Establishment, Design and Stocking Densities of New Native Woodlands

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Native Woodland Scheme Information Note No. 5

Native woodlands are an important reservoir of biodiversity, containing a host of specialist and non-specialist woodland flora and fauna. Today, nearly 2% of the land area of Ireland contains woodlands that are largely indigenous in nature, although often containing exotic and naturalised tree and shrub species (Perrin *et al*., 2008). It is widely recognised that woodland biodiversity is best protected through woodland expansion aimed at reversing woodland fragmentation in the landscape generally.

This Information Note examines the principal issues surrounding the creation of new native woodlands. Introduced in late 2001, the primary objective of the Native Woodland Scheme (NWS) is the conservation of existing native woodlands and the creation of new native woodlands. However, where appropriate, the production of quality wood is a secondary objective under the NWS. Therefore, initial establishment spacings and subsequent management regimes may vary, depending on the species involved and whether the objectives are wholly conservation-based, or involve conservation and wood production. This document is intended to provide guidance within the context of the NWS regarding establishment methodology and design.

Experience and guidance from the UK is outlined and though it is clear that not all of it is applicable under the NWS, it does provide a useful context when approaching this subject under Irish conditions. Attention is drawn to the required standards under the NWS, as set out in the *Native Woodland Scheme Manual* (2008). Alternative proposals must be highlighted in the Native Woodland Plan and approved by the Forest Service.

INTRODUCTION

There has been very little experience in Ireland to date in the design and establishment of new native woodlands. In order to develop guidance and recommendations regarding planting mixtures, spacing and design, the experience of native woodland establishment in the UK has been assessed (Rodwell & Patterson, 1994). The preferred method of expanding native woodlands in grant-aided schemes in Scotland is through natural regeneration. Planting is eligible for grant-aid but only if natural regeneration will not succeed. In Scotland, the overall objective, as in England and Wales, is to primarily deliver conservation and biodiversity benefits via expansion of native woodland with occasional reference to wood production (Rodwell

& Patterson, 1994; Anon, 1998; Harmer, 1999). There is very little prescriptive information from the UK regarding the production of quality wood when designing and planting new native woods.

In Ireland, new native woodlands are generally established on *greenfield* sites, i.e. pasture, arable sites, etc., which are funded in Ireland under Element 2 of the NWS. However, there are sometimes opportunities to convert existing non-native woodlands to native woodlands, an activity which is funded under Element 1 of the NWS. One example concerns the conversion of conifer woodlands adjacent to streams, rivers and lakes to native riparian woodland – see *Native Riparian Woodlands – A Guide to Identification, Design, Establishment and Management* (Woodlands of Ireland, 2008). A further example includes the conversion of non-native stands on old woodland sites that have considerable potential as future native woodland, i.e. that contain diverse ground, field and/or shrub layers dominated by native species (Pryor *et al*., 2002; Humphrey *et al*., 2003).

Whatever situation is being considered, the overriding objective is to promote the most suitable native woodland community for the site. In existing old woodlands this can be ascertained from the ground flora and shrub layers in addition to any native trees present. On greenfield sites soil type and fertility, in addition to adjacent old woodland or hedgerow boundaries provide indications as to the most appropriate woodland community to establish. However, there are occasions when native species are found growing successfully on sites that are not typical for that species, e.g. hazel and ash planted in hedgerows in upland sites with acid soils. Under these circumstances these species are misleading as they cannot regenerate successfully from seed and are not suitable in the creation of new native woodlands in these locations.

Details of native woodland communities found in Ireland are provided in the *Native Woodland Scheme Classification System* (Cross, 2008) in Appendix 7 of the *Native Woodland Scheme Manual* (Forest Service, 2008). This should be consulted at the planning stage subsequent to the ecological survey of the site.

In Ireland, native woodlands are highly fragmented, often isolated and most stands are small. A recent survey (Perrin *et al*., 2008) found that 50% of woodlands are 6 ha or less and only 3% exceed 50 ha. This fragmentation has undoubtedly resulted in a loss of biodiversity, especially of those species requiring forest interiors or large expanses of forest (Peterken, 2002). New planting can, in part, help to reduce fragmentation and prevent further loss of biodiversity and perhaps even reverse it. To this end consideration at a landscape level is required, whereby new planting enlarges or links existing woods, or creates a denser network. Peterken (2002) shows that isolation becomes minimal when 30% of the landscape is wooded but at least 50% cover is required to create 'internal' habitats, at which point the landscape changes from an open matrix with scattered woodland to a woodland matrix with 'holes'. Therefore, when considering establishing and designing new native woodlands, efforts should concentrate on planting close to existing stands in order to maximise conservation and biodiversity objectives[1].

DESIGN AND PLANTING PATTERNS

Though experience in creating new native woodland in Ireland is limited, interest in this subject is considerable and this is reflected in a moderate increase in the number of applications for Element 2 of the Native Woodland Scheme in recent years. In this section a broad outline of how this subject is approached and the experience derived of new native woodland establishment in the UK is outlined in order to provide a basis for subsequent recommendations under the Native Woodland Scheme.

Native woodlands show a great variety of structure and species-composition even within a single woodland type, resulting from a combination of natural site factors and management history. The best guarantee of success is to match sensitively the species choice and planting pattern to the natural character of the site, notably the landform/topography, soil and existing vegetation. There is no point in precisely designing the detail of future canopy structure, because nature will inevitably alter the details. A robust but varied pattern which gives each species a good chance of contributing to the mature woodland structure, will generally be best (Rodwell & Patterson, 1994).

In the UK a combination of planted clumps and open areas is recommended (Fig. 1). There are six main variables used to develop planting pattern:

1. Species composition of clumps
2. Clump size and location
3. Spacing of overstorey, understorey and minor species in adjacent clumps

1 *The conservation assessments of native woodlands undertaken in 2006 under the EU Habitats Directive found that all designated woodland habitat types – old oak woodland, alluvial woodland, bog woodland and yew woodland – are in 'poor' or 'bad' condition. Contributing factors include fragmentation and small size of stands. Ireland is obliged to rectify this state of affairs and planting new native woodland will be an important step towards this goal.*

Fig. 1: A newly planted native woodland in Scotland. Note the differential spacing and clumping pattern (as depicted by the tubes used to protect the trees from browsing) which results in increased diversity as the woodland develops.

4. Spacing of overstorey, understorey and minor species within clumps

5. Size of gaps between clumps

6. Size and location of larger open areas; minimum % of open area.

Experience with **intimate mixtures** where numerous species are planted together indicate that it is difficult to maintain all the species used. Growth rates are frequently badly matched and slower growing species are eliminated. It is best to use two or three well-matched species at most and intimate mixtures should only be used where they serve a specific purpose, such as softening species or woodland type boundaries. Great variety can be achieved by altering the other variables (Rodwell & Patterson, 1994), and using:

1. **Single species clumps** or **clumps comprising 2 to 3 well matched species** ranging in size from single isolated overstorey species to larger stands of 50 m or more in width (Figs. 2a & 2b).

2. **Gaps between adjacent clumps** can be varied from approximately 7 m (which will eventually close over in most cases) to 20 m or more (Fig. 2c).

3. **Clumps of slow-growing overstorey** or **understorey and minor species** should be large enough to prevent excessive shading by adjacent groups of taller overstorey (Fig. 2d).

4. **Spacing within clumps** or **in adjacent clumps** can also be varied to avoid the appearance of rows and grids and to provide a range of light and other conditions, which should favour wildlife diversity. The simplest tactic is to vary spacing in adjacent clumps rather than within a single clump, but the latter method will be valuable on irregular sites (Fig. 2e).

5. **Gap widths** of 10 m are recommended to encourage shade tolerant woodland herbs; larger widths will favour woodland margin plants and animals.

6. Larger open areas greater than *c.* 25 m across can be used to provide glades and accommodate valuable habitats and biodiversity features present, e.g. marsh, fen, rocky outcrops, open water, etc.

In the UK, where natural regeneration is supplemented with planting, stocking rates are generally low; in Scotland, where conservation objectives are the norm, an average of at least 1600 stems/ha across the site is required in order to define the site as established (Anon., undated).

All of these guidelines should be used flexibly and the pattern should be dictated primarily by the character of the site and the specific objectives required. Figures 2a to 2e derived from the UK experience (Rodwell & Patterson, 1994) are used for illustrative purposes and should be considered in tandem with the terms and conditions of the NWS, set out in the *Native Woodland Scheme Manual* (Forest Service, 2008).

Fig. 2a: Using pure clumps with one to three well-matched species to develop mixed woodlands (adapted from Rodwell & Patterson, 1994).

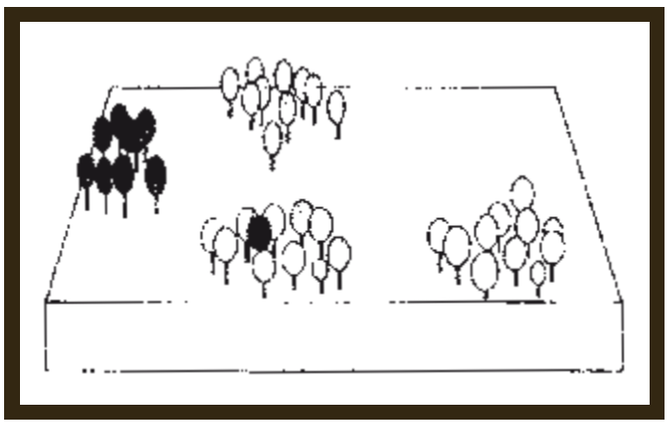


Fig. 2b: Using varied clump size to increase diversity in new native woodlands (adapted from Rodwell & Patterson, 1994).

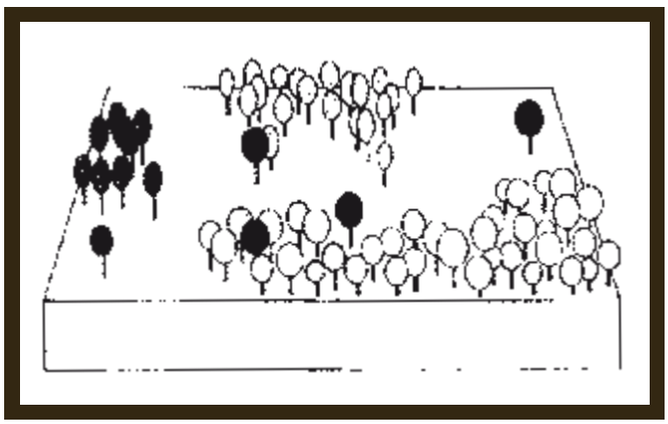


Fig. 2c: Using varied spacings between clumps to increase diversity in new native woodlands (adapted from Rodwell & Patterson, 1994).

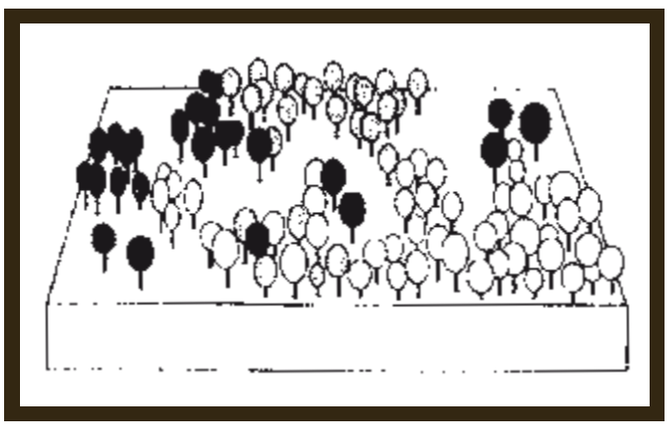


Fig. 2d: Allowing enough room around slow-growing shrubs to prevent excessive shading by adjacent trees (adapted from Rodwell & Patterson, 1994).

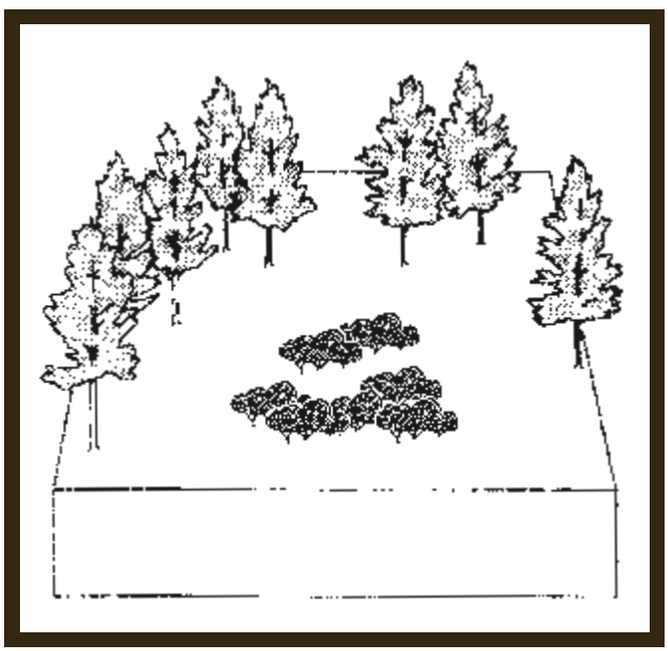
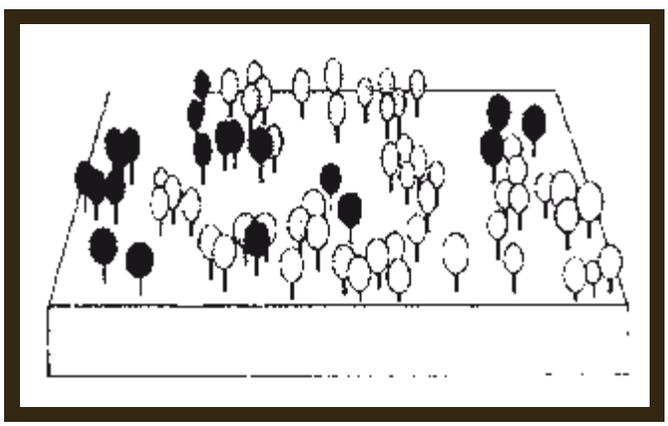


Fig. 2e: Using varied spacing within clumps to increase diversity in new native woodlands (adapted from Rodwell & Patterson, 1994).



APPLICATION OF THE NATIVE WOODLAND SCHEME

Management objectives

The objective is to design, establish and eventually create woodlands with a diverse structure and a natural woodland character. Attaining the native woodland community most suitable for the site is of paramount importance. The native woodland type being created must be specified using the classification system (Cross, 2008) outlined in the *Native Woodland Scheme Manual* (Forest Service, 2008).

Decisions regarding the management of sites under the NWS all stem from the **on-site objectives**. Depending on a number of factors, the objectives can be nature conservation alone or can combine an element of wood production. Many sites will combine a variety of objectives, including recreation. Objectives are decided based upon:

- landowners' wishes/objectives for the site
- ecological report, especially the assessment of current or potential nature conservation values of the site and ecological suitability for various species
- silvicultural site assessment – suitability for growing various species and wood production potential

The objectives should be clearly stated as part of the application process of the NWS. Of particular relevance are the necessary site and silvicultural requirements and adherence to the Native Woodland Plan template. The design specification and species recommended should be included in the NWS Native Woodland Plan (Forest Service, 2008). The plan should be kept as simple as possible as overcomplicated prescriptions often result in impractical and costly outcomes. In addition, if the owner intends to manage the site with wood production as an associated objective, a complex assemblage of species with poor economies of scale should be avoided.

In contrast to the UK, experience to date in Ireland suggests that caution should be applied particularly when leaving large gaps in new native woodlands. It can make establishment complicated, cause problems with subsequent cleaning operations, delay canopy closure and in some landscapes, encourage non-natives getting a foothold.

Further guidance on the management of broadleaves for wood production, which is outside the scope of these guidelines, can be obtained in Joyce *et al*. (1998), Horgan *et al*. (2003) and Little & Cross (2005).

Establishment methods

In Ireland, within the timeframe of the NWS, planting is the most common method of establishment, with or without natural regeneration. Where natural regeneration is highly probable and expected to occur an extension from 4 to 8 years within the NWS can be obtained after consultation with the Forest Service.

Under the NWS, between 18-20% of the site must comprise Areas of Biodiversity Enhancement (ABE), which includes open space and retained habitats (Forest Service, 2008). Open space may be incorporated during the initial establishment stage to increase biodiversity, e.g. glades and uneven agedness, and/or to improve the visual aspect within the landscape, e.g. the creation of non-linear, wavy boundaries. This represents the initial step in the development of a diverse woodland containing a matrix of woodland canopy and open habitats. In the NWS Native Woodland Plan all non-woodland habitats should be described using Fossitt (2000). As the woodland develops, suitable management can be applied to retain or (if appropriate) expand these open habitats. In addition, these woodlands have a tendency to develop natural gaps as they approach the thicket stage and beyond. Therefore if it is the intention that open spaces should be kept open, this should be specified in the NWS Native Woodland Plan as well as the operations required to achieve this objective.

Natural regeneration

In situations that are considered to be both **practical** and **appropriate**, natural regeneration may be used as a means of establishing native woodland. The establishment of a suitable native overstorey through natural regeneration is regarded from the ecological perspective as being the most desirable approach to establishing new native woodland cover, both within existing woodland and on greenfield sites. Natural regeneration can be considered as an important management tool, particularly in the restructuring and ongoing perpetuation of existing woods. A detailed study on natural regeneration in Ireland (Blackstock, 1998) outlining the advantages and difficulties, will form the basis of a future NWS Information Note.

It is entirely appropriate and desirable that natural regeneration is promoted within the NWS. During the planning stage areas identified as suitable for natural regeneration and where it will be promoted should be identified on the Native Woodland Plan map and the associated operations specified in the NWS Native Woodland Plan. In some situations natural regeneration can be very prolific and rapid, especially following disturbance within woodlands (Fig. 3). On greenfield sites contiguous to existing native woodland, and areas cleared of exotic and/or naturalised overstorey and understorey and minor species within long-established native woodland, new woodland of high conservation value can be established relatively quickly. Elsewhere it may take many years, i.e. on former pasture sites.

Fig. 3: A vigorous stand of respaced ash at Charleville demesne, Co. Offaly. The ash established rapidly from natural regeneration after a number of large oak trees were removed *c.* 30 years ago.

In Ireland however, there are a number of specific obstacles that compromise natural regeneration, especially climatic conditions and biotic factors. Conditions that mitigate against natural regeneration include:

1. No suitable seed sources
2. Low frequency of mast years for specific species, i.e. oak (*Quercus petraea* & *Q. robur*) and hazel (*Corylus avellana*)
3. Extensive seed predation, i.e. birds, mice, squirrels, etc.
4. Browsing by rabbits, hares and deer
5. Where aggressive, exotic and/or native species are dominant
6. Lack of understorey species allowing the forest floor to receive too much light and becoming colonised by grasses, bramble, etc.
7. Oak mildew and defoliating insects
8. Frost damage
9. Luxuriant ground flora of competitive plants that adversely affect seedling growth, e.g. grassland
10. Where clearances within existing woodlands are too large
11. A lack of the necessary skills and experience amongst the forestry profession required to encourage natural regeneration

In the case of oak, scarification prior to a mast event can aid natural regeneration. However, in some situations operations such as scarification may be inappropriate and planting only should be considered. An example is where the ground flora/ shrub layer has very high conservation value and it is inappropriate to disturb the soil. Similarly, where *Rhodendron ponticum* is present in the vicinity disturbed soil is an ideal seed bed for its establishment – see NWS Information Note No. 3: *The Control of Rhododendron in Native Woodlands* (Woodlands of Ireland, 2007c).

In summary, natural regeneration should be encouraged but cannot always be relied upon to establish new native woodlands. Some pioneer species such as birch (*Betula pendula* & *B. pubescens*) and alder (*Alnus glutinosa*) may regenerate profusely whilst other species such as hazel and oak can be very difficult to establish through natural regeneration. In practise, natural regeneration is used in conjunction with planting to establish native woodlands in Ireland.

Planting

Where natural regeneration is impractical planting will be the preferred establishment method at the outset (Fig. 4). Furthermore, where natural regeneration is attempted but does not result in a sufficient woodland cover by year 4, supplementary enrichment planting will be required to meet Forest Service NWS standards. If planting is taking place either alone or to supplement natural regeneration, consideration of numerous factors is required, including the origin of the planting stock, the woodland community that is being promoted, soil conditions and owner's objectives, i.e. conservation with or without wood production, recreation, etc. Objectives will vary from site to site and at the discretion of the applicant.

Origin of planting stock

In order to maintain genetic integrity and diversity through the application of genetic conservation principals only native trees and shrubs of Irish origin should be used where planting is envisaged (except Scots pine which is believed to have become extinct in Ireland and hence all current planting stock traces its origins to Scottish trees grown in Irish seed orchards). Irish native trees and shrubs have adapted and evolved over long time periods and are considered best suited to local conditions. All planting stock used in the NWS must be derived from suitable seed sources from within the island of Ireland (Forest Service, 2008).

Fig. 4: A recently planted oak-ash-hazel woodland at Ballyvary, Co. Mayo, created under Element 2 of the NWS. The young woodland in the foreground is an extension of an adjacent, existing hazel-dominated woodland on the rising ground in the background.

Due to the relatively small size of Ireland, the limited geographical variation, the recent arrival of the flora and fauna, the relatively limited biodiversity and the widespread planting of species of unknown origin and provenance the island of Ireland is designated as one seed zone (Little & Cross, 2005). Genetic studies and provenance trials in Ireland show that genetically distinct local populations occur as well as considerable variation in specific growth-related traits (Kelleher, 2003, Kelleher *et al*., 2004a, 2004b, Kelleher *et al*., 2005; Thompson & Lally, 2000). Where possible, seed should be sourced from local populations. This will ensure that the genetic integrity of a site is maintained. Specifically, in designated Special Areas of Conservation (SAC) and/or Natural Heritage Areas (NHA) and on greenfield sites adjacent designated sites, seed should be sourced from local populations. Where this is not possible it should be sourced from the nearest comparable area, i.e. from trees and shrubs growing on the same soil types with similar climatic conditions and altitude. While it is difficult to put a hard and fast boundary to 'the nearest comparable area', a radius of *c.* 30 km would be reasonable. On greenfield sites that are geographically distant from designated sites, stock may be sourced from further afield. However, the planting stock sourced should nonetheless be from similar site conditions with respect to climate, altitude and soil types.

Plant spacing – general

The stocking density recommended by the forester and ecologist should be discussed with the Forest Service before being finalised in the NWS Native Woodland Plan. Overstorey, understorey and minor species spacing will vary depending on the objectives, as will final stocking densities. Subsequent respacing will almost certainly be required where wood production is an objective. Although the NWS is only in place less than a decade in Ireland, it has already demonstrated how well some native species can perform when selected to grow on appropriate sites, e.g. alder and birch.

As there may be possibilities for producing quality wood under the NWS, tree establishment experience of Irish forestry should also be drawn upon (Joyce *et al*., 1998), especially recent research relevant to hardwood production (Horgan *et al*., 2003).

As a general rule of thumb:

- **Close spacings** of 2 m or less should be used where timber quality is important and also to accelerate canopy closure to provide earlier opportunities for specialist woodland plants and animals to colonise.
- **Wider spacings** of 3-5 m commonly adopted in conservation planting will result in slower canopy closure and a bushier form of tree or shrub (Rodwell & Patterson, 1994). However, experience with spacings of this nature indicate that subsequent maintenance is very difficult and hence, wider spacing are generally not recommended.

For planting under the NWS the following guidelines are recommended:

1. It is proposed that for all species the widest spacing used should be **no more than 2.5 m x 2.5 m** where conservation is the sole objective (to give an average target density of 1600 stems/ha across the site). It is important to provide full details in the NWS Native Woodland Plan. The proportions of the species used will depend upon site conditions and the native woodland type being developed. Planting pattern will

normally integrate clump planting and open areas. As well as attaining conservation objectives over a shorter timeframe by accelerating canopy closure, closer spacings (e.g. 2.0 m x 2.5 m to give 2000 stems/ha) will also result in less follow-up maintenance, especially vegetation control (Fig. 5).

2. It is recommended that where there is a wood production objective, planting should reflect this with spacings of **2 m or less**. In other words, higher planting densities should apply, to give a minimum final stocking density across the site. This will allow for thinning and stem selection as the woodland develops. Final densities will depend on the species being established and are discussed later. Where wood production is an objective, management details for specific native species are provided elsewhere (Little & Cross, 2005).
3. A further option integrating both elements above is to plant pioneer species, i.e. birch or alder, at a spacing of 2.5 m x 2.5 m, where appropriate. When the woodland reaches about 6 m, reduce stocking to 1000 and 800 trees/ha respectively, and introduce groups of light sensitive species such as oak, cherry (*Prunus avium*) and ash (*Fraxinus exselsior*).

However, it should be borne in mind that the over-riding characteristic of all light sensitive species is their light demanding nature and therefore the need for vigilance in the provision of additional growing space in line with the woodland's development. Whilst in the young growth stage the light sensitive species listed will tolerate some shade. However, oak and cherry in particular, quickly become shade-intolerant and their survival and growth is dramatically reduced if they are not released from competition. Moreover, competition results in the development of dead branches which in the case of cherry are retained on the stem for many years. In cherry, dead branches greater than 3 cm provide direct access for fungi which quickly spread resulting in serious stem decay. Cherry is therefore best grown at 2.0 m x 2.0 m spacing and subsequently managed to free up the crowns as the woodland develops so that they develop under conditions of almost free-growth, i.e. where crowns are free to develop unhindered by adjoining trees. This is best achieved in small areas of *c.* 0.4 ha within the woodland matrix or near the boundary of the woodland in plots no greater than 1 ha. If free-growth and artificial green pruning (at intervals as frequent as every two years) are combined, a clean bole of up to 6 m can be achieved. Furthermore, these woodlands need careful management to prevent whipping of the leaders of the introduced species by the adjacent birch. In addition, whatever mixture is applied should be in keeping with the most appropriate native woodland community for the site.

Fig. 5: A proposed 'greenfield' site for Element 2 of the NWS in the uplands of Co. Wicklow. The development of new native woodland on former pasture sites requires careful maintenance subsequent to planting, especially to control bracken and grasses, at least until the trees and shrubs have outgrown the competing vegetation.

Planting sensitive species

Some species which are found in old native woodlands are especially sensitive to conditions which may be found in newly established woodlands such as exposure, light, drought, frost and strong weed competition. For example, yew (*Taxus baccata*) is intolerant to severe and prolonged frost (Thomas & Polwart, 2003) and holly (*Ilex aquifolium*) to drought, heavy shading and browsing (Peterken & Llyod, 1967). Many sensitive species tend to colonise later in natural successions and are adapted to moderate shade and shelter and to well-developed woodland soils (Rodwell & Patterson, 1994).

The most practical solution for sensitive species within the limited timeframe of the NWS where prospects of adequate natural colonisation are poor is to plant them at the outset, but to take special care to restrict them to the most suitable parts of the site, especially along sheltered edges and glades, and to favour them in subsequent tending operations. Alternatively, one may consider point 3 described above and introduce sensitive species at the pole stage, e.g. cherry in a birch-alder mixture.

Native Woodland Scheme Element 2: Establishment on greenfield sites

Establishing native woodlands on greenfield sites may be achieved either through planting alone or through a combination of natural regeneration and planting. In most cases it is impractical to expect natural regeneration to colonise the site in the timeframe of the NWS, especially where seed sources are distant and/or on sites that have not had previous woodland cover for a century or more. In such cases, the absence of a seed bank and soil mycorrhizae coupled with exposure mitigate against adequate natural regeneration.

Conservation

Where conservation is the **only** objective in establishing native woodlands the final target stem densities across the site should be lower compared with areas where wood production is an objective. A good example where conservation only is the sole objective is where a new area of woodland is being established on a greenfield site with soils of low fertility contiguous to an existing designated native woodland of high nature conservation value, i.e. extension of an SAC woodland. Under these circumstances spacings of *c.* 2.0 m x 2.5 m are recommended which will result in an average target density of **2000 stems/ha*** across the site. It is imperative that these spacings are agreed with the Forest Service after consultation during the planning phase.

Wood production

Greenfield sites where soils are fertile and of sufficient depth, i.e. approx > 50 cm, to enable vigorous growth are particularly suitable for wood production. Shallower soils may be suitable for species such as hazel, birch and alder. Where **wood production** is also an objective the following spacings are recommended when planting single species clumps:

- 2.0 m x 1.5 m – ash, birch or cherry (the latter in small groups only; < 30 trees) (approx. 3,300 stems/ha*). Where early thinning of cherry will not be carried out it is preferable to plant it at 2.0 m x 2.0 m spacing. Previous comments on the management of cherry should be taken into account, i.e. Option 3, page 8).
- 2.0 m x 1.8 m – common alder (approx. 2,800 stems/ha*) where thinning commences early, by year 10 at the latest. Where early thinning of alder will not be carried out on time it is preferable to plant at 2.5 m x 2.5 m.
- 2.0 m x 0.75 m – sessile or pedunculate oak (approx. 6,600 stems/ha) is the standard planting recommendation in Ireland where oak is grown in pure clumps in conjunction with other species depending on the woodland community being developed. Alternatively, the oak can be intermixed with alternate lines of birch at 2 m spacing to give an overall density of 4,500 stems/ha. Recent observational evidence favours a square spatial arrangement, i.e. 1.3 m x 1.3 m. In addition, where conditions are favourable excellent quality oak can be produced at stocking levels as low as 4,000 stems/ha.

Where appropriate mixtures are used (Table 1), final densities will depend on whether there is a wood production objective included. The higher densities indicated previously should apply if this is the case. Otherwise the lower density of 2,000 stems/ha will suffice. The suggested mixtures in Table 1 are derived from Joyce *et al*. (1998), Horgan *et al*. (2003), Rodwell & Paterson (1994) and silvicultural practitioners in Ireland.

If approved minor and understorey species are being planted it is recommended that they comprise up to 20% (or more if justified) of the grant-aided area and are best located at the fringes of overstorey plantings at a spacing of 3.0 m x 3.0 m (approx. 1,100 stems/ha, e.g. holly and hazel). Additional understorey, 'edge' or 'mantle' species, which also soften the edges of newly-created woodlands include rowan (*Sorbus aucuparia*), hawthorn (*Crataegus monogyna*), blackthorn (*Prunus spinosa*), cherry, aspen (*Populus tremula*) and grey willow (*Salix cinerea*). The use and location of minor and understorey species at establishment should be matched to site conditions and light sensitivity, i.e. rowan should be planted at the outer edge where it will not be subject to shading. Edge/mantle species are site-specific and should be detailed in Part 4 and 5 of the NWS Native Woodland Plan and listed in the Certified Species Map.

An example of how a new native woodland is established with a projection over time with respect to its development is graphically depicted in Figures 6a-6c.

Native Woodland Scheme Element 1: Conservation – conversion from non-native woodland to native woodland

Where non-native woodlands are being converted to native woodlands design and establishment are critical factors to consider. The conversion of conifer plantations in riparian zones is dealt

* **Note:** *this does not imply blanket nor grid planting; emphasis is placed on spacing as opposed to density or stems/ha.*

Table 1: Examples of potential mixtures of native timber trees.

[a]**Nursing and [b]other mixtures for shelter and frost protection**	Birch nursing oak[a] (acid, moderately infertile; heavily thinned/coppiced)
See earlier comment on light demanding characteristics of these species	Birch in mixture with oak, ash and cherry (main spp planted when birch reaches 6 m. Birch heavily thinned)
See earlier comment on light demanding characteristics of these species	Alder with oak, ash and cherry (on heavy soils alder can be used to substitute birch as an overhead screen)
	Scots pine and oak[b] (Scots pine planted *3-4* years in advance of oak, but **not** on heavy soils
[c]**Intimate even-aged mixtures**	Birch with alder (wet, heavy clay soils)
	Oak with hazel (moderately fertile soils)
	Birch and Scots pine (moderately infertile soils)
	Ash with wild cherry (gean) (fertile, loamy soils – near neutral pH)

a *Oak can be planted at the same time or after birch, depending on birch density and degree of protection required. Planting birch at the same time requires a robust design, i.e. group or band spatial arrangement.*

b *In the establishment of permanent mixtures each species is provided with sufficient growing space, to enable both components to remain until at least the end of their respective rotation period. However, critical to their success is the need for a robust design, i.e. planted in a pattern without the need for intervention will ensure the survival of each species. Band or group type spatial arrangements best meet this criterion. For example, in the case of an oak/Scots pine mixture, the oak would be planted in groups of up to 100 m^2 alternating with Scots pine planted in groups of about 50 m^2. Alternatively the oak would be planted in bands 10 m in width, alternating with 6-8 m wide bands of Scots pine. The oak would be planted at a stocking density of about 6,000 stems/ha (1.3 m x 1.3 m spacing). To curb coarse growth and enhance the form of the Scots pine the stocking density should be in the order of about 4,500 stems/ha (1.5 m x 1.5 m spacing). If contemplating establishing such mixtures the initial slow growth of Scots pine should be borne in mind. Typically this slow early growth results in it taking up to 10 years to even catch up with the oak, thereby offering the oak no protection from frost and wind during a critical stage of its development.*

c *Only suitable where a woodland manager is employed beyond year 4 of woodland establishment. The success of intimate mixtures depends on the level of skill and commitment of the woodland manager. Success is especially dependant on management being exceptionally diligent in releasing the slower growing, threatened species. Intimate mixtures are more suitable for conservation only objectives. Understorey and minor species may be included, especially at the edge of internal clump plantings, woodland edges and boundaries.*

with elsewhere – see NWS Information Note No. 4: *Native Riparian Woodlands – A Guide to Identification, Design, Establishment and Management* (Woodlands of Ireland, 2008).
In particular, the conversion of conifer and other non-native plantations on old woodland sites presents opportunities for woodland biodiversity enhancement (Pryor *et al*., 2002; Humphrey *et al*., 2003) as well as some potential quality wood production. It is recommended to consult the detailed guidance note regarding the conversion of plantations on ancient semi-natural woodland sites to native woodland in the UK (Thompson *et al*., 2003). On all kinds of disturbed sites, including conifer plantations that are being removed, the time required to approximate to the desired semi-natural woodland flora is likely to be longer and the outcome more uncertain than for more natural sites (Rodwell & Patterson, 1994). (This is particularly true for reclamation sites and arable farmland, where the model woodland field layers may never fully develop by natural colonisation, and plants more typical of field margins and edges will remain for long periods of time).

Spaced group planting

In situations where the previous non-native woodland canopy is being removed (either at maturity or earlier due to biodiversity considerations), and where reasonably large coupes are created or in very sparsely stocked areas, e.g. in areas felled of conifers leaving a scattering of broadleaves, a possible solution to the problem may be found in the use of **spaced group planting**. By virtue of their favourable physical features and soil properties, many old woodland sites are eminently suitable for broadleaf species but are typically a haven for colonisation

Fig. 6a: A proposed design and planting pattern for Type B1: an oak-ash-hazel woodland on relatively deep, fertile brown earth soil (Cross, 2008). In addition to the primary goal of conservation and biodiversity enhancement, there is also a wood production objective. This planting pattern is robust as the oak and ash are planted as separate blocks within the overall planting matrix. Oak comprises 75% of the total woodland matrix with the remainder comprising ash, hazel, hawthorn, spindle (*Euonymous europaeus*) and guelder rose (*Viburnum opulus*). The minor understory species are concentrated toward the edges to ensure they receive sufficient light.

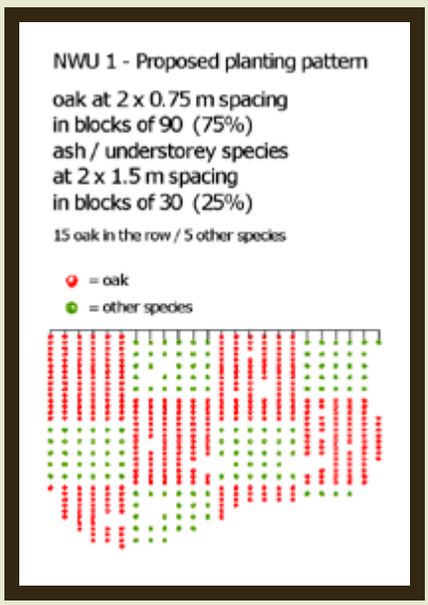


Fig. 6b: The woodland in Fig. 6a as projected after forty years. Note how the straight lines of the original grid system are being gradually lost.

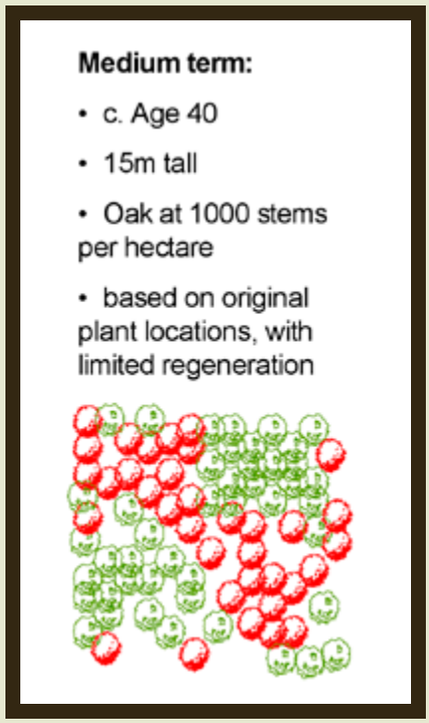
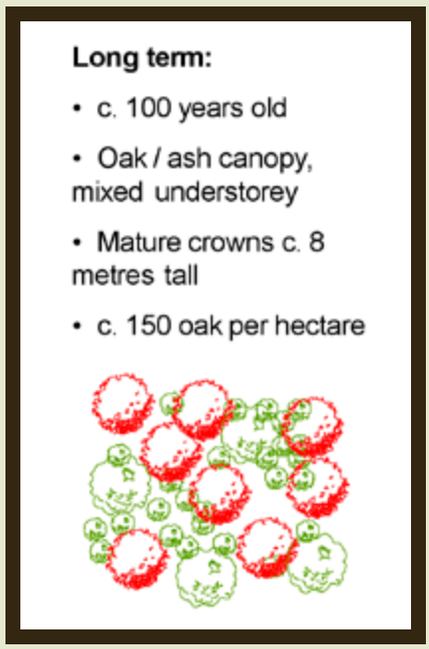


Fig. 6c: The oak-ash-hazel woodland as projected after approximately 100 years. At this stage a more mixed canopy has developed with understorey species.



by a wide range of competing woody and non-woody vegetation. Experience has shown that establishing woodland on such sites by conventional methods, 'clearfell and replant', whilst being both risky and expensive, the resultant trees are often less than satisfactory. Spaced group planting is a system that is not only particularly suitable to areas having the potential to be colonised by field and shrub layer floral species, but its effectiveness is directly correlated with the intensity and vigour of the invading volunteer species via natural regeneration.

This system can be adopted where conservation is the only objective but is particularly suitable where wood production is sought under a continuous cover forest system (Fig. 7). However, this system is **very dependent on intervention** otherwise poor quality timber will result. Where conservation is the sole objective a spacing of 2.5 m x 2.5 m is recommended (subject to agreement with the Forest Service).

The principle underpinning the proposed system where wood production is also an objective is that trees are planted in compact groups, within which individuals are closely spaced. The rationale is that one of the trees close to the centre of each group will ultimately be a 'candidate' for removal at maturity as a quality timber specimen. These trees, having benefited from the shelter and self-pruning effects of the peripheral trees in the group, as well as the shelter provided by the colonising species in the intervening areas, will not only have enhanced form, but the lower sections of their stems will be branch-free. However, cognisance should be taken of inter-group competition, as in the absence of timely intervention there is a danger that by virtue of their larger crowns, peripheral trees in the groups will grow faster than those in the centre. This problem can be alleviated by either the provision at establishment of more growing space to the trees at the centre of the groups and/or their early release by the removal of some inferior competing dominants.

The spacing within groups will be influenced by the species concerned. For example, species having poor apical

Fig. 7: The creation of an oak-ash-hazel woodland on a fertile soil adjacent existing old native woodland at Charleville demesne, Co. Offaly. The adjacent woodland provides shelter and a seed source for natural regeneration which is being promoted in a 20 m wide strip along the woodland boundary. The close spacing of the planted trees provides the option of managing for quality wood production (Image courtesy of Sasha Bosbeer).

dominance such as oak, should be planted in groups ideally consisting of up to 25 plants, set at a spacing of about 1.2 m x 1.2 m. Conversely, given suitable growing conditions wild cherry has excellent apical dominance and needs plenty of room for crown development. Where conditions are favourable, groups comprising as little as 10 plants at circa 2.5 m x 2.5 m spacing can be successful. In less favourable conditions and/or where there is a risk of abiotic or biotic damage, it would be prudent to increase group size.

With canopy species prone to epicormic shoot development, e.g. oak, consideration should be given to the planting of an understorey species such as hazel or holly around the perimeter of each group. The understorey species can be planted at a wider spacing, circa 2 m apart and 2 m from the main species. Also, where there is little evidence of immediate colonisation by trees in the intervening areas, early side shelter should be provided by planting some hardy species such as birch around the perimeter of the groups. While the mixing of species within groups is generally not recommended, mixed species plantations can be established under the proposed system if desired. This is best achieved by planting of individual groups with different species.

The spacing between groups will be governed by the objective of the plantation and species being used. If, for example, the groups consist of oak and wood production is an objective, then at most 100 groups/ha will be required, which equates to a group spacing of 10 m centre to centre. By contrast, an ash coupe would require up to 150 groups, reflecting a spacing of approximately 8 m between group centres. This, of course, ignores the fact that, with a system such as this, there is a strong probability of some excellent specimens of various species being produced from both natural regeneration, coppice growth and introduced species in the intervening areas.

If the intervening areas are colonised by vigorous native volunteer species, intervention can be confined to the maintenance of access paths linking the various groups, thereby facilitating their tending requirements. This also facilitates the removal of any trees interfering with the group planting. If on the other hand, colonisation is not expected pioneers should be planted at the outset. It will be necessary to supplement the existing cover with some fast growing species such as birch or alder, if appropriate to the woodland community being developed.

For old woodland sites the spaced group system has enormous potential, offering the owner a cost-effective method of producing quality wood in an environmentally acceptable manner, whilst also taking into account biodiversity and conservation aspects. The benefits of adopting the spaced group planting system are:

- Low impact – ground preparation confined to group positions
- Close to Nature – little impact on soil and/or water, with little disturbance to natural flora and fauna
- Reduced costs – less time on weeding, planting, cleaning, shaping and tending
- Quality hardwood production – enhanced form and light branching due to close spacing within groups
- Minimum intervention – reduced maintenance, self pruning
- Dual purpose – satisfies both conservation and wood production objectives

It is imperative that if group systems are used that there is proper layout of the site before supervision of the planting operations and a follow up system detailing the operations schedule to ensure intervention takes place at the correct times.

SUMMARY

The principal objective of creating new native woodlands within the context of the NWS is to focus on conservation and biodiversity enhancement criteria. In general, this means developing a woodland community comprised of native trees and shrubs of Irish origin that is suitable to the prevailing site conditions. Wood production is also possible within the overall biodiversity objective, where applicable.

Silviculture has been defined as the art and science of cultivating woodlands for all their diverse range of uses. It also needs to be remembered that since every site is unique, there is no standard recipe for achieving these objectives. In Ireland there is currently a lack of knowledge and training in the techniques and methods of achieving multiple objectives. Provided the necessary research is put in place to develop new techniques and also to adapting existing techniques to local needs, this will result in time, in increased competence and improve the application of the required silvicultural systems.

The success of establishing new native woodland areas either within existing woodlands or on green field sites depends on site factors, climatic variables, establishment techniques employed and follow-up measures. These variables mean that results can vary considerably from site to site. Establishment may be achieved by natural regeneration, planting or a combination of both methods. These guidelines provide assistance to practitioners depending on the objectives involved, i.e. conservation with and without wood production.

A degree of flexibility is required in the application of the guidelines as each site will require its own specific prescription. Where planting, the availability or otherwise of specific species from year to year also implies flexibility and alternative planting mixtures. (For example, when oak is in short supply its use may be reduced by increasing the birch component in the creation of oak-birch-holly woodland. This would effectively push the woodlands development more toward the pioneer phase of the oak-birch-holly woodland type. If this occurs after Forest Service approval, the Forest Service must be notified and the changes approved before planting).

Experience of the NWS to date indicates that it has been a great success in creating awareness for the potential of our native woodlands to address conservation, biodiversity, recreation, carbon sequestration and limited wood production objectives. Wider application of NWS Element 2: Establishment (of new native woodlands) coupled with uninterrupted grant aid has the potential to significantly expand native woodland cover, increase and enhance woodland biodiversity, and produce quality native hardwoods to the benefit of conservation and forestry policy objectives, land owner's income and the National economy.

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