewhat earlier than the pollen evidence for forest recovery and indicate that some of the fields must have been abandoned before 3300 BC. The most significant result from the dating of the pine stumps comes from Belderrig, seven kilometres west of the Céide Fields and from the Lacken area eight kilometres to the east. In Belderrig valley, on a low terrace just west of the Neolithic farm site, a pine stump with roots 45 cm above the mineral soil has been dated to circa 4500 BC, clearly predating the arrival of farming in the region. As the location is not in a low lying basin it suggests that peat formation is underway in the area just as had been assumed for the void in settlement to the west of Belderrig. To the east of Céide Fields on a plateau just west of Killala Bay, a pine stump in peat has been dated to circa 2600 BC. The roots of the stump are 1.4 metres above the mineral soil. Close by a second stump dated circa 3200 BC is 1.8 metres above the mineral soil. While the basal peat has not been dated at this location, it is highly unlikely that this depth of peat could have accumulated at this location in the time since the arrival of farming.

The indications emerging from these dates suggest that the early formation of bogland was not confined to the area west of Belderrig but was of much more widespread occurrence and predates the arrival of farming in the area. When the Belderrig and Lacken evidence for early peat formation is considered, the so-called 'landnam' within Céide Fields could be open to an alternative interpretation. If the pine forest was under stress and already beginning to disintegrate as bogland became established, the area could have provided inviting grazing land without the necessity for major forest clearance. Like Groenman's explanation for the coincidence of elm decline and the evidence for farming, the failure of forest due to natural causes such as climate change may have been the catalyst for the extensive spread of farming throughout the area rather than farmers being seen as the cause for even the temporary decline of forest.

It may well be that during the Irish Stone Age, the forest influenced human activity more than human activity affected the forest.

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THE USE OF IRELAND'S WOODLAND IN MEDIEVAL TIMES

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Abstract

The main documentary evidence on the uses of woodland in medieval Ireland is provided by the Old Irish law-texts, which date from the seventh to ninth centuries AD. A text on the law of neighbourhood entitled Bretha Comaithchesa contains a list of twenty-eight trees and shrubs, divided on economic grounds into four groups of seven. The seven most important trees are described as the 'lords of the wood', and are listed as the oak, hazel, holly, yew, ash, Scots pine, and wild apple. It is of particular interest that the pine is included in this list, as it is generally held to have become extinct in Ireland in later medieval times. A ninth-century commentary on this law-text states that the pine is valued as a source of resin.

The law-texts also provide information on other uses of woodland, in particular the right of landowners to graze their livestock in wooded commonage during the summer months. There were also privately owned woods, in which trespass by livestock would incur heavy fines. As in other medieval societies, deer and wild pig were hunted or trapped in woodland, though there are no records of royal hunting preserves.

Introduction

I am most grateful to the organisers of this conference on Ireland's Native Woodland for asking me to contribute a brief account of what Old and Middle Irish texts tell us of woodland use. By far the most important of these documents are the early Irish (Brehon) law-texts, which date from between the seventh and ninth centuries AD. Luckily for posterity, the authors of these texts were accustomed to treat each topic in very considerable detail, so they provide us with a great deal of information not merely on strictly legal issues but on many aspects of early Irish economic history. The use of woodland is mentioned in various law-texts, but our main source is *Bretha Comaithchesa* 'judgements of neighbourhood', which can be dated to the eighth century. It provides a classification of the economic value of twenty-eight trees and shrubs. They are arranged in four groups of seven: the seven 'lords of the wood' (*airig fedo*), the seven 'commoners of the wood' (*aithig fhedo*), the seven 'lower divisions of the wood' (*fodla fedo*), and the seven 'bushes of the wood' (*losa fedo*) (Kelly 1976). The author does not provide us with a complete inventory of all native Irish woody plants, but his list gives a fairly comprehensive and logical classification.[1]

I deal first with the 'lords of the wood'. There is nothing surprising about the lawyer's choice of the seven most valuable trees in the wood, namely oak, hazel, holly, yew, ash, Scots pine and wild apple. A ninth-century legal commentary on *Bretha Comaithchesa* even provides us with a brief explanation as to why each of these trees is particularly esteemed. The value of the oak is said to derive from 'its acorns and its use for woodwork'. In modern times, an abundant acorn-crop (*dairmes*) is not the subject of wide general interest or even deemed worthy of comment in the newspapers. In medieval times, on the other hand, a good crop of acorns was an

[1] Native trees and shrubs missing from the list are purging buckthorn (*Rhamnus cathartica*), alder buckthorn (*Frangula alnus*), bird cherry (*Prunus padus*), dogwood (*Cornus sanguinea*), guelder rose (*Viburnum opulus*), and privet (*Ligustrum vulgare*). Honeysuckle (*Lonicera periclymenum*) and ivy (*Hedera helix*) are included in some versions of the *losa fedo* 'bushes of the wood'.

event to be recorded in the annals as it meant well fattened pig, a favourite dish at early Irish feasts. A legal commentator from about the twelfth century calculates that in a good year a single oak can provide enough acorns to fatten one pig. The oak-tree was also highly regarded for the quality of its wood – it has emerged recently that oak-wood was even exported from Ireland to provide beams and rafters for the roof of Salisbury cathedral, dated by dendrochronology to the spring of 1222. Another use of oak also frequently mentioned in legal material is the provision of bark for tanning leather. Early Irish law took a poor view of the person who cuts off the bark of an oak-tree belonging to somebody else. He must pay a fine of one ox-hide – an appropriate penalty – and must cover the wound with a mixture of smooth clay, cow-dung and fresh milk until there has been the width of two fingers' new growth on all sides, i.e. until the tree has properly recovered. This technique is clearly the equivalent of the various modern air-excluding preparations used when a tree has been damaged or pruned. While on the topic of damage to oak-trees, I should also mention a reference in an undated scrap of vellum inserted into the fourteenth-century Yellow Book of Lecan in the Library of Trinity College Dublin. It records that 'an abundance of moths came into West Connacht so that they did not leave a leaf on an oak in the whole territory of O'Flaherty'. This is no doubt a reference to the moth *Tortrix viridana*, capable of defoliating large areas of oakwood. Finally, I should note that the texts contain no references to a distinction between *Quercus robur* and *Quercus petraea* – both are simply *dair* (also spelled *daur*).

It might seem surprising to find the relatively small hazel-tree (*coll*) included among the 'lords of the wood', but it was clearly of considerable importance in the early Irish economy: our legal commentary states that it was valued for 'its nuts and its rods'. Hazel-nuts were a highly prized element in the human diet and good nut-years were regularly recorded in the annals. For example, the Annals of Ulster record that in the year 836 there was such a heavy crop of hazel-nuts that the rivers were blocked, and a similar entry was made in 1066. Sometimes, the annals record that both the acorn-crop (*dairmess*) and the nut-crop (*cnómess*) were abundant in a particular year. Hazel-rods were widely used in the construction of fences, enclosures and house-walls. We are told in a law-text that a lord is entitled to receive a cartload of rods – presumably hazel-rods – every year from each of his clients.

The next three 'lords of the wood' are said in our legal commentary to be prized mainly for the quality of their wood. Thus, the holly-tree (*cuilenn*) was valued for providing shafts for chariots, while the yew (*ibar*) furnished the material for domestic vessels, such as bowls, mugs, etc. The ash (*uinnius*) was used to make furniture and spear-shafts. In addition, the text contains a reference – rather obscurely worded – to the use of holly-branches as winter-fodder for livestock. The feeding of the uppermost – and relatively spineless – branches of holly to cattle is known to have been practised in Kerry within living memory. Writing in the late fourteenth century, Count John de Perilhos – a Catalan pilgrim to Saint Patrick's Purgatory, Co. Donegal – states that the beasts of the area 'eat only grass instead of oats, and the leaves of the holly which they roast a little on account of the prickles which are in the leaves' (Mahaffy 1914). In early Irish legal material, there is even mention of a special hook designed for cutting holly and ivy. In this context, it should also be noted that our texts indicate that little or no hay was saved in Ireland before the Anglo-Norman invasion (Kelly 1997). There would therefore have been a special need to procure food for livestock during harsh winters when grass-growth was held in check by low temperatures.

The sixth member of the 'lords of the wood' is of especial interest because it is a tree, which is generally held to have become extinct in Ireland in later medieval times, and to have been reintroduced around 1700 (Mitchell 1976, Forbes 1933). This is the Scots pine (*Pinus sylvestris*), for which the well-attested Old Irish term is *ochtach*, which is used in a seventh-century gloss to explain Latin *pinus* 'pine'. Strangely, our ninth-century legal commentary makes no mention of the uses of the wood of this tree, and refers to it merely as a source of resin (*bí*). Pine-resin was used to make pitch for caulking boats, preserving wood, etc. Other literary texts from this period refer to the use of pine-trees for the masts of ships and for the construction of dwelling-houses. A Latin life of Saint Samthann describes how monastic builders spent four days in the woods of Connacht searching vainly for pines with which to build a refectory. An adequate number was eventually found through the miraculous intervention of the saint. This story suggests that a decline in the abundance of the tree was already underway around the beginning of the first millennium and fits in with the evidence of pollen-analysis.

The seventh of the 'lords of the wood' is the apple-tree (*aball*), which is stated to be of value for its fruit and its bark (*a mess ocus a rúsc*). In present times, the fruit of the wild crab-apple (*Malus sylvestris*) is not held in high esteem, except to make a tart jelly. But in the early Christian period, sources of vitamin C with the capacity to keep fresh well into the winter would have been much appreciated. Our texts tell us little about the early development of the cultivated apple in Ireland. One assumes that the early Irish would have noticed that individual apple-trees in the woods had slightly sweeter flesh or larger fruit. From as early as the ninth century we find a distinction in the texts between the wild and cultivated apple. However, it seems impossible to ascertain whether the early Irish cultivated apple derived solely from selected strains of the native apple or whether there was introduction of grafts or seeds from elsewhere. The technique of grafting apples, vines and other fruit-trees was well known to the Romans and is likely to have been witnessed by Irish monks on the Continent. As the Church is known to have been instrumental in the introduction of many food-plants to Ireland, it is probable that varieties of the cultivated apple were brought here in the early Christian period. It would be of interest to know whether any of the traditional Irish apple-varieties of more recent times – such as the Kerry Pippin, Blood of the Boyne or Irish Peach-apple – contain any genes going back to the native wild apple of Irish woodland. A name in the Irish language would indicate a variety of considerable antiquity. To my knowledge, the only variety with a distinctive Irish name is a cider-apple called the Cocagee, apparently an anglicisation of *cac a' ghé* 'goose-shit'. This seems a very strange name for an apple and I would be most grateful to hear from anyone who has seen this variety and can describe its appearance.

As we have seen, the other reason given in the legal commentary for allotting a high value to the apple-tree is its bark (*rúsc*). I have no explanation for this reference. The late Frank Mitchell made the point that the apple is a relatively small and valuable tree and that it would make no sense to damage it by stripping it of its bark (pers.comm.). However, the word *rúsc* is well-attested in the meaning 'bark, container made of bark' and seems to have no other meaning documented in the texts. John Tierney has suggested that the inner bark of the apple-tree may have been used to dye cloth yellow (pers.comm.)

Leaving the 'lords of the wood', I turn now to the seven 'commoners of the wood': alder, willow, whitethorn, rowan, birch, elm, and wild cherry (?). No distinction is made between different species of willow or birch. These are seven substantial and useful trees and damage to any of them attracts severe penalties, though considerably less than those for 'lords of the wood'. Thus the penalty-fine (*díre*) for one of the 'lords' is two milch cows and a three-year-old heifer, whereas the penalty-fine for one of the 'commoners' is only a milch cow.

Less information is provided in our sources about the uses of the 'commoners'. There are references to the use of the wood of the alder (*fern*) in the manufacture of shields, masts and tent-poles. The willow (*sail*) was employed in the construction of dwelling-houses, generally light impermanent structures. In addition, as in modern times, willow-rods were used for basket-making, wattling, tying up cattle, etc. The whitethorn (*scé*) features prominently in Irish folklore of more recent times as a tree with magical properties. In the early period, however, other trees – particularly oak, hazel, yew and rowan – have more association with the supernatural. There is little information on the use of the rowan (*cáerthann*), but it features prominently in literary sources and its beauty is widely extolled in verse. The graceful appearance of the birch (*beithe*) likewise attracted the attention of early Irish poets.

A 'commoner' of particular interest is the elm (*lem*), as the palaeobotanical evidence points to a catastophic decline in the abundance of this tree during the first millennium – Frank Mitchell puts it at about 500 AD. It is significant, therefore, that we find it included in our eighth-century tree-list. Furthermore, the word is an occasional element in place-names, such as *Lemchaill* 'elm-wood', and *Lemdruim* 'elm-hill'. It is well-known that cattle are particularly partial to elm-leaves and the Roman author Cato states that elm-leaves were routinely fed to sheep and cattle. An Irish text describes elm as 'the sustenance of cattle' and 'friend of cattle', so it is likely that the same practice was widespread in early Ireland. It may indeed have contributed to the decline of this tree, though elm-disease may also have been to blame.

The identity of the seventh tree in the 'commoners of the wood', *idath*, is uncertain. From a reference in a ninth-century poem, we know that this tree has edible berries – that is the extent of our information. I suggest that it refers to the wild cherry (*Prunus avium*), stones of which have been found at a number of excavations. The earliest archaeological evidence of the cultivated sweet cherry (*Prunus cerasus*) comes from an eleventh-century pit in Winetavern Street, Dublin. In general, this fruit belongs to the period after the Anglo-Norman invasion, and is known in Irish as *sirín* (or *silín*), a borrowing from Middle English *cherrie.*
The seven 'lower divisions of the wood' are listed as blackthorn, elder, spindle-tree, whitebeam (?), arbutus, aspen and juniper (?). The penalty-fine for damage to these trees is a yearling heifer. The blackthorn (*draigen*) is mentioned in early Irish sources mainly in the context of its sloes, which are included in legal commentary among the less prized categories of fruit. A ninth-century text makes a distinction between the wild sloe (*airne fiadain*) and the sweet sloe (*airne cumra*). This implies that some form of cultivated plum was grown in Ireland at this period, but no further details are provided. Little information is given in the texts about the elder (*trom*) or spindle-tree (*féorus*). The tree-name which I translate as whitebeam (*Sorbus aria*) is *findcholl*, of which the literal meaning is 'white hazel'. But the hazel (*Corylus avellana*) already has a place among the 'lords of the wood', so the best guess seems to be that this name refers to the white undersides of the leaves of the whitebeam (Bertoldi 1927).

The most interesting tree in this group is the arbutus (*caithne*), now mainly confined to the south-west of Ireland, with a few trees around Lough Gill in Co. Sligo. In earlier times it was no doubt found at other locations near to the west coast. There is good place-name evidence of its former presence near Inchicronan, Co. Clare. In his article 'The forests of the counties of the Lower Shannon valley' Thomas Westropp records the name Derrynacaheny, which is doubtless an anglicisation of *Doire na Caithne* 'the oak-wood of the arbutus', i.e. a wood which is predominantly of oak, but with some arbutus (Westropp 1908-09). The sixth member of the 'lower divisions of the wood' is the aspen, for which the Irish term is *crithach* 'the shivering one'. The final tree in this category is *crann fir*, which has not been conclusively identified. A reference in a ninth-century poem indicates a fruit-bearing tree, perhaps juniper (*Juniperus communis*).

The seven least valued 'shrubs of the wood' have a penalty-fine of one sheep. There is considerable variation between the manuscripts, but the oldest version lists a fern and six woody shrubs: bracken, bog-myrtle, furze (gorse), bramble, heather, broom, and wild rose. A ninth-century legal glossator recognises the absurdity of imposing a fine for minor damage to such plants, and states that there is no penalty for cutting a single stem.

Conclusion

I conclude by discussing some of the uses of woodland in addition to the provision of timber, rods, firewood, nuts and fruit. The Old Irish law-texts make a distinction between privately owned woodland and woodland which is part of the commonage owned by a particular community. Any damage to private woods incurs a severe fine, except where there are special circumstances such as the need to cut rods to carry away a dead body or to gather firewood to cook a meal. In commonage, on the other hand, the people of the locality would have had the right to pick fruit, cut wood and graze their stock during the summer months. In some parts of the country, such woodland must have been very extensive and not sufficiently grazed to prevent regeneration. A ninth-century text gives the three principal wildernesses or wooded areas of Ireland as the Great Wood of Cooley in Co. Louth, the Wood of Déicsiu (probably on the slopes of Slieve Gallion, Co. Tyrone) and the Wood of Moithre in Connacht (Meyer 1906). In another ninth-century text, we find a reference to a great wood (*Fid Mór*) to the west of the Sperrin mountains (Mulchrone 1939) There has been much debate on the location of the Wood of Fochluth, mentioned in Saint Patrick's fifth-century Confession as being 'near the western sea'. The Patrician scholar Ludwig Bieler placed it near Killala in Co. Mayo, but without providing definite proof (Bieler 1979).

Our sources give us relatively little information on the ways in which woodland was managed by the early Irish. It is clear that privately owned woods would normally have been surrounded by a ditch or wall. A law-text on land-values emphasises that the worth of a wood is increased if there is access by road. A passage in the twelfth-century tale *Cath Ruis na Ríg* provides evidence of the use of the 'coppice and standards' method of wood-management, whereby a few large trees are allowed to grow to maturity while the underwood is regularly coppiced to yield a crop of rods every decade or so. The author makes a vivid comparison between an army in which all the lesser warriors have been slain – leaving only the great champions – and an oak-wood in the middle of a plain in which all the underwood (*cáel*) has been removed, with only the great oaks remaining (Hogan 1892).

Finally, in many societies one of the principal human uses of woodland was for the hunting of game, particularly by kings and nobles. For example, the Scottish *Leges Forestarum* 'laws of the forests', which date from the twelfth and thirteenth centuries, were designed to protect the king's hunting preserves from deer-poaching, tree-cutting and grazing by livestock. The early Irish aristocracy likewise clearly enjoyed hunting, particularly of the red deer (*Cervus elaphus*) and the wild pig (*Sus scrofa*), but there are no records of royal deer-forests or hunting preserves in our texts. Although chasing deer with hounds is also mentioned, the Old Irish law-texts concentrate mainly on trapping in pits or with hidden spikes. Such traps may be set in common land, but public warnings must be made as to their location so as to avoid injury to people or domestic livestock.

APPENDIX 1

List of twenty-eight trees and shrubs as arranged in the eighth-century law-text *Bretha Comaithchesa* 'judgements of neighbourhood'

Airig fedo 'lords of the wood'
Dair 'oak' (*Quercus robur, Quercus petraea*)
Coll 'hazel' (*Corylus avellana*)
Cuilenn 'holly' (*Ilex aquifolium*)
Ibar 'yew' (*Taxus baccata*)
Uinnius 'ash' (*Fraxinus excelsior*)
Ochtach 'Scots pine' (*Pinus sylvestris*)
Aball 'wild apple-tree' (*Malus pumila*)

B. **Aithig fhedo** 'commoners of the wood'
Fern 'alder' (*Alnus glutinosa*)
Sail 'willow, sally' (*Salix caprea, Salix cinerea,* etc.)
Scé 'whitethorn, hawthorn' (*Crataegus monogyna*)
Cáerthann 'rowan, mountain ash' (*Sorbus aucuparia*)
Beithe 'birch' (*Betula pubescens, Betula pendula*)
Lem 'elm' (*Ulmus glabra*)
Idath 'wild cherry (?)' (*Prunus avium*)

C. **Fodla fedo** 'lower divisions of the wood'
Draigen 'blackthorn' (*Prunus spinosa*)
Trom 'elder' (*Sambucus nigra*)
Féorus 'spindle-tree' (*Euonymus europaeus*)
Findcholl 'whitebeam (?)' (*Sorbus aria*)
Caithne 'arbutus, strawberry tree' (*Arbutus unedo*)
Crithach 'aspen' (*Populus tremula*)
Crann fir 'juniper (?)' (*Juniperus communis*)

D. **Losa Fedo** 'bushes of the wood'
Raith 'bracken' (*Pteridium aquilinum*)
Rait 'bog-myrtle' (*Myrica gale*)
Aitenn 'furze, gorse, whin' (*Ulex europaeus, Ulex gallii*)
Dris 'bramble' (*Rubus fruticosus* aggregate)
Fróech 'heather' (*Calluna vulgaris, Erica cinerea*, etc.)
Gilcach 'broom' (*Sarothamnus scoparius*)
Spín 'wild rose (?)' (*Rosa canina,* etc.)

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FUNNY BUMPS IN THE WOODS! USING ARCHAEOLOGY TO IDENTIFY HISTORICAL CHANGES AND USES IN OUR NATIVE WOODLANDS

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Abstract

The purpose of this short paper is to encourage those interested in identifying historical changes and uses in our native woodlands to move beyond written historical accounts and cartographic depictions of ancient woodlands and as a complementary methodology to conduct field survey, i.e. to walk through and particularly around and outside of them. It does not purport to be an academic discourse of the subject, but rather an ideas paper.

As will be illustrated by some Irish examples, considerable physical evidence for historical changes and uses of woodlands can be garnered from the aforementioned places. In addition to the commonly referenced forms of timber production, standards pollards and coppices, examples of charcoal-making, iron-working, deer parks, rabbit warrens, glass-making and lime production are identifiable.

Introduction

Early maps, such as that held by the Manuscript Library of TCD illustrating Laois and Offaly c. 1562 AD (see Aalen *et al*. 1997) are temptingly deceptive for those interesting in identifying historical changes and uses in our native woodlands. The accuracy in form with which these woodlands are illustrated and their juxtaposition with readily identifiable towns, rivers and bog-land expanses would suggest that any vestiges of such woodland that survived the deforestation of the landscape from the seventeenth century onwards can be relatively easily located.

It might be presumed that sufficient endeavour would also result in the discovery of features within or on the immediate edges of such vestige ancient woodland closely associated with their historic demarcation and control, namely external boundary markers in the form of earthen 'wood banks'. In Britain medieval examples of these 'wood banks' consist of a wide bank, surmounted either by a sturdy hedge or fence with an external ditch. On later examples walls were built instead of hedges, whilst in other cases the exterior face of the bank was sharply revetted with dry-stone walling.

We also know from the historical sources that at least some of these woods, especially coppice woods, were intensively and conservatively managed from the medieval period onwards. As such, many would also have had an internal arrangement of banks and ditches, either indicating compartmented ownership or as a means of fencing off young coppices to prevent browsing by domestic animals and deer or other forms of trespass such as the collecting of nuts (nutting) or firewood, the latter having a significant economic value in their own right. A particularly good example of internal woodland division and management is recorded on a map of Ecclesall Woods, Sheffield, England dating from 1725 AD (Hart, 1993).

It might also be reasonably presumed that structures and features associated with charcoal-making and iron-working, and other processes requiring woodland resources such as glass-making furnaces and limekilns for lime production as well 'holly hags' for fodder in deer parks, would also survive relatively intact within or on the immediate edges of such vestige ancient woodland (Neeson, 1991; Rackham, 2000).

However, despite nearly three decades of research only a handful of such features have been recorded within the older woodlands in Ireland, Rackham's work in Offaly and Waterford probably being the most noteworthy (Rackham, 1995). That is not to say that such features do not exist, but rather that we need to revise our ideas of where we should look and what it is exactly we should be looking for.

'Seeing the wood in the trees' or where to look

Whatever the cause of their demise, the four-fold increase in population on the island between 1700 and 1840 AD undoubtedly having as significant an impact as the demands of the aforementioned earlier industries (see Rackham, 2000), it is evident that at national level surviving vestiges of ancient woodland are for the most part likely to be exceedingly small and fragmentary. Much more importantly, it may be more productive to think of them as surviving in a 'mobile form'. To put it another way, if they have survived for the last two centuries it is more likely that their genetic progeny have been 'hiding out', if not 'floating' around within a given townland or locality, rather than staying put in fixed place maintaining a continuous ancient woodland cover since the late seventeenth century.

In his paper on 'trees outside forests', Meyen (2003) argues that trees surviving in linear field boundaries may be in part the 'remnants' of ancient woodland. Whilst acknowledging the impact of the trend from the mid-eighteenth century onwards for many large landowners to improve their lands by planting trees, as well as the Royal Dublin Society prizes and medals for tree planting, one need only extend the 'genetic progeny' argument a little further to come to the conclusion that within many small broadleaf or mixed conifer/broadleaf copses as well as demesne woodlands surviving in the Irish countryside today there are the genetic progeny of ancient woodlands.

Whilst detailed research on this subject is still being undertaken in Northern Ireland by Thomas and Smithers (2003) even a cursory examination of any number of rural first edition OS six sheets from the Irish midlands, followed by their subsequent revisions, will undoubtedly produce numerous examples of small 'floating' woodland belts or copses. Consequently, the environs of both these demesne woodlands and small 'floating' woodland belts or copses would seem to provide a good geographic location to begin archaeological fieldwork.

'Funny bumps outside the woods' or what to look for

The question that then follows this assumption is what to look for. Again, on the basis of the documentary and upstanding physical record in England, it might be presumed that even where the original trees are long gone extensive complexes of external 'boundary' banks or related 'internal' banks and ditches would survive, if only in an ephemeral way. The situation could well be similar for 'saw pits' and charcoal-making mounds or pits. Whilst there is good documentary evidence for the activities themselves, there are only a limited number of real physical examples.

Wood banks, deer park boundaries and rabbit warrens

Survival of internal woodland banks is rare, but two examples have been brought to the attention of the author: within Glending wood, Co. Wicklow (Grogan, E., pers. comm.) and at Balrath, Co. Meath (Dunne, S., pers. comm.).

External woodland banks or ditches, subsequently re-used and/or re-modelled for field boundaries, are less rare. The best examples known to the author are those documented in association with 'deer parks'. There appears to be little published research on 'deer parks' in Ireland. Despite their importance in the historical record in Medieval England, they receive scant reference in the main medieval archaeology textbooks for Ireland. Of those that are discussed, more often than not in local journals or pamphlet-like publications, most are of seventeenth century date and later. These include the Phoenix Park in Dublin, which was bought by the Duke of Ormonde in 1663 AD, who then enlarged the area, built an enclosing wall and introduced deer, partridge and hawks. However, there are some one hundred and twelve 'Deerpark' townlands recorded in the *General Alphabetical Index to Townlands, Towns, Parishes and Baronies of Ireland* (published in 1861, hereinafter referred to as the "Index") and it seems not unreasonable to speculate that some of these may be of earlier Anglo-Norman origin.

At Glending, Co. Wicklow a significant portion of the circuit of seventeenth century external 'wood bank' and 'deer park' earthen boundary bank survives. On the western side it is incorporated into the later demesne boundary (where it is surmounted by an impressive stone wall) and on the eastern side as an internal demesne field boundary (where its exterior face is revetted with dry-stone walling). Another example is that at Leap Castle, Co. Offaly. To the east of the sixteenth century towerhouse and at the far eastern side of the 'demesne' the present field banks and ditches preserve much of the original circuit of the 'deer park'.

Rabbit Warrens are another Anglo-Norman introduction associated with woodlands and which have, like deerparks, maintained an association with the successor to the Anglo-Norman manors, namely landscaped Demenses and Parklands. There are some twenty-three 'warrenstown' townlands and seventeen 'coney' townlands recorded in the *Index.* Rabbit warrens within woodlands are known from Castle Bernard Demesne, Co. Offaly where there is a 'Coneyburrow Wood' and at Templehouse Demesne, Co. Sligo where there is a 'Rabbitburrow Wood', both areas which are still under tree cover.

Charcoal-making platforms, mounds or pits

Like woodland banks, good physical examples of charcoal-making platforms, mounds or pits are rare. The one notable exception is at Glendalough, Co. Wicklow where over eighty charcoal-burners' mounds have been recorded, most of which are presumed to date to the thirteenth or fourteenth centuries (Eogan & Kilfeather, 1997).

Yet we know that there was an ever-increasing demand for charcoal for iron production across Europe from the mid-sixteenth century onwards following the development of 'blast furnaces' and that Ireland was no exception. By the mid-seventeenth century historical documents record over one hundred and fifty large ironworks around Ireland, some quite industrialised in scale. These included very large works at Draperstown, Co. Derry, Mountrath, Co. Laois, Drumshanbo, Co. Leitrim and Enniscorthy, Co. Wexford, areas in relatively close proximity to major outcrops of iron ores as well as woodlands (Neeson, 1991; Rackham, 2000).

However, recent archaeological excavations undertaken in relation to the *Bord Gáis Éireann* gas pipeline to the west project has thrown some light on these features and may explain the difficulty in identifying them. At Aghamore, near Kinnegad, Co. Westmeath an area of medieval charcoal making and metalworking (dating to the twelfth to thirteenth centuries AD) was identified and excavated (Byrnes, 2003). The site was situated in what is now a grass meadow, on a level platform slightly raised above the surrounding boggy land and overlooking the course of the Kilwarden River. In total nine ore-extraction pits and scoops, three shallow sub-rectangular charcoal making pits, eight bowl furnaces and three shallow linear features were uncovered and excavated.

The interesting point about the site is that none of the features were evident before the site had been stripped of the turf (humus) and cultivation soil and more importantly, whilst in an area which historically was probably always open grassland (Aghamore being the anglicised version of *Achadh Mhór* or the large field), the neighbouring townland name of Derrymore indicates there was also an extensive woodland nearby in Early Historic and medieval periods.

Glass working

Glass working is another woodland dependent post-medieval industrial activity for which there is good documentary evidence. This is particularly so for the early seventeenth century in Cos. Offaly and Laois where glass furnaces were recorded at Lusmagh, Shinrone, Birr, Blueball, and Portarlington. More recently one of the extant furnace sites has been excavated at Glasshouse, near Shinrone, Co. Offaly (Farrelly and O'Brien 2000).

Lime production

Last but not least in the woodland dependent activities under discussion is lime production. Limestone blocks were reduced to a powdered form by burning in these structures, and subsequently used either as an agricultural fertilizer (particularly in hilly areas with acid soils) or as lime mortar or white wash for buildings. Its use as an agricultural fertilizer continued until the nineteenth century when it was replaced by imported guano and other artificial manures. Lime mortar and whitewash were still commonplace in the 1950s.

The size and form of the structures vary considerably. Small round kilns are common in the western part of the country, whilst more substantial and architecturally impressive examples are found in the east and south west, especially where associated with demesnes or estates (see Aalen *et al*. 1997). In addition to the association with woodlands, these examples are also often associated with quarries. A particularly impressive example is that on the Blessington to Naas road (R410), to the west of Glending Wood, Co. Wicklow, whilst another example was identified by the author in a small vestige broadleaf copse at Torreen, near Fermoy in Co. Cork. Woodlands with the name 'Limekiln wood' are also known from Garryhinch Demesne, Co. Offaly and Templehouse Demesne, Co. Sligo.

Conclusion

Whilst physically identifying ancient woodlands in the flesh, as it were, is a difficult, if worthwhile task, archaeological field survey as a complementary methodology has the potential to identify important edge- or near-woodland dependent monuments and features. As such it can significantly contribute to our understanding of the historical location, nature, extent, and of uses of these natural resources as well as being a particularly enjoyable and productive past time.

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THE NATIVE WOODLAND BUSINESS IN COUNTY WICKLOW FROM THE 17TH CENTURY

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Abstract

Wicklow has the highest percentage forest cover in the Republic of Ireland. Most of the present woodland consists of productive plantation forests established in the 20th century. These form the basis of a successful forestry industry. Many are now in the second rotation. The current area of woodland far exceeds that present in the county at the start of the 17th century when the forest cover was in the order of 2-3%, a figure that fluctuated to a small degree over the following two centuries as the woodland was harvested and new trees planted. In 1908 the county had a forest cover of 3.5%.

The woodland formed part of private estates mainly between the 17th and 19th centuries. The Watson-Wentworth estate, centred at Coolattin near Shillelagh, subsequently owned by the Fitzwilliam family, was the largest and owned 36,000 ha of land. 950 ha of this comprised coppices and scrub woods, mostly the former. This represented a high proportion of the woodland area in the county with the woods extending from Shillelagh through to Rathdrum.

These, mainly oak, woodlands were a significant revenue source for the estate and were managed in a disciplined manner on a coppice with standards system. The business was market driven with cordwood for charcoal making, structural and ship timber and, in particular, bark for the leather tanning industry being the main products.

Introduction

County Wicklow has been at the centre of the forestry restoration initiative in Ireland over the last century. The county is seen as having some of the best forests in the country, both man made and semi natural. This is reflected in a strong forestry tradition and a dynamic timber industry employing about 1,000 people based around a forest area of circa 43,000 ha.

Great progress has been made in enhancing the forest cover in the county. It has increased from 2.7% in 1840 to 3.5% in 1902 to just over 21% today. The acceptance of forestry as a sustainable industry in the county may have its roots in the business and associated skills that were to the fore over the previous 400 years. Most of the present woodland consists of productive plantation forests established in the 20th century. Many of these are now in the second rotation. Some are growing on sites occupied by deciduous woodland in earlier times.

There is uncertainty over the extent of forest cover that existed in the county from around 1600 and on what happened to the resource between then and the start of the 20th century. However, we know there was a substantial market-driven business centred on native woodland in Wicklow and elsewhere in Ireland in the 17th and 18th centuries. The business generated good profits for its owners but eventually went into decline because of a change in market dynamics resulting from a decline in demand for its main products. Some would argue that the business declined because the timber resources became exhausted. This paper aims to provide an overview of the business. To facilitate the process a snapshot is taken of the events surrounding the management of one particular estate, the Watson -Wentworth estate in Wicklow, which became the property of the Fitzwilliam family towards the end of the 18th century. To put the research into context, the level of

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forest cover in Ireland as a whole, and in particular County Wicklow, over the last four centuries will initially be briefly explored. The research draws heavily on a plethora of papers held in the National Archives, the National Library of Ireland, the Sheffield Archives and further a field, in addition to other published material. Noteworthy are papers by Jones (1986), Loeber (1994), Kelly Quinn (1994), in addition to McCracken's book (1971).

Woodland cover

We were told in school that Ireland was once a thickly wooded country. The woodland clearance was said to have accelerated in the seventeenth century after the arrival of the English planters and the turmoil that followed. There is a consistency in how the story is related. The evidence is usually no more than a repeat of what someone else wrote, often based on thin evidence, rarely on any new research. As Foster (2001) points out: "*when faced with complications and confrontations of Irish history, where axes and whetstones lie conveniently to every hand, there is an understandable temptation to simplify the story by adherence to one big idea".* In the forestry context the one big idea relates to how the *vast* woodlands of Ireland were exploited by the foreign invaders from the start of the 17th century. In the 18th Century an anonymous Munster poet supported this view in the poem" Kilcash" and its haunting lines, *'Cad a dhéanfaimid feasta gan adhmad? Tá deireadh na Coillte ar lár….'* 'Now what will we do for timber? The last of the woods are gone….'. Jonathan Swift (1735) who also contributed in no small way to this impression states: *'I believe there is not another example in Europe, of such a prodigious quantity of excellent timber cut down, in so short a time, with so little advantage to the country, either in shipping or building'*. Reasons put forward for the alleged clearance included a desire by the new landowners to liquidate assets, the need to drive the Irish out of their hiding places and to supply timber for shipbuilding, charcoal making, house building and fuel, the manufacture of barrels and bark for the tanning industry. McCracken (*op.cit*) estimated that 12-14% of the country was still covered in woodland at the beginning of the 17th century. However, Forbes (1932) had earlier challenged the claims that Ireland had been heavily forested in 16th and 17th century. His views were rejected, however, by Neeson (1991), an Irish Nationalist with no training in professional forestry, primarily on the basis that Forbes, being an Englishman, was biased, and did not understand the situation. Forbes's views are shared by Rackham (1995), who states that it is a myth that Ireland was heavily wooded in the 17th century and agrees with Forbes that the country was one of the least wooded areas in Europe with a likely woodland cover then of some 2-3 per cent. Recent work in Belfast by Hall (2000), and others, also points towards evidence that the great forest clearance in Ireland may well have taken place prior to the arrival of the Vikings. Data on timber exports from Ireland, and on the quantities of timber used to make charcoal, pipe staves and so on would tend to support this view. Exports for instance were in the order of 7,000m^3 /annum (McCracken, *op.cit*) during the 17th and 18th centuries and the volume of wood consumed in a large charcoal driven iron smelting plant at Monart, just west of Enniscorthy, around the same time only amounted to about 10,000m^3/annum, (Barnard 1985). We know there were many other active charcoal smelters throughout the country but it is hard to relate the alleged clearance of almost one million hectares of woodland to the relatively modest requirements of such activities. Equally, we read about millions of pipe staves being manufactured and exported in the 16th and 17th centuries but when the volumes of timber concerned are annualised they are less than 10,000 m^3. Assuming a conversion factor of 50 percent from round timber to final product this equates to some 20,000 m^3 or the produce from 60-100 ha, depending on stocking levels.

All of these data would support the view held by a number of authors that the figure for woodland cover at the beginning of the 17th century was more likely to be in the order of 2-4%.

There is also uncertainty over the level of forest cover that existed in Wicklow from 1600 and on what happened to the timber resource between then and the start of the 20th century. We know there was more woodland in the county in earlier times from pine stumps, dating back hundreds of years, which are commonly found beneath the peat at high elevations in the Wicklow hills. McEvoy (1944) cites evidence of the primeval forest in addition to oak and birch charcoal pits, at 363 m above sea level on the lee side of the Wicklow hills.

The current area of woodland in Wicklow far exceeds that present at the start of the 17th century when only about 2% of the area appears to have been covered by trees. This figure fluctuated to a small degree over the following two centuries as the woodland was harvested and new planting took place, albeit it at a low level. In 1908 the county had a forest cover of 3.5% (7,695 ha), Department of Agriculture and Technical Instruction for Ireland (1908). This included the trees planted by landlords and their tenants during the so- called "age of enlightenment" in the eighteenth and the first half of the nineteenth centuries. These amounted to about 1,175 ha, (Carey, Unpublished, 2005).

Documentary evidence is thin on the ground apart from good records for one or two of the larger estates, notably the Watson-Wentworth estate (subsequently the Fitzwilliam estate centred at Coolattin near Shillelagh, which is dealt with in some detail below) and to a lesser extent the Meath estate. Many records, including most of those from the 17th century Petty Down Survey, also perished in the Four Courts fire in 1922. There is reference to the presence of woodland in Wicklow near Enniskerry, Glencree, Glendalough and Newcastle in the 12th century. Le Fanu (1893) states that the Royal Forest at Glencree had faded from memory by the 16th century. He refers to a systematic onslaught on the timber in the forest in 1290 with the establishment of large timber works at Glencree and Newcastle when Eleanor, the wife of Edward 1st, was building her castle at Haverford in Wales. By 1304 the forest at Newcastle was reduced to 48 ha. Hore (1856) refers to woods and fastnesses in Shillelagh and Glenmalure and to timber from Wicklow being the main supply for building houses in Dublin. He also cites Wicklow timber being used in the roof of Westminster Hall and the spire of the ancient detached bell-tower of Worcester Cathedral which "rose 150 feet above the stone work of the tower made of massive timber, un sawed, polished only with an exe, not having one sawed side". Hayes (1794) comments that the timbers which support the chapel of King's college Cambridge, which was built in 1444, and the roof of Henry 8th's chapel in Westminster as being from Shillelagh. Hore (*op.cit*) also refers to the use of the proverb, "the Irish will never be tamed whilst the leaves are on the trees" as being generally misunderstood. It did not imply that the Irish could not be conquered so long as the country was full of woods but rather that the best season for carrying on war against the natives was after leaf fall in the autumn.

The 1835-1840 Ordnance Survey maps provide the most reliable estimate of the level of forest cover in the county in recent times. The map for Wicklow shows a forest cover of some 5,600 ha, representing 2.7% of the overall land area. The woodland was concentrated in areas such as the Vale of Clara, The Avoca Valley and near Shillelagh. An earlier map by Neville (1760) shows woodland and trees and suggests a woodland cover at the time of only 1,100 ha or some 0.5 % of the area of the county. The cover in the 1760s showed many similarities with the 1840 map, apart from one or two exceptions. Notable is the presence of some 100 ha of woodland in the Oakwood area of the Wicklow gap on the Neville map, a feature absent from the 1840 OS maps for the areas. This may be related to the presence of the United Irishmen camp in the area in 1798 (O'Donnell 1798). A search through earlier maps of Wicklow, notably Petty's Hibernia Delineatio published in 1683, based on the Down Survey of the 1650s and Boazio's map of Ireland produced in 1609, shows a scattering of woodland in Ireland generally and within Wicklow. Woodland areas are consistently shown near Arklow, the Avoca river, Enniskerry and Rathdrum.

A limited number of surveys and associated estate maps also provide a valuable insight into the areas of woodland that existed at in the early 17th and on into the 18th century. Most were on privately owned estates. The estates provided the basic structure for land ownership. The Watson-Wentworth estate was the largest and comprised 36,000 ha of land. There were 67 "Landed Gentry" in the county in 1838, each owning more that 410 ha of land. Besides the Watson-Wentworth estate, five owned between 8,000 and 10,000 ha, ten between 2,000 ha and 7,000 ha (Nolan, 1993). Maps for the woodlands on the Watson-Wentworth estate, and the Bayly estate at Ballyarthur in the Avoca valley in the 18th century, provide some indication of the woodland distribution at the time. Two maps of the Bayly estate dated 1700 and 1812 survive: these show a woodland area of 52 ha in 1700 that declined to 43 ha in 1812 (Bayly, E. personal communication). Evidence for the Meath estate suggests a woodland area of 5.7% in 1679 (Forbes *op.cit*).

The maps and surveys for the Watson-Wentworth estate are more comprehensive and informative and cover the period 1671-1775. These, together with other papers for the estate, provide a good insight into the woodland management business in the county from the 17th through to the 19th centuries and form the main focus of this paper.

The Watson-Wentworth Estate

The original estate, subsequently called the Coolattin estate, had its roots at the start of the 17th century. Henry Harrington, who had been granted the area in 1578 (Loeber *op.cit*), sold it to a Welshman, Calcott Chambers around 1609 whose brother subsequently sold it on to Thomas Wentworth (The Earl of Stafford and Lord Lieutenant for Ireland). Stafford was packaging together a substantial area of land in the county for his own benefit. One of his key objectives was to convert the timber on the lands into pipe staves for export. However, for this and other reasons, he upset too many people and in 1641 was executed. After this the lands passed to his brother, subsequently through two generations, including both the 1st and 2nd Marquis of Rockingham, and finally to the 4th Earl of Fitzwilliam in 1782. The Fitzwilliams continued to manage the estate, albeit on a smaller scale, on into the 20th century when it was sold off to speculators in 1978.

The Irish estate was essentially an outlier of the main Watson -Wentworth estate at Wentworth in south Yorkshire. The building of the main residence at Wentworth with a frontage of 182 metres between 1724 and 1750 at a cost of £82,500 - about €10 million at today's prices (Young, 2000), was financed to a significant degree by revenues from the woodland business and land leases related to the Wicklow estate.

Interest in the Shillelagh and surrounding woods goes back to the early part of the 17th century when there was a growing awareness of their potential value, particularly for ship-building, and a conflict with the needs of the pipe stave and charcoal industries. However, concern was also expressed because of the presence of "shake" in the timber that would tend to downgrade its value.

A number of surveys of the woodlands were carried out between 1611 and 1775. Although the earlier surveys suggested some 2,500-3,500 ha of woodland existed in the Shillelagh area, some of this may have extended into north Wexford. The later surveys done on the Watson-Wentworth estate indicated a woodland area of 600-800 ha between 1728 and 1749 comprised of coppice woodland with some scrub. The area in 1749, which amounted to some 800 ha, and extended from Shillelagh to Cashaw and on into Rathdrum, represented almost 73 % of the area of woodland for the county estimated from Neville's map in 1760. The estate dominated the woodland business in the county.

The Woodland Business Management System

The business centred on the management of 30 separate coppice woods. These were managed on a coppice with standards (reserves) system. This was geared towards the production of a number of primary and secondary timber products. These included timber for shipbuilding, construction, charcoal production and a range of secondary products and bark for the tanning industry.

The coppice system involved the reproduction by stool shoots of suckers after the cutting of trees close to the ground - or "smack smooth"- (McEvoy *op.cit*) at an angle to facilitate water runoff. Rotation lengths varied from 20-34 years, averaging 24. The rotation was related to the strong market for bark, which was widely used for leather tanning, and the fact that tannin levels in bark tend to peak at this age. It also satisfied the needs of the charcoal industry by providing manageable and easily combustible sizes of timber.

Typically, a number of trees called *reserves* or *standards* were left to grow on to about one hundred years to provide larger timber. These were not even aged and after each cut of under wood they usually consisted of a large number of young trees (*wavers*) of about 20 years of age and a smaller number of more mature trees (*black barks*) grown on for a number of coppice cycles. The wavers were thinned gradually leaving a few selected trees to reach maturity at about 100 years by which time four coppice cycles would have been obtained. Sessile oak was the dominant tree species, apart from small proportions of birch, ash, hazel, alder and sally. Preference was for a monoculture of oak. Production data are sparse but Harmer and Howe (2003) suggest a range of 3.6-5.1 m^3/ha/ annum for oak coppice in Britain. We have no information on the origins of the particular system in the area or on when it was introduced to Ireland. However, it was widely practised in Britain and in Europe generally in earlier times. Dubourdieu (1991) states that two thirds of the broadleaf forests in France - 4.9 million ha - are managed using simple coppicing or coppicing with standards.

The system was also practiced on other estates throughout Wicklow including the Carysfort and Meath estates and on smaller estates such as those belonging at the time to Cunningham, Tighe, Bayly, Tottenham and La Touche, the last including one side of the well known Glen of the Downs. Nisbett (1903), based on a 1902 survey of the woodlands in the county, estimated that just over 50%, some 3,200 ha, had formerly been coppice woodlands. The scheme was approved and supported by the RDS and at its meeting on the 30th June 1791 it awarded Francis Synge of Glanmore estate near Ashford a premium of £2 "for every acre of coppice wood sufficiently fenced against cattle"(Dublin Society 1791). This is equivalent to about €500 per ha.

The structure, management, and business generated by the woodlands at the Watson-Wentworth estate in Wicklow is outlined in some detail by Jones (*op.cit*). Surveys carried out in 1724 and 1749, besides giving the area, tenant name and age also give the date for felling and comments on the condition of each coppice. Protection against animal trespass was seen as being essential and double ditches were often used for the purpose. A Trespass Book dated 1713 gives a good insight into the steps taken to ensure compliance with related procedures. Although paid Coppice Keepers were employed for protection there are lots of references to coppices being damaged by grazing animals.

The resident Land Agent was responsible for the coppice woods, assisted by a small team of Coppice Keepers and a substantial number of Woodmen recruited from among the estate tenants. The Head Coppice Keeper was paid £9-4s-9d (about €1100) in 1749 while the other Coppice Keepers were each paid about € 340. Woodmen, including woodcutters, squarers, sawyers, cleaves, barkers, ditchers, hedgers and carters, were paid on a piece rate basis.

Woodland Products Timber for Building including Ship-building.

This was sold squared, sawn and in the round. The ship building products included keels, rudders, deck beams, boat boards, plank logs, gunwales and many other items including thousands of ship pins. These were sold direct to shipbuilders or to dealers. Most of the ship timber went to Wicklow and Dublin but some was exported to Whitehaven in Wales.

The building timber included a wide range of timbers used in construction from purlines, to beams, riberrys, rafters, laths, shingles, doorcases, clapboards. There were many customers. Interesting items in 1718 included 134 tons of squared timber delivered to Trinity College, Dublin from the woods at Tomnafinnoge, Ballykelly and Drummin at a price just over £3 per ton (€300), timber for churches at Castleruddery, Coolkenno and Clonegal and 70 tons delivered to Wicklow Courthouse for £176. Some industrial items such as millshafts, cartshafts, axle beams, plough shares, mill wheels and barrel staves were also manufactured in addition to furniture items such as chair bottoms, backs and rails.

Bark

Throughout history oak bark has been used for tanning leather. The tannic acid derived from ground bark seeps through the pores of animal hides, draws out the water and coats each fibre with a preservative. Bark was usually removed from trees in the spring and ground in specially constructed bark mills located close to or in the larger coppices. Prices were attractive and doubled between 1700 and 1735 and remained more or less the same until they peaked during the period between 1790 and 1815 (Linsay 1975). There were eight bark mills across the Wentworth – Watson estate in the early part of the 18th century. According to the account books for 1707-1708, two bark mills were constructed in Roddenagh and Coolelug woods at a cost of about £8 each (just less than €1,000). The mills were therefore relatively cheap to construct and moved as felling years changed from one coppice to another. Jones (*op.cit*) suggests that water powered bark mills may have operated on the estate from as early as 1711.

Bark was sold by the barrel to a number of tanners. These were about 17 in number with addresses in Dublin, Waterford, Wexford, Wicklow and elsewhere. Production varied between years and is summarised in Table 1. Between 1707 and 1719 annual revenue from bark sales averaged almost £1,400, the equivalent of about €170,000. This represented 45% of the total gross sales for timber and bark.

Cordwood for charcoal

Charcoal is a carbon product obtained from the controlled burning of wood with a restricted air supply. Although it is commonly used now as a source of fuel for barbecues, historically its greatest use has been in the metal industries, particularly in the manufacture of iron and steel. The presence of substantial quantities of iron ore and limestone, which is used as a flux in iron- making and timber, together with the difficulty of sending timber profitably any distance by water transport, are attributed by McCracken (*op.cit*) to the widespread growth of ironworks in Ireland during the period. Over 160 ironworks were established in Ireland during the 17th and 18th centuries (Andrews 1956) of which about eighteen were in Wicklow. Some dated from the early part of the 17th century and were located in places such as Aughrim, Avoca, Ballard, Ballinaclash, Carnew, Vale of Clara, Glendalough and Woodenbridge. One of the largest ironworks was located at Monart, west of Enniscorthy (Barnard *op.cit*). This was established in the 1650s in an area recorded to have 600 ha of woodland and is estimated to have consumed in the order of 10,000m^3/annum. Many ironworks were destroyed during the 1641 rebellion after which some were restored. As timber prices were considerably lower than in Britain, the iron ore was often imported from areas such as the Forest of Dean and the processed iron re-exported. The ironworks are perceived as being vast consumers of wood. However, the sparse figures available do not appear to support this hypothesis. For instance the process required about 20 cords of timber (51m^3) or 2.25 tons of charcoal to make one ton of bar iron from iron ore. Averaging annual export figures for bar iron from Ireland for the seventeenth/eighteenth centuries, given by Andrews (*op.cit*), gives a figure of 193 tons per annum, the equivalent of just under 10,000m^3 of timber. This in present day terms cannot be considered as being a substantial quantity. However, there were wide fluctuations between years with a maximum of 1,692 tons exported in 1697 to a minimum of 14 tons in 1740.

Cordwood sales were an important source of revenue for the Watson-Wentworth estate, but not to the same extent as bark and other timber sales. The accounts show that cordwood sales were almost exclusively to a local ironmaster, a John Chamney, and that the amounts averaged about 983 cords or 2,500 m^3 per annum.

Financial returns

The records for the estate provide a good insight into the nature and profitability of the woodland business in the 18th century.

Table 1 gives a summary of the timber and bark sales for the period 1707-1718. Total gross revenue from timber and bark sales amounted to £42,389 of which £18,134 came from bark.

Table 1. *Gross revenue from timber and bark sales at the Watson-Wentworth estate in Wicklow 1707-1718 and number of barrels of bark produced*

Timber Sales (£)	Bark Sales (£)	Total Sales (£)	Average annual sales (£)	Number of barrels of bark
24,255	18,134	42,389	3,532	45,162

The accounts also provide information on costs of production. These are summarised in Table 2. The profit margin for all products was high, being best for timber, bark and hog staves. The more minor timber products were also profitable. For instance, between 1707-1719 total costs for these amounted to £615 compared to revenues of £2,653.

It is not possible to extend the accounts from the Watson- Wentworth estate to other areas in the county. However, snippets of information do exist. In 1809, one hundred years later, Radcliffe (1812) stated that 527 barrels of bark had been produced from a wood of 65 ha in the Avoca valley. The bark cost 4s and 8 pence /barrel to produce and sold for £1-9-0 representing a profit margin of 87%. This was the peak period for bark prices. Prices had increased four-fold during the century.

Table 2. *Costs of production and selling price for the main timber products, including bark, between 1701and 1718*

Product	Production cost	Sale price	Approximate margin	Margin as a % of sales Price
Squaring timber	3 s-2 p/ton	£2-5-0/ton	£2-1-10	93
Cordwood	1s-6p/cord	4-6s/cord	3-4s/cord	74
Bark	1 s/ Barrel	7s-9p/Barrel	6s-9p/Barrel	87
Barrel staves	12s/1000	£1-8s-4p/1000	16s/1000	56
Hogstaves	17s/1000	£ 6-10s/1000	£5-13/1000	87
Firkin staves	8s/1000	£1-8s-4d/1000	£1/1000	70
Laths	3s-6p/1000	12s-8p/1000	9s-2p/1000	72
Lock stops	£1/1000	£4/1000	£3/1000	75

Summary and Conclusions

Wicklow, like the rest of Ireland has gone through turbulent times over the last 400 years. The woodland cover, now 21%, is almost six times what it was in 1902. The roots of the industry relate to a very different system of forest management carried on in the 17th through to the 19th century, whose products were driven by different markets to those existing today and most of which are unlikely to exist in the future. The coppice with standards system generated substantial profits for at least one large estate owner at the time and probably others. As the demand for some of the main woodland products, bark, charcoal and ship timber went into decline in the second half of the nineteenth century interest in a continuation of the coppice with standards system waned and the woods entered an age of uncertainty. By the turn of the 20th century most were in a poor derelict state or had been partially converted into coniferous forest (Nisbett *op.cit*). Some are now owned by Coillte and are being considered for conversion back to "native" broadleaf woodland with funding hopefully coming through the Native Woodland Scheme. Others are owned by the National Parks and Wildlife Service and managed for conservation and biodiversity. Apart from a desire to somehow or other recreate the past, there is uncertainty over the purpose, given the changing markets for timber and timber products. This uncertainty may tend to undermine the scheme unless the objectives and the issue of who pays are clarified. Questions remain as to the overall sustainability of the coppice with standards system. Dubourdieu (*op.cit*) suggests it is non sustainable given that it typically removes four crops every century and ultimately results in soil degradation. Whether it was this issue or changes in the market dynamics and /or the socio-economic changes that took place in Wicklow and elsewhere in the 19th and 20th century remains to be further explored.

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THE CULTURE AND SPIRITUALITY OF WOODLANDS

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Abstract

There was once a deep-rooted connection between people and trees. Ireland is almost unique in the developed world in experiencing near-total deforestation within living memory. In the process, we lost our intimacy with nature, which we are only now tentatively re-establishing.

We have some evidence of our ancient ancestors' spiritual relationship with trees, and we find that they possessed a richness missing from modern Irish life, of practicality combined with respect and reverence.

Our recent history - of colonisation and dispossession, of hunger for land - became a potent folk memory, which permeated our attitudes towards the way we treated nature up to the present day.

This generation is less affected by the old folk memory. The economic 'spring tide', which has lifted our boats, insulated us from the harsher side of nature, and it gives us some breathing space to look more sympathetically on the many gifts trees and woodlands give us.

But other powerful forces are also at work. Now, nature tends not so much to be fought against as dismissed, in the midst of an unprecedented development boom. We are also losing that link with farming and the soil — so important for a healthy relationship with nature.

Ireland's young tree movement is trying (and sometimes bravely succeeding) in promoting a new tree culture, a culture of ownership of something we had previously considered as not belonging to us; a challenging task for a nation preoccupied with prosperity and materialism.

This paper examines our past and present relationship with trees and woods and explores our hopes and expectations for the future.

Main text

The way we think about trees and woods will tend to determine the way we treat them. The actions of a utilitarian society will be very different from those of a society in which trees and woods fulfil many functions. The title of the paper I have been asked to write includes the word 'culture'. If we have to mention culture, in the broad sense of the word, we have either lost it or are on the way to losing it. For culture is something essentially unconscious. It is about that which we are or that which we do. We should not have to dissect and analyse it. I think it is appropriate to think in these terms, because for as long as I have known Ireland, it has been a society which lacks a tree culture.

Having lost that tree culture, efforts are being made to reclaim it, or to make a new culture. The Native Woodland Conference can be seen as one element of this campaign. We are not trying to pretend that we have a particular culture, as we do at a broader, national level. We already freely admit that we have lost our tree culture and that we must begin again from scratch.

The tragic loss of Ireland's tree culture happened many centuries ago. The story is one that has been told many times, of an island's woodlands which were already seriously depleted even before the more concerted assault by the colonising power began in the 1500s. It is a story of an island's timber reserves which became so depleted that, in just one century, Ireland ceased to be a net exporter of timber and became a net importer. Ireland is in an almost unique position in Europe: it has undergone almost total deforestation. Was this the result of Ireland's domination and exploitation by England? If we had retained our Gaelic laws and customs and were in charge of our own destiny, might we be facing the same situation? It is quite possible that we might.

Wood was our ancestors' chief resource. Ancient writers wisely observed that forests always recede as civilisations develop. The Roman poet Ovid, for example, wrote that during the '*Golden Age*' before civilisation began, '*even the pine tree stood on its own hills*', but when the Iron Age succeeded it, '*the mountain oak and the pine were felled*.' This trend is explained simply by the fact that trees have been the staple fuel and building material of almost every society for over 5000 years, right up until coal and then oil and concrete displaced it from the mid-1800s onwards. Without vast supplies of wood from forests, the great civilisations of Sumeria, Assyria, Egypt, Greece and Rome, China, Western Europe and North America would never have emerged.

In his book *The Forest Journey*, John Perlin (2001) observed that:

> *'Wood is the unsung hero of the technological revolution that has brought us from a stone and bone culture to our present age.'*

The result of generations of exploitation without replenishment has been the total annihilation of the ancient wildwood and the almost total destruction of our native forests, of which only tiny remnants remain. This exploitation continued even as the island was being reforested with plantations. It is continuing even today, as developments nibble away small areas of native woodland. For a long time, trees and woods were treated at best indifferently and at worst in a hostile way. It has proved extremely difficult to protect these remnants where they are owned privately rather than by the State. Native woodlands are still treated as the poor relation in current State policy. Why has it been so difficult to conserve even these tiny remnants, considered by many conservationists to be the most important part of our national heritage?

Societies which have undergone great technological change have also tended to destroy their forests (except possibly Japan), whereas traditional societies have tended to conserve their forests. Throughout the world, wherever traditional societies or their remnants survive, a common theme is their respect — and reverence — for forests. The reason seems to be that trees and forests are integral parts of their spirituality.

An example of this traditional attitude towards trees is the Haida, the indigenous people of the Queen Charlotte Islands in Western Canada. Their trees and forest ecosystem are under threat from the logging industry. Western red cedar is the loggers' favourite because of its excellent timber qualities. But it is also at the heart of the Haida culture. Their belief is that the first peoples who lived on the islands thousands of years ago turned into cedar trees. They recognise that the spirit of these peoples is still in the trees and whenever they go into the forest to harvest timber, they understand there is a life force for which they ask permission to cut down a tree. Like with many indigenous societies, they possess an approach to forests and to nature in general which combines utility with respect.

Insofar as we understand the culture and traditions of our own ancestors, this was the case in Ireland as well. At a time when the forest was more abundant, and when wood was such a vital resource, it is no wonder that the forest was perceived as the primary matrix of our ancestors' sustenance, culture and spirituality. A mythology and folklore about each individual species of tree developed from these material and spiritual needs.

Our ancestors learned, through centuries of intimate living with forests, not only a myriad of practical uses for each tree but also understood the spirit of each species of tree itself. They came to know which trees were benign and which were benevolent. For these early peoples, the forest was a food store, a source of medicines, firewood, shelter and the centre of their spiritual world.

The time-honoured attitude of reverential and grateful interdependence with the living earth, although still embraced by the early Celtic church, was gradually superseded by a belief system which separated the 'spiritual' from the 'material'. The idea that human beings have dominion over the earth and its creatures is Judeo-Christian. It was propagated by successive rulings of the Christian church which made it heretical to venerate objects like trees. Trees were once highly regarded in ancient Irish societies. The Brehon laws had a hierarchy of fines to be paid by anyone who cut down a tree without permission. If the last native forests were finally devastated by the colonisers from the 1500s onwards, the Christian church did nothing to stop them and might have endorsed their actions.

I was brought up in an orthodox Irish Roman Catholic atmosphere, but also with a background in natural history. This stimulated me to ask why there was no mention of reverence for Nature within the Irish church. Why should Nature — on which we depend for our sustenance and our ultimate survival — be almost completely ignored?

My answer to this was that the educational and cultural backgrounds of members of the church did not include such interests. Additionally members of the dominant church came from a wider society which held a similar attitude. However, although organised religion has lost the power and influence in society it once possessed, there is still an indifference to Nature. This is compounded by our unfortunate history, in which trees and woodlands were associated with the privileged classes.

The phrase, "You can't eat the scenery" is often quoted and, indeed, if Nature is seen merely as a pleasant backdrop to that which is seen as the real drama of human life, I don't see us making much headway in advancing a true conservation culture. If we are to succeed in reversing centuries of indifference and exploitation of native woodlands, we need to re-align or re-focus our efforts.

We have tended to promote the ecological value of our native woodlands, and of course, this is undeniably true. Most campaigners come from a scientific background, so this approach is understandable. But it will not be enough. John Feehan (2004) explains how we need to approach the problem, when he spoke during a presentation on conservation of biodiversity:

> "*We need to reach a point of being able to say: This enhances my world, enhances my life, makes the world a better and richer place, with same kind of reason and sincerity as we would say a better health service or transport system makes my world a richer place to live in."*

This means that we have to make native woodland conservation, and conservation in general, something that ordinary people can relate to in a deeper way. And education and ethics are at least as important as science.

As I mentioned at the beginning of this paper, as we think, so do we act. The challenge to this generation of conservationists is to make conservation meaningful and to instil reverence for the richness of native trees and woodlands. The best way we can do this is by harnessing the skills and talents that are undoubtedly out there; to bring as many people into intimate contact with Nature as possible, preferably from an early age. In this context, the People's Millennium Forests Project and the Woodlands of Ireland group have made a brave start in democratising native woodlands and their conservation.

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