THEME 2

The Ecology and Current Status of Ireland's Native Woodlands

IRELAND'S NATIVE WOODLANDS IN A EUROPEAN CONTEXT

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KEYWORDS: Potential native woodlands, distribution, Ireland.

Abstract

Ireland's woodlands are part of the temperate mesophytic deciduous broadleaved forests that extend across much of Europe between northern Portugal and Scotland in the west and central Russia and northern Ukraine in the east. Based on the recently published Map of the Natural Vegetation of Europe, 4 forest formations with 9 forest units are recognised within Ireland, including acidophilous oak forests, mixed oak-ash-hazel forests and mixed alder-oak-ash forests with willows. These woodlands are examined in terms of their species composition and distribution and compared with similar woodlands in Britain and the continental mainland. It is shown that as a result of the mild, moist climate and the different species composition, especially the absence of numerous species common in Britain and on the continental mainland, Irish woodlands are distinctive and, in some cases, unique at a European and even a global level.

Introduction

Ireland lies within the zone of temperate mesophytic deciduous broadleaved forests, which in the European lowlands extend from the Atlantic coast between northwest Iberia and southern Norway as far east as the Ural Mountains (Bohn *et al.,* 2002). This area of distribution narrows progressively eastwards, eventually dwindling to a narrow band between the boreal (coniferous) forests to the north and steppe vegetation to the south (Fig 1). These forests are typically dominated by beech (*Fagus sylvatica**), hornbeam (*Carpinus betulus*) and species of oak (*Quercus robur* and *Q. petraea*). Other important and widespread constituents include sycamore (*Acer pseudoplatanus*), elm (*Ulmus* species), ash (*Fraxinus excelsior*), birch (*Betula* species) and lime (*Tilia* species). Conifers, such as Scots pine (*Pinus sylvestris*), European spruce (*Picea abies*), silver fir (*Abies alba*) and yew (*Taxus baccata*), play only a limited role. There are considerable variations within these forests associated with climatic and biogeographical differences; Ireland is situated on the extreme western or oceanic edge of their distribution. This paper examines the principal characteristics and the distribution of native Irish woodlands and highlights the differences from, and similarities with, those in Britain and the continent.

General character of Irish woodlands

Continental botanists are often struck by the distinctive character of Irish woodlands **. This is the result of a combination of several factors. Firstly, Ireland has a much smaller species complement compared to both Britain and the mainland of Europe (see for example Webb 1983), a consequence of its island status and recent geological history. Of particular note is the absence or extreme scarcity as native of numerous species that are important constituents of forests in Britain and, to a greater extent, the European mainland. These include many of the trees listed above but in particular beech, the principal forest-forming species over much of temperate Europe (Table 1).

* Nomenclature follows Stace (1997)
** Throughout the text the term 'forest' refers to the formation at a European level. The term 'woodlands' refers to the small remnants of forests remaining in Ireland.

Secondly, as a result of the mild, moist climate, Irish woodlands are characterised by an abundance of so-called 'oceanic' or Atlantic species. These include flowering plants, e.g. bluebell (*Hyacinthoides non-scripta*), ferns, e.g. hay-scented buckler fern (*Dryopteris aemula*) and a large number of mosses and liverworts. In addition there is a suite of sub-Atlantic species which extend eastwards in Europe in cool, moist, montane climates, e.g. honeysuckle (*Lonicera periclymenum*), foxglove (*Digitalis purpurea*) (Roisin, 1969) (Fig 2). Thirdly, a combination of the reduced species diversity and the climate results in some species being very much more abundant and having a much wider ecological amplitude in Ireland than elsewhere in Europe (Webb, 1982). These include common and familiar Irish species such as ash and holly (Table 2). Ash, for example, is widespread across Europe but thrives best on deep, moist soils; as an important component of the canopy it becomes mostly confined to valleys and deep ravines as the climate increases in continentality. In Ireland, however, it is one of the commonest trees (Higgins *et al.,* 2004), occupying the habitat left vacant by the absence of beech (Dierschke, 1982). In contrast, in sub-montane areas of central Europe where the climate is closest to Ireland, beech is the dominant tree, often accompanied by oak, ash, sycamore, elm and hornbeam. It declines in importance or is absent only where the soil is too dry, too wet or too nutrient poor.

Finally, Irish woodlands have a semi-evergreen appearance. This can be attributed to the abundance of evergreen species, such as holly (*Ilex aquifolium*), ivy (*Hedera helix*), both as a liane and in the field-layer, and bramble (*Rubus fruticosus* agg.), but even deciduous trees and shrubs may retain their leaves in sheltered areas until early winter. Grasses, certain herbs, e.g. woodrush (*Luzula sylvatica*), primrose (*Primula vulgaris*), numerous species of fern, and the abundance and luxuriance of mosses, liverworts and lichens, both as epiphytes and on the ground also contribute to the evergreen character. These last are of particular significance in a European context, especially in the west of the country (Kelly, this volume).

Irish woodland types and their European significance

The potential natural distribution and character of European forest vegetation is illustrated and described in the Map of the Natural Vegetation of Europe (Bohn *et al.,* 2002). In this map 9 forest units within 4 Formations are recognized within Ireland. These include montane birch forests (of which no extant examples occur), acidophilous oak forests, mixed oak-ash forests and mixed alder-ash-oak forests (Bohn *et al op. cit*.; Cross, 1998). There are, in addition, numerous types of wetland forests, including bog woodlands and alder and birch carr on cutaway peats, most stands of which are very small (Kelly & Iremonger, 1997; Cross & Kelly, 2003) (See Table 1 in Kelly, this vol).

It is important here to emphasize that the forest units referred to above represent the **potential** vegetation, i.e. the hypothetical vegetation that would develop on a particular substrate under the prevailing climatic conditions in the absence of human activity. They should not be confused with the actual vegetation occurring in remnants of forest that exist today, even though they may closely resemble the potential vegetation. Further, potential forest vegetation as indicated by Figs 4 to 8 covers a very much greater area than existing stands.

In this section the principal potential forest units occurring in Ireland are examined in relation to their character and distribution in Europe. For ease of reference the classification unit of Fossitt (2000) is given in brackets. More detailed descriptions of the existing flora of each unit within Ireland, along with a conspectus of Irish native woodland communities according to different classification systems, can be found in Kelly (this vol – see in particular Table 1).

1. Acidophilous oak forests (WN1)

Acidophilous oak forests occur as relatively fragmented stands across central Europe from the Atlantic coast (between Portugal and Scotland) to western Russia and northern Ukraine on free-draining or intermittently moist, poor, acidic, often sandy soils (Fig 3). The most extensive stands lie outside the area of the natural occurrence of beech forests, viz, the West Cantabrian Mountains and Galicia, southwest France, British Isles, Poland, Belarus and Ukraine. Small stands occur locally within beech forests on warm, dry slopes unsuitable for beech regeneration.

Unifying features across Europe are the dominance of oaks (*Quercus petraea* and *Q. robur*) with birches (*Betula pubescens, B. pendula*) in the canopy and calcifuges in the shrub and herb layers. The shrub layer typically contains rowan (*Sorbus aucuparia*), alder buckthorn (*Frangula alnus*) (more or less absent within these woodlands in the British Isles), hazel (*Corylus avellana*) and, in more Atlantic regions, holly. A dwarf shrub layer with ericaceous species, e.g. bilberry (*Vaccinium myrtillus*), ling heather (*Calluna vulgaris*), or dwarf broom species (*Genista* species) is also characteristic. Species such as cow-wheat (*Melampyrum pratense*), bracken (*Pteridium aquilinum*) and grasses such as *Agrostis capillaris* and *Deschampsia flexuosa* characterize the herbaceous layer. Bulbous species are rare. The northern forests are much poorer in species than those in the south while Atlantic species are absent from eastern Europe where boreal species, e.g. Scots pine (*Pinus sylvestris*) and cowberry (*Vaccinium vitis-idaea*), play a bigger role. In western Europe, ferns and other moisture-loving species are prominent. Many of these are confined to mountainous areas further east. Lianes are also a striking feature.

In Ireland, acidophilous oak woodlands are largely confined to upland areas of poor, acidic rocks. *Quercus petraea* is the dominant species in the tree layer, typically with *Betula pubescens*, and the shrub layer is dominated by holly. Two units are recognised (Figs 4a, 4b). In drier parts of the country the woodlands are relatively species-poor and characterised by the absence of many of the species occurring further west. Typically, mosses and liverworts are relatively sparse. This drier variant has close similarities with communities in Britain (See note 3). Similar communities on the continent are distinguished by the presence of alder buckthorn, Scots pine and European spruce.

In the hyperoceanic west the flora is richer with a greater abundance of ferns. Of particular note is the luxuriant bryophyte and lichen flora, constituting c.66% of the total flora (Kelly, 1981). These include southern Atlantic species of bryophytes with a Macronesian-tropical world distribution, here reaching their most northerly known localities in the world (Birks, 1996). This hyperoceanic variant is confined to Ireland and Britain (Rodwell, 1991), although an analogue is found in the warmer, hyperoceanic acidophilous oak woodlands of Iberia, albeit with a greater number of 'thermophilous' elements, of which only a few, e.g. *Arbutus unedo*, reach Ireland. The British Isles may therefore be considered as the European headquarters of these woodlands.

2. Oak-ash forests (WN2)

European oak-ash forests centre on the British Isles with a southern outlier in the foothills and interior of the Pyrennees and Cantabrian Mountains in southwest France and northern Spain (Fig 5). There are isolated occurrences in northwest France and on the west coast of southern Norway. They occur on base-rich, often calcareous soils, in regions with year-round precipitation, mild winters and cool to warm summers, outside the natural area of oak-hornbeam forests and beech forests. They are very much richer in species than the acidophilous oak forests. Oak (*Q. petraea, Q. robur*) and ash are the dominant trees, with occasional lime and locally sycamore, beech and yew. There is a species-rich shrub layer, typically dominated by hazel with hawthorn and holly, although the last is very much less abundant than in the acidophilous oak forests. The herb layer is characterised by an abundance of spring-flowering species, of which bluebell is a prominent feature.

A characteristic and striking feature of the Irish oak-ash woodlands is the absence of a number of species that play an important role elsewhere. The Norwegian unit, for example, contains boreal elements of the flora, e.g. *Ribes spicatum, Alnus incana*. The British woodlands contain field maple (*Acer campestre*), hornbeam and lime (*Tilia cordata*) in the tree layer, dog's mercury (*Mercurialis perennis*) in the herb layer and the lianes clematis (*Clematis vitalba*) and black bryony (*Tamus communis*) (Rodwell 1991). Mediterranean elements, e.g. butcher's broom (*Ruscus aculeatus*) and spurge-laurel (*Daphne laureola*), are characteristic in southwest France and northern Spain.

In Ireland, ash plays an important and often dominant role in the canopy, although this is partly anthropogenic. The shrub and herb layers are characteristic for the type with bluebell, primrose and the ferns *Polystichum setiferum* and *Phyllitis scolopendrium* finding optimal conditions. Occasional Mediterranean-Atlantic species, e.g. madder (*Rubia peregrina*), also occur. At least 3 variants can be recognised:

Q. petraea woodlands with bluebell on base-rich acidic soils (Intermediate between Fossitt Units WN1 and WN2). This is a transitional type to the acidophilous oak woodlands. It is widespread in the lowlands across much of the southern and northeastern parts of the island. Very similar woods occur in Britain and the extreme northwest of France but *Quercus robur*, rather than *Q. petraea*, is the dominant species. They do not occur outside these areas (Fig 6).

Oak (*Quercus robur*)-ash-hazel woodlands on calcareous soil with wood speedwell (*Veronica montana*) and a species-rich field layer (Fossitt Unit WN2). They are widespread across the central lowlands. The absence of the numerous species occurring in Britain distinguishes the Irish woodlands, which are very distinctive and may even be considered an endemic community (Fig 7).

A variant of b) above occurs on shallow, often rocky soils. The canopy is typically low and extensive areas are dominated by hazel scrub, such as is found in the Burren. Similar vegetation occurs in parts of northwest England but again the presence of additional species differentiates them from the Irish communities. Yew is locally frequent, in places forming small, monodominant stands (WN3 of Fossitt). According to Thomas and Polwart (2003) yew only appears to form single-species stands in the oceanic climates of Ireland, Britain, the Crimea and Caucasus and locally also in Sardinia and Corsica.

3. Alder-ash-oak forests with willows (WN4)

Forests of alder, ash and oak with willows, poplars and elms occur on river flood plains (alluvial forests) and other wet lowlands, principally on mineral soil. Alluvial forests occur throughout Europe but they display marked floristic variations depending on the temperature, precipitation and flooding regimes. The plants and communities are adapted to the mechanical stress of flowing water and periodic flooding at different seasons. The soil may be well drained, and dryout between flooding episodes. Forests with a similar species composition also occur on heavy, poorly drained gleyed clays not subject to flooding but which dry out superficially in the summer.

In Ireland (Fig 8) these woodlands are characterised by a canopy of alder, ash and oak (*Q. robur*) with a shrub layer of hazel and willow (mostly *Salix cinerea* ssp. *oleifolia*) and a species-rich herb layer. The vegetation on alluvial sites is very similar to that on heavy, wet clay soils such as occur on drumlins and they are usually classified as the same vegetation type, although there are differences in species composition and physical attributes.

The river channels in alluvial forests are typically fringed by a belt of so-called gallery forests (Fossitt WN5), dominated by willows (e.g. *Salix fragilis, S. alba*) *S. cinerea* ssp. *oleifolia, S. viminalis*). The nutrient input from flooding encourages the growth of tall herbaceous perennials such as nettle (*Urtica dioica*) and reed canary-grass (*Phalaris arundinacea*). This vegetation type occurs in Britain, although the extent of both alluvial and non-alluvial forest is very small and they differ from Ireland in that they contain a suite of other species, such as lime, field maple and dog's mercury. On the continent there is a much richer flora with, among other species, hornbeam and the elms *Ulmus laevis* and *U. minor*. The Irish woodlands are, therefore, distinctive and possibly unique.

4. Other woodlands

Numerous other woodland types, mostly small in extent and occurring on poorly drained soils, are found throughout the island. Of particular note are the alder woodlands in areas subject to lake flooding, ash-alder woodlands in seepage areas and birch woodland on former raised bogs. These last are complex and varied stands, strongly influenced by peat depth and hydrological conditions. While downy birch is typically the commonest tree species, alder may occur in sites influenced by ground water and various shrub willows characterise the shrub layer (van der Sleesen & Poole, 2002). Their distribution reflects that of the former raised bogs and they are therefore largely restricted to Ireland, parts of England, the Netherlands and northwest Germany. Small stands of birch woodland occur on a few intact raised bogs; these are extremely rare, even in Ireland and with the destruction of similar Atlantic raised bogs elsewhere in Europe they may be considered unique (Cross, 1987).

Discussion

While attention tends to focus on the biodiversity of tropical forests, it is often overlooked that Europe has a great diversity of forests rich in species. Some species, e.g. *Quercus petraea* and its associated plant communities, are restricted to Europe (Anon., 2000) and consequently they may be considered to be of global significance. Public perception, however, and even that of conservationists and foresters, is that Irish woodlands are relatively unimportant, with a few notable exceptions, e.g. the Killarney Woods. Part of this prejudice may be attributed to the small size of individual stands, the overall scarcity of the resource and the poor quality of the timber.

Even at a European level their significance is not fully recognised. Several types are listed for protection under the EU Habitats Directive, including 'Old oak woods with *Ilex* and *Blechnum* in the British Isles' (acidophilous oak woodland), 'residual alluvial forests' (alder-ash-oak forests with willows), '*Taxus baccata* woods' and 'Bog woodland'. Strangely, and regrettably, however, the oak-ash woodlands and the alder-ash-oak woodlands, other than the alluvial stands, are not included, even though these are some of the rarest and most distinctive woodland types in western Europe. They cannot therefore be designated for protection in their own right as Special Areas for Conservation (SACs), although some are included within other categories, e.g. ash-hazel woodland on limestone pavement, and several are protected at national level within nature reserves or national parks or are listed as potential Natural Heritage Areas.

The importance of protecting examples of all our woodland types cannot be overstated. Ireland, along with Britain, has the greatest concentration of Atlantic acidophilous oak woods in Europe and unique stands of oak-ash forests and alder-ash-oak forests with willows. There is also a variety of wetland woods, the exact importance of which still has to be determined. On-going national surveys may identify additional woodland types and help to elucidate the significance of those already recorded.

Table 1. *Species common or important in woods in Britain or on the European mainland that are absent or very rare as native within Irish woodlands.*

Trees	Shrubs	Herbs
Beech (*Fagus sylvatica*) Elms (*Ulmus minor, U. laevis, U. procera*) Field maple (*Acer campestre*) Hornbeam (*Carpinus betula*) Lime (*Tilia* species) Sycamore (*Acer pseudoplatanus*)	Cornelian cherry (*Cornus mas*) Medlar (*Mespilus germanica*) Alder buckthorn (*Frangula alnus*) Wayfaring tree (*Viburnum lantana*)	Wood small-reed (*Calamagrostis epigejos*) Touch-me-not-balsam (*Impatiens noli-tangere*) Dog's mercury (*Mercurialis perennis*) Herb Paris (*Paris quadrifolia*)

Table 2. *Atlantic species occurring in woods which are more abundant in Ireland and western Britain than on the European mainland.*

Trees and lianes	Dwarf shrubs, herbs and ferns
Ash (*Fraxinus excelsior*) Holly (*Ilex aquifolium*) Grey willow (*Salix cinerea ssp. oleifolia*) Ivy (*Hedera helix*)	Ling heather (*Calluna vulgaris*) Bluebell (*Hyacinthoides non-scripta*) Great wood-rush (*Luzula sylvatica*) Hay scented buckler fern (*Dryopteris aemula*) Water dropwort (*Oenanthe crocata*) Filmy ferns (*Hymenophyllum species*) Hard fern (*Blechnum spicant*) Royal fern (*Osmunda regalis*)

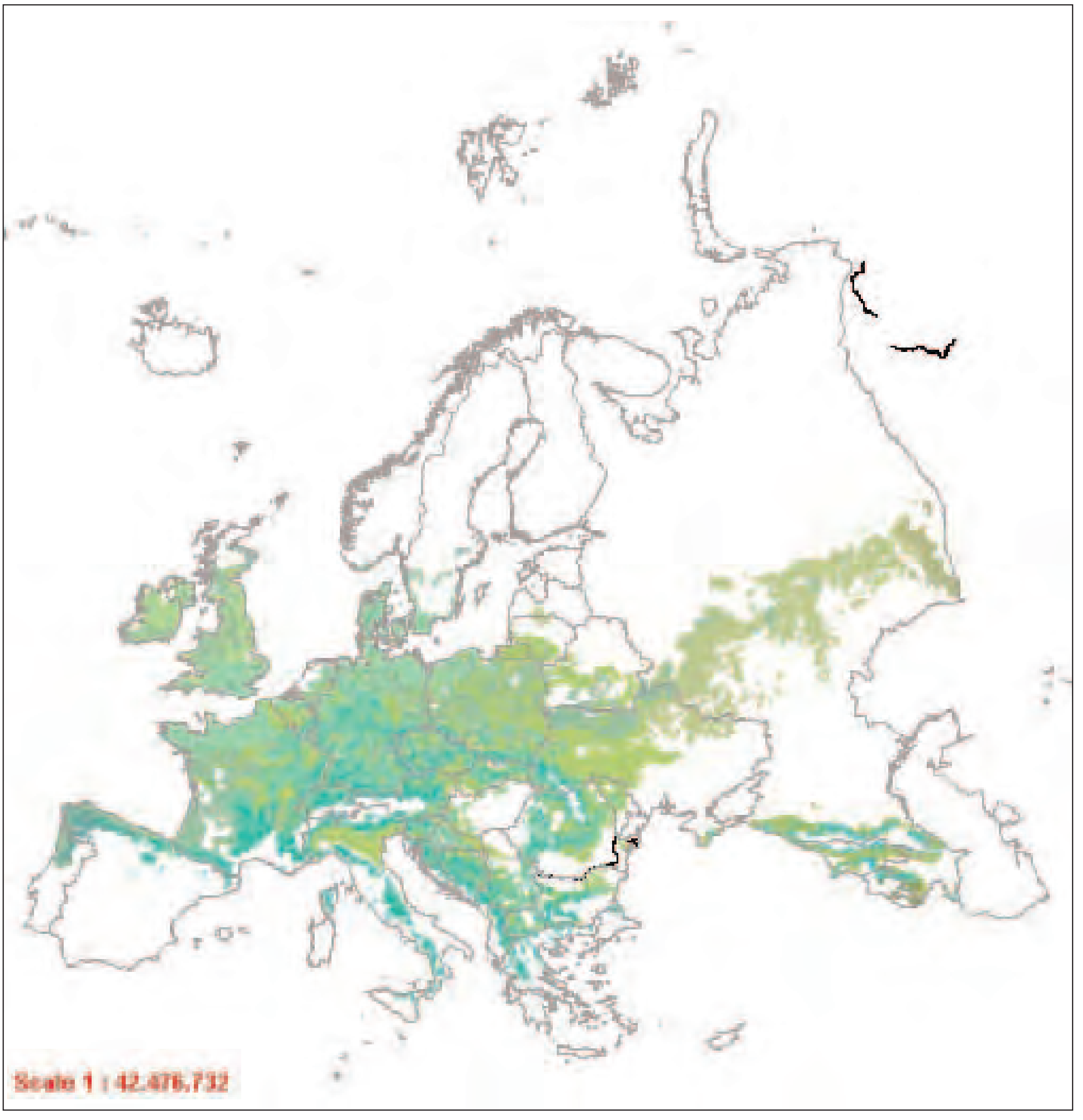
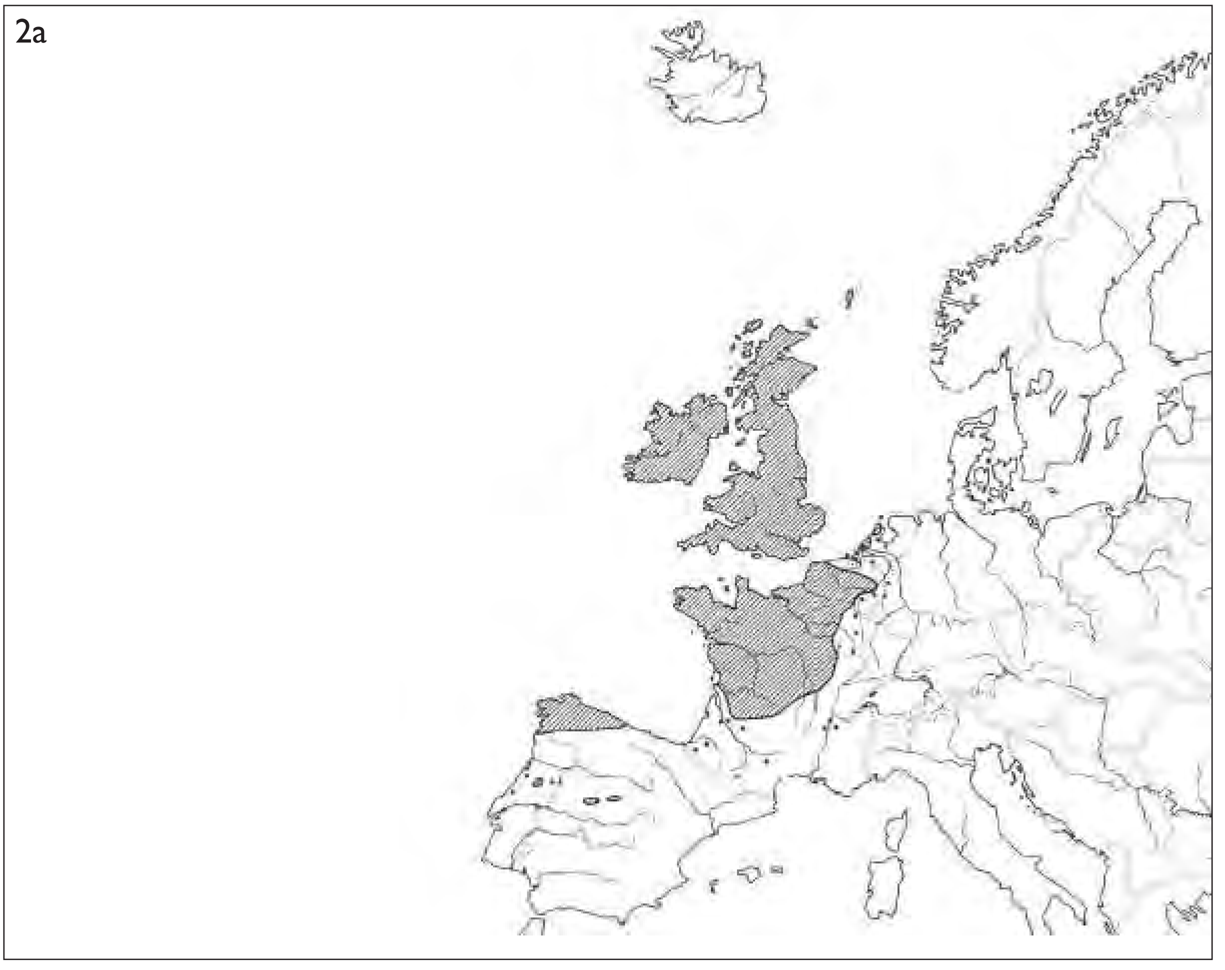


Figure 1. *Potential distribution of temperate deciduous forest in Europe.*



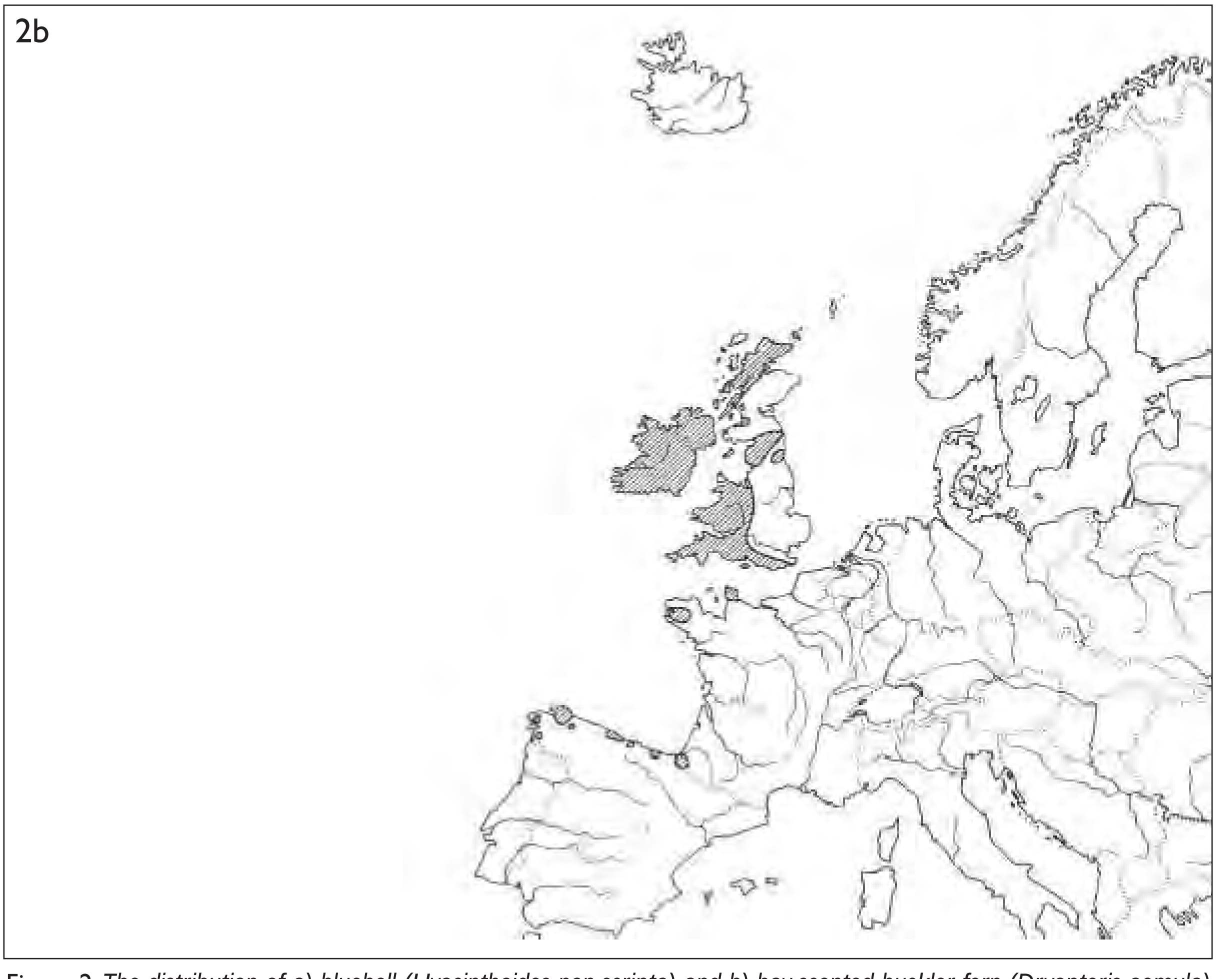


Figure 2. *The distribution of a) bluebell (Hyacinthoides non-scripta) and b) hay-scented buckler fern (Dryopteris aemula) in Europe.*

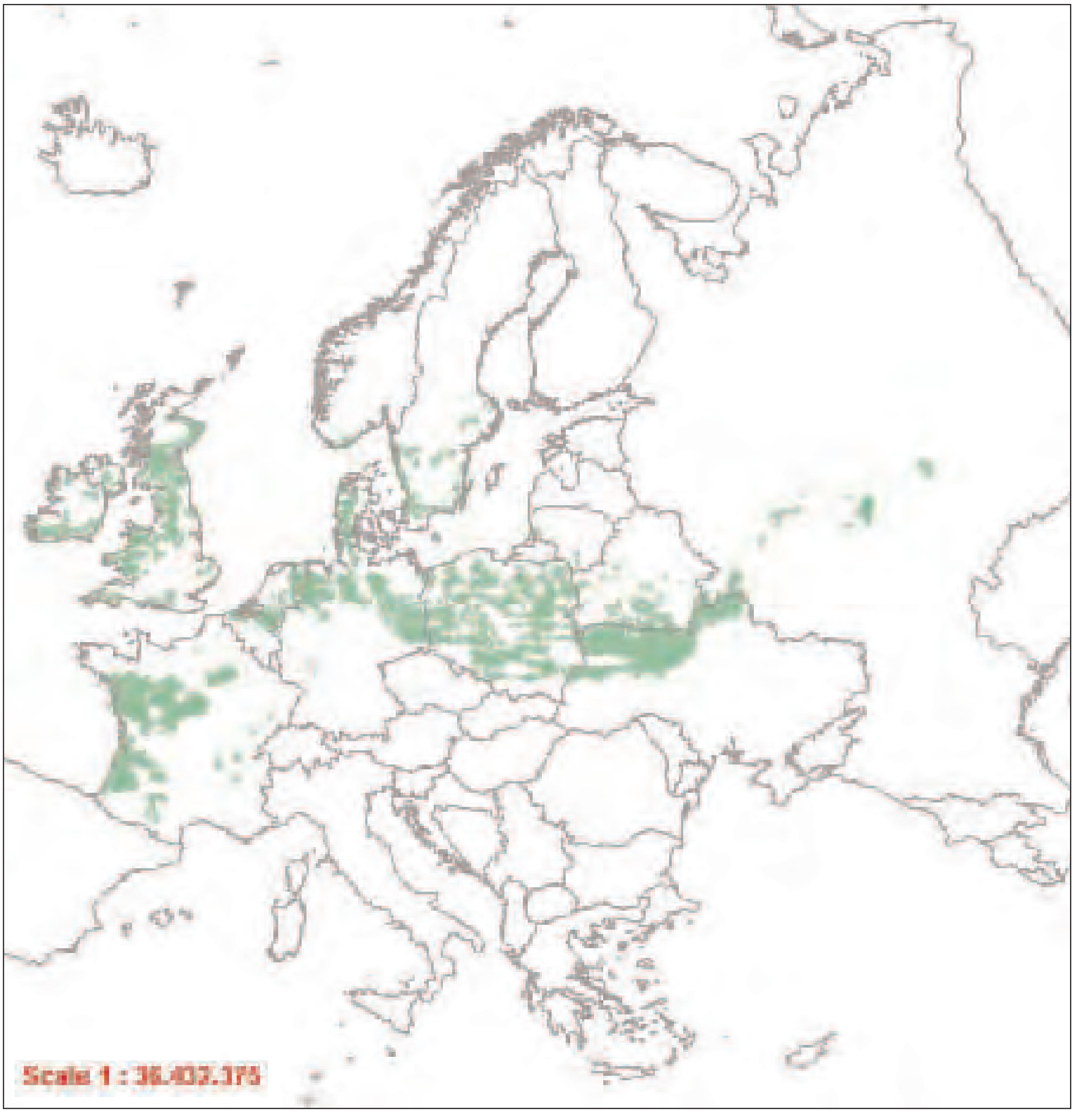
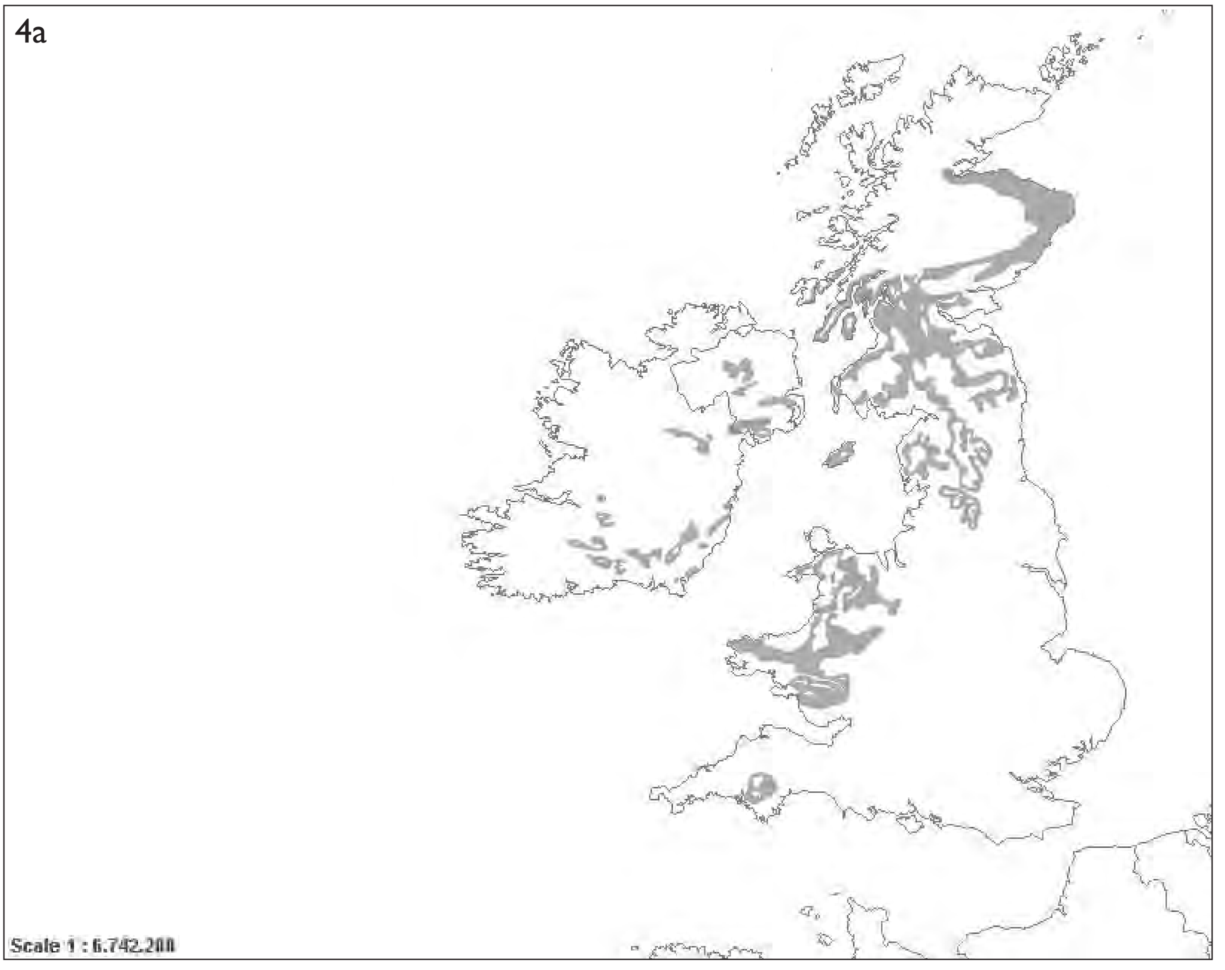


Figure 3. *Potential distribution of acidophilous oak woodland in Europe.*



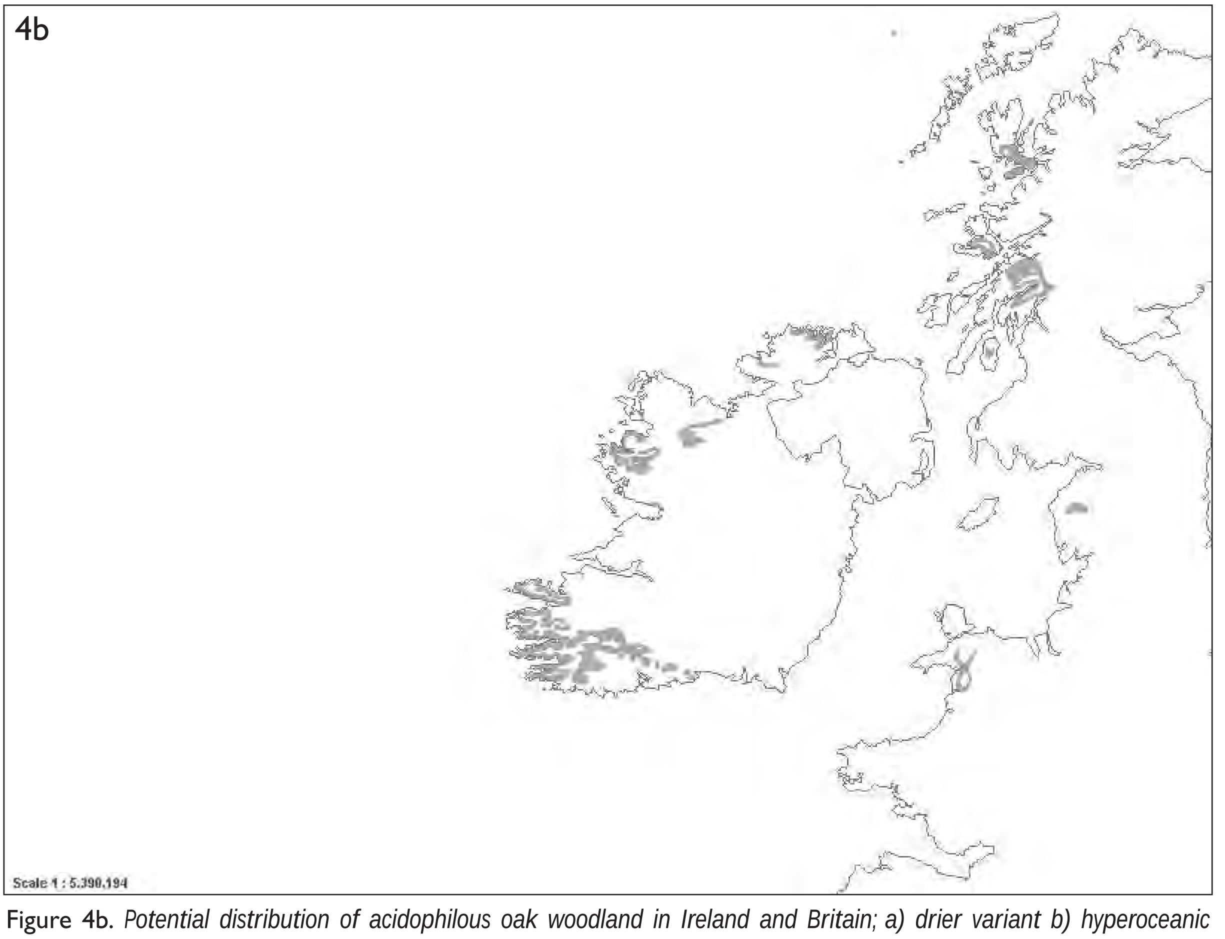


Figure 4b. *Potential distribution of acidophilous oak woodland in Ireland and Britain; a) drier variant b) hyperoceanic variant.*

Figure 5. *Potential distribution of oak-ash forests in Europe.*

Figure 6. *Potential distribution of oak woodlands with bluebell.*

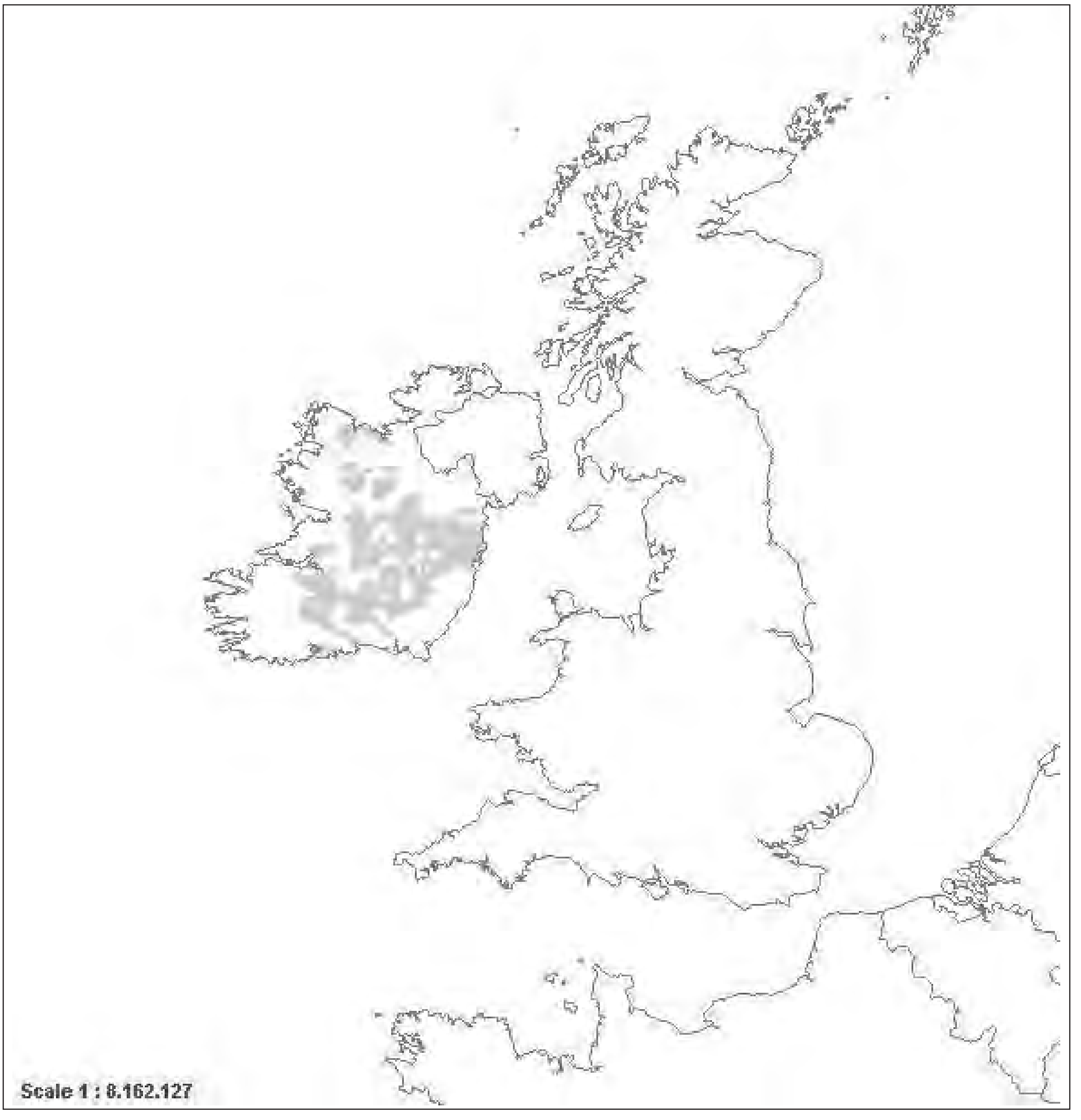
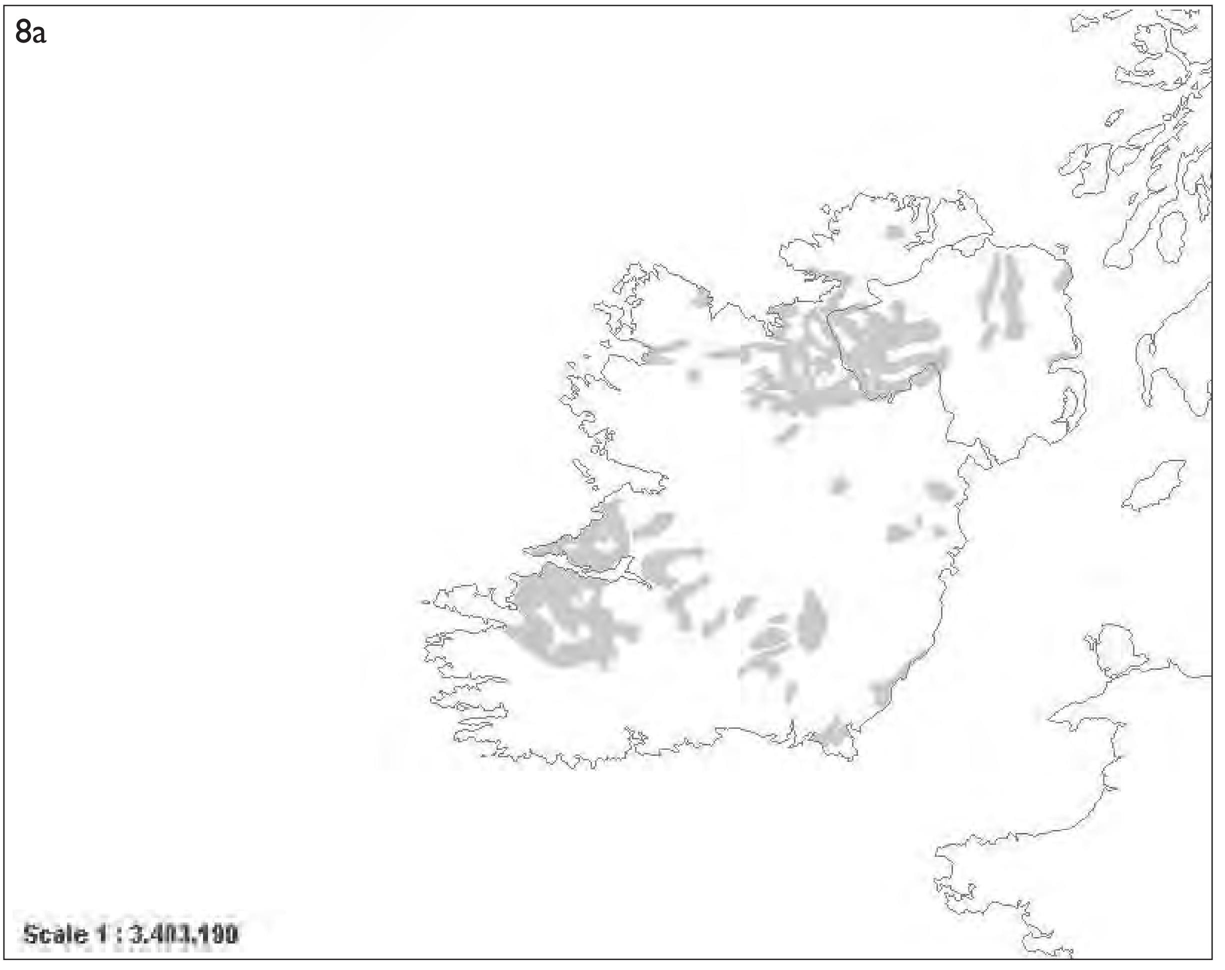


Figure 7. *Potential distribution of oak-ash-hazel woodlands in Ireland.*



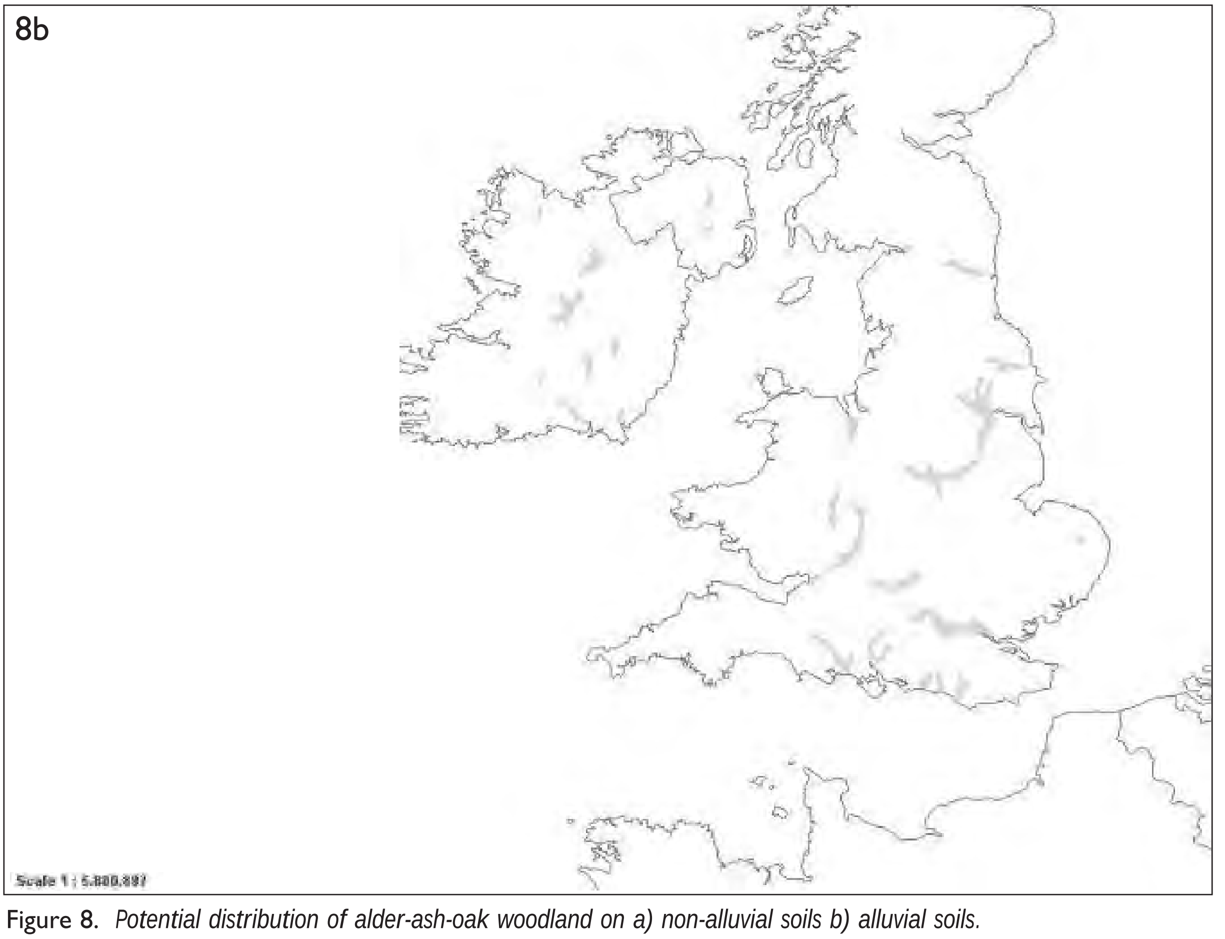


Figure 8. *Potential distribution of alder-ash-oak woodland on a) non-alluvial soils b) alluvial soils.*

Acknowledgements

I would like to thank Dr. Daniel Kelly for his helpful and constructive comments on the first draft of this manuscript.

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IRISH NATIVE WOODLAND PLANT COMMUNITIES

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KEYWORDS: semi-natural woodland, phytosociology, wetland woods, threatened plants, extinction

Abstract

The flora of Irish native woodlands is poor in flowering plant species by European standards, but rich in bryophytes.

Plant communities are difficult to define and classify, and there has been a lack of consensus concerning both methodology and nomenclature. I present an overview of Irish native woodland communities, bringing together the main systems currently in use. These woodlands show two principal gradients of variation: from strongly acid soils to base-rich soils, and from well-drained sites to sites prone to waterlogging and even flooding. The salient features of each community are briefly outlined. Four are priority type habitats under European legislation; a fifth, the *Alnus glutinosa-Carex paniculata* community, is known from only two or three sites and also deserves special recognition.

The shrinkage and fragmentation of the area of native woodland has apparently led to the loss of some species and the future of others is in the balance. The threats to our woodland communities are briefly outlined.

The woodland flora

The Irish woodland flora is poor in flowering plant species compared to Continental or even British woodlands. At canopy level, we have no native species of beech *(Fagus)*, lime *(Tilia)*, maple *(Acer)* or hornbeam *(Carpinus)*. The impoverishment is equally striking in the shrub and field layers (Webb, 1952).

Our woodland flora does contain elements that would not be predicted by a simple model of floristic attenuation. Irish whitebeam *(Sorbus hibernica)*[1] retains its status as our only endemic tree, though the distinctions between it and its relatives are by no means obvious. The Mediterranean-Atlantic element (Preston & Hill, 1997) includes several species which find in Ireland the northern limit of their world distribution. Strawberry tree *(Arbutus unedo)* is a highly distinctive plant that attracted the comment of English newcomers in the 16th century (Watts, 1984). The species has a strongly disjunct distribution, its headquarters being in the Mediterranean region. Its Irish distribution has apparently contracted over the centuries (Mitchell, F.J.G 1993) but it is still plentiful around the Lakes of Killarney. Irish spurge (*Euphorbia hyberna)*, classified in the Suboceanic Southern-Temperate element, is plentiful in woodland glades in Cos. Kerry & Cork; it is also found in the south-west of England but only at a handful of sites (Preston & Hill, 1997; Preston *et al.*, 2002).

The Oceanic (or Atlantic) category consists of species that are more or less restricted to the western fringes of Europe (Preston & Hill, 1997), i.e. to a belt characterised by mild winters, cool summers and ample rainfall at all seasons. Many species in this category are characteristic of humid and shaded microclimates. Oceanic species are well represented in the Irish woodland flora, especially in the west. Several woodland ferns are strongly oceanic, notably hay-scented buckler fern (*Dryopteris aemula)* and the three filmy ferns (Tunbridge filmy fern (*Hymenophyllum tunbrigense)*, Wilson's filmy fern (*Hymenophyllum wilsonii)* and Killarney fern (*Trichomanes speciosum)).* The distribution of Wilson's filmy fern in Ireland corresponds nicely to the regions where the mean number of rain days per annum exceeds 200 (Preston *et al*., 2002; Haughton *et al.,* 1979). The

[1] Nomenclature follows Stace (1997) for vascular plants, Smith (2004a) for mosses and Paton (1999) for liverworts.

Oceanic category also includes substantial numbers of moss, liverwort and lichen species (cf. Ratcliffe, 1968). Several Oceanic species find in Ireland their European headquarters, *e.g.* Killarney fern and the moss *Daltonia splachnoides.* Farther afield, the same or related species are often found in the montane rain forests of tropical regions. An instructive case is that of a liverwort that was described from a specimen from Torc Waterfall near Killarney, under the name *Plagiochila killarniensis.* Until recently, this was considered to be a species of the Atlantic fringes of Europe, extending from Sutherland south to Madeira and the Azores. However, comparative studies have found that our taxon is indistinguishable from a previously-described species, *Plagiochila bifaria* (Sw.) Lindenb., that is widespread in the New World Tropics (Heinrichs *et al.,* 1998). These authors conclude that *"P. killarniensis"* is merely a temperate-zone extension of the range of *P. bifaria.* Its spores were presumably carried across the Atlantic on the prevailing south-westerly air flow.

Our bryophyte flora deserves celebration. To quote a recent review, "Ireland has one of the richest bryofloras in Europe and a wealth of Atlantic bryophytes that is shared only with western Scotland. It is no exaggeration to claim that Ireland's bryophytes are among the most important elements of the island's flora, since about 51% of European liverworts occur (compared to less than 10% of European flowering plants) and the moss flora is almost as rich" (Holyoak, 2003). These are good reasons for bryophytes to be important to Irish ecologists and environmentalists. Additional reasons are that they tend to occupy relatively clearly-defined ecological niches – and can be identified at any time of year!

The woodland community

A biological **community** may be defined as "any grouping of populations of different organisms found living together in a particular environment" (Allaby, 1998). The assemblage of plant species that one finds at a particular location constitutes a single **stand** of vegetation. By considering together similar stands from a range of locations we build up a generalised picture of the community. Some species will occur across a range of communities; others will be more restricted ecologically and may be more or less diagnostic for a particular community. However, a species is seldom strictly confined to a single community, so identification of a community should always be based on a combination of species, not just a single one.

Why do we need to classify and name plant communities? As David Webb (1954) commented, "One cannot think coherently about a large number of objects without classifying them mentally". We need to classify Irish woodlands into categories in order to assess the range of diversity present; to assess the degree to which Irish woods differ from those of other regions; to determine the distribution and frequency of different woodland types; and to develop management strategies appropriate to different woodland types.

One might think that the poverty of the Irish flora would simplify the task of classifying the vegetation, but that is questionable. We lack many ecological specialists – species that are more or less restricted to a particular community, and hence constitute good diagnostic species. Conversely, some species occupy a broader niche in Ireland than they do elsewhere; they show 'unusually wide ecological and synecological amplitudes' (Mooney & O'Connell, 1990), i.e. they are found across a broad spectrum of communities. The result is that the distinction between one community and the next may be more blurred than in other regions.

There is currently a lack of consensus on the nomenclature to use in describing Irish plant communities. Use of the phytosociological system of Braun-Blanquet was pioneered in Ireland by Braun-Blanquet & Tüxen (1952); an outline of the system, together with a conspectus of Irish plant communities, is presented by White & Doyle (1982). The basic unit of vegetation in this system is the **association**, a "plant community, of a definite floristic composition, distinguished by the presence of a certain characteristic combination of species".
A simpler, habitat-based classification of vegetation is presented in the Heritage Council's 'A guide to habitats in Ireland' (Fossitt, 2000). The 'Native Woodland Manual' (Forest Service 2002, unpublished) is based on Fossitt's system but subdivides some of her categories. Recent accounts of the potential natural vegetation of Ireland (Cross, 1998 & this volume) and of Europe (Bohn *et al.,* 2004) describe and map a range of forest types that show varying degrees of correspondence to the communities described below. In this review, I present these systems alongside one another, as far as possible (Table 1). The British National Vegetation Classification (Rodwell, 1991), based on data from Great Britain and the Isle of Man, is also highly relevant to Irish vegetation studies.

Irish woodland communities: A brief review

Irish woodlands are distributed across two principal environmental gradients. The first is a gradient in soil pH and fertility levels, from strongly acid and base-poor to base- and nutrient-rich soils. The second is a gradient in soil moisture, from well-drained sites to sites subject to waterlogging or even flooding. Native woodland survives mainly at the ecological extremes: on infertile, acid podsols, on rocky limestone outcrops or in swampy hollows.

Acidophilous woodlands

Probably the most extensive category of native woodland is the Blechno-Quercetum association (Braun-Blanquet & Tüxen, 1952; Kelly & Moore, 1975), which equates with Oak-holly-birch woodland, habitat code WN1 of Fossitt (2000). These are woods of acid soils over siliceous rocks such as Old Red Sandstone or granite. There is usually a deciduous canopy dominated by sessile oak *(Quercus petraea)* and a shiny evergreen understorey of holly *(Ilex aquifolium)*. Diagnostic species in the field layer include frochan *(Vaccinium myrtillus),* hard fern *(Blechnum spicant)* and great woodrush *(Luzula sylvatica).*

The Blechno-Quercetum scapanietosum (Moss- and lichen-rich oak woodland) is a subdivision distinguished by its rich cryptogamic flora. Boulders and tree trunks are swathed in a luxuriant growth of mosses, liverworts and filmy ferns *Hymenophyllum* spp. Most of the diagnostic species belong to the Oceanic element in the flora. This community is found mainly in the west and clearly develops in response to year-round high rainfall and high humidity. In parts of Ireland with similar substrata but lower rainfall, a relatively drab counterpart develops, distinguished as the Blechno-Quercetum typicum (Species-poor oak woodland on drier sites). This lacks the Oceanic diagnostic species of the preceding community. Wavy hair-grass *(Deschampsia flexuosa)* is often abundant.

A third subdivision, the Blechno-Quercetum coryletosum (Oak woodland with hazel and ash) is distinguished by the presence of hazel *(Corylus avellana)* in the understorey and by a richer herb flora, with species such as wood sanicle *(Sanicula europaea)* and wood sedge *(Carex sylvatica).* Where grazing levels permit, a lush growth of ferns develops, commonly including scaly male fern *(Dryopteris affinis)*. This is normally a community of somewhat better soils. As its name suggests, this represents a transition between the Blechno-Quercetum and Corylo-Fraxinetum associations; it may be very rich in species, especially in higher-rainfall areas (cf. Kelly & Moore, 1975; Coroi *et al.* 2004). A species-poor variant was recorded on strongly acid soil in the dry and sunny south-east (Poole *et al.,* 2003).

Woodlands of base-rich soil

Native woodlands on base-rich soils tend to be less evergreen and more flowery. Most can be classified within the Corylo-Fraxinetum association (Braun-Blanquet & Tüxen, 1952; Kelly & Kirby, 1982), which largely corresponds to the Oak-ash-hazel woodland (WN2) of Fossitt (2000). There is commonly a canopy dominated by ash *(Fraxinus excelsior)* and/or pedunculate oak *(Quercus robur)* and an understorey dominated by hazel. Alternatively, hazel may be the dominant species, forming scrub with or without a scattering of larger trees. Well-developed ashwood is rare in Ireland; a fine example is found on the scree slopes below the limestone escarpment of Hanging Rock, near Belcoo, Co. Fermanagh. The field layer in the Corylo-Fraxinetum is commonly rich in broadleaved herbs. Most of these flower in spring or early summer, availing of that 'window of opportunity' before the expanding canopy foliage cuts off most of the light. The **geophyte** life form is characteristic: plants with bulbs, tubers or rhizomes that release their pent-up energy into a burst of spring growth, followed by early senescence and decay (*e.g.* pignut *(Conopodium majus),* bluebell *(Hyacinthoides non-scripta))*.

The Corylo-Fraxinetum is a broad grouping which has proved difficult to subdivide satisfactorily (cf. Kelly & Kirby, 1982; Cross, 1992; Coroi *et al.,* 2004). One variant, the Corylo-Fraxinetum veronicetosum, occurs on moist, somewhat leached soils and is distinguished by the presence of a combination of wood speedwell *(Veronica montana)*, bluebell, golden saxifrage *(Chrysosplenium oppositifolium)* and/or lady fern *(Athyrium filix-femina)*. Woodland on deep, well-drained, base-rich soils tends to be fragmentary or heavily managed, or both. The few examples studied appear to lack distinctive species; they are classified as Corylo-Fraxinetum typicum.

At the far extreme of the pH spectrum, the Corylo-Fraxinetum neckeretosum (Oak-ash-hazel woodland on shallow, often rocky soils over limestone) is distinguished by the abundance of bryophytes, including calcicolous species such as *Tortella tortuosa, Fissidens dubius* and *Neckera crispa.* The ash-hazel woods of the Burren belong here; the characteristic mosses are also found on open limestone pavement.

Limestone pavement is also the habitat for native yew woodland (WN3), a priority type habitat under European Union legislation (Fossitt, 2000). The only extensive yew-wood in Ireland today is Reenadinna Wood in Killarney National Park (Kelly, 1981; Mitchell, 1990a; Perrin, 2002). Small stands of yew occur by Lough Derg and elsewhere. The flora of yew woodland is similar to that of Burren-type hazel woods but generally with a sparser field layer. The limestone rock is generally concealed under a blanket of mosses. *(Taxus baccata* woodland is also recognised as a distinct category, W13, in the British National Vegetation Classification; however, this comprises the yew woods on the chalk of south-east England, which differ sharply in having an extremely poor bryophyte flora as well as a depauperate field layer (Rodwell, 1991)). The pollen record shows that yew woodland was formerly more widespread in Ireland (cf. O'Connell, this volume). The Burren appears to have supported 'considerable stands of yew-woodland' between 5000-2000 years ago (Watts, 1983); the species survives there today only as scattered individuals, clinging to cliff faces or stunted by browsing.

Wetland woods

Irish wetland woods are more diverse and in general more natural than woodlands on well-drained soils; they also contain a higher proportion of 'priority type habitats'. In our attempts at classifying them, a first division is between oligotrophic sites on acid peat (usually dominated by downy birch *(Betula pubescens))*, and mesotrophic to eutrophic sites (Kelly & Iremonger, 1997; Cross & Kelly, 2003). The mesotrophic-to-eutrophic group is further divided between sites that are liable to flooding for considerable periods, at least in winter, and sites that are subject to waterlogging but not to prolonged flooding. The Osmundo-Salicetum association (Braun-Blanquet & Tüxen, 1952) (Willow-alder carr on fen peat, WN6 subcategory 1), is a widespread community of sites prone to flooding, such as around many of our lakes. The Braun-Blanquet name is less than ideal, as royal fern *(Osmunda regalis)* is only occasional in this community; in Ireland it is much commoner in open habitats. Purple loosestrife *(Lythrum salicaria)* and the mosses *Climacium dendroides*, *Calliergon cordifolium* and *Homalia trichomanoides* are better diagnostic species.

River valleys may include a diversity of hydrological regimes at different levels and different distances from the river channel (or channels), and hence may include a diversity of woodland types (Kelly & Iremonger, 1997; Coroi *et al.*, 2004). In the Salicetum albae (Willow woodland alongside river channels (riparian woodland), WN5), the moving flood-waters have a marked fertilising effect, producing a rank field layer with nutrient-demanding species such as hemlock water dropwort *(Oenanthe crocata)*, cleavers *(Galium aparine)* and stinging nettle *(Urtica dioica)*. (This community was erroneously labelled as 'Salicetum albo-fragilis' by Kelly & Iremonger, 1997).

'Alluvial forests with *Alnus glutinosa* and *Fraxinus excelsior* (Alno-Padion, Alnion incanae, Salicion albae)' are listed as an EU priority type habitat (Fossitt, 2000). The best surviving fragments of comparable old alluvial forest in Ireland are in the Gearagh - a unique area formed by the braided channels of the R. Lee (White, 1985) - and beside the R. Nore in the Abbey Leix demesne, Co. Laois. The prevailing vegetation-type in these fragments is the Corylo-Fraxinetum deschampsietosum (wet pedunculate oak-ash woodland WN4). The most distinctive species are tufted hair-grass *(Deschampsia caespitosa)*, thin-spiked wood sedge *(Carex strigosa)* and water avens *(Geum rivale)*. A similar (but possibly distinct) community is found on the impervious clays of the drumlin belt in Ulster and Connaught.

The Carici remotae-Fraxinetum (Ash-alder-remote sedge woodland, WN6 subcategory 2) is a widespread community of flushed sites subject to waterlogging but not to flooding. The species-rich field layer commonly has a 'grassy' appearance, principally owing to the abundance of remote sedge *(Carex remota)*. A specialised microcommunity of calcareous flushes is distinguished as the Equiseto telmatejae-Fraxinetum (calcareous springs FP1). This is characterised by the apple-green pleurocarpous moss *Palustriella commutata* (syn. *Cratoneuron commutatum)*, often associated with great horsetail *(Equisetum telmateia).* These flushes are lime-saturated, and both substrate and mosses are commonly encrusted with white deposits of calcium carbonate. Such 'petrifying springs with tufa formation' are another priority type habitat (Fossitt, 2000).

The *Alnus glutinosa-Carex paniculata* community (alder carr with tussock sedge WN6 subcategory 3) is characterised by huge tussocks and treacherous pools. It develops in peaty mires that are fed by calcareous springs, and corresponds ecologically and floristically to the **swamp carr** of East Anglia. This community is known from only two or three sites in Ireland (Kelly & Iremonger, 1997), and deserves special recognition. The best-developed stand is in Cloghereen Pool Wood in Killarney National Park; it is threatened by *Rhododendron ponticum* invasion.

Woodlands on acid peat vary according to the degree of drainage. The Vaccinio uliginosi-Betuletum (Dry birch woodland WN7, subcategory 1) develops where the upper layers are well drained, usually as a result of artificial lowering of the water table associated with peat-cutting. Downy birch is an active colonist in such habitats; this type of woodland is steadily expanding, as increasing areas of bogland are cut away and then more or less left to Nature. This is, in general, a species-poor community, lacking in distinctive elements. The field layer is commonly dominated by brambles *(Rubus fruticosus* agg.) The topography is often irregular, with old peat cuttings and drains concealed in the undergrowth. (The community name is potentially confusing as bog bilberry *(Vaccinium uliginosum)* is absent from the Irish flora; the community was placed under the older name Betuletum pubescentis in Kelly & Iremonger (1997)).

The *Sphagnum palustre-Betula pubescens* community (Wet birch woodland with *Sphagnum* WN7, subcategory 2) occurs on acid peat in waterlogged hollows. Sally *(Salix cinerea)* is common as well as birch. The woodland floor is dominated by a carpet of green bog-mosses *Sphagnum* spp., mainly *S. palustre* and *S. recurvum* agg. Other characteristic species of this community include star sedge *(Carex echinata)* and that giant among mosses, *Polytrichum commune*.

The last priority type habitat is that of woodland on intact raised bog. The best surviving example is on All Saints' Bog in Co. Offaly (Cross, 1987). The dome of this bog appears to be flushed by upwelling water and supports some 20 ha of birch woodland. The woodland floor is composed of an undulating carpet of *Sphagnum* spp. The field layer includes bogland species such as crowberry *(Empetrum nigrum),* hare's-tail cottongrass *(Eriophorum vaginatum)* and cranberry *(Vaccinium oxycoccus).* This community is provisionally placed in the Salicetum auritae association (Wet birch woodland with *Sphagnum* WN7 subcategory 3).

Forest shrinkage and species survival

The area of native woodland in Ireland has shrunk to a mere vestige in the course of the past two millennia. Changes to the woodland composition have been qualitative as well as quantitative. How many woodland species have already been lost? And how many have dwindled past the point of no return?

One major loss is beyond dispute. We had extensive forests of Scots pine *Pinus sylvestris,* and they disappeared. (We do not know when or how). We know very little about the flora associated with the Irish pine forests, but we may surmise a resemblance to the present-day semi-natural pine forests of Scotland and Continental Europe. Species particularly associated with semi-natural pine forest in Scotland include a number of mycorrhizal herbs. These include two orchids (creeping lady's-tresses *(Goodyera repens)* and lesser twayblade *(Listera cordata)* – both widespread) and several Pyrolaceae: common wintergreen *(Pyrola minor),* intermediate wintergreen *(P. media),* round-leaved wintergreen *(P. rotundifolia),* one-flowered wintergreen *(Moneses uniflora)* and serrated wintergreen *(Orthilia secunda)* (Rodwell, 1991; Kelly & Connolly, 2000). Creeping lady's-tresses and one-flowered wintergreen are unknown in Ireland; the other species mentioned are scarce to rare here (cf. Table 2), and are not found mainly in woodland. Interestingly, round-leaved wintergreen occurs in a pine-dominated plantation in Co. Wexford (J. Cross, pers. comm.). One of the most characteristic species of Scottish pinewoods is the plume moss *Ptilium crista-castrensis;* this species was not known from Ireland until 1987, when it was found in a corrie on Mweelrea, Co. Mayo (Blockeel, 1988); it should be looked out for in acid woodland habitats.

Assessment of the status of rare species is bedevilled by the deficiencies of biological recording in Ireland, especially in the Republic. However, the New Atlas (Preston *et al.*, 2002) gave a fillip to the recording of rare species, and I believe the data in Table 2 provide a fair approximation to reality. It is clear that woodland species have continued to go extinct on this island in recent centuries. It is also clear that a substantial number of surviving woodland specialists have declined steeply and that the viability of surviving populations is in question. Four of these (narrow-leaved helleborine *(Cephalanthera ensifolia),* yellow bird's-nest *(Monotropa hypopitys),* common wintergreen and intermediate wintergreen) were included in the shortlists of species considered characteristic of 'old woods'/'old forest' by Henry (1914) and Praeger (1934). The woods that now belong to Killarney National Park – the most extensive and diverse area of native woodland in the island – formerly supported both narrow-leaved helleborine (last recorded at Derrycunihy in 1902) and yellow bird's-nest (last recorded at Muckross in 1896) (Scully, 1916). The former species has been sought assiduously in its old Killarney sites but not re-found (Hodd, 1999). Of the sole Irish site for starved wood sedge *(Carex depauperata),* in Co. Cork, a report for 1996 recorded that "the 20 tussocks seen here in August 1989 had now dwindled to just seven plants, of which only four produced fruiting culms" (O'Mahony, 1997). Four of the species in Table 2 are currently protected in the Republic of Ireland under the Wildlife Act of 1976 (Curtis, 2000). Seven are legally protected in Northern Ireland; however, one of these is clearly extinct and another appears not to have been seen in the past 18 years.

Reasons for the decline in our woodland flora are not hard to find. The small area and fragmented distribution of native woodland in recent centuries will have created difficulties for many species. Woodland specialists tend to have limited powers of dispersal, and are slow to regain lost territory. A recent study on nettle-leaved bellflower *(Campanula trachelium)* in Ireland has demonstrated reduced genetic diversity and lower reproductive success in very small populations (Smith, 2004b). Climate change may accentuate difficulties in dispersal and establishment, especially of drought-intolerant Oceanic species.

Many wetland woods have been affected by drainage and peat-cutting. For instance, All Saints' Bog, with its unique bog woodland, has been the site of large-scale moss peat extraction in recent years by Erin Horticulture Ltd. The company is now relocating operations to an alternative site, under a compensation package recently worked out with the National Parks & Wildlife Service (Hurley, 2004). Major effort and resources will be required to restore the damaged areas and to save this bog's unique features.

Felling of broadleaved high forest was widespread as recently as the 1960s. Native woodland communities have also been suppressed through underplanting with conifers or beech *(Fagus sylvatica)*. They continue to be suppressed through invasion by alien species, chiefly *Rhododendron ponticum,* which continues to expand unchecked in many parts of the island. Other invasive species that are having major impacts locally include cherry-laurel *(Prunus laurocerasus)*, red-osier dogwood *(Cornus sericea),* beech and sycamore *(Acer pseudoplatanus)*. Heath fires nibble the edges of upland woods, as happened in Killarney National Park in the great fire of 1984. (Strawberry tree, however, may have been favoured by fire, in the past at least (Rackham, this volume)). Many woods have been subjected in recent decades to unsustainable levels of grazing, as a result of headage payments for sheep (Mitchell, G.F. 1993) and/or laissez-faire attitudes to the expanding populations of feral deer and goats. Overgrazing affects woodland plant communities through the elimination of vulnerable species from the field layer, and the expansion of tolerant species (cf. Mitchell, 1990b; Kelly, 2000). In the longer term, the elimination of tree saplings over extended periods threatens the survival of many woods, including some that are both legally 'protected' and of recognised international importance.

Table 1: *A conspectus of Irish native woodland communities*

Phytosociological system of Braun-Blanquet	Fossitt (2000) habitat classification	Bohn *et al*. (2004) Map of the Natural Vegetation of Europe (Titles of map units condensed)
Acidophilous woodlands		
Blechno-Quercetum Blechno-Quercetum scapanietosum	WN1 Oak-birch-holly woodland WN1 Oak-birch-holly woodland	F1 West Irish-west British hyperoceanic, moss- and lichen-rich sessile oak forests
Blechno-Quercetum typicum	WN1 Oak-birch-holly woodland	F2 East Irish-British oak forests, mostly with downy birch & holly
Blechno-Quercetum coryletosum	(WN1-WN2 intermediate)	F32 Irish-British-Norman mixed pedunculate ash-oak forests with bluebell
Woodlands of base-rich soil		
Corylo-Fraxinetum Corylo-Fraxinetum veronicetosum	WN2 Oak-ash-hazel woodland WN2 Oak-ash-hazel woodland	F28 Irish pedunculate oak-ash forests on rich basiphilous soils
Corylo-Fraxinetum typicum	WN2 Oak-ash-hazel woodland	F28 Irish pedunculate oak-ash forests on rich basiphilous soils
Corylo-Fraxinetum neckeretosum	WN2 Oak-ash-hazel woodland	F29 Irish-English hazel-ash forests on shallow calcareous soils
Corylo-Fraxinetum neckeretosum *Taxus facies*	WN3 Yew woodland	F29 Irish-English hazel-ash forests on shallow calcareous soils (local variant)
Wetland woods		
Corylo-Fraxinetum deschampsietosum	WN4 Wet pedunculate oak-ash woodland	U23 Irish-British pedunculate oak-alder-ash forests with sally
Salicetum albae	WN5 Riparian woodland	U7 Irish-British hardwood alluvial forests in combination with willow alluvial forests
Carici remotae-Fraxinetum	N6 Wet willow-alder-ash woodland	U23 Irish-British pedunculate oak-alder-ash forests with sally
Osmundo-Salicetum	WN6 Wet willow-alder-ash woodland	-
Alnus glutinosa-Carex paniculata community *	WN6 Wet willow-alder-ash woodland	T1 Alder carrs, partly with downy birch, sally, bay-leaved willow, Norway spruce
Equiseto telmatejae-Fraxinetum	FP1 Calcareous springs	-
Vaccinio uliginosi-Betuletum	WN7 Bog woodland	T4 Birch carrs, partly with Scots pine
Sphagnum palustre-Betula pubescens community **	WN7 Bog woodland	
Salicetum auritae	WN7 Bog woodland	
* Rodwell (1991) ** Birse (1982)		

Table 2. *Very rare and extinct species in the vascular plant flora of Irish woodlands*

Numbers are counts of 10km x 10 km Irish grid squares in which a species has been recorded as native.
NI = Northern Ireland, RI = Republic of Ireland.
Sources: Curtis 2000, Curtis & McGough 1988, Hackney 1992, Preston *et al*. 2002.

Scientific name	English name	Last recorded before 1970	Last recorded between 1970-86	Recorded since 1986	Legally protected?
1 Extinct prior to the 20th century					
Pinus sylvestris	Scots Pine	0	0	0	-
Carex buxbaumii (1)	Club Sedge	1	0	0	-
2. Became extinct during the 20th century					
Hordelymus europaeus (2)	Wood Barley	1	0	0	NI, since 1985
3. Very rare species					
Gymnocarpium dryopteris (3)	Oak Fern	8	2	0	NI, since 1985
Adoxa moschatellina (4)	Moschatel	1	0	1	NI, since 1985
Cardamine impatiens	Narrow-leaved Bittercress	0	0	1	RI, since 1980
Carex depauperata	Starved Wood Sedge	0	0	1	RI, since 1980
Geranium sylvaticum	Wood Cranesbill	2	0	2	NI, since 1985
Orthilia secunda (5)	Serrated Wintergreen	4	1	2	NI, since 1985
Melampyrum sylvaticum	Small Cow-wheat	14	3	3	NI, since 1985
Hypericum hirsutum	Hairy St. John's Wort	5	0	5	RI, since 1980
Cephalanthera longifolia	Narrow-leaved Helleborine	21	3	7	RI, since 1999
Monotropa hypopitys	Yellow Bird's-nest	13	3	8	NI, since 1985
Campanula trachelium	Nettle-leaved Bellflower	6	1	10	RI, 1980-2000
Pyrola media	Intermediate Wintergreen	28	6	13	no
Pyrola minor	Common Wintergreen	30	6	14	no

Notes
1. Last recorded in 1886 (Hackney 1992)
2. Last recorded in 1949 (Hackney 1992, Preston *et al*. 2002)
3. Last recorded in 1986 (Hackney 1992) - perhaps extinct
4. Possibly introduced (Hackney 1992)
5. In Ireland recorded only in bog and wet heath, but found in woodlands over most of its range.

Acknowledgements

For helpful information and discussion, I thank John Cross, Fraser Mitchell, Paul Hackney, George Smith and Roger Goodwillie.

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FAUNA OF SEMI-NATURAL WOODLANDS IN IRELAND

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KEYWORDS: invertebrates, birds, bats, biodiversity, conservation, microhabitats

Abstract

Throughout the world native woodland habitats generally have a high biological diversity and there is a positive correlation between animal diversity and persistence of the woodland. In Ireland, even though there is almost no primary native woodland and very little planted deciduous woodland of more than 200 years duration, about half of the species of insect, a quarter of species of breeding bird, and almost all species of terrestrial mammal have a preference for woodland habitats. It is in the invertebrates where most woodland biodiversity is to be found; a point of some significance when we consider Ireland's obligations to the Biodiversity Convention. It takes hundreds of years for a deciduous woodland ecosystem to reach its climax state but it may only take a few days to destroy it.

There are few comprehensive studies of invertebrates, or even of birds and mammals done in woodlands in Ireland. Animals are not as obvious as flora, they often require special sampling techniques, and their availability for sampling is frequently seasonal. However, certain animal taxa have been identified as being potentially valuable in studies of woodland ecology and these include snails, hoverflies, butterflies and moths, ground beetles, longhorn beetles and birds. Our understanding of woodland faunas shows that in order to conserve species and maintain biodiversity we must pay attention to the maintenance of micro-habitats such as wet hollows, woodland glades and rides and forest streams. In particular, it is vital to allow trees to become over-mature, die, fall and rot *in situ* in order to provide the habitats required by specialist woodland invertebrates. Measures to conserve the invertebrates will directly and indirectly help birds and mammals, such as the bats.

Natural woodland in Ireland

One of the difficulties in assessing and discussing the fauna of natural woodlands in Ireland is identifying exactly what habitats are being considered. To many naturalists a woodland habitat is typified by a block of trees with a definite outer boundary and a closed canopy with no other habitat of any significance breaking that continuity. This can be described as a closed-canopy woodland. However, in many places woods don't have definite boundaries but thin out at the edges and merge into the adjacent habitat of pasture land, or in Ireland, this may be bog. It is also quite possible that woodland can have clearings of grassland in the middle; or if the grassland is more dominant then one could consider the environment as being of grassland with patches of woodland. These forms of woodland are described as savannah woodland, or wood pastures, and it may well be the case that a landscape with this mosaic of habitats has been the normal type of woodland in Ireland for many hundreds of years. From the view point of the fauna it makes an enormous difference whether a woodland is closed canopy or of the open savannah type. It also makes a huge difference to the apparent area occupied by natural woodlands in Ireland if savannah-type woodland is included in the definition. Old hedgerows comprising native trees and shrubs, are very important habitats for many invertebrates and birds in Ireland and are often regarded as being woodland ecosystems when considering woodland faunas.

Relatively little work has been done on woodland faunas in Ireland and so for the purposes of this contribution, a wide definition of 'native woodland' has been adopted and the use of the term 'semi-natural woodland' would seem more appropriate. This means that the following discussion draws on data from studies of truly ancient or primary natural woodland (>400 years of continuous forest cover) and it also includes data on the fauna of long-standing or secondary native woodland (about 200 years continuous cover); both of these categories of woodland being rare or uncommon in Ireland. With such a paucity of data on woodland faunas, it is useful to also take account of studies where stands of trees that are composed of native species but are of less than 200 years standing were involved. In Fossitt (2000), these woodlands would all be classified as semi-natural woodland but it is not unusual for those studying fauna to widen the definition even further and include long-standing linear woodland such as hedgerows and tree lines in their consideration of native woodland habitats.

Ecological attributes of native woodlands

Woodland habitats are primarily described by botanists who classify them using phytosociological criteria (e.g. Cross this volume, Kelly this volume, Fossitt, 2000). Two major text books that present detailed discussions of woodland ecology (Barnes *et al.,* 1998; Kimmins, 2004) rely heavily on examples from North America and devote a disproportionately small amount of space to the fauna. Work done in other European countries show there is a good understanding of faunas of native woodlands (e.g. Peterken, 1974 & 1981), but as natural woodland in Ireland has historically lacked so many of the native trees found on the European continent (beech, field maple, hornbeam, lime, sweet chestnut, horse chestnut and sycamore) one must be careful when drawing conclusions and making generalisations about the fauna. Important characteristics of woodland that affect woodland faunas include:

- A high structural (physical) diversity (e.g. herb, shrub and canopy layers), which is positively correlated with faunal diversity.
- Woodlands create their own more stable microclimate (less wind, higher humidity, buffered temperatures, less light, lower quantity of rainfall reaching the ground), which positively influences faunal stability.
- A high botanical diversity (including mosses, herbs, lichens and fungi) support a high faunal diversity, and all of this leads to a significantly greater biodiversity (complexity of food webs, of species, of genes). This can be simply summarised by saying that the producers (trees, shrubs, herbs, epiphytes) are only half the ecological story, as the consumers (herbivores, carnivores, decomposers comprising of the fauna, bacteria and fungi) process all of the energy in the forest ecosystem.
- Like all ecosystems, woodlands pass through a recognised succession of changes towards a climax state with a different community of species at each stage. Some ecosystems can almost complete their succession in a matter of years (an organically polluted river can recover in 5-10 years and a seashore can recover from oil pollution and cleaning with detergents in 10-15 years) but forests take hundreds of years to reach a state of climax. Some scientists believe that the forest soil may even take a thousand years to develop its mature fungal flora. In the long-term, climax ecosystems characteristically show diversity, stability, resilience, persistence and sustainability.
- A significant proportion of species found in native woodland are specialists, with long life-cycles, low reproduction rates, small population sizes, poor ability to disperse and colonise new places, and may be prone to extinction. Such species have been termed 'K-selected' species and it is believed that their presence in woodland might be used to indicate continuous forest cover in an area. Such species are known to include mosses, lichens, fungi and invertebrates.

Fauna of native and semi-natural woodland

Ireland has a depauperate flora and fauna due to this island's glacial history and geographical isolation from continental Europe (see Sleeman, Devoy & Woodman, 1986). There is good evidence from cave deposits to suggest that Ireland's woodland fauna was once much more diverse (e.g. Scharff *et al.,* 1903) but that the loss of continuous forest cover as people created pasture woodland and selectively felled particular tree species, led to the demise of many invertebrates, mammals and birds. For example, the loss of Scot's pine (*Pinus sylvestris*) as a native tree, shows how the destruction of woodland may have led to some of Ireland's insect fauna becoming extinct in historical times (Speight, 1985a & b). The loss of great spotted woodpecker, goshawk, capercaillie and red kite and a number of other birds associated with woodland, are also well documented and discussed (e.g. D'Arcy, 1999; Hall, 1981). Spectacular mammals that were largely associated with woodland habitats in Ireland include wolf, brown bear and perhaps the wild boar, but these are all extinct here now. The story of the demise of the wolf has been meticulously pieced together by Fairley (1975). For a more general discussion of woodland decline, see Mitchell (1986) and Cabot (1999).

Even though there are few examples of long-standing woodland in Ireland today, there is still a widely held view that the woodland fauna makes a particularly important contribution to national biodiversity and that the remaining fragments of native woodland are generally rich in animals species (Nairn, 1988; Whelan, 1995). As has already been indicated, woodland studies in Ireland have tended to concentrate on botanical knowledge for purposes of classification and conservation assessment. In Little, 2005 (this volume) Gaughran and McInerney did separate studies on invertebrates. A study of Ballyannan Wood in Co Cork, which is at least 350 years old, recorded 35 species of gastropods and 59 species of hoverflies making it one of the few general studies of ancient woodland that included data on more than one group of animals (Gittings, 2004).

Invertebrate fauna

Studies involving the invertebrate faunas of Irish woodlands tend to be focussed on a specific invertebrate taxon that is found in woodlands as well as other habitats, rather than being a wide-ranging study of the invertebrates in woodland. Thus there is a body of information on woodland snails in Ireland because these animals were surveyed as a part of a project resulting in a distribution atlas (Kerney, 1999). Over the last 30 years a substantial amount of knowledge has been assimilated about hoverflies (Diptera; Syrphidae) some of which are woodland specialists, and this is published in numerous papers by Dr Martin Speight. The gall wasps and several families of minute wasps that are often associated with trees and woody shrubs have been comprehensively studied by Dr Jim O'Connor and Dr Robert Nash and their results published by the Irish Biogeographical Society. Soil faunas, including those of woodland ecosystems have been sampled by Dr Tom Bolger and his co-workers while working on a project concerned with acid rain. Beetles have been sampled from woodlands beside Lough Ree (Good, 2002); and carabid beetles have been used in Northern Ireland to help assess the conservation value of woodland sites (Day *et al.* 1993) and these ground beetles have also been used in oak woodlands by Fahy & Gormally (1998) at Derryclare Wood, Co Galway and Poole *et al.* (2003) at Kilinahue Wood, Co. Wexford.

Several generalisations can be made about the invertebrates of native woodlands.

- This is where most of the biodiversity of woodland is to be found.
- Invertebrates have two primary requirements, namely food and cover.
- Invertebrates of woodlands include many diverse animal groups and within most of the taxa there are specialists confined to woodland habitats.
- There are an estimated 16,000 insect species in Ireland and it is estimated that half of the Irish insect species are dependent on deciduous woodland.
- In Britain it has been observed that some native trees have a far greater diversity of insects than other species of native tree:

Scientific name	**Common name**	**Number of insect species**
Quercus spp.	oaks	284
Salix spp.	willows	266
Betula spp.	birches	229
Crataegus monogyna	hawthorn	149
Prunus spinosa	blackthorn	149
Populus spp.	aspen/poplars	97
Malus sylvatica	crab apple	93
Pinus sylvestris	Scot's pine	91
Alnus glutinosa	alder	90
Ulmus spp.	elms	82
Corylus avelana	hazel	73
Fraxinus excelsior	ash	41
Sorbus aucuparia	rowan	28
Juniperus communis	juniper	20
Ilex aquifolium	holly	07
Taxus baccata	yew	04

Number of insect species found to be associated with native trees in Great Britain (after Rose & Harding 1978).

- Insects are particularly diverse with several groups especially associated with woodland habitats e.g. longhorn beetles, bark beetles, ladybirds, leaf beetles, weevils and true bugs.
- Soil faunas reach their greatest diversity and abundance in undisturbed, uncompacted forest soils with an accumulation of leaf litter e.g. earthworms, snails and slugs, millipedes, centipedes, woodlice, insects, mites, spiders, false scorpions.
- Phytophagous (herbivorous) insects such as butterflies and moths (Insecta; Lepidoptera) feed directly on the trees and shrubs. Studies in Britain have shown that some woody plants are better than others for Lepidoptera (Anon., 1973) :
  - outstanding : oak, birch, goat willow
  - extremely good : hawthorn, blackthorn other willows
  - very good : apple, poplars, elm, alder, hazel, wild roses & brambles
  - good : ash, rowan honeysuckle and gorse
- British data show that tree and shrub species native to an area support a greater diversity and abundance of species than non-native trees. Sometimes introduced trees can be prone to pest outbreaks in which case diversity is low but abundance of a species can be enormous.
- Invertebrates live in microhabitats and the availability of microhabitats determines species diversity e.g. convolutions in tree bark, standing dead wood, rotting dead wood on forest floor, over-mature trees with rot holes where branches have come off, pools left after trees fall, damp or wet hollows, sunny glades and woodland rides, glades where sun reaches rock outcrops in wood, diverse flora with flowers for nectar and pollen, lichen and moss growth on trees and rocks, toadstools.

Several management actions can be undertaken to maximise the diversity and abundance of the invertebrate fauna in native woodland by encouraging a diverse ground flora, by paying attention to the maintenance of micro-habitats, by avoiding the use of insecticides and limiting the entry of heavy machinery that leads to soil compaction.

Invertebrates can be used to assess and monitor the value of management actions for conservation and it has been suggested that taxa such as snails (Mollusca; Gastropoda), hoverflies (Insecta; Diptera; Syrphidae), moths and butterflies (Insecta; Lepidoptera), ground beetles (Insecta; Coleoptera; Carabidae) and longhorn beetles (Insecta; Coleoptera; Cerambycidae) might all be suitable candidates. It is noted that Gittings (2004) used the first two of these groups in his assessment of Ballyannan Wood in Co Cork and that (Day *et al.,* 1993; Fahy & Gormally 1998; Poole *et al.,* 2003) used ground beetles.

Birds

Birds are a highly visible and audible part of woodland ecology that are often at the top of their food chain. One quarter of Irish breeding birds use woodland as their primary habitat choice. Studies on woodland birds in Ireland include an investigation of the bird communities in Killarney (Batten, 1976), breeding bird communities of sessile oak woodland (Wilson, 1977), breeding and wintering bird communities of Glenveagh National Park, Co.Donegal (MacLochlainn, 1984), a study of breeding bird communities of broad-leaved woodland in the Glen of the Downs, Co.Wicklow (Nairn & Farrelly, 1991) and a comparative study of breeding bird populations of oakwoods and conifer plantations (Whelan, 1995). A survey currently underway is studying the breeding birds of Wicklow oakwoods (MacLochlainn, 2004). Several specialist woodland birds that are present throughout most of Europe including Great Britain; such as tawny owl, great spotted woodpecker and nuthatch; are absent from Ireland. On the other hand, studies have found that more generalist species like blue tit and goldcrest, breed at higher densities in Irish woods than in British ones, probably because they are able to occupy a wider ecological niche due to the absence of other species.

The ways in which birds use woodland show a great deal of variability and consequently their requirements of the woodland are also diverse. For example birds,

- may use woodland for breeding (sparrowhawk, stock dove), feeding (treecreeper) or roosting (rook, starling);
- they may be resident all year round (wood pigeon, long-eared owl), summer visitors (blackcap, wood warbler, redstart) or winter visitors (fieldfare, brambling);
- they may use the canopy (tits, jay, crows, sparrowhawk), wood edges and rides (blackcap, finches, spotted flycatcher) or the woodland floor (thrushes, woodcock, robin, wren).

Those that breed in woodland need cover in which to build their nests such as hollow trees, tree holes and ivy, and they may require song posts from which they can declare their territory. For feeding it depends upon whether the species are specialised insect feeders, or may require seeds or berries, or perhaps they are more omnivorous and change their food preferences according to their age or season. It is commonly the case that the young of a number of omnivorous species are more dependent upon insects than are the adults. Some species only use the woodland for roosting but feed in other places such as farmland like the rook and jackdaw. When these birds enter the woodland they seek cover from predators and shelter from wind and rain. Whelan (1995) found that soil fertility, tree species and vegetation structure influence the population density and species diversity within woodland.

To many people the birds are a measure of woodland's value to conservation, and they can certainly be used to monitor the effects of management actions. In order to maximise the diversity and abundance of birds, the food supply can be increased through measures to encourage insects already mentioned and by planting trees and shrubs that produce large amounts of fruit such as the Family Rosaceae or 'mast' from trees like alder, ash and oak. Breeding sites are more available in older trees that support growths of ivy or produce tree holes or become hollow. In the absence of mature trees, provide different types of nest boxes. Most perching birds benefit from an abundance of sheltered sunny edges, rides and clearings around the wood and the availability of song posts. The use of biocides (fungicides, herbicides, insecticides) is detrimental to all life forms, but birds being higher up the food chain are susceptible to the problems caused by bio-magnification. Some species of birds are sensitive to disturbance and need remote areas for their well being.

Mammals

There are very few species of mammals in Ireland with only a very few being woodland specialists i.e. red squirrel, pine marten, long-eared bat. Mammals such as fox, badger, wood mouse, hedgehog, pygmy shrew, deer species and several bats reach their highest densities around the edges of native woodland and in woodland rides and clearings, but are not totally dependent upon these habitats. Whelan (1995) noted that the mammals of Irish woodlands need food, cover and breeding sites. He divided species into those that prefer woodlands (wood mouse, bank vole, red squirrel, grey squirrel, pine marten and deer species) and those that use the woodland for cover and open areas for feeding (pygmy shrew, hedgehog, bat species, Irish hare, badger and fox). Dr Caroline Shiel carried out a detailed study of Leisler's bat, a European rarity, which has highly significant populations in Ireland. She found that this species, favours situations where broadleaved woodland borders on pasture fields for feeding (Shiel *et al.* 1998) and so this species is partially dependent on the presence of semi-natural woodland. Whilst the contents of this paper are mainly concerned with conservation and biodiversity, it has to be noted that some mammals such as deer and grey squirrel, are seen as a threat to woodlands by foresters (e.g. Whelan, 1994; Coad, 1995).

Semi-natural woodland is an important habitat for mammals, and as several species are at the top of the woodland food chain, mammals can be used to monitor the success of conservation measures. Many mammals require invertebrate food so by protecting invertebrates one is also encouraging them. For some species, disturbance by people is an issue, so parts of a wood need to be kept remote and access restricted. Bats require roosting sites and use different sites between summer and winter. Hollow trees are a scarce commodity in younger woodland and in these circumstances bat boxes have proven to provide a good substitute for natural sites.

Conservation & Biodiversity

With so little semi-natural woodland in Ireland, it has been a matter of concern to conservationists for many years that these precious sites are being allowed to deteriorate and be lost to activities such as commercial felling, scrub clearance, under planting with exotic conifer species, and the spread of invasive species like *Rhododendron*, cherry-laurel and red-osier dogwood (e.g. Nairn, 1988; Kelly, 1990). At the same time there is a growing awareness that semi-natural woodlands are biodiverse habitats that need to be monitored and protected. Coillte have been very active in promoting the protection of such sites in their care and their training course manual is a model of an action to raise the knowledge and understanding of conservation measures (Coillte, 2001). There are also many small publications and guidelines that promote biodiversity and include information on how to protect invertebrates, birds and mammals in semi-natural woodlands (for example Saillet (1983), Stubbs (1972), Angelstam (1999), Forest Service (2000), Anon (not dated)).

At the end of the day, it is important to realise that biodiverse, semi-natural woodlands cannot be created over a short time period. The species found in a recently planted wood are mainly common and widespread and only rarely reflect the variety characteristic of ancient woodland sites. It takes hundreds of years for a deciduous woodland ecosystem to reach its climax state but it may only take a few days to destroy it!

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IRISH NATIVE WOODLANDS AND THEIR ASSOCIATED FUNGI AND LICHENS

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Abstract

Irish native woodlands are under-recorded for both fungi and lichens. The relative permanence of lichens, as compared with fungi, has resulted in a more in depth lichen record. Records have been published on a 10km grid basis rather than by particular habitats. As most 10km squares that contain native woodland also contain planted woodland, it is not possible to list taxa of native woodland alone.

Fungi have been mostly recorded from woodlands and the woodlands most frequently recorded were planted in old demesnes. With few exceptions, fungal records have been carried out during one to two day visits, so only the species fruiting at that time were noted. More recent work has shown that such visits see less than one third of the macromycetes species that appear over the autumn/winter period.

About half of Irish native tree species form mycorrhizal associations with macromycetes; the fruit-bodies of these species tend to appear earlier in the autumn than those of true saprophytes. The timing of flushes of both mycorrhizal and saprophytic macromycetes is very weather dependant. The poor distinction (in terms of warmth and wetness) between summer, autumn and winter in Ireland causes great variability in timing of fruiting from year to year.

Oak woodlands of all types form the richest (and most recorded) native habitat for macromycetes in Ireland; willow and birch scrub woodlands may be as rich but have not been recorded to date. Ash woodlands are relatively poor in macromycetes.

Introduction

This review will first describe how fungi and lichens live and the different problems associated with recording lichens and macrofungi in the field. Examples will be taken from Derryclare Wood near Lough Inagh in Co Galway, from the Birch Grove near the summit of Howth, Co Dublin, and from broadleaf woodland in Co Meath. Since many of the macromycetes found in woodland are attached to mycorrhizal mycelia associated with about half of the Irish native tree species, the mycorrhizal status of Irish native woodland trees, where known, is discussed in the context of the comparison of macromycete biodiversity in different native woodland types. Finally recommendations are made about systematic recording in the field, record management and woodland management.

The biology of fungi and lichens in woodland

Fungi

Fungi are mostly microscopic, colourless, heterotrophic organisms, which permeate their substrate (soil, wood, dead or live plant tissues) by means of filamentous hyphae. The hyphae are between 2 and 15mm in diameter and function as feeding, storage and translocating structures. The hyphae of one individual can be interconnected at one central point, or more commonly in a three-dimensional network. In some fungi, hyphae can form parallel aggregates, such as the white mycelial cords which are often seen connecting the reproductive structures in puffballs to the 'feeding' mycelium, or the black invasive rhizomorphs of the honey fungus, *Armillaria mellea.* These rhizomorphs can form a 'super-mycelium' which is very large (4 ha. has been claimed) and very old (10,000 yrs has been claimed). Most fungi are much smaller and have much shorter lives than the statistics for *A.mellea*; some are less than 500mm in width and will live for only a few weeks at normal soil temperatures.

After a period of vegetative growth, the length of which is determined as much by the species of fungus as by its environment, a mycelium goes into reproductive mode. Reproduction is almost universally by spores, which are usually produced on or in structures that are designed to disperse the spores away from the parent. Time-dispersed spores simply persist after their parent mycelium has decayed. Space dispersed spores are most commonly carried passively by moving air, water, or animals, but may display active mechanisms in order to become airborne. A few are motile (in water only).

Microscopic sporing structures take less time and material to organise, than massive fruitbodies, such as the brackets of *Ganoderma applanatum* or the giant puffball (*Calvatia gigantea*) both of which may weigh several kilogrammes and are capable of liberating billions of spores in their lifetime.

All heterotrophs eventually exhaust or destroy their habitat, so it has been assumed that the lifetime of an individual fungus mycelium is usually determined by the life of one or more limiting components of its substrate, in which the mycelium is embedded. Spores are the usual means of escape, and some reproductive structures, such as the time-dispersive 'resting' zygospores of the Zygomycotina, are only formed when the substrate is almost exhausted.

Fungi in woodlands, however, can be very long-lived by comparison with the moulds, such as *Penicillium* spp., which have been the subject of most laboratory experimentation. The woodland fungi that live in and on soil organic matter are presented with continually renewed substrate in the form of comminuted, partially decayed leaf and twigs, while those that decay wood inhabit extremely bulky and durable substrates in the form of stumps, trunks and major branches. Those fungi that cause disease, such as cankers in the woody part of their long-lived host, may have a niche that persists for decades, while those that are symbiotic with the roots of longlived tree species, such as *Quercus* spp. and *Taxus baccata* have a resource that lives for centuries, if not millennia.

It is not surprising, therefore, that woodlands support the richest diversity (of all ecosystems) of fungi with large reproductive structures, which are vernacularly called fruit-bodies, toadstools, mushrooms, brackets, conks, cups, stink horns, etc. In temperate and sub-Arctic woodlands, most of the reproductive structures attached to mycelia living in soil organic matter or with live roots, appear on the soil surface towards the end of the growing season, when temperatures are falling and more importantly when the soil has been recharged with water, but before the first frosts of winter. Most of the fungus fruit-bodies seen in Irish woodlands only survive for a few days before they are eaten by animals (ranging from fly maggots and slugs, to mammals, including people), or are rotted by bacteria and moulds. The fruit bodies which are formed on mycelia inhabiting wood live longer than those formed on soil; some live for a few weeks, many live for months, and some are perennial. Woodlands also support a great number of fungi that cause disease in all parts of the trees and of other woodland plants. Most of the disease fungi are microscopic, but have been well documented in a European context (Smith *et al*., 1988; Buczacki & Harris, 1981).

Lichens

Lichens are not single individuals, but a symbiosis between fungi and algae or photosynthetic bacteria. The fungal partner's mycelium, produces most of the bulk of the thallus and so determines the shape, pattern of growth and colour of the lichen. The fungal partner also produces spores in sexual reproductive structures, which are often a different colour from the rest of the thallus. The photosynthetic partner grows in small pockets just under the densely woven surface (cortex) of the thallus, where it is at once protected from grazing and exposed to light. Both partners can survive drying and rewetting, and lichens are commonly found in exposed places where no other organisms can survive. As these exposed places, such as tree bark and stone surfaces, usually provide neither nutrients nor water, the lichen is dependent on rain, mist and cloud water for the supply of both necessities. In woodland, particularly if the canopy is dense as in commercial plantations, the upper third of the trees provides a good environment for lichens, if cover/abundance and diversity of taxa are used as criteria. In relatively open native woodlands and in mature parkland, where mature trees have spread their canopies wide, the whole tree provides a good environment for lichens.

Lichens are usually slow-growing, but can be extremely long-lived, unless they are eaten (by molluscs and by insect larvae), used for building materials by birds, become diseased (see Folan & Mitchell, 1970), or are poisoned by sulphur dioxide in polluted air.

Most lichens exhibit one of three growth-forms. Crustose species are more or less immersed in their substratum, but may still form a thin cortex which is a different colour from the substratum. The fungus fruitbodies appear as small spots or more complex shapes on the surface. This growth form is easily overlooked.

Foliose species form a 'leafy' thallus parallel to but separate from the substratum, to which it may be attached by specialised mycelial strands called rhizinae. The upper cortical surface of the thallus is always different from the lower medullary surface. Fungal fruiting bodies can be produced within or on the surface of the thallus.

Fruticose species form small bushy outgrowths or long beard-like structures emanating from a single point of attachment to the substratum. The branches are very often round in cross section, but where they are flattened, both sides are cortical. Fungal fruit bodies are produced on the surface of the branches.

Identification of fungi and lichens in the field

Fungi

It is possible to make a preliminary identification of most fruitbodies in the field, without recourse to a microscope, by using one or more of the various field guides (e.g. Phillips, 1981; Cortecuisse & Duheim, 1996), but some genera require microscopy of their spores to distinguish species with very similar fruitbodies from one another. Microscopic examination of cap surfaces, spores, and other details, provides valuable laboratory confirmation of field identifications. Preservation of specimens is not difficult with fresh field material; the best method is warm-air drying, using commercially available domestic mushroom dryers (available on the European mainland (Howard Fox, pers.comm.)). The laboratory 'environment' may also make it possible to use Internet resources, such as the library of photographs of named species.

As with most identification tasks, practice brings familiarity with common species making it easier to 'spot' new species in the field. Increasing familiarity with the field guide(s) makes it easier to find the correct section of the book quickly and to use their keys, where provided.

Lichens

Many lichens have obvious features and can be identified from these, using one or more of the standard guides (Duncan, 1959, Dobson, 1992). A hand lens is useful as some diagnostic features are less than 1mm across. There are three chemical reagents which produce useful colour reactions in cortex and/or medulla; they can be used in the field, provided that they can be carried safely. As with the fungi, further laboratory study is required to determine the names of some taxa, and is useful to confirm field identifications in many.

A comparison of the difficulties of recording macrofungi and lichens.

Most fungal mycelia are immersed in soil or in plant material, whereas lichen thalli need light and are therefore in conspicuous places.
Fungal mycelia are useless for identification (except by expensive, laborious and longwinded DNA typing methods), whereas lichen thalli have many useful characteristics for identification.

Fruitbodies of saprophytic and mycorrhizal fungi do not need light, and may be inconspicuous. However most need access to free air in order to disperse spores; fungi with animal-dispersed spores may be totally cryptic, as in the truffles (*Tuber* and *Choiromyces* spp.). Fruitbodies of lichens are borne on the thallus and are usually very obvious.

Most fungal fruitbodies are fleshy and soft and are short-lived in nature, whereas lichen fruitbodies are persistent. It is best not to postpone the identification of fleshy fruitbodies, but lichen identification can be postponed, provided that the specimens are dried.

A fungal species list of a woodland can only be reasonably complete after repeated collections each year over several years. A lichen taxa list can probably be established in one collection per decade, provided that the upper parts of the trees are thoroughly explored.

Records of lichens and fungi found in Ireland

Fungi and lichens are under- recorded in Irish native woodlands. The key reference for lichens is Seaward & Hitch (1982) and those for fungi are Muskett & Malone (1978, 1980, 1983, 1985). Adams & Pethybridge (1910) published a *Census catalogue of Irish Fungi* almost a century ago.

The Lichen Atlas (Seaward & Hitch, 1982) is a set of distribution maps of individual species on a 10km grid basis in Great Britain and Ireland. As most 10km squares that contain native woodland also contain planted woodland, it is not possible to list taxa of native woodland alone, though each map has a commentary which discusses the substrates and habitats of that species. Less than half the Irish 10km squares had been recorded by 1982; the fullest coverage is in the south east (Wicklow, Wexford, Carlow Kilkenny), and in the south west (West Cork and Kerry). Most of the midlands of Ireland have not been explored for lichens.

Muskett & Malone (1978) list the Gasteromycete (puffballs) species found in Ireland in alphabetical order, followed by a list of dates and sites. Each record is given a citation number from the complete Irish mycological bibliography (Muskett, 1976). The site descriptions are often too brief to even identify which woodland was surveyed. The separate listing of the original references adds a further stage to the connection of record and place.

Muskett and Malone (1980 and 1983) used the same pattern when compiling the lists of Hymenomycetes (mushrooms and toadstools) and Ascomycotina respectively. Their last list (Muskett & Malone, 1985) is of micro-fungi, which are outside the scope of this review.

All three publications, Muskett & Malone (1978, 1980 & 1983) also list 72 of the 'Demenses, estates, woodlands, etc, frequently searched for fungi' together with their Vice-county code and grid reference. A quarter of these sites (18) are in or near Dublin (Dublin 9, Wicklow 6, Meath 2, Kildare 1); a further third are near Belfast (Down 14, Antrim 9). This skewed distribution towards the eastern counties in the island reflects the location of professional mycologists in universities and Government agencies. A further six sites are in or near the 'honeypot' of Killarney, and were surveyed by the British Mycological Society forays of 1885 and 1935. Muskett and Malone (1980) also refer to an intensive mycological survey of Clare Island (Rea & Hawley, 1912), which not only involved the island, but notable woodlands in West Mayo (7 sites).

Thus the majority (54 out of 72) of the most recorded places are either on the east coast or in two areas that were last intensively studied many decades ago. Many of the woodlands for which fungal lists have been published have changed in the decades since. There are important native woodlands for which no records exist, particularly from the west (Donegal, Sligo, Galway, Clare and Limerick), the south (Waterford, Wexford, Carlow-Kilkenny), and from the midlands of Ireland.

With the exception of the south eastern counties in the case of lichens, and of Mayo in the case of fungi, the deficits in fungal and lichen records match quite well

An example of this type of omission is Derryclare Wood, by Lough Inagh in Galway (grid. ref .L 840 500). This wood was not mentioned in any of Muskett and Malone's (1978, 1980, 1983) site lists, even though the nearby Ballinahinch estate (planted) wood was listed. Derryclare was identified as a scientific site of 'national importance' by An Foras Forbartha (1981) and consisted at that time of 'semi-natural oakwood with rich communities of lichens and invertebrates, which have been partly studied'.

Derryclare wood is 300km from Dublin and 95km from Galway and is even too remote from local habitation for significant harvesting of dead wood for firewood (Folan & Mitchell, 1970). It is dominated by *Quercus petraea*, with some emergent *Betula pubescens* and *Sorbus aucuparia*, and *Corylus avellana, Ilex aquifolium* and *Crataegus monogyna* in the shrub layer. Folan & Mitchell (1970) catalogued the lichens of the wood, finding 98 taxa, adding 32 new taxa to the 576 already listed for Vice County H16 (West Galway) and three that were new to Ireland. West Galway then contained 42% of the known lichen flora of Britain and Ireland. The apparent richness of this single vice-county was not only due to the favourable unpolluted climate of the area, but to the diligence and hard work, over several decades, of the second and senior author of the paper.

The authors also identified seven microfungi which were parasitic on lichens; six of these were new to Ireland. They are the only fungi listed for Derryclare Wood.

Records of fungi are also patchy in both time and space as exemplified by those of two unmistakable taxa in Muskett & Malone (1980); there are seven records of *Daedalea quercina* (Maze gill). This fungus forms a conspicuous and unmistakable hard (and therefore persistent over many months) creamy coloured bracket up to 15cm across, and is 'virtually restricted to oak' (Phillips, 1981). There are no records for West Galway, one from Brackloon Wood in Mayo (1910-11) and one from Kerry (Cromaglouin Wood in 1856). The other five records are from Wicklow (3) and Down (2) and none is more recent than 1948. There are two records of *Clavariadelphus fistulosus*, one from Cranmore, County Antrim, in 1840 and the other from the 1910/11 Clare Island Survey. This fungus forms slim tapering wands between 10 and 30cm high, growing from half buried twigs 'of frondose and coniferous trees, especially beech' (Phillips, 1981), and can be easily overlooked, as fruit bodies only last about two weeks and appear 'late' (October-February). This species appeared in the author's 17 year old planted ash wood in 2000 and has just (20/11/2004) appeared in his 12 year old planted birch-oak wood. It has to be more common and widespread than the text books opine and than the Irish records indicate.

Results from medium and long-term studies of particular woodlands in Ireland

Birch Grove, Howth Castle Demesne, October-December 1995.

This small patch of naturally regenerating birch is sited above the planted mixed broadleaf/coniferous woodlands of the old demesne. Local pollen studies (Cooney, 1994) showed that birch scrub had been present in the locality since C15th, but that fires were frequent up until 1970. In 1995 fifteen 10m x10m 'permanent' quadrats were studied by Roche (1996) from October to February 1996. On each of 25 visits he recorded the numbers and identity of macromycetes fruiting on the ground in each quadrat. He also collected soil samples from each quadrat and carried out a variety of laboratory tests on these soil samples. In general the soils consisted of a thin acid peaty A/B horizon over sandy parent material.

Thirty five macromycete species were identified over the five month period, but no new species appeared after the turn of the year. The species numbers recorded on each visit (Figure 1) showed three peaks (late October (12), mid November (11) and early December (10)). So, a single visit on the best day, would only have recorded 37% of the species appearing over the whole study period. The median number of taxa found on each visit was 8, just under 25% of the total list.

Peak numbers of fruitbodies were found in mid October (78), early November (140) and in late November (62) (Figure 2). Large numbers of fruitbodies did not coincide with the largest number of species; indeed, on 8/11/95 less than twenty fruitbodies, belonging to 11 species, were recorded.

Roche (1996) assigned the fungi he named into two groups; mycorrhizal and saprophytic. The mycorrhizal species were less numerous, less frequent and fruited earlier than the saprophytic species (Table 1). The most widespread of the mycorrhizal species were *Paxillus involutus* (in 11/15 quadrats), *Amanita muscaria* and *Russula ochroleuca* (each in 4/15 quadrats). The first two species are particularly associated with birch (Phillips, 1981). The most widespread saprophytic species were *Collybia dryophila* (in 10/15 quadrats), *C.butyracea* (in 7/15 quadrats) and *Mycena epipterygia* (in 9/15 quadrats).

Table 1. *The numbers of mycorrhizal and saprophytic fungal species, their peak frequencies, and the date on which the peak occurred in the Birch Grove, Howth Castle Demesne, Co. Dublin in 1995.*

	Saprophytic species	**Mycorrhizal species**
Number of species	19	16
Peak numbers (caps/sq.m)	0.3	0.11
Date of peak	Nov.3	Oct 4

Mixed woodland on neutral gley soil at Jealoustown, Dunshaughlin, Co Meath, surveyed continuously1974-2004.

The oldest part of this woodland forms part of a C19th estate as well as a parish boundary, and is marked as a woodland strip on the 1840 six inch Ordnance Survey. In 1974 it consisted of *Ulmus campestris*, *Fraxinus excelsior, Crataegus monogyna, Acer psuedoplatanus, Fagus sylvatica* and *Quercus robur.* All the elms (which died during the next 5 years) were ca 30-35 y.o, meaning that the woodland had grown up since the 1940s.

The younger parts of the woodland were planted by the author; *Salix caprea x viminalis* (1974), *Populus nigra* (1978), *Fraxinus excelsior, Alnus glutinosa, Salix* spp and *Corylus avellana* (1983-1990), *Betula pubescens, Quercus robur, Fraxinus excesior* and minor spp. (1992).

As these woodlands are all within 100m of the author's home, they have been under frequent, if not regular, surveillance since 1974. Any new species of macromycete has been identified and recorded. The list for the entire 2ha. now numbers over 100, but includes those from meadow and garden (ca 38 spp). The mycoflora of the youngest wood is expanding faster than that of the older woods, but new species are still appearing in the oldest woodland.

A few species have appeared once only in the thirty years, all in the oldest wood; *Verpa conica, Mutinus caninus* and *Calvatia gigantea* each appeared as single fruitbodies sometime in the 1990s. *Leotia lubrica, Boletus porosporus* and *Pluteus salicinus* appeared for the first time in 2004, and may well recur next year.

Nineteen species have appeared every year since 1974, but a further 35 species have appeared every year since they first arrived after 1974. Eight of these 'constant' species (all on dead wood of various dimensions) can be found at any time of year, but the rest are seasonal.

The biggest number of species found on one day was 26 on 6/9/04, ca 42% of the 63 species ever found over the last thirty years, which is bigger than the 31% found by Roche (1995) on one day, within his quadrats.

However, the 26 include the eight perennial xylophagous species, such as *Ganoderma applanatum* and *Diatrype disciformis*, and the 63 includes species that have appeared sporadically over the thirty years. A more comparable fraction with that of Roche (1996) would be restricted to fruitbodies of constant species occurring on the ground and would be 18/46 or 39%, which is not significantly different from Roche's 37%.

Another indication of the sporadic nature of fruiting, is the behaviour of *Armillaria mellea*, which has appeared twice (on a hawthorn stump in 1980, and on a poplar stump ca 10m from the first sighting, in 1996). This pathogenic fungus has also killed four ornamental shrubs and conifers in the same general area over the 24 years from its first appearance. It is more likely that the mycelium has persisted in a vegetative state than that six new infections gave rise to the fruitbodies and killed the four ornamentals.

Some conclusions from these two studies are as follows:

1 Any woodland will yield a small number (10 - 20) of xylophagous species at any time of year.
2 A single visit in one year will yield at most 40% of the species occurring at that site, but most visits will yield much less than 40%.
3 Repeated annual single visits will extend the list of fungi for a particular site, but because of the great year-to-year variability in fruiting times, a number of species which are in fact constant, may be recorded sporadically (present one year but absent the next).

Mycorrhizal associates and macromycete diversity

Roche (1995) in his study, distinguished between mycorrhizal and saprophytic species. All Irish native trees are mycorrhizal. However, only about half of them form ecto-mycorrhizas (ECM) with fungi, classified in the Ascomycotina and in the Basidiomycotina, that are macromycetes and form visible fruitbodies on the surface of the ground under their tree associates. The twelve native trees which associate with macromycetes are *Alnus glutinosa, Betula* spp., *Corylus avellana, Populus tremula, Quercus* spp., and *Salix* spp.

ECM partnerships are not absolutely specific, as each tree species associates with several fungal species, and some fungal species associate with more than one tree species. For instance, *Betula* spp. associate with *Amanita muscaria* and *Paxillus involutus and Leccinum versipelle* on acid sandy soils, as in the Birch grove on Howth, with *Lactarius vietus, L. torminosus, Leccinum scabrum* and *Cortinarius betularum* on heavier neutral soils as near Dunshaughlin, and with *Leccinum holopus* in *Sphagnum* as in the birch woods on All saint's Bog and Clara Bog in Offaly.

It is worth noting here that willows (there are five native species) also host several ECM macromycetes, and are more abundant and widely distributed in Ireland than most other tree species. However, willow scrub and wet willow woods are particularly impenetrable because of their low stature compounded by their tendency to fall over and reroot, and because the ground underfoot is frequently uneven and very wet in places. There are very few records of fungi from willow woodland in Ireland.

The other fifteen native tree species (*Crataegus monogyna, Frangula alnus, Fraxinus excelsior, Ilex aquifolium, Malus sylvestris, Prunus* spp., *Sorbus* spp., *Taxus baccata*, and *Ulmus glabra*) have different mycorrhizal systems (vesicular-arbuscular, VAM), in which the associates are microfungi in the taxonomically difficult family Endogonaceae. These fungi never form macroscopic fruitbodies, are very difficult to isolate into pure culture, and are rarely identified even to genus. However they are the predominant form of mycorrhizal association, infecting over 90% of vascular plant species in Ireland and worldwide.

It follows that woodlands which are dominated by tree species with ECM associates should have a richer macromycete flora, and that woodlands that contain several different ECM host trees, such as oak with birch and willow, will be richer than woodlands that only have one ECM host tree species. Woodlands that are poor in ECM host trees, such as those dominated by *Fraxinus excelsior* are poor in macromycete species, not only because of the VAM associate, but also because the dead ash leaves never have a chance to build up a humus layer. The dead leaves are rapidly buried by *Lumbricus terrestris* and other earthworms within two months of falling. Half buried fallen twigs yield several species of small macromycetes, such as *Xylaria hypoxylon, Sarcoscypha coccinea, Clavariadelphus fistulosus* and *Cyathus striatus*, but most of the larger pieces of wood are removed for firewood before they decay.

Recommendations for management of woodlands for fungi and lichens.

Some of the general recommendations for native woodland management, such as the preservation of both standing and fallen dead wood, the elimination of domestic grazing animals, and the creation of gaps and glades, have obvious beneficial effects on both fungi and lichens.

Dead wood is the habitat of at least thirty macromycete species in Ireland, and of many microfungi as well. Some of these fungi are essential for specific insect associates. There are several lichens that are also dead wood specialists.

Sheep and cattle eat and trample fungal fruitbodies; cattle in particular will congregate in woodland (if allowed to) during wet weather, in hot, sunny weather and in windy weather. During those periods they enrich the woodland soil with excreta, disturb the organic soil horizons and eat dead twigs and rotting wood. Their faeces produce an alien fungal flora, more typical of grazed grassland.

Gaps and glades allow light to reach the sides of trees, which encourages the colonisation of the lower branches and trunks by lichens. Generous spacing of mature specimens by carefully controlled thinning would have a similar effect.

Recommendations for information management

A national fungal recording centre should be established. As long as fungi are regarded as being more like plants than anything else, the National Herbarium at Glasnevin, Dublin, would seem to be a better location for this centre than the universities. The latter institutes will soon lose their Botany Departments if they have not lost them already, as 'Life Sciences' take over. There is no room in modern 'Life Science' for field biology or for the recording of non economic organisms. Things that have no price (like wilderness, and clean air) have no value.

During the next few years, while professional mycologists are still employed in or attached to the Universities, they should be encouraged to record and to educate non-professionals as well as students to make and submit their own records. Most of the fungal records that do exist in Ireland were compiled by groups of 'amateurs' under the supervision of a professional during the golden years of 'Natural History' in the late C19th and early C20th. We should repeat the exercise before it is too late.

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WOODLAND HISTORY OF THE COILLTE ESTATE – SURVEY & POLICY DEVELOPMENT

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KEYWORDS: woodland history, old woodland sites, woodland biodiversity, nature conservation, silviculture

Introduction

Sites with a continuous history of woodland cover are considered to be of high nature conservation value because they are more likely to support woodland specialist species, i.e. species of plant and animal (primarily invertebrates e.g. insects, spiders, slugs and snails) that require woodland habitats and that have difficulty adapting to open habitats or non-woodland conditions. History of woodland cover – and particularly the length of time a site has supported continuous woodland cover – is widely regarded as a key factor influencing woodland biodiversity (Peterken, 1993). Woodland history and its link to biodiversity has received much attention in research across Europe, while ecological research has produced lists of woodland specialist species for some groups of organisms, e.g. vascular plants (Hermy *et al.*,1999; Honnay *et al,.* 1999). Detailed inventories have been prepared in Britain, from documentary records and maps, of "ancient" woodlands which are defined as sites that have been continuously wooded since 1600 A.D. (England and Wales) or since 1750 A.D. (Scotland) (Peterken, 1993; UKWAS, 2000). This work is now being extended to woodlands in Northern Ireland (S. Thomas, this volume).

In Ireland, the exploration of woodland history in the landscape and its links to woodland biodiversity has been less systematic and there are large gaps in our knowledge. For example, there is no national inventory of ancient woodlands. This may be due to the fact that old Irish maps and documentary records can be difficult to find and access. What evidence does exist indicates that the history of woodland in the Irish landscape is complex and quite different to that found in Britain (Rackham, 1995). Furthermore, our knowledge of many important groups of flora and fauna (e.g. fungi, lichens and invertebrates) in Ireland is incomplete, and so it is difficult to make definitive statements about the correlation between the biodiversity of woodland sites and their woodland history.

Despite these uncertainties, the bulk of available evidence points to the fact that woodlands with a long history support a more diverse complement of woodland-associated species than do plantation forests of recent origin, and this in turn implies that older woodlands are more functional as woodland ecosystems. The importance of old woodlands to biodiversity is recognised in international forest management standards (e.g. IFCG 1999; UKWAS 2000), and appropriate management of these sites is a prominent component of guidelines on Sustainable Forest Management (SFM).

As part of its programme to implement SFM across its estate, Coillte Teoranta, the Irish Forestry Board, is developing policy on the management of sites with a history of woodland cover. As a first step, a woodland history survey was undertaken for the Coillte estate, with the objective of identifying sites that have a history of woodland cover prior to having been planted in the 20th Century. In this paper, the results of this survey are presented, with a discussion on the development of policy on how these sites should be managed. Coillte owns and manages about 60% of the national forest area of the Republic of Ireland (Coillte, 2004), and so its woodland history survey contributes significantly to our understanding of woodland change in the wider Irish landscape within the past 200 years.

Survey Method

The woodland history survey consisted of a desk study in which the historical Ordnance Survey maps were examined and compared with the current Coillte forest inventory (Garrett, 2001). The Ordnance Survey maps were selected as a reference point for this survey because: they provide uniform coverage over the entire country; they were compiled at a large scale (i.e. 6":1 mile); and they were produced to a high level of detail and accuracy, making them readily interpreted. Two editions of the Ordnance Survey maps were examined for this study: the first edition (compiled during the period 1833 to 1844 A.D.); and the third edition (compiled during the period 1900 to 1915 A.D.).

For all Coillte properties, the *extent* of woodland cover shown in the 1st and 3rd editions of the Ordnance Survey maps was traced and digitised into Coillte's GIS (ARCView) database.

The Ordnance Survey maps indicate the type of woodland cover that was present at the time, illustrated by means of quite detailed map symbols which differentiate, for example, between broadleaf and conifer trees. The *woodland type* shown as present in the 1st and 3rd editions of the O.S. maps was recorded and input into the GIS, using a simple recording system specially adapted by Garrett (2001) from the broad landcover categories used in the Coillte inventory and referred to as "LandUse Types" (Table 1).

Finally, each site that was found to have a history of woodland cover was categorised as a particular *site type* according to its woodland history using the system presented in Table 2. There were four *site types* created for sites with any history of woodland cover (Table 2). A fifth category – "Recent Plantations" – denotes sites that have no recorded history of woodland cover, i.e. were not wooded since the 1830s and were planted on open ground during the 20th century (after 1915). The woodland history data, once collated, were compared with 2004 Coillte inventory data to provide an overview of the current forest composition of these sites.

Results

NOTE: All figures presented are rounded up to the nearest 100 hectares.

The Coillte estate amounts to a total of 444,700 hectares, of which 386,400 hectares currently support forest/woodland cover of various types (Coillte, 2004). In all, 50,100 hectares were found to have some history of woodland cover between the 1830s and the 1910s, of which just over 27,000 hectares constitutes old woodland sites – i.e. sites that have apparently been continuously wooded since the 1830s (Table 3). This latter area amounts to 7% of the forested land owned by Coillte. The majority of forest on Coillte land (i.e. 87%, Table 3) has no recorded history of woodland cover and consists of 20th century plantations (i.e. post-1915).

Comparison of the woodland/forest area present in the 1830s, the 1910s and the present-day (as denoted by Coillte inventory), shows that the general trend since the 1830s has been a significant increase in woodland cover (Figure 1). Between the 1830s and the 1910s, the area of woodland present on land constituting the current Coillte estate had increased by 12,000 hectares, or 36%. This was the cumulative result of clearance of 4,200 hectares of woodland from some areas and of establishment or planting of about 16,400 hectares of new woodland in other areas (Figure 2). Most of what was cleared had been classified as 'brushwood' on the Ordnance Survey 1830s maps (Table 1), but reasonable areas of 1830s mixed high forest and broadleaf high forest, as well as small areas of conifer high forest, had also disappeared by the 1910s. Of the new plantations established between the 1830s and the 1910s, over half (8,500 hectares or 52%) were predominantly of conifers (Figure 2). A substantial area of mixed conifer/broadleaf stands was also established during that time (6,100 hectares or 37%), while very little of what was established consisted of pure broadleaves (900 hectares or 5%).

After the 1910s, the State afforestation programme resulted in an increase of over 340,000 hectares in the area of land supporting forest or woodland – a massive 740% increase in the forest area extant during the 1910s (Figure 1). While the area of broadleaf high forest (BHF) on Coillte land has remained more or less constant, at around 10,000 hectares, since the 1830s, the main trend post-1910s is the large-scale establishment of conifer high forest on open ground.

Focusing on the old woodland sites, i.e. those sites that have been wooded apparently continuously since the 1830s, the main trends observed from analysis of the maps are: a steady decrease in the area of broadleaf high forest as a result either of inter-planting with conifers to form mixed high forest by 1910s or of replacement with conifer high forest by 2004; and a significant decrease in the area of mixed high forest between the 1930s and 2004 as a result of replacement with conifer high forest.

Currently, over half (57%) of the total area of Coillte's old woodland sites support conifer high forest, with broadleaf high forest and mixed high forest accounting for 16% and 18% respectively.

Figure 3 shows the relative abundance of canopy species on those Coillte old woodland sites which currently support "high forest" (i.e. excluding scrub or clearfelled areas). These data were derived from an analysis of "Species 1", or the dominant canopy species, recorded for each forest subcompartment in the Coillte inventory. It should be noted that species present as secondary canopy species in a stand, are not represented here – this is especially important for mixed high forest.

Of the area of old woodland sites that currently support high forest, conifers are the dominant canopy species, accounting for over 77%. The primary function of the Coillte inventory is to record crop species, hence broadleaves, particularly non-commercial species that occur naturally on many of these sites, are under-recorded.

Spruces (both Sitka spruce *Picea sitchensis* (Bong.) Carr. and Norway spruce *Picea abies* (L.) Karst.) are the dominant species over 45% of the area of high forest on old woodland sites. Firs (predominantly Douglas fir *Pseudotsuga menziesii* (Mirb.) Franco), account for 18%; pines (mostly Scots pine *Pinus sylvestris* L.) account for 8%, while larches (mostly Japanese larch, *Larix kaempferi* (Lamb.) Carr.) and other conifers account for 6%. Native broadleaf species are dominant over 13% of the area of high forest on old woodland sites. Dominant species here are oak (both sessile oak, *Quercus petraea* (Mattuschka) Lieblein, and pedunculate oak *Quercus robur* L.), ash (*Fraxinus excelsior* L.) and birch (*Betula pubescens* Ehrh.). Substantial areas (8%) are dominated by beech (*Fagus sylvatica* L.), while other non-native broadleaved species (e.g. sycamore *Acer pseudoplatanus* L.) account for the remaining 2%.

Most of the conifer stands present on old woodland sites are <20 years old, having been planted in the period 1991 to 2000. The age structure varies among conifer species: most of the young stands (<20 years old) are of Sitka spruce, while the Norway spruce stands tend to be older (>40 years). This is likely to be indicative of the fact that many old woodland sites, which were planted with Sitka spruce in the 1950s, were clearfelled during the 1990s, after a 40-year rotation, and replanted with a second crop of the same species.

Discussion

The results of this survey indicate that old woodland sites have a history of plantation and management that goes back at least to the 1830s A.D., for example many sites have had conifers interplanted with broadleaves since at least that time. The old woodland sites themselves are predominantly low-lying, sheltered sites, with soils (mostly brown earths) that are very well suited to growing trees for timber production. The average yield class for conifer species on old woodland sites today is higher than average for the Coillte estate – 19.7 for Sitka spruce and 16.3 for both Norway spruce and Douglas fir – indicating that these sites are, in general, productive. This probably accounts for the very survival of woodland at these sites – people retained or planted woodland on these sites because they were good for growing timber. The direct and indirect influences of human activity on both the extent and character of Irish woodland habitats is likely to extend back in time for thousands of years before the 1830s (Mitchell & Ryan, 1997). Old woodlands should perhaps be viewed as anthropogenic habitats, whose character is closely linked to the forest management or silvicultural practices adopted.

The extent to which Irish old woodland sites can be viewed as "ancient" woodland (in the sense of the UK definitions) is uncertain. Rackham (1995 and this volume), when comparing woodland cover between the 1830s Ordnance Survey maps and the Civil Survey maps of Ireland which date from the mid-1600s, found that only about one-tenth of the 1600s woodland had remained in the same place by the 1830s. This suggests that most old woodland sites originated as pre-1830s plantations – only a minority have a more ancient origin, with some perhaps representing links (albeit highly modified) to the natural forests of pre-history. Rackham (*op. cit.*) emphasised the importance of backing up the examination of maps with field observations when searching for "ancient" woodland in the Irish landscape.

Ecological surveys commissioned by Coillte over portions of its estate have been ongoing since 2001 (O'Sullivan, 2003) and have covered many old woodland sites. Woodland stands were assessed primarily on their vegetation and structure (extent and species composition of canopy, understorey and ground flora). Data from these surveys are not yet fully collated, but the old woodland sites were found to vary widely in terms of their current ecological or habitat quality. Many support a range of typical native woodland flora, while others appear to lack any of the features typically associated with ancient woodland (Pryor *et al.,* 2002). This mirrors results of a similar survey in the UK of ancient woodlands on the Forestry Commission estate (Spencer, 2002).

From an ecological or nature conservation objective, the objective is to manage old woodland sites 'in a manner that retains and enhances their semi-natural characteristics' (IFCG, 1999; UKWAS, 2000). This requires forest managers, whose management efforts are traditionally focused on the trees, to take a broader, 'whole forest' approach to forest management. The semi-natural characteristics of an old woodland site include (Pryor *et al.,* 2002):

- Existing native woodland or scrub habitat
- Diverse stand structure, e.g. presence of an understorey
- Presence of old 'veteran' trees and dead wood
- Habitat diversity, i.e. pockets of wetland (e.g. marsh) or open heath/grassland
- Woodland species present in ground flora and invertebrate fauna
- Intact soil profile and ground topography

Some of these features can be readily identified and mapped by forest managers, and thereby protected as 'biodiversity hotspots' (Pryor *et al.,* 2002), while others are difficult for forest managers to identify and assess (e.g. ground flora, invertebrate fauna) and may require the input of specialists.

As stated earlier, old woodland sites are varied, both in the extent to which semi-natural characteristics are present, and in their pre-1830s history and origin. Likewise, the management prescription required to conserve semi-natural characteristics will vary for each site. For example, some sites will yield significant benefits to nature conservation if restored to native broadleaf cover, while other sites appear to lack any potential for restoration. Add to this the fact that many old woodland sites are popular as recreation areas among local communities, and have a history of access and amenity use. Furthermore, they are productive sites capable of producing high quality hardwood and softwood timber. Old woodland sites, therefore, are complex and varied, and require management prescriptions that address the particular values inherent in each site. For Coillte, development of policy on the management of old woodland sites is challenging. The issue is to achieve balance between environmental, economic and social objectives in managing these sites.

Coillte Policy

The critical factors influencing the conservation of semi-natural characteristics of old woodland sites are: the silvicultural system adopted in stand management; tree species selection; and effective identification and protection of "biodiversity hotspots" (Pryor *et al*., 2002). Coillte's policy on old woodland sites focuses on: adoption of Low Impact Silvicultural Systems (LISS) and reduction in the size of clearfells; tree species diversification, favouring broadleaves and light-crowned conifers; and use of ecological surveys to aid in identification and mapping of 'biodiversity hotspots'.

A range of management options may apply to a particular old woodland site, depending on site characteristics, as follows:

- Retain native woodland cover where it currently exists;
- Restore to native woodland cover, where appropriate[1];
- Broadleaf timber production in areas where quality timber can be achieved;
- Conifer timber production favouring diverse light-crowned species, e.g. pines, larches, Douglas fir;
- Conifer timber production using Norway spruce or Sitka spruce where the site has been found to be of low ecological value and is not silviculturally suited to light-crowned conifers.

Further work will refine the management objectives for old woodland sites, including quantification of the area to be restored to native woodland.

Conclusions

Native woodland conservation is receiving much welcome attention (Forest Service, 2000). A paper such as this, which presents data on large areas of conifer-dominated forest, might seem out of place in a conference concerned with the status and conservation of native woodland in Ireland. However, native woodland biodiversity is not confined to present-day native woodlands – the importance of woodland history should not be ignored. Certain woodland species of vascular plant, e.g. bird's nest orchid (*Neottia nidus-avis* (L.) Rich), appear to thrive under the shade of conifers on old woodland sites. By focusing only on the management and restoration of native woodland, we may be ignoring important aspects of the conservation of native woodland biodiversity. Perhaps we should broaden our view of woodland conservation to be more inclusive of the potential habitat value of mixed and conifer high forest stands, focusing more on the silvicultural techniques adopted in forest stand management.

The following are some suggested measures which would support the conservation of old woodland sites at national level:
Extension of woodland history survey to full national coverage and extension to include examination of the Civil Survey of 1650s ("ancient" woodland);
Surveys of biodiversity of Irish old ancient woodland sites (flora and fauna) and provision of this information to forest owners and managers;
Ongoing development and promotion of forest management skills required for the implementation of LISS and CCF systems;
Support for compilation of long-term management plans for old woodland sites, based on stand inventory and survey as required, incorporating the ful range of management objectives that apply.
Integration of grant schemes focusing on nature conservation, amenity and high quality timber production, in recognition of the fact that management of individual sites frequently entails a combination of all of these objectives.

Old woodland sites represent a significant nature conservation resource. They also have value for amenity/recreation and high quality timber production. With the increasing focus in society on values that are outside economics, old woodland sites should be viewed as sites where investment in their appropriate management will yield tangible environmental and social benefits. Stronger emphasis on their silviculture and conservation at national level is required.

[1] The decision to restore to native woodland cover is based either on presence of semi-natural woodland characteristics as highlighted by Coillte's ecological surveys (O'Sullivan, 2003) or on independent evidence that the site has an "ancient" woodland history.

Table 1. *Categories adopted to record woodland type, as indicated by map symbols on 1st and 3rd Editions of Ordnance Survey maps (scale 6":1 mile). An asterisk in column 1 indicates labels that do not exist as a "LandUse Type" in Coillte's inventory, i.e. labels devised specifically for the woodland history survey.*

Label – Woodland Type	Full Name – Woodland Type	Description of map legend
BHF	Broadleaf High Forest	Broadleaves = ~90%-100% woodland canopy
MHF	Mixed High Forest	Broadleaves and Conifers each = 10%-90% woodland canopy
CHF	Conifer High Forest	Conifers = ~90%-100% woodland canopy
BRUSHWOOD*	Brushwood	Scrub-like broadeaves. Either young, immature stand of trees or scrub vegetation.
SCRUB	Scrub	Lower-density scrub-like broadleaves
PARKLAND *	Parkland	Scattered mature broadleaves on open ground.
OPEN *	Open	No trees or shrubs present.

Table 2. *The history of woodland cover between the 1830s and 1910s A.D., recorded broadly as "site types". See Table 1 for explanations of woodland types listed for each edition of the Ordnance Survey maps.*

Site Type Recorded	1st Edition O.S. 1833-1844 A.D.	3rd Edition O.S. 1900-1915 A.D.
Old Woodland Site (OWS)	BHF/MHF/CHF/ BRUSHWOOD/SCRUB	BHF/MHF/CHF/ BRUSHWOOD/SCRUB
Interrupted Old Woodland (IOW)	BHF/MHF/CHF/ BRUSHWOOD/SCRUB	OPEN
Parkland (PKLAND)	PARKLAND	PARKLAND
Long-Established Plantation (LEP)	OPEN	BHF/MHF/CHF/ BRUSHWOOD
Recent Plantation (RP)	OPEN	OPEN

Table 3. I *Summary results of woodland history survey of entire Coillte estate, as recorded from Ordnance Survey maps (Scale 6":1 mile). Area figures rounded up to nearest 50 hectares.*

Woodland History	Area (hectares)	Area (% Total Coillte Estate)
Old woodland site	27,100	7%
Interrupted old woodland	4,250	1%
Parkland	2,400	(<)1%
Long-established Plantation	16,400	4%
Recent plantation	336,250	87%
TOTAL area of forested land on Coillte Estate	386,400	100%

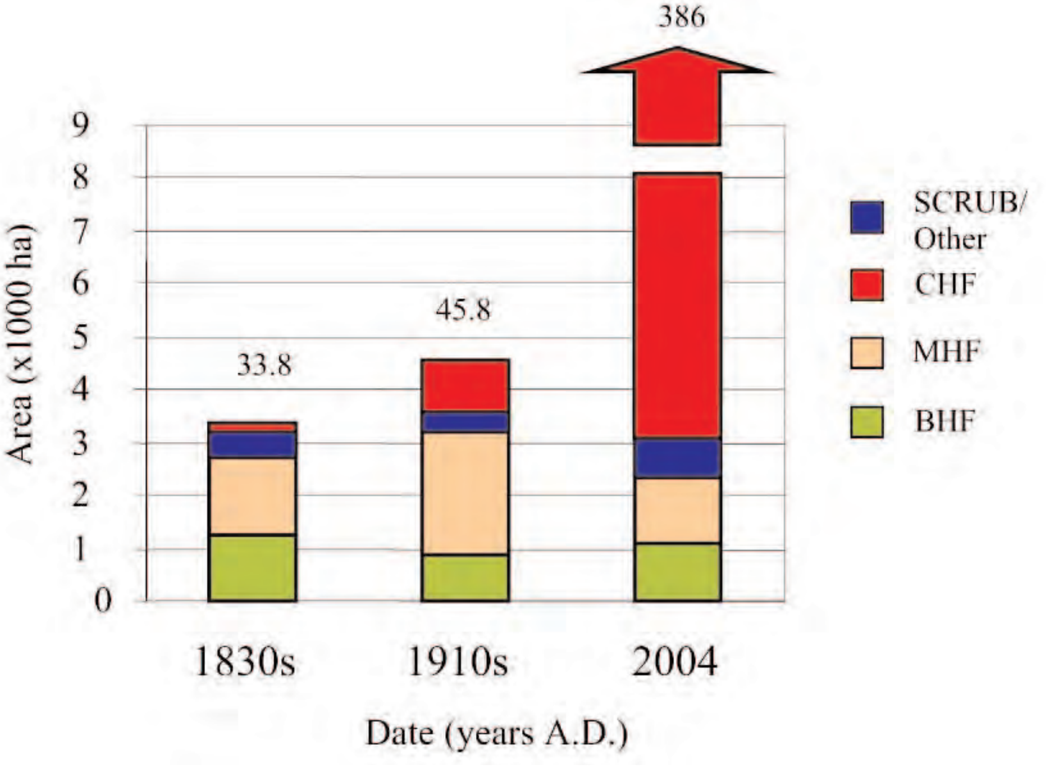

Figure 1. *Area and type of woodland recorded on the Coillte estate since the 1830s A.D. Data for the 1830s and 1910s were recorded from Ordnance Survey maps. Data for 2004 were obtained from Coillte inventory.*

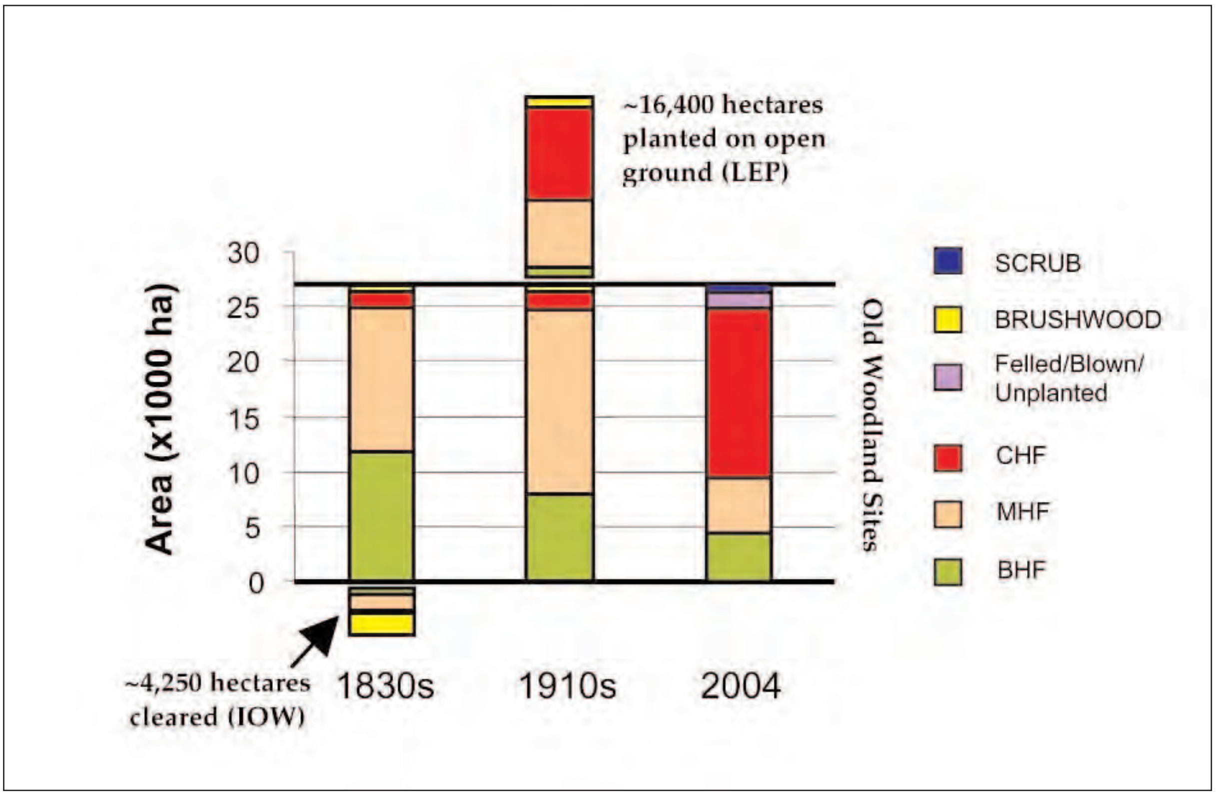

Figure 2. *Changes in the composition of woodland recorded on Coillte sites with a history of woodland cover between 1830s and present-day. Present-day composition of LEP or IOW sites (see Table 2) is not shown.*

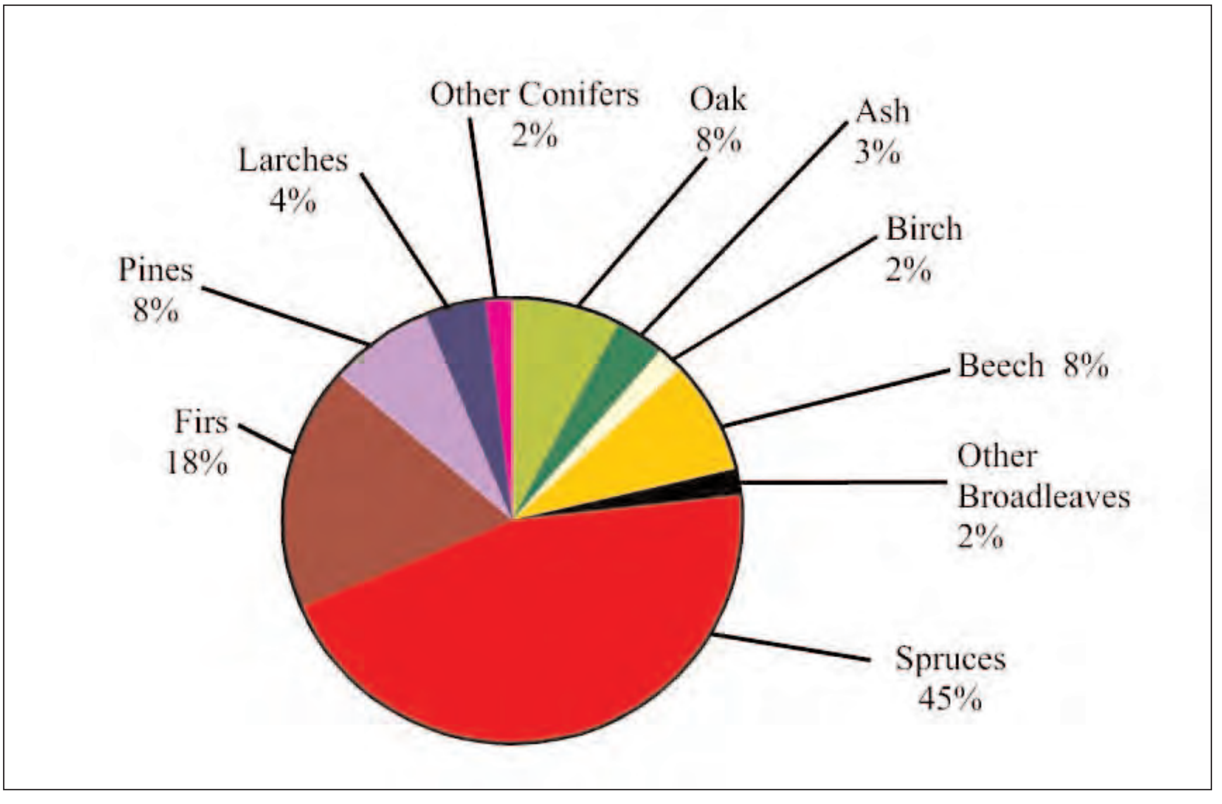

Figure 3. *Breakdown of dominant canopy species by area on old woodland sites. Data from Coillte inventory, 2004.*

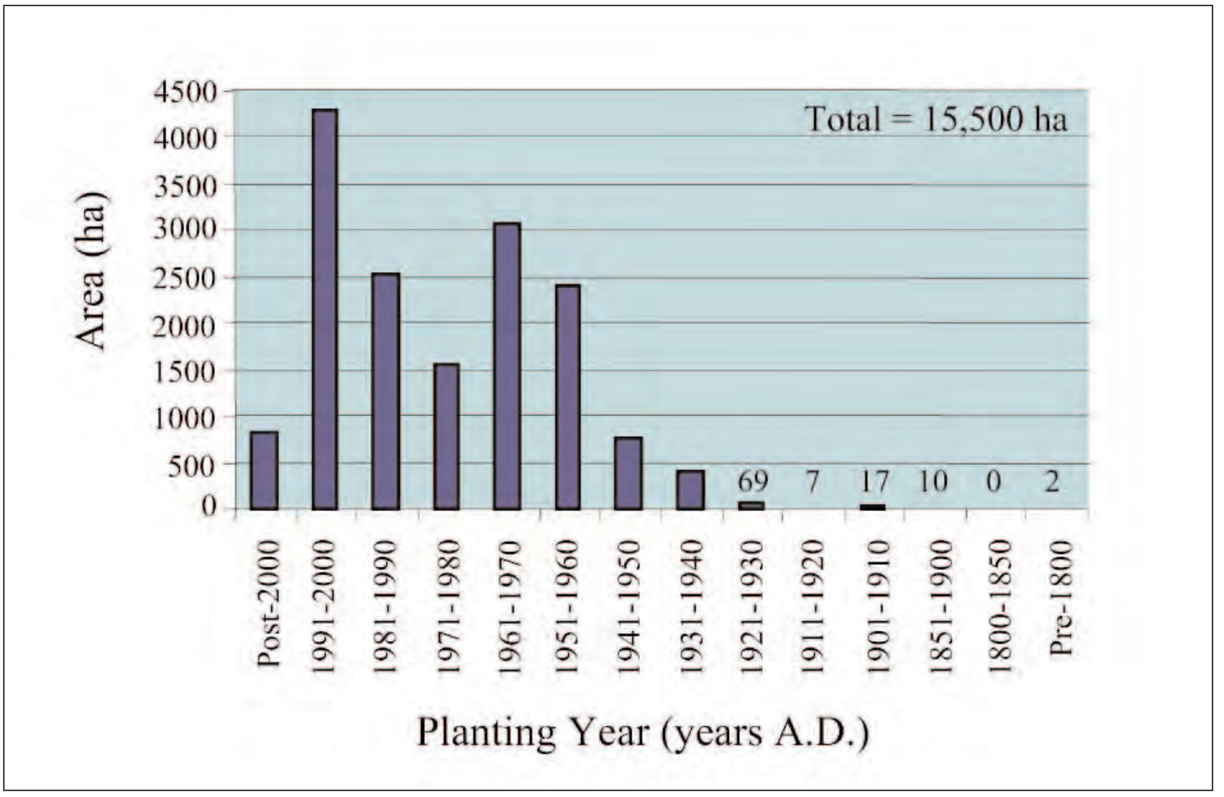

Figure 4. *Age-class distribution of conifer stands on old woodland sites. Stand age is presented in terms of the year in which the stand was planted.*

Acknowledgements

The woodland history survey of the Coillte estate was completed in 2001 by W. Garrett. Subsequent data analysis in 2004 was carried out by D. Dunphy and R. O'Shea (Coillte). Some of the content of this paper is the product of discussions among Coillte's Policy Development Group on Old Woodland Sites, which includes A. Pfeifer, P. Doolan, E. O'Connor, T. Crowley and P. O'Tuama, with additional input from Dr M. Carey.

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A NATIONAL SURVEY OF NATIVE WOODLAND IN IRELAND: USING THE 2003 DATA TO EVALUATE THE CONSERVATION STATUS OF SITES

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KEYWORDS: *native woodland, GIS, conservation*

Abstract

This study calculated that there are 87,298 ha of putative native woodland in the State in stands of 1 ha or more. A field survey of 312 sites in the south-east of Ireland found that the majority of sites were < 10 ha and pedunculate oak-ash-hazel woodland was the most frequently recorded native woodland type (24% of surveyed sites). The two most frequently occurring non-native species were sycamore and beech. An approach was put forward for separately evaluating the conservation status and the threat level of the surveyed woods. The conservation score was based on species richness, area, diversity of structure and habitats, nativeness, natural regeneration, dead wood and the presence of features and species of interest. The threat score was based on the abundance of exotic and invasive species, sub-optimal grazing regimes and damaging activities.

Introduction

The potential vegetation for much of Ireland is woodland (Cross, 1998). However, millennia of human activity and climate change have dramatically reduced native woodland cover and that which remains is limited in extent, scattered in distribution and much modified. Today, Ireland is one of the least wooded countries in Europe, with only about 9% of the State now covered with trees (Gallagher *et al.,* 2001). Woodland cover was estimated at less than 1% of the total land area at the start of the 20th century (Neeson, 1991), and the recent figure reflects an active State policy of afforestation since that time. The majority of Irish woodland today comprises commercial plantations of exotic species.
The need for a national inventory of native woodland has been recognised in the National Biodiversity Plan (Anon., 2002). The present study aims to make the important initial steps in this process, identifying all potentially native woodland sites in the country and beginning the field survey process. The dataset for the completed phases of the national survey of native woodland have been published (van der Sleesen & Poole, 2002; Higgins *et al*., 2004). This paper aims to set out the rationale for how the data can be used to evaluate the conservation status of sites and on which future management decisions and monitoring regimes can be based.

Ratcliffe (1977), in his nature conservation review, highlighted the factors that affect the conservation value of a site and these have been widely applied to habitat conservation (Cross, 1992; Spencer & Kirby, 1992; Kirby, 1988; Lockhart *et al*., 1993; Woodland Trust, 2002; Kirby *et al.,* 2002; Neville, 2002; van der Sleesen & Poole, 2002). Key native woodland attributes that affect the conservation value of a site include naturalness (e.g. species composition), woodland age, woodland size and the management regime for the site.

Some of Ireland's woodlands are closer to their potential natural state than others and usually these woodlands have a high conservation value. Naturalness is an important factor, and applies both to the species composition and structure of a wood. Woodland age is often highly valued with a large number of specialist species, particularly invertebrates and lichens, found exclusively in old woodlands (Woodland Trust, 2002). Old woodland sites also often contain features that have resulted from past management, for example large coppice stools, banks and ditches, and these may add to the structural and species diversity of the site. Such historical features are also often of interest in their own right (Rackham, 1990).

Larger woodland sites usually have a higher conservation value than smaller sites as they contain a greater core area (Laurence, 1991) in which true woodland conditions prevail and also because they usually contain higher levels of biodiversity (Woodland Trust, 2002). Many woods are completely surrounded by intensively managed farmland. This can restrict the movement of species and gene flow between sites; it also restricts the potential of a woodland site to expand. Thus, the proximity of other semi-natural habitats, for example semi-natural grassland to woodland sites increases its conservation potential.

One third of the vascular plant species present in Ireland are naturalised introductions (Webb, 1983). Most of these species are relatively benign but a few are invasive and can out-compete native species, resulting in the degradation of semi-natural habitats. Of these species cherry laurel (*Prunus laurocerasus*[*]), rhododendron (*Rhododendron ponticum*), sycamore (*Acer pseudoplatanus*) and beech (*Fagus sylvatica*) are among the more widespread exotics and have achieved local dominance in many places. The negative effects of rhododendron in native acid oakwoods and on heath are well documented and many native woods, especially in areas with acidic soils, are badly affected (Neff, 1974; Cross, 1982; Hayes *et al*., 1991; Barron, 2000).

Grazing and browsing are a natural part of the woodland ecosystem (Putman, 1994; Vera, 2000). However, the continued expansion of introduced grazing species, particularly *Cervus nippon* Temminck (sika deer) and the intense grazing of woodlands by domestic stock, chiefly cattle and sheep, has severely reduced the field layer in many Irish woods and limited the success of natural regeneration (Hester *et al*., 1998; Higgins *et al*., 2001).

Native woodland is also threatened by the underplanting of broadleaved stands with exotic species, mainly conifers. Although this was practiced widely in the past, it is no longer common, and at some sites conifers and broadleaved exotics are being removed to promote a more native habitat. In recent years there has been growing recognition of the need to preserve the genetic integrity of native species (Martin *et al.,* 1999) and projects such as the Native Woodland Scheme and the People's Millennium Forests have placed emphasis on using not only Irish seed, but on sourcing it as locally as possible.

When devising a protocol that evaluates the conservation status of sites, all the key attributes of semi-natural woodland sites discussed above must be considered. Importantly the data must then be recorded and scored using standard reproducible methodologies.

Mapping of native woodlands

Methods

One of the primary aims of this project was to identify and demarcate every block of putative native woodland in the country $\geq$ 1 ha and wider than 40 m (with the exception of riparian woodland where the width was reduced to 20 m). The Forest Inventory and Planning System (FIPS) was used as the primary data source for identifying and mapping native woodland. FIPS is a GIS platform produced by the Forest Service that uses a combination of 1993-1997 satellite imagery and 1995 panchromatic orthophotos to digitally map the majority of woodland in the State. The FIPS dataset was modified following the methods listed in Higgins *et al.* (2004) to produce a national map of putative native woodland.

Results

From the modified FIPS dataset it was calculated that there were 77,047 ha of putative native woodland in Ireland. A study of 2000 aerial photographs estimated that approximately 10,251 ha of native woodland were missing from FIPS, mostly due to the recent development of significant areas of scrub woodland. Therefore the total figure for native woodland in Ireland was corrected to 87,298 ha.

[*] Nomeclature for vascular plants follows Preston *et al*. (2002)

Field survey of native woodlands

Methods

325 sites in the counties of Carlow, Kilkenny, Laois, Wexford and Offaly were selected for field survey using the modified FIPS dataset. Only the western part of Co. Offaly was surveyed as eastern Offaly had been surveyed as a pilot study during 2001 (van der Sleesen & Poole, 2002). Field work was conducted between April 8th and 3rd October 2003. Of the 325 sites selected, 312 were visited, 214 were assigned a habitat type, 204 were selected for a full field survey and 248 relevés were recorded. To ensure that a broad range of woodland types was selected, criteria such as woodland size, woodland age, geographical position, conservation designation and ownership were considered. Certain geographical areas within the relevant counties were found to have a low density of woodland sites according to FIPS and so aerial photographs were used to identify any further possible areas of native woodland in these areas.

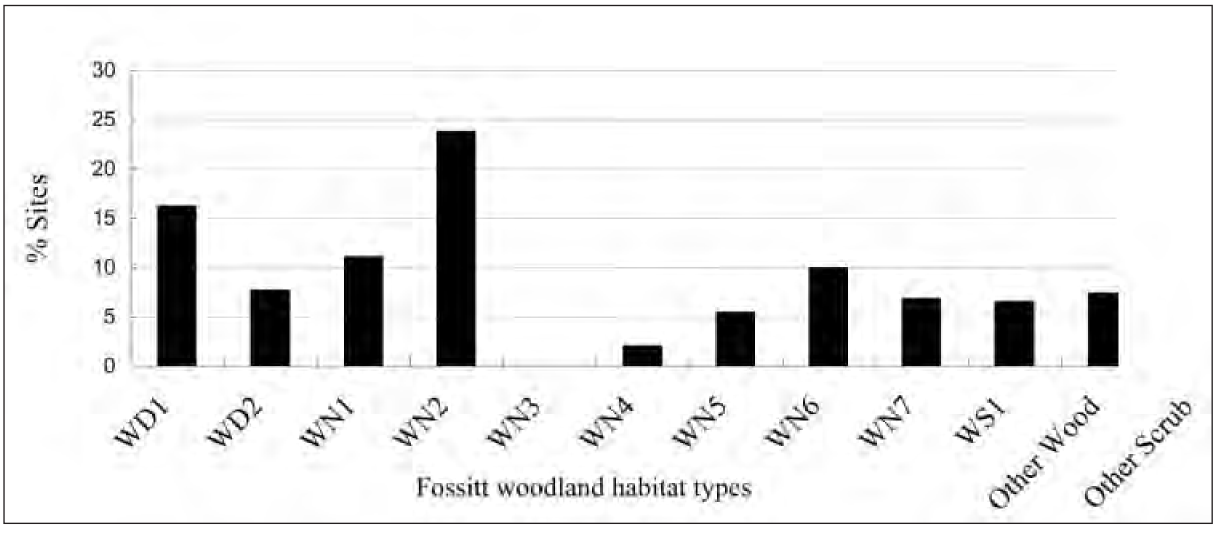
The field survey methods were divided into three sections. Firstly, the description and general survey of a site was undertaken, including features such as site area, topographical position, hydrological features and vegetation types using Fossitt (2000). Secondly, relevés were taken for each woodland vegetation community within a site. Within each 10 x 10 m relevé, plant species cover was recorded using the Domin scale. A soil sample was also collected and pH, loss on ignition and total phosphate were measured in the laboratory. Thirdly, to obtain structural data, the size, abundance and quality of the trees were measured. The plot size was increased until *c.* 40 trees had been recorded in order to ensure the assessment of large trees (dbh > 7cm) (Higgins *et al.,* 2004).

Results

Almost 80% of native woodland parcels identified from FIPS were less than 5 ha in extent. Due to their scarcity, larger woodlands were prioritised during the field survey. Nonetheless, sites less than 5 ha still comprised 40% of surveyed woods and only 3% of sites surveyed were > 50 ha.

Pedunculate oak-ash-hazel woodland, category WN2 (Fossitt 2000), was the most frequently recorded habitat type, and was identified at 24% of the surveyed sites (Fig. 1). Highly modified woodlands (WD1 and WD2) were abundant; they usually consisted of WN1 (sessile oak-holly-birch) or WN2 type vegetation that had high components of non-native species, particularly beech and sycamore, in the canopy. Yew woodland (WN3) was the only category of native woodland that was not recorded during the field survey. Wet woodland types were less frequent than woodland over drier soils, with wet pedunculate oak-ash woodland (WN4), recorded at only 2% of sites, being the rarest.

Fig. 1: *Occurrence of woodland habitat types (Fossitt 2000) in sites surveyed (n = 214).*



Definition of Fossitt (2000) categories used: WD1 (mixed) broadleaved woodland, WD2 mixed broadleaved/conifer woodland, WN1 oak-birch-holly woodland, WN2 oak-ash-hazel woodland, WN3 yew woodland, WN4 wet pedunculate oak-ash woodland, WN5 riparian woodland, WN6 wet willow-alder-ash woodland, WN7 bog woodland, WS1 scrub, other wood includes WD3 (mixed conifer woodland) and WD4 (conifer plantation), other scrub includes WS2 (immature woodland) and WS5 (recently-felled woodland).

All woodland included in this survey contained a higher number of native species than non-native. Nine sites (out of 204 where a relevé was recorded) were composed entirely of native species and in total 197 of these had a flora that was 80-100% native. No site contained fewer than 69% native species. Sycamore and beech were the two most frequently occurring non-native species recorded in the survey and were recorded at 162 and 154 sites respectively (Table 1).

Table 1. *The thirteen most abundant tree species in the survey area, represented by the number of stems and the basal area.*

Tree species	No. of stems	% of all stems	Basal area (m²)	% of basal area
Fraxinus excelsior	2031	19.37	49.61	15.50
Betula pubescens	1591	15.18	28.59	8.93
Corylus avellana	1370	13.07	10.42	3.26
Quercus robur	992	9.46	80.36	25.10
Alnus glutinosa	843	8.04	22.18	6.93
Salix cinerea	780	7.44	11.12	3.48
Fagus sylvatica	576	5.49	31.15	9.73
Crataegus monogyna	490	4.67	5.27	1.65
Ilex aquifolium	385	3.67	3.82	1.19
Quercus petraea	338	3.22	25.78	8.05
Q. petraea x Q. robur	293	2.80	18.59	5.81
Acer pseudoplatanus	204	1.95	9.95	3.11
Sorbus aucuparia	182	1.74	2.86	0.89
Other	408	3.89	20.39	6.37
Total	**10,483**		**320.08**	

Ash (*Fraxinus excelsior*) was the most frequent species in terms of number of stems, comprising 19.4 % of all measured stems, but pedunculate oak (*Quercus robur*) contributed the highest proportion of total basal area at 25.1%. Table 1 also demonstrates how frequent *A. pseudoplatanus* and *F. sylvatica* were in the canopy.

Evaluating the Conservation Status of surveyed woods

Methods

To retain compatibility between the conservation scores calculated during this phase of the survey and those calculated during the pilot study (van der Sleesen & Poole, 2002) the actual scoring system used for each group of data was based on the pilot study wherever possible.

Of the data types collected during 2003, four of the most important indicators of the naturalness of a woodland were native species diversity (including the presence of notable or rare species), natural regeneration potential, heterogeneity of structure and the presence of dead wood (Ratcliffe, 1977; Neville, 2002). In addition other data were recorded that could be used to assess the conservation status of a site. The most important were area, woodland age, diversity of woodland and other semi-natural habitat types, the presence of hydrological and other landscape features, features of interest such as the presence of old coppice stools, and the proximity of other semi-natural habitats.

These key elements of the woodland data were used to produce 15 categories of data (sub-scores) that contributed to an overall conservation score for each surveyed site (Table 2). While the overall conservation score of a site was useful for making comparisons between sites, examination of the values for the different categories provided a clearer insight into the particular issues that affected each site.

As criteria 1-6 in Table 2 directly represent naturalness, they were allocated some of the highest scores. Criteria 7-15 contain data that can enhance the naturalness or development of a wood. In order to ensure that these criteria would not contribute more to the final conservation score than the naturalness criteria 1-6, the weighting of each was generally expressed as 1 or 0. However, two sub-scores were more heavily weighted; area, with scores of 1-6, and the number of native habitats in a wood, with scores of 1-4. Area scores above 3 were reserved for the 12.5% of field sites that had an area greater than 20 ha. A score greater than two for the number of semi-natural habitats was reserved for the 14% of field sites that had more than two habitat types.

Table 2. *Data used to assess the conservation value of each site.*

Data	**Calculation of score**	**Max**
Naturalness/Development categories		
1. No. of native vascular plants	1=<40 species, 2=40-59 spp., 3=60-80 spp., 4=>80 spp.	4
2. No. of bryophyte species	1=<5 species, 2=5-10 species, 3=>10 species	3
3. No. notable lichen species	0=0 species, 1=1-3 species, 2=4-5 species, 3=>5 species	3
4. Regeneration of tree species[1]	0=0, 1=1-4 saplings, 2=5-10 saplings, 3=>10 saplings	3
5. Horizontal diversity[2]	1=σ of <10 cm, 2=σ of 10-20 cm, 3=σ >20 cm	3
6. Notable species[3]	0=0 species, 1=1 species, 2=2 species, 3=≥3 species	3
Contributing categories		
7. Area (ha)	1=<5, 2=5-9.9, 3=10-19.9, 4=20-49.9, 5=50-99.9, 6=≥100	6
8. Native habitat types[4]	1= 1 habitat, 2=2 habitats, 3=3 habitats, 4=>4 habitats	4
9. Presence in the 1840s	0=woodland not mapped, 1=woodland mapped	1
10. Adjacent semi-natural habitats	0=no adjacent semi-natural habitats 1=≥1 adjacent semi-natural habitats	1
11. Natural hydrological features	0=none 1=≥1 of the hydrological features listed in the methods	1
12. Standing dead/damaged wood	0=none of the dead wood categories recorded at a level of frequent or higher 1=one of the dead wood categories recorded at a level of frequent or higher	1
13. Woody debris	0=none of the woody debris categories recorded at a level of frequent or higher 1=one of the woody debris categories recorded at a level of frequent or higher	1
14. Coppiced/pollard	0=none, 1=coppice or pollard recorded	1
15. Man made features	0=none 1=ditches, walls, ruins, exclosures, lazy-beds or other notable feature	1
Maximum Score		**36**

[1]Regeneration of tree species refers to the total number of saplings (> 2m) recorded in each relevé – when two or more relevés were recorded at a site the highest value was used. [2]Horizontal diversity as described above is the standard deviation (σ) of tree diameter (dbh) for each site; when two relevés or more were recorded the highest value was used. [3]Noteable vascular plant species are listed in Higgins et al. (2004). [4]All native habitats listed in Fossitt (2000) could contribute to the number of native habitats, as long as the area the habitat covered represented at least 5% of the woodland. The majority of recorded habitat types were woodland.

As stated above, a conservation score can be a useful tool when monitoring native woodland sites, but it can also be used to rank sites which have been surveyed in a similar manner. However, the ranking is based only on the conservation importance of the site as native woodland and does not take account of individual species, such as protected mammals or birds, for which a native woodland site may be an important habitat.

Certain factors can detract from the conservation status of a site and these must also be evaluated. The five factors that present the greatest threat to the natural status of a woodland site are the presence of invasive shrub species, sub-optimal grazing pressure, a high proportion of non-native species in the canopy, a high proportion of non-native species in the flora, and damaging activities such as dumping, felling of natives etc (Table 3). The lowest threat score for grazing was allotted to sites with a low to moderate level of grazing, as plant species diversity has been shown to be higher under these grazing levels (Kelly, 2000; Higgins *et al*., 2004).

Table 3. *The five factors used to assess the threat level to native woodland. The maximum score is 13 and the minimum is 0.*

Threat Category	Calculation of Sub-score	Max.
Invasive shrub species	0=none recorded, 1=low level invasiveness, 2=high level invasiveness	2
Grazing	0=low/moderate grazing, 1=no grazing, 2=high grazing, 3=severe grazing	3
Non-native canopy	0= low cover value for non-native species recorded in the canopy 1=a non-native species recorded in the canopy as abundant or dominant	1
Damaging activities	0=no damaging activities, 1=1 damaging activity, 2=2 damaging activities, 3=≥3 damaging activities	3
% of non-native species	0=0%, 1=1-5%, 2=6-10%, 3=11-20%, 4=≥20%	4
Maximum Score		13

Results

The three sites from this survey that had the highest conservation value using the evaluation system described above are listed in Table 4.

Table 4. *The three sites from the 2003 study with the highest conservation scores*. The maximum possible score is 36.*

County	Site Name	Score	Rank
Carlow	Borris	27	1
Wexford	Killoughrum Forest	26	2
Offaly	Cushcallow	24	3

**It should be noted that two of the most important native woodland sites in the survey area, Abbeyleix and Charleville were not assessed in this survey because both woodlands have been studied extensively in recent times (Kelly & Fuller 1988; van der Sleesen & Poole 2002).*

When the conservation score is viewed in the context of the threat score, more informative comparisons can be made. For example the top ranking site in terms of conservation score is Borris in Co. Carlow, but this site also had the second highest threat score of 9 due to the high level of invasive shrub species, the high percentage of non-native vascular plants and the high number of damaging activities.

Discussion

Mapping

The figure of 87,298 ha of native woodland, calculated from the modified FIPS dataset, only includes sites ≥ 1 ha so there is a difficulty in making comparisons with previous estimates for native woodland cover in Ireland. However, the figure agrees well with a recent estimate by O'Sullivan (1999) of no more than 100,000 ha of broadleaved woodland (which will include exotic broadleaved species) and is close to the figure of 84,000 ha given by Cross (1987). Until a more complete field survey of the country has been carried out it will be difficult to provide an accurate figure for the area of native woodland in Ireland.

Field Survey

As this field survey was restricted to one geographical region of the country, most conclusions are only pertinent to woodland in this region and only limited statements can be made regarding the national native woodland resource. Nonetheless, important information about the woodland of this region has been gathered.

In the survey area, as was the case nationally, the majority of sites were small (< 10 ha) and very few sites exceeded 100 ha. The most significant woodland type encountered, both in terms of frequency and abundance, was oak-ash-hazel woodland (WN2): this result is not surprising given the predominantly calcareous bedrock and brown earth soils in the region. It differs from the perceived notion, however that acid oak woodland (WN1) is the most abundant native woodland type that remains in Ireland (Neff, 1974; Poole *et al.,* 2003). As the native woodland survey is extended, a more accurate assessment of the extent and distribution of the different woodland types will evolve.

The high number of sites assigned to mixed broadleaved woodland (WD1) is a direct result of the widespread abundance of the two exotic species beech and sycamore in the canopies of the woodlands surveyed. The impact of these species has been noted by previous authors (Dierschke, 1982; Quinn, 1994) and Higgins *et al*., (2004) demonstrated that they have a negative impact on the native flora.

This survey has attempted to identify the main factors pertinent to native woodland conservation and to summarise these by way of a scoring system that can be used to assess and monitor the status of a site. However, such a system comes with provisos; sites must be judged on their overall merit, and the application of a single number to a site could prove to be misleading if used inappropriately. To avoid this, the sub-scores for each of the factors that were considered to be of merit were retained. This means that the overall status of a site can be easily assessed but, more importantly, the factors that contribute to that status are also clearly understood. When assessing a woodland site, the criteria indicating how valuable, in conservation terms, a site is have been separated from those that reduce this value and it is important that they are examined in the context of each other.

Conclusion

This first phase of the National Native Woodland Survey has brought together a range of datasets, both GIS and non-GIS based, that provide information on the many native woodland sites throughout the country.

The field survey of woodland in the south-east of Ireland has resulted in a network of 204 surveyed sites that have helped to define and increase the understanding of the woodland resource in this previously little studied region. In addition to supplying baseline data, the survey has highlighted management issues, in particular that of invasive species. The impact of non-native canopy species, most importantly beech and sycamore, will require careful consideration when planning the future conservation management of native Irish woodland.

An assessment and monitoring scheme has been proposed that should be adopted for the remainder of the native woodland project. On completion of the survey a network of studied sites representing the heterogeneity of native woodland types in the country will be available as a conservation and research resource.

Acknowledgements

The authors would like to acknowledge the assistance of the staff of the National Parks and Wildlife Service (NPWS) and the Botany Department at Trinity College Dublin. We would also like to thank the other members of the project team: S. Waldren, J. Dowse, E. Cole, F. Dunne, A. Browne, N. Roche, M. McCorry, K. Connolly and G. MacGrath.
The research was funded by NPWS and The Forest Service.
FIPS was provided by The Forest Service.

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BACK ON THE MAP: THE SEARCH FOR NORTHERN IRELAND'S ANCIENT WOODLAND

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KEYWORDS: Ancient woodland, long-established woodland, historical, maps

Abstract

Preliminary map work has found around 2,750 woodland areas greater than 0.5 ha in Northern Ireland that have been continuously present since the first edition Ordnance Survey maps were produced in the 1830s. During 2004 and 2005 these sites are being subjected to further detailed archival work and field survey to distinguish ancient woods (present since at least 1600) from long-established sites (present since 1830 but not proven to be ancient).
Detailed archival evidence from cartographic and written sources, such as 17th century Bodley and Raven maps and Ordnance Survey memoirs (19th century), is being collated for a subset of sites for which the best archive evidence exists. Trees, vascular plants, bryophytes and a range of pre-determined physical features are being recorded in each wood.
Archive research alone will produce a core list of woodlands that may be classified with some certainty as either long-established or ancient. Analysis of the field survey data for these sites will enable derivation of a provisional list of species and features characteristic of each type and these will then be applied to categorise the remaining sites as either long-established or ancient.

As well as recording antiquity, the final inventory will classify woods as semi-natural or plantation (broadleaved, conifer, or mixed). Losses to woodland since the 1970s and areas of wood pasture / parkland and scrub are also being mapped in the field. The inventory will enable protection of Northern Ireland's ancient woodland and will be a valuable tool for spatial planning for conservation.

Background

Ancient woods (areas wooded since at least 1600) are rich reservoirs of both biodiversity and historical information. Our most diverse habitat, they embody a conservation heritage of infinite enormity, providing a haven for rare and threatened invertebrates, lichens, bryophytes, higher plants, birds and woodland mammals. Plants and certain animals associated with ancient woodland have limited dispersal and adaptation abilities. As it has taken ancient woodland many centuries to evolve, the species that the habitat supports are accustomed to stable conditions, and are therefore extinction prone. Vulnerable species are more likely to occur in ancient woodland than in any other habitat in the British Isles (Peterken, 1993). Ancient woodland is also important for its undisturbed soils and for the historical and archaeological features it preserves. In Ireland, earthworks, including raths and ringforts, and in some areas wood banks and boundaries (Rackham 1995) give us a picture of past land use. Old coppice stools, pollards, charcoal hearths, ore furnaces and kilns point to past woodland management practices and their connection with local industrial history.

Woodland cover is very low in Northern Ireland – at 6% of land area it is the lowest in Europe with the exception of Iceland - and ancient woodland is thought to be very scarce, probably less than 0.2 % (Rackham, 1995) yet protection of all woodland is weak. Ancient woodland has no specific protection since Northern

Ireland currently has no comprehensive record of its ancient woodland. Ancient woodland inventories were produced in Britain 10 to 20 years ago, around the time when the importance of ancient woodland increasingly started to be recognised. Since then, the concept of ancient woodland has become central to the development and implementation of conservation policy and strategy, at a national and international level. The lack of an ancient woodland inventory puts Northern Ireland at a severe disadvantage, as it is an essential tool for meeting biodiversity and sustainability commitments. The UK Government has made a commitment to halting the decline and fragmentation of ancient woodland (Anon., 1999). The UK native woodland Habitat Action Plans explicitly include targets for no further loss of ancient semi-natural woodland and restoration of replanted ancient woodland as one of their main targets (Anon., 1995; Anon., 1998). The Northern Ireland Biodiversity Strategy recommends that remaining ancient semi-natural woodland sites should be protected, enhanced and extended, and incentives provided for their management (Anon., 2002).

Northern Ireland's woodland history

In the last 10-15 years, the commonly held earlier view that the forests of Ireland were still extensive until the 17th century, and owe their demise to wanton destruction and cavalier exploitation by English colonists, is largely discredited. Documentary records are less abundant than in England, but in Ireland they can be examined in conjunction with both archaeological evidence, and a rich legacy of pollen evidence in peat bogs and lake sediments which can give us fairly accurate information about the historical period, thanks to the use of tephra dating. This method uses the presence of layers of volcanic ash within the peat cores from Icelandic eruptions of known dates to pinpoint the origin of pollen layers with far more accuracy than is possible by radiocarbon dating (Hall, 2000). The picture that emerges is that substantial clearance started during the Neolithic period and that Ireland was already poorly wooded by 1600. This is borne out by archaeological evidence and the vast number of raths and ringforts suggesting a large population in the Iron Age and Early Christian period, which indicates that the survival of large tracts of wildwood was impossible. The Civil Survey of 1654-56 indicates that at this time Ireland was one-third as wooded as contemporary England. Even by that date much of this may have been secondary woodland, with war, disease and famine having put paid to most of the original "wildwood" which covered much of the British Isles after the last Ice Age. (Rackham, 1995).

In Northern Ireland, the date of 1600 has double significance. As well as being the conventional division between "ancient" and "recent" woodland, it coincides roughly with the beginning of the Plantation of Ulster, which saw an influx of English and Scottish settlers in the north, changes in social structures, reallocation of landholdings and further turmoil and unrest which led to a wave of mapping and recording. While some felling was undoubtedly due to English settlers, with a great deal of timber needed to build the number of Plantation castles dating from this time, they also carried out some planting, as can be seen by the age of some of the trees in landscaped demesnes. It was actually the huge population explosion running up to the Great Famine, and the associated demand for every scrap of possible cultivable land, which sounded the death knell for possibly some 90% of this woodland (Rackham 1995). The Land Acts from the late 19th century onwards then resulted in land ownership passing to tenants and further clearance of woodland, creating today's rural landscape of farms (Tomlinson, 1997).

The ancient woodland inventory

The first phase of the project to create an ancient woodland inventory (AWI) for Northern Ireland was carried out by Queens University Belfast (Tomlinson *et al.* 2003). Through comparison of Ordnance Survey (OS) maps from the first edition of the1830s to the most recent maps (mainly dating from the 1960s and 1970s), and an intervening series dating from around 1900, a baseline digital map was produced of all woodland areas (including wood pasture, parkland and scrub) which had been continuously present since the 1830s (see Fig 1). Around 2,750 polygons of potentially ancient woodland over 0.5 ha were discovered, the majority less than 2 ha in area, and covering less than 1% of the land area of Northern Ireland (see Table 1).

In 2004 and 2005 the Woodland Trust is carrying out detailed archival research and field survey to establish the antiquity of each of these areas and to categorise them as:

- Ancient woodland (established before 1600)
- Long-established (established before 1830 but not proven ancient)
- Recently cleared

and as either:

- Semi-natural
- Plantation (broadleaved, conifer or mixed)

Methods

Creating the ancient woodland inventory involves a certain amount of detective work, piecing together evidence from old maps, written historical sources and fieldwork. Historical sources for Northern Ireland for the period of interest vary in their quality, availability and consistency, and like all historical sources need careful interpretation within an understanding of the political and social context of the time. Alone, they would be inadequate to enable classification of individual woods as ancient or long-established and fieldwork is therefore essential. Field survey can pick up clues that would never be available from the archives, but in Northern Ireland so little work has been done in the past to identify those features and species that may typify ancient woods in the Province, that fieldwork alone would also be inadequate. For the purposes of producing an inventory of ancient woodland in Northern Ireland, historical research and field survey are both needed to complement each other. Because there is, relatively speaking, so little woodland left that is long established, potentially ancient; the intention is to carry out this work for all those sites.

Archive research

Archival research is focusing on 17th century sources such as the Bodley maps of 1609, Raven's maps of the Clandeboye Estate from 1625, Petty maps from the 1650s and the Civil Survey of 1654. Initially it was thought that there would be a lack of material due to the various misfortunes which have befallen Irish records, but fortunately such early records still exist. These surveys and maps were created mainly as a consequence of the Plantation of Ulster and therefore tend to cover the west of Ulster. Evidence of trees and woodlands in these 17th century sources is taken as one positive indication of antiquity. Other records which are being consulted include estate maps, OS Memoirs from the 1830s and the county registers of trees. These later sources can help to suggest which woodlands are the result of planting in the years prior to the 1830s, rather than being ancient. The 1830s maps themselves are also a very useful source, with information being extracted such as wood shape (sinuous or straight boundaries) and wood type (symbols on these maps differentiate between young plantation, for example, and mature, more "natural" woodland, and between coniferous and broadleaved woodland).

Common difficulties in interpreting the sources include issues over orientation and symbolism of maps and the original purpose of creating the records. No maps prior to the first edition OS maps in the 1830s cover the whole of the Province and thus some areas have more historical evidence from the 17th century than others. In any case, a single source cannot show that a site is definitely either ancient or long-established. Rather, historical research must aim to build up a body of evidence based on a rich variety of different sources, which can then be used in conjunction with fieldwork to make a judgment on the likely antiquity of a wood.

Field survey

Field survey involves recording a list of higher and bryophytes and relevant physical features (as determined by Tomlinson *et al.*, 2003). During spring and summer of 2004, 4,995 ha of woodland in Northern Ireland were surveyed. A unique standard check-list, made up of plants characteristic of woodland in Northern Ireland, was used to record trees, vascular plants, mosses and liverworts in each polygon. This survey work will continue in 2005 and may go on into 2006.

The survey method was a thorough walk through the wood, with the whole wood being covered in a series of traverses, approximately 50m to 100m apart or on a more irregular path to fit the conditions and shape of the wood (Kirby, 1988). The boundaries of each wood were also examined due to their importance as historical management indicators (Tomlinson *et al.,* 2003). Surveyors used current OS maps (dating from 1960s and 1970s) at 1:10,000 scale on which were marked the boundaries of polygons identified by Tomlinson *et al*. (*op.cit*) as long-established (potentially ancient) woodland. Conventional symbols were used for map annotation.

Information about the wood's canopy and condition was recorded in order to enable classification as semi-natural or plantation, and whether the area was conifer (>80% conifer species), mixed (between 20-80% conifer) or broadleaved (>80% broadleaved species). The presence of scrub and wood pasture / parkland and any changes since the production of the current OS maps, indicating woodland loss, were also recorded.

The use of a map and hand drawn sketch allowed the annotation of ancient trees, physical features and unusual / rare species of vascular plant or bryophyte for each polygon. Also defined were the internal boundaries between areas of different canopy condition e.g. semi-natural and plantation.

The list of vascular and bryophyte plant species was recorded on a five point semi-quantitative scale (DAFOR - Dominant, Abundant, Frequent, Occasional, Rare) for each site during the walk through the site, and the location of unusual/rare species of vascular plants and bryophytes were mapped. Ancient trees, coppice stools, pollards and their species were noted on the maps.. Eight-figure grid reference (using Global Positioning Systems), girth, height at which the girth was measured, the accessibility of the tree (e.g. private or public access), whether the tree was dead or alive, standing or fallen was also recorded. Information on ancient trees will also be fed into a separate project by the Woodland Trust and Ancient Tree Forum recording ancient trees across the British Isles (www.ancient-tree-hunt.org). Other physical features which could have historical significance, such as boundary banks, internal walls, banks, ditches and drainage ditches were mapped, and basic information such as dimensions was noted, as was any evidence of land use post 1600. The situation and adjacent land use of each polygon was recorded.

Anticipated results and their uses

Historical research so far has highlighted those woods for which good archive evidence is available – i.e. a number of sources dating back to the 17th century which strongly suggest that a wood is either ancient or long-established. The species and physical features associated with these historically documented woodlands will be analysed using multivariate (both classification and ordination) and univariate statistical methods. These investigations will show whether species and physical features can be found that characterise ancient and long-established woodland in the North of Ireland and can be used to help distinguish one from the other. The findings of these analyses will then be applied to help classify the remaining sites once they have been surveyed and researched. Some preliminary analysis by Tomlinson *et al*., (2003) tentatively suggested bryophytes may also be helpful in establishing antiquity of Northern Irish woods, which is the reason for including these in field survey.

The resulting digital inventory will show all ancient and long-established woods, with historical and ecological data attributed to each, and will be made freely available via the web, though hard copies will be available on demand (www.backonthemap.org.uk). Information will be in different formats suitable for both professional and academic audiences, and for the general public. While the Woodland Trust's primary motivation is to secure the protection of ancient woodland and thereby enable the maintenance and enhancement of woodland biodiversity across the whole of the Northern Irish landscape, the inventory will inevitably generate interest among a great diversity of professions and will hopefully stimulate further study of ancient woodland in Northern Ireland.

In terms of policy and woodland management practice, spatial information about ancient and long-established woodland should enable better protection and management of these woods through planning policy, biodiversity action plans, site designation and grant incentives (e.g. for restoration of planted ancient woodland sites, or creation of new native woodland to buffer and extend existing ancient woods).

As a tool for better understanding Northern Ireland's landscape history, the inventory could be the starting point for further research into particular woods and estates, thus increasing our knowledge of the landscape as a whole and how it has been transformed over the centuries. While local history has long been a popular study in Northern Ireland, the level of interest in the history of woodland has not matched that in England, Scotland and Wales. As providers of shelter, food, fuel and sport over the centuries, old woods that still exist today are a rich source of information on our social history. There are still many questions to be explored: Was there a tradition of wood-pasture in Ireland and if so, what form did it take? Was coppicing practised widely and, if so, why did it apparently die out much earlier than in England? What sort of archaeological and landscape features are associated with ancient woods in Ireland?

It is hoped the inventory will also provide a huge step forward in the understanding of the ecology of ancient woods in Northern Ireland and stimulate further study and research in this area. Much of our understanding of ancient woodland originated in southern England and work in Northern Ireland still lags behind. Through the ancient woodland inventory we have the opportunity to investigate ancient woodland from the perspective of Ireland, which has a more oceanic climate than England.

Conclusions

The UK's largest woodland conservation charity, the Woodland Trust has four key objectives:

- No further loss of ancient woodland
- Improved woodland biodiversity
- Expansion of new native woodland
- Increased public awareness and enjoyment of woodland

The ancient woodland inventory for Northern Ireland is, we believe, essential to achieving the first two objectives, but will also make a major contribution to the last two.

Table1. *Size range of long-established (potentially ancient) woods in Northern Ireland (modified from Tomlinson et al. (2003))*

Size range (ha)	No polygons	Cumulative no polygons	No polygons as % of total	Area (ha)	Area as % of total
< 0.49*	146	146	5.3%	?	?
0.5 - 0.99	839	985	30.7%	599.15	5.2%
1.00 - 1.99	709	1694	25.9%	994.47	8.7%
2.00 - 4.99	563	2257	20.6%	1729.05	15.1%
5.00 - 9.99	240	2497	8.8%	1679.4	14.7%
10.00 - 39.99	210	2707	7.7%	3762.22	32.9%
>40.00	28	2735	1.0%	2680.74	23.4%
Total	2735	2735	100.0%	11445.03	100.0%

* Polygons < 0.50 ha but which are contiguous with larger polygons and therefore included in the inventory.