# Native Riparian Woodlands – A Guide to Identification, Design, Establishment and Management

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woodlands OF IRELAND
Coillearnacha Dúchasacha

Native Woodland Information Note No. 4

Riparian woodlands are one of the rarest native woodland types in Ireland and are threatened by clearance and drainage activities. However, the Native Woodland Scheme (NWS), implemented by the Forest Service (Department of Agriculture, Food and the Marine) in partnership with Woodlands of Ireland, the National Parks and Wildlife Service (Department of Arts, Heritage, Regional, Rural and Gaeltacht Affairs), the Heritage Council, Inland Fisheries Ireland and others, provides an opportunity to protect and enhance existing native riparian woodland, and to create new areas of native riparian woodland on greenfield sites. Where appropriate, the scheme also facilitates the conversion of conifer plantations within riparian zones into native riparian woodland. These applications have the potential to realise significant biodiversity and environmental benefits, not only in terms of promoting a rare form of native woodland, but also in terms of protecting and enhancing water quality and the aquatic ecosystem. Given that streams, rivers and lakes act as corridors and 'stepping stones' in the landscape, these positive effects extend far beyond the site itself.

The purpose of this Information Note is to provide guidance on the identification, design, establishment and management of native riparian woodlands. It provides background information on native riparian woodland in Ireland, and reviews the ecological and protective functions such woodland play *vis-à-vis* the aquatic system and water quality. It also describes the different native woodland types that occur in Ireland, to aid in the identification of the most appropriate type(s) to promote on a particular site. The Information Note then addresses the practical issues associated with the three main ways in which the Native Woodland Scheme can be applied in riparian areas, i.e. managing existing native riparian woodland; restoring native riparian woodland on conifer plantation sites; and establishing new native riparian woodlands on greenfield sites.

This Information Note has been developed with input from a number of key authorities and bodies active in the area of native woodland and freshwater management in Ireland. Given that it deals with a type of woodland development that is largely unexplored, the note should be regarded as an initial attempt to draw together up to date information and current best practise, and further versions are likely as experience grows. The note is intended as a guide to inform the development of applications under the Native Woodland Scheme on riparian sites. Attention is drawn to the operational procedures *Forestry Standards and Procedures Manual* (Forest Service, 2015) and to the terms and conditions of the scheme, set out in the *Native Woodland Conservation Scheme* (Forest Service, 2015a) and *Native Woodland Establishment GPC 9 & GPC 10* (Forest Service, 2015b). Of particular relevance are the necessary site and silvicultural requirements, adherence to the Native Woodland Plan template, and specific requirements regarding sites adjoining water bodies.

## INTRODUCTION

Well-managed native riparian woodlands play an important part in conserving and expanding woodland biodiversity, in addition to providing habitats essential to the lifecycle of freshwater organisms. The term 'riparian woodland' is interchangeable with 'alluvial woodland', which is defined as 'woodland that is subject to periodic flooding by a stream, river or lake, even at irregular and infrequent intervals but for long enough periods to determine the vegetation. The water may originate directly from the water body or from the rising water table. The soil will be principally alluvium'.

The protective function of native riparian woodland is particularly relevant to water quality, which also affects instream biodiversity value. Their value for nature conservation, landscape enhancement and recreation are exceptional. Most importantly, they are often the only woodlands remaining in some landscapes, and therefore, the last refuge for woodland species. They provide a vital conduit for the transfer of nutrients between terrestrial and aquatic ecosystems and play a vital role in capturing nutrients and silt which run off from adjacent lands.

**Fig. 1: A view of the riparian woodland at Durrow, Co. Laois, adjacent the Erkina River. This woodland is one of the largest remaining alluvial woodlands in Ireland. It is currently managed by Coillte under the EU LIFE 05 project. Under Annex 1 of the EU Habitats Directive, this site is given 'priority' status. Note that access is maintained on one bank, particularly for angling.**

### An overview of the history of native riparian woodlands in Ireland

Woodlands comprising native species dominated the Irish landscape for over 5,000 years after the last glaciation. Their subsequent decline was primarily due to clearance for settlement and agriculture – see NWS Information Note No. 2: *A History of Woodland Management in Ireland: An Overview* (Woodlands of Ireland, 2007a). It is almost certain that most of the woodlands remaining by the 18th century were generally situated in outlying inaccessible areas, in private estates and along river valleys, particularly in southern and western regions (McCracken, 1971; Rackham, 1995). Recent figures (Perrin *et al.*, 2008) indicate that only *c.*1.1% of Irish woodlands is indigenous in nature and that many are mixed with introduced tree and shrub species. Increased mechanisation and drainage in more recent times has allowed for the clearance of woodland in difficult terrain, especially along river valleys. Arterial drainage schemes undertaken principally between the 1950s and 1970s have altered and reduced riparian woodlands (Environmental Protection Agency, 1996). These activities have also tended to eliminate connectivity between aquatic and terrestrial ecosystems, thereby greatly reducing the natural interaction between river channels and their floodplains. Indeed, in most of Ireland's river catchments, the aquatic zone has effectively been removed from the floodplain as a result of drainage schemes.

In some areas, afforestation with coniferous plantations has also impacted negatively on native riparian woodlands and the aquatic ecosystem, particularly where planting was carried out up to the water's edge (Hickie, 1997; Heritage Council, 1999; McGarrigle & Cleneghan, 2004). In such cases, excessive shade coupled with siltation during ground preparation and harvesting undoubtedly had negative impacts on the aquatic system. It is also likely that some native riparian woodland fragments were converted to conifer plantations. As a result of all these factors, there are very few extensive natural riparian woodlands extant in Ireland, and most of those that remain are fragmented and are much reduced in area.

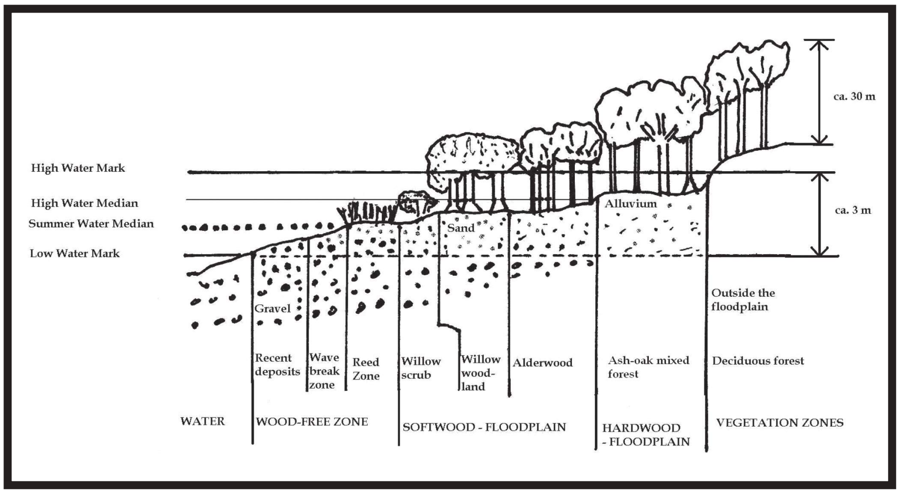
### Current Policy: The Native Woodland Scheme (NWS)

Introduced in late 2001 by the Forest Service, NWS is a grant package that provides funding to restore existing native woodland and to establish new native woodland on a range of sites, including those adjacent to waterbodies such as streams, rivers and lakes. On such sites, the scheme provides a mechanism to address the dual purpose of conserving and expanding native riparian woodland, ***and*** protecting and enhancing the adjacent aquatic habitat and water quality. The NWS also encourages appropriate wood production as a secondary objective where compatible with biodiversity, using 'close-to-nature' continuous cover silvicultural systems that take into account the sensitivities of the existing habitats and soils.

There are two elements of the NWS – full details contained in *Native Woodland Conservation Scheme* (Forest Service, 2015a) and *Native Woodland Establishment GPC 9 & GPC 10* (Forest Service, 2015b), both relevant within the context of native riparian woodlands. Element 1: Conservation provides funding for the protection and enhancement of *existing* native woodland and also, in certain circumstances, the conversion from non-native woodland (e.g. conifer forest) to native woodland. Element 2: Establishment provides funding for the establishment of *new* native woodland on *greenfield* sites, including those adjacent to water bodies.

The extent of Ireland's freshwater aquatic resource is substantial, with an estimated 16,000 km of main river channel and 16,000 km of tributaries and streams. There are also some 5,000 lakes totalling approximately 200,000 hectares. In addition, there is *c.*7,000 ha of conifer plantation forestry directly adjoining water bodies along the western seaboard, a portion of which is suitable for transformation into native riparian woodland. Currently, native woodland is not a dominant feature of these ecosystems, indeed a large proportion of Ireland's rivers and lakes have very little native riparian woodland cover. It is therefore apparent that there is considerable potential for using the NWS to improve the current situation. In addition, the National Native Woodland Survey (Perrin *et al.*, 2008) will enable the strategic targeting of the NWS in riparian areas. This would also enable Ireland to address current policy requirements under the EU Habitats Directive which requires Member States 'to take measures to maintain or restore natural habitats and wild species at a favourable conservation status, introducing robust protection for those habitats and species of European importance (Council Directive 92/43/EEC of 21 May 1992 on the conservation of natural habitats and of wild fauna and flora).

**Fig. 2: Schematic cross-section through the entire floodplain vegetation sequence adjoining a river. The alderwood can equally occur in the same location as the willow woodland. (Adapted from Ellenberg, 1996).**




**Note:** The NWS is ***not*** applicable to non-wooded habitats such as marsh, peatland, herb-rich grassland, etc., which are of considerable biodiversity interest. Important non-wooded habitats can be included in NWS projects as part of the 20% Areas for Biodiversity Enhancement allowance. See *Land Types for Afforestation* (Forest Service, 2016a) which must be adhered to with reference to site suitability criteria.

## THE RIPARIAN ZONE AND THE AQUATIC BUFFER ZONE – DEFINITIONS

For the purposes of this Information Note, a broad, functional definition of the riparian zone is used, i.e. 'Any land which adjoins, directly influences, or is influenced by a body of water' (Land & Water Resources Research & Development Corporation, 1998). Using this definition as the basis, the riparian zone includes:

- the land immediately alongside small streams and rivers, including the riverbank itself;
- gullies and depressions that sometimes run with surface water or are filled by groundwater influenced by nearby rivers or lakes;
- areas surrounding lakes; and
- wetlands on river floodplains that interact with the river in times of flood.

The riparian zone is therefore a discrete ecological and geographical entity (Fig. 2). Effectively, the riparian zone is the point of contact between the land (i.e. the terrestrial ecosystem) and the freshwater body (i.e. the aquatic ecosystem), and can be represented by a gradual or abrupt change from land to water. For the purposes of this Information Note an aquatic zone is defined as 'a permanent or seasonal river, stream or lake shown on an Ordnance Survey 6 inch map' (Forest Service, 2000a).

Riparian soils are subject to periods of saturation. In the context of woodland ecosystems, the time, duration, depth and periodicity of flooding are all important controlling factors. In addition, seepage areas within floodplains maintain a high water table locally, even when the river is not in flood. In the case of lakes, the riparian zone includes the lake margin up

to the high-flood watermark. Although unaffected by floodwaters, the margin of a spring-fed lake (such as those located in the drumlin belts on heavy-textured soils) can also be regarded as a riparian zone, as it may have, or can support, important wet woodland communities.

For practical woodland management purposes, the riparian zone can be divided further according to habitat protection and wood production objectives. The area targeted for habitat protection is defined in the *Forestry and Water Quality Guidelines* as the Aquatic Buffer Zone (ABZ), where management inputs are largely limited to operations designed to encourage natural habitat development (Forest Service, 2000a). The definition of the ABZ is '…an area adjacent to an aquatic zone [i.e. waterbody] and managed for the protection of water quality and aquatic ecosystems'. The width of the ABZ varies between 10 and 25 m, depending on the slope of the adjacent terrain, and soil erodability (Forest Service, 2000a). Despite their title, adherence to these 'guidelines' are in fact mandatory to all grant-aided projects and all licensed activities.

On many sites, the riparian zone will actually extend beyond the required ABZ. Outside the ABZ, there is a clear potential for wood production, using 'close-to-nature' silvicultural systems that retain a continuous canopy cover. The NWS is flexible enough to accommodate alternative objectives within the same site.

## ECOLOGICAL AND PROTECTION FUNCTIONS OF NATIVE RIPARIAN WOODLAND

Native riparian woodlands fulfil a number of key ecological and protection functions, which justify their conservation, enhancement and expansion. These functions are described in detail in the following sections.

### Ecological functions

#### Woodland biodiversity

Native riparian woodlands are biodiversity 'hotspots' and are often the only refuge for specific communities of flora and fauna of high conservation value. These refuges act as a primary source for the expansion of threatened species into other areas. Water is a powerful dispersal agent and assists colonisation: some species, such as common alder *(Alnus glutinosa)*, are adapted to water-borne dispersal. The creation of riparian woodlands results in an increase in flora and fauna associated with this ecosystem.

#### Instream biodiversity

Overhanging vegetation creates niches and supplies invertebrates and leaf-litter into the aquatic zone (i.e. stream, river, lake). This provides a vital food source for aquatic fauna (fish, invertebrates, etc.), especially in oligotrophic (nutrient poor and acidic) systems. In addition, there is a transfer of coarse organic matter from the woodland to the aquatic zone and, in the case of truly alluvial woodland, a transfer of nutrients from the stream to the woodland during flood events.

#### Temperature and shade

Stretches of overhanging woodland vegetation provide shade and cover, resulting in cooler areas with a more even temperature regime within the aquatic zone. This helps to regulate instream temperature extremes. Shade reduces water temperature and consequently helps to prevent oxygen depletion.

### Mitigation and curative functions

#### Flood control

Existing and new native riparian woodlands have an important role in regulating and controlling water flow. In upland areas, they reduce the speed of run-off into the aquatic zone. On floodplains, they act to slow water flow and increase groundwater recharge. By reducing flow and increasing evapotranspiration from the canopy, such woodlands reduce flooding (World Wildlife Fund, 2007a). The creation of gulley woodlands in upland areas buffer flood flows when they mature, thereby slowing flows down. Large woody debris which falls into gulley streams act as barriers that also reduce energetic flows. In addition, strategically planting trees directly in the path of floodwaters on lowland floodplains creates a leaky barrier effect which holds back floodwaters in the riparian zone.

#### Silt trapping

Sediment trapping is enabled by slowing the overland flow of water, allowing infiltration and "filtering" through vegetation before entry into the aquatic zone. This function is particularly relevant in the ABZ and significantly reduces sediment entry into the aquatic zone, which could otherwise cause serious damage to instream biodiversity, especially fish.

#### Nutrient trapping

Organic and inorganic nutrients within the overland flow of water are trapped mainly through infiltration and subsequently, through uptake by plants and the binding of phosphorus to clay and organic matter. This reduces the potential for eutrophication of the waterway. Some nutrients trapped in riparian woodland are "reintroduced" into the aquatic environment typically in the form of particulate organic matter, rather than as dissolved nutrients.

#### Partial shading

Partial shade leads to a reduction in primary productivity of instream plant communities (i.e. the amount of biomass produced through photosynthesis per unit area and time) that would otherwise be promoted by elevated dissolved nutrient levels in combination with full exposure to incident light levels. This reduces

channel domination and clogging by instream plants (macrophytes) and algae. In the context of increasing ambient temperatures as a result of climate change, riparian woodland, through partial shading, may play a crucial role in protecting and maintaining aquatic biodiversity and in particular, salmonid populations.

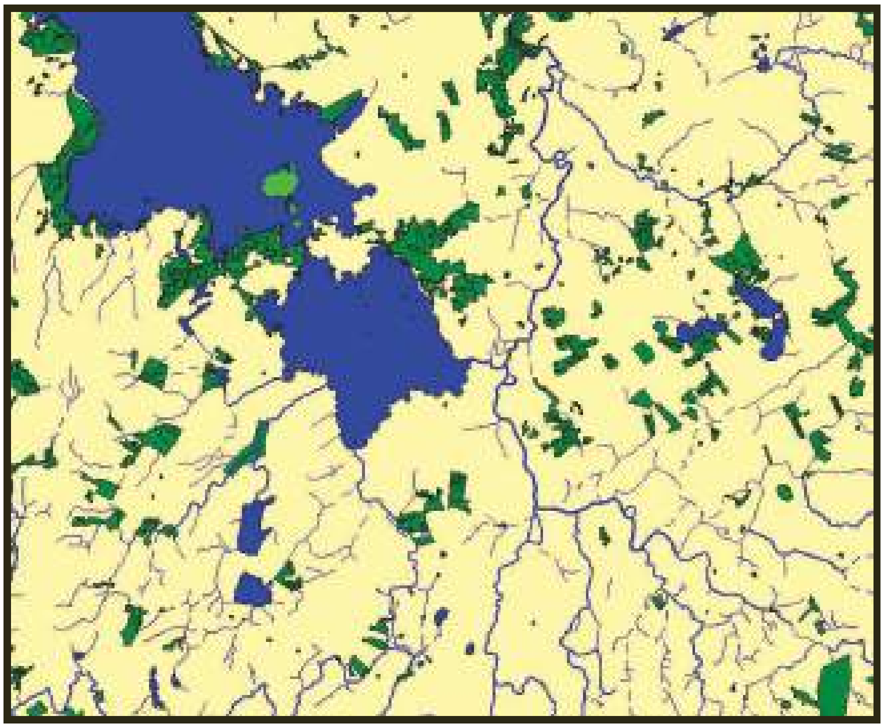
## Connectivity

As linear features in the landscape, native riparian woodlands can reduce fragmentation by connecting isolated woodlands, thereby creating greater structural diversity and critical mass, and ensuring the long-term viability and integrity of woodland ecosystems (Fig. 3). Restoring linkages between highly fragmented woodlands facilitates the spread of flora and fauna. Connectivity is both longitudinal along aquatic corridors, and lateral, from terrestrial to aquatic ecosystems. Measures to re-establish connectivity between aquatic and terrestrial ecosystems that have been separated as a result of drainage schemes resulting in canalisation of channels and lowering of the watertable, are relevant in this context.

## Erosion prevention

Trees and woodland alongside streams and rivers can reduce erosion by alleviating or reducing bank undercutting and preventing subsequent collapse, especially when strategically established on vulnerable banks. Tree and shrub roots also bind soils on steep slopes, thereby protecting them from erosion. In addition, the creation of upland woodlands act as a robust buffer between heavy storm rainfall and the ground surface. Trees intercept a large proportion of incoming precipitation (Farrell *et al.*, 1998; Boyle *et al.*, 2000). They also provide temporary storage and protect soils from erosion.

**Fig. 3: Using regional data derived from Geographic Information Systems (GIS), it is possible to define the exact location of streams, rivers and lakes (in blue), and existing semi-natural and plantation forests (in green). Fragmentation of native riparian woodland cover can then be reversed, by identifying and targeting key sites for native riparian woodland establishment. (Image derived from Loughs Conn and Cullin, and their environs, Co. Mayo, courtesy of Inland Fisheries Ireland).**



## Strategic application of the NWS – potential benefits

The potential for addressing most of the issues described in the previous section via the NWS is considerable. For example, 'Good status', as defined by the Water Framework Directive (WFD), equates approximately to Q4 in the national scheme of biological classification. Fresh water bodies of a lesser status are required to reach this status by the year 2015. Based on the most recent evaluation, *c.*70% of Ireland's river channel length would achieve this target. However, significant efforts are required to improve the remaining *c.*30%. An even greater challenge will be to prevent the deterioration of the Q5 and Q4-5 channels, which equate to 'High status' under the WFD. The number of water bodies with this level of quality has been in continuous decline since reporting was established in the 1970s, i.e. Q5 sites have halved during this period (Environmental Protection Agency, 2006). By strategically establishing riparian woodlands along river channels and lake margins, the mitigation and curative functions of this ecosystem can be utilised to protect the biodiversity associated with water bodies with the highest water quality status, in addition to improving the quality of those water bodies that fall below Q4 status (for

example, freshwater pearl mussel (*Margaritefera* spp.) catchments). However, this measure would need to be applied in conjunction with other measures, such as reducing the nutrient load on a catchment basis, *via* adequate septic tank design and construction, farm nutrient management plans, etc.

In addition, it is possible that the potential for surface water acidification could be reduced where native broadleaves are planted in riparian zones in order to replace conifers in catchments with base poor geology. In acid-sensitive catchments, native riparian woodlands planted at low density may be particularly beneficial compared to the more aerodynamically rough conifer canopies, planted at high density. This is mainly due to the sparser vegetation of the emergent broadleaf woodlands and the reduced surface area presented, especially after leaf fall. In the UK, it is recommended that total forest cover should not exceed 30% of the catchment in acid-sensitive areas (Gagkas *et al.*, 2006). In Ireland, in acid sensitive catchments planted during the latter half of the last century with conifer plantations, there is an opportunity to transform considerable portions in and adjacent to riparian zones as these conifer crops are harvested. (See page 10).

Also, studies carried out in large conifer plantations in the west of Ireland (Allott *et al.*, 1992; Farrell, 1995; Farrell *et al.*, 1998) demonstrated that the majority of acid events were driven by marine-derived ions (as opposed to airborne pollutants) which were scavenged from the atmosphere following storm events between November and March. Further research is required to assess the environmental impact of broadleaves in acid sensitive areas under Irish conditions. It is clear that a mix of birch (especially *Betula pubescens*), Scots pine *(Pinus sylvestris)*, sessile oak *(Quercus petraea)* and perhaps rowan *(Sorbus aucuparia)* has the best chance of succeeding in acid-sensitive areas (Collier & Farrell, 2007).

## NATIVE WOODLAND TYPES IN RIPARIAN ZONES

The following section outlines the various woodland types encountered in riparian zones. It provides guidance on the appropriate native trees and shrubs to use when developing native woodland either on a greenfield site, or as part of a restoration project involving the conversion from conifers to native woodland. Further guidance is available in Native Woodland Information Note No. 6: *The Classification of Native Woodlands in Ireland and its Application to Native Woodland Management* (Cross et al., 2010).

There are several native woodland types in Ireland that may occur in riparian zones, depending on the frequency, duration and depth of flooding, summer groundwater levels, and the nature of the substrate. The formal classification is complex as subtle variations in the above parameters may have pronounced impacts on the vegetation. Familiarisation with native woodland types is critically important for ecologists and foresters involved in developing plans under the NWS. The descriptions below are based on a variety of sources, including Cross *et al.* (2010); Cross & Kelly (2003), Fossitt (2000) and Perrin *et al.* (2008).

- On alluvial soils along the banks of slow-flowing lowland rivers and on islands, where the land is frequently flooded and the water table is permanently high, stands of so-called **'gallery forests'** occur. Since they are adjacent to high-order (lowland) streams in the lower reaches of rivers, soils are poorly-drained. However, they are of a high fertility status, with pH ranging from 5 to > 6.5. When cleared, the landuse is typically pasture or wet meadow.

  These woods are dominated by tree- and shrub-willows (*Salix* spp.)* with alder and locally, purging buckthorn *(Rhamnus cathartica)*. They are characterised by tall eutrophic herbaceous species such as nettle *(Urtica dioica)*, water dropwort (*Oenanthe* spp.), sedges (*Carex* spp.) and reed grass *(Phragmites australis)*, with bindweed *(Calystegia sepium)* and other herbs such as meadow-sweet *(Filipendula ulmaria)*, creeping buttercup *(Ranunculus repens)* and yellow flag *(Iris pseudacorus)*. In the past, these areas were sometimes used for growing osiers *(Salix viminalis)*.

  **Examples:** Fiddown Island, Co. Kilkenny; the lower reaches of the River Shannon.

  **Note:** These sites may contain the larger, narrow-leaved tree willows, such as *Salix alba* and osier, which are doubtfully native. However, it is not recommended that they should be removed.

  When developing new woodlands with these sites and soil attributes, the following species are appropriate: sally *(Salix cinerea)*, alder, and on drier ground, ash *(Fraxinus excelsior)*, pedunculate oak *(Quercus robur)* and guelder rose *(Viburnum opulus)*. Purging buckthorn should only be planted if it occurs in the vicinity.

- On slightly higher ground away from the river channels, **wet pedunculate oak-ash woodland with willows** occur. They are characteristically located adjacent to high-order streams and rivers where the surrounding land is enclosed. Soils are mostly well-drained but subject to relatively frequent flooding which may persist for several days or even weeks in winter or spring. Soil fertility is high and pH ranges typically between 5 and > 6.5. Hence, most of these woodlands were cleared and the land used for pasture and/or arable crops.

  They are characterised by pedunculate oak and ash, with a shrub layer mostly of hazel *(Corylus avellana)* with willows (especially *S. cinerea*), hawthorn

* Nomenclature follows Preston *et al* 2002.

**Fig. 4: A view of the Gearagh on the River Lee near Macroom, Co. Cork, during the 1950s. A considerable portion of the woodlands was subsequently permanently flooded during the creation of a dam as part of a hydroelectric scheme. (Photo Norman Ashe)**

*(Crataegus monogyna)* and holly *(Ilex aquifolium)*. The field layer is species-rich and is dominated in spring by species such as lesser celandine *(Ranunculus ficaria)*, wild garlic *(Allium ursinum)* and bluebell *(Hyacinthoides non-scripta)*. Later in the year, species such as meadow-sweet, tufted hair-grass *(Deschampsia cespitosa)*, nettle, brambles (*Rubus fruticosus* agg.) and ferns are common. Alder may occur in wet depressions.

**Examples:** The Gearagh, Macroom (Fig. 4); Bandon River near Dunmanway, Co. Cork.

When developing new woodlands with these site and soil attributes, the following species are appropriate: pedunculate oak, ash, alder, hazel, sally, hawthorn, spindle *(Euonymous europaeus)* and guelder rose.

The following three categories are similar in that they occur on saturated soils that are sometimes inundated/ flooded. Soils are generally fertile with pH > 5. Due to their very wet nature, such sites are only suitable for pasture (wet meadow) when cleared.

- **Wet willow-alder-ash woodland** is common on permanently saturated organic or heavy, alluvial soils, in stagnant areas or on soils that are flushed with nutrient-rich springs and seepage areas. They occur principally on lakeshores and, unlike the above, the floodwaters tend to be stagnant rather than flowing. This type is dominated by willow, alder or ash or by various combinations of all three. The ground flora commonly includes creeping bent *(Agrostis stolonifera)*, meadow-sweet, common marsh-bedstraw *(Galium palustre)*, purple loosestrife *(Lythrum salicaria)*, skullcap *(Scutellaria galericulata)* and a variety of mosses.

  **Examples:** the shores of Lough Leane, Kerry; Hazelwood, Lough Gill, Co. Sligo; lake shores on the upper Shannon.

- Woodlands of **flushed** or **spring-fed** sites occurring within the riparian zone often on medium order streams. They are dominated by alder or ash, with a ground flora dominated by sedges (*Carex* spp.), especially remote sedge *(C. remota)*, and grasses. Other species present may include bramble, creeping buttercup, meadow-sweet, marsh-bedstraw, yellow pimpernel *(Lysimachia nemorum)* and lady-fern *(Athyrium filix-femina)*.

- **Petrifying springs** occur very locally at the foot of slopes on the upper edge of the floodplain. They can be identified by deposits of calcium carbonate, which leaves a white crust on the vegetation. Alder and ash are the commonest tree species and characteristically there are often beds of giant horsetail *(Equisetum telmateia)* present, up to 1 m tall in the summer. These sites are usually very small.

  **Examples:** Camcor River, Co. Offaly; Knocksink Wood, Co. Wicklow.

When developing new woodlands with the site and soil attributes of the three categories above, the following species are appropriate: sally, alder, ash and birch, with oak (*Q. robur* or *Q. petraea*, depending on the soil), hazel, rowan and holly on drier soils.

**Note:** Petrifying springs are priority habitats under the EU Habitats Directive. They are very delicate habitats with a distinctive and sensitive fauna. The areas of calcium carbonate deposition should not be planted, drained or damaged by vehicles or even by walking on them, as the process of deposition is very slow. Planting should be set far back from the springs. It should be restricted to areas beside or below the springs, but preferably not above, in case it interferes with the hydrology of the site.

- Along low- and mid-order upland, mountain streams, i.e. the headwaters, at or below the altitudinal tree line and down to sea level in the foothills of mountain ranges, small, narrow stands of **montane alluvial woodland** occur. These differ considerably from those of lowland rivers, as the substrate is usually more acidic (pH < 5) and less fertile and the flooding regime is characteristically spatey, i.e. the river rises and falls rapidly over the course of a few hours and the flood waters do not persist for more than a few days at the very most. When cleared, these sites are considered marginal for agriculture and are used for extensive grazing. At low altitude and in sheltered locations woodland stands are typically characterised by alder, ash and shrub willows, especially eared willow *(Salix aurita)*, birch, rowan and sessile oak. With increasing altitude, especially in exposed regions, alder, ash and sessile oak occur less frequently with alder and ash becoming very rare above *c.*200 m OD in most regions.

  **Examples:** Glengarriff, Co. Cork; Killarney Woods, Co. Kerry.

  When developing new woodlands with these site and soil attributes, the following species are appropriate: eared willow, birch (mostly *B. pubescens*), holly, rowan and possibly sessile oak, especially where soils are well drained. In the foothills and in sheltered locations, especially on wetter, less acidic soils, which tend to be heavier and poorly drained, sally should be used instead of eared willow and alder and ash may also be included in the mixture.

## MANAGEMENT PLANNING UNDER THE NATIVE WOODLAND SCHEME

Under the NWS, when applying for the management of an existing native woodland (Element 1), a Native Woodland Plan must be submitted as part of the application, following a fixed template set out in the *Native Woodland Conservation Scheme* (Forest Service, 2015a). As part of this process, the site is assessed by a NWS Participating Forester and Participating Ecologist (both individuals having fulfilled specific criteria to work with the scheme), in close liaison with the owner. As part of the required consultation process, the Forest Service consults with the local Inland Fisheries Ireland staff where a riparian aspect is involved and (where relevant, i.e. within designated sites) the National Parks and Wildlife Service (NPWS). It is recommended that where riparian areas are concerned, that the appropriate statutory bodies are consulted ***before*** the management plan is developed and submitted to the Forest Service. Under NWS Establishment (Element 2) please consult *Native Woodland Establishment GPC9 & GPC10* (Forest Service, 2015b).

In relation to native woodlands in riparian habitats, the Native Woodland Plan should take into account criteria outlined in the *Native Woodland Conservation Scheme* (Forest Service, 2015a), the classification and site issues outlined above, and the following general criteria:

- The plan must be long-term, i.e. greater than 20 years duration, and guided primarily by conservation, water quality protection and other ecological considerations.
- The plan may involve more than one native woodland type, depending on site area, proximity to the water body, soil type diversity and fertility, and altitude. For example, an overall NWS application may involve the promotion of a particular native riparian woodland type (or types) on the riparian area within the site, and on adjacent land, a non-riparian native woodland type.
- The plan should incorporate any available historical information for the site. This information may provide valuable 'pointers' regarding past land uses, vegetation cover, etc., – see NWS Information Note No. 1: *Cartographic and Historical Sources for Native Woodlands* (Woodlands of Ireland, 2007b).
- Under NWS Element 2, the establishment of trees in riparian areas must be achieved with the minimum of disturbance, in order to avoid any adverse effects on the aquatic zone.
- Species mix should be based primarily on woodland classification criteria (Cross, *et al*., 2010) and on the site conditions, as outlined in the previous section. This should be supported by a rudimentary soil survey which should address soil type, soil depth and hydrology, and in extreme cases, laboratory analyses if necessary, in order to ascertain the appropriate woodland type to establish.
- Other factors such as altitude, channel size and orientation, grazing pressure and angling interests must be considered.
- Fencing requirements must be carefully assessed (see page 18). Access from the opposite bank, provision of stiles, hinged water barriers/gates, the presence of deer, livestock, rabbits and hares, etc., must all be taken into consideration.

## APPLICATION OF THE NATIVE WOODLAND SCHEME

The following section describes the principal applications of the NWS in riparian areas, i.e.

- managing existing native riparian woodland (under Element 1: Conservation);
- restoring native riparian woodland on conifer plantation sites (under Element 1: Conservation); and
- establishing new native riparian woodlands on 'greenfield' sites (under Element 2: Establishment).

### Managing existing native riparian woodland (under Element 1)

Deciding how to manage an existing native riparian woodland will depend on the woodland's current values for conservation, water quality protection, recreation, wood production, etc., and whether these values are threatened or in decline. The impact of the woodland on the aquatic zone will also be a factor, including the degree of shading and overhanging vegetation, the effect of woody debris on flow, etc. The following summarises the main considerations involved when deciding on management. These are derived mainly from experiences gained in managing native riparian woodlands in Scotland (Parrott & MacKenzie, 2000), which is equally applicable to projects under the NWS in Ireland - see *Native Woodland Conservation Scheme* (Forest Service, 2015a).

Since existing native riparian woodlands are usually vulnerable, tiny fragments of what is now a rare habitat type, **nature conservation** must be the highest priority objective. Wherever possible, these remnants should be expanded. Usually, the principal management operations required are:

- the reduction of grazing pressure (primarily through fencing), to permit natural regeneration; and
- the removal of exotic species, especially aggressive invasive floral species such as rhododendron *(Rhododendron ponticum)*, Japanese knotweed *(Fallopia japonica)*, etc.

As set out below, a number of other factors should also have a bearing on planning.

- ***Size***
  Larger woodlands are generally able to support a greater diversity of wildlife.
- ***Connectivity***
  Restoring linkages between highly fragmented woodlands facilitates the spread of flora and fauna.
- ***Longevity***
  Ancient woodlands are most valuable for nature conservation, as they are typically the most diverse and may shelter many scarce species rarely found in more recent woodland.
- ***Naturalness***
  Modifications that decrease naturalness include past management (e.g. a continual favouring of oak at the expense of other species), high grazing pressure and the presence of exotics. Management should be focussed on returning the wood to a more natural state.
- ***Age-class distribution***
  Representation of all age classes from seedlings to mature and senescent trees favours high biodiversity. Large, even-aged mature woodlands dominated by one or two species may cast too much shade, and consideration should be given to opening up the canopy through the creation of small coupes and/or respacing/thinning. Care must be taken to ensure that coppice regrowth does not overwhelm regenerating seedlings.
- ***Structural diversity***
  Securing good structural diversity within the native riparian woodland will increase species diversity and will also help greatly in achieving a balanced light regime in the adjoining aquatic zone. It is inadvisable to restructure very small or narrow stands, as there is a higher proportion of edge effect.
- ***Continuity***
  Care should be taken to ensure a continuity of species in old/ancient woodlands through the retention of refuges, i.e. areas of high conservation value that are left untouched. Interventions should always be kept to a minimum and carried out in stages, if possible.
- ***Presence of other habitats***
  Riparian woodlands may form a mosaic with other habitats including bogs, wet meadows and scrub. Such habitats add to the diversity of the riparian zone, and care should be taken not to impact upon them adversely.

Another key management objective should be **enhancement of the habitat quality in the adjoining and downstream freshwater ecosystem**. The management of native riparian woodland can have a profound positive influence on the freshwater quality and associated biodiversity. This influence is particularly apparent in the immediate vicinity of the watercourse, where tree roots reinforce the bank and where bankside vegetation casts shade, leaves and woody debris on the water. Within this immediate area, the interaction of nutrients between the aquatic and terrestrial habitats also takes place. This part of the riparian zone is included in the ABZ stipulated under the *Forestry & Water Quality Guidelines* (Forest Service, 2000a). Management in this area needs to be carried out with great care, with a focus on the impact not only on the woodland itself, but also on the freshwater habitat. For example, operations within the ABZ will largely focus on maintaining the existing native

tree and ground vegetation cover, and undertaking additional operations to enhance both the woodland and the aquatic system, e.g. the removal of non-natives such as sycamore *(Acer psuedoplatanus)* and Cherry laurel *(Prunus laurocerasus)*, and the possible removal of selected native trees, to counteract tunnelling. In general, operations undertaken to restore a woodland's conservation value also benefit the freshwater habitat, although the work will need to be carried out with great sensitivity.

Within the ABZ, the canopy should be managed to ensure that excessive shading due to tunnelling is avoided, especially in salmonid nursery headwaters. When seeking to manage light levels reaching a watercourse, it is important to take account of the following factors.

- ***Tree species***
  Exotic species frequently cast heavy shade.
- ***Crown height***
  Dense coppice regrowth may cast heavier shade than a high crown.
- ***Aspect***
  Trees on the south bank will cast more shade than those on the north bank.

A balance must be found between removing and retaining riparian trees for conservation benefits; the primary objective is to optimise woodland biodiversity while also assisting the achievement of the natural carrying capacity of all in-stream fauna. For example, where required, tree felling (coppicing and/or respacing) within the ABZ should be carried out in a way that avoids excessive debris falling into the watercourse, as this can cause problems downstream.

Outside the ABZ but still within the riparian zone, **wood production** may also be an objective. Due to the high soil fertility status often encountered in these areas, excellent timber quality can be achieved for species adapted to the elevated watertable conditions, e.g. alder, birch and ash. The production of wood (along with other products and services) is encouraged under the NWS, where compatible with the priority biodiversity objectives, and the publication *Realising Quality Wood from Ireland's Native Woodlands* (Little & Cross, 2005) sets out silvicultural guidelines. In addition to the safeguards stipulated in the *Forest Harvesting and the Environment Guidelines* (Forest Service, 2000b), the following are of particular note, not only within existing native riparian woodlands, but also on sites undergoing conversion from non-native (e.g. conifers) to native woodland status.

- Careful consideration should be given to harvesting methods employed where access is poor (i.e. timber extraction on steep slopes and over uneven or wet terrain) and on sensitive sites, where damage may result.
- On sensitive sites, it may be appropriate to use extraction methods that impact least on the ground, such as horses, light all-terrain vehicles (ATVs), pedestrian skidders and log-chutes. It should be noted that these methods do not automatically result in minimal impact – operator skill and experience are essential. Alternatively, timber may be sawn within the wood using a portable saw.

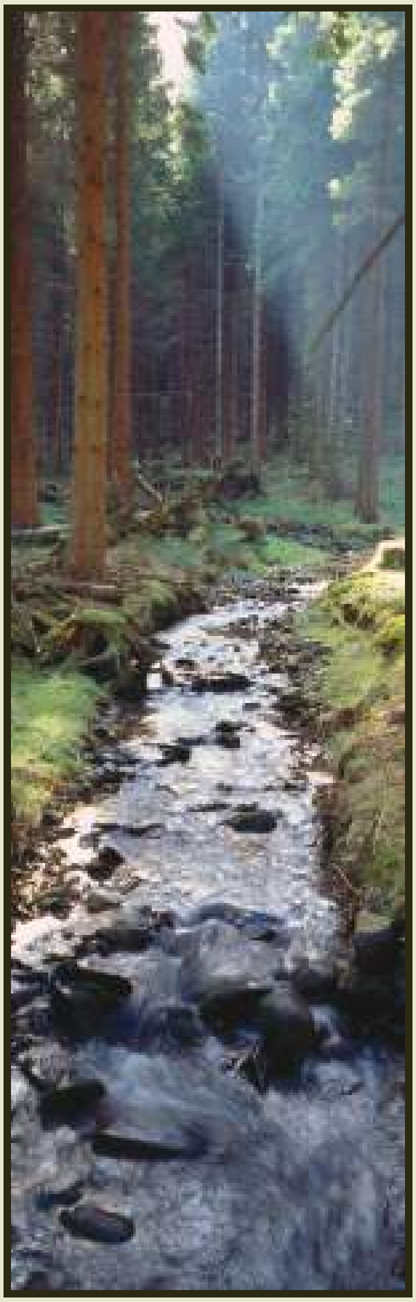
## Restoring native riparian woodland on conifer plantation sites (under Element 1: Conservation)

Prior to the issuing of *Forestry & Water Quality Guidelines* (Forest Service, 2000a), riparian zones were often planted with conifer crops close up to the edge of watercourses. This practice resulted in heavy shading and a reduction in biodiversity and productivity in freshwaters. Shade also hinders the development of riparian vegetation and exposes riverbanks to excessive erosion (Parrott & MacKenzie, 2000). Meanwhile, the lack of any protective buffer between the forest and the aquatic zone increased the likelihood of siltation and bank erosion, particularly during establishment and harvesting operations. Where appropriate, Element 1: Conservation of the NWS can be used to fund the conversion of existing non-native forest to native woodland *Native Woodland Conservation Scheme* (Forest Service, 2015a). This provides an opportunity to restructure these forests, by converting the existing conifer plantation within the riparian zone into native riparian woodland, thereby creating a permanent protective buffer to the aquatic zone from forestry operations associated with the adjacent conifer crop. In effect, after the removal of the conifers, an appropriate ABZ is created, comprising natural ground vegetation and strategically planted groups of appropriate native trees and shrubs (i.e. approximately 20% tree/shrub cover within the ABZ). Outside of the ABZ but still within the riparian zone, the most appropriate native woodland type is developed via planting (and natural regeneration).

In Scotland, where plantation conifers have been removed from the riparian zone, the healing process has already begun to pay dividends (Parrott & MacKenzie, 2000). For example, the process can lead to:

- the restoration of native riparian ground flora;
- the re-establishment of wildlife corridors;
- the restoration of bank stability;
- the recovery of instream biodiversity, including flora and fauna;
- the re-occupation of spawning and nursery areas, and consequential contribution to the recovery of salmonid fisheries; and
- the enhancement of the visual landscape, whereby native riparian woodlands are used to integrate conifer plantations more naturally into the landscape.

**Fig 5: Mature conifer plantation adjacent a salmonid spawning stream, River Tweed catchment, Scotland. Conversion to native riparian woodlands is usually best carried out after harvesting of the site, incorporating an appropriate ABZ comprising natural ground vegetation and strategically positioned groups of native trees and shrubs.**



However, depending on how it is carried out, the removal of conifers can radically alter light and temperature regimes virtually overnight. This can be a major issue, particularly in the case of upland streams, where excessive light and heat can negatively affect instream biodiversity. The open, disturbed riverbank may also be very suitable for colonisation by invasive exotics, e.g. rhododendron and Japanese knotweed.

The re-designed riparian zones may be used for recreation (e.g. access for walkers and anglers) and wood production, where compatible with the biodiversity objectives.

In converting the riparian zone from conifers to native riparian woodland, the following considerations apply:

- Within the ABZ, the operations will generally focus on the sensitive removal of non-native trees; the encouragement of natural ground vegetation, and, where appropriate, strategic low density group planting and natural regeneration of suitable native tree and shrub species, to directly benefit the aquatic habitat.
- The Forestry Act applies regarding the need for a Felling Licence, and all operations must adhere to the *Forest Harvesting & the Environment Guidelines* (Forest Service, 2000b) and other environmental guidelines and requirements, and to the *Code of Best Forest Practice – Ireland* (Forest Service, 2000c).
- In narrow channels (< 5 m) planning and subsequent operations should allow sufficient light to reach the aquatic zone in order to restore natural functions, i.e. the development of aquatic flora and fauna communities. The new native riparian woodland should also consist of more than a single line of trees for it to evolve as a functioning woodland ecosystem. Where practicable, it should include all of the natural floodplain.
- Planning should take into account the number and scale of similar and other types of operations elsewhere within the overall catchment. At the catchment level, felling and other operations associated with conversion into native riparian woodland should be reduced in scale and phased. This is particularly important in sensitive areas, such as peatlands, water supply catchments and catchments where fresh water pearl mussels are present. As a general rule of thumb, do not expose more than 20% of the river/stream bank over a 3-year period. This ensures that the shade provided by the conifers is removed progressively, allowing the riparian zone to recover before further felling takes place. This can easily be achieved particularly where conifer blocks within large plantations are being harvested over an extended period.
- In general, it is more practical to remove conifers from the ABZ along with blocks of adjacent conifers and establish a protective riparian buffer woodland subsequently. Harvesting can be done sequentially in blocks as small as possible, especially in sensitive catchments, i.e. between 5 and 15 ha in total – see *Forest Harvesting and the Environment Guidelines* (Forest Service, 2000b).
- In most situations, conifer removal and conversion to native riparian woodland within the riparian area is best undertaken when the conifer crop matures and is ready for harvesting. However, a number of different scenarios may arise whereby it may be justified to remove the conifer crop in the short-term, even if immature. For example, such action may be justified on ecological grounds where the conifer forest is fragmenting two adjoining areas of native riparian woodland, or where the benefits to the aquatic zone outweigh other considerations. Similarly, for operational efficiency and to avoid

windblow, it may not be possible to retain a small area of immature conifers if older, mature stands are being felled and replaced in the immediate vicinity.

- Prioritise conifer removal in gently sloping and flat riparian zones as opposed to steep gradients, as the former have the greatest potential in terms of buffering capacity and recovery of biodiversity with respect to the terrestrial (river/stream bank) and aquatic zones.
- In practice, it will usually be necessary to fell trees that are within falling distance of the watercourse. Fell trees away from the waterbody, and deploy brash matting for harvesting and extraction routes, to protect the soil. In sensitive areas, felling and extraction should only be carried out during dry weather conditions. In addition, plan extraction to minimise stream crossings. For all operations within the ABZ, adhere to the requirements set out in the *Forestry and Water Quality Guidelines* and the *Forest Harvesting and the Environment Guidelines* (Forest Service, 2000a & 2000b).
- It may be possible to use lop-and-top as 'dead hedging', to protect selected areas of planting and/or regeneration from grazing animals.
- As a general rule, during conifer removal, all logs, woody debris and lop-and-top should be kept out of the watercourse and the ABZ. However, in some cases (particularly where the watercourse is eroded and featureless), it may prove very beneficial to incorporate large woody debris into the watercourse. For example, rejected logs or root-plates can be securely positioned at strategic points, to slow flow velocity, create pools and shelter, thereby improving structural diversity and instream habitats. However, this operation should only be undertaken after careful planning and consultation with the local Inland Fisheries Ireland staff (and the NPWS), where applicable.
- The presence of a remnant native riparian woodland fragment on or adjacent to the site, creates the possibility of using natural regeneration as a way to restock the area cleared of conifers. Indeed, clearfelling often leaves ground conditions, often with an appropriate seedbank, that is very conducive to colonisation. Otherwise, restocking as native riparian woodland will involve planting. The *Native Woodland Conservation Scheme* (Forest Service, 2015a) provides full details regarding the use of natural regeneration within NWS projects, and requirements regarding the source of all planting material used.
- The focus within the ABZ is to encourage natural ground vegetation augmented by strategically positioned groups of appropriate trees. In upland and exposed areas, especially adjacent to conifer plantations, birch and willow are better options compared to alder, especially as alder very rarely occurs naturally in these areas. In addition, alder tends to have a tall, vertical structure so that when the conifers are harvested subsequently, the alder is liable to be windthrown with the consequent loss of the protective woodland buffer. Birch and willow provide a more resilient structure in these circumstances.

**Note:** The Forestry and Freshwater Pearl Mussel Requirements will apply to all potentially impacting forest operations within the catchments of pearl mussel populations in rivers designated candidate Special Areas of Conservation (cSACs) for the species (Forest Service, 2008).

## Establishing new native riparian woodlands on greenfield sites (under NWS Element 2: Establishment)

### Establishment strategies and design

When establishing a new native riparian woodland on a greenfield site, careful planning is needed in order to achieve the most suitable woodland community and structure for the site, so as to optimise the various ecological and protective benefits to the aquatic ecosystem *Native Woodland Establishment* GPC9 & GPC10 (Forest Service, 2015b). In effect, an appropriate 10-25 m wide ABZ is created, comprising natural ground vegetation and strategically planted groups of trees and shrubs. Outside of the ABZ but still within the riparian zone, the appropriate native woodland type is developed, by planting and natural regeneration. The following guidelines have been derived from the experience in Scotland (Parrott & MacKenzie, 2000) and elsewhere in the UK (Rodwell & Patterson, 1994), and also from experiences in Ireland to date. These guidelines are in no way definitive, but are nevertheless a useful starting point (see also Appendix 1).

The principal factors to consider when establishing new native riparian woodland on a greenfield site are as follows:

- location;
- design at the landscape level;
- use/feasibility of colonisation through natural regeneration;
- species choice for planting;
- planting patterns;
- size/type of adjacent waterbody; and
- the orientation of the river channel (which dictates light penetration).

**Note:** many of these factors are also directly relevant to projects involving the conversion from conifer forest to native riparian woodland, carried out under NWS Element 1 (see previous section).

### Location

There are many different types of locations that are appropriate for the establishment of new native riparian woodlands, ranging from sites adjacent to existing woodland to sites isolated from existing woodland. Sites that may not be appropriate include those incapable of supporting the sustainable development of native woodland, and sites where woodland development is deemed

ecologically inappropriate due to the presence of an existing (non-woodland) habitat of ecological significance. Unsuitable sites include blanket bog and heath, raised bog, freshwater marsh, semi-natural grassland/meadow, and riparian zones adjacent headwaters above the altitudinal tree line, i.e. above *c*.500 m.

Suitable locations that are designated under national and/or European legislation often have restrictions regarding some operational activities. In these instances, the Forest Service consults with the appropriate authority – the NPWS – as part of the application process. The local Inland Fisheries Ireland staff should be also consulted with in the case of sites involving riparian areas.

Refer to *Native Woodland Establishment GPC 9 & GPC 10* (Forest Service, 2015b), to *Environmental Requirements for Afforestation* (Forest Service, 2016) and *Land Types for Afforestation* (Forest Service, 2016a) for full details on site suitability, operational management and requirements. Attention is also drawn to *Woodlands and Water: Creating new native woodlands to protect and enhance Ireland's waters* (Forest Service, 2016b) which describes the use and applicability of native woodland establishment with regard to aquatic zones in a national context.

## Design at the landscape level

Woodland design is influenced primarily by ecological, soil and climatic considerations. The following points are most relevant:

1. The presence and distribution of existing native or semi-natural woodland, particularly existing native riparian woodland, should be taken into account in terms of: (i) proximity to potential seed sources for natural colonisation; and (ii) promoting woodland connectivity.

**Fig 6: While still bearing the yolk sac from their ova, newly hatched salmon alevins remain in the loose gravel on the stream bed. They depend on pristine water quality and are extremely sensitive to physical compaction or siltation at this critical stage of their life cycle. Any disturbance to their habitat during the incubation or hatching period (i.e. November to May) will almost certainly result in large scale mortalities of these fish during their early life stages.**

2. Areas of the site subject to flooding and consequent soil moisture fluctuations should be clearly identified, as they will greatly influence design.

3. Size, shape and location should be considered with regard to the character of the landscape locally. Also, size and shape are factors in determining the development of the field layer and consequently the fauna. For example, small, narrow stands tend to be well-lit and are therefore unlikely to develop a complete woodland flora due to edge effect.

4. The pattern of topography and soils, as well as the natural character of the floodplain, will dictate species choice.

5. The design of riparian woodlands should also incorporate open areas, up to 20% of the total area, except in woodlands under 10 ha which are linear and very narrow. Open areas may include the following.

- Habitats unsuited to woodland, such as peatland, wetland and rock outcrop.
- The first 5 m (7 m on larger rivers subject to OPW Drainage maintenance) on each bank immediately adjacent to the aquatic zone should be allowed to develop into a thick herbaceous, sward, to enhance bank stability and to increase filtration potential. (Occasional strategically planted trees immediately adjacent to the watercourse can be used to create shade on pools or to offset bank erosion).
- Areas reserved for angling purposes, where applicable, which are strategically located in most cases.
- Land used to stagger the development of the woodland, by delaying colonisation in certain areas until other areas are well established. This creates structural diversity and may be a useful strategy in the more fragile areas of the site which can be left to natural regeneration as opposed to planting.

The amount of open ground should not follow any fixed formula but depend upon the character of the ground, the presence of other habitats, and the particular mix of objectives for the site in question.

Fig. 6: A native woodland established in 2003 under NWS Element 2 at Ballyvary, Co. Mayo. Planting in the foreground complements the existing naturally-regenerated native woodland in the background and on the right bank. The left bank is unplanted to a distance of c.5 m back from the river, to allow for access and the development of a herbaceous sward.

## Use/feasibility of colonisation through natural regeneration

In the establishment of new riparian native woodlands (and the restocking of former conifer forest with native riparian woodland), colonisation through natural regeneration from nearby seed sources is ecologically preferable to planting, as it results in a more natural matching of trees and shrubs to local conditions and consequently, a more irregular structure and higher degree of naturalness. Natural colonisation is also more likely to conserve local genetic distinctiveness and diversity than planting. The main factors to consider are as follows:

- Where vigorous natural regeneration is likely due to the proximity to nearby seed sources, the process of establishment is often much simpler compared to planting with nursery stock. In practice, however, whether or not natural regeneration will actually occur to a sufficient degree requires careful judgement. Furthermore, seed trees may not be present nearby for each and every species required for the site. Therefore, supplementary planting is necessary, for at least some species. (Note: Natural regeneration is encouraged under the NWS, however due to its unpredictability it cannot be included in the species mix to achieve the required stocking density under *Native Woodland Establishment GPC 9 & GPC 10* (Forest Service, 2015b)
- Where wood production is also an objective or where a greater diversity of trees and shrubs is required, a balance must be struck between natural colonisation and planting.
- As set out in *Native Woodland Establishment GPC9 & GPC10* (Forest Service, 2015b), natural regeneration should be encouraged in addition to planting. Such areas should be focused in parts of the site where natural regeneration is most likely to occur, such as along hedgerows and adjacent to old woodland or scrub.
- Preparatory operations such as scarification especially facilitates wind blown (e.g. birch, willow and ash) and bird/animal (e.g. rowan, sessile oak, guelder rose and holly) dispersed seeds.
- Depending on soil and other site factors, some species lend themselves to prolific natural colonisation in riparian areas. For example, alder and willow may colonise riparian zones if there is a seed source upstream. Seed from these species that falls into the aquatic zone is carried downstream and deposited along the banks during flood events. Other species such as aspen *(Populus tremula)* may colonise vigorously via suckers.
- Where natural colonisation is dominated by a particular species, intervention will be needed to ensure that a reasonable balance of native species is represented and/or that negative impacts are avoided. For example, natural regeneration of predominantly alder along narrow streams may result in tunnelling if it is not intermittently coppiced and/or interspersed with other suitable native trees and shrubs.

## Species choice for planting

As set out in *Native Woodland Establishment GPC9 & GPC10* (Forest Service, 2015b), all species proposed for planting under the NWS must be acceptable under the scheme and representative of the native woodland type (or types) identified as being the most appropriate for promotion on the site. A native woodland application may contain a number of native woodland types on the same site. In particular, riparian woodland often grades into a non-riparian woodland types with increasing distance from the aquatic zone. Each woodland type is treated differently with respect to management prescription. All species selected for planting should reflect the appropriate native woodland type for the area in question. However, it should be emphasised that during the establishment phase it is not possible to achieve the entire species assemblage and attributes associated with long-established riparian woodlands (see pages 6 to 8).

The following recommendations are based on the natural distribution of native trees and shrubs on different soils in Ireland (Cross, 2005; Fossitt, 2000) (see also Native Woodland Types in Riparian Zones above).

- Planting the maximum number of native species does not maximise biodiversity. Each woodland type is restricted in the number of native trees and shrubs it can support by factors such as soil type, soil moisture, altitude, etc. Planting the full range of native trees and shrubs will result in establishment failure and mortality, with suitable species out-competing unsuitable species. Therefore, matching suitable species within their biogeographical range is of far greater ecological value, even if the number of species planted is low.
- As set out in *Native Woodland Establishment GPC9 & GPC10* (Forest Service, 2015b), all planting material used under the NWS must be: (i) derived from suitable seed sources (and cuttings - willow only) from within Ireland; and (ii) fully traceable from seed/cuttings collection to the planting site. Further restrictions may also apply in relation to designated areas and the NPWS should be consulted. These measures are vital in order to conserve and promote Ireland's genetic biodiversity.
- Other considerations may apply, which may favour the increased use of one particular species over another. For example, willow (cuttings) might be prescribed at key areas to promote riverbank stability, or to avoid excessive shading in salmonid nursery streams.
- The principal tree and shrub species to be used in riparian woodlands are common alder, willow, birch, ash, sessile oak (along upland streams) and pedunculate oak (on base-rich lowland soils). Some trees, such as alder and willow, are particularly well adapted to the riparian habitat as they tolerate frequent immersion. Others, such as oak, downy birch and ash, can also survive temporary flooding. Where ecologically appropriate, minor species may include wild cherry *(Prunus avium)*, aspen, hazel, holly, rowan, elder, yew, hawthorn, blackthorn, guelder rose, spindle and purging buckthorn. These should generally be positioned toward the outer edge of the riparian zone.

Care should be taken not to allow certain species to proliferate too vigorously, particularly aspen and alder which can form large pure clumps in a relatively short time.

## Planting patterns

Planting patterns should endeavour to mimic freely developing native woodland, as this provides for a considerable variation in horizontal and vertical structure (in the layering of the canopy and understorey, i.e. **stand structure**), and species composition. A key component in planting pattern design should be the nature and size of the water body adjacent to the riparian zone. The pattern should aim to achieve optimal penetration of light to the water body so that aquatic biodiversity is optimised. A robust but varied pattern is best, one which gives each species a good chance of contributing to the mature woodland structure in the right places and without relying heavily upon future stand management (Appendix 1). A combination of planted clumps and open areas should be used. This is best achieved by creating an irregular mix of five vegetation structural habitats: open ground, occasional large trees, trees with open glades, scrub thicket and closed woodland canopy. The distribution and management of the taller vegetation elements should reflect stream orientation and provide sufficient light to allow the development of a largely continuous cover of ground vegetation along the margins of the aquatic channel. In narrow streams and rivers, maintain about half the length of a stream open to sunlight, with the rest under dappled shade (Broadmeadow & Nisbet, 2002; Forestry Commission, 2003). Equally, the design should also facilitate flood control, where applicable. Strategically planted woodland achieves this by slowing the flow and by intercepting floodwaters from inundated land adjacent to the channel as the flood waters recede (World Wildlife Fund, 2007a, 2007b).

Where thinning is not part of future management operations, intimate mixtures using numerous species within clumps should not be used, as the slower growing species will be eliminated. It is far better to use two or three well-matched tree species planted separately. Intimate mixtures of trees and shrubs can, however, be used to good effect to soften/grade woodland edges.

### Size/type of adjacent waterbody

The nature of the adjacent water body will influence the design of new riparian woodlands, i.e. a lake or a river. In small upland streams, which are often important nursery areas for salmonids, it is important not to encourage excessive shading and tunnelling through dense planting. A monoculture of alders, a common feature on many drained channels in Ireland, can have a particularly heavy shading effect (O'Grady, 2006). Where stream widths are less than 5 m, consideration should be given to planting at a low density and only on one bank and/or to use willow, mountain ash or common ash, which produces a lighter canopy.

### The orientation of the channel

The orientation of the watercourse channel is important as the shade cast during the day is determined by aspect. Wooded channels with an east-west orientation will allow light to reach the stream/river bed for a considerable portion of the day. In lowland river channels greater than 10 m in width and with an east-west orientation, consider establishing woodland on both banks. In contrast, those with a north-south orientation will have a very restricted light regime, unless the stream is of sufficient width to counter shading effects. In this case, it is more appropriate to establish trees on one bank. Alternatively, if both banks are planted, a varied species assemblage reflective of the most appropriate native riparian woodland type identified for the site should be used. This will result in a canopy of trees with different profiles and heights, which will usually allow sufficient incident light to reach the bed and banks of the channel, thereby preventing a tunnelling problem (O'Grady, 2006). The inclusion of the required ABZ, which is largely open in nature, will further guarantee against tunnelling, at least in the short to medium term. A maintenance programme that includes stumping back and heavy pruning implemented at regular intervals (i.e. approximately once every decade) will be necessary.

### Ground preparation and drainage

Most of the following section is derived from *Native Woodland Establishment GPC9 & GPC10* (Forest Service, 2015b), the *Environmental Requirements for Afforestation* (Forest Service, 2016) and various UK publications and guides (Forestry Commission, 2003; Broadmeadow & Nisbet, 2002; Parrott & MacKenzie, 2000). Detailed site planning is vital, outlining the ecological priorities, site constraints and specific work practices. This should be developed after consultation with the local Inland Fisheries Ireland staff (and NPWS local staff if the site is within, adjacent to, or upstream of a designated site, i.e. SPA, NHA & SAC). In aquatic zones subject to arterial drainage, consultation with the Environment Section, Engineering Services, Office of Public Works, is necessary, especially to allow access along channels for drainage maintenance and where the proposed measures will significantly affect the drainage of the site, i.e. drain blocking. In addition, useful guidelines on ecological assessments for Natura 2000 sites subject to arterial drainage are available (Office of Public Works, 2007).

- Ground preparation should not be carried out within the ABZ, as stipulated in the *Environmental Requirements for Afforestation* (Forest Service, 2016).
- Mechanical drainage should never be used in riparian woodland, especially where the primary objective is nature conservation. Where cultivation is proposed, limit to light scarification or scrap mounding, avoiding the wetter areas of the site altogether.
- The drainage system on restoration sites should be redesigned where practicable to allow drains to terminate before reaching the outside edge of the ABZ. Ideally, all drainage channels should taper out before entering the riparian woodland. This maximises the diffusion of sediment loads, as water gently fans out over the woodland floor before entering the aquatic zone. Slowing surface run-off will promote infiltration of the water into the soil. Sediment is also filtered out from the flow by ground vegetation and the shrub layer within the ABZ.
- In existing native riparian woodlands, drains conveying water from elsewhere in the catchment should not be blocked or interfered with. However drains originating from within the woodland may be modified, subject to consultation with the relevant parties and approval. For example, straw bales pinned in place with heavy willow cuttings can be used to block drains and to slow water flows.
- Where adjacent conifer plantations terminate at the riparian zone, the creation of some large and numerous small sediment traps at the end of drainage channels within the conifer plantation on even ground is desirable. This should be done during the establishment phase, and ensure they are ***not*** located in the ABZ. Sediment traps should have no direct outflow into the aquatic zone and should be accessible to machines where excess sediment needs to be removed (Forest Service, 2003 & 2016). Where slopes are too steep to allow installation of proper sediment traps in the adjacent conifer plantation, small traps such as straw bales should be used.

- Even though the restoration of riparian woodland usually enhances the landscape, some operations (such as conifer clearfelling and fencing) may be visually intrusive and careful landscape design and planning is required. In addition, archaeological monuments and sites may also be present, including those more closely related to water (e.g. bridges, mill races, weirs, etc.). These should be protected during all operations. At all times, adhere to relevant Forest Service guidelines vis-à-vis landscape and archaeology.

## Planting and maintenance

- Ultimately the objective is to achieve 20% canopy cover within the ABZ, using strategically positioned groups of trees. planted at a density of 3,300 trees/ha (2 m x 1.5 m). Outside the ABZ ca. 80% of the area (excluding the open space allowance) should be also planted at a density of 3,300 trees/ha.
- Do not carry out ground preparation within the ABZ; pit planting is the norm except in very wet areas where inverted mounding may be carried out. Outside the ABZ scrap mounding is preferred as it increases the depth of available topsoil without inverting subsoil which is often less suitable for tree growth. Slit and notch planting are typical planting methods used on mounds.
- On very difficult upland riparian sites, consider planting in small groups (up to 0.5 ha). Depending on the costs, these may be fenced off and/or protected using individual tree guards (lower density planting may facilitate the latter option).
- Fertiliser application is generally avoided under the NWS; the focus instead is on selecting the most appropriate native species which is dependent on the site fertility and conditions. However, situations may arise where some level of fertiliser – applied by hand at planting – is deemed appropriate. For example, fertiliser application may be beneficial in developing protective native woodland on conifer conversion sites adjacent to upland rivers and streams, where soils may be very acid and infertile. However, in all cases, fertilisers should not be applied within the ABZ – see *Environmental Requirements for Afforestation* (Forest Service, 2016).
- Do not apply chemicals in the ABZ with the possible exception of the treatment of exotics, subject to the approval from the relevant bodies. The on-site use of chemicals outside the ABZ should be kept to a minimum and should not be applied if heavy rainfall is forecast or during high winds – see *Environmental Requirements for Afforestation* (Forest Service, 2016). Chemical usage should be primarily restricted to spot application of appropriate herbicides to control competing ground vegetation during the first few years of growth, and the treatment of exotic invasive species, i.e. Japanese knotweed, rhododendron, etc. If treating exotics within the ABZ, do not include a surfactant in the solution, as this is extremely toxic to instream fauna, i.e. use 'Roundup Biactive' or similar.
- In conifer conversion sites where large pine weevil *(Hylobius abietis)* is a recurring problem, consider leaving the site unplanted (i.e. fallow) for 4 years prior to replanting with native broadleaves; this allows the weevil population to decline as the remains of the conifer crop (lop and top, etc.) breaks down. Otherwise, use scrap mounds and large broadleaf transplants (2 + 2 years or older) to reduce the incidence of girdling/ring barking. Plants may be dipped with cypermethrin prior to planting. If subsequent treatments are required, this must be carried out using a hand-held applicator, but ***not*** within the ABZ.
- On fallowed sites, spot application of glyphosate (***without*** a surfactant, i.e. use 'Roundup Biactive' or similar) to control vegetation soon after planting is recommended in year I and subsequent years, if necessary. Subsequent cleaning of ground vegetation within the ABZ during the establishment phase must be carried out manually.
- In sites isolated from suitable woodland seed sources, the introduction of suitable ground flora species should be considered once canopy closes.
- Access paths for angling and recreation should be maintained, where applicable.
- Excessive shading from developing cover in the ABZ should be prevented, particularly in fishery nursery areas. This can be achieved by coppicing, thinning and/or high pruning. Care should be taken not to interfere with nesting birds and animal refuges (e.g. otter holts) during maintenance.
- In the aquatic zone, leave *existing* large woody debris dams in place, unless they become infilled with sediment and brash and form a barrier to fish migration (Forestry Commission, 2003).

**Fig. 7: A well-designed hinged water barrier straddling an upland stream, which prevents deer and livestock access while allowing debris to pass through.**

## Fencing

Fencing native riparian woodlands requires particular care and attention in both planning and execution. Fence height will depend on the browsing species present, such as deer, sheep and other livestock. Netting may be used to exclude rabbits and hares. Tree guards may also be appropriate especially if planting into existing woodlands, or where small areas are being planted. The line of the fence and materials to be used are also critical factors to get right – see *Forestry Standards and Procedures Manual* (Forest Service, 2015) for requirements and specifications under the NWS. Well-designed and erected fences will reduce long-term maintenance costs. The following should be considered (after Parrott & MacKenzie, 2000);

- the behaviour of the watercourse at all levels of flow, especially in full spate;
- the need to maintain access for livestock and people; and
- access for future management, especially where excessive vegetation growth may lead to tunnelling.

In most cases it will be possible to hold most of the fencing back above the height of even the most extreme flood. However, this may not be possible in all cases, depending on ownership and boundaries. Fences should not be placed too close to riverbanks as flood debris may severely damage fence lines. Where fences are subject to flood events, they should be designed so that they restrict the flow of water in a flood as little as possible. Therefore:

- set fence lines at least 5 m back from the aquatic channel;
- where the fence is prone to flood damage, use line-wires rather than netting, to reduce the amount of debris snagging on fences; and
- angle the fence away from the channel, to enable it to shed debris downstream rather than trapping it.

Where it is impossible to avoid placing fences across the direction of the water flow, the following applies:

- Take particular care to firmly fix key strainers and posts, bracing these with stays as necessary.
- Separate the fence into more and less vulnerable sections, using two strainers 'back-to-back. This avoids losing tension along long stretches of fencing, should one section fail.
- Intentionally build in weak links which will give way under moderate pressure, preventing excessive strain on posts and strainers. The 'sacrificial' sections should be designed to minimise the cost of reinstating the fence after the flood has subsided. For example, downstream sections may be less securely fastened so that if the fence is breached, re-tacking can be done rather than replacement with a new fence.

If necessary, consider the use of water gates (Fig. 7) and fenced off drinking areas to prevent livestock from getting around fences at low water. In addition, stiles, kissing gates, and badger gates may be desirable in some locations.

## Managing exotic species

Non-native and naturalised species are generally undesirable in existing and newly established native riparian woodlands. Some can be particularly invasive on particular sites, especially sycamore, Himalayan knotweed *(Polygonum polystachum)*, Japanese knotweed, Himalayan balsam *(Impatiens glandulifera)*, Giant hogweed *(Heracleum mantegazzianum)*, laurel, beech *(Fagus sylvatica)* and rhododendron. Further details on the control of rhododendron and laurel are set out in the NWS Information Note No. 3: *The Control of Rhododendron in Native Woodlands* (Woodlands of Ireland, 2007c). Some sites may be subject to naturally regenerating conifers originating from plantations located close to the aquatic zone. These include Sitka spruce *(Picea sitchensis)*, Norway spruce *(P. abies)* and Lodgepole pine *(Pinus contorta)*.

Generally, the priority placed on removing these species should be determined on a site-by-site basis, depending on:

- the degree of dominance and likelihood of invasion, i.e. whether they pose a serious threat to the native flora; and
- the proximity of the species to freshwater. In this case, control measures involving herbicide use need to be carefully applied, i.e. glyphosate ***without*** the surfactant 'Mixture B'. In addition, it may not be appropriate to uproot, for example, entire rhododendron bushes that are rooted in the bank immediately adjacent to and overhanging the aquatic zone, as this may result in siltation and bank destabilisation locally.

On sites involving the conversion (under Element 1 of the NWS) of conifer forest to native riparian woodland, invasive species should be removed before or during conifer removal, to reduce the incidence of regeneration on the freshly cleared, disturbed soil. On such sites, occasional spruce or pine that appears naturally among the establishing native riparian species can play a role as a nurse crop. However, they should be removed between years 10 and 15 to ensure that they do not dominate and proliferate further.

On all sites, invasives such as rhododendron, laurel and Japanese knotweed should be eradicated or maintained under control. Ideally, this operation should be carried out before these species overwhelm the native flora and natural regeneration, and before they begin to cause bank erosion. Control can be achieved through stump cutting and respray, physical uprooting, ring-barking and stem injecting with herbicide. In all cases, extreme care should be taken so as not to compromise adjacent freshwater or ground flora (Woodlands of Ireland, 2007c; Environmental Agency, 1996; Forest Service, 2000a). The actual method used will depend on the species present, site terrain and accessibility, ecological sensitivity, and local public concerns. It is important to ensure that invasive species rooted in the banks of the watercourse are cut and subsequently killed. This may entail treatment from within the aquatic zone or, in the case of steep gullies, by using ropes and harnesses. In all cases, sources of infestation upstream that may colonise treated areas downstream should also be removed.

Non-native tree species (e.g. Sitka spruce, beech, sycamore) can be eliminated by ring-barking or felling-to-waste, particularly on very wet areas where extraction would create excessive site damage. This approach will also provide deadwood and useful niches for certain species of fauna. Possible future health and safety implications should be fully considered before deciding to ring-bark, as the operation may result in significant quantities of overhead deadwood. Where pursued, bear in mind that excessive felling-to-waste will hinder access across the site (e.g. for subsequent planting and vegetation management), and creates the potential for both small and large woody debris entering the ABZ and aquatic zone. Also, most broadleaved species will regrow vigorously from the cut stumps. Therefore, cut stumps should be painted with an appropriate herbicide, and any regrowth should be treated after a year or two of growth.

If present, veteran specimens of non-natives may be retained, as they provide a rich habitat for a wide range of flora and faunal species (e.g. lichens, hole-nesting birds, etc.). Many also have a significant historical, cultural or landscape value. However, any natural regeneration arising from these trees should be controlled, particularly where site conditions are conducive to their establishment. This is particularly important in the case of sycamore and beech.

## SUMMARY

Riparian zones occur where terrestrial and aquatic ecosystems overlap. As such, their appropriate management and extension can have major beneficial impacts far beyond their immediate locality. The NWS provides an opportunity to restore, manage and create new native riparian woodland in riparian zones.

In summary, the key factors are as follows:

- In this context, the riparian zone includes land adjacent to rivers, streams, lakes and wetlands.
- On restoration sites and new establishment sites, the primary focus within the ABZ is on the creation of an open habitat with approximately 20% tree cover, developed in the form of strategically positioned groups of trees. This area is managed primarily with aquatic zone protection in mind.
- Outside the ABZ but still within the riparian zone, native riparian woodlands can be managed for conservation in conjunction (where appropriate) with wood production. The aim is to produce moderate volumes of high quality wood using continuous cover forestry principles.
- All operations concerning the establishment and management of riparian woodlands must be applied sensitively, with due regard to the aquatic zone and the often inherent wet/saturated soil conditions.

With careful design and with sensitive establishment, management and maintenance techniques, it is possible to significantly increase Ireland's riparian woodland resource, with consequent benefits for woodland and aquatic biodiversity, and water quality.

## ACKNOWLEDGEMENTS

Woodlands of Ireland would like to thank the following for the contributions made toward realising this information note: the authors, for their dedication, time and patience; Mike Donaghy, World Wildlife Fund, Ronald Campbell, Tweed Foundation and Iain Malcolm, Fisheries Research Services, Pitlochry, for hosting a fact-finding tour in Scotland in April, 2007; the Marine Institute, Newport, Co. Mayo, and its staff, especially Russell Poole and Liz Ryder, for hosting a seminar on the topic in November, 2007; Marius Urwin, Forestry Commission, Wales, for his contribution and experience during the seminar held at the Marine Institute; Huw Denman, SelectFor Ltd., Wales, Edward Farrell, UCD and Orla Fahy, Forest Service for comments. Finally, to all the relevant organisations who provided input in various ways, i.e. Forest Service, Marine Institute, Inland Fisheries Ireland, National Parks and Wildlife Service, Environmental Protection Agency, Coillte, Bord na Móna, Sylviron Ltd., Office of Public Works, Environment Section, Engineering Services.

Images courtesy of the Forest Service and Woodlands of Ireland unless otherwise stated.

Reprinted and updated January, 2017.

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APPENDICES

## Appendix 1: Recommendations associated with planting mixtures when establishing new riparian woodlands (adapted mainly from Rodwell & Patterson, 1994).

When establishing riparian woodlands, considerable variety can be obtained by altering species composition, clump/group size, tree/shrub spacing, gap and open space size. Robust and viable woodlands can be created using single species clumps or clumps composed of two to three well-matched species, i.e. alder, willow and birch, ranging in size from single isolated trees to larger stands of 50 m or more in width. Clumps of slower growing trees and shrubs, e.g. holly, guelder rose, spindle, etc., should be large enough to prevent excessive shading by adjacent groups of taller trees. Gaps between adjacent clumps can be varied from about 7 m (which will eventually close over in most cases) to 20 m or more. Gap widths equivalent to the height of the mature canopy will stay well-lit, favouring flora and fauna species of woodland margins and open ground. Shade-tolerant woodland herbs will colonise more rapidly where smaller gaps of 10 m or so are incorporated.

In large riparian woodlands, open areas greater than 25 m across can be used to provide glades and accommodate valuable habitats as well as facilitating future colonisation and regeneration of trees. Close spacing 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 floral and faunal species to colonise. Larger spacings result in a bushier form of tree and shrub. It is easier to vary spacing between adjacent clumps than within clumps, although the latter may be an option on irregular sites.

Where small, narrow riparian woodlands are being created, try to achieve as much width as possible, as this increases the biodiversity and protective potential of the resultant woodland. Greater structural and species diversity is achieved as well as a greater seepage area for incoming drainage waters from the surrounding landscape.

In summary, the following incorporates much of the above:

- Pure clumps or clumps with two or three well-matched species are used to develop mixed woodlands.
- Varied clump size is used to increase diversity in new riparian woodlands.
- Enough room should be left to allow shrubs to develop without excessive shading from adjacent trees.
- Vary spacing between and within clumps to increase diversity in new riparian woodlands.
- Maximise woodland width as much as possible to increase biodiversity and protective functions.