Ireland's Native woodlands: A summary based on The National Survey of Native Woodlands

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Abstract
A summary of the national survey of native woodlands, undertaken between 2003 and 2008, along with a preliminary survey of possible ancient and long-established woodland, is presented. The total area of native woodland was ca. 85,000 ha, the woodlands were unevenly distributed geographically and individual woodlands were small (average size 6.6 ha) and highly fragmented. They showed considerable diversity in terms of species complement and vegetation type and the woods were classified into 4 major types – sessile oak, ash, alder and birch – and 22 sub-types. Native woodlands showed considerable structural variation, both vertical and horizontal, depending principally on the canopy species, management and grazing regime. Regeneration of most species was generally poor. Many woods are currently unmanaged and there was little timber of merchantable quality. A conservation assessment found that the highest scoring sites were concentrated in the west and in Wicklow. Invasive alien species, especially sycamore, beech, rhododendron and cherry laurel, and inappropriate grazing regimes (under- or over-grazing) were found to be the main threat. The importance and value of our native woodlands is discussed and the desirability of combining conservation with timber production is highlighted.

Keywords: *Survey, native woodlands, classification, characteristics.*

Introduction

The expansion of native Irish forests following the last glaciation and the subsequent decline to their nadir in the early part of the 20th century is well documented (e.g. Mitchell and Ryan 1997, Feehan 2005). The remnants of these original forests that may have survived, or those which sprung up following the devastation caused by the famines of the 19th century, have undoubtedly coloured the perception of our native woodlands ever since and it is probably true to say that many landowners and foresters still considered them to be of little value, economically or otherwise.

In recent decades, however, their importance for biodiversity, conservation and general environmental benefit ("ecosystem services") has been increasingly recognised. Nonetheless, apart from a few detailed studies, e.g. the Killarney Woods (Kelly 1981), hazel-ash woods (Kelly and Kirby 1982), wetland woods (Kelly and Iremonger 1997, Cross and Kelly 2003), knowledge of their distribution, extent and character remained poor. Further, it was recognised that existing classifications (e.g. White and Doyle 1982, Fossitt 2000, Cross 2005) were based on limited data and were therefore incomplete and possibly inappropriate.

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To rectify this situation, the National Parks and Wildlife Service, in association with the Forest Service, undertook a detailed, systematic National Survey of Native Woodlands (hereafter referred to as the Survey) between 2003 and 2008 (Perrin et al. 2009). This Survey was partly driven by requirements under the EU Habitats Directive, under which several woodland types (oak, alluvial, yew and bog woodland) are designated for protection within Special Areas of Conservation (SACs). Further, with the introduction of the Native Woodland Scheme by the Forest Service in 2000, a better understanding of the resource was also required.

The Survey examined not just at the woodland flora, structure, physical characteristics and conservation value of the woodlands, but also collected information of relevance to foresters and landowners with an interest in their economic value, e.g. tree size, timber quality. The information gathered represents the most detailed and comprehensive study of native Irish woodlands ever undertaken. This paper summarises the results of these surveys while also drawing on other relevant literature.

Methods

The basis for the survey was a modified version of The Forest Inventory Planning System (FIPS) (Gallagher et al. 2001), a GIS system based on a combination of satellite imagery (1993-1997) and aerial photographs (1995) that mapped and provided attribute data on wooded areas in the State (Higgins et al. 2004). This was augmented with information from the Coillte database, the Soil Parent Material Classification Project and the National Parks and Wildlife Service database of digitised habitat maps of areas designated for conservation. The accuracy of the combined data was checked against the 2000 series of colour aerial photographs. Additional data was obtained from literature and personal communication with foresters, ecologists, etc. and information on the size of areas was updated from the National Forest Inventory (Anon. 2007), published towards the end of the survey.

A subjective stratified sampling procedure was used to ensure that a broad range of woodland types were sampled and to include certain types of woodland which might have been missed in a purely randomised approach. Sites selected included:

- woodlands within designated areas and large blocks of woodland, for which little or no data existed;
- isolated woodlands in largely unwooded landscapes;
- valley woodlands;
- woodlands marked on the 1st edition Ordnance Survey Maps (taken as dating from 1830).

Woodlands, which upon examination were dominated by non-native trees or shrubs, were excluded. The number of sites selected per county was proportional to the total area of native woodland present in each county. To qualify for selection, stands had to be >1 ha in area, >40 m wide (>20 m along lakeshores and riverbanks), have a canopy height >5 m (>4 m in wetland woods), a canopy cover >30% and consist of >50% native species. For the purposes of this survey Scots pine[1] was not

[1] Because of the large number of species referenced in this paper, only the common names are given in the text. See Tables 4 (woody) and 5 (non-woody) in Appendix 1 for lists of the botanical names of the species.

considered to be a native species, although its extinction in Ireland is relatively recent and it is often held to be semi-native. See Roche et al. (2009) for a detailed discussion on its status

In each site a general survey was conducted in which the following were recorded:

- location in relation to topography (e.g. upper slope, valley floor), altitude, slope and aspect; area and boundaries (based on FIPS);
- soil type;
- presence of water-bodies;
- vascular plants and bryophytes (excluding epiphytes);
- surface cover for each strata using the DAFOR scale (dominant, abundant, frequent, occasional, rare);
- vegetation communities based on Fossitt (2000);
- dead wood;
- land use, including grazing regime and past and present management;
- tree regeneration;
- alien invasive species; artefacts, e.g. walls, ditches, old buildings, etc.

Within each site one or more 10 × 10 quadrats or relevés was sampled in which the following data were recorded:

- 10 figure grid reference;
- all species of vascular plants and bryophytes growing on the ground with their percentage cover (using the Domin scale);
- number of seedlings/saplings of all tree species; tree height, DBH (if >7 cm) and crown position (to allow for variations in tree density the plot size was augmented where necessary to enable 30 trees per quadrat to be recorded);
- presence of merchantable timber (DBH >40 cm) including the estimated commercial log length and the presence of stem defects.

In addition, five soil samples were taken in each relevé, bulked and analysed for pH, % loss on ignition and total phosphorus (mg g^{-1}). The relevé data were subjected to a series of statistical analyses to classify the vegetation. A conservation and threat score was calculated for each site. Further details of the methodology are given in Higgins et al. (2004) and Perrin et al. (2008).

In addition to the sites selected from the FIPS database, supplementary relevé data were obtained from several other sources, principally van der Sleesen and Poole (2002) covering eastern County Offaly and Browne et al. (2000) covering parts of 3 riverine Special Areas of Conservation (the lower Barrow, Upper Shannon and Unshin). In total, the survey included 1,320 sites and 1,667 relevés.

The results are published in six volumes (Perrin et al. 2008). In addition, a database was compiled with details of each site and relevé surveyed, including GIS information of the areas of native woodlands indicating the location of the sites surveyed. Following the main survey, a provisional inventory of ancient and long-established woodlands was also undertaken, based on documentary evidence supplemented with field data from the main survey and some additional survey work. Results are presented in Perrin and Daly (2010) and recorded in a GIS and database. The results of both surveys are also available on the National Parks and Wildlife Service website (NPWS 2012).

Results

The area and distribution of native woodlands

It is difficult to obtain precise figures for the area of native woodland. According to the most recent figures from the National Forest Inventory (Anon. 2007) there are ca. 130,000 ha of land under native species, representing ca. 2% of the land area of the country. However, this figure includes small stands and narrow strips within conifer plantations which cannot be considered as native woodland. John Redmond, Forest Service (pers. comm.), estimates that there are ca. 85,000 ha of woodland with a canopy consisting of >80% native species, including hazel and willow scrub, representing 1.25% of the land surface. In addition, there are 36,000 ha of mixed conifers and native trees in which the latter constitute between 20-80% of the cover. The total area under native species which may be considered as native woodland is therefore likely to be considerably higher than 85,000 ha.

Native woodlands occur scattered throughout the country but there is a concentration in some upland areas, e.g. in the mountain valleys of Wicklow, Waterford, Kerry and Donegal, and also in central Clare. Low hazel woodland is particularly extensive over the shallow limestone of Clare and Galway and extensive birch woodland has developed in parts of the midlands. The least wooded counties are Carlow, Louth and Dublin while the blanket bogs of north-west Mayo and Connemara are also largely devoid of native woodlands. In the more fertile parts of the country, native woodland is typically confined to agriculturally less attractive areas, such as esker ridges or valley sides, as well as occurring around former demesnes where they were often planted for shelter, game cover or for landscaping (Figure 1).

The average size of the 1,320 woodlands surveyed was 6.6 ha. 50% were less than 6 ha in area, only 3.3% exceeded 50 ha and very few exceeded 100 ha. However, these figures are based on the National Forest Inventory which is now more than 15 years old. Many native woodlands have been fragmented through interplanting with non-native species in the past. In the intervening period non-native stands have been removed in a number of places and the cleared areas left to regenerate naturally or have been planted with native species, thus considerably expanding the area of individual woodlands. Nonetheless, by international standards Irish native woodlands are very small and fragmented.

Species of native woodlands

A total of 1,083 species were recorded in the Survey of which 175 were exotic species. Of the remaining native species, 27 were ferns and horsetails, 277 were bryophytes and 604 flowering plants. (For a list of vascular plants mentioned in the text see Appendix 1). About 80% of all species occurred in fewer than 10% of the sites. The bryophytes were under-recorded, partly because some may have been overlooked on account of their size but also because a systematic recording of epiphytes did not form part of the survey's intent. Of the exotic species, the majority occurred only in very small numbers or were localised.

Of native species, the most frequently occurring was bramble, found in 98% of all sites, closely followed by ivy (96%). The most frequently occurring trees were hawthorn, ash and holly, occurring in 92%, 90% and 85% of sites, respectively. Of

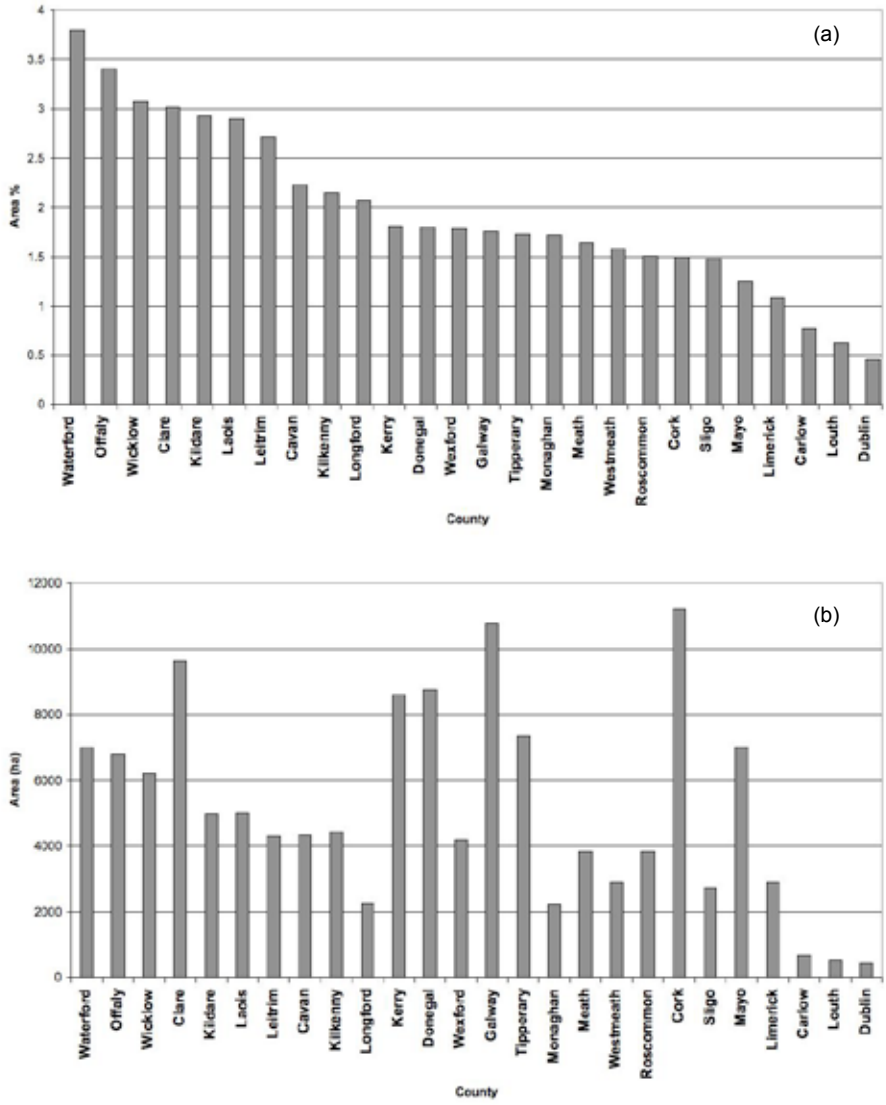

Figure 1: *Area (a) and density (b) of native woodland per county.*

the herb layer, broad buckler-fern, herb-Robert, creeping buttercup and meadowsweet were the most frequent species (Table 1). Some vernal species, e.g. lesser celandine, were probably under-recorded when sites were surveyed late in the season. Rare species, such as wood melick and narrow-leaved helleborine, were very localised and for that reason may have been overlooked in the general survey: they appeared to be confined to ancient woodlands.

Table 1: *The 20 most abundant vascular plants occurring in native woodlands.*

Common name	Latin name	% occurrence
Bramble	*Rubus fruticosus*	98.0
Ivy	*Hedera helix*	96.6
Hawthorn	*Crataegus monogyna*	92.3
Ash	*Fraxinus excelsior*	90.2
Broad buckler-fern	*Dryopteris dilatata*	89.8
Holly	*Ilex aquifolium*	85.4
Honeysuckle	*Lonicera periclymenum*	84.5
Herb-Robert	*Geranium robertianum*	83.2
Grey willow	*Salix atrocinerea*	78.2
Creeping buttercup	*Ranunculus repens*	73.6
Common birch	*Betula pubescens*	72.4
Sycamore	*Acer pseudoplatanus*	72.1
Meadowsweet	*Filipendula ulmaria*	72.1
Wood avens	*Geum urbanum*	71.6
Nettle	*Urtica dioica*	71.5
Hazel	*Corylus avellana*	70.2
Scaly male-fern	*Dryopteris affinis*	69.6
Beech	*Fagus sylvatica*	68.6
Enchanter's nightshade	*Circaea lutetiana*	65.5
Violet	*Viola* spp.	65.4

Types of native woodland

Based on analyses of the 1,667 relevés, native woodlands were classified into 4 principal types: sessile oak-woodrush, ash-ivy, alder-meadowsweet and birch-purple moor-grass woodlands. These reflect two major soil gradients: acidic-basic and wet-dry. Each type was sub-divided into numerous sub-types giving a total of 22 sub-types, two of which are sufficiently distinctive to be considered as separate, but minor, types – yew and willow woodland. In addition, hazel woodland in the west of the country may be a distinct type, although closely related floristically to ash woodlands. Brief descriptions are given below and in Table 2. More detailed descriptions, along with affinities to other classifications, can be found in Cross et al. (2010).

Sessile oak-woodrush woodland

Sessile oak woodlands occurred on acidic, well-drained mineral soils, mostly podzols with a pH typically ca. 4.5 - 4.9, in upland areas, frequently on hillsides and valley sides. They were characterised by a dominance of oak, mostly sessile oak but sometimes pedunculate oak or the hybrid (Q. × *rosacea*), typically forming a canopy ca. 18 m high, although individual trees exceeded 30 m. Downy birch was the

principal associated species, other trees playing a minor role. Holly formed the shrub layer but rhododendron was often abundant, especially in areas of high rainfall. On more fertile soils, for example at the base of slopes and beside streams, ash and hazel may occur along with other species characteristic of ash-ivy woodlands.

A dwarf shrub layer of bilberry and sometimes ling heather was typically present. These often formed a mosaic with the herb layer which was usually species-poor and often dominated by woodrush. Ferns were abundant and honeysuckle and ivy were constant. Some of these woodlands, especially in the west and in sheltered humid sites elsewhere, were noted for the richness and luxuriance of the mosses, liverworts and lichens.

Ash-ivy woodland

Ash woodland was the most extensive and widespread woodland type in Ireland occurring throughout the country on base-rich, usually calcareous soils, with a pH mostly >6.0, although occasionally <5.0. Ash woodlands display considerable diversity, occurring on a range of soil types, including deep, moist, fertile loams; dry, shallow sandy or gravelly soils; gleys subject to periodic waterlogging and excessively drained rendzinas over limestone pavements.

The canopy, which exceeded 20 m on deep soils, was typically dominated by ash but often contained a considerable amount of pedunculate oak. Typically, ash woods had a much richer vascular flora than sessile oak woods with a variety of trees species present, usually in small amounts. The shrub layer was usually dominated by hazel, often with hawthorn and a variety of other species. The vernal flora was typically well developed and colourful and could be dominated by bluebell. Later in the summer, ferns and enchanter's nightshade were often prominent. Dense tangles of bramble also occurred. The bryophyte flora, while diverse and sometimes species-rich, was usually more poorly developed than in oak woodlands.

Low-growing woodland in which hazel was the principal component of the canopy, was an important variant of ash woodlands. It was particularly well developed on the shallow limestones of Clare and Galway, although also occurring elsewhere. While this may form an early successional sere to ash woodland, it may belong to the so-called Atlantic hazel woods, which have only recently been described (Coppins and Coppins 2010) and which may be "climax" woodland. These woodlands are characterised by a suite of bryophytes and lichens that by and large do not occur on more recently developed stands.

Alder-meadowsweet woodland

Alder woods were widespread throughout the country on wet, poorly drained, gleyed, mineral or peaty soils with an average pH ca. 6.2. Like ash woods, alder woods showed considerable variation.

Although alder was constantly present, it was not always dominant, with other species, such as ash or grey willow often forming the canopy or sometimes co-dominant. The shrub layer consisted mostly of grey willow, although locally hawthorn could be abundant. A variety of other trees and shrubs were also be present at times, although typically in small quantities. The characteristically thin canopy and the

variety of micro-habitats, such as wet depressions, drier hummocks and tree bases, resulted in a species-rich and sometimes luxuriant herb layer. The bryophyte layer, while relatively diverse, was typically scanty.

Birch-purple moor-grass woodlands

Birch woodlands were widespread throughout the country, principally on acidic substrates, pH 4.3-5.0. Their main concentration was on undifferentiated, dried-out peat of cutaway raised bogs in the midlands but they also occurred locally elsewhere on mineral soils. Birch is the only major tree species in Ireland which can tolerate wet, acidic conditions and birch stands were also found on wet oligotrophic peat on both high bog and cutaway. Downy birch was overwhelmingly the dominant species in these woodlands and was by far the commonest species in the country as a whole. Silver birch, although widespread, was relatively uncommon: of 13,220 birch stems measured within relevés only 17 were of silver birch.

Characteristically, birch woods are species-poor and birch was overwhelmingly dominant, other tree species playing very much a secondary role, although locally Scots pine could be an important constituent. The herb layer was typically poorly developed and characteristically dominated by a few species, e.g. bracken. In contrast, the moss layer may be well developed, although again not species-rich. A very distinctive community dominated by *Sphagnum* species could occur on both high bog and cutaway, forming so-called "bog woodlands". Locally, where there was ground water influence, the flora was richer with elements of alder woodlands.

Yew-carnation sedge woodland

These were distinctive and rare and confined to limestone outcrops in the southwest of the country. The overwhelming dominance of yew, with some ash, beech and both native oak species resulted in very species-poor and poorly developed shrub and herb layers. The moss layer in contrast was often luxuriant but dominated by just a few species.

Willow-nettle woodland

Willow woods occurred principally on nutrient-rich alluvium along the banks of slow-flowing lowland rivers. They were subject to frequent inundation and their roots were almost permanently waterlogged. Several species of tree willow dominated, including the native grey willow, but the most prominent species were white willow, crack willow and the common osier, which were probably introduced several centuries ago, principally for basket making. These woodlands were characterised by a very distinctive and luxuriant flora of tall herbs.

Alluvial woodland

Alluvial woodland is a generic term for a complex of ash, alder and willow woodlands subject to periodic flooding alongside rivers and on lake shores. It also includes spring-fed systems. Alluvial woodland is specifically protected as a priority habitat under the EU Habitats directive.

Table 2: *Frequency (%) and basal area of the principal tree species.*

Species	% of trees	% of basal area
Downy birch	21.3	13.6
Ash	18.5	15.4
Hazel	10.1	4.9
Grey willow	8.0	6.1
Alder	7.2	7.9
Sessile oak	6.8	18.3
Holly	6.0	2.6
Pedunculate oak	4.9	14.1

Ancient and long-established woodlands

The first comprehensive maps of Ireland (the Down and Civil Surveys) were drawn in the 1650s and after this date planting of new woodland was widely encouraged. Ancient woodlands are therefore defined in Ireland as areas which have been wooded since 1660. Long established woodlands are sites which have been continuously wooded since the 1st edition Ordnance Survey maps but for which no documentary evidence has been found that they date back to 1660 (Perrin and Daly 2010). However, any woodland which appears on the 1st edition Ordnance Survey maps should be considered as potentially ancient, unless there is evidence to the contrary. Woodlands that have developed since the 1st edition Ordnance Survey maps are called recent woodlands. Rackham (2005) summarised the demise of Irish woodlands, which he considered "a series of disasters" and concluded that "little ancient woodland survives".

For a given size, ancient and long-established woodlands had significantly more vascular plant species than recent woodlands. They also tended to have a suite of species which were less common or rarer in younger woods, e.g. bugle, wood anemone, red campion (Perrin and Daly 2010). Further research is required to ascertain whether they contain other species of significance, e.g. invertebrates, lichens. They did not necessarily contain ancient trees and in fact were often characterised by the lack of old trees because they had been intensively managed in the past. Rackham (2003) contends that many ancient woodlands in England have survived only because they were of economic value in the past.

These woods are particularly valuable for their biological as well as cultural importance as they may contain plant and animal species and communities which are confined to, and indeed dependent upon, the continuous presence of woodland cover throughout the historical period. In this respect they are irreplaceable and should be considered as living national monuments and managed accordingly. The area of ancient or long-established woodlands is unknown but, based on an examination of the 1,320 sites in the Survey, is at least 16,674 ha. There are undoubtedly other sites which have not yet been documented: these may still be native woodland, or have been subsumed into other broadleaved or conifer plantations. A provisional list of putative ancient and long-established woodlands is given in Perrin and Daly (2010).

Woodland structure

Woodland structure may be considered in terms of vertical structure, i.e. the canopy, shrub, herb and bryophyte layers, and horizontal structure, i.e. varying density of trees, clearings etc. Age and size of the stand and of individual trees and shrubs, as well as past management and current landuse all determine the structure. Even-aged stands appear to be the rule rather than the exception, even in unmanaged forests (Peterken 1993), and this is related to periods of regeneration, which are often related to certain events, restricted in time e.g. felling, storms.

Typically, there are 4 or 5 layers: the canopy, shrub, dwarf-shrub (principally in oak and birch woodlands), herb (or field) and the moss (or ground) layers. In some woods a sub-canopy may be present and occasional emergents may occur, especially in low-growing woodlands. One or more layers may be absent or poorly developed for a variety of reasons, e.g. age of the stand, heavy grazing. Horizontal variation in structure is influenced by factors such as changes in soil type, wind throw, crown damage and felling. Ride-lines, clearings, streams, pools, etc. provide additional variation and important habitat for edge species and flight-lines for invertebrates, birds and bats.

Of 47,416 trees recorded in the Survey, the most frequently occurring species were birch, ash and hazel. Sessile oak and pedunculate oak were much less frequent (Table 3). However, in terms of basal area the most important trees were sessile oak, ash, pedunculate oak and birch. Alder was more frequent than the oak species but the basal area was much less. These figures reflect both the size and abundance of the species, oak tending to have lower stocking rates but forming larger trees, whereas birch and alder tend to have higher stocking rates but are smaller trees. This is illustrated in the frequency curves (Figure 2) which also suggest a much lower turnover of the oaks, although it also reflects the longevity of these species. The large number of small diameter ash reflects the high rate of regeneration.

Regeneration

Most native Irish tree species require a high light climate to regenerate successfully, but different species display different strategies and some are shade tolerant. Oak (Kelly 2002) and birch species are both light demanding. In contrast, ash seedlings can survive for many years under relatively low light levels. This may be because the buds of seedlings open a few weeks before the buds of trees in the upper canopy allowing assimilation to occur before the light climate declines. Subsequently, they take advantage of gaps in the canopy by growing rapidly into these gaps (Wardle 1959). Rowan seedlings also tolerate relatively low light levels (Pigott 1983). Both holly (Peterken and Lloyd 1967) and yew (Perrin 2002, Perrin et al. 2006) are shade tolerant.

Of the major forest trees, ash seedlings (<25 cm) were by far the most abundant, sometimes carpeting the forest floor, and accounting for 75% of all recorded regeneration. Furthermore, in terms of the ratio of seedlings per adult stem, ash (79:1) was by far the highest. However, very few survived to reach 2 m in height (saplings). In contrast, the ratio of holly seedlings per adult stem was only 9:1, but 10% survived to exceed 2 m. Regeneration of oak species was poor – only 2.1% and 0.4% of all

Table 3: *Summary of the main woodland types and their principal species. Names in italics indicate the most common species.*

Woodland type	**Characteristic species**			
	Canopy	**Shrub layer**	**Dwarf shrub layer**	**Field layer**
Sessile oak – woodrush:	*Sessile oak*, *Common birch*, Ash.	*Holly, Rowan, Rhododendron*, Hazel.	*Bilberry*, Ling heather.	*Woodrush, Hard fern, Broad buckler-fern*, Wood sorrel Hay-scented buckler fern, Bracken, Honeysuckle, Ivy.
Ash-ivy:	*Ash, Pedunculate oak*, Birch, Cherry, Grey willow, Crab apple, Beech, Sycamore, Alder.	*Hazel, Hawthorn*, Holly, Spindle, Guelder rose.	Usually absent.	*Bluebell, Bramble, False wood-brome,* Anemone, Violet, Lesser celandine, Primrose, Enchanter's nightshade, Herb-Robert, Lady fern, Soft shield fern.
Alder-meadowsweet:	*Alder*, Grey willow, Ash, Downy birch.	*Grey willow,* Hawthorn, Hazel, Guelder rose.	Absent.	*Meadowsweet, Creeping bent, Creeping buttercup*, Remote sedge, Herb-Robert, Enchanter's nightshade, Water mint, Marsh bedstraw, Yellow flag.
Birch-purple moor-grass:	*Downy birch,* Rowan, Scots pine.	Grey willow.	Bilberry.	*Bramble, Bracken,* Purple moor-grass.
Yew-carnation sedge:	*Yew*, Ash, Beech, Oak spp.	*Hazel*.	Absent.	Carnation sedge, Bramble, Violet, Barren strawberry, False wood-brome.
Willow-nettle:	White willow, Crack willow, Common osier.	Grey willow.	Absent.	*Meadowsweet, Nettle, Reed canary-grass*, Water dropwort, Bindweed, Angelica, Marsh marigold.

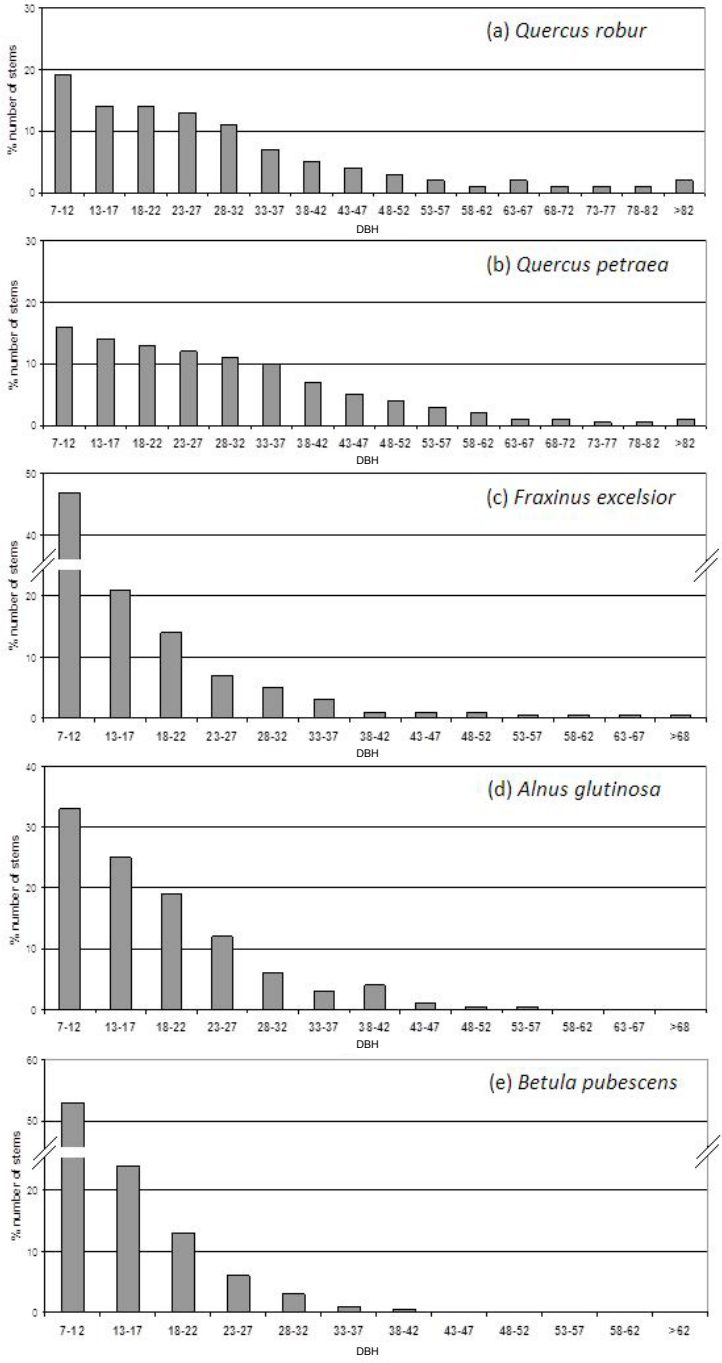

Figure 2: *Tree size (DBH) frequency distributions for the principal canopy-forming species.*

regeneration for sessile and pedunculate oak, respectively - and the ratio of seedlings per adult stem was also low (6.5 and 2, respectively). Large numbers of oak seedlings are occasionally recorded both in time and space but only a minority survive more than a few years (Kelly 2002).

In contrast to the situation under a canopy, regeneration of native species in light gaps and clearings can be prolific, especially in the absence of grazing and if the herb layer is poorly developed. Early successional species such as birch and grey willow, often accompanied by ash, can regenerate in large numbers, along with smaller quantities of holly, rowan, hazel, alder (on moist soils) and oak, to form dense stands within a few years.

Timber

The Survey highlighted the absence of good quality timber in most woods. Data collected from ca. 67,900 stems showed that <4% reached or exceeded a DBH of ≥40 cm, the size considered to be of merchantable quality for saw-log. Of the total number of trees recorded, just over 12% were oak (both species), of which 21% were of merchantable size accounting for 60% of all stems of merchantable size. Ash constituted 16% of the total number of trees but only 3% were of merchantable size, representing 12% of all stems of merchantable size. Of the other native trees, only very small numbers were ≥40 cm DBH. Non-native trees, mostly beech and sycamore, represented 6% of the total number of stems measured but over 14% were of merchantable size.

Of the stems of merchantable size only 60% were of merchantable quality, due to a number of defects, principally forking (29%), heavy branching (21.5%), bending (17%) and heavy ivy (15.5%). Eighty-nine percent of the oak stems of merchantable size had lengths of merchantable quality compared with only ca. 10% each for ash, birch and alder.

Deadwood

Deadwood is an integral and essential element of any woodland and is a means by which nutrients are recycled. It is also a habitat for a great variety of organisms, being particularly important for certain bryophytes, lichens and saproxylic invertebrates and fungi. Different types of deadwood provide different niches, each with its own suite of associated organisms. Several categories were recognised: fine woody debris (<5 cm diameter); coarse woody debris (>5 cm diameter); standing dead (branches and/or trunks); uprooted trees/root plates (which may not always be dead); snags/snapped trees, all of which could be in different states of decay.

The amount of deadwood within Irish woodlands is poorly documented. The Survey undertook a rough assessment using a scale of abundance (abundant, frequent, occasional, rare). Results show that fine woody debris and coarse woody debris were frequent to occasional in the majority of sites, standing dead/damaged wood was relatively uncommon and snags and snapped trees were rare or absent. Sweeney et al. (2010) found that the mean volume of dead logs in a small sample of oak forests was ca. 20.5 m^3 ha^{-1}, and in ash forests 27 m^3 ha^{-1}. Ninety percent of logs were <20 cm diameter. Mean snag density in the same stands was 92 ha^{-1} for oak and 87 ha^{-1} for ash,

most being <20 cm diameter. These relatively high figures may reflect the high rate of competition between stems within the woodlands surveyed.

Invasive alien plant species

Very few woodlands, even if remote, were entirely free of alien plants in one or more layers of the woodland. Abundance varied from scattered individuals to dense, sometimes dominant stands. The Survey found that the most frequently occurring alien tree species were sycamore, which occurred in 72% of sites, beech (69%) and Sitka spruce (25%). Seedlings and saplings of sycamore were much more common than beech. The abundance of the two broadleaf species reflected both their wide ecological tolerance to soil pH and their widespread planting. Both species could be invasive and had major detrimental effects on native flora and fauna through the dense shade that they cast. However, they were not universally problematic; sycamore was more vigorous in ash woods on moist, base-rich soils and beech in both ash and oak forests on drier base-rich to acidic sites.

The most abundant shrubs were rhododendron (23% of sites), cherry laurel (20%) and snowberry (12%). Rhododendron was particularly invasive in sessile oak woods where its dense shade severely affected the native flora and fauna, especially in more humid areas, as well as causing difficulties for management (e.g. Cross 1982, 2002). Cherry laurel was more common on base-rich soils which are generally less suitable for rhododendron. It was less invasive than rhododendron but observations suggest that in recent years regeneration by seed appears to be increasing. Other species which were locally invasive, and potentially problematic, include red-osier dogwood and Himalayan balsam in wetland woods (see also Kelly and Iremonger 1997), Japanese knotweed, Himalayan honeysuckle, wild clematis, and some conifers (e.g. western hemlock) (Figure 3).

It should be noted that native woodlands which were severely infested with alien plant species were not surveyed. Consequently the above figures may underestimate the number, area and severity of sites affected and may reflect a bias in site selection. This may partly explain the apparent greater frequency of sycamore than rhododendron, although the former has a much greater ecological tolerance, occurring on a wider range of soil types.

Grazing

Grazing is an integral part of the ecology of natural woodlands. At low levels it facilitates structural diversity, encourages high levels of biodiversity in the field and ground layers, maintains open areas and promotes regeneration by reducing competition from certain herbs (Perrin et al. 2006, 2011). Where grazing pressure is too high the woodland structure is damaged (e.g. loss of shrub layer), regeneration of native species is reduced and there is a decline in herbaceous species, although the cover and diversity of bryophytes may increase (Kelly 2000). Unpalatable species, e.g. rhododendron, beech, however, are often favoured (e.g. Cross 2002). If the grazing pressure is very low or absent the field layer may become dominated by a few aggressive species, e.g. bramble, to the detriment of other species growth and regeneration of trees (Perrin et al. 2006, 2011). Open areas, which are important

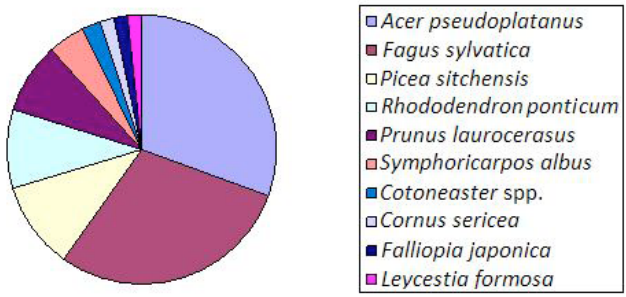

Figure 3: *Frequency (%) of invasive alien trees and shrubs at surveyed sites.*

for certain invertebrates and birds, may be invaded by trees and shrubs or become dominated by dense stands of bramble or bracken.

The Survey found that overgrazing was not a national problem in a geographic sense but was confined to a relatively few specific localities, particularly certain unenclosed upland areas where there were large numbers of deer, e.g. Wicklow Mountains, south Kerry and east Galway. Sheep and feral goats were more common in upland than in lowland areas but were recorded much less frequently than deer. In the lowlands the principal grazers were cattle, with the highest incidence of grazing recorded in Co. Clare. In many lowland areas enclosed woods were considered to be undergrazed and overgrazing was found to be limited to a few woodlands where domestic stock were overwintered.

There is, however, considerable evidence that in recent years, and especially since the Survey was completed, that the population of deer has increased in many parts of the country (Purser et al. 2009). Damage to native woodlands from deer grazing is now more widespread and severe and particularly acute in parts of Wicklow and Kerry. This could become an even greater problem if muntjac deer, recently reported from a few locations, should become well established.

Management

Signs of former management are widespread and common (Figure 4). Many older sites are highly modified, although they may not have been managed for many years and have reverted to a relatively natural appearance, e.g. Killarney Woods (Bradshaw and Quirk 2001), Wicklow Woods (Jones 1986, Carey 2009). There was a high frequency of old stems of non-native broadleaves (36% of sites) and conifers (34%) throughout the country. Old woodlands tended to have been managed more than young woodlands, some of which showed no signs of management, e.g. in inaccessible sites or on cutaway bog. Most woodlands showed some signs of felling, even if only occasional stems have been cut or pollarded. Mature coppice was recorded from 18% of sites and appears to be widespread, although it was not always easy to differentiate systematic coppicing regimes (as is known to have been practiced in Wicklow; Carey 2009) from a single felling event. Recent felling was recorded in 12% of sites, including

woodland clearance for housing. Felling of ash for hurleys, both legal and illegal, was recorded in some woodlands, particularly in counties where hurling is strongest!

One of the most striking features of the woodlands surveyed was that few appeared to be actively managed currently, although in 20% of sites there was evidence of recent planting. However, certain management activities, e.g. clearance of cherry laurel, can be quickly masked by new growth and it is possible that management activities had been overlooked.

Of non-forestry related management, livestock grazing was the most common landuse, being recorded in ca. 39% of sites. Cattle were the most common grazers, principally in the lowlands, followed by sheep and, much less frequently, horses. Amenity was also a common landuse, both casual and actively encouraged, as evidenced by the creation and maintenance of paths.

Conservation

The Survey undertook a semi-quantitative assessment of 1,312 sites for which data were available using 15 criteria, including size, species diversity, structural diversity, habitat diversity, age of woodland, etc., to evaluate their conservation quality. Emphasis was placed on the naturalness of sites, i.e. characteristics regarded as indicative of more natural aspects of native woodland, such as high (native) species diversity, high structural diversity.

Higher scoring sites tended to be relatively large, ancient or long-established woodlands with structural and species diversity and often contained more than one woodland type. They showed either a pronounced westerly distribution or occurred in Wicklow. Low scoring sites were generally uniform and species-poor with a tendency

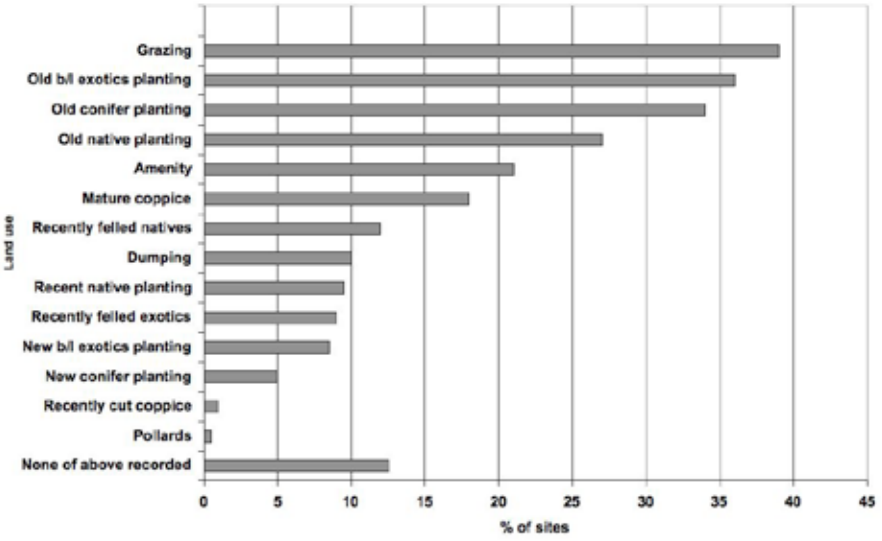

Figure 4: *Frequency (%) of observed management and landuse at surveyed sites.*

to occur in the east or intensively agricultural parts of the country. All the highest scoring sites were found within nature reserves, Special Areas of Conservation (SACs), National Parks or proposed Natural Heritage Areas (pNHAs).

The conservation scores must, however, be interpreted with some caution as all woodlands were compared, irrespective of type. In particular, they tended to undervalue alluvial woodland sites, which were not assessed as a separate category, and yew and bog (birch) woodlands, which were small and naturally species-poor but of very high conservation value by virtue of their rarity.

A threat score was also calculated, which took account of grazing pressure, presence of exotic and invasive species and damaging management activities. The principal threat came from invasive alien plants and over-grazing, but no site was considered under severe threat and over 17% of sites had no threat. However, as previously noted, the prior selection process, by which sites with a high density of invasive alien species were excluded, may have underestimated this threat.

Discussion and conclusions

This paper summarises the very large amount of information collected in the course of the National Survey of Native Woodlands in Ireland. The Survey provides the most comprehensive overview of the native woodland resource to date and serves as a basis for future reappraisal of its significance, role and function.

The Survey highlights the fragmented nature of the resource, the very small area of ancient or long-established woodlands remaining, and from a forestry point of view, their very limited value for timber production. On the positive side, it identifies the remarkable diversity which is present in terms of woodland types and plant species-richness, which is likely to be reflected in the diversity of other organisms, e.g. invertebrates (Cotton 2005), fungi (Dowding 2005). This information will provide a foundation on which to develop strategies for both future forestry and conservation policies, landuses which are not mutually exclusive but can be mutually beneficial.

Native woodlands are part of our natural and cultural heritage and their European significance should not be overlooked (Cross 2006). Their importance for biodiversity is recognised by the fact that over 30,000 ha receive some form of protection under either national or EU legislation. In addition, they play an important role in ecosystem services, e.g. soil protection, hydrological regulation, carbon sequestration, climate change mitigation etc., and they are an important genetic resource. Properly managed, they can also be a valuable and renewable source of raw material, e.g. construction timber, fuel biomass, veneer timber.

It is neither practical nor desirable for all our stands of native woodland to be designated for conservation/biodiversity, although their inherent value should not be ignored. Many sites within SACs and pNHAs can, and perhaps should, be managed for timber production, although conservation should always take precedence over timber production within known ancient woodlands. The challenge is how to maximise both environmental benefit and economic return. The value of native woodlands for timber production is still often overlooked, despite a considerable volume of literature on the subject, e.g. Bulfin (1992), Joyce et al. (1998), Gallagher (2005) and Little and Cross (2006). This may be because existing woodlands are perceived as a greater

management challenge than the creation of new plantations.

Appropriate management and restoration of neglected native woods can result in profitable, small-diameter timber, as demonstrated by the success of Coed Cymru (2011) in Wales. The quality of larger timber and the woodland as a whole can be gradually improved while, at the same time, the conservation value of the woods and the benefit to the general environment can be enhanced. While some landowners in Ireland are already managing their native woodlands for both timber production and biodiversity, the development of a similar organisation in Ireland would greatly promote the value of native woodlands and assist landowners to maximise both the economic and conservation benefits of their woodlands.

Practical implications

- While native Irish woodlands cover only a small area and are highly fragmented, they nonetheless contain a diversity of woodland types and structure and a great wealth of species, all of which require careful management to maintain their conservation value.
- Ancient woodlands, i.e. those sites which have been wooded since at least 1660, are particularly important for their biological and cultural significance and should be very carefully managed.
- Invasive alien species and over- or under-grazing are the principal management issues which need to be addressed.
- Few native woodlands are currently managed for timber production and they contain little good quality timber. Properly managed, native woodlands could provide both environmental benefits (e.g. biodiversity, ecosystem services) and an economic return to landowners.

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Appendix 1

List of common and Latin names (after Preston et al. (2002)) of plants mentioned in the text, divided between woody species (Table 4) and non-woody species (Table 5).

Table 5: *Woody species*.

Common name	Botanical name
Alder	*Alnus glutinosa* (L.) *Gaertn*.
Ash	*Fraxinus excelsior* L.
Beech	*Fagus sylvatica* L.
Birch - downy	*Betula pubescens* Ehrh.
Birch - silver	*B. pendula* Roth
Cherry - bird	*Prunus padus* L.
Cherry - wild	*Prunus avium* L.
Cherry laurel	*Prunus laurocerasus* L.
Common osier	*Salix viminalis* L.
Crab apple	*Malus sylvestris* Miller
Elm	*Ulmus glabra* L.
Guelder rose	*Viburnum opulus* L.
Hawthorn	*Crataegus monogyna* L.
Hazel	*Corylus avellana* L.
Holly	*Ilex aquifolium* L.
Honeysuckle	*Lonicera periclymenum* L.
Ivy	*Hedera helix* L.
Ling heather	*Calluna vulgaris* (L.) Hull
Oak - sessile	*Quercus petraea* (Matt.) Liebl.
Oak- pedunculate	*Q. robur* L.
Red-osier dogwood	*Cornus sericea* L.
Rhododendron	*Rhododendron ponticum* L.
Rowan	*Sorbus aucuparia* L.
Scots pine	*Pinus sylvestris* L.
Sitka spruce	*Picea sitchensis (*Bong)
Snowberry	*Symphoricarpos alba* Duh
Spindle	*Euonymus europaeus* L.
Sycamore	*Acer pseudoplatanus* L.
Western hemlock	*Tsuga heterophylla* (Raf.) Sarg.
Whitebeam	*Sorbus hibernica* E.F. Warburg
Wild clematis	*Clematis vitalbe* L.

Willow - almond	*Salix triandra* L.
Willow - crack	*S. fragilis* L.
Willow - goat	*S. caprea* L.
Willow - grey	*S. atrocinerea* L.
Willow - white	*S. alba* L.

Table 6: *Non-woody species*.

Common name	**Botanical name**
Angelica	*Angelica sylvestris*
Bilberry	*Vaccinium myrtillus*
Bindweed	*Calystegia sepium*
Bluebell	*Hyacinthoides non-scripta*
Bracken	*Pteridium aquilinum*
Bramble	*Rubus fruticosus*
Broad buckler-fern	*Dryopteris dilatata*
Bugle	*Ajuga reptans*
Carnation sedge	*Carex flacca*
Creeping bent	*Agrostis stolonifera*
Creeping buttercup	*Ranunculus repens*
Enchanter's nightshade	*Circaea lutetiana*
False wood-brome	*Brachypodium sylvaticum*
Filmy fern	*Hymenophyllum species*
Hard fern	*Blechnum spicant*
Hay-scented buckler-fern	*Dryopteris aemula*
Herb-Robert	*Geranium robertianum*
Himalayan balsam	*Impatiens glandulifera*
Himalayan honeysuckle	*Leycesteria formosum*
Japanese knotweed	*Fallopia japonica*
Lady fern	*Athyrium filix-femina*
Lesser celandine	*Ranunculus ficaria*
Marsh bedstraw	*Galium palustre*
Marsh marigold	*Caltha palustris*
Meadowsweet	*Filipendula ulmaria*
Narrow-leaved helleborine	*Cephelanthera longifolia*
Nettle	*Urtica dioica*
Primrose	*Primula vulgaris*

Purple moor-grass	*Molinia caerulea*
Red campion	*Silene dioica*
Reed canary-grass	*Phalaris arundinacea*
Remote sedge	*Carex remota*
Soft shield fern	*Polystichum setiferum*
Violet	*Viola riviniana/reichenbachiana*
Water dropwort	*Oenanthe crocata*
Water mint	*Mentha aquatica*
Wood anemone	*Anemone nemorosa*
Wood avens	*Geum urbanum*
Wood melick	*Melica uniflora*
Wood sorrel	*Oxalis acetosella*
Woodrush	*Luzula sylvatica*
Yellow flag	*Iris pseudacorus*