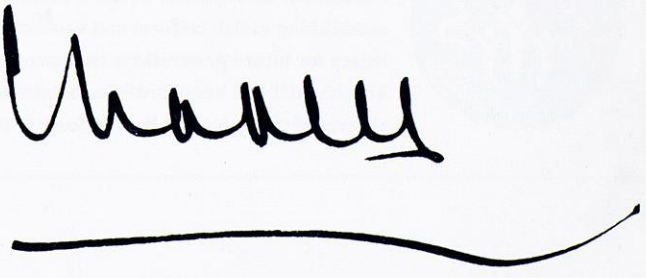
Restoring and Managing Riparian Woodlands

ST. JAMES'S PALACE

Well-managed riparian woodlands play an important part in providing habitat essential to the life-cycle of salmon and sea-trout. Stocks of both species are now at their lowest recorded levels. Our remaining Scottish native woodlands are also under threat - only about 2% of the original forest cover remains, and many of the remnants are riparian woodlands.

Tackling these important issues together is eminently sensible and I am delighted that Scottish Native Woods is publishing such practical guidance on what to do and how to do it. I hope this publication will have a wide readership among both fishery and land managers.



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Cover photo: Restructuring of riparian woodland: horses are used to extract exotic species in order to minimise ground damage
(John Parrott / Scottish Native Woods)

The Millennium Forest for Scotland

The Millennium Forest for Scotland Trust is using £12 million of National Lottery funds pledged by the Millennium Commission to fuel a nationwide effort to help restore our distinctive native woodlands. It is also re-establishing social, cultural and economic links between communities and their woodlands to provide a lasting legacy for future generations to appreciate and enjoy.
This booklet has been funded substantially through the MFS initiative. Scottish Native Woods' area projects are also significantly funded by the Trust to provide woodland management advice.

The Wild Trout Society

The Wild Trout Society is a conservation organisation dedicated to promoting the preservation and careful management of wild trout habitats. We publish an annual magazine, and a quarterly newsletter. We carry out conservation projects - we have sponsored work in Scotland on the River Don, the Tweed and tributaries, and on the Esk and Liddle - and we offer advice to those who wish to start their own work. Our affiliated Wild Trout Trust is a registered charity dedicated to funding conservation projects and education.
Further details are available from: The Wild Trout Society, 92 - 104 Carnwath Road, London, SW6 3HW.

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Introduction

***Riparian* woodlands are those found in association with fresh water - by burns, rivers and lochs. Native riparian woodlands are of special significance because:**

- their value for nature conservation, landscape and recreation are exceptional; most importantly, they are often the only native woodlands remaining in our upland landscapes, and therefore the last refuge for woodland species
- they play a crucial role in helping to maintain the health and productivity of rivers and burns: they protect river-banks, control erosion, capture and recycle mineral nutrients and increase biodiversity; they benefit fisheries by reducing siltation of spawning grounds, supplying invertebrates and leaf-litter for food, and providing shade and cover.

Riparian, *adj.* relating to, or living or occurring on the bank of a natural body of water, esp. a river
[L. *riparius* - *ripa,* a river-bank]

Neil MacKenzie / Scottish Native Woods

"In prehistoric times ... every strath and glen sheltered extensive forests ... the margins of all freshwater lochs, rivers and burns were well-wooded."

Neil MacKenzie / Scottish Native Woods

Small remnants of native riparian woodland in the uplands have an importance out of proportion to their extent...

In prehistoric times, up to 80% of Scotland's land area was clothed in forests. These native forests began to colonise the land after the retreat of the last Ice Age, some 10,000 years ago. They were dominated by Scots pine, oak, birch and alder. Every strath and glen sheltered extensive forests and, except in some high mountain areas, the margins of all freshwater lochs, rivers and burns were well-wooded.

Over the millennia the forests gradually diminished as trees were cleared for agriculture and settlement. Climate change lowered the treeline and increased the area of blanket bog and peat. Natural regeneration of the woodland was hindered by the overgrazing of sheep and deer. Grazing has been, and still is, a major factor in the fragmentation and decline of our native woodlands. Numbers of red, roe and Sika deer in the Scottish uplands have risen substantially over the past 50 years. They currently exceed 500,000. Sheep numbers have fluctuated at around 7-9 million over the same period. Moreover, the range for all grazing animals has contracted dramatically with the expansion of afforestation schemes, placing further pressure on unenclosed and vulnerable native woodlands. Native woodlands have also suffered directly from underplanting with conifers in commercial plantations, and from imprudent muirburning. Today only 2% of the land area supports native woodland, over 90% of the original forest having been destroyed.

The loss of riparian woodland, the intensification of agriculture and the spread of commercial afforestation have had an impact on freshwaters too, with serious implications for salmonid fisheries. Pollution from fertilisers and pesticides reduces freshwater biodiversity. Overgrazing in the uplands damages riparian vegetation and exposes riverbanks to erosion, causing spawning areas to silt up. Large-scale conifer afforestation causes the acidification of some catchments. With the loss of riparian woodland, energy inputs from invertebrates and leaf-litter decline, and the shelter afforded by deep pools, undercut banks and woody debris is lost.

Salmon and sea-trout stocks have dwindled to their lowest on record, with many rivers reporting less than 50% of the catches recorded 45 years ago. Whilst the causes of the decline in fisheries are many and varied, it is widely held that degradation of the aquatic environment has contributed to the problem.

John Parrott / Scottish Native Woods

Holding muirburn well back from the riparian zone may allow some of these remnants to regenerate

Alan Watson / Forest Light

Scotland's natural environment is its greatest economic asset. The nation's wild landscapes, lochs, rivers and native woodlands together support a tourism industry valued at £2.1 billion per year. Of this, wildlife eco-tourism takes a significant share: currently worth £57 million a year, it is expected to rise to £100 million in the next 5 years. Scotland's burns and springs supply a whisky industry worth £2.7 billion a year. The salmon and sea trout rod fishery generates £70 million per year, and supports 3,500 jobs.

At the start of this new millennium, there is a steadily growing awareness of the environmental, social and economic values of our natural heritage. We are becoming more conscious of our responsibility to manage this asset for the benefit of future generations.

There is also a developing consensus on the importance of riparian woodlands and their special relationship with freshwater. A number of landowners and fisheries trusts have already embarked on projects to restore riparian woodland. There are compelling environmental and economic arguments for improving riparian management. Not least of these are the many European directives on conservation of threatened species and habitats and the protection of water quality. In policy development and planning, Government is demonstrating an increasing readiness to engage with interested parties, including the general public. More than ever, it is the concerns and actions of these parties that drive policy forward.

Riparian woodlands hold a key position in Scotland's natural environment. With concerted and appropriate management, they will play a unique and vital role in the restoration of the land, its freshwater resources and its fragile rural economies.

The purpose of this booklet is to take a fresh look at the way in which we manage our riparian environment. The booklet first explores the ecological relationship between native riparian woodland and fresh water, and then provides guidance on the management and restoration of these woodlands.

Why are riparian woodlands important?

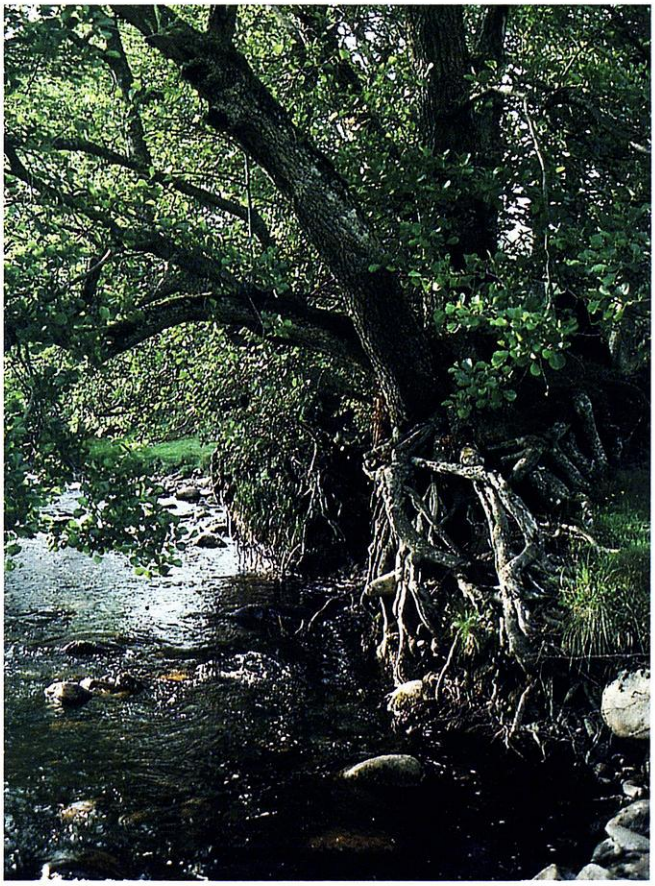
Riparian woodlands occupy a unique position in our natural environment, at the meeting-point of two major ecosystems: land and fresh water. In this zone, terrestrial and freshwater ecosystems overlap and interact.

Because of their special status, semi-natural riparian woodlands are of outstanding significance in two important respects:

- they fundamentally influence the health and productivity of freshwater ecosystems
- they have an exceptional value in terms of conservation, amenity and productive potential in their own right.

The influence of trees on freshwater lochs and rivers

Semi-natural riparian woodlands have a major beneficial impact on another ecosystem - fresh water. Woodlands profoundly influence the physical, chemical and biological characteristics of a watercourse, with significant implications for biological productivity, including fish production.



John Parrott / Scottish Native Woods

The roots of alder reinforce river-banks...

Neil MacKenzie / Scottish Native Woods

... and provide a haven for fish

The roots of riparian trees, particularly deep-rooting species such as alder, bind river-banks and retard the process of erosion. They encourage watercourses to scour a deep channel rather than spreading laterally, and secure the stability of undercut banks. Undercuts and deep pools provide shelter and shade; both are important requirements for salmonid fish, such as salmon, brown and sea trout.

Fallen trees and other woody debris play an important role in freshwater ecosystems, especially where this accumulates as 'debris dams'. Woody debris provides shelter for fish, and traps organic matter.

Trees and other vegetation cast shade over rivers and burns. This prevents excessive growth of water-weed, controls rises in water temperature, and affords shelter for fish. The degree of shading depends on a number of factors: the height and type of the vegetation, the density of the canopy, the size of the watercourse and aspect. For instance, trees on the north bank of a burn cast less shade than those on the south bank. Some species, such as birch, cast lighter shade than others, such as oak or alder.

The influence of riparian woodlands on the chemistry of fresh waters depends on a variety of conditions including the hydrology of the catchment, soils, underlying geology, tree species and age, and extent of the woodland. The impact relates in particular to the way in which trees take up minerals from the soil and recycle them. By capturing nutrients from the soil, trees may affect the balance of minerals in groundwater released to a watercourse. As trees shed their leaves, a proportion of these minerals will be returned to fresh waters in the form of organic matter.

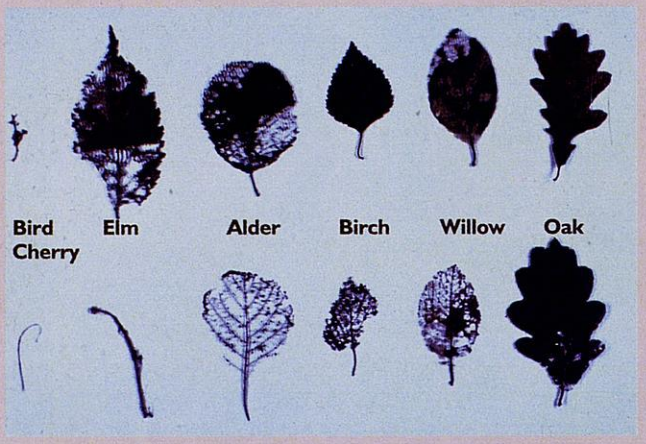
Where nutrients are too abundant in the soil, such as the margins of arable land or grass leys, woodland may act as a buffer. It can intercept run-off and 'lock up' surplus nutrients before they reach a watercourse, thus minimising the risk of water pollution.

The importance of leaves and woody debris in freshwater habitats

Forestry Commission Picture Library

Leaf litter

In most ecosystems, the main energy input is derived from its primary producers: green plants trapping the sun's energy by photosynthesis. In upland burns and rivers, however, primary production may be limited by unfavourable conditions, such as low water temperature or the scarcity of nutrients. In such watercourses, the main source of energy may come from outside the burn, principally from leaves and other organic matter falling or being washed into the burn. This material is processed in stages by a series of micro-organisms and invertebrates. Leaves are first 'conditioned' by fungi and bacteria, then broken down by a 'production line' of invertebrates - classified as 'shredders' or 'collectors', depending on their method of feeding. They include the larvae of stoneflies, mayflies, caddisflies, water-beetles and midges, as well as worms. These are in turn preyed upon by larger animals, including salmonid fish.



Peter Collen / Freshwater Fisheries Laboratory

Samples of leaves after 30 days (top row) and 126 days (bottom row) processing in a stream

Neil MacKenzie / Scottish Native Woods

Decaying leaves provide the raw material for a major food-chain

A critical factor in the breakdown of this organic matter is that different species are processed at different rates. The leaves of some tree species (such as bird cherry) may be broken down within a few weeks, whereas the leaves of other species (such as oak) may still be intact after several months (see photo opposite). This means that the diverse leaf-litter produced by most semi-natural woodlands will provide a continuous food supply throughout the autumn and winter to sustain a rich and productive aquatic ecosystem.

Woody debris and debris dams

Large woody debris (LWD) in the form of branches, root boles or even entire trees fall into rivers and streams during windblow, mortality or landslips. In the past, such debris would have accumulated naturally in all forested streams. More recently, woody debris has been actively removed from managed river systems because it hindered navigation and flood control, impeded drainage within agricultural areas of the floodplain or was thought to restrict the movements of salmon. In many upland headwater streams the native riparian woodlands have long since disappeared or are in such poor condition, with open canopies and limited regeneration, that they no longer generate much debris.

There is now a considerable wealth of knowledge about the value of woody debris in the ecology of streams and rivers. The conclusions are that woody debris plays a crucial role in rivers and that its removal is detrimental to natural stream functioning.[1]

Key functions of woody debris and debris dams in rivers are:

- **to regulate the energy of running water by decreasing the velocity and helping to increase floodwater storage;**
- **to help maintain channel form and stability. Dams which extend across the stream and create a stepped profile deliver the best long-term stability and trap the more mobile debris. Although such dams appear rigid the smaller debris will shift with changes in river flow and allow fish to pass through;**
- **to increase aeration and quality of the water, maintain water temperatures and assist with the retention of sediment;**
- **to trap and retain organic material, thus providing more food for**

invertebrates and fish. Debris dams are especially valuable in the months following autumn leaf fall when they are able to slow the downstream transport of leaf litter;

- **to provide cover for fish. Fallen trees and branch litter in streams divert and obstruct the flow which helps to create a more complex diversity of pools and gravel deposits which are important fish spawning and rearing areas. The woody debris and the creation of deep pools offer protection against predators, particularly birds and mammals during periods of low flow ;**
- **to increase the number of territories for fish. Submerged debris can raise the carrying capacity of a burn for young salmonids by increasing the potential for concealment. Juvenile salmonids defend territories from neighbours on sight. A more diverse substrate helps isolate neighbours visually, thereby increasing the number of territories.**

In almost every study, the removal of debris has resulted in the loss of important habitat features and a reduction in fish populations. Similarly, the removal of native trees, the natural source of the woody debris, by clearance or pruning, will disrupt the supply of wood.

Despite concern that debris dams might occasionally constitute a barrier to fish movements, there is little evidence of natural dams hindering access for fish. In any case, the positive benefits of natural debris dams are likely to far outweigh any disadvantages.

Within British river systems recent research has shown that the removal of large woody debris destabilises the debris that remains and results in increased sedimentation of pools downstream and a loss or reduction in the size of the remaining pools. In addition, channel and bank erosion will increase and there will be an overall reduction in habitat diversity for fish and invertebrates. Following the clearance of large woody debris, rivers can take many years to recover their diversity and stability.[2]

Neil MacKenzie / Scottish Native Woods

There are two major ways in which riparian woodlands contribute directly to the productivity of fresh waters:

- firstly, through the input of terrestrial invertebrates falling into the water - insects and spiders falling from the canopy of overhanging trees, earthworms washed into streams during storms, and the adult stages of aquatic insects such as caddisflies. In summer, when aquatic invertebrates may be in short supply, terrestrial invertebrates form up to 90% of the salmonid diet, especially that of trout.

- secondly, through the input of leaves and other organic matter into streams. This forms the basis of major food-chains, and in certain situations, can provide 90% of a stream's energy budget. (See Box opposite.)

Neil MacKenzie / Scottish Native Woods

"In summer, when aquatic invertebrates may be in short supply, terrestrial invertebrates form up to 90% of the salmonid diet"

1 These benefits relate primarily to the natural inputs from native riparian woodland. Woody debris which enters a stream during logging operations, particularly if there is a large volume of conifer debris, can result in temporary destabilisation and sedimentation of the river channel.

2 See page 26 for guidelines on the management of woody debris.

The role of riparian woodlands in freshwater ecosystems

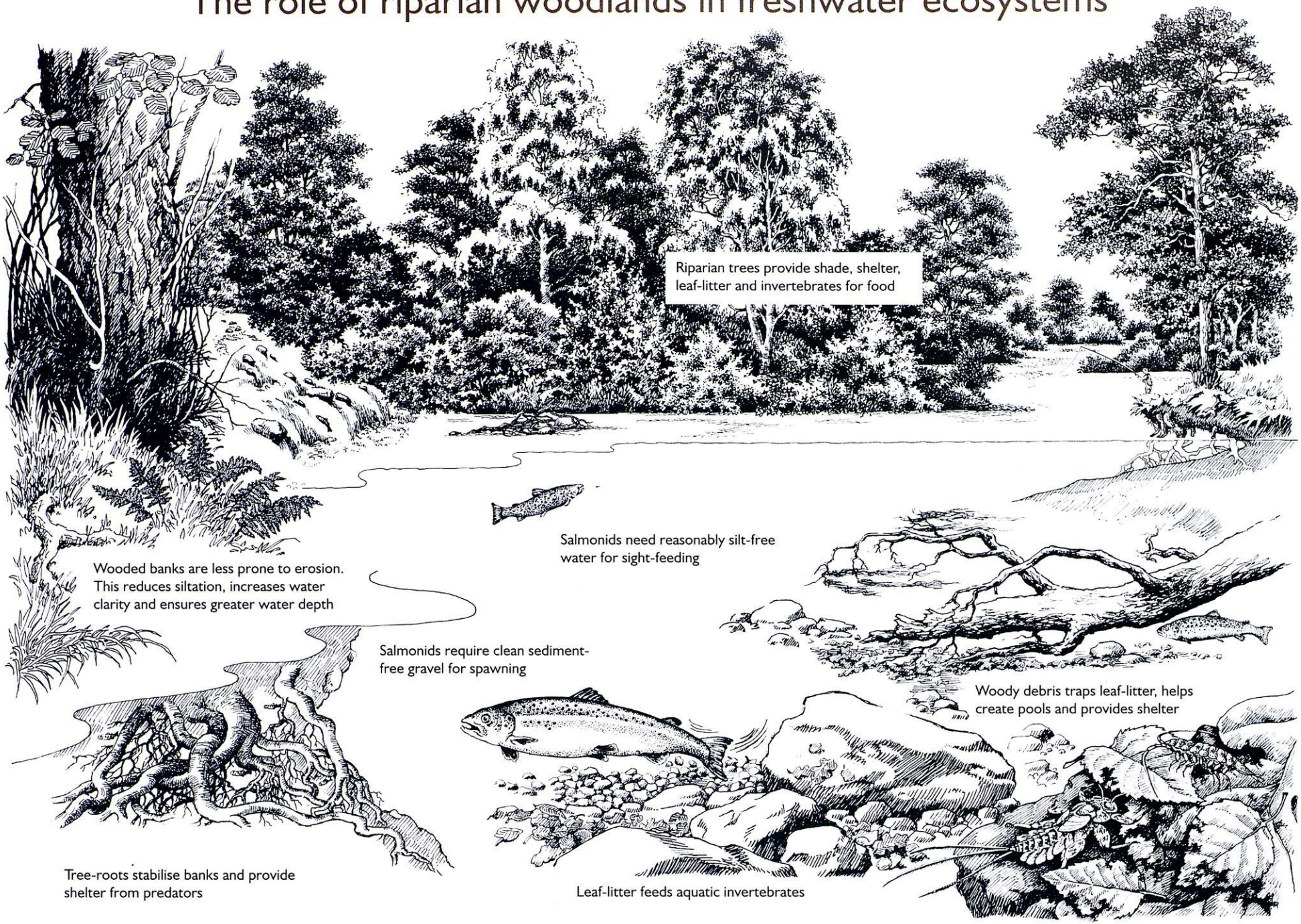


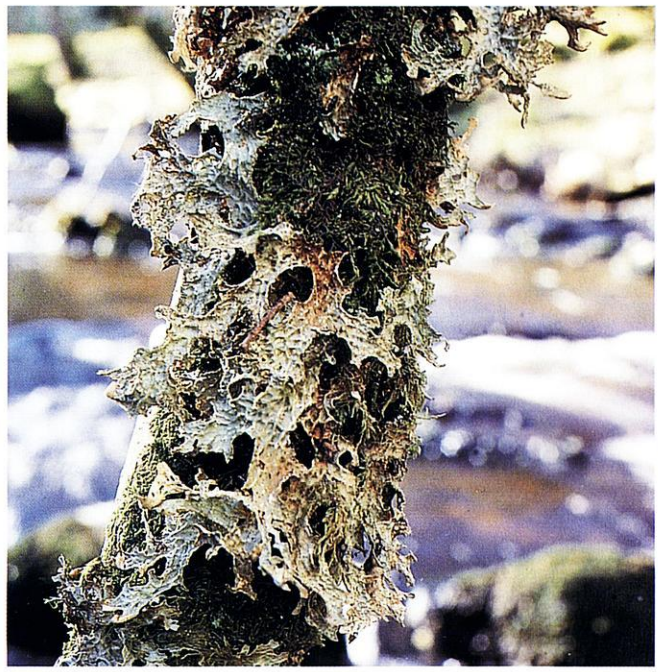
Illustration by Heather Insh

The intrinsic value of semi-natural riparian woodlands

Riparian woodlands vary greatly in their composition of tree species and ground flora, reflecting the wide range of sites they occupy. Sites vary in terms of topography, soils, microclimates and management. Alluvial deposits, springs, exposed crags, waterlogged ground and shifting river channels each support different types of vegetation. The result is a mosaic of varied habitats supporting a diversity of wildlife. They include some of the most pristine native woodlands in Scotland, as well as some of the most fragmented.

Fertile flood-plains have been largely cleared of woodland to make way for agriculture. Consequently, alluvial forests are now a rare and threatened habitat throughout Europe. On the other hand, many less accessible riparian woodlands have largely eluded interference by man. Steep crags or boggy ground restrict access and keep exploitation and grazing to a minimum. As a result, gorge woodlands shelter some of our least disturbed natural habitats.

Natural diversity and past management together account for the exceptional conservation value of many riparian woodlands. A high proportion of them are long-established or 'ancient' woods, and provide a continuous link with the forest of Scotland's prehistoric past. These sheltered and relatively undisturbed habitats maintain a moist microclimate, providing a refuge for many sensitive species; including numerous Atlantic mosses, ferns and lichens which are virtually confined to these riparian habitats.



John Parrott / Scottish Native Woods

Many plants, such as lungwort, depend on the moist microclimate of riparian woodlands

Cambridge University Collection of Air Photographs

A view of the lower Spey floodplain taken in 1947

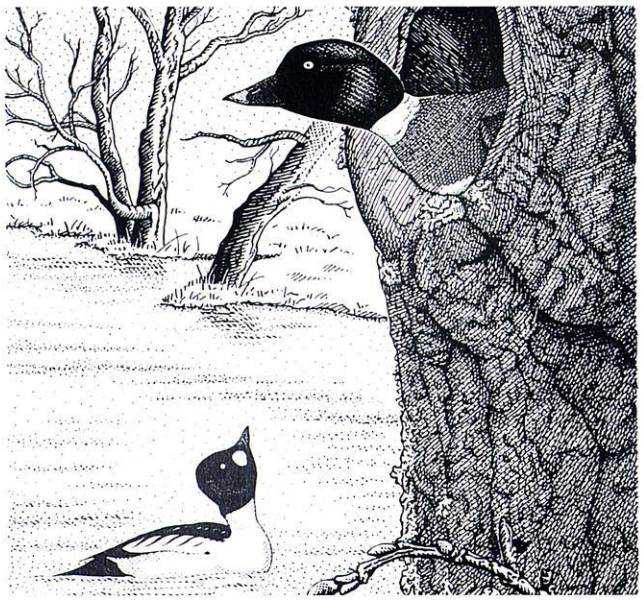
The Role of the Floodplain Forest

The floor of a river valley is known as the floodplain - an area which may be inundated by floodwaters at periodic intervals. In prehistoric times the natural river floodplain consisted of a mosaic of forest, wetland and meadow over a varied topography of river terraces, meandering channels and oxbow lakes. Since then most floodplains throughout Europe have been cleared of their forests to make way for agricultural land, settlement and power generation while river engineering has often restricted the natural movement of the river. In Britain, the most extensive fragments of semi-natural floodplain forest are to be found along the River Spey.

Today, a better understanding of flood control and the need to cater for future fluctuations in the climate have led to a developing interest in the management of the whole river catchment, including the restoration of many floodplain forests. There is now a greater recognition of the value of these native forests. Restoring more natural floodplains could bring many benefits:

- **increased biodiversity of the river system;**
- **conservation of a mosaic of different habitats, including the creation of woodland corridors to link existing native woodland fragments;**
- **increased fish productivity as a result of higher organic input and larger biomass of invertebrates;**
- **high quality timber production from native oak, ash and other hardwoods which can grow faster on the fertile floodplain;**
- **improved water quality through the action of the floodplain as a buffer against nutrient run-off and other pollutants from agricultural land and intensive conifer afforestation;**
- **deposition of sediment and other flood debris;**
- **less damage during spates through natural flooding onto the floodplain;**
- **reduced costs of flood protection measures.**

Riparian trees provide nesting and resting sites for a wide range of wildlife dependent on fresh water for food, such as otters and Daubenton's bat. Most bat species in Scotland utilise riparian woodlands for foraging and as vegetated corridors to connect with other habitats.



Dave Pullan

Many animals, such as goldeneye, depend on riparian trees for roosting and nesting sites

Riparian woodland corridors help the movement of many animal species and are especially valuable for the recolonisation of sites by species displaced by habitat loss, pollution or other threats.

In the least wooded parts of the uplands, where there has been a long tradition of grazing by sheep and deer, and inappropriate muirburn, riparian trees are frequently the only trees in an otherwise treeless landscape. Here, riparian woodlands assume an importance out of proportion to their extent. These remnants provide refuges for woodland species and offer the possibility of restoring natural tree cover to some of Scotland's most degraded landscapes.

Riparian woodlands have an exceptional amenity value, especially in terms of their impact on the landscape. By their very nature, semi-natural riparian woods follow and reinforce natural landforms in the uplands. Especially in autumn, these species-rich woodlands enhance the landscape with a splendid tapestry of colours and textures.

Riparian woodlands provide a natural environment of outstanding quality for recreational activities, such as walking and fishing.

With careful management, riparian woodlands may provide sheltered grazing for stock, firewood or opportunities for small-scale timber production.

Riparian Woodlands and Beavers

Janos Jurka / Naturfotografera

One of the most important mammals of rivers and wetlands in Europe is the beaver *Castor fiber*. Its extinction in Scotland some 350 years ago due to overhunting and habitat destruction has left our riparian ecosystem all the poorer for its loss.

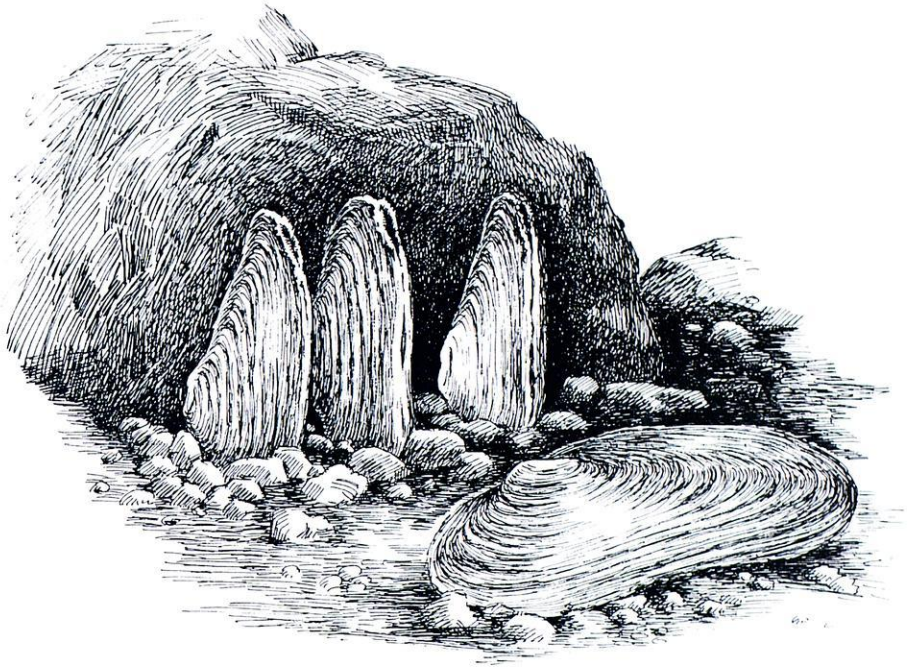
As a major modifier of the wetland environment, the beaver is able to create a more diverse riverine habitat by stimulating vegetation succession. Its ability to construct small ponds and dams increases wetland habitat, traps organic matter and nutrients, increases the amount and variety of invertebrates available to fish and stores water during dry periods. Dams built by the European beaver are not an impediment to fish migration, except perhaps temporarily during periods of low stream flow.

The beaver's diet comprises herbaceous plants and young broadleaved trees, particularly aspen, birch, oak and rowan, which are largely collected from within 100 metres of the water's edge. They do not normally eat conifer trees. Foraging by beavers will result in the selective coppicing of tree and shrub species and an increase in the diversity of the riparian habitat.

Recently, Scottish Natural Heritage initiated a proposal to re-introduce the European beaver. A pilot project involving the release of a small population is likely to be established in the near future. The natural predators of the beaver – lynx, wolf and brown bear - are now extinct in Scotland and an introduced beaver population will be monitored closely to ensure numbers do not exceed the carrying capacity of their habitat. Concerns about the beaver's impact on scarce tree species such as aspen, or on areas where riparian woodland structure is poor as a result of overbrowsing by other mammals (deer, sheep, rabbits), will be addressed by a major riparian woodland restoration programme within the entire catchment of the beaver release site.

The return of the beaver to Scotland, when integrated with the catchment-scale restoration of riverine habitats, will have tremendous long term benefits for both the freshwater and the riparian woodland environments.

Freshwater Pearl Mussel



The freshwater pearl mussel *Margaritifera margaritifera* was once common throughout Europe and Russia. Over the past 100 years populations have been dramatically reduced or lost due to pearl fishing and pollution from agricultural run-off and aquaculture. Scotland now harbours half of the world's remaining mussel colonies.

The mussels have a unique life cycle which depends on viable populations of salmon and trout. Mussel larvae, or glochidia, are released into the water and eventually land on the gills of fish. They remain on the gills for a few weeks, doing no harm to the host fish, and eventually fall off to settle in the riverbed. Individuals live up to 100 years.

Colonies of mussels live partly buried in coarse sand or gravel and feed by filtering organic material from the water. In this way they help to clean the water and gravel beds in spawning areas. Mussels therefore play a valuable role in the ecology of freshwater. Their disappearance from many Scottish rivers may be just one more contributory factor in the deterioration of the riverine environment and the decline of salmon and sea trout populations.

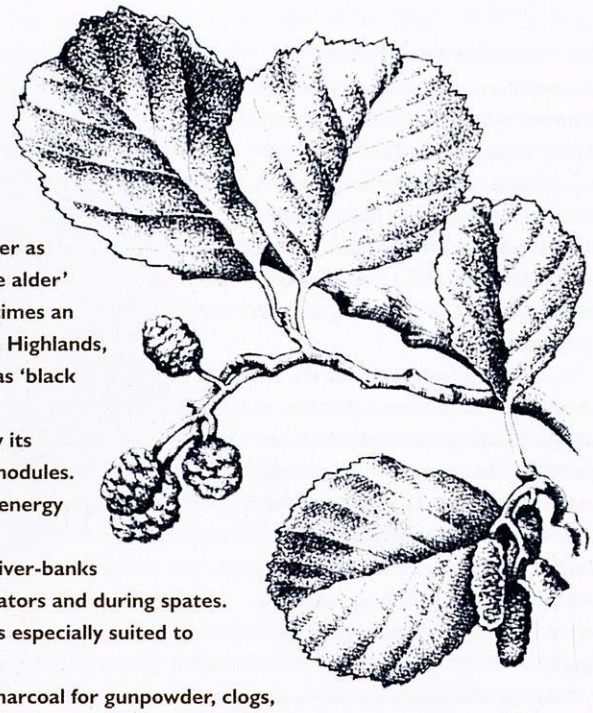
The freshwater pearl mussel is now fully protected in law and pearl fishing is banned. However, the species remains vulnerable to pollution and will depend on a healthy and diverse riparian environment to ensure its survival.

Mussels and otter prints by Heather Insh

Dietmar Nill

Known also as the water-bat, Daubenton's bat roosts in riparian trees and feeds over water, often using its feet to gaff invertebrates from the water-surface

Alder - a riparian specialist



Heather Insh

Of all the trees and shrubs which occur in riparian woodlands, probably the most frequent and most ubiquitous is alder. It occurs in a wide range of riparian and wetland habitats from 500m down to sea-level. In the uplands, it most commonly associates with willows, birch, ash, hazel and bird cherry, but it also frequently occurs in almost pure, even-aged stands. These usually originate from a period of colonising disturbed and newly-exposed substrates, such as banks and islands of alluvium deposited by a river as it shifts its channel. Alder also occurs on flushed areas on slopes. Such 'slope alder' woodlands are characteristic of the Highlands. Old alder pollards are sometimes an indication of traditional wood pasture management. In parts of the western Highlands, some of the most extensive coppices were dominated by alder, and known as 'black woods'.

As a pioneer species, it is capable of rapid early growth, partly assisted by its symbiotic association with the nitrogen-fixing bacterium *Frankia* in its root nodules. Its ability to fix atmospheric nitrogen makes alder a key contributor to the energy budget of upland burns, where nitrogen is frequently in poor supply.

Alder is deep-rooted. As a result, it is particularly effective in stabilising river-banks and retarding erosion. Root-masses provide shelter for small fish from predators and during spates. Alder is relatively resistant to grazing compared to other broadleaves and is especially suited to coppicing.

It has been used extensively throughout Scotland for the production of charcoal for gunpowder, clogs, firewood and timber. Due to its resistance to rot when immersed, it was used in the construction of crannogs, waterwheels, piers, bridges and bank revetments. Alder logs were sometimes soaked in peat-bogs after felling, when they assumed an attractive reddish stain. This 'Scots mahogany' was used for furniture-making.

Lorne Gill / Scottish Natural Heritage

What are the benefits of riparian management?

Virtually every land-holding in Scotland has access to one or more watercourses. On farms, burns are often the only source of drinking water for livestock, while many holdings derive a significant income from fishing.

Care of this freshwater resource and its associated riparian margins holds a key place in the good management of any holding whether it is a farm, a sporting estate or a forestry plantation. Riparian corridors are often the main focus of wildlife and landscape interest. They also perform a more mundane yet critical role as a buffer zone between a watercourse and the more managed environment of a farm or commercial forest.

Restoring natural riparian habitats will bring significant environmental improvements, including:

- **less erosion**

Over-intensive use of the riparian margins, whether from grazing or excessive shade, may lead to erosion. Holding livestock or conifers back from the riverbank will allow vegetation to develop and protect the banks.[3]

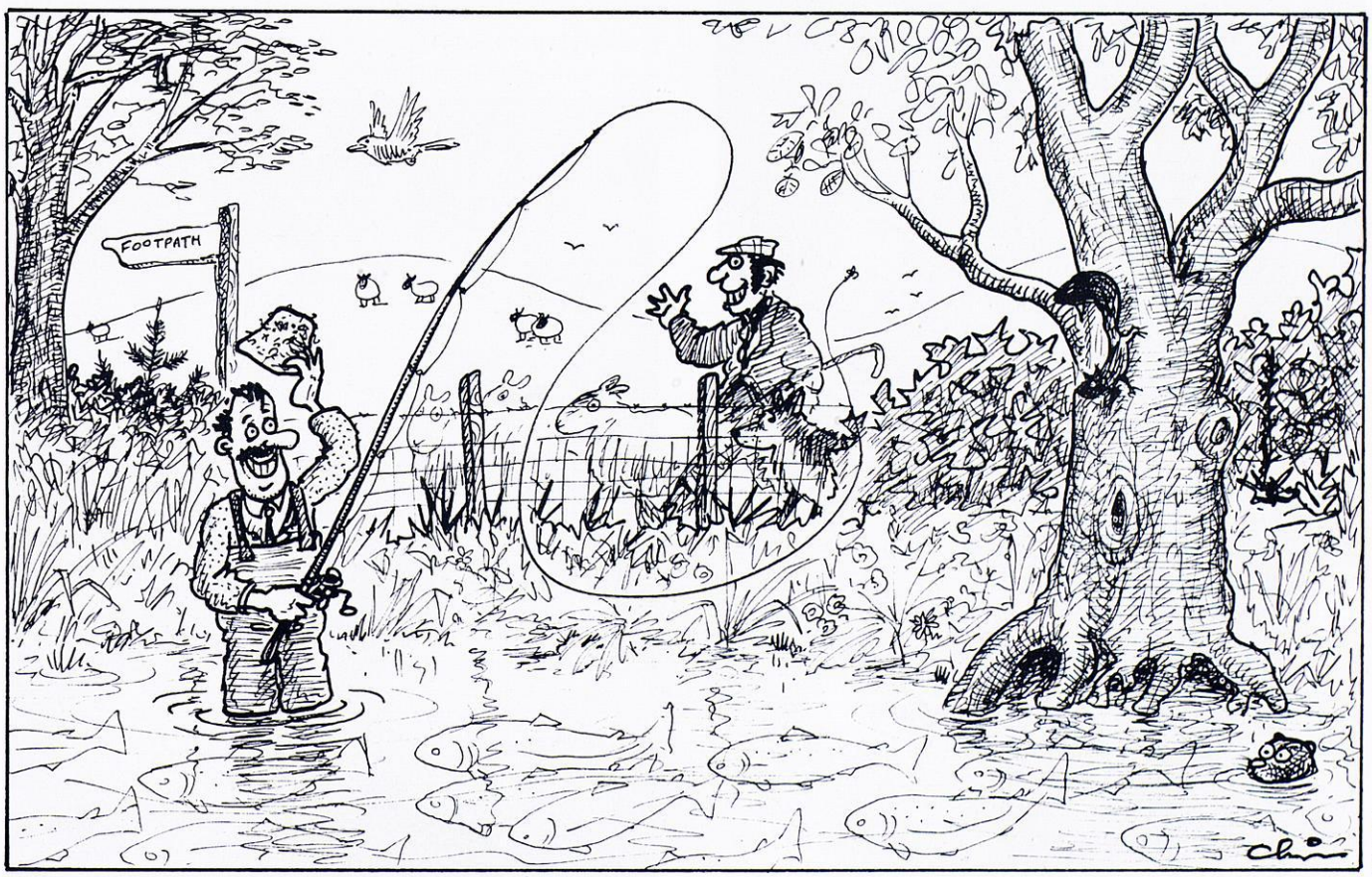
- **better water quality**

Buffer areas reduce diffuse pollution of watercourses from surface run-off, leaching, and stray farm inputs, such as pesticide spray drift and fertiliser, or from ground disturbance during forestry operations. The most effective buffer is provided by a combination of trees and shrubs with a field layer of grasses and herbaceous plants, such as may be encountered in native woodland. The grasses trap sediment, while the deeper-rooted trees and shrubs capture and 'lock up' excess nutrients. Buffer zones are essential in the protection of domestic water-supplies from faecal and chemical contamination.[4]

- **healthier fisheries**

Buffer zones benefit fisheries by stabilising riverbanks, reducing water pollution and siltation of spawning areas, and providing shade, shelter and feeding for fish.

3 see page 32
4 more information on buffer strips is given in Environment Agency 1996a



Chris Tyler

"Care of this freshwater resource and its associated riparian margins holds a key place in the good management of any holding"

cover for game

Riparian habitats can provide shelter for deer and cover for pheasants and other gamebirds.

improved habitats for wildlife

Natural riparian habitats support a rich and varied fauna and flora. Riparian habitats provide valuable refuges and corridors for wildlife, especially in intensively-managed farmland or forest. Riparian buffer zones shelter a wealth of wildlife valuable in natural pest control in a similar manner to semi-natural headlands or 'beetle-banks'.

John Parrott / Scottish Native Woods

Premature felling of inappropriately sited conifers will help the recovery of native ground flora

improved amenity values

Natural riparian habitats enhance the landscape. They soften the visual impact of large expanses of uniform man-made landscape, particularly in intensive arable or conifer plantations. They also provide an attractive linear environment well-suited to the provision of public access.

good neighbours

More than any other habitat, the consequences of mismanaging freshwater are felt far beyond their source. Just as the maintenance of march fences nurtures good relationships with neighbours, so too with the management of watercourses.

On a farm, restoring natural riparian habitats will also increase the efficiency of farm operation. Gains to be made include:

improved livestock management and health

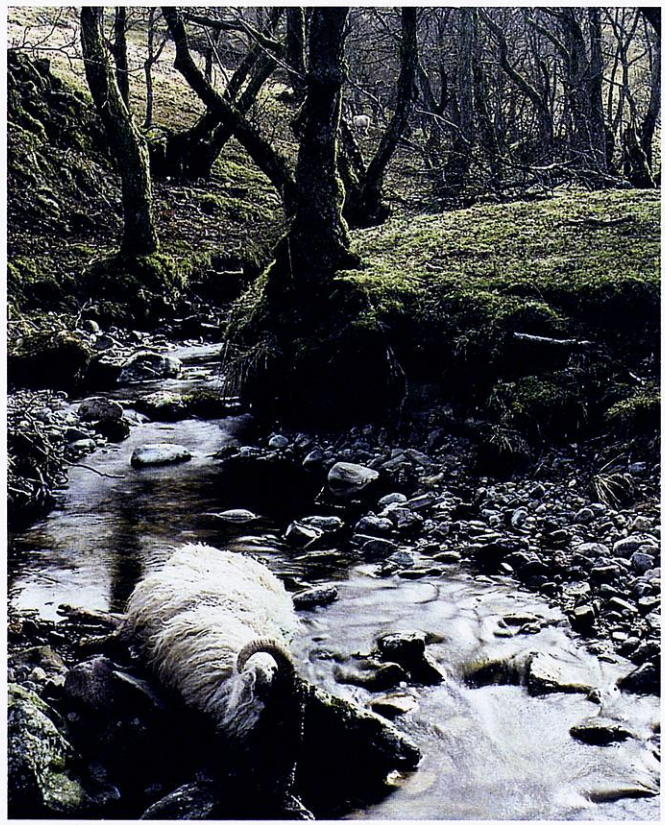
Allowing unrestricted access to watercourses has a number of drawbacks for the control of livestock. Fencing off riparian margins can benefit the livestock farmer through:

- easier gathering
- lower risk of loss or injury of livestock falling in gullies, gorges and broken ground
- isolation of stock (e.g. between farms, accredited or organic herds)
- controlled access to clean water for drinking.

On hill-farms, riparian woodlands often provide valuable shelter for livestock. It is usually possible to regenerate these woodlands in stages by excluding stock from a proportion of the woodlands on a rotational basis, while still maintaining adequate shelter for stock.

use of unproductive ground

On every farm there are a few marginally productive areas, such as steep, broken, boggy or flood-prone ground, or awkward corners in arable fields. Many of these occur along watercourses. Conversion to natural riparian habitats can provide an alternative use for these areas, reduce wastage of farm inputs and streamline farm operations. Establishing woodland will provide shelter and produce timber, assisted by any stray nutrients leached from farmland.



John Parrott / Scottish Native Woods

Uncontrolled access to watercourses causes poaching and erosion, and may lead to loss or injury of livestock

How to restore and manage riparian woodlands

Planning riparian management

Planning the management of a riparian woodland will include the following stages:

- **surveying** the site
- **evaluating** the site's qualities and opportunities
- deciding on the management **objectives**
- determining the necessary **operations**
- drawing up a chart showing **cashflow**
- preparing a **management plan**

This process is essentially no different for riparian woodlands than for other habitats, except in one important respect: management of woodland in the immediate vicinity of a watercourse can have a profound influence on freshwater habitats. Therefore, it is often useful to identify this riparian zone as a separate management unit where objectives and operations will be tailored accordingly.

Listed below are the principal objectives which are likely to apply to riparian woodlands:

- maintaining or restoring a native woodland ecosystem
- maintaining or restoring freshwater habitats
- producing timber
- maintaining and enhancing aesthetic value
- conserving historical and cultural features
- providing opportunities for recreation

Most riparian owners will have several objectives in mind, some with a higher priority than others.

Further guidance on surveying, the selection of objectives and management planning is provided in Scottish Native Woods' leaflet *Surveying and Planning Management in Native Woodlands (2000a)*.

John Parrott / Scottish Native Woods

"Many of our riparian woodlands exist only as tiny remnants ... Securing the long-term future of these vulnerable woodlands must be a high priority."

Managing existing riparian woodland

Deciding how to manage a woodland will depend primarily on the objectives, the woodland's current values (*e.g.* for conservation, recreation, timber) and whether these values are threatened or in decline.

For the achievement of each of the above objectives, a number of issues and principles need to be considered. These are discussed below.

■ **maintaining or restoring a native woodland ecosystem**

Many of our riparian woodlands exist only as tiny remnants, composed entirely of old trees. Securing the long-term future of these vulnerable woodlands must be a high priority. Wherever possible, these remnants should be expanded.

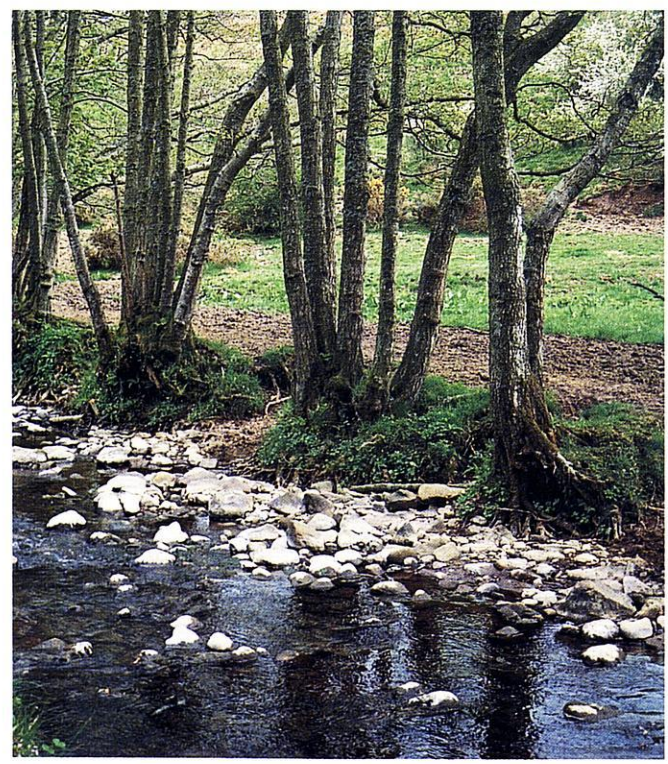
The management required to restore any native woodland must be assessed on an individual basis. Often the most urgent tasks are to reduce grazing to a level that permits regeneration or to remove exotic species. Plans for management are best guided by considering the many factors which influence the value of a woodland for conservation. These include:

- **size** – larger woods are generally able to support a greater diversity of wildlife.
- **connectivity** – native woodlands are often highly fragmented; restoring linkages between isolated remnants facilitates the movement of plants and animals. Riparian woodlands are especially valuable as corridors linking other areas of woodland.
- **longevity** – ancient woodlands, which may have occupied a site continuously for many centuries, are typically the most biologically diverse, and shelter many scarce species rarely found in more recent woodland.
- **naturalness** – woodlands which have been least modified by man support a greater diversity of wildlife. A long history of grazing or the introduction of exotic species typically lead to a loss of biodiversity. Past management may have modified the balance between species. Oak, for instance, may have been favoured or planted at the expense of less valued species. Returning woodland to a more natural state will usually increase its value for wildlife.
- **age-class distribution** – representation of all age classes from seedlings to mature and senescent trees favours high biodiversity. The presence of young trees, often completely missing in grazed woodland, indicates the woodland is regenerating. Old trees provide a wide range of niches to suit different species, whilst decaying wood is a valuable habitat for many scarce insects and fungi.

  When a woodland's canopy is closed, there may be little opportunity for all but the most shade-tolerant species to regenerate. It may be desirable to encourage regeneration by creating gaps in the canopy by thinning or by felling of small coupes, especially where the woodland is even-aged and dominated by one or two species. Care must be taken to ensure that coppice regrowth does not overwhelm regenerating seedlings.
- **structural diversity** - woodland is structured in layers. The canopy, understorey and field layers provide habitat for different species. A diverse structure supports a wider range of species. A healthy balance of species and age-classes will usually ensure good structural diversity, though the structure of some woodlands may also be improved by coppicing.
- **continuity** - many woodland species are sensitive to abrupt change and benefit from the retention of stable refuges. Interventions should always be kept to a minimum and carried out in stages if possible.
- **presence of other habitats** - riparian woodlands may contain a mosaic of other habitats including mires, wet meadows and scrub. Such habitats add to the diversity of the riparian zone.

■ **maintaining or restoring freshwater habitats**

The management of riparian woodland may have a profound influence on the well-being of freshwater and associated fisheries. This relationship is particularly intimate in the immediate vicinity of a watercourse, where tree roots reinforce the bank and the canopy casts shade, leaves and debris on the water.



Peter Collen / Freshwater Fisheries Laboratory

Grazing and trampling by livestock prevents tree regeneration, damages riverbanks and impoverishes freshwater habitats. Excluding stock and singling some stems of these coppiced alder (see page 24) will benefit both woodland and fishery

The width of this riparian zone will depend on the extent of the floodplain, the height of the canopy and the topography. As a minimum requirement, the riparian zone should extend to at least a tree's height from the edge of the floodplain or riverbank, further on the south bank and on steep valley sides.

Management interventions in this zone need to take account of the impact on both woodland and freshwater habitats. In the great majority of cases, operations undertaken to restore the nature conservation value of a riparian woodland will also benefit freshwater habitats.

Particular attention may need to be paid to the manipulation of the canopy in this zone. Light levels influence the productivity of freshwater algae, as well as the development of ground flora on the riverbank, and consequently the bank's exposure to erosion. When seeking to manage light levels reaching a watercourse, it is important to take account of:

- **tree species** – exotic species frequently cast heavy shade[5]
- **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 retaining riparian trees for conservation benefits, and managing them for possible gains in fish productivity.

Particular care is required in the planning and execution of all management operations in the riparian zone to avoid contaminating the water. This applies especially to the use of chemicals.[6]

When felling trees in the riparian zone, an effort must be made to avoid excessive debris falling in the water, as this can cause problems downstream. However, placing large stable debris in a watercourse may enhance freshwater habitats by helping in the creation of pools and in the provision of shelter.[7]

producing timber

The fertility, high water-table and shelter offered by many riparian sites can produce high yields of timber. With sensitive management, it is often possible to successfully integrate production of native hardwoods with other objectives.

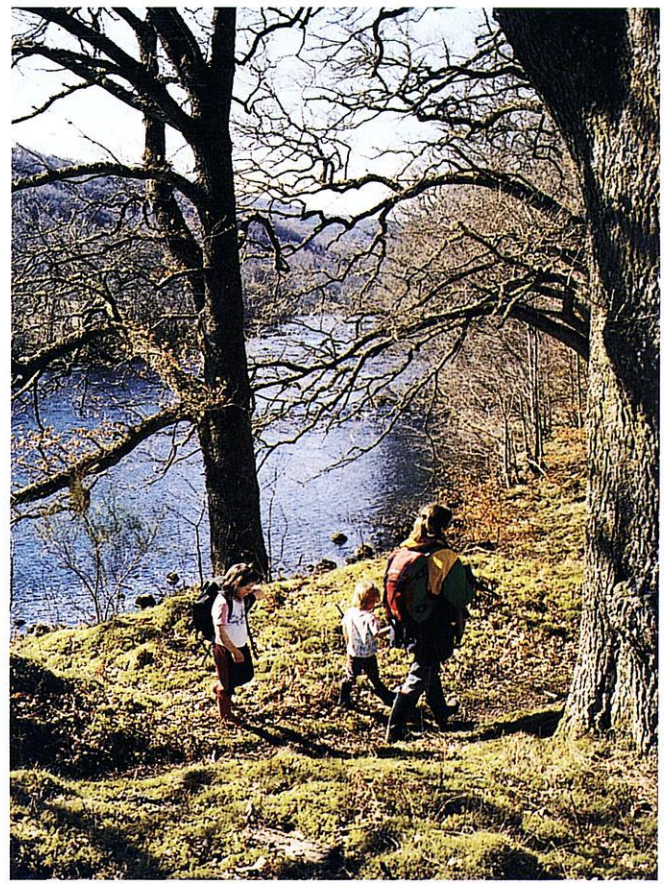
Careful consideration must be given to methods where access is poor. Extracting timber on steep, uneven or boggy terrain is often difficult and will quickly damage sensitive sites. It may be advisable to avoid using a forwarder except when the ground is very dry or frozen. On sensitive sites, it will be appropriate to use extraction methods which impact least on the ground, such as horses, light ATV, pedestrian skidder or a log-chute. Alternatively, timber may be sawn in the wood using a portable saw.

maintaining and enhancing aesthetic value

Without careful planning, some operations (such as clearfelling and fencing) may be visually intrusive. The restoration of native riparian woodland will usually enhance the landscape in the long-term.[8]

conserving historical and cultural features

Sites of archaeological interest are frequent in riparian woodlands. Bridges, march dykes, mills and associated tracks, weirs, lades and sluices add a historical dimension to the value and interest of riparian woodlands. They should be managed in accordance with FC guidelines.[9]



John Parrott / Scottish Native Woods

Riparian woodlands provide excellent opportunities for informal recreation

providing opportunities for recreation

Water provides a very strong focus for informal recreation in woodlands. Existing routes, such as old carriageways, often follow river corridors and few rivers are without footpaths used by anglers.

It is usually appropriate to maintain this pedestrian access, although some management of visitors may be appropriate on environmentally sensitive or eroding sites. Some low-key upgrading of surfaces may occasionally be necessary, especially on wet ground.[10]

5 the management of exotic species is discussed on page 21
6 further guidance is given in *Forests & Water Guidelines* (Forestry Commission 1993)
7 see page 26
8 see *Forest Landscape Design Guidelines* (Forestry Commission 1994)
9 see *Forest & Archaeology Guidelines* (Forestry Commission 1995)
10 see *Forest Recreation Guidelines* (Forestry Commission 1992)

Native or exotic?

When the glaciers retreated from Scotland at the end of the last ice age, some 10,000 years ago, plants started to recolonise the land. As soils improved, the first trees began to arrive. Birch was the first, followed rapidly by other pioneers, including hazel, aspen, rowan, willow, Scots pine and juniper. Oak, elm and ash became established later while alder was one of the last trees to colonise Scotland, arriving around 7,000 years ago. The tree and shrub species which colonised the land naturally are considered native to Scotland. They are listed on page 29.

These natural forests reached their maximum extent about 5,000 years ago and covered most of Scotland's land area. Only bogs, wetlands, mountain tops and some exposed coastal areas were without trees.

Many other trees and shrubs have been introduced to Scotland. Some have become naturalised, that is, they are able to spread naturally in our woodlands. Notable among these are sycamore, beech, rhododendron, European larch and various conifers, many of them North American.

Some species native to Scotland have been planted outside their natural range, notably Scots pine which is not considered to occur naturally outside a core area in the Highlands.

When considering riparian restoration, whether this comprises the re-creation of new habitats or the management of existing ones, it is very important to distinguish between those species which would occur naturally at a site, and those which are introduced.

Species which occur naturally in a particular location, "locally native" species, are adapted to local conditions and support the greatest diversity of wildlife. These species have evolved together over millennia, and form part of naturally balanced self-sustaining ecosystems. They fit together like pieces in a jigsaw puzzle.

Introduced or "exotic" species, on the other hand, are pieces from a different jigsaw puzzle. In their new, alien environment, they invariably provide habitat for fewer species of animal and plant. Many exotics, especially beech, rhododendron and conifers, cast a heavy shade. Their leaf litter is slow to breakdown and produces acid humus. These conditions are often inimical to the native ground flora. As light levels fall and litter accumulates, so the flora becomes increasingly impoverished.

Exotic trees may adversely affect the freshwater environment, too. In-stream productivity falls as shade increases, while the leaf-litter is less readily digested by aquatic invertebrates. Exotic species support a relatively poor invertebrate fauna, so reducing this important source of food for fish during the summer. Run-off from acid humus may also be a concern in poorly-buffered waters. Where exotics cast a heavy shade by a watercourse, the ground flora is often sparse, leaving riverbanks exposed to erosion.

There are also aesthetic considerations relating to exotic species. Whilst non-native trees may be appropriate in designed landscapes, in arboreta or commercial plantations, they frequently look out of place in native woods.

Most importantly, exotic species often require more management. Freed from the natural checks and balances of their own ecosystem, many exotic species readily invade native woodland. The moist fertile conditions which typically prevail in riparian woodlands particularly favour the spread of many exotics.

Sycamore thrives in ashwoods, often occupying spaces vacated by elm following the ravages of Dutch Elm Disease. Both beech and *Rhododendron ponticum* are shade-tolerant; they pose a particular threat because they are able to invade relatively well-stocked woodland.

Some species may rapidly become dominant, to the detriment of native flora and fauna. The impact of these species is considerable, and their eradication can be very costly.

Even in the relatively simple ecosystems of temperate forests, the successional changes, the cycling of nutrients and the dependence of one species upon another are remarkable in their subtlety and complexity. The maintenance of this equilibrium is even more critical where two ecosystems meet and interact, where two jigsaw puzzles become intertwined, as they do in riparian woodlands.

John Parrott / Scottish Native Woods

Because of its shade-tolerance, beech is able to invade this lochside oakwood

Managing exotic species

Throughout Scotland, many semi-natural riparian woodlands have been significantly affected by the introduction of exotic species.

Many riparian woodlands have been planted through, to a greater or lesser degree, with exotic trees and shrubs, either with the aim of increasing their amenity value or for timber production. In Victorian times especially, there was a vogue for 'improving' native woodlands by under-planting with exotic species, such as sycamore, beech, rhododendron and a variety of conifers.

More recently, especially with the expansion of planting in the uplands, numerous remnant riparian woodlands have been enclosed within the boundaries of commercial plantations, most of which are dominated by exotic conifers such as Sitka spruce. Some native riparian woodlands are suppressed or are being actively invaded by exotics. Decisions about whether to remove or control exotic species in these woodlands will be influenced by:

- the degree of dominance and likelihood of invasion by exotic species
- the proximity of exotic species to freshwater, and
- the mix of management objectives.

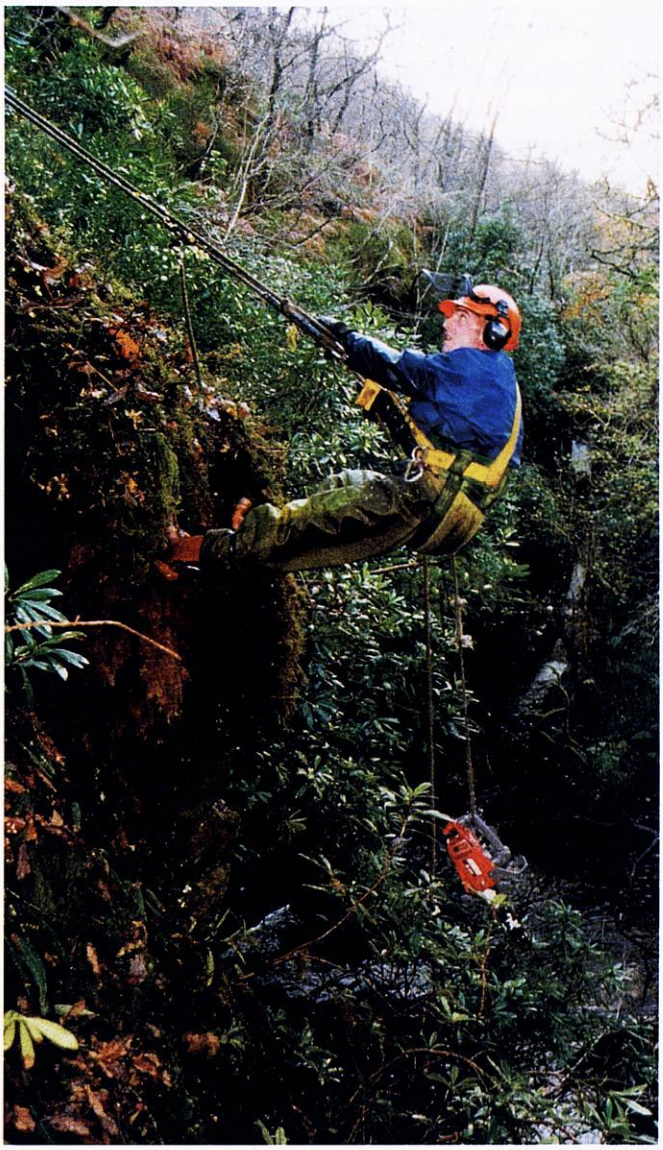
Where exotics are compromising the integrity and biodiversity of native woodland or freshwater habitats, or where they are likely to do so in the future, serious consideration must be given to their removal.

Decisions will have to be made with regard to the fate of the exotic trees and will depend on the value of the timber as well as the sensitivity of the site and ease of access. Where it is not economic to extract timber, or where the level of damage will not be acceptable, it may be advisable to fell timber and leave it lying *in situ*. The resultant decaying wood will provide important habitat for many fungi and insects.

However, even small quantities of felled timber may hinder access through a wood, rendering future management more difficult. Furthermore, the practice of felling to waste is not always readily accepted by the general public. It may be necessary to explain to the local community the reasons for 'felling to recycle', while emphasising the benefits for wildlife.

An alternative option may be to kill standing trees by ring-barking or injecting trees with herbicide.[11] This will leave standing dead wood, a very valuable habitat for hole-nesting birds and a specialised insect fauna.

For a variety of reasons, it may be decided to retain some of the exotics. They may form too great a component of the wood to be removed all at once; some may be host to scarce lichens, such as is sometimes the case with old sycamores; some may provide shelter or nest sites for otters, bats and birds; or some may be retained for their aesthetic or historical value.



Forestry Commission Picture Library

Rhododendron often invades gorge woodlands, swamping the native flora. Eradicating it from these situations may be an exacting task

If the retained trees are seeding and regenerating, it is important to take into account the commitment required to manage regeneration, and to bear in mind that opening of the canopy and ground disturbance associated with felling may release shaded seedlings and encourage a new flush of regeneration.

After felling, most broadleaved species will regrow from the stumps. To control this, the cut stumps may be painted with an appropriate herbicide and any regrowth treated after a year or two's growth.

Many species of non-woody exotic plants colonise riparian woodland, where conditions are often favourable for their growth. Some of these are spread by water, from seed left behind by receding floods. Some species, such as giant hogweed, Japanese knotweed and himalayan balsam, are highly invasive and may, in places, become aggressively dominant. They can shade out the native flora, prevent regeneration and encourage bank erosion. Their removal should be a priority.[12]

11 stem injection is described in Willoughby & Dewar (1995)
12 for further information see *Guidance for the control of invasive plants near watercourses* (Environment Agency 1996b)

Restoring native riparian woodland in commercial plantations

In many forests established before the Forestry Commission Guidelines came into operation, conifers were planted close up to the edge of watercourses. Today, the impact of this practice is evident in river systems throughout Scotland. Heavy shading has reduced the biodiversity and productivity of fresh waters. Shade has also hindered the development of riparian vegetation, and exposed river-banks to excessive erosion. Remnants of native woodland enclosed within plantations have been hemmed in by conifers and have had little opportunity to regenerate.

Neil MacKenzie / Scottish Native Woods

Conifers cast heavy shade throughout the year and are shallow-rooting; planted in close proximity to burns, they destabilise banks

As plantations are re-structured to meet the new guidelines, there is an opportunity to restore natural habitats in the riparian zone and reverse this decline.[14] Where plantation conifers have been removed from riparian areas, the healing process has already begun to pay dividends.

Gains in freshwater and woodland biodiversity are considerable. With the removal of a conifer canopy, the native ground flora may be restored and wildlife corridors re-established. As riverbanks revegetate, they regain their stability. Fisheries recover as spawning and nursery areas are reoccupied.

The landscape benefits too as fingers of native woodland push up into gullies, helping plantations to blend more naturally into the natural land-form.

The restoration of a more natural riparian zone also opens up new opportunities for informal recreation. Riparian corridors frequently represent the most visually interesting areas within plantations. Capitalising on the special synergy that exists between water and native woodlands, routes through riparian woodland can provide the core for new path networks.

In the longer-term, and where there is no conflict with other objectives for the riparian zone, the better soils and shelter may favour the production of native hardwoods such as oak and ash on a long rotation.

The redesigned riparian zone should be sufficiently wide to allow enough light for the restoration of natural functioning of the freshwater ecosystem and riparian margins. Where practicable, it should certainly include all the floodplain. This distance will vary according to several factors including topography and aspect. In

Scottish forestry policy in the 21st Century

Since the 1950s there has been an almost threefold expansion of woodland in the Scottish uplands. Currently there are about 1.4 million hectares of woodland covering 19% of mainland Scotland and the Inner Hebrides. Over 80% of this woodland is dominated by non-native conifers, principally Sitka spruce and lodgepole pine. These forests were planted with the prime objective of producing timber for a nation deforested by war and heavily dependent on imports.

In recent years, forestry policy has evolved rapidly. The Forestry Commission (FC) is now committed to sustainable forestry aimed at delivering a broad spectrum of environmental, social and economic benefits. The role of native trees and shrubs is seen as fundamental to the achievement of many of these objectives.

The FC has produced guidelines to assist the design and management of forests in relation to a wide range of issues, including wildlife conservation, water quality, landscape and recreation. These guidelines set standards for both the public and private sector, and apply to all types of forest.

As plantations reach maturity, the opportunity is being taken to re-design plantation forests to meet or exceed these standards. This restructuring provides an opportunity to restore natural habitats, increase biodiversity and boost the role of native species in our production forests.

There are also benefits for production. Compared to even-aged monocultures, mixed crops have been shown to be more wind-firm, more productive, and less prone to pests and diseases. Self-sown trees and uneven-aged stands are also more resistant to windthrow.

As part of the Forestry Commission's changing philosophy, the general public is being encouraged to take a greater interest in the management of our forests. Planting and felling proposals are published and comments invited from the public.[13] Forest Enterprise consults widely on their Forest Design Plans and is developing working partnerships with a variety of interested parties including local communities and fisheries trusts.

The adoption of a more integrated, inclusive approach represents a major opportunity for restoring native riparian woodlands and freshwater habitats in commercial plantations. In many plantations, native woodland remnants are mostly confined to the margins of watercourses. Many of the potentially most productive headwater burns for salmonids are enclosed within upland plantations. Nowhere will the restructuring of our production forests bring greater benefits than in the riparian zone.

13 The Public Register of New Planting and Felling Applications is updated weekly, and may be consulted at FC offices or by visiting FC's website (see page 36)

practice, it will usually be necessary to remove conifers for a minimum distance equivalent to a tree's height from a watercourse.

Restructuring is usually undertaken when the final crop is harvested. However, where conifers are jeopardising the future of native woodland remnants or freshwater habitats, consideration must be given to restoring the riparian zone at the earliest opportunity, felling crops prematurely if necessary. Where the cost of these fellings cannot be covered by timber sales, or where extraction would cause unacceptable environmental damage, crops may be felled to waste or 'to recycle'.

Where a remnant native woodland has survived along a burn, it is likely that riparian woodland will become established by natural regeneration. An excellent seed-bed for regeneration often remains following the removal of a conifer crop. However where native seed-sources are limited, it may be necessary to plant.[15] It is important to use native species of local origin.

As with all re-stocking, good deer management is a fundamental prerequisite for successful establishment. Riparian areas are especially attractive to deer, and provide excellent opportunities for linked deer glades. 'Lop and top' may sometimes be used as a dead hedge to protect selected areas of regeneration.

Where an eroded featureless watercourse is in need of restoration, the incorporation of large woody debris can be very beneficial. Reject logs or root-wads can be securely positioned to improve in-stream habitats.[16]

Acidification

Large-scale conifer afforestation can have a number of adverse effects on hydrology and water quality. In particular, conifer plantations efficiently filter acid pollutants from the atmosphere, commonly known as 'acid rain'. Their dense, evergreen canopy 'scavenges' these pollutants, mainly oxides of nitrogen and sulphur, from the air, especially under damp and misty conditions. Unfortunately, this acidified rain can then find its way into watercourses, assisted by forest drainage.

Acidification is a problem on poorly-buffered catchments, such as on granite, where dissolved minerals are insufficient to neutralise the deposited acidity. The resulting decrease in water pH can adversely affect freshwater ecosystems, causing a dramatic decline in invertebrate numbers and diversity. The development and hatching of salmonid fish are also hindered, especially when there are episodes of 'acid shock', as may happen after snow-melt. Fish populations may be severely reduced, and in extreme cases, lost altogether.

The relatively small area of forest involved in the redesign of riparian buffers means that this is likely to have a marginal impact on forest scavenging. However, the resulting improvements to freshwater habitats could aid the recovery of fish and invertebrate populations as pollutant emissions continue to decline.[17] The ameliorative effect of restructuring and increasing the width of riparian buffers is currently being researched in acidified catchments in Scotland.

17 The UK government has made a commitment to reduce acid emissions by 80% by 2010

14 the *Forests & Water Guidelines* are currently being revised
15 see page 30
16 see advice on management of LWD on page 26

John Parrott / Scottish Native Woods

Natural regeneration of native species will replace conifers felled in the riparian zone

Coppicing and pollarding

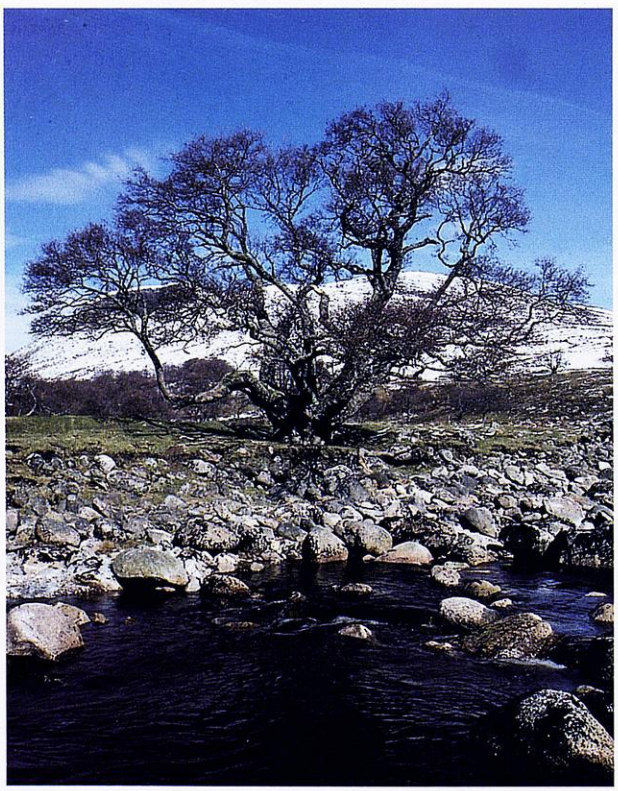
Coppicing and pollarding are techniques traditionally used to manage trees on a more or less regular cycle. Trees are coppiced by cutting young stems cleanly just above ground level. Shoots will appear from dormant buds or the cambium to form several new stems. Pollards are formed in a similar manner but the cut is made at some height (usually 1.5 – 3 metres) from the ground.

Coppice traditionally provided a sustainable yield of small-wood for many purposes including fuel, building, charcoal, creels and tan-bark. Coppice stools are periodically cut close to the ground, and allowed to re-grow for several years before re-coppicing. Coppice woodland is cut in coupes over a rotation of 5-30 years depending on species and products required. Most broadleaved species will coppice successfully especially if first coppiced while still young. Those most often managed as coppice include hazel, oak, ash and alder. Coppice regrowth is very palatable to livestock, so it is vital to keep grazing to a minimum.

Pollarding was traditionally used to manage trees in areas of 'wood pasture' where livestock were present. Pollards were cut high to prevent livestock browsing the regrowth. Pollarded trees provided a supply of small-wood, and the foliage was cut and fed to livestock as winter fodder and for veterinary purposes.

Coppice is naturally stable, but regularly cut pollarded trees can also survive to a great age, their form enabling them to survive gales. Ancient pollards and coppice stools often provide many clues about the history and culture of an area.

Besides their historical significance, pollards provide niches for a great diversity of plants and animals; bats roost in their hollows, ducks nest in their crowns. Pollards are particularly important for rare lichens and insects dependent on decaying wood.



John Parrott / Scottish Native Woods

Many veteran trees such as this alder are 'naturally pollarded'. They have a high biodiversity value, and should be managed with care

Managing coppiced and pollarded trees in the riparian zone

Coppiced and pollarded trees are frequently found in riparian woodlands. Often they have been neglected for many decades, and decisions have to be made regarding their future management.

Deciding how to manage pollards will depend primarily on their conservation value, and their condition. If the trees are old, or hollow, or covered in lichens and mosses, they may be host to an exceptional flora and fauna. Unless a pollard has a top-heavy or unbalanced crown, it may be best left untreated. Because of the historical significance and exceptional biodiversity of ancient pollards, it is worth seeking professional advice.[18]

There may be several options for managing neglected coppice. In recent years, traditional coppice regimes have been reinstated in many coppice woodlands, but the success of such an enterprise depends on a ready market for a variety of products. In many formerly coppiced woodlands, it will be most appropriate to manage for greater biodiversity. Often, neglected coppice is even-aged and uniformly shady. Its conservation value is likely to increase with more diversity of structure, age and light levels.

Options for managing coppice stools are :

- **retention**

This will be the preferred option for some old stools, which may have lost the vigour to regenerate successfully after cutting. Old coppice is a valuable habitat for lichens, especially on base-rich soils in the west and in gorges. Hazel, ash and elm host a particularly rich lichen and bryophyte flora, which can be damaged by coppicing.

- **re-coppicing**

If this option is pursued, it is essential to ensure that enough light penetrates to support vigorous regrowth. There may be sufficient light along edges – on the boundary of a wood, along a track or a burn - to coppice individual stools. Otherwise it is necessary to coppice a sufficiently large coupe to allow light in, typically 0.1 – 0.2 hectare.

It is also vital for the success of regrowth to exclude grazing animals. Even small numbers of roe deer will prevent stools regenerating. If grazing levels are low, piling brash onto the cut stump or using it to build dead hedges may be sufficient to discourage browsing.

In the first instance, it is probably advisable to experiment on a small scale, and to monitor results. If browsing damage to new shoots is unacceptable, any further coppicing should be postponed until grazing is under control.[19]

18 see Read (2000)
19 more details on the practical aspects of coppicing are available in Harmer (1995) and Mummery *et al* 1997

Heather Insh

singling

An alternative option is to select the most upright stem for retention, and cut the remaining stems close to the stool. This will produce a single vigorous stem. Singling is a less risky option than coppicing where there are concerns over the level of grazing. Converting coppice to high forest may reduce future management costs and yield timber in the longer term.

In general, it is best to avoid applying an even treatment over a large area. Greater structural diversity will be provided by a mosaic of different treatments undertaken over a period of time. Many woodland species require continuity of habitat, both in space and time, and are sensitive to abrupt change. It is therefore important to maintain refuges and corridors of stable habitat.

Special care must be taken to avoid damaging old and hollow trees. Old trees support scarce species such as slow-growing lichens which do not readily colonise new habitats. Cracks or hollows in riparian trees are important roosting sites for bats, and are favoured sites for otter holts, both of which are protected by law.

Management is best undertaken in winter when trees are dormant. Such work is easier when trees are leafless, and regrowth of coppice stools is more vigorous and more reliable. In addition, there is likely to be less damage to the ground flora and less disturbance to breeding birds and other animals. Special consideration may have to be given to managing neglected coppice growing on riverbanks. In particular, it is not uncommon to find overgrown alder coppice along both banks of a small burn. In such cases, the heavy shade depresses in-stream productivity. Often too, stock have regained access to the banks. The dense shade, combined with grazing, suppresses riparian vegetation and weakens the banks. Coppice stools may subsequently be undermined by erosion and may lean. Eventually they may fall over completely, tearing the rootplate from the ground.

In such circumstances, it is recommended to remove grazing, increase light levels and render leaning or 'pedestalled' trees more stable. This may be achieved by re-coppicing, but singling may be a more satisfactory option. Singling will lift the canopy, allowing more light to the banks and water surface, and should require less ongoing management than coppice. Pollarding some of these singled stems would provide new niches for wildlife in future years, and may salvage the future of leaning stems on undercut riverbanks.

It may be desirable to maintain shade over pools in summer, when temperatures are high and water-flows are low. High canopy on the south bank of a burn will most readily provide this shade.

Material cut during coppice management can either be removed or left on site. Where there is sufficient volume and reasonable

access, it may be worth investigating local markets for products such as charcoal, firewood or crafts.

Surplus material can often be put to good use on site. Where the banks of a stream are badly eroded, the brash may be laid at the toe of the bank and secured with stakes. This material will encourage the deposition of silt, while willow and alder stakes are likely to take root. Alder, willow and hazel can also be 'layered' to fill gaps. Larger material can be used to improve in-stream habitats (see below).

Surplus cut material may be used to build artificial otter holts,[20] used to build dead hedges to deter browsing or piled above the flood level to provide shelter for a variety of wildlife. Decaying wood is an important and rather scarce habitat. Larger surpluses can be chipped to surface paths. If material must be burnt, it is important to avoid damaging botanically valuable sites.

If more than 5 cubic metres of timber are to be felled in any 3-month period, it is necessary to apply for a felling licence from the Forestry Commission.[21]

20 Ward *et al.* 1995

21 managing riverside coppice and pollards may be grant-aided; where grant-aid is provided through the Woodland Grant Scheme, felling licences are issued as part of the WGS contract.

Managing Large Woody Debris

The importance of large woody debris in the functioning of freshwater ecosystems has become increasingly recognised in recent years. Described as the 'backbone of a stream', large woody debris plays a key role in increasing habitat diversity and stability, easing downstream flooding and providing cover for fish. The role of large woody debris (LWD) is described more fully on page 8.

Although LWD accumulates naturally in watercourses bordered by woodland, additional debris may be introduced where there is insufficient input.

A good opportunity to do this may present itself during the re-structuring of commercial plantations. Trees rejected during harvesting, especially windblown trees complete with root-wad, are likely to be suitable. As long as conditions will allow safe access and there is no risk of damaging banks, large material may be most easily placed in a watercourse by a harvester or forwarder.

The following recommendations for the management of LWD in headwater rivers[22] are adapted from Linstead & Gurnell (1999):

- **Indiscriminate removal of LWD should be avoided.**
- **Some removal of LWD may be necessary where it causes damaging floods or accumulates at bridge arches etc. Removal should be confined to a restricted length of the channel.**
- **Where flooding is a less severe or localised problem, selective removal of debris is preferable to complete removal since the major environmental benefits of LWD dams are retained when the most stable pieces of wood are not disturbed. Stable dams are the most valuable and often extend across the full channel width creating a step in the water surface at both low and high flows.**
- **Inputs of large quantities of small wood debris from riparian management and forestry operations can cause excessive sealing of active dams, making them too effective a barrier to fish movement. Such wood input should be avoided or selectively removed.**
- **The addition of LWD improves physical habitat and counteracts stream incision. The introduced pieces should form the key pieces of stable debris accumulations. They should be at least as long as the channel width with a diameter of at least 0.1m or 5% of the channel width, whichever is the larger. LWD should be securely keyed into the bed of the river, jammed in a constriction in the channel or braced by boulders, rock outcrops or riparian trees. If dams are not sufficiently leaky to allow passage of fish, small debris should be selectively removed without destabilising the larger wood.**
- **Riparian woodland is the natural source of LWD. Tree clearance and pruning close to the river channel will disrupt the supply of wood. The management of riparian trees should therefore be minimised within a buffer strip along the river margin.**

22 LWD is defined as pieces of dead wood larger than 0.1 metre in diameter and 1.0m in length. Headwater rivers are 10 metres or less in width

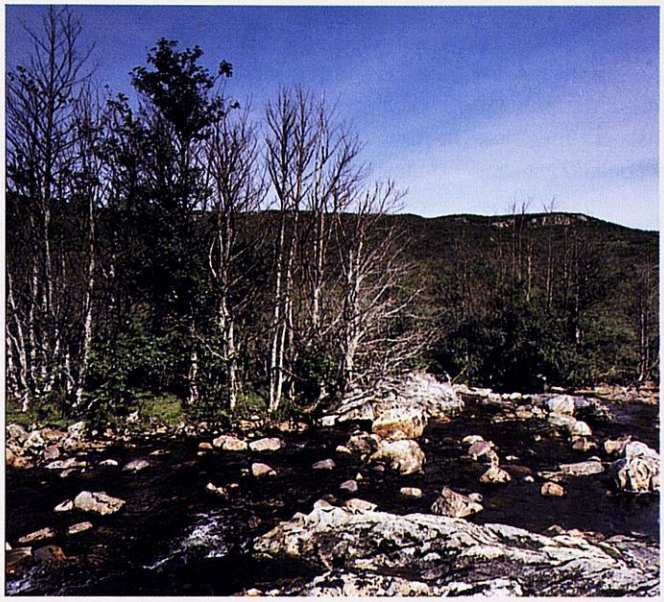
Heather Insh

Foliage loss in alders

From time to time many of our native trees suffer foliage loss due to a variety of causes, including attacks by bud-mining or defoliating caterpillars and beetles. These attacks do not normally result in any permanent damage to the affected trees. However, there are two afflictions which could pose a more serious threat to the health of the alder population. Heavy losses of alder would have severe consequences for the health of rivers and could affect fish stocks. *Phytophthora* disease and Crown Dieback are conditions which can eventually be fatal. The most noticeable symptom associated with both disorders is the partial or complete loss of the foliage in a tree's crown.

Phytophthora disease develops from the bottom of the tree upwards. The fungus which causes the disease infects and kills both the roots and bark of the tree. The first visible symptom is often the presence of tarry or rusty spots on the bark low down on the trunk. When most of the bark at the base of the trunk has been killed, crown symptoms become evident. In mid to late summer the leaves of affected alders are abnormally small, yellow and sparse; they often fall early, leaving the tree bare. If the fungus continues to kill the bark around its stem the tree will die, although the survival of even a narrow strip of bark can support some new growth from the trunk and major branches.

Phytophthora disease typically affects riverside alders, and spreads by means of free-swimming spores. It has now become a serious problem in England and Wales where over 10% of the riparian alder population are known to be diseased or dead. In Scotland, the disease was first recorded in1996 but to date there have been only three confirmed reports - one on the R. Spey and two on the R. Avon (a probable fourth case from the R. Tweed was recorded in 1999). However, depending upon its severity, the disease may have gone unrecognised and be more widespread than these records would suggest.



Neil MacKenzie / Scottish Native Woods

Foliage loss in alders affected by Crown Dieback

At present there is no recommended management for alders affected by *Phytophthora* disease. The felling of diseased trees would not eliminate contamination of the site as the fungus could still be retained in infected roots and soil.

In contrast to *Phytophthora* disease, Crown Dieback of alder develops from the top of the tree downwards. The first symptoms of the condition are the presence of dead and dying leaves or leafless twigs along branches during the growing season. These symptoms are associated with patches of dead bark (lesions) on the branches. Trees suffering from dieback take on a skeletal appearance, but dead shoots and branches disintegrate rapidly so that evidence of the condition can soon vanish. The death of affected trees is common, but some may survive if the bark on their stems is not completely killed. In such cases, new shoots can develop from the base of the trunk to form a new crown beneath the dead, disintegrating top.

Crown Dieback in alders first became noticeable in northwest Scotland during the early 1980s. Within the last decade it appears to have become widespread throughout the Highlands, with a few recorded outbreaks in the south of Scotland. At present, its cause or causes remain unknown. Because of this, no specific management is recommended and there is no case for the felling of affected trees. It is probably advisable to avoid using diseased alder stems for in-stream operations such as bank stabilisation in case this helps spread infections.

The Forestry Commission is currently conducting research into Crown Dieback and Phytophthora disease of alder in Scotland. Reports of suspected cases would be welcomed, and should be made to Dr Steven Hendry in the Pathology Branch of Forest Research (Northern Research Station, Roslin, Midlothian, EH25 9SY. Tel: 0131 445 6945; Email: steven.hendry@forestry.gov.uk), from whom further information can also be obtained.

Steven Hendry / Forestry Commission

Tarry spots low on the trunk are often the first sign of *Phytophthora*

Re-establishing riparian woodland

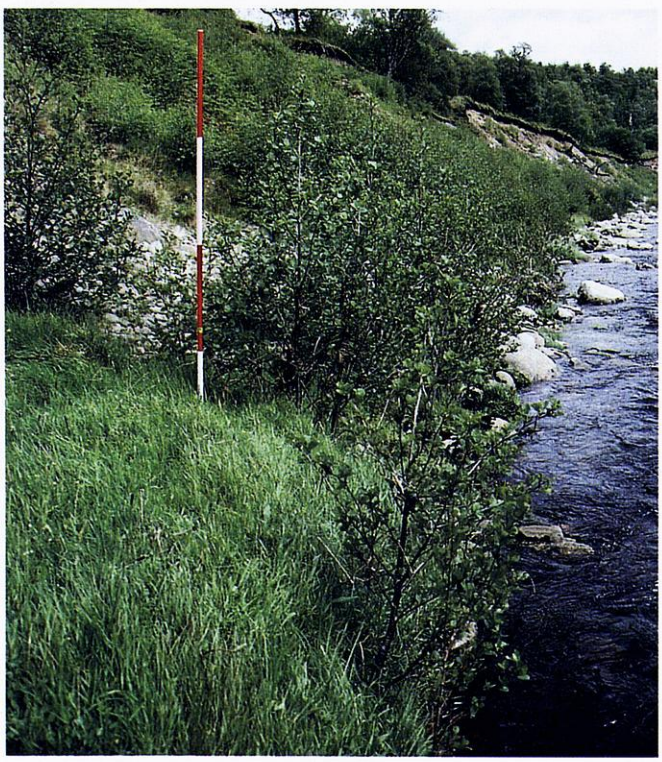
Native woodland is the natural climax vegetation in the riparian zone along most of Scotland's watercourses from near the source to the sea. Even high above the natural tree-line, trees straggle up sheltered gullies. Given the value of riparian woodlands, their re-establishment should be a high priority.

Where a site is able to regenerate naturally, this is almost always the preferred method of re-establishing native woodlands. Compared to planting, natural regeneration usually produces woodland which is better matched to the site. It is likely to be more natural in appearance, species composition, genetic distinctiveness and diversity.

Because their root systems have developed *in situ*, self-sown seedlings are often more robust than trees transplanted from a nursery. They are more tolerant of grazing and drought, and less likely to be dislodged by floods.

Natural regeneration may be possible on some parts of a site and not others. Alder will for instance quite often colonise a strand-line, forming a narrow ribbon of trees, while more fertile, less disturbed ground further back from the bank may support a dense grass sward. Improved grassland, even if it has regressed significantly, rarely allows tree seedlings to regenerate naturally.

It is also important to remember that natural riparian habitats typically form a mosaic of woodland and open habitats, such as mires and meadows. These non-woodland habitats often have a high conservation value, and should not be planted. If they form enclaves within a fenced regeneration scheme, for instance, they may require management, such as seasonal grazing, to maintain their condition.



John Parrott / Scottish Native Woods

Alder regenerating on the strand-line will bind an eroding river-bank

Encouraging natural regeneration

The successful recolonisation of a site by woodland depends on several factors, chiefly:

- the species composition, proximity and extent of the seed-source
- site characteristics, especially the nature of existing vegetation and soil type
- grazing pressure

The seed-source:

The dispersive powers of tree and shrub species vary enormously. Species which are especially good at colonising new sites, the 'pioneer species', usually seed prolifically. Many are dispersed by wind. Their seeds are light and often winged. Examples are birch, willow, ash and Scots pine.

John Parrott / Scottish Native Woods

Willow produces an abundance of light seeds carried by wind and water

Other species, such as oak, hazel, rowan, hawthorn and elder are dispersed by birds or small mammals. As an adaptation to their riparian environment, alder seeds float on water. They are carried across lochs and down rivers and deposited on riverbanks by receding floods. A few species, such as aspen, gean and blackthorn, can spread vegetatively by throwing up shoots from a shallow root-system.

Depending on species and exposure, seed-fall may only be adequate for regeneration in the close vicinity of a wood. However very light seeds, such as those of willow, birch and pine may be blown great distances. On the right ground, birch regeneration will usually be plentiful within 100 - 200 metres of a woodland, depending on the direction of the prevailing wind.

The site:

In order to become established, tree seedlings have to successfully compete with surrounding vegetation for light, water and nutrients. Some species are better adapted to certain

conditions than others. Pioneers such as birch typically require high light levels. They will often germinate on poor mineral soils as long as there are openings in the existing vegetation cover. The much larger-seeded hazel, on the other hand, will regenerate in quite shady conditions as an understorey in woodland among grass or light bracken.

In general, tree seedlings will colonise sites with scant vegetation cover more readily than fertile sites with a vigorous grassy sward or weed growth. Eroded banks and gravel deposits are often excellent sites for regeneration of pioneers such as alder, willow, birch and Scots pine.

■ **Grazing:**

The level of grazing is critical to the successful establishment of tree seedlings. Very often, seedlings appear but fail to become established because they are repeatedly grazed back. Tree species differ in their palatability to stock. Aspen and willow are particularly attractive, whereas alder and birch are less so. Pine may be severely browsed in winter, when broadleaves are leafless.

On many sites, all that may be required is to fence out domestic stock and control other herbivores, such as deer and rabbits. Where advance regeneration has been held in check by grazing, tree establishment is often rapid and prolific.

Where a well-established grass sward is hindering the establishment of tree seedlings, it may be advisable to break up the soil surface, a process known as 'scarification'. Poaching by domestic stock (especially cattle or pigs) may expose pockets of mineral soil to provide a seed-bed. When stock are used to scarify a site, they should be removed just before seed-fall.

Livestock may also assist regeneration on sites with light to moderate bracken cover. Where bracken is dense, repeated cutting will often weaken it sufficiently to allow species such as hazel and ash to regenerate.[23]

If there are already some tree seedlings present, it is usually worth excluding grazing and monitoring progress. If regeneration is inadequate after 4 – 6 years, consideration may then be given to further treatments or direct planting.

Judging whether a site will regenerate naturally and what intervention may be required requires close observation and experience. If there is doubt about the success of natural regeneration, it will usually be best to seek advice.

Scotland's Native Trees And Shrubs

Alder	*Alnus glutinosa*
Ash	*Fraxinus excelsior*
Aspen	*Populus tremula*
Birch, silver	*Betula pendula*
Birch, downy	*Betula pubescens*
Blackthorn	*Prunus spinosa*
Cherry, bird	*Prunus padus*
Cherry, wild (gean)	*Prunus avium*
Elder	*Sambucus nigra*
Elm, wych	*Ulmus glabra*
Hawthorn	*Crataegus monogyna*
Hazel	*Corylus avellana*
Holly	*Ilex aquifolium*
Juniper	*Juniperus communis*
Oak, pedunculate	*Quercus robur*
Oak, sessile	*Quercus petraea*
Pine, Scots	*Pinus sylvestris*
Rose, dog	*Rosa canina*
Rose, guelder	*Viburnum opulus*
Rowan	*Sorbus aucuparia*
Whitebeam, rock	*Sorbus rupicola*
Whitebeam	*Sorbus arranensis*
Whitebeam	*Sorbus pseudofennica*
Willow, goat	*Salix caprea*
Willow, grey	*Salix cinerea*
Willow, eared	*Salix aurita*
Yew	*Taxus baccata*

All of these species may be found in the riparian zone where soil types are appropriate. Some trees, such as alder and willow, are particularly well adapted to the riparian habitat as they can tolerate frequent immersion while oak, downy birch, ash and wych elm can also survive temporary flooding. Along some Highland rivers, Scots pine is a coloniser of exposed shingle beds. Small shrubs such as gorse, broom and some of the montane willows such as tea-leaved willow *Salix phylicifolia* and downy willow *Salix lapponum* also occur along watercourses.

A few native trees and shrubs are rare or have a restricted natural distribution in Scotland, for example yew, guelder rose and rock whitebeam *Sorbus rupicola*. Scots pine occurs naturally only in the Scottish Highlands, while *Sorbus arranensis* and *S. pseudofennica* are found only on Arran.

23 bracken may also be controlled by spraying, but foliar spraying should not be undertaken close to watercourses

John Parrott / Scottish Native Woods

A buffer of broadleaved riparian woodland will trap agricultural run-off, reduce pollution and benefit fish and other wildlife

Establishing woodlands by direct planting

When native woodland is unlikely to colonise a site naturally, it will be necessary to establish trees and shrubs by planting.[24] The objective should be to create woodland in which the composition and structure of tree, shrub and field layers will eventually approach those of nearby semi-natural woods.

To achieve this, it is vital to get a good match between the site and the type of woodland. Altitude, aspect, soil fertility and wetness all determine the type of woodland which a site will support. The design of a new woodland may be partly guided by careful observation of semi-natural riparian woods in the locality. These woodlands may provide a useful model, but it should be borne in mind that many are likely to have been modified by past management, such as grazing.

An 'ecologically informed design' will sensitively match species choice and planting pattern to the natural character of the site – its landform, soil and existing vegetation. Conditions in the riparian zone may vary markedly from place to place. Base-rich flushes, free-draining gravel deposits and deep alluvial silts may all occur in close proximity on one site. Each of these soils will support different species, so the end result may be a complex mosaic of different woodland types.

The National Vegetation Classification (NVC)[25] describes 19 major types of woodland in UK, 13 or so of which occur within river corridors in Scotland. The Box below shows the species characteristic of each woodland type. Not all the species listed are native throughout Scotland; planting should be confined to species native to the locality.

Planting distances and configurations should be chosen to ensure that the woodland appears and functions as naturally as possible. This can be achieved by varying spacing between trees and combining planted clumps with areas of open ground. To avoid fast-growing species becoming dominant, it is advisable to use 2–3 well-matched species within clumps, rather than intimate mixtures.

The Woodland Grant Scheme stipulates average stocking densities while allowing up to 20% of a scheme as open ground for access, glades and non-woodland habitats.[26] Establishment grants may be awarded *pro rata* if only a proportion of a scheme is planted, in widely-spaced clumps for instance.

Trees and shrubs should be planted up to the riverbank, where they will be of greatest benefit to freshwater through their inputs and by stabilising the bank. Along small burns, where the tree canopy may eventually close over the water surface, it may be decided at a later date to thin, pollard or high-prune trees to maintain light levels.

It is best to avoid mechanical ground preparation, as this disturbs the soil profile and often encourages weed growth. Screefing or turfing by hand before planting is usually adequate. Drainage and fertiliser applications should be avoided.

When sourcing trees from nurseries, it is important to stipulate planting stock of local genetic origin. Apart from considerations of genetic integrity, they will be better adapted to local conditions. Some trees, especially willows, will grow from cuttings so long as they are planted deeply enough to find the water-table. They should be planted as pointed stakes.

Sometimes weed growth will need to be controlled for 2-4 years until trees are well established. The use of mulch mats, strimming around the base of the tree or the application of a systemic herbicide are satisfactory forms of weed control. However, herbicides should not be used next to watercourses.

It is very important to protect planted trees from grazing animals. Domestic stock, deer, rabbits, hares and voles can all decimate unprotected trees in a matter of days. Fencing is usually required and the use of tree-shelters or mesh-guards is usually recommended.[27]

24 further guidance on the creation of new native woodlands is provided in Rodwell & Patterson 1994
25 Rodwell, J.S. ed. 1991
26 minimum stocking density is usually a minimum of 1100 stems per hectare, equivalent to an average spacing of 3 metres
27 further guidance on planting is given in Scottish Native Woods 2000b

Typical species composition of native woodlands in Scotland (adapted from Rodwell & Patterson 1994)

NVC type		TREES														SHRUBS							
		Alder	Ash	Aspen	Downy birch	Silver birch	Wych elm	Gean	Bird cherry	Holly	Pedunculate oak	Sessile oak	Rowan	Scots pine	Goat willow	Blackthorn	Elder	Guelder rose	Hawthorn	Hazel	Juniper	Eared willow	Grey sallow
W4	Birch woodland with purple moor-grass	•	.	.	●	.	.	.	.	.	.	.	.	.	•	.	.	.	.	.	.	•	●
W6	Alder woodland with stinging nettle	●	•	.	•	.	.	.	.	•	•	.	.	.	•	•	•	•	•	•	.	.	•
W7	Alder-ash woodland with yellow pimpernel	●	●	.	•	.	.	.	○	•	•	•	•	.	•	•	•	•	●	●	.	.	●
W8	Lowland mixed broadleaved woodland with dog's mercury	.	●	○	•	•	○	○	.	•	●	○	○	.	•	•	•	•	●	●	.	.	•
W9	Upland mixed broadleaved woodland with dog's mercury	•	●	○	●	.	•	.	•	•	○	•	●	.	.	.	•	.	•	●	.	.	•
W10	Lowland mixed broadleaved woodland with bluebell	.	.	.	.	●	•+○	○	.	•	●	○	•	.	.	•	•	•	●	●	.	.	.
W11	Upland oak-birch woodland with bluebell	.	.	○	●	○	.	.	.	•	○	●	•	.	.	.	.	.	•	•	○	.	.
W16	Lowland oak-birch woodland with blaeberry	.	.	○	○	●	.	.	.	.	●	○	•	.	.	.	○	.	.	.	.	.	.
W17	Upland oak-birch woodland with blaeberry	.	.	.	●	○	.	.	.	•	○	●	•	.	.	.	.	.	○	○	○	.	.
W18	Scots pine woodland with heather	.	.	.	○	○	.	.	.	.	.	.	•	●	.	.	.	.	.	.	•	.	.
W19	Juniper woodland with wood sorrel	.	.	.	○	.	.	.	.	.	.	.	•	•	.	.	.	.	.	.	●	.	.

KEY

● major species through out the range ○ major species locally or in part of range • minor species throughout the range ○ minor species locally or in part of range

Restoring eroded riverbanks

Bank erosion is a widespread problem to which the solution is often as simple as it is effective – to reduce grazing. Once stock are removed, vegetation usually recovers quickly. Poached ground is often a good seed-bed for regenerating native trees and shrubs.

This is likely to be the cheapest and the most effective method of protecting a riverbank. The natural vegetation which develops will provide habitats for a diversity of species and requires little maintenance.

Where erosion is acute, it may be wise to take further measures to stabilise riverbanks. Conventional 'hard engineering' methods of bank reinforcement, such as rock rip-rap, are costly, visually intrusive and often ineffective. More natural 'bio-engineering' methods are environmentally sustainable, self-maintaining and more sympathetic to the natural environment.

The techniques used will depend on the nature of the watercourse and the materials available. It is often possible to stabilise banks using willow or alder. Several techniques are available, all of which rely on the ability of these species to root from stakes driven into the bank. In conifer plantations, it may be possible to use conifer logs and tops to protect the toe of the bank.[28]

28 Description of these techniques is outwith the scope of this publication, but they are described in Environment Agency (1998) and (1999)

Alison Espie / FWAG

Grazing and bank erosion

Riparian owners are often prompted to take action to protect riverbanks following a major flood event, when banks collapse and the real cost of erosion becomes acutely apparent. Before tackling the problem, it is important to understand the causes of erosion.

Erosion is a natural process, but it has been exacerbated by the immense changes to our landscape brought about by human activities. Four thousand years ago, Scotland's landscape was dominated by native woodland. This natural forest, its canopy and its roots effectively bound and protected the soil, and kept erosion to a minimum. River catchments acted like a sponge, soaking up water during the winter and releasing it during the summer.

The natural forests' protective cloak has now been largely cleared and replaced by farmland, moorland and plantation. Only 2% of the original forest remains, while about 75% of our land area is either farmed or managed for sport or commercial forestry. Drainage of arable and grazing land, moor-gripping, afforestation, river engineering and the confinement of rivers by flood defences have all led to increased run-off rates. Meanwhile, we use our floodplains and riparian land ever more intensively, weakening the land's natural defences against erosion. With global warming and predictions of higher rainfalls already becoming reality, the problem of erosion appears unlikely to decrease.

The process of erosion is relatively straightforward. Most commonly, soil is washed away when the protective layer of vegetation is weakened or damaged. This process is often initiated by overgrazing with livestock. Most damage occurs in the winter when the vegetation is dormant and the ground is wet. Besides the impact of grazing itself, cattle trample riverbanks, while sheep create rutted paths and rub themselves against undercuts. Where grass is closely-cropped, this creates ideal conditions for rabbits, placing the turf under further stress.

The shorter the turf, the shallower the root system. Eventually, the fabric breaks down, banks are trodden down or collapse as they are undercut. The end result is an unnaturally wide and shallow river channel and a barren environment with little to offer freshwater organisms, including fish.

Fencing in the riparian zone

Fencing riparian schemes requires particular care in both planning and execution. Choosing the line of the fence and the materials and construction to be used are all critical to the success of a scheme. Expert advice will often save later disappointments. Well-designed and erected fences will reduce long-term maintenance costs. In particular, it is necessary to take account of:

- the behaviour of the watercourse at all levels of flow, especially in full spate, and
- the need to maintain access to water for livestock.

In many situations, it is possible to hold most of the fencing back above the height of even the most extreme flood. On floodplains, however, this may not be possible. Floods, and especially the debris which they transport, can be very damaging to fences. It is important to remember that channels shift, and to avoid placing fences too close to the riverbank, especially where a bank is being actively eroded.

Knowing where a river bursts its banks during a flood will guide the design of a fence. In flood-prone areas, fences should be designed so that they restrict the flow of water in a flood as little as possible:

- use line-wires rather than netting, to reduce the amount of debris snagging on fences
- angle the fence to shed debris downstream rather than trapping it

John Parrott / Scottish Native Woods

Fencing in riparian situations may demand special techniques

Neil MacKenzie / Scottish Native Woods

Water-gates require regular checking, especially after floods

- avoid concave sections which might channel and accumulate debris.

Where it is impossible to avoid placing fences across the direction of water-flow:

- take particular care to firmly secure 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 in long stretches of fencing
- 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 so as to minimise the cost of re-instating the fence after the flood has subsided. It may for instance be possible to secure the upstream end of each wire firmly, while tacking the downstream end. It is easier to staple wires back on to posts than to erect a new fence.

Water-gates

In any riparian scheme, it is necessary to ensure that stock cannot walk round the end of a fence at low water. Often the easiest solution is to site the crossing-point at a gorge or waterfall where the gradient of the bank prevents stock gaining access. On gentler slopes it is usually necessary to erect a water-gate. Using an existing structure, such as a bridge, is the ideal option, but a purpose-built water-gate is often necessary.

Several designs are used depending on the width and nature of

the water-course, and accessibility for transporting materials. On accessible sites up to 8 metres width, telegraph poles are often used to support a water-gate. The effectiveness of a water-gate relies on the right choice of design, careful construction and regular checking. After heavy rain or snow-melt, it is especially important to remove debris that occasionally fouls on a water-gate and jams it open.

Similar care has to be taken when fencing at the margins of a loch. Account has to be taken of fluctuations in water-level (especially drawdown from a hydroelectric scheme), and possible damage by storms and ice.

Access for drinking and crossing-points

When fencing off riparian margins, it is often necessary to maintain access to a water-course for watering livestock. A fenced watering-bay should be positioned where it is least likely to be damaged in a flood. The fences should be angled downstream to shed debris, using braced posts. If necessary, fencing can be designed to lift in a flood, using the same principle as a watergate.

Alternatively, it may be easier to provide water-troughs or stock-operated pasture pumps. Depending on the lie of the land, troughs may be filled by gravity, hydraulic ram pumps or mains water.

Access may be required across a watercourse for farm vehicles. It is often convenient to combine watering-bays with crossing-points. Drinking-points and fords should preferably have a hard base.

When fencing riparian schemes, it is important to consider the need for gates and deer-jumps to ease the removal of stray livestock, kissing-gates or stiles on footpaths for visitor access, and the possible need for badger-gates. It is also essential to check fences and water-gates regularly, and especially after floods.

Monitoring

John Parrott / Scottish Native Woods

Electrofishing may be used to monitor changes in fish populations after habitat improvements

When planning riparian schemes, it is important to include some provision for measuring progress. Monitoring provides valuable feedback as to the effectiveness of management, and can prompt timely adjustments to a scheme if results do not meet expectations. It will also help guide management decisions on other sites.

Monitoring relies on the accurate recording of selected parameters in the form of a baseline survey at the beginning of a scheme. These might include changes in vegetation, fish populations or the profile of riverbanks. This survey will be repeated at intervals to provide an objective measure of a scheme's progress.

One of the simplest and quickest forms of monitoring is fixed-point photography. This will detect only fairly coarse changes such as increases in vegetation height and the erosion of banks, but it has many advantages over other more time-consuming and costly methods.[29]

Alan Drever / Scottish Native Woods

John Parrott / Scottish Native Woods

Regeneration on an eroding riverbank – in 1994 (left) when grazing was removed, and five years later (right)

29 monitoring methods are described in Scottish Native Woods 2000c

Making it happen

Planning and funding riparian management

By their very nature, schemes for improving riparian management are often rather complex and typically require good communication with many parties. The following are the main keys to success:

A **Advice** – it is useful to seek professional advice at an early stage. Most agencies (such as Scottish Natural Heritage, Scottish Environment Protection Agency, Forestry Commission, Scottish Executive Rural Affairs Department) and many non-governmental organisations are able to offer advice. Knowing what will work, what funding is available and who to speak to will save time and money. Some advice is free of charge, but the cost of any advice is likely to be considerably less than the savings made and the extra funding which an adviser is likely to identify.

B **Breadth** – demonstrating a broad spectrum of benefits from a scheme will attract greater support from a wider range of stakeholders and widen funding opportunities. For instance, a scheme which aims to meet multiple objectives such as improved habitats for wildlife, healthier freshwater habitats and opportunities for recreation will be more attractive to funders than one with a single narrow focus such as a more productive fishery.

C **Collaboration** – very often, many different people have an interest in an area of riparian land. Besides the landowner, a tenant farmer may graze the land, an angling club may lease the fishing rights, and the public may have right of access along a right of way. Moreover, a watercourse often forms the boundary between two farms or landholdings. Improving riparian management is likely to bring benefits to all these parties, as well as neighbouring riparian owners, so it is in everyone's interest to cooperate in bringing riparian schemes to fruition. By working together, farmers, foresters, riparian proprietors and local communities can all benefit from riparian improvements.

D **Design** – one of the difficulties with many riparian schemes is that the areas involved are often small, whilst the perimeters are long. As grants are often paid on an area basis, but major costs are often involved with fencing, many schemes seem at first glance to be financially impractical. However it may be possible to render them more viable by re-thinking a scheme's design, either by including a wider riparian zone or by co-operating with a neighbour.

Chris Tyler

'By working together, farmers, foresters, riparian proprietors and local communities can all benefit from riparian improvements ...'

E **Enthusiasm** – for a scheme to be successful, it is often necessary to interest and engage with several parties. To motivate these people effectively, it helps to be able to project your vision with enthusiasm.

F **Funding** – there is no national scheme tailored specifically to the needs of riparian management. However, because of the wide-ranging benefits from improvements in riparian management, there are many possible sources of financial assistance. Some of these may be regionally or catchment-based, so it is not possible to give comprehensive guidance on funding sources, except on a site-by-site basis. Furthermore, national grants are frequently reviewed. The principal sources of grants for establishing and managing riparian woodlands are: The Woodland Grant Scheme (WGS), administered by the Forestry Commission, and the Farm Woodland Premium Scheme (FWPS - currently under review), administered by Scottish Executive Rural Affairs Department (SERAD).

There are however many other sources of funding for riparian management, including various grants from SERAD and SNH. Scottish Native Woods can give further advice on suitable sources of funding.[30]

Farming tenants and riparian woodlands

A great deal of riparian land is farmed by crofting or agricultural tenants. These tenants often depend on access to a water-course to water livestock, but rarely own fishing rights. There is much scope for fishing proprietors, landlords and tenants to co-operate over improving riparian management, bringing benefits to all. A landlord cannot legally resume agricultural land from a tenancy for the purposes of a woodland scheme, but in many instances the economic benefits are often greatest when tenants apply for grants. Various changes in legislation have made this possible.

30 see Scottish Native Woods 2000d. More information may be available on our website www.scottishnativewoods.org.uk later in 2000

Sources of advice

Most of the bodies listed below are able to give some advice on aspects of riparian management. If their local offices are not in the telephone directory, contact their headquarters or visit their websites as below:

Scottish Native Woods (SNW)	**see details opposite**	
Forestry Commission Scotland (FCS)	**0131 334 0303**	**www.forestry.gov.uk**
Scottish Natural Heritage (SNH)	**0131 447 4784**	**www.snh.gov.uk**
Scottish Executive Rural Affairs Department (SERAD)	**0131 556 8400**	**www.scotland.gov.uk**
Scottish Environment Protection Agency (SEPA)	**01786 457700**	**www.sepa.org.uk**
Association of District Salmon Fishery Boards	**0131 343 2433**	

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SCOTTISH NATIVE WOODS

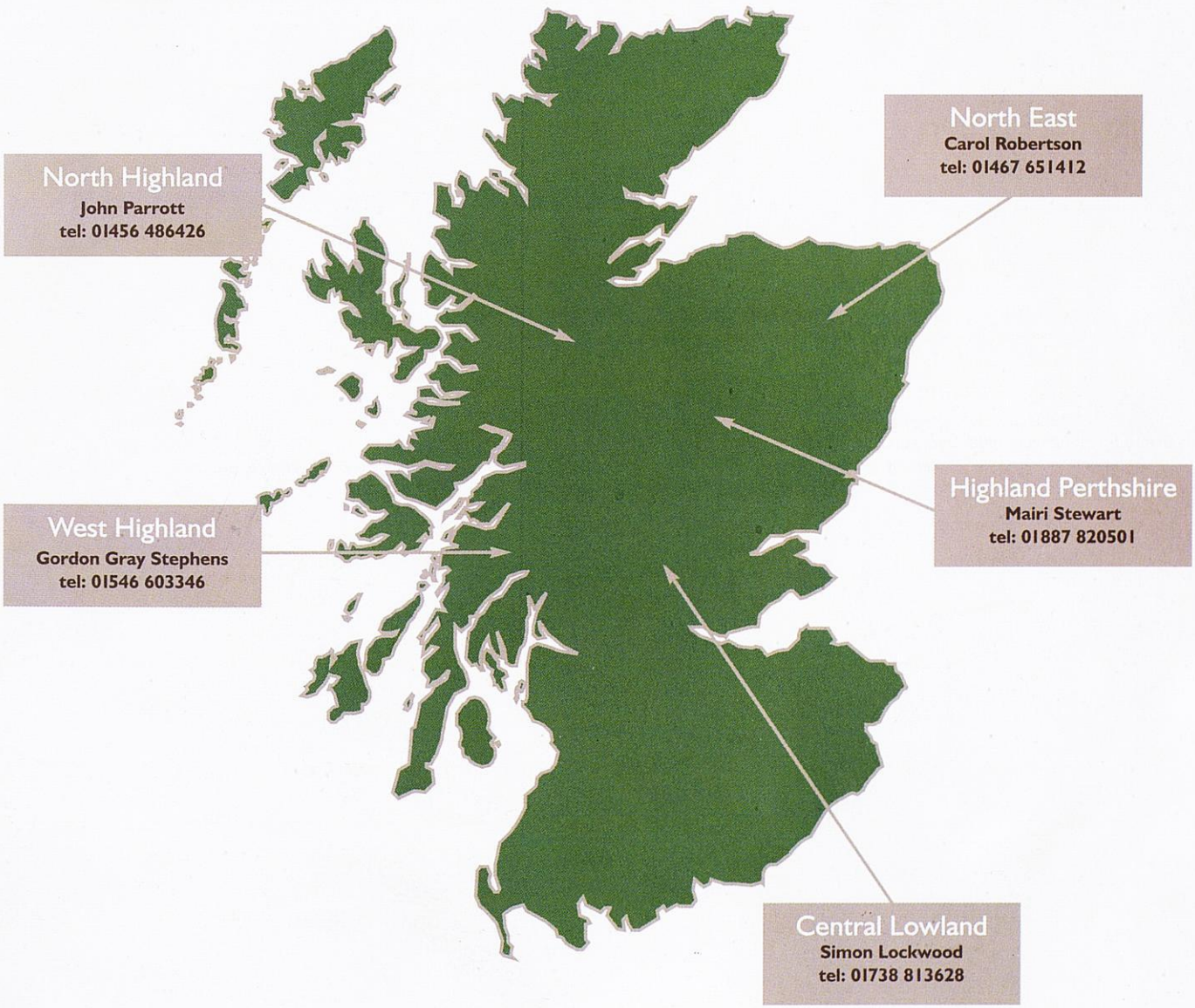
Scottish Native Woods

is a charity dedicated to the restoration of Scotland's native woodlands. Founded in 1988, it aims to raise awareness of native woodland issues and provide free advice to the owners and occupiers of native woodlands through its area-based Initiatives.

SNW's Initiative Managers offer the following advisory service:

- surveying
- management planning
- preparation of grant applications
- cashflow forecasting
- supervision of contractors
- monitoring.

For more details, contact your local Initiative Manager, or SNW Central Office, tel: 01887 820392



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