Forestry Commission

FORESTS & WATER

GUIDELINES

FOURTH EDITION

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FOREWORD

The Forests & Water Guidelines last underwent major revision in 1993; they were reprinted with amendments to administrative details and legislation in 2000. Ten years have passed since the last substantial review, therefore it was thought timely to update the Guidelines so that they continue to reflect the most recent research and experience.

Forestry is a devolved area leading to the development of national agendas. In parallel with developments in the forestry sector, regulation of many operations associated with forest planning and management has also reflected national concerns. Nevertheless the Forests & Water Guidelines have been compiled as a UK document because many of the issues, such as air pollution, act at an international scale and the vast majority of recommendations are common across the UK. In this context it is pleasing that the Guidelines have been extended to Northern Ireland.

In the last decade, forestry in the UK has been faced with many new pressures and opportunities. These must be resolved and progressed within the framework of sustainable forest management. Guidelines in general underpin the UK Forestry Standard: the Government's Approach to Sustainable Forestry and the Forests & Water Guidelines, in particular, play a key role in ensuring that forest design, planning and operations protect and enhance the water environment without jeopardising the economic viability of woodlands and forests.

A working group was formed in 2001 comprising representatives from the water regulatory authorities (the Environment Agency and the Scottish Environment Protection Agency), Forest Research and the Forestry Commission's Policy and Practice Division. For the first time, representatives from the Joint Nature Conservation Committee and Northern Ireland's Forest Service and Environment and Heritage Service were invited. The Guidelines are based on the consensus view of the scientific issues informed by knowledge of practical implementation.

Following extensive revision, the main changes include: a larger section on water and the law; greater emphasis on protecting and enhancing the ecological value of the freshwater environment; and more attention to the opportunities provided by forestry for benefiting fresh waters. The section dealing with the effects of forestry on the freshwater environment has been updated and extended while a new section brings together those issues that are best addressed at a catchment scale reflecting the needs of the EC Water Framework Directive. In dealing with acidification, the critical load approach now includes the contribution from nitrogen in addition to sulphur and its application has been extended. Water quantity as well as quality is considered; the design and management of the riparian buffer area receives greater attention; and the potential benefits of forest restructuring are highlighted.

Good forest management is not merely about avoiding harm – it requires proactive and imaginative measures. Successful forest management is ecologically, aesthetically and economically rewarding. These Guidelines provide a sound basis for the sustainable management of the water environment by forest planners and managers.

David Bills

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- Scottish Borders Council
- Scottish Environmental Protection Agency (SEPA)
- Scottish Executive Water Environment Unit
- Scottish Landowners' Federation
- Scottish Native Woods
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- The Atlantic Salmon Trust
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FORESTS & WATER GUIDELINES

1. INTRODUCTION

Background

Forests and their management can affect the quantity and quality of water moving through catchments. The *Forests & Water Guidelines* advise owners and managers how woodlands and forests influence freshwater ecosystems. They give guidance to forest managers on how forests should be designed and operations planned, and to practitioners on how field operations should be carried out in order to protect and enhance the water environment.

Good forest management is not merely about avoiding harm, whether to water running through the forest or to downstream users; it requires active and imaginative measures. Successful forest management is ecologically, aesthetically and economically rewarding. In contrast, poor planning and management can lead to increased acidification, exacerbate water shortages, contribute to local flooding, and increase soil and stream erosion, turbidity, sedimentation, and pollution. These in turn can reduce aquatic wildlife leading to a loss of biodiversity and damage to fish stocks and dependent fisheries. Where drinking water is abstracted, costs of treatment can increase. There can also be a loss of some forest soil and thus a reduction in sustainability and potential productivity.

The Guidelines apply equally to the state and private sectors. Grant approvals throughout the UK, felling licences in England, Scotland and Wales, and all forestry operations are subject to the standards set out in this document. The *Forests & Water Guidelines* have no formal legal status but, in the event of a prosecution, failure to follow the Guidelines is likely to affect adversely the position of the forest owner, contractor, or subcontractor.

Strategies for the location and management of forests are changing – changes which these Guidelines attempt to reflect. Until recently the creation of forests has been primarily in the uplands whereas in future more woodlands are likely to be established in the lowlands, including areas close to towns and cities. The planting of new native woodlands is being encouraged through grant initiatives in each country. Many small farm woodlands have been established in lowland arable landscapes since the 1980s. The multiple benefits of riparian native woodland are increasingly being recognised and the creation of more wet woodlands, including floodplain forests, is a specific target under the UK Biodiversity Action Plan. The relationship between forest and water differs from the uplands to the lowlands and between forest types; this edition of the *Forests & Water Guidelines* addresses both traditional and new developments. Finally, restocking after felling presents an important opportunity for diversifying forests in line with current forestry objectives and management practice.

The planting and regeneration of riparian native woodland are being encouraged to help protect and enhance the fresh water environment. The River Oich, north Scotland.

The *Forests & Water Guidelines* were first published in 1988 following a 'water workshop' organised by the Forestry Commission (FC) and the Water Research Centre at York in 1986. Since then there have been two revisions, in 1991 and 1993, to ensure that the Guidelines continue to reflect the results of recent research and experience. This fourth edition draws on continuing studies of the various environmental effects of land use, pollutant inputs and forest operations, widens consideration of the impact of lowland and native woodland expansion on the fresh-water environment, updates information on legislation, and extends the Guidelines to include Northern Ireland.

Trees and woods in and around towns and cities can greatly improve the quality of life for those who live and work there.

Water and the law

It is an offence to cause or knowingly permit the entry of poisonous, noxious or polluting material into any controlled waters. Forest managers must meet their legal obligations under the Control of Pollution Act 1974 as amended by the Water Act 1989 (in Scotland), the Water Resources Act 1991 (in England and Wales), the Food and Environment Protection Act 1985, the Environment Act 1995, the Drainage (Northern Ireland) Order 1973, the Water (Northern Ireland) Order 1999, the Fisheries (Northern Ireland) Act 1966 as amended by the Fisheries (Amendment) Act (Northern Ireland) 2001, and other relevant legislation, when carrying out all forestry operations. Advice is available from the FC in Great Britain and, in Northern Ireland, from the Forest Service, the Environment and Heritage Service (EHS), Rivers Agency, and the Department of Agriculture and Rural Development. When in doubt forest managers should liaise in advance of operations with the local office of their water regulatory authority or water undertaker.

Throughout these Guidelines the term *water regulatory authority* should, in Scotland, be taken to refer to the Scottish Environment Protection Agency (SEPA); in England and Wales, to the Environment Agency; and in Northern Ireland to EHS and the Rivers Agency. The term *water undertaker* should, in Scotland, be taken to refer to Scottish Water; in England and Wales, to the water utility companies; and in Northern Ireland to the Department for Regional Development's Water Service. In Scotland, the District Salmon Fishery Boards have statutory responsibilities for salmon and sea trout. In England and Wales, salmon and sea trout are included in the responsibilities of the Environment Agency for fisheries in general. In Northern Ireland, responsibility for the supervision and protection of salmon and freshwater fisheries rests with the Department of Culture, Arts and Leisure (DCAL). The Fisheries Conservancy Board (NI) has statutory responsibilities for the conservation of salmon and freshwater fish, as do the Loughs Agency in the Foyle and Carlingford areas. Addresses are given in Appendix 1 (addresses of individual District Salmon Fishery Boards can be obtained from the Association of Salmon Fishery Boards).

In addition, consultation is specifically required or advised when undertaking the following operations:

- **Aerial application of pesticides**
  Consultation with the water regulatory authority or water undertaker is legally required prior to aerial application within 250 m of water. In addition, there may be a need, under the Control of Pesticide Regulations 1986, to contact one or all of the following: the relevant authorities of Local, Marine and National Nature Reserves and Sites of Special Scientific Interest; the Chief Environmental Health Officer; occupant or agents of nearby property and institutions such as schools and hospitals; and bee keepers. Details are given in Section 6.

- **Applications of pesticides in or near water using hand held or tractor mounted equipment**
  Consultation and/or agreement with the water regulatory authority or water undertaker is legally required prior to all types of application for the control of weeds in or near water. In this context, 'near' generally means the banks of watercourses or lakes.

- **Aerial application of fertilisers**
  Consultation and agreement with the water regulatory authority or water undertaker is strongly recommended prior to the aerial application of fertilisers.

- **Applications of sewage sludge, waste soil or compost, waste wood, bark, or other plant material**
  Prior to making applications of sewage sludge, waste soil, compost or other plant wastes, these activities must be registered as exemptions with the Environment Agency in England and Wales, and with SEPA in Scotland. Under the Waste Management Licensing Regulations 1994 (as amended), sewage sludge may be applied to forest land as long as this results in ecological improvement and does not cause levels of potentially toxic elements in soils to exceed those permitted under the Sludge (Use in Agriculture) Regulations 1989 (as amended). In addition, these Licensing Regulations allow for waste soil or compost, waste wood, bark or other plant material to be applied to forest land, subject to an upper limit of 250 t ha^{-1} y^{-1} and subject to the application resulting in an overall ecological improvement.

  In Northern Ireland, under the Pollution Control and Local Government (Northern Ireland) Order 1978, sites are required to have a licence for depositing of waste. The deposit of sewage sludge on land for the purpose of fertilising or otherwise beneficially conditioning that land is exempt from having a licence under Schedule 6 of the Waste Collection and Disposal Regulations (Northern Ireland) 1992. The waste must be deposited directly onto the land, and the person depositing the waste must provide particulars to the Local Authority where the deposit is made. The Sludge (Use in

Agriculture) Regulations (Northern Ireland) 1990 do not apply to sludge use in forestry.

- **Disposal of 'listed substances' to ground**
  Under the Groundwater Regulations 1998 and in Northern Ireland the Groundwater Regulations (Northern Ireland) 1998, permission is needed from the Environment Agency in England and Wales, SEPA in Scotland, and the EHS in Northern Ireland to dispose of 'listed substances' to ground. The purpose of the regulations is to protect groundwater from pollution caused by careless disposal of potentially harmful and polluting substances. Authorisation is required for the disposal of pesticides (including sprayer washings) but not for normal use covered by relevant codes of practice.

Additional regulations apply to the following operations:

- **Regulations on oil storage**
  The Control of Pollution (Oil Storage) (England) Regulations 2001 affect those storing more than 200 litres of oil, including petrol and diesel, above ground in one or more containers (including mobile bowsers and drums). The regulations establish minimum standards for the containment of oil, including adequate secondary containment such as bunds and drip trays. They also cover location of oil facilities to minimise the risk of collision damage. These regulations will be enforced by the Environment Agency in England. It is thought that Wales and Scotland will introduce similar regulations in due course.

- **Pesticides with a buffer zone requirement that are applied by ground crop sprayer**
  For certain types of these pesticides, there is a legal obligation to carry out and record the results of a Local Environmental Risk Assessment for Pesticides (LERAP). By carrying out and complying with that LERAP, users may be able to reduce the size of buffer zone required. While users retain the option simply to comply with the existing buffer zone, they will still have an obligation to record that decision. Further details can be obtained at: www.pesticides.gov.uk/farmers/leraps.htm

- **Applications of nitrogen fertiliser within Nitrate Vulnerable Zones (NVZs)**
  Protection of Water Against Agricultural Nitrate Pollution Regulations came into force in 1996 in Scotland, England, Wales and Northern Ireland. Together with subsequent amendments in 2002 and Action for Nitrate Vulnerable Zones Regulations, they identify NVZs as areas where nitrate pollution from agriculture is a problem. Although the legislation does not cover forests, it is recommended that any nitrogen fertilisation of forests within NVZs adheres to the restrictions contained within these Regulations.

There are two significant pieces of European legislation that affect forests and water: the Directive on the Conservation of Natural Habitats and Wild Fauna and Flora 92/43/EEC and the Water Framework Directive 2000/060/EC.

The Directive on the Conservation of Natural Habitats and Wild Fauna and Flora 92/43/EEC is commonly known as the 'Habitats Directive'. It seeks through national regulations to protect biodiversity. The mechanisms for achieving the purpose of the Directive are:

- The establishment of a network of sites across Member States through the designation of Special Areas of Conservation (SACs). Together with Special Protection Areas (SPAs), which were originally classified under the Birds Directive 79/409/EEC, this will lead to a range of sites across Europe known as the Natura 2000 network. These sites seek to protect the natural habitats listed in Annex I and the species listed in Annex II of the Directive. Full designation should be completed by 2004 (provisional sites are already being treated as if designated).

- Legislation to avoid deterioration and significant disturbance within these sites.

In the UK, the national legislation was passed through the Conservation (Natural Habitats &c.) Regulations 1994 for the purpose of implementing the Habitats Directive (SI No. 2716). Amongst other things these Regulations affect a wide range of people whose activities may have impacts on the sites the Directive aims to protect.

The Water Framework Directive 2000/060/EC establishes a framework for protecting and improving inland surface waters, transitional waters, and coastal waters through a requirement to achieve 'good surface water status', a term that refers both to their chemical and ecological quality. The Directive also aims to protect the quality of groundwater (both quantitatively and chemically) and to ensure that the water needs of adjacent wetlands are adequately met. This Directive thus greatly extends the coverage of 'water quality' measurement spatially (to all surface waters) as well as incorporating other standard areas of assessment not previously

covered (such as hydrology, habitat structure, fish assemblages, phytoplankton, and other aquatic plants).

One of the first principal challenges of the Water Framework Directive will be to set up a system of river basin management planning within which the protection, improvement and restoration of surface waters can be monitored and reported. The precise requirements for implementing the Directive in the UK have yet to be determined. It is clear, however, that River Basin Management Plans could require changes to forest design, planning and management, as these have the potential to affect water quality, water quantity, and habitat structure, and thus the ecological status of fresh waters. The development of River Basin Management Plans will require close partnership working between the forestry sector and other stakeholders.

Water regulation and legislation are described more fully in Appendix 2.

Forest regulation

It is government policy to encourage the sustainable management of existing woods and forests, and an expansion of tree cover to increase the many diverse benefits that forests can provide. Implementation is achieved by a range of regulatory instruments and incentives, which are primarily operated by the FC in Great Britain or the Forest Service in Northern Ireland. These procedures, coupled with strict environmental standards, ensure that forests and woodlands are properly planned and managed. The principal regulatory instruments, incentives, and processes are:

- **The UK Forestry Standard**
  In 1998 the FC and the Forest Service in Northern Ireland published the UK Forestry Standard with the aim of setting standards for the sustainable management of all forests and woodlands in the UK. The standard draws on a body of supporting publications whose purpose is to give detailed guidance on specific topics. In Great Britain there are guidelines on landscape design, nature conservation, community woodland design, recreation, and archaeology. In Northern Ireland there are guidelines on forest recreation, timber harvesting, and conservation. Guidelines on water and soil conservation apply to the UK.

- **The UK Biodiversity Action Plan**
  In 1994 the UK Government published the UK Biodiversity Action Plan (UK BAP) setting out a programme to conserve and enhance biodiversity in response to the commitments under the Convention on Biological Diversity. As well as specific targeted action plans for priority species and habitats, it includes measures for integrating biodiversity into all sectors of land use and business. The Countryside and Rights of Way Act 2000 which applies to England and Wales, obliges ministers, government departments and the National Assembly for Wales to have regard to the conservation of biological diversity in carrying out their duties. The Secretary of State in respect of England and the National Assembly for Wales are also required to publish lists of habitats and species of principal importance for the conservation of biological diversity, and to take steps to protect habitats and species. Forestry is contributing significantly to the UK BAP by means of environmental guidelines under the UK Forestry Standard, through habitat action plans for six types of native woodland, and by its contribution to other action plans. Many species action plans are relevant to forestry.

- **National forestry strategies**
  Strategies for separate parts of the UK (*England forestry strategy – a new focus for England's woodlands 1999, Forests for Scotland – the Scottish forestry strategy 2000, Woodlands for Wales – the National Assembly for Wales strategy for trees and woodlands 2001)* outline the sustainable forest management of existing woodland for multiple benefits and identify the needs and opportunities for new woodland planting. They link forest planning with that of other competing land uses and so help to inform regional strategies on how best to achieve sustainable land-use.

- **Regional forestry strategies**
  In Scotland, Indicative Forestry Strategies identify those areas at a regional level where significant planting is to be preferred or where there are particular environmental sensitivities that must be addressed and satisfied before approval can be given for grant aid. They are drawn up by the local planning authority in partnership with landowners and forestry and environmental interests. In drawing up such strategies, the planning authorities should consult with SEPA.

  Regional Forestry Frameworks is the generic term used for forestry and woodland strategies and/or action plans at the English regional government level. The Government accepted in 2001 that there should be support for the preparation of regional strategic frameworks for forestry where regions wish to have them. These frameworks are primarily a device for

translating the England forestry strategy down to the regional level. It is anticipated that all frameworks will be complete by 2005. They will provide a means of better integrating forestry policy with the various economic, social and environmental strategies that each region must produce and help to enforce forest regulation through links to the regional sustainable development frameworks, spatial strategies and biodiversity plans. The Environment Agency will be a key stakeholder in the development and consultation process for regional forestry frameworks.

- **Local forestry frameworks**
  These sit within indicative forestry strategies and during their development provide a means of addressing key local issues. The concept was introduced in 1998 and the first three frameworks are now in place in Scotland. These are managed and funded by a regional working group comprising the Local Authority, FC and Scottish Natural Heritage. The group seeks to resolve local issues by considering the available evidence and the views of interested parties.

- **Local Biodiversity Action Plans (LBAPs)**
  LBAPs are now in place in most parts of Britain. Although non-statutory, these documents provide guidance on the conservation and enhancement of locally important species and habitats. LBAPs and other local designations are generally identified in Statutory Local Plans.

- **Forestry grant schemes**
  The FC and the Forest Service Northern Ireland give grants for the establishment and management of woodlands. Their Terms and Conditions stipulate that 'you must meet the standards of environmental protection and practice set out in our published guidelines current at the date of approval'. In many cases the applicant will be expected to provide details of how water issues will be dealt with in a particular woodland. The *Forests & Water Guidelines* apply to all work and failure to abide by them can result in the withholding or reclaiming of grant. Plans of operations under the Dedication Scheme in Great Britain must also work to current standards.

- **Felling licences, forest design plans and forest plans**
  With certain exceptions, it is illegal to fell trees in Great Britain without prior approval from the FC. Felling is permitted if a felling licence has been obtained. This can be issued on its own, as part of a grant scheme, or as part of a Forest Plan (private sector) or Forest Design Plan (public sector). It is government policy that areas felled will be replanted or naturally regenerated, except where felling is allowed for environmental improvement or to enable development authorised under planning regulations. Forest plans are a set of maps and documents that outline the felling, thinning, and restocking work to be carried out on a property over a 20-year period. They give detailed proposals for the first 10 years and approvals are based on these. Before giving permission to fell trees, the FC will consider whether the standards of their environmental guidelines will be met. Trees protected by Tree Preservation Orders must not be felled without prior consent from the relevant planning authority. Deforestation may require prior consent from the forestry authority under the Environmental Impact Regulations (see below).

- **Environmental Assessments**
  Formal environmental assessment procedures for new woodland were introduced in 1988. These were replaced by new regulations in 1998 and again in 1999 for Great Britain and in 2000 for Northern Ireland. Under the new regulations, those who propose to carry out a forestry project involving afforestation, deforestation, road works or quarrying that may have a significant effect on the environment must apply for consent from the FC in Great Britain or the Forest Service in Northern Ireland to carry out the work. The local FC Conservator or Forest Service Headquarters (NI) can decide whether a particular project requires an environmental assessment.
  An FC publication *Environmental impact assessment of forestry projects* is available on the FC website. Guidelines are also available on the Forest Service (NI) website: www.forestserviceni.gov.uk.

- **Public Register**
  A public register of new planting and felling applications is held at local FC Conservancy offices. The Public Register is also available on the FC's Internet site (www.forestry.gov.uk) in the 'Grants and Licences' section. The Register is updated weekly and holds details of applications on a rolling 4 week basis. This allows people to find out about their local area and to make comments if they wish.

- **Consultation**
  The FC has agreed a process of consultation with local authorities and a number of statutory bodies before determining applications either under grant

schemes or for a felling licence. These arrangements are revised from time to time by the FC and the statutory bodies. Most planting and felling proposals are uncontroversial; the Regional Advisory Committees of the FC have a conciliatory role in those few cases where problems do arise.

Potential problems can often be resolved through dialogue in the field.

Liaison

Although the FC and the Forest Service (NI) have a formal process to take account of water interests, forest managers will benefit from establishing contact with the appropriate water regulatory authority and water undertaker and, when appropriate, seeking advice. In Scotland, early liaison with the District Salmon Fishery Boards or Regional Fishery Trusts/Foundations in relation to fisheries issues is recommended; addresses can be obtained through the Association of Salmon Fishery Boards. In Northern Ireland, consult the Department of Culture, Arts and Leisure (DCAL), the Fisheries Conservancy Board and the Loughs Agency. Relevant contact details are given in Appendix 1.

Forest Enterprise's Forest Design Plans are subject to consultation and consideration by local Forest District Environmental Panels. These are set up by each Forest District to facilitate an exchange of information and views between forest managers and individuals or organisations with specialist or local knowledge, with the purpose of reconciling management objectives within environmental constraints. Panels meet regularly and play a key role in aiding forest design planning and improving relationships with local communities. In Northern Ireland, District Consultative Committees consider the likely impact of Forest Service activity on the environment and how local environmental and social interests may be accommodated within Forest Service plans.

Training

Training is an essential element of good management practice. The FC's Forestry Training Services and the Northern Ireland Forest Service's Training School at Pomeroy offer a wide range of forestry courses. Although most courses include a water element, specific courses are held on the freshwater environment, including: the application of the Guidelines; the planning and control of forest drainage operations; and the planning and operation of forest harvesting sites from an environmental standpoint. It is important that all forest staff and contractors understand the standards that are appropriate to their work.

Certification

The UK Woodland Assurance Standard (UKWAS), was introduced in 1999 as a means of providing independent certification for forest management. It is a voluntary scheme developed and run by a wide range of stake-holders in UK forestry, including the Government, private forest and woodland owners, the wood processing sector, people who work in forests, and environmental and community groups. An UKWAS booklet and woodland managers' guide were published in 1999 and 2000 respectively. The booklet sets out the standards of environmental and community care that forest management must meet in order to gain UKWAS certification, while the guide explains the procedures to be followed by woodland managers in applying for certification. The UKWAS incorporates the requirements of the UK Forestry Standard but is more detailed in addressing specific aspects of forest management or types of operation. Owners whose woodland management is audited, or inspected, to the UKWAS by independent auditors accredited by the Forest Stewardship Council (FSC) may use the FSC's internationally recognised trademarks on their products.

2. CATCHMENT WATER PATHWAYS

This section describes the movement of water through three contiguous zones within a catchment (Figure 1) – the *adjacent land*, the *riparian zone* and the *aquatic zone* (Figure 2) – and outlines the effects of forestry on the freshwater environment. These issues are explored further in Section 4.

The adjacent land

This is the largest zone and principal water gathering ground. Water enters a catchment as precipitation, and passes into the soil through the vegetation layer which can exert a strong influence on both the quantity and quality of the water. The quantity of precipitation reaching the soil as throughfall and stemflow is reduced by the interception loss; that is, the proportion retained by the vegetation layer and subsequently evaporated back to the atmosphere. Forests, particularly of conifers, have a higher interception loss than grassland due to their relative size and the surface roughness of their canopies. The quality of throughfall is also altered by the evaporative loss, as a result of the capture of mist, aerosols and pollutant gases, and by chemical interactions within the vegetation layer. Having passed through the vegetation layer and into the soil, water is taken up by vegetation and returned to the atmosphere (through the process of transpiration), retained by the soil, or leaves the soil as drainage.

The amount of water following each of these routes is influenced by the nature of the vegetation and therefore by land-use practices. For example, interception and transpiration losses vary between different types of forest and non-forest vegetation, as well as being strongly affected by rainfall amount and pattern. Cultivation and harvesting will reduce evaporation due to the removal of the vegetation, and result in more water leaving the soil as drainage. The overall effect on the quantity of drainage water will therefore depend on the mix of vegetation and forest practices in a catchment.

Drainage water can take a number of pathways over and through the soil and bedrock *en route* to the catchment outlet. The pathways taken will depend on topography, soil, drift deposit and underlying geology, and will have a marked influence on the timing, volume and quality of water reaching the aquatic zone. Steep slopes, poorly draining soils or shallow impermeable bedrock result in superficial pathways and a fast catchment response time to precipitation. Gentle slopes, freely draining soils, deep drifts and porous bedrock result in deeper pathways and a delayed and attenuated response. Superficial waters tend to be soft, brown and acidic, reflecting their short passage through the upper organic soil horizons. Waters following deeper pathways tend to be harder, clearer and more alkaline, due to the longer period in which they are in contact, and able to react with, soil and rock minerals.

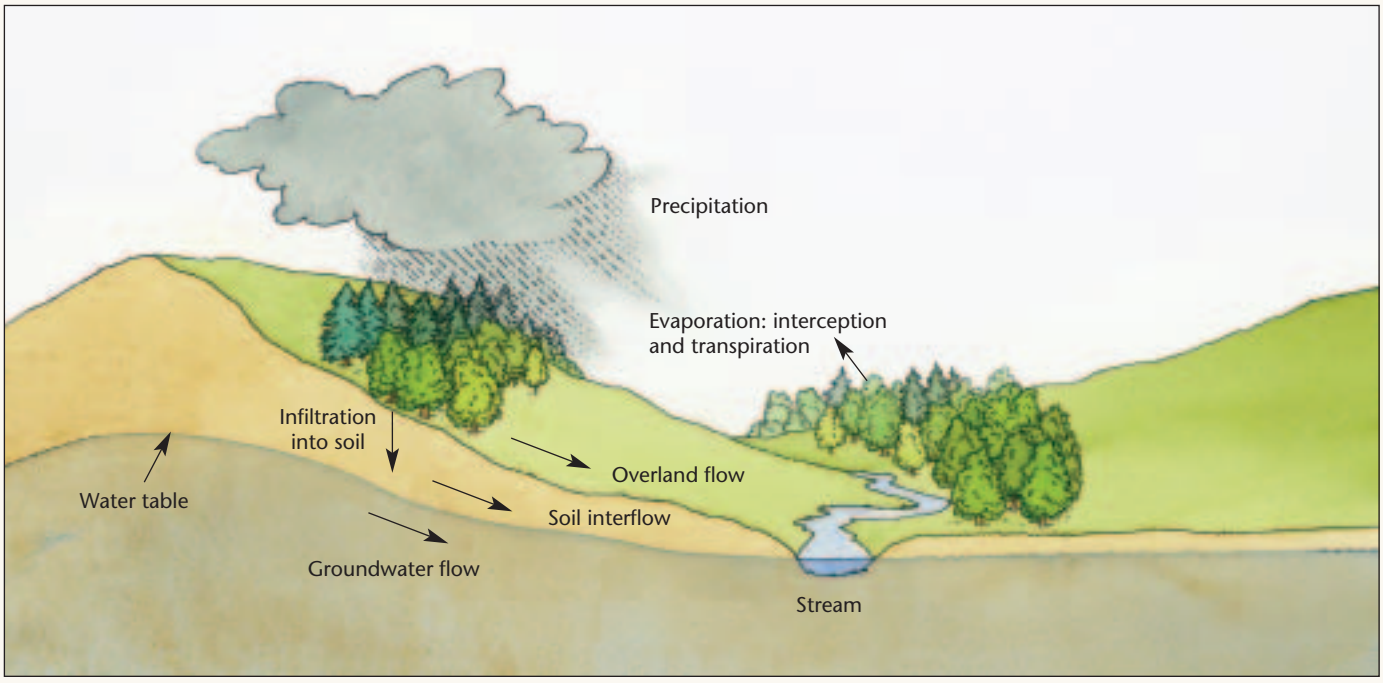


Figure 1 Water pathways.

Forest operations can alter drainage water pathways which, in turn, may have a significant effect upon water quality and quantity. In some soil types ploughing and drainage favour surface pathways and lead to faster run-off so that streams peak earlier and reach higher flow rates. In these circumstances, soil disturbance can result in a marked increase in erosion and sedimentation. This may have significant consequences for water interests downstream, which may be difficult, expensive or impossible to put right. Legal action may follow the pollution of streams or the killing of fish. Faster run-off could also reduce the time that conditions remain suitable for fishing and fish migration, contribute to downstream flooding, and enhance the erosion of stream channels, leading to loss of habitat and land.

The effects of poor practice may not always be readily apparent, particularly in catchments underlain by porous rocks that form aquifers for drinking water. For example, the careless use of pesticides can lead to the contamination of soil drainage that may not reach a river or borehole abstraction point for several decades. In some areas, groundwater is the sole source of both public and private water supply. Once contaminated, it may be difficult or impossible to restore. Pesticide applications within recharge areas for aquifers must, therefore, be planned very carefully.

The riparian zone

The term 'riparian zone' may be defined in various ways; at its simplest it is the land immediately adjoining the aquatic zone and influenced by it. However, riparian zones also exert important controlling influences on the waters that they border. Bank vegetation helps to bind soil and increase bank stability; overhanging vegetation provides shade and modifies water temperature; and twigs, leaves and terrestrial invertebrates that fall into the water provide a source of food for aquatic organisms. Some of the soils in riparian zones are often at or near to saturation, and it is here that water flowing through the soil and bedrock of the adjacent land may re-emerge to contribute to stream flow. Marginal vegetation in riparian areas may therefore provide a buffer, helping to trap sediment, absorb nutrients, and reduce the levels of pollutants in drainage water. This buffering potential, however, is critically dependent on water levels as repeated flooding and drying can cause the release of stored sediments and pollutants.

Riparian zones are frequently ecologically rich because of the variety of habitat types present, thus offering areas of refuge and migration corridors for insects, birds and mammals. Some animals require both freshwater and riparian habitats at different stages of their life cycles, so an absence of suitable riparian areas will lead to an absence of such animals in the adjacent watercourse. The wetness of the soils and the characteristic instability of stream banks mean that the zone is very sensitive to disturbance. In places where natural flooding occurs, large tracts of wet woodland may extend across the floodplain, though this habitat is very scarce and fragmented throughout the UK. Forest management must be directed towards protecting and encouraging the diversity of habitat types in the riparian zone, both for the benefit of the water bodies they surround and of the forests themselves. Extension and restoration of wet woodland is a target of the UK Biodiversity Action Plan.

The aquatic zone

The aquatic zone is the ground frequently or permanently under water, forming streams, rivers, ponds and lakes.

The uplands are an important source of water for public supply. Many reservoirs have been built during the last 150 years and much of this water requires only minimal treatment. Water from upland reservoirs is therefore relatively cheap, compared with supplies drawn from lowland rivers. However, upland water supplies are very sensitive to disturbance and even limited deterioration can disrupt water treatment facilities, adding to treatment costs. The uplands also contain a large number of small private water supplies that are at even greater risk from disturbance since they frequently undergo no form of treatment at all. Forests can reduce the reliable yield of water making it necessary to seek alternative or supplementary supplies.

Upland waters are often valuable for fisheries, wildlife and recreation, although many within sensitive areas have been adversely affected by acidification. Headwater streams can provide important spawning habitat for salmonids and are particularly vulnerable to forest operations because a large proportion of their catchments may be affected. The consequences for all watercourses are serious if spawning gravels are infilled by sediment, or streams are blocked by fine debris from tree felling. Good forest management will protect the aquatic zone from such damage and seek to restore or mitigate any degraded habitat for fisheries and wildlife. Forest managers are strongly advised to seek the advice of the water regulatory authority. Managers in Scotland are also advised to contact the local District Salmon

Fishery Board or Fishery Trust before undertaking such work; in Northern Ireland, consult the Department of Culture, Arts and Leisure (DCAL), the Fisheries Conservancy Board and the Loughs Agency.

Lowland waters tend to be under greater pressure as a result of agricultural, urban and industrial pollution. Forestry is generally a less intensive land-use than agriculture, and the planting of woodlands on arable land in the lowlands is likely to have advantages in terms of water quality. Trees can also play an important role in the rehabilitation of both contaminated and derelict land, including landfill sites, when planted and managed appropriately. However, the water-use of some types of woodland, including short rotation coppice, can exceed that of grassland, arable crops or bare soil, and may pose a problem where there is a water shortage. On the other hand, this greater water-use and the ability of woodland to delay surface run-off could help to reduce downstream flooding. The full impact of lowland land-use on aquifer recharge patterns, river flows, flooding and wetlands remains unresolved and is the subject of ongoing research.

A woodland pond displaying the transition from the aquatic zone through the riparian zone to the adjacent land.

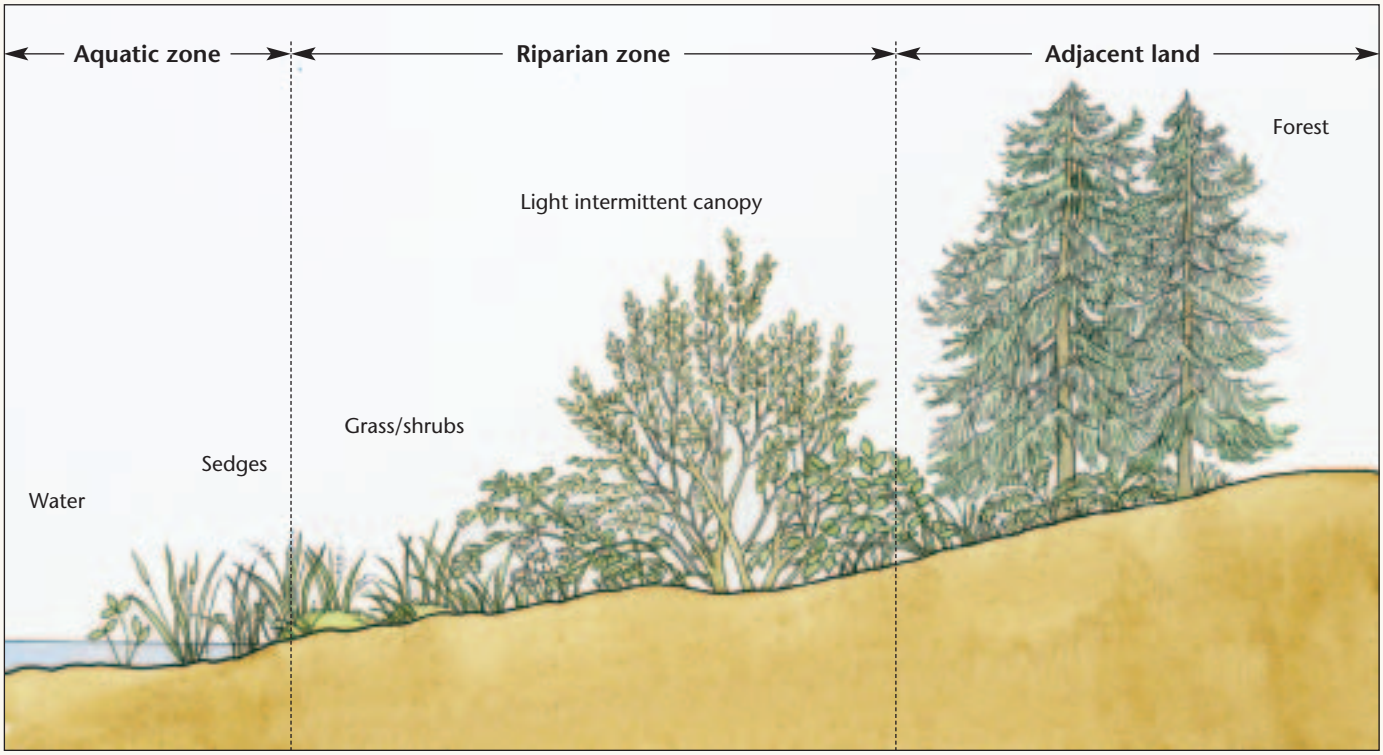


Figure 2 Sketch to show the aquatic zone, riparian zone and adjacent land.

3. FRESHWATER ENVIRONMENTS: VALUES AND USES

Fresh waters are probably subject to a wider variety of human uses than any other natural ecosystem. These uses and other human activities exert pressures on fresh waters – some within the water body itself (e.g. organic pollution), some in the nearby surrounding area (e.g. removal of riparian vegetation), some as a result of catchment land-use (e.g. urbanisation and land drainage), and some that may extend well beyond the boundaries of an individual catchment (e.g. acid deposition and inter-basin water transfer). Of course, rivers and lakes fulfil a far broader role as habitats for a large range of plant and animal species. There has been an increasing recognition that the valuable contribution made by fresh waters to the conservation of biodiversity is inextricably linked to the economic, aesthetic, and recreational services that they provide. It is now widely accepted that some form of integrated catchment (or basin) management is essential in order to safeguard the natural functioning of freshwater ecosystems and thereby to enhance their value to society. This means that the uses to which they are put (e.g. water supply, power generation, navigation, fisheries) must be integrated with each other, and in a way that does not jeopardise the natural characteristics of rivers, lakes and wetlands. The implementation of the Water Framework Directive is seen as an important mechanism for securing integrated catchment management.

Requirements of wildlife

Freshwater management should always seek to maintain or restore the natural features, processes and habitats appropriate to the site. This will help to meet the needs of aquatic wildlife, satisfy the general requirements for wildlife conservation under government forestry policy, and at the same time ensure that the water body is likely to be suitable for most other purposes. Appendix 3 lists the freshwater organisms found in the UK that are subject to statutory protection under the Wildlife and Countryside Act 1981 or the Wildlife (Northern Ireland) Order 1985 as well as species included in Annexes to the EC Habitats Directive and 'Priority Species' under the Biodiversity Action Plan.

The ecological requirements of freshwater plants and animals differ from species to species, encompassing a natural range in water chemistry, temperature, oxygenation, flow velocity, depth, and substrate type. Some of the broad requirements of organisms include:

- adequate light reaching the water to support aquatic plants and algae and to maintain temperatures suitable for animal metabolism;
- a range of natural physical features, such as pools, riffles, gravel bars, fringing wetlands, ponds and backwater channels, dry river terraces, alluvial floodplains connected to the river, and steep, shallow and undercut banks;
- vegetation appropriate to the site, such as algae and mosses on stony stream beds; rooted plants in the silt or sand of less turbulent waters; and bankside trees, shrubs, and ground vegetation;
- seasonal patterns in flow regime, lake level, and water temperature;
- water free of contaminants (or water containing contaminants at less than harmful concentrations);
- appropriate levels of plant nutrients.

The requirements of three animals that provide important indicators of the health of the freshwater environment are described on pages 11 and 12.

Mayfly (Order: Ephemeroptera, various species)

Forty-seven species of mayfly are found in British fresh waters. They fall into eight different families and are diverse in their size, shape and preferred habitat. Their life cycle moves from egg, through aquatic nymph, to flying adult, but species vary considerably in the time it takes to complete the cycle. Some of the smaller insects may produce two generations in a year. For others, the nymphal stage can remain in the water for up to two years.

Common to all at the nymphal stage are the three tails and the gills on the abdomen, through which oxygen is absorbed from the water. Algae form much of the diet, but some species may be partly carnivorous. They tend to be most active at night. In flowing waters there is a recognised downstream drift with the current. They are an important source of food for fish. In productive waters as many as 1000 nymphs have been counted in a square metre of stream bed.

Mayflies are unique in having two adult, winged stages. Initially they become a dull coloured 'sub-imago', but after a short while the final skin moult occurs and a brightly hued insect takes flight. This can be a spectacular sight on chalk streams, and alkaline lakes, where swarms gather in the evening sun, rising and falling in a rhythmic pattern. Adults do not feed and because of their short life span they must quickly mate and lay their eggs in water to begin the cycle again.

Most mayfly species require water of the highest quality. They are sensitive to pollution and are used by freshwater biologists to measure changing conditions.

Dipper (*Cinclus cinclus*)

This is a bird of rapid streams and clear, oxygen-rich waters. Its presence is usually a sign that all is well with the territory it occupies. In general this will be at least a kilometre in length for a pair of birds, but it can vary with the width and productivity of the water.

They feed on a varied mix of insect larvae and other aquatic life, much of which is caught under water through a curious and characteristic habit of 'walking' on the stream bed. Birds wade or dive into the water and hold themselves on the bottom using their wings to promote a downward force.

Nesting takes place from April to June. The nest is an elegant dome shape formed from moss and leaves, normally hidden under a bank or bridge. From time to time, they are found behind waterfalls through which the birds fly. The eggs are white, usually four to six in a clutch and take around 16 days to hatch. Chicks spend a further 19 to 25 days in the nest.

First sight of a dipper is likely to be a bird flying low over the water, or maybe sitting on a rock mid-stream, bobbing up and down – from where it gets its name.

Dippers are sensitive to disturbance and will move on if the water becomes polluted. Acidification is a particular problem as it can severely reduce their food supply of aquatic insects.

Otter (*Lutra lutra*)

The otter lives along streams, rivers, lakes, marshes and coasts and is adapted to life in water. Inland it is generally a shy and largely nocturnal creature. Individuals may have a range of 40 km or more and are rarely seen; the main sign is the presence of their droppings or 'spraints' at conspicuous locations. Otters are very sensitive to human disturbance and are protected under UK and European legislation (see Appendix 3).

Prey is mainly fish (especially eels), although frogs, crayfish, small mammals and birds are occasionally taken. Adults explore the water's edge and make long underwater searches, often remaining submerged for up to 30 seconds.

Otters require ample cover for lying up and breeding. Riparian and adjacent broadleaved and coniferous woodland and scrub, regardless of area, may form important habitat for nesting and teaching life skills to the cubs. There is no specific breeding season and otters can have cubs at any time of the year. Nests or 'holts' are built in cavities amongst tree roots, holes in the river bank, or within piles of rock, logs, fallen timber or coarse woody brash. The eroded, open root systems of mature bankside trees of ash, sycamore and oak often form good nesting sites. Hollow trunks also provide secure cover. Gestation commonly lasts around 60–70 days and litter size is usually two to three young. Cubs stay in the holt until 2–3 months old.

The otter is another key indicator of the health of the freshwater environment. After many years of decline due to water pollution and habitat destruction, it is now responding to conservation efforts and starting to make a comeback in a number of parts of the UK.

Requirements of fish

The presence of a healthy, self-sustaining, native fish population is usually an indication of a satisfactory environment.

Salmonid fish, which predominate in upland waters, require:

- cool water for spawning and growth. The optimum temperature varies according to life stage with spawning requiring lower temperatures than adult growth. In general, water temperatures should be in the range 5–20°C and should not exceed 21°C. Some shade is helpful, but not too much (preferably no more than 50% canopy cover).
- well-oxygenated water with a range of depths and velocities to cater for different sizes of fish. Tributary streams as narrow as 20 cm may not support adult fish at all times of year but they are often important for spawning, particularly for trout.
- suitable pH (ideally 6–9) and low levels of dissolved aluminium ions. As the pH falls below 6, physiology and growth are increasingly affected both directly and indirectly (through the effect on food organisms). Eggs, alevins, and smolts are particularly vulnerable.
- relatively silt-free water and clean gravel for reproduction. The survival of incubating eggs and newly hatched alevins depends on the free movement of oxygen-rich water through the 'redds' – patches of gravel in which eggs are deposited. If this flow is blocked by fine sediment during incubation, survival rates will fall dramatically.
- reasonably clear water in the growing season for sight feeding. Although colour (e.g. peat staining) has to be very dark before it hinders sight feeding, turbid water can cause problems such as during spate conditions with a heavy load of suspended solids.
- a variety of habitat types and in-stream cover, such as deep pools, riffles, glides, stones and rocks, large woody debris, tree roots, and undercut banks for visual isolation and protection from predators.
- terrestrial and aquatic invertebrates for food.

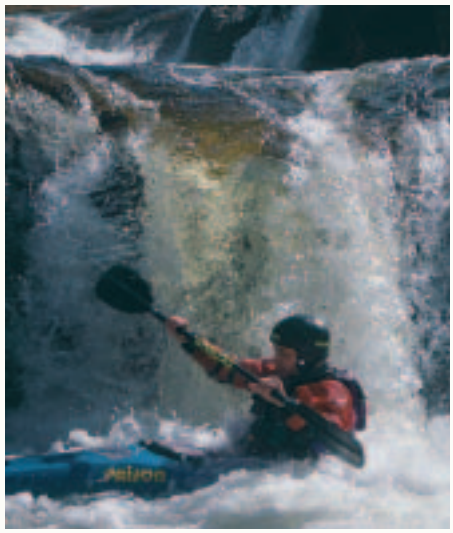
- free passage between rivers, lakes and feeder streams. This applies particularly to migratory species but is also relevant to resident species, such as brown trout, that can move considerable distances within rivers to spawn. Access is impeded if streams are culverted improperly or are too shallow – a problem aggravated in small streams by deep gravel deposition that may result in summer flows becoming subterranean. Artificial barriers, large woody debris dams that become sealed with brash and sediment, and excessive turbidity may also bar upstream migration. Migratory species also require freedom from major or frequent disturbance of the channel.

Coarse fish, which predominate in middle and lower reaches of some rivers and still waters, may require different conditions from salmonids. Some species need plants as spawning sites and some need warm water to mature. Some are tolerant of poorer conditions such as lower concentrations of dissolved oxygen or greater turbidity. In addition to coarse fish, lowland reaches usually contain salmonids and may be used by migrating fish. The rule must be to establish the requirements of the fish communities by consulting the local fishery interests to ensure that conditions are protected or improved.

Fish eggs and fry require oxygen-rich water for their survival and are sensitive to siltation of their spawning grounds.

Principal uses

Water in and flowing from forested catchments may be used for abstraction for drinking purposes, hydro-electric power generation, agriculture and irrigation, industrial purposes, fish farming, and recreational uses, such as angling, canoeing, and sailing.



A canoeist on the River Etive, Scotland.

An automatic irrigator moving along beds of Sitka spruce seedlings.

Requirements of water-users

The requirements of water-users vary considerably. Most users need a reliable yield with appropriate seasonal flows and a supply that is relatively free of contaminants, including a moderate pH and low sediment content. If these regimes change, problems may occur with possible increased costs for specific water-users or the general public to ensure water quality standards are met. Even limited degradation can cause difficulties for downstream users by reducing the capacity of a water body to absorb legitimately discharged effluents. Flood control is an important issue to a wide range of people.

4. EFFECTS OF FORESTS ON THE FRESHWATER ENVIRONMENT

Forests can have a number of positive and negative impacts on the freshwater environment which this section describes in detail. Recommended forestry practices to address these issues are given in Sections 5 and 6.

Siltation and turbidity

Good forest management minimises soil disturbance, compaction, and protects the soil resource. Forest planting can therefore help to reduce the higher rates of soil erosion that are associated with more intensive land uses, such as arable cropping. The bare cultivated soils associated with autumn-sown winter cereals are particularly at risk of erosion by heavy rainfall or strong winds. Strategically placed woodlands in the form of shelterbelts or riparian buffer zones can help to reduce soil losses from such sites.

Conversely, poor management can lead to large quantities of sediment entering surface waters. There have been instances where cultivation, drainage, harvesting, road building and a lack of adequate road maintenance have caused unacceptable turbidity levels, seriously disrupting water treatment works and water supplies. The financial consequences of such incidents can be very great and may even involve legal action or the construction of new treatment works. Sediment can also have a high nutrient, metal or pesticide content, which can contribute to the enrichment and contamination of downstream waters, particularly reservoirs and lakes where the sediment may remain for a considerable period of time. In addition, increased erosion represents a loss of the soil resource and a reduction in potential productivity (see FC *Forests and soil conservation guidelines*).

Sediment-laden run-off can seriously damage the freshwater environment and pollute water supplies.

High turbidity levels due to inputs of fine sediments such as clay, silt and fine sand can have an adverse impact on the aquatic flora and fauna. Light penetration is reduced, affecting overall productivity, fish feeding and migration. Suspended sediment can also affect fish respiration. When fine sediment settles it can damage spawning areas by physically covering and 'cementing' gravel redds, trapping fry and reducing the oxygen supply to fish in their early life stages. Siltation may also blanket plants and modify substrates leading to a decrease in invertebrate diversity.

Large inputs of coarse sediment can have a serious impact, leading to the destabilisation of stream beds and channels, the shallowing of watercourses, blockage of pipelines and water intakes to treatment works, and a long-term reduction in reservoir storage capacity.

Acidification

The primary cause of acidification is the deposition of acidifying sulphur and nitrogen compounds derived in part from the combustion of fossil fuels. Acidification of fresh waters occurs where the inputs of these pollutants exceed the buffering (neutralising) capacity of the soils and the underlying rocks through which water passes before entering streams, rivers and standing water (Figure 3). The buffering capacity of these receiving waters is also an important factor. The most acidified areas in the UK are in the uplands where catchments with base-poor, slow weathering soils and rocks coincide with high pollutant inputs in the form of large volumes of moderately polluted rainfall. Although most pollutant inputs are now declining due to emission control, surface water acidification remains a particular problem in parts of central and southwest Scotland, Cumbria, the Pennines, Wales and the Mourne Mountains in Northern Ireland.

Before the industrial revolution, waters in upland areas were generally unpolluted, with good stocks of salmonids and other fish. Today, where surface water acidification has occurred, fish populations have declined or, in some instances, been lost completely. Other wildlife has also been seriously affected, with reduced numbers of some birds like the dipper, and an impoverished diversity of aquatic invertebrates.

In many upland areas, surface waters are sources of supply for domestic use. Increased acidity and consequent increased solubility of aluminium and manganese have implications for public and private water supplies,

The combustion of fossil fuels is a major cause of acid rain.

influencing compliance with water quality standards and potentially increasing the cost of water treatment.

The quantity of sulphur and nitrogen pollutants deposited at a given site is strongly influenced by the nature of the vegetation layer. Forest canopies can significantly increase the capture of some of these pollutants in the atmosphere. This increased capture, often termed scavenging, is a function of the stand structure which creates turbulent air mixing. The effect therefore becomes more important as trees grow and the height of the stand increases (Figure 3). The enhanced capture of mist, which can contain large concentrations of sulphur and nitrogen, is greatest at high altitude because of the increased duration of cloud cover and high wind speeds. Long-term studies continue in order to determine the magnitude of this scavenging effect and its role in acidification, and also to validate models of deposition.

The main pollutant of concern until recently has been sulphur due to its established role in surface water acidification. Continuing reductions in sulphur emissions, however, have shifted attention to the role of nitrogen. Nitrogen emissions have proved more difficult to control because their main sources are motor vehicles and agriculture. Although nitrogen emissions have been declining slowly since the late 1980s, they now exceed sulphur emissions. Forest growth is characteristically limited by below optimum availability of nitrogen, and drainage water from forests and woodlands generally has very low nitrate concentrations. Consequently nitrogen deposition would not normally be expected to pass through undisturbed forest ecosystems and result in acidification of water. However, nitrate leakage from older forest stands has been identified in areas of high nitrogen deposition, such as in parts of Wales and south Scotland. There is concern that forest soils are becoming increasingly saturated with nitrogen and that this could lead to a marked rise in nitrate losses and thus acidification. Nitrogen deposition and its role in acidification continue to be investigated in a number of research programmes.

Changing management practices, e.g. continuous cover forestry, may also affect the scavenging potential of the canopy and consequently soil and stream chemistry. Potential effects of changing practice will be the subject

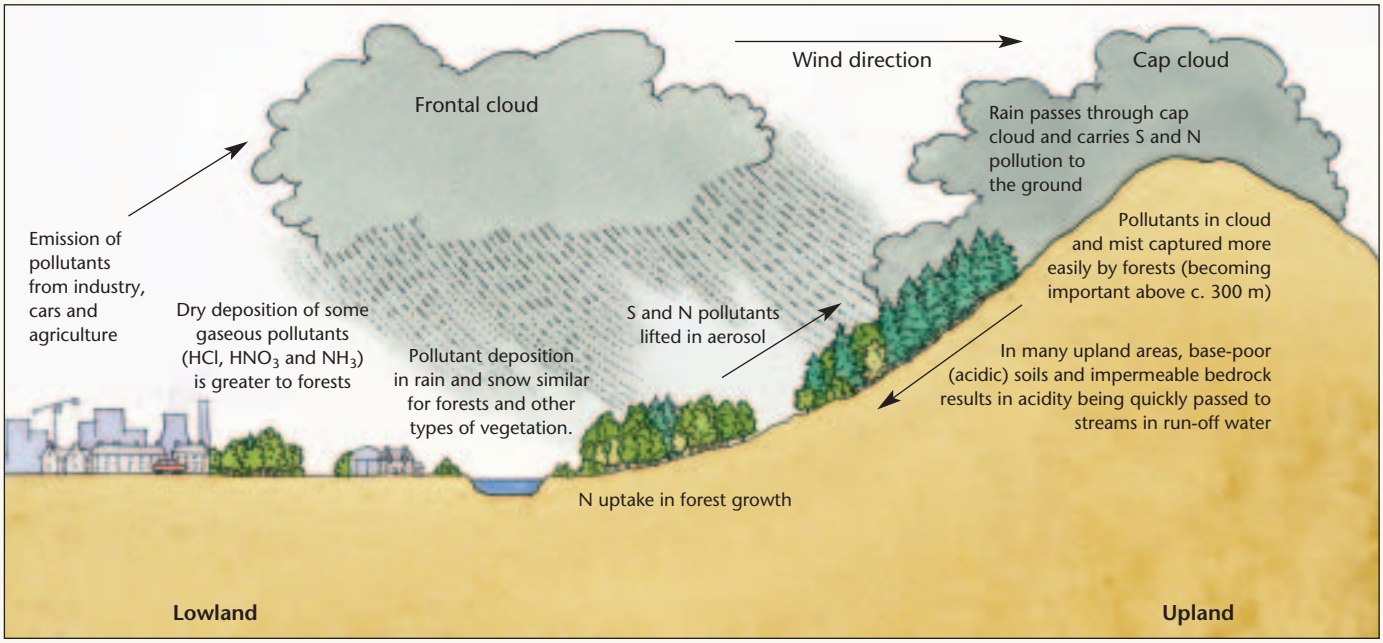


Figure 3 Interactions between forests and acid deposition.

of further research. The possible depletion of base cations in soils as a result of the removal of harvested material from the site and the effect on stream chemistry are not fully understood; these need to be investigated further.

Significant nitrate leakage is also known to result from harvesting operations. This is due to increased rates of mineralisation and nitrification in the soil in the absence of uptake by the trees. This pulse may last for 2–5 years, depending upon the rate of revegetation. While an increase in nitrate concentrations in soil and stream waters poses only a very small risk of exceeding environmental quality standards, of more concern is the short-term increase in hydrogen ion concentration which may contribute to acidification and increase aluminium solubility. In acid sensitive catchments, avoiding the clearfelling of large areas in a short space of time reduces the likelihood of such problems.

While pollutant emission reductions have led to some improvement in water quality in the worst affected areas, biological recovery has so far been very limited. In fact some areas of Wales have continued to show a decline in fish and invertebrate populations. This has raised questions about the capability of wildlife to recolonise damaged areas and whether the chemical improvements have been sufficient to support acid sensitive species. Forest restructuring may have a role to play in promoting biological recovery in acidified systems by opening up stream sides to sunlight. The removal of the heavy shading cast by bankside conifers has been shown to improve freshwater and riparian habitats, and increase fish numbers where water quality is suitable.

Nutrient enrichment

There is concern that the nutrient, and hence the ecological, status of fresh waters, particularly standing waters, may be significantly changed following the aerial application of phosphate fertilisers in their catchments. Fertilisers may be accidentally sprayed or blown into watercourses, or may be transported indirectly via subsequent leaching or run-off. Nutrient releases following large-scale felling operations may also contribute to ecological changes. Soil erosion is another important transport mechanism, since nutrients bound to soil particles can be subsequently released in the receiving water body. The main concern is with upland waters that are naturally nutrient-poor and where biological activity is usually phosphorus limited. In extreme cases, phosphorus enrichment can produce excessive algal growths, resulting in dissolved oxygen fluctuations and disruption of the ecosystem. In addition, excess

Excessive run-off of phosphate can result in eutrophication and algal blooms.

phosphate could require improvements to be made to treatment works, or result in increased treatment costs.

The generally higher nutrient status of lowland soils means that woodlands rarely require fertiliser applications. Nutrient inputs tend to be much lower compared with agriculture and thus woodland planting on ex-agricultural land may help to protect water quality within sensitive areas such as NVZs. The main exception concerns conifer forests, which can enhance the capture of nitrogen pollutants from the atmosphere and concentrate nitrate levels in groundwater, particularly in areas of low rainfall. High nitrogen inputs can occur where forests are down-wind of local pollutant sources, such as intensive pig- and poultry-rearing units. This is likely to be an increasingly important consideration with the expansion of NVZ areas.

Heavy rainfall following fertilisation with urea could lead to high ammonium concentrations in stream waters, interfering with water treatment processes and causing an unacceptable taste in drinking water. Fish deaths could also result where water pH is high as ammonia becomes more toxic with increasing alkalinity.

Organic pollution of watercourses may also occur following the spreading of sewage sludge and other organic wastes. This can encourage bacterial growth and increase oxygen depletion resulting in fish deaths.

Colour, iron and manganese

One particular problem with upland supplies draining from areas with peaty soils, whether forested or not, is the high level of water colour. Colour levels vary greatly from year to year for complex reasons. Climatic factors such as the incidence of drought are believed to be important. The intensity of livestock grazing, moorland and forest drainage work, soil drying under forests and soil re-wetting following harvesting, may also play a part. However, research indicates that colour levels tend to be only marginally

higher in forest streams and those subject to felling compared with moorland streams. Long-term monitoring has shown a consistent rising trend in dissolved organic carbon concentrations across many forest and moorland sites, which is often associated with water colour. This is thought to be due to the increased mineralisation of soil organic matter brought about by climatic warming.

Increased colour can interfere with water treatment processes, cause taste problems, and add greatly to treatment costs. It will also reduce light penetration and may thus affect plant growth and productivity. Conversely, the dissolved organic carbon component of increased colour may help to reduce the toxicity of metals such as aluminium by forming non-toxic complexes.

In some areas, depending on geology, high iron and manganese levels can result from soil disturbance and erosion following forest operations. This can add to water treatment problems and lead to dirty water supplies, consumer complaints and failure to comply with the EC water directives. Iron, in particular, may be precipitated and coat stream beds, leading to harmful effects on the flora and fauna.

High iron levels can lead to unsightly staining of stream beds and damage the freshwater environment.

Pesticides

Pesticides can pollute water supplies and have serious effects on the aquatic environment. The ability of some chemicals to give obnoxious tastes and odours at extremely low concentrations can be particularly problematic, and markedly increase the cost of water treatment. Water undertakers have a statutory duty to limit the concentration of any individual pesticide in drinking water supplies to less than 0.1 part per billion, necessitating complex and expensive water treatment.

Synthetic pyrethroids used to protect transplanted seedlings against *Hylobius* can be extremely toxic to fish, aquatic plants and invertebrates. Organophosphates can build up to damaging levels in birds and other wildlife and are no longer approved for use. Also of concern are the recently confirmed, and significant, sub-lethal effects of very low pesticide levels on fish reproduction and physiology. Usage must be in accordance with manufacturers' guidance and be kept to the minimum for effective treatment. Very strict attention needs to be given to reducing off-site drift, the safe and legal disposal of waste and preventing accidental spillage. Since 1 April 1999, disposal of surplus and waste pesticide to land requires authorisation under the Groundwater Regulations. Existing controls on the use of pesticides aim to give complete protection; instructions must be followed meticulously. It is a legal requirement for pesticide treatments either to be carried out by certified operators as assessed by the National Proficiency Test Council or directly supervised by certified operators.

The low usage of pesticides and general absence of contamination within well-managed forests means that forest planting can help to offset the greater pollution threat from more intensive lowland land-uses. In particular, forestry can play an important role in protecting sensitive areas, such as groundwater protection zones, from contamination.

The use of hand-held applicators is the most common method of applying herbicides in forestry.

Chemicals

The use of fire-fighting chemicals can pose a threat to the freshwater environment. Synthetic detergents and protein foams have a high oxygen demand, which can lead to fish death by asphyxiation in receiving watercourses. The spillage or careless disposal of concentrates presents the greatest risk to water quality during operational use.

Woodland planting on badly designed landfill sites could lead to tree roots disrupting the protective clay cap. The resulting inflow of rain water would increase the volume of leachate and thus the risk of contaminating local groundwaters and streams. Conversely, the higher water-use associated with some types of forest, compared to shorter vegetation, could reduce this problem. Planting to restore mineral workings and contaminated land has both potentially positive and negative effects which will vary depending on the nature of the site. For example, increased acidification of inadequately buffered materials could lead to the greater mobilisation of some metal pollutants, while the ability of forests to accumulate soil organic matter could enhance the retention of others. Lower leachate volumes would also be beneficial on such sites. To ensure that the benefits of restoration are maximised and the negative impacts minimised, schemes must be site-specific, well designed, and well managed.

Fuel oils and lubricants

The primary concern arising from the use of fuels and lubricants in the forest is the risk of spillage leading to water pollution. Both the accumulation of small spills during routine handling and larger accidental spills can lead to serious contamination of soils, surface run-off and groundwaters. All oils, and in particular diesel, can quickly migrate through the soil and small quantities are sufficient to taint drinking water supplies and disrupt water treatment processes. Oils can have a toxic effect on freshwater life and can prevent the transfer of oxygen through the water surface, causing aquatic animals to suffocate. Bio-oils are less persistent in the environment, but can still pose a risk of pollution through accidental spillage or misuse.

Water yield

Water yields from catchments containing closed canopy conifer forest are usually less than from moorland or grassland catchments due to greater interception losses. This loss increases with forest height and canopy development and is greatest in the wetter and windier parts of the UK. Though assessments of the degree of reduction in a given catchment cannot be exact, research suggests there may be a 1.5–2.0% reduction of potential water yield for every 10% of a catchment under mature conifer forest. Work is in progress to enable a reliable prediction to be made on yield reductions in different areas. Water yields from newly planted young forests or felled areas are unlikely to differ significantly from moorland catchments.

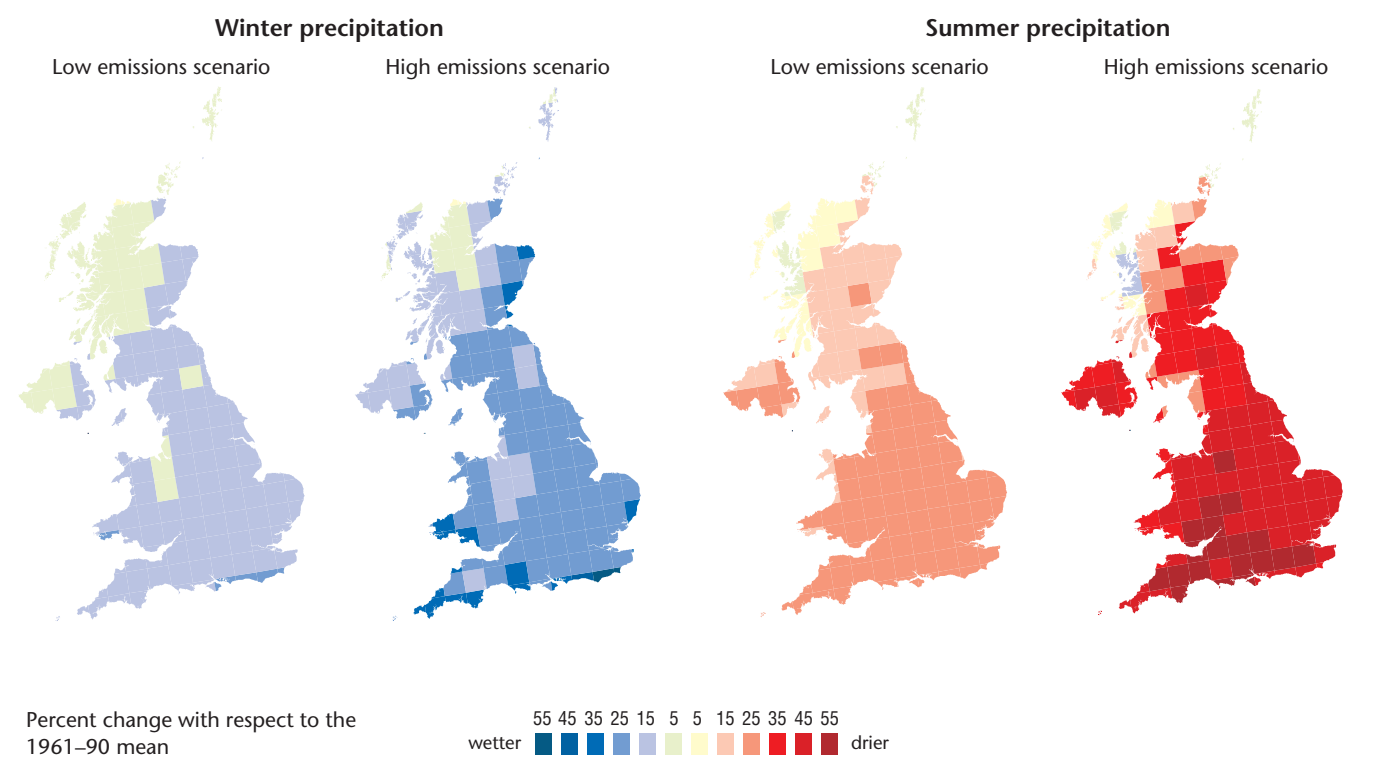
The drier and less windy climate in the lowlands reduces the interception loss, but tree transpiration rates may be higher due to roots reaching deeper soil water reserves. The net effect of a mature conifer forest can be a marked reduction in the limited water yields that characterise these areas, amounting to as much as 70% or more. This can have important implications for the quality and quantity of lowland groundwater resources and the maintenance of river flows.

Evaporation from broadleaved woodland is generally much less than from conifers due to reduced interception losses during the leafless period. Studies have shown that groundwater recharge under beech and ash woodland on chalk can be expected to be similar or slightly higher than that under managed grassland, except perhaps in extreme drought years. Therefore woodland planting should help to protect and may even enhance chalk groundwater resources. Recharge under broadleaved woodland on drier sandy soils, however, is likely to be reduced compared to grass. This is because of the deeper rooting of trees enabling transpiration to continue unaffected by water stress for a longer period during the summer than for grass. Tree species is another important factor, with some broadleaved species having a much higher water-use than others. Two notable examples are short rotation coppice crops of poplar and willow. These species are able to sustain very high transpiration rates on moist or wet soils, resulting in a 50% or greater reduction in water yield for a fully established crop compared with grassland – this is the exception rather than the rule for broadleaved species.

Climate change predictions for 2080 suggest increased winter and decreased summer precipitation across the UK, resulting in little change in annual precipitation in the west and north but lower totals (by 5–15%) in the south and west (see Figure 4). Annual and seasonal temperature, and therefore evaporation, are expected to increase over most of the UK. The net effect on water resources is likely to be:

- increased winter run-off and groundwater recharge, particularly in the north;

Figure 4 Climate change prediction maps for 2080 showing percentage change in winter and summer precipitation for the low and high emission scenarios. Source: UKCIP02 Climate Change Scenarios (data provided by Tyndall and Hadley Centres for UKCIP).



- increased rainfall intensity and flood risk in both the north and south;
- increased or decreased summer run-off in the south depending on the extent to which the greater winter recharge can offset higher summer losses and the relative contribution of groundwater sources.

Forests could help to either moderate or exacerbate the impact of these changes and thus consideration needs to be given to the best design of forest for a particular location. Forest evaporation may also be influenced by climate change, with higher carbon dioxide concentrations contributing to increased water-use efficiency and thus reduced water losses.

Base flows

Summer base flows in rivers can often be critical for wildlife, fisheries, water supply, or the disposal and dilution of effluent. Research suggests that the reduction in water yield associated with upland conifer forests has a limited effect on these flows. Indeed, the cultivation and drainage of wet soils prior to planting can significantly increase base flows, an effect that declines slowly with drain infill and subsidence, but may persist throughout a complete rotation. Base flows may be reduced in head-water catchments by the continued growth of a forest or temporarily increased by tree felling, but they appear to be relatively unaffected by forestry in larger catchments. The situation is different on lowland aquifers in drier parts of the UK, however, where large areas of conifer forest or crops of short rotation coppice can be expected to result in a significant decline in summer base flows. This is because of the greater potential reduction in water yield and the fact that base flows tend to form a much larger proportion of the annual run-off.

Base flows appear to be relatively unaffected by forestry in large catchments.

Peak flows

Many adverse impacts can be related to high peak flows, which are often associated with more acid conditions, coloured water, increased erosion of bankside habitat and spawning gravels, greater siltation, and localised flooding. Altered peak flows may also have an impact on the timing and duration of suitable flows for fishing and fish migration as well as the refill of reservoirs, which could pose a problem for water supplies.

Forestry can have a range of effects, depending on the type and scale of forest operation. In one study, the ploughing and drainage of a complete catchment was shown to result in a significant increase in peak flows – of the order of 15–20%, decreasing to 5% after 20 years – and a decrease in the time to peak of up to one-third. These effects were greatest for moderate rainfall events and tended to decrease in relative terms with increasing storm size. The impact of smaller-scale drainage treatments will depend on the location of the site with respect to the catchment outlet. Quicker run-off from sites close to the catchment outlet will help to reduce overall peak flows, while the opposite is likely to be the case for more distant sites. Poor drainage practice could contribute to localised flooding and serious erosion and siltation. Fish migration may also be affected.

Forest establishment and growth appear to have a small effect on peak flows, with the impact of clearfelling often being difficult to detect. Overall, research suggests that the contrasting effects of the different stages of the forest cycle will even out at a larger catchment scale, such that upland forests are unlikely to affect downstream flood risk.

The much lower water yields associated with lowland conifer forests can be expected to reduce peak flows, with benefits for flood control. This will be enhanced by the drier, organically richer soils under such forests, which can receive and hold more rainwater.

Research suggests that upland forestry has a small effect on high flows.

Floodplain forests may have an important role in attenuating flood peaks, as well as providing many other environmental benefits. Flood flows are able to spread out over natural floodplains and the presence of a diverse woodland structure, e.g. multiple woody dams on the woodland floor, is likely to aid the retention and delay the release of flood waters. Strategically placed floodplain forests may therefore offer a means of assisting downstream flood defence. However, several concerns need to be investigated: the effect of the backing-up of flood waters in developed areas, river access for maintenance, a reduction in engineered flood control, and an increased risk of large woody debris blocking downstream structures. Floodplain woodland is unlikely to cause a significant reduction in storage capacity within flood storage areas due to the minor area occupied by the trees themselves (usually less than 1%).

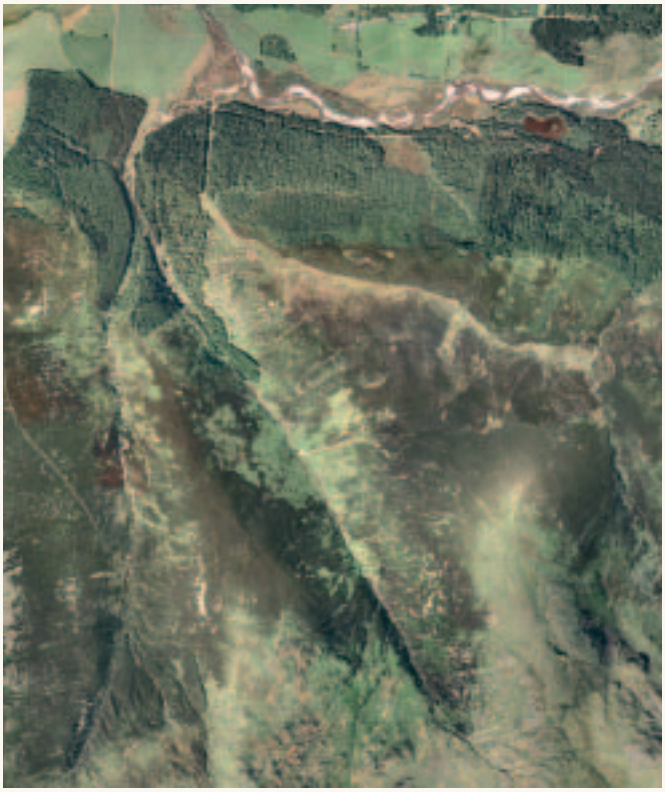
The greater 'hydraulic roughness' of floodplain woodland could help to hold back flood waters for the protection of downstream communities.

Shade and shelter

The structure and composition of riparian vegetation can have a dramatic impact on the aquatic environment. A key factor is the degree of shade. On one hand, too much shade leads to bare, eroding banks; wider, shallower channels; and reduced productivity of fish and aquatic invertebrates. On the other hand, too little shade can result in a lack of shelter; more extreme temperature fluctuations, including the risk of lethal high temperatures for fish during summer months; and contribute to excessive weed growth. A cover of relatively open, native woodland is thought to provide the best combination of shade and shelter. However, planting on engineered flood banks should in general be avoided as this can lead to instability and restrict access for maintenance work.

5. CATCHMENT PLANNING

This section deals with issues that need to be addressed at a catchment scale; Section 6 covers those that are more appropriately dealt with at the site level. Catchment issues include the contribution of forestry to acidification and eutrophication, the effects of forestry on water yield, flows and flooding, and the design of riparian buffer areas. Catchment management planning will be increasingly driven by the Water Framework Directive which requires the production of River Basin Management Plans. The sensitivity of any water catchment to forest operations must be identified and taken into account at the planning stage. The degree of sensitivity depends on the quality of freshwater habitats and the requirements of water-users.



Aerial view of a partly forested headwater catchment.

Acidification: critical loads and catchment assessments for new planting and restocking

Reduction in the emission of acid pollutants is the principal way of solving the general problem of surface water acidification. In the UK there has been a marked reduction in sulphur (S) emissions, and hence deposition, since the late 1960s and a slow response to this has been detected in some surface waters since the early 1980s. UK nitrogen (N) emissions have declined since the late 1980s but future trends in nitrate concentrations of surface waters remain uncertain. The European Union has agreed to further S and N pollutant reductions by 2010, but these will not result in the recovery of all acidified waters or remove the risk of continued acidification in all currently susceptible areas. Investigations continue to assess the effectiveness of emission reductions in reducing pollutant inputs, and to identify the rates and extent of recovery in terrestrial and aquatic ecosystems.

The increased capture of acidic pollutants by forests could delay the recovery of acidified waters or even lead to further acidification in the most sensitive areas. Large-scale conifer afforestation represents the greatest threat while the replanting of existing forests can also be a cause for concern.

In order to protect the freshwater environment, the forestry authorities will take the scavenging effect into account when considering new planting or restocking plans. To this end it is necessary for both the forestry authority and applicants to identify which areas are most at risk. The critical load approach is well fitted for this purpose. A critical load is defined as the maximum load of a pollutant that a given ecosystem can tolerate without suffering adverse change. For fresh waters, critical loads can be calculated which, provided they are not exceeded, should ensure the maintenance of water chemistry suitable for the protection of populations of fish and other freshwater biota. The Department of the Environment, Transport and the Regions (DETR), now the Department of Environment, Food and Rural Affairs (Defra) have recalculated critical loads for fresh waters based on the original data from 10 km^2 grid square samples, but this time incorporating the role of N as well as S. Having compared these with total pollutant

Forests are particularly effective at scavenging acidic pollutants in cloud water.

inputs of S and N, DETR/Defra have derived maps that indicate where critical loads for total acidity for fresh waters are exceeded. Since vegetation and soils retain much of the N deposition, N pollutant inputs were estimated from the measured nitrate concentrations in run-off.

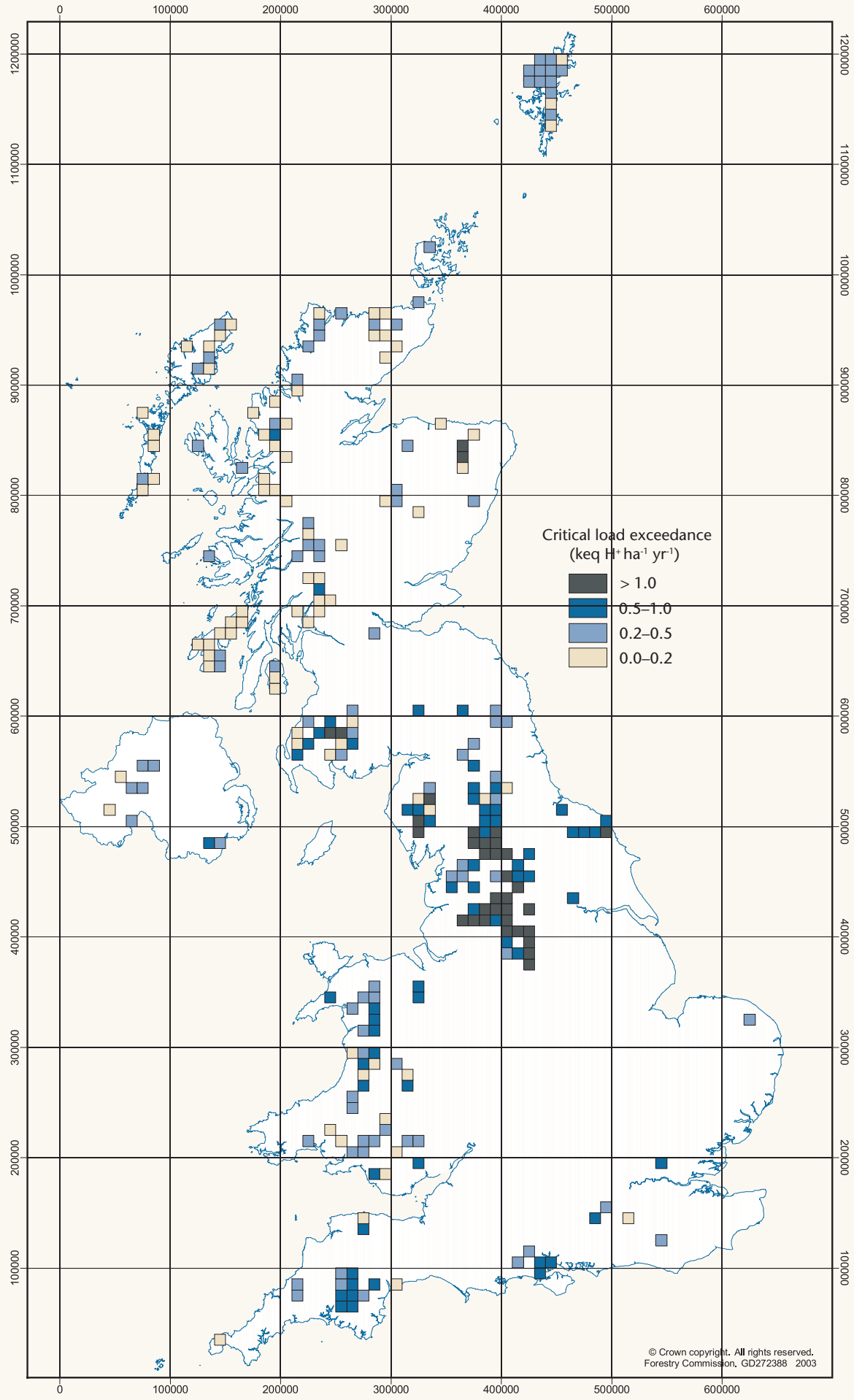
Figure 5 shows the exceedance of critical loads of total acidity for UK freshwater ecosystems based on 1995–97 pollutant depositions (DETR, 2001). Since depositions are expected to continue to decline up to 2010 and beyond, the use of this map to identify where there may be acidification problems allows for a safety margin. However, because of sampling and scale factors there is a possibility of waters in areas bordering exceedance squares being at risk. Consequently, consideration needs to be given to the impact of new planting and restocking plans in all adjacent squares as well. In exceptional circumstances, sites may be at risk even though they fall outside a critical load exceedance or adjacent square. In view of the requirement to protect candidate SACs, site-specific data, if available, should be used to assess acidification risks for designated river catchments.

The indicative nature of the 10 km^2 scale critical load exceedance map means that a more detailed catchment-based assessment may be required for determining the actual susceptibility of individual waters to a forest scavenging effect within both exceeded and adjacent critical load squares.

For new planting, the forestry authorities, taking advice as necessary from the appropriate water regulatory authority, will determine the need for the more detailed assessment. Factors considered include the size of the planting scheme, species mix, altitude, the proportion of forestry already in the catchment, soils, geology, and the sensitivity of local water-uses. Broadleaved woodland poses less of an acidification threat due to the smaller scavenging effect, but the impact of larger planting schemes merits consideration. Additional guidance is available on the procedure for undertaking catchment-based assessments (see Appendix 4). Where an assessment is required the forestry authorities and the water authorities or regulators will discuss details with the applicant. In some cases, assessment will be possible on the basis of existing information. Where sufficient information is not already available, assessment is likely to involve the collection of one or more water samples at high flow (preferably in January, February, or March, when conditions tend to be most acidic) from the main watercourse receiving drainage from the area proposed for new woodland. The results from the chemical analyses will be used to calculate the receiving water's critical load. This will then be compared with the 1995–97 total pollutant deposition of S and N (latter estimated from the measured nitrate concentration in run-off) for the appropriate grid square. Where the combined deposition total exceeds the freshwater critical load, approval of a planting grant is unlikely until there are further reductions in pollutant emissions.

Gauging high flows at Loch Dee, Galloway. Stream water samples for critical load assessments should be collected at high flow.

Figure 5 Critical loads exceedance map for UK freshwaters.



The re-design of forests will create a greater mix of tree ages with increased species, structural diversity, and open space. This should bring about an overall reduction in the forest scavenging effect, which will be greatest in the more extensively forested catchments. Harvesting temporarily eliminates pollutant scavenging until restocked crops approach canopy closure at around 15 years of age. By this time, agreed emission reductions are predicted to protect many catchments from the risk of further acidification. The combination of these factors means that in the future forest replanting will be less likely to contribute to the exceedance of freshwater critical loads. Exceptions might include higher altitude stands (>300 m) at which level the scavenging of pollutant cloud deposition is known to increase markedly. Where conifer forest occupies a large proportion of the catchment above this altitude, consideration should be given when reviewing forest design plans (in the state sector) and forest plans (in the private sector) to selective deforestation, subject to a detailed catchment-based assessment as part of an Environmental Impact Assessment under environmental impact regulations applying in the different countries. In the case of catchments designated as candidate SACs in critical loads exceedance and adjacent squares, a detailed catchment-based assessment is required for forest replanting under the Habitats Directive regardless of altitude.

The short-term release of nitrate that can follow the large-scale harvesting of some forest sites may pose an additional acidification threat within acid-sensitive areas and there may be a need to carry out a site impact assessment. The need for assessment will be determined by the forestry authorities taking advice as necessary from the appropriate water regulatory authority. Factors that will be considered include catchment size, the timing of felling operations, species mix, local soils and geology, and the presence of fish. Appendix 5 gives additional guidance on the procedure for undertaking site impact assessments. Sites believed to be at risk would require coupe size to be reduced and the adoption of management practices designed to minimise nitrate losses.

Although nitrate leaching can be reduced by whole-tree harvesting, a much larger, longer-term threat of soil and water acidification is presented by the greater removal of base cations in harvested produce. Consequently, whole-tree harvesting is not recommended in critical load exceedance or adjacent squares, except on steep sites where whole trees have to be extracted to roadside.

Biological recovery of streams showing chemical improvement in response to emission reductions may benefit from the opening out of stream sides. Where practicable, these areas should be targeted for earlier clearance of stands casting heavy shade and cleared riparian zones linked to aid upstream migration of fish and invertebrates.

Water yield, river flows and flooding

The potential reduction in water yield from conifer forests is likely to be a problem where the supply is being, or is planned to be, fully exploited. This is increasingly the case in many catchments as the demands on water resources continue to grow. In the uplands, this may include catchments used for the generation of hydro-electricity, impoundment for water supply or river regulation. In the lowlands, areas draining to heavily exploited groundwater aquifers or rivers with an identified low flow problem are most at risk. Also in many catchments the needs of river ecology, fisheries and other water-uses will have to be considered in addition to the demands for supply. Where new planting is proposed in such locations, early consultation with the water regulatory authority and/or water undertaker will clarify whether there is a problem. Consideration needs to be given to the scale and age distribution of the forest cover, as well as the nature of forestry practices, since these will determine the overall impact on water yield and flows. It is likely that the effect of a well-managed forest of mixed ages and species will be much less than that of a uniform mature conifer crop.

The lower water-use of broadleaved woodland poses much less of a threat to water resources, and may even enhance supplies in some areas. Large-scale planting of short rotation coppice crops of poplar and willow will have the greatest negative impact and therefore should be avoided in sensitive locations.

Conifer forests have been found to have a small effect on peak flows, particularly in larger catchments. The main risk is posed by poor cultivation and drainage practices, both of which are addressed in Section 6.

Woodlands established on floodplains may aid flood control, as well as providing a range of other environmental benefits, including improvements to water quality, nature conservation, fisheries, recreation, and landscape. Action to restore floodplain woodlands, however, is dependent on a number of concerns being adequately resolved (see Section 4). These issues need to be addressed through consultation with the water regulatory authority, (e.g. within Environment Agency Catchment Flood Management Plans) and through continuing research. Work is under way to determine the locational principles that could be used to identify sites where the planting of woodland would be both feasible and desirable for flood control.

Nutrient enrichment

Waters vary in their sensitivity to nutrient enrichment from forestry, with nutrient-poor (oligotrophic) waters most at risk of nutrient pollution. Aerial phosphate fertiliser applications present a significant threat and must be carefully planned to ensure that phosphate losses from consecutive applications in a given catchment do not exceed environmental quality standards in receiving lakes or reservoirs. Applications exceeding a total area of 50 ha in any 3-year period may pose a problem; the effect will depend on the soil properties, timing of application, size of the catchment and the characteristics of the water body. Early consultation with the water regulatory authority will establish whether a more detailed site assessment is required.

The ability of conifer forests to enhance the capture of nitrogen pollutants from the atmosphere and concentrate nitrate levels in groundwater may be a cause for concern in certain NVZs. The main areas at risk are those receiving low rainfall where the concentrating effect of evaporation will be disproportionately large. Consideration should be given to avoiding large-scale conifer planting within NVZs receiving <650 mm annual rainfall.

Riparian forestry and buffer areas

A buffer area is required both in existing forests and new planting to protect the riparian and aquatic zones from disturbance. This means that the buffer will generally extend beyond the riparian zone (see Section 2). Key aspects of the design of the buffer area are management, width, choice of species, structure, and landscaping. For further advice see FC publications *Forest nature conservation guidelines*; *Forest landscape design guidelines; Forests and soil conservation guidelines; Forest design planning;* and also the Scottish Native Woods' booklet *Restoring and managing riparian woodlands*.

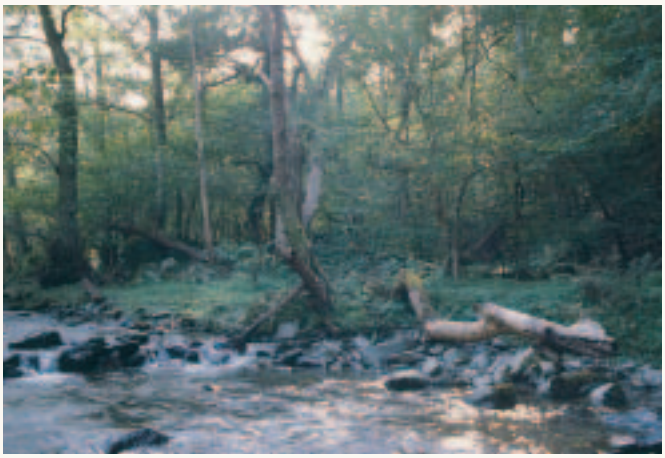
- **Management**
  The structure and composition of riparian vegetation can have a great influence on the aquatic environment. Species mix is important and the buffer area should be managed to protect both water quality and freshwater habitats. There is a need to balance the requirements of different water-uses, such as fisheries, with those of other wildlife. This is especially the case in terms of the desired level of shade and the frequency of intervention necessary in the form of thinning, coppicing or felling to maintain a particular set of conditions. Management should reflect the sensitivity and intrinsic value of a given watercourse; a riparian/aquatic habitat survey and early consultation with the water regulatory authority, the conservation agencies (Scottish Natural Heritage, English Nature, Countryside Council for Wales, and the Environment and Heritage Service), and local fishery bodies will help to inform this process (see Appendix 1). Opportunities for redesigning and enhancing the buffer area will arise, particularly after clearfelling. Imaginative management will make a positive contribution to multipurpose forestry. On appropriate sites, consideration should be given to the needs of priority and protected species, such as the otter, water vole and freshwater pearl mussel (see Appendix 3). Full details of riparian zone management are given in FC *Forest nature conservation guidelines* (see also Bulletin 112 *Creating new native woodlands*, and Practice Guides 1–8 *The management of semi-natural woodlands*). The effect of riparian forest management on the freshwater environment has been reviewed by Broadmeadow and Nisbet (2002).

Riparian management involving the streamside clearance of Sitka spruce.

- **Width**
  The desired width of the buffer area depends on a consideration of its principal functions – water quality protection, moderation of shade and temperature, maintenance of riparian and aquatic habitat diversity and ecological integrity, and landscape improvement. These should be related to site sensitivity and a balance achieved between

benefits and costs. In terms of providing adequate protection for the aquatic zone, a width of 20 m on either side will generally suffice for larger watercourses with a channel more than 2 m wide. A minimum buffer width of 20 m should also be left along the shore of lakes and reservoirs. For small streams, practical constraints mean that the minimum buffer widths should be 10 m on either side for channels 1–2 m wide and 5 m on either side of channels up to 1 m wide (unless highlighted as being important for fish spawning when a minimum buffer width of 10 m should also apply to either side of channels less than 1 m wide). Where the natural riparian zone exceeds these widths, the dimensions of the buffer area should be correspondingly increased, up to twice the minimum recommended width. Greater widths should be considered where there is scope to restore native floodplain woodland. Steep ground that is dissected by numerous small streams is a special problem; it may not be possible, or desirable in terms of landscape design, to create buffer areas alongside the smallest of streams.

- **Choice of species**
  The vegetation within the riparian zone should preferably be native to the location and soils. Natural regeneration is the favoured means of establishing native tree and shrub species when an appropriate seed source exists and any conifer regeneration is manageable. Where natural regeneration is unsuitable, planting may be necessary; stock raised from local seed sources should be considered. Densely shading trees should be interspersed with lighter foliaged trees such as birch, willow, rowan, ash, hazel, aspen and bird cherry. Leaf litter from these latter species decomposes more rapidly than litter from oak, beech and most conifers, and is therefore more valuable to aquatic invertebrates, especially in small streams. Nevertheless, species whose litter has a low decomposition rate are also of value. A mixture of species is likely to maximise food availability to stream detritivores because of differences in the time and duration of leaf fall and in litter decomposition rates. Large-scale planting of alder should be avoided. Although its roots can help to bind bank sides, provide underwater shelter and add nutrients by fixing nitrogen, it casts a heavy shade and may contribute to acidification within critical load exceedance squares. Furthermore alder is susceptible to *Phytophthora* and special care should be taken to avoid introducing the fungus by planting infected stock.



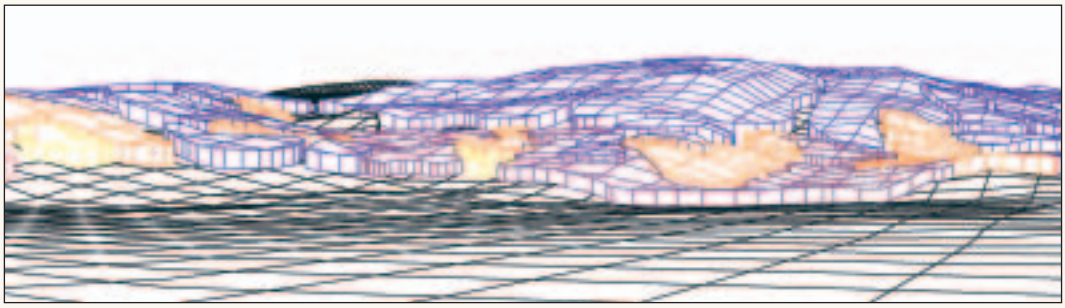
An open canopy of native broadleaved woodland provides a high quality riparian habitat and enhances the aquatic zone.

- **Structure**
  In general the aim should be to establish and maintain an open woodland canopy by creating an intricate mosaic of five vegetation habitat types: open ground, occasional large trees, trees with open glades, scrub thicket, and closed canopy woodland. Together these provide the structural diversity that is attractive to woodland fauna and to the plants that flourish in semi-woodland conditions. About half of the length of a watercourse overall should be left open to sunlight, with the remainder being under dappled shade from trees and shrubs. The level of shade should allow the development of a more or less continuous cover of ground and bankside vegetation.

- **Landscape**
  The width of the buffer area should be varied, preferably reflecting the local topography – for example, retreating from the stream more in hollows and advancing towards it on knolls and spurs. Introduce variations in density and species composition, not only in the buffer area but also in the transition to adjoining stands, so that the whole composition is in harmony with the landscape. Try to link riparian woodland with other native woodland on the adjacent land. There may be a requirement for a limited amount of conifer planting almost to the water's edge to obtain satisfactory visual linkage across a stream. See FC *Forest landscape design guidelines* and *Forest design planning: a guide to good practice* for further information.

The extension and restoration of wooded buffer areas can be very important in protecting the riparian and aquatic zones in non-forested catchments. One of

A composite photograph of a relatively uniform, first-rotation forest prior to re-design.



A computer simulation of the forest design plan.

A sketch to show the future appearance of the re-designed forest with greater species and structural diversity.

the main benefits is in helping to control diffuse pollution from adjacent agriculture by retaining sediments, nutrients and pesticides in land drainage; in this context land drains should terminate before the wooded buffer areas for the buffer area to be most effective. Riparian woodland can also provide much-needed shade and shelter to limit high summer temperatures and aquatic weed growth, especially in warmer parts of the UK. It provides an important edge habitat between agricultural land and the aquatic zone and can create a key wildlife corridor linking other woodland habitats to form a continuous Forest Habitat Network. The exclusion of livestock is generally helpful in reducing both the erosion of stream banks and the overgrazing of riparian vegetation. Fencing should usually be avoided on flood prone sites where it could interfere with flood control and access.

On some watercourses in England and Wales, particularly those designated as 'Main River' for flood defence purposes, periodic access for maintenance is required. In such access areas, advice should be sought from the Environment Agency as a consent may be required for the planting of trees within 9 m of the watercourse. In Northern Ireland many watercourses are designated for maintenance and flood defence purposes, and as periodic access will be required advice should be sought from the Rivers Agency. In Scotland powers for flood prevention for non-agricultural land rest with the local authority and usually apply to developed areas. The local authorities have duties to maintain watercourses and periodic access may be required for this purpose. Check the location of such watercourses with the local authority.

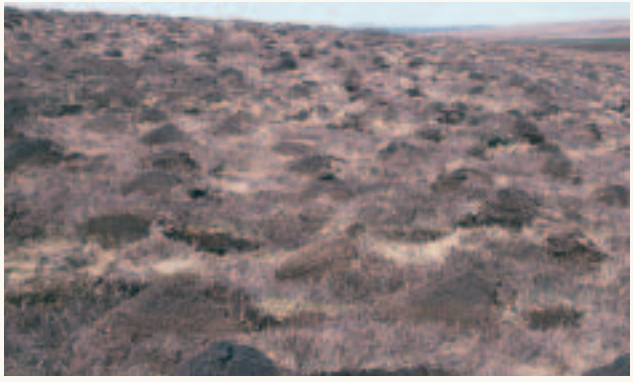
6. SITE PLANNING AND FOREST OPERATIONS

This section provides specific recommendations on forest operations. Good site planning is an essential part of any forest operation. The UK Forestry Standard describes a methodical approach: consideration of available techniques and resources; the potential environmental impacts of the work; and liaison with appropriate bodies to assess the sensitivity of the area and the existence of any legal requirements. Usually there will be a need for a detailed site assessment and the production of a well annotated map (site plan) showing pertinent information, particularly site constraints. In many instances this must be done during the preparation of forest plans and grant scheme applications, i.e. well in advance of the operations themselves.

Ground preparation

Cultivate sites only where necessary. Plan all cultivation and drainage meticulously. Machinery should not work in streams or buffer areas or ford streams, except where purpose built fords already exist. Further useful information is contained in FC Bulletin 119 *Cultivation of soils for forestry*. The following measures will minimise adverse effects:

- For new planting in the uplands, scarifiers are recommended for freely draining soils and continuous acting mounders or excavator based mounders for wet soils. Moling or ripping may be required on ironpan, heavy or compacted soils. Restrict moling to slopes <8% (4.5°) due to the high risk of erosion. On peaty soils, use excavator mounding or spaced furrow ploughing; both should be shallow (e.g. 30 cm) to expose as little mineral soil as possible. Most mineral soils are more erodible than peats, and they can be a source of toxic aluminium entering watercourses in acid sensitive areas. Loose sandy or loamy soils are more erodible than compact soils or clays. If exposing mineral soil is unavoidable, a plough without a tine is preferred. There is less need for cultivation in the lowlands, except for weed control or the disruption of compact layers.



Excavator mounding of a new planting site.

- When establishing new native woodlands, less intensive cultivation is preferred. Patch scarification or hinge mounding are likely to be the most suitable techniques and ploughing should generally be avoided. Ripping should only be used where there is an ironpan or other compacted horizon that will pose a serious obstacle to rooting. Very wet soils should either be left unplanted or alternatively mounded and planted with a species appropriate for such conditions. Drains should be used only as a remedial measure if there is a need to control discharges from natural or pre-existing man-made channels.

Scarification of a clearfelled site.

- Cultivation of restocking sites will depend on topography, soil type and the techniques used in the first rotation. In general, scarifiers are appropriate for better drained soils, although brash raking alone without cultivation may suffice on some sites, particularly if ploughed for the first rotation. Excavators or continuous acting mounders are suitable for wetter sites. Tine ploughing or ripping may be necessary if an ironpan was not broken in the first rotation.

- The use of trench mounding on new planting or restocking sites requires particular care to ensure that individual trenches do not carry large amounts of water, which could result in serious erosion and siltation. Trenches longer than 30 m pose the greatest risk, especially if mineral soil is exposed.

These must be connected to the local drainage system and meet the appropriate standards in terms of gradient and layout. On steep or complex topography this may not be possible therefore the following measures should be taken: ensure that individual trenches are no longer than 30 m; on long slopes, turn the bottom 2 m length of spoil trenches to alternate sides to reduce the likelihood of water flowing directly into a lower trench; and leave an unditched area between consecutive bands of spoil trenches to act as a sediment trap (Figure 6). On restocking sites lying adjacent to or within critical load exceedance squares, avoid filling deep trenches (>50 cm) with fresh brash; this can promote nitrate leaching and thus acidification.

- Provide collecting (cross) drains at a spacing that will control run-off in cultivation channels, including mole channels, e.g. at 40–70 m on slopes less than about 5% (3°). Provide cut-off drains so that cultivation channels do not carry water from large areas lying above.

- When ploughing and cross-draining on slopes over about 9% (5°), lift the plough above each pre-marked drain line to provide a clear turn-out and a local trap for sediment. The drain line should include a 3–5 m wide strip of vegetation between the ends of the furrows and the drain itself. On complex terrain, this may not be necessary or indeed practical. This strip can be planted, i.e. on turfs. When ripping or moling on wet soils, the cultivation channels should intersect the drain.

- Align drains up-valley to maintain an even gradient throughout their length (see Figure 7). Drain gradients should not exceed 3.5% (2°) and should be less on easily erodible soils.

- Keep drain ends back from the riparian zone and especially from steep gully sides bordering that zone or the stream. Avoid drains or cultivation channels discharging surface water onto neighbouring pastures or properties.

- Discharge from a drain should, as far as possible, be on flat ground so that the water can fan out rather than be allowed to emerge in a concentrated flow. Do not end drains in natural channels, ephemeral streams or old ditches running directly into a watercourse.

- Consider doubling the recommended width of buffer area on very erodible sites. However, the emphasis should be on minimising soil disturbance through careful choice of cultivation practice, rather than relying on the protective function of buffer areas.

- Install collector drains immediately after cultivation, especially where large volumes of run-off could reach a forest road. Roadside drains will often exceed the permissible gradient for cross-drains and are therefore at risk of serious erosion. Try to avoid any water other than that from the drainage of roads entering roadside drains.

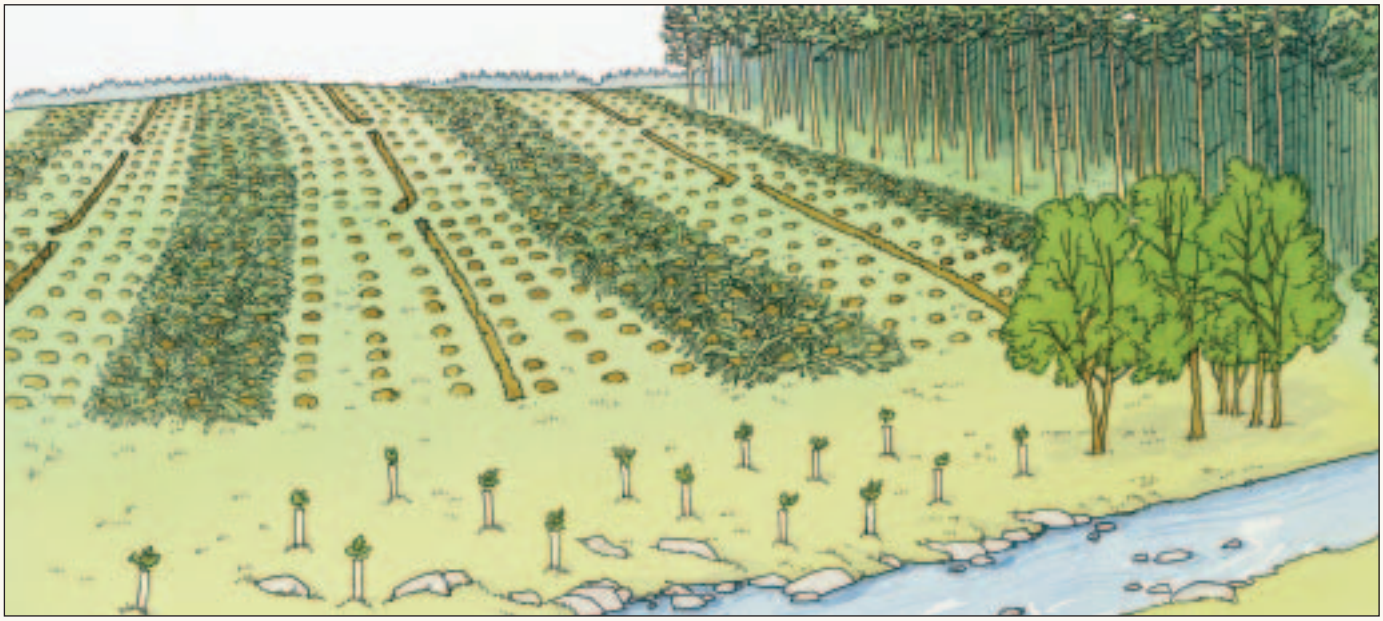


Figure 6 On steep terrain, it is important to ensure that water does not flow from one trench to another by diverting run-off to alternate sides.

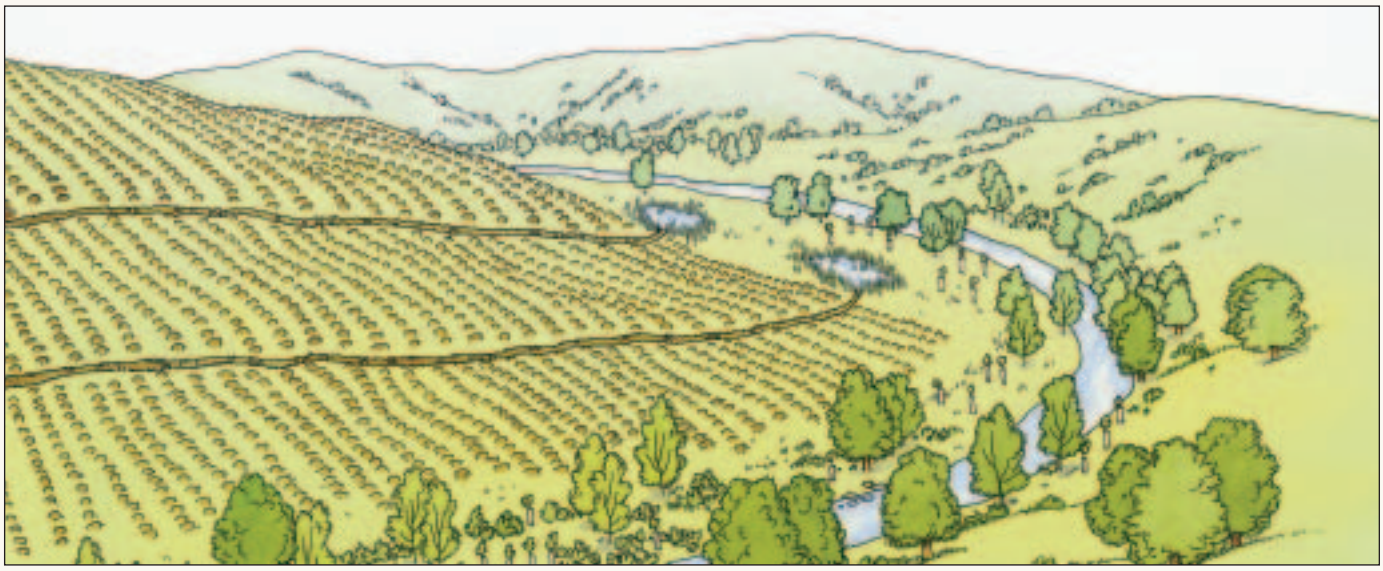


Figure 7 It is necessary to align drains up-valley in order to maintain an even, shallow gradient.

- If the above measures are taken, silt traps will not be necessary except in areas of high erosion risk where they can provide added protection. Where possible, ensure that there is machine access for periodic emptying. If silt traps fill rapidly there are likely to be more fundamental problems and remedial action may be required. Spoil should not be dumped in the buffer area.

- Never divert natural watercourses, however small or ephemeral, into cultivation channels or drains.

- Avoid diverting drains to adjacent catchments to prevent overloading the recipient stream. The risk is greatest in high rainfall areas.

- Organise drain maintenance and silt trap cleaning to avoid the spawning season or the period when salmonid eggs and alevins are living in the gravel. In the uplands, maintenance should only take place from June to September. In lowland rivers, consult the local fishery interest.

- The cleaning of old drains that flow directly into watercourses presents a serious threat. Where this is necessary, it is essential to consult the local water regulatory authority.

- After clearfelling, opportunities exist to correct problems caused by pre-existing deficiencies in the drainage system. For instance, consider blocking or bypassing existing drains that lead directly into watercourses to create an effective buffer area.

A silt trap to capture suspended sediment in water issuing from roadside drains.

Managing riparian vegetation and large woody debris

In general, try to keep about half the length of a watercourse overall open to sunlight (see Section 5). Inspect buffer areas at regular intervals (e.g. every 5 years) to determine the need for beating up, thinning or the control of regeneration by undesirable conifer species. Check for the presence of protected and priority species such as otter, water vole and freshwater pearl mussel (see Appendix 3). Where present, modify plans to protect their habitat and avoid disturbance to the species. Seek advice as necessary from conservation agencies (see Appendix 1). Areas of dense shade in established riparian woodland may require selective thinning or where appropriate, coppicing or pollarding, especially on the south side of streams. This is particularly the case where fisheries are important.

Coppicing is unsuitable where grazing pressure is high due to the threat to regrowth and thus tree survival. Identify individual trees of high value and retain where they pose no threat to personal safety.

There may be a need to control invasive plant species such as giant hogweed and Japanese knotweed, which thrive in the riparian zone and whose dispersal is often assisted by water. Seek advice on acceptable methods of control from the local water regulatory authority.

Large woody debris can play an important role in increasing habitat diversity in headwater catchments. Riparian woodland is the natural source of large woody debris and leaf litter, which provide a valuable food source for aquatic insects and other creatures. These benefits relate primarily to native riparian woodland and bankside trees in particular. Buffer areas should be managed to produce mixed age and species diversity to provide a regular supply of large woody debris to the watercourse, but without restricting access for maintenance where required. On wind-firm harvesting sites lacking broadleaved trees, consider leaving the occasional conifer tree in the riparian zone to provide large woody debris inputs until the new riparian woodland becomes established. Further detailed information on the benefits of riparian woodland and the role of large woody debris is provided by Scottish Native Woods (2000) and Linstead and Gurnell (1999).

Dams of large woody debris generally pose only a limited obstruction to fish movement. Avoid inputs of large amounts of brash during harvesting operations, since it can seal dams, prevent the passage of fish and destabilise channels. Consider removing relic sediment-laden dams formed by brash or dislodged tree stumps where they present a barrier. Some removal of naturally occurring large woody debris may be required where it poses a flood hazard. Where access permits, remove windblown conifer trees which have fallen across watercourses except where an individual tree forms a stable open dam. It is recommended that advice is sought from local water regulatory authority staff on the timing of any removal work and on the general management of woody debris in streams.

Large woody debris dams can increase habitat diversity and water storage, to the benefit of the aquatic environment.

Road construction and maintenance

Forest road work requires meticulous planning and execution if damage to streams is to be avoided. Some forest roads are covered by planning legislation and certain work may require consent from the FC or Forest Service under the Environmental Impact Assessment legislation. Advice on planning and environmental impact requirements for forest road work should be sought from the local FC Conservancy Office or, in Northern Ireland, from Forest Practice Branch in Forest Service Headquarters. Advice should be sought from the relevant water regulatory authority for any work in rivers, especially for construction of bridges and culverts, as a consent may be required. The following measures should be considered during the planning and design of forest roads to prevent damage to streams:

- Build roads outside buffer areas wherever possible.
- Avoid using acidic, metal or sulphide-rich spoil from mine workings for road construction. Acid metal-rich drainage water can be extremely toxic to aquatic organisms.
- Roadside drains should not intercept large volumes of water from the ground above. Any watercourse, however small, that is intercepted by a road should be culverted or bridged at that point. Culverts for road drainage should be of a sufficient size and spacing to avoid overloading, blocking or washout. Roadside drains likely to carry high sediment loads must not be allowed to discharge directly into streams, but must discharge to a buffer area of adequate width (see Section 5). Drains on the upper side of the road may need culverts to the lower side a short distance before stream crossings so as to prevent direct discharge (see Figure 8).
- Where appreciable sediment movement is unavoidable, silt traps should be constructed and provision made for maintaining them. Cleaning should be done in dry weather from June to September, to avoid the salmonid spawning period. Spoil should not be dumped in buffer areas.

Figure 8 Roadside drains should discharge to a buffer area so that any suspended sediment can be filtered out before the water reaches a steam.

- Culverts should be well bedded to avoid settlement and protected above by an adequate cover of road material.

- Erosion should be prevented at both ends of culverts by reinforcing the substrate and side/head walls where necessary.

- Down flumes or other suitable structures should be provided at the outflows of hanging culverts, with rock or concrete aprons as stilling areas.

- Culverts in fish-bearing streams must not be a barrier to fish movement. The aim should be to produce a culvert floor that has the same gradient and level, and carrying similar bed material and flow, as the original stream. A bridge may be necessary if these conditions cannot reasonably be met. All culverts and bridge sills should be designed to ease fish passage, even at low flows. Further details are available in *River crossings and migratory fish: design guidance (2000)* on the Scottish Executive website.

- Avoid erosion of roadside embankments and cuttings by using intercepting trenches or terracing. Try to keep embankments and cuttings at no greater slope than the natural angle of repose to encourage revegetation, otherwise added stabilisation will be needed. Consider artificially revegetating exposed soil if natural re-establishment is slow. Such measures are especially important on highly erodible soils or near culverts. Similar considerations apply to borrow pits.

An incorrectly positioned 'hanging' culvert that presents a barrier to fish movement.

A correctly positioned culvert with a sufficient depth of water to permit fish movement.

- Surface road material should be carefully selected since very fine material can wash off easily or present a dust problem. Avoid using quarry dust as a surface dressing.

- Consider the temporary use of straw bales within roadside drains to filter out suspended sediment during construction and maintenance work. Bales should not block culverts and should be carefully removed when road work is finished to avoid large releases of sediment.

During construction:

- It is of overriding importance where fisheries are significant that any in-stream work must be carried out during periods when there is the least likelihood of damage to fish. June to September is a favourable period for such work if damage to eggs and alevins is to be avoided, but other local factors may have a bearing on the decision. Seek advice from the local fishery interest.

- Consult the water regulatory authority, other riparian owners, tenants and fishery interests before extracting gravel from a watercourse. Consult the nature conservation agency if the river is designated as, and flows through, a Special Area of Conservation, Special Protection Area or Site/Area of Special Scientific Interest. Extraction undertaken little and often is preferable to one major extraction event. Excavate dry shoals, where possible, preferably from the landward sides of bars and channels abandoned by the river. Removing gravel from energetic rivers may cause significant destabilisation and erosion of the bed and banks. On many rivers consent is required; in some rivers gravel extraction is illegal.

Straw bales can be used within a stream to filter out suspended sediment during construction and maintenance work.

- Wherever practicable, avoid road construction near streams in periods of wet weather.

- Keep cement or raw concrete out of watercourses when constructing bridges or crossings. Cement can be lethal to fish and other aquatic life.

During maintenance:

- Keep roadside drains and culverts clear of debris to avoid blockage and wash-out. Avoid unnecessary disturbance of the vegetation along the roadside drain; when cleaning is required, consider leaving undisturbed sections to act as temporary sediment traps.

- Inspect silt traps regularly and clear out as needed.

- Carry out maintenance of drains and silt traps discharging into sensitive watercourses in dry weather from June to September.

- Maintain an adequate cross-camber and minimise the formation of wheel ruts; they will erode, and road surface material will be carried into the drains.

- Maintain a ground cover of vegetation on embankments and cuttings.

- If herbicides are to be used to control vegetation in drains and on roads, observe HSC *Safe use of pesticides for non-agricultural purposes*, MAFF/HSC *Code of practice for the safe use of pesticides on farms and holdings (*Green Code), DARD *Code of good agricultural practice for the prevention of pollution of water* and FC Field Book 8 *The use of herbicides in the forest*. Use of chemicals should be minimised where possible.

- Inspect roads and associated drainage during, or soon after, intense rainstorms.

- Inspect roads, drains and silt traps before and after any intensive use of forest roads – such as harvesting or rallying – and take remedial action quickly.

Harvesting

Good planning and management, including attention to detail, can do much to minimise any adverse effects of harvesting operations on streams. Make sure that felling and extraction teams and supervisors fully understand and observe any special working instructions.

Felling operations can disturb the soil and remove part or all of the intercepting canopy, allowing more precipitation to reach the ground. The extent of exposure and disturbance of the soil are determined by the scale of operation and the equipment used. Small-scale operations are likely to involve smaller mechanical equipment and cause less impact, whereas large-scale operations pose the greatest risks. Thinning may pose a particular risk because of more restricted options for extraction routes and a lack of brash to protect them. Potential dangers to be avoided are significant increases in sediment and ingress of excessive amounts of bark or woody debris; these can smother the stream bed, damage spawning grounds, block streams, and prevent fish movement. Where whole-tree harvesting is to be used, refer to the FC Practice Guide *Whole-tree harvesting: a guide to good practice*. The following measures will help to protect streams:

- Liaise with the local water regulatory authority at the early planning stage when harvesting within critical load exceedance or adjacent squares and with the water undertaker when harvesting in water supply catchments (see Section 5). In both acid sensitive and water supply catchments, consider phased felling and limiting coupe size to minimise negative effects.

- Locate any private or public water supplies and give them the necessary protection.

- Where possible, stack timber on drier sites outside of buffer areas. Do not block roadside drains. Consider the precautionary use of straw bales and/or brash along the downslope side of timber stacking areas in situations where wet weather is likely to create a high risk of sediment-laden run-off entering drains or streams.

- Plan felling and extraction to minimise the number of stream and drain crossings. Where crossing a stream or drain is unavoidable, temporarily install a log bridge, pipe or other form of protective structure. Consider constructing or installing permanent structures where there is a need for repeated trafficking over a number of years. Measures to protect drain and stream crossings are described in FC Work Study Branch Report *Soft ground working – review of methods to minimise site disturbance*. Advice should be sought from the relevant water regulatory authority as a consent may be required. Even small runnels which may be dry before felling may flow again during operations; consider piped crossings for them.

A well-constructed log bridge will help to protect stream crossings from damage.

- Choose the best machine combination for the ground conditions including appropriate traction or flotation aids. Avoid ground skidding on soft soils. Try to avoid long straight ground extraction routes on steep slopes, especially in high rainfall areas. Cable-crane extraction, particularly of shortwood, causes much less soil disturbance than skidding or forwarding. Avoid the formation of worn trails by the repeated dragging of tree tops. Where necessary, dig offlets at intervals to prevent water being channelled down trails.

Polypropylene pipes should be used, even on small runnels, to protect crossing points.

- Tree crops on unstable slopes may be unsuitable for clearfelling due to the risk of initiating slope failure and serious erosion. Consider alternative felling practices such as selection systems.

- Large piles of brash at roadside processing sites are a potential source of organic pollution. Wherever possible, these should be sited on drier ground away from watercourses. If drainage is to a roadside drain, this should discharge to a buffer area and not directly into a stream (subject to other access requirements).

- On soft soils, provide and maintain an adequate supporting brash mat for the principal vehicle routes. Brash may have to be transported from where it is plentiful. Wherever possible, avoid using tracked vehicles for long distances on forest roads and if feasible organise the site so that stacking can be carried out without bringing machinery on to the forest road. Where this is not possible, use brash thatching to prevent damage to the road. Thatching or ramps of stones or logs should be considered for protecting heavily used access points.

- On sites prone to erosion, try to work during spells of good weather.

- Felling in the riparian zone will be an infrequent event once the recommended vegetation has become established; where it is needed, fell trees away from the stream. On wind-firm harvesting sites lacking broadleaved trees, consider leaving the occasional conifer tree in the riparian zone to provide large woody debris inputs until the new riparian woodland becomes established (see Section 5).

Timber extraction by cable-crane can help to minimise soil disturbance on sensitive sites.

A well-organised felling site with a harvester operating on a protective brash mat between timber zones.

- Check for the presence of protected and priority species such as otter, water vole and freshwater pearl mussel (see Appendix 3). Where present, modify felling plans to protect their habitat and avoid disturbance to the species. Seek advice as necessary from conservation agencies.

- Keep streams and buffer areas free from harvested branches and tops as far as practicable.

- Prevent water running down any wheel ruts or extraction tracks by digging offlets at intervals.

- Make sure that haulage roads, drains and culverts are adequate and in good repair before work starts. Never let extraction and haulage machines destroy a road in the hope that it can be repaired cheaply afterwards – erosion can be very serious, and either expensive or impossible to put right. Minimise the formation of wheel ruts; they will erode, and road surface material will be carried into the drains.

- Inspect local watercourses regularly for evidence of discoloration or sediment deposition, particularly at drainage outlets from harvesting sites. Trace any pollution sources and immediately apply remedial action by modifying operating procedures and constructing silt traps if necessary. If there is any erosion risk associated with the operation of machinery on temporary tracks, protect the ground surface with brash or stone aggregate.

- Protect buried water conduits and pipelines against damage by machinery and vehicles.

- Avoid fuel spillages. Carry out machine re-fuelling and maintenance outside buffer areas and away

from bridges and culverts. Waste or recovered oil should be put into impermeable plastic containers and removed from the site for subsequent disposal. Prepare and put in place a contingency plan. Details are given in Section 6, Storage and handling of chemicals, fuel oils and lubricants.

Pesticides

Forest managers should refer to HSC *Safe use of pesticides for non-agricultural purposes*, MAFF/HSC *Code of practice for the safe use of pesticides on farms and holdings* (Green Code), DARD *Code of good agricultural practice for the prevention of pollution of water* and FC Field Book 8 *The use of herbicides in the forest* for detailed guidance.

Before using pesticides anywhere in the catchment where they might get into water, particularly where large-scale applications are involved, it is recommended that there should be prior liaison with the water regulatory authority.

Formal consultation requirements are outlined below:

- Prior to the aerial application of pesticides within 250 m of a watercourse, consultation with the water regulatory authority is legally required under the Control of Pesticide Regulations 1986 and Control of Substances Hazardous to Health Regulations 1988. Consultation should take place at an early planning stage wherever possible, and legally must occur not less than 72 hours before an application begins.

- In certain circumstances, wider consultation and notification are legally required for the aerial application of pesticides. These are listed below in order of the length of prior notice:

  – Scottish Natural Heritage, English Nature, the Countryside Council for Wales, or the EHS in Northern Ireland, as appropriate, must be consulted if any part of the land to which pesticides are to be applied is, or lies within, 1500 m of a Local Nature Reserve, National Nature Reserve, SSSI or Natura site giving at least 72 hours notice.

  – Local bee-keeper groups must be notified at least 48 hours before application.

  – The Chief Environmental Health Officer for the district must be notified 24–48 hours before pesticide application.

  – Occupants or agents of property within 25 m of the treated area must be notified 24–48 hours before application.

  – The person in charge of any school, hospital, or other institution within 150 m of the flight path must be notified 24–48 hours before application.

- In England and Wales, the user also has a responsibility to notify the water undertaker well in advance of any pesticide application to land in close proximity to watercourses or water bodies used for public water supply. Likewise, the user should notify SEPA in Scotland and the Water Service of the Department of Regional Development in Northern Ireland.

- The consent of the water regulatory authority and undertaker is required if an application of herbicide is intended for the control of aquatic weeds or bank-side vegetation. The MAFF *Guidelines for the use of herbicides on weeds in or near watercourses and lakes* requires that only those products approved for use in or near water should be used and only with the prior agreement of the water regulatory authority.

- Authorisation is required from the Environment Agency, SEPA, or the EHS under the Groundwater Regulations for the disposal of waste pesticides to land.

Key action points when applying pesticides are:

- Consult with, and obtain consent if necessary from, the water regulatory authority or water undertaker.

- Prepare a contingency plan to deal with accidental spillage.

- Store chemicals securely outside buffer areas. Guard against accidental spillage.

- Read container labels and follow the instructions meticulously. This is a statutory requirement of the Control of Pesticide Regulations.

- Pesticides must be mixed and applied under the control of a certified person.

- Avoid overspraying drains.
- Do not spray or apply granules within 10 m of permanent watercourses (this does not apply to drains that are separated from watercourses by a buffer area), 20 m of lakes and reservoirs, or 50 m of a borehole or well.
- Spray only when wind conditions are appropriate and with the correct droplet size to minimise drift. The safest conditions to spray are when there is a steady light breeze (Force 2 on the Beaufort Scale, 3.2–6.5 km h^{-1}) blowing away from sensitive areas.
- Do not apply chemicals if heavy rain is expected or if there is a risk of wash-off because the ground is frozen, snow-covered, or baked dry.
- Do not wash out sprayers, containers or similar near any watercourse, however small.
- Do not puncture, bury, or burn empty containers or waste packaging. Ensure they are disposed of by prior arrangement with the local authority or by a licenced waste disposal contractor, in line with Waste Regulations.
- Seek advice from the appropriate water or waste regulatory authority about the safe disposal of unwanted pesticides.
- Never store or soak planting stock that has been treated with an insecticide in a watercourse prior to planting. All synthetic pyrethroids are extremely toxic to fish, aquatic plants and invertebrates.

Fertilisers

Key action points when applying fertilisers are:

- Contact the water regulatory authority and water undertaker when planning aerial fertiliser applications to establish the nutrient sensitivity of lakes, reservoirs or other water bodies and agree plans (see Section 5 for details).
- In catchments of sensitive water bodies, consider applying fertiliser by hand or ground machine, phasing aerial treatments over several years, or using slower release fertilisers.
- Do not apply fertilisers in very wet weather or if heavy rain is forecast. Do not apply if the ground is frozen, snow-covered, or baked dry, when the risk of wash-off is at its greatest.
- Restrict the use of fertilisers in the buffer areas to hand applications and avoid treating the aquatic zone.
- Store fertilisers and locate dump sites outside buffer areas.
- Prepare a contingency plan in case of spillage. Contact the water regulatory authority in the event of a spillage and take immediate action to gather up the spill and prevent the contamination of watercourses.
- In forests within Nitrate Vulnerable Zones it is recommended that, although the legislation *The protection of water against agricultural nitrate pollution regulations* 1996 and 2002 amendments does not cover forests, the restrictions concerning nitrogen fertilisation contained within these regulations should be adhered to.

Modern helicopter guidance systems allow precise targeting of aerial fertiliser treatments.

The possibility of using sewage sludge as a forest fertiliser has received increasing attention in recent years. While sewage sludge can be a relatively cheap and useful form of fertiliser and although there may be environmental advantages resulting from its application to forest soils, its use is restricted to certain types of site due to the risk of nutrient enrichment and heavy metal contamination of surface run-off and groundwater resources. Forest managers should refer to FC Bulletin 107 *A manual of good practice for the use of sewage sludge in forestry* for detailed guidance. New sludge products are continually being developed; seek advice from the water regulatory authority or water undertaker regarding their suitability for application to forests.

Key action points when applying sewage sludge are:

- Contact the water regulatory authority and water undertaker when planning sewage sludge applications.
- Apply sludge only to sites that satisfy the criteria detailed in the manual of good practice. Do not apply when the water table is near the surface or when the soil is saturated. Recent work indicates that immature sandy soils have a very low binding capacity for metals contained within sludge; thus avoid applications to this soil type.
- Do not apply in wet weather or if heavy rain is forecast.
- Do not apply to buffer areas or within 50 m of a well or borehole.
- Prepare a contingency plan in case of spillage. Contact the water regulatory authority in the event of a spillage and take immediate action to gather up the spill and prevent the contamination of watercourses.

Storage and handling of chemicals, fuel oils and lubricants

Chemicals, fuel oils and lubricants can have a serious effect on aquatic life and can taint water supplies; they must be kept out of drains and watercourses. Plan for careful use of these substances with proper attention to storage and refuelling areas. Waste or recovered oil resulting from machinery repair and maintenance should be should be put into impermeable plastic containers and removed from the site for subsequent disposal. Where appropriate, the use of biodegradable oils should be considered.

Care is required during transportation to avoid accidental spillage. Bowsers should be fit for the purpose and weight restrictions must be observed. All containers must be secured and attention given to proper load distribution.

Fuels should be stored in tanks fit for use with secondary containment, which may comprise an external or integral bund, and sited outside buffer areas. Smaller fuel containers such as cans and small drums should also be stored within bunded areas or within separate impermeable containers or bunkers. Tanks should be refuelled using a transfer hose and should be locked when unattended. Steps need to be taken to protect storage areas and machinery from vandalism. Advice on secure storage arrangements can be obtained from the water regulatory authority. In England the Control of Pollution (Oil Storage) (England) Regulations 2001 establish minimum standards for the containment of oil (see Section 1).

Particular care is required whenever fuel or lubricants are poured from cans or drums, for example when refueling chainsaws. A funnel should always be used and consideration given to using external drum top mats or basal pans to absorb minor spillage. Carry out machine refuelling and maintenance outside buffer areas and away from bridges and culverts.

The Environment Agency, SEPA, and EHS provide guidance on protecting the water environment from oil pollution in the form of Pollution Prevention Guidance Notes (PPG02 covers above-ground storage tanks; PPG08 covers storage and disposal of oil; and PPG18 covers spillages and fire-fighting run-off).

Fuel oils should be stored in secure tanks with external or integral bunds. The PVC cover has been removed for refuelling.

A contingency plan should be drawn up to deal with accidental spillages. The plan should include relevant telephone numbers (water regulatory authority, downstream local landowners, water-users, water undertaker, and accredited spill contractor) and record the availability of equipment to carry out remedial work in advance of the arrival of the water regulatory authority or accredited spill contractor. For example, booms, absorbent sheets and/or pillows should be available to contain and absorb spillages preventing them from entering nearby watercourses. Machine operators should carry a small supply of absorbent sheets and/or pillows in their cab, and there should be central stocks of materials and equipment packed and ready for use in emergency trailers (in Northern Ireland these stocks are held by the EHS); for further information read FC Technical Development Branch Report No 7/93.

Absorbent materials can help to soak up spillages and prevent the contamination of watercourses.

Ponds for fire-fighting or wildlife

Fire-fighting plans may require the construction of artificial ponds or water-holes to ensure a ready supply of water. Ponds may also be excaveted for conservation purposes. These should either be constructed separately from streams or by diverting water into an excavated pond to one side of a stream channel (not by damming the stream itself, which is illegal). The stream is thus kept open, the movement of fish is not impeded and the pond does not silt up so quickly. Construction of certain types of dams in streams in England and Wales requires a licence from the Environment Agency; in Scotland written agreement must be obtained from fisheries organisations; and in Northern Ireland consultation with both the Rivers Agency and Inland Fisheries of the Department of Culture, Arts and Leisure is necessary.

Ponds should be constructed separately from streams or by diverting water to an adjacent excavation.

There is a legal requirement not to impede the passage of migratory fish. The construction of ponds and any maintenance work should be carried out in dry weather from June to September to avoid the spawning and incubation periods of salmon and trout. Further guidance can be obtained in SEPA's *Ponds, pools and lochans: guidance on good practice in the management and creation of small waterbodies in Scotland (2000)* and the *Forest nature conservation guidelines (1990)*.

Fire-fighting foams

Try to locate stores and mixing points outside buffer areas, and minimise stream crossings by machinery during fire-fighting operations. Prepare a contingency plan in case of spillage of concentrates or large volumes of pre-mixed solution.

FOREST OPERATIONS WORKING CHECKLIST

All operations

- Consult the water regulatory authority and, where appropriate, the water undertaker, local fishery interests and conservation agencies at the planning stage, to establish the sensitivity of the catchment and any legal requirements, such as consents for bridges and culverts.
- Prepare a site plan and map, detailing site constraints and special working practices.
- Ensure that working instructions are understood and observed.
- Make sure that fuel oils, lubricants and chemicals are handled carefully during transportation and used and stored safely outside the buffer areas. Guard against spillages and use bunded tanks and transfer hoses. Always use a funnel whenever pouring fuel or lubricant from cans or drums and consider using a top mat or basal pan to absorb minor spillages.
- Refuel and maintain machinery outside of buffer areas and away from bridges and culverts.
- Prepare a contingency plan in case of accidental spillage of fuel oils, lubricants or chemicals.
- Ensure that all operators know the contingency plan for dealing with any accidental spillages.
- Ensure that materials to contain and absorb spillages are readily available.

Ground preparation

- Where cultivation is advisable, scarifying or continuous or excavator mounding is recommended on all but the wettest soils. On peaty soils excavator mounding or spaced furrow ploughing is preferred.
- Do not plough deeper than is necessary; a maximum of 30 cm is recommended.
- Restrict moling to slopes less than 8% (4.5°).
- Ensure that individual spoil trenches created on restock or other sites are no longer than 30 m unless connected to the local drainage system and meeting the appropriate standards for gradient and layout.
- Avoid filling deep (>50 cm) spoil trenches with fresh brash when working within critical loads exceedance and adjacent squares.
- Stop plough furrows and drain ends short of buffer areas.
- Do not end drains in natural channels, ephemeral streams or old ditches.
- Avoid drains or cultivation channels discharging surface water onto neighbouring pastures or properties.
- Consider doubling the recommended width of buffer area on very erodible sites.
- Where possible, avoid trafficking within buffer areas.
- Machinery should not work in or ford streams, except where purpose-built fords already exist.
- Provide cross-drains at a spacing that will control run-off from cultivation channels.
- Align drains so that the gradient does not exceed 3.5% (2°).
- Align drains up-valley to maintain an even gradient.
- Leave 3–5 m wide drain-side buffer areas at the ends of plough furrows on slopes over 9% (5°).
- Prepare silt traps or pools where there is a high risk of erosion. Ensure machine access for periodic emptying and do not dump spoil within buffer areas.
- Confine drains maintenance in the uplands to June–September to avoid fish spawning periods or alevins living in the gravel.
- Do not divert natural watercourses into drains.
- Inspect local watercourses regularly for discoloration or other evidence of sediment inputs, particularly at drainage outlets. Trace any sources and apply immediate remedial action.

Riparian management

- Check for the presence of protected or priority species before work commences (see Appendix 3). Where local knowledge is lacking, seek advice from the conservation agencies.
- Maintain about half the length of a stream overall open to sunlight, with the rest under dappled shade from appropriate trees and shrubs.
- On wind firm harvesting sites lacking broadleaved trees, consider leaving the occasional conifer tree in the riparian zone to provide large woody debris.
- Leave large woody debris dams in place unless they become infilled with sediment and brash, forming a barrier to fish.

Road construction and maintenance

- Build roads outside buffer areas wherever possible.
- Avoid construction near streams in wet weather.
- Avoid using acidic, metal or sulphide-rich spoil from mine workings for road construction.
- Avoid using quarry dust as a surface dressing.
- Plan so that roadside drains do not intercept large volumes of water from ground above.
- Plan so that roadside drains do not discharge directly into watercourses, but rather through a buffer area of adequate width.
- Make culverts big enough and install anti-erosion measures.
- Install culverts that will not obstruct the passage of fish even at low flows.
- Do any essential in-stream work when damage to fisheries is least likely, i.e. in the period of June to September.
- Consult the water regulatory authority and other interests before extracting gravel from a watercourse.
- Keep cement and raw concrete out of watercourses.
- Keep drains and culverts clear of debris and maintain silt traps. Do not dump spoil within buffer areas.
- Carry out drains maintenance only in dry weather in the period of June to September and consider leaving undisturbed sections or using straw bales to act as temporary sediment traps.
- Ensure that road cambers are adequate and rutting is kept to a minimum.
- Avoid erosion of embankments and, where possible, maintain a vegetation cover.
- Inspect roads, drains and silt traps for damage after intense storms and also before and after any intensive use such as timber extraction or rallying.

Harvesting

- Liaise with the water regulatory authority and other relevant interests at the planning stage.
- Locate private and public water supplies and give them the necessary protection.
- Consider phased felling or reducing the scale of operations in acid sensitive and water supply catchments.
- Choose the best machine combination for the ground conditions. Avoid ground-skidding on soft soils.
- Avoid the formation of worn trails in cable-crane extraction by the repeated dragging of tree tops.
- Check for the presence of protected or priority species before work commences in the riparian zone.
- On wind firm harvesting sites lacking broadleaved trees, consider leaving the occasional conifer tree in the riparian zone to provide large woody debris.
- Fell and extract in sensitive areas during dry weather.
- Avoid using tracked machines for long distances on forest roads.

- Protect heavily used access points with brash, logs or stone.
- Protect underground culverts and pipelines.
- Choose drier sites for stacking timber outside buffer areas; do not block roadside drains. Consider bunding the area with straw bales or brash if wet weather gives rise to a risk of sediment run-off.
- Where possible, site large brash heaps on drier ground, outside buffer areas.
- Plan extraction to minimise stream crossings.
- Use pipes or a log bridge where extraction routes must cross watercourses.
- Avoid long ground extraction routes on steep ground, especially in high rainfall areas.
- Do not allow surface run-off to occur along extraction tracks. Use offlets to divert water where necessary.
- Use brash mats whenever necessary to protect the soil.
- Do not let machines work in streams.
- Fell trees away from streams.
- Keep branches and tops out of streams and buffer areas.
- Inspect local watercourses regularly for discoloration or other evidence of sediment inputs, particularly at drainage outlets. Trace any sources and apply immediate remedial action.

Pesticide, fertiliser and sewage sludge application

- Contact the water regulatory authority and other appropriate organisations before work starts and obtain consent if necessary.
- Consider applying fertiliser by hand or ground machine, phasing aerial treatments over several years, and using slower release fertiliser in catchments with sensitive water bodies.
- Apply sewage sludge only to sites that satisfy the criteria detailed in the manual of good practice.
- Observe HSC *Safe use of pesticides for non-agricultural purposes*, MAFF/HSC *Code of practice for the safe use of pesticides on farms and holdings* (Green Code), DARD *Code of good agricultural practice for the prevention of pollution of water* and FC Field Book 8 *The use of herbicides in the forest* when controlling vegetation in drains with herbicides.
- Store chemicals securely, outside buffer areas.
- Read container labels and follow the instructions meticulously.
- For use in or near water, use only those pesticides and adjuvants that have specific approval as stated on the label, for these locations.
- Pesticides must be mixed and applied under the control of a certified person.
- Use correct spray dosage rates.
- Pay attention to short-term weather forecasts and do not apply when wind conditions are inappropriate or heavy rainfall is expected. Do not apply if the ground is frozen, snow-covered or baked dry.
- Do not spray or apply over watercourses.
- Do not spray or apply pesticide granules within 10 m of streams, 20 m of lakes and reservoirs or 50 m of a borehole or well.
- Do not apply sewage sludge to buffer areas or within 50 m of a borehole or well.
- Do not wash out equipment near any watercourses, however small.
- Do not puncture, bury or burn empty containers or waste packaging.
- Seek advice from the water regulatory authority on the safe disposal of empty containers and unwanted pesticides.
- Obtain authorisation from the water or waste regulatory authority for the disposal of waste pesticides to land.
- Do not soak insecticide-treated plants in drains or streams.

USEFUL SOURCES OF INFORMATION

Forestry Commission publications

The UK Forestry Standard (1998)

Guidelines

Forest nature conservation (1990)
Forest recreation (1992)
Lowland landscape design (1992)
Community woodland design (1992)
Forest landscape design (2nd edition) (1994)
Forests and archaeology (1995)
Forests and soil conservation (1998)

Guideline Notes

1. Forests and peatland habitats (2000)

Practice Guides

The management of semi-natural woodlands:
1. Lowland acid beech and oak woods (1994)
2. Lowland beech–ash woods (1994)
3. Lowland mixed broadleaved woods (1994)
4. Mixed ashwoods (1994)
5. Upland oakwoods (1994)
6. Upland birchwoods (1994)
7. Native pinewoods (1994)
8. Wet woodlands (1994)

Whole-tree harvesting: a guide to good practice (1997)
Forest design planning: a guide to good practice (1998)
Restoration of native woodland on ancient woodland sites (2003)

Practice Notes

8. Using local stock for planting native trees and shrubs (1999)

Handbooks

6. Forestry Practice (1991)
8. Establishing Farm Woodlands (1991)

Field Books

8. The use of herbicides in the forest (1995)
14. Herbicides for farm woodlands and short rotation coppice (1996)

Bulletins

86. Forests and surface water acidification (1990)
95. Forest fertilisation in Britain (1991)
107. A manual of good practice for the use of sewage sludge in forestry (1992)
112. Creating new native woodlands (1994)
119. Cultivation of soils for forestry (1999)

Work Study Reports

35/91 Soft ground working – review of methods to minimise site disturbance (1991)
7/93 Oil and chemical spillages (1993)
10/93 Storage and transport of urea for stump treatment (1993)
14/93 Storage and handling of diesel fuel oil in forest and woodland environments (1993)

Northern Ireland specific publications

Environmental guidelines for timber harvesting (2001)
Code of good agricultural practice for the prevention of pollution of water (2003)
Code of good agricultural practice for the prevention of pollution of air and soil (2003)

Other publications

Department of the Environment and Forestry Commission (1991).
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DOE, Belfast and Forestry Commission, Edinburgh.

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The safe use of pesticides for non-agricultural purposes, approved code of practice, control of substances hazardous to health regulations.
HSE Books, Suffolk.

Ministry of Agriculture, Fisheries and Food (1995).
Guidelines for the use of herbicides on weeds in or near watercourses and lakes.
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Pesticides: Code of practice for the safe use of pesticides on farms and holdings.
MAFF, London.

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Environment Agency Research and Development Technical Report P211. Environment Agency, Bristol.

UK National Focal Centre for Critical Loads Mapping (1998).
Status of UK critical loads and exceedances.
Centre for Ecology and Hydrology, Monks Wood, Huntingdon.

Linstead, C. and Gurnell A.M. (1999).
Large woody debris in British headwater rivers: physical habitat role and management guide.
Environment Agency Research and Development Technical Report W185. Environment Agency, Bristol.

Scottish Environmental Protection Agency (2000).
Ponds, pools and lochans: guidance on good practice in the management and creation of small waterbodies in Scotland.
Scottish Environmental Protection Agency, Stirling.

Scottish Native Woods (2000).
Restoring and managing riparian woodlands.
Scottish Native Woods, Aberfeldy.

Scottish Executive (2000).
River crossings and migratory fish: design guidance.
Scottish Executive, Edinburgh.

Environmental Change Research Centre (2001).
Acidification of freshwaters: the role of nitrogen and the prospects for recovery.
Environmental Change Research Centre Report No 79, University College London, London.

National Expert Group on Transboundary Air Pollution (2001).
Transboundary air pollution; acidification; eutrophication and ground-level ozone in the UK.
Centre of Ecology and Hydrology.

Broadmeadow, S. and Nisbet, T.R. (2002).
The Effect of Riparian Forest Management on the Freshwater Environment.
SNIFFER Report SR(02)06F. Foundation for Water Research, Marlow, Bucks.

Sime, I. (2003).
River runners. Freshwater pearl mussel, Atlantic salmon and lampreys.
Scottish Natural Heritage, Battleby.

GLOSSARY

Acid
An acid is a compound capable of transferring a hydrogen ion in solution.

Acidification
A continuing loss of acid neutralising capacity manifested by increasing hydrogen ion concentrations and/or declining alkalinity. May be applied to a catchment or to waters.

Alkalinity (acid-neutralising capacity)
and
Acidity (base-neutralising capacity)
A sample of pure water brought to equilibrium with air containing carbon dioxide at its normal partial pressure has a pH of around 5.6. Waters having a pH greater than this are said to possess alkalinity or acid-neutralising capacity, mainly in the form of bicarbonate and carbonate ions which react with added acid (hydrogen ions). Waters having a pH value less than 5.6 are said to possess acidity or base-neutralising capacity.

Note that 'acid-neutralising capacity' is synonymous with 'alkalinity'. However, the former expression can be used in a more general sense to refer to the ability of a catchment (not just a water body) to neutralise acid inputs.

Alevins
Newly hatched fish with a yolk sack, which live in the 'redds' or spawning gravel.

Aluminium (labile)
Aluminium is present in water in many different forms or species, the total concentration of which constitutes the variable most often measured. Labile aluminium is an operationally defined, fast-reacting fraction of that total, believed to provide a better measure of aluminium toxicity.

Rapid passage of water samples through a cation-exchange resin column is often used to provide the operational separation of labile and non-labile fractions, the fast-reaction (i.e. labile) species being removed by the resin. Because the separation is empirical, the results obtained are likely to be sensitive even to apparently minor differences in the measurement procedures used.

Aquifer
A geological formation, group of formations or part of a formation that can store and transmit water in significant quantities.

Base (alkali)
A base used to be regarded solely as a chemical species capable of accepting a proton from another substance, and this definition is applicable throughout this report. However, strictly speaking, a base is now defined more generally as a chemical entity capable of donating a pair of electrons (see Acid, above).

Base cations
The cations of strong bases: calcium, magnesium, potassium and sodium.

Base flow
Sustained run-off consisting largely of groundwater.

Borrow pit
A temporary excavation used to obtain soil for a construction project and normally backfilled.

Brash
The residue of branches and tops, sometimes called 'lop and top', left on site following harvesting.

Brash mat
A mat of brash placed in rows on which harvesting and timber extraction vehicles run to reduce soil damage.

Brash thatching
The use of brash to bind together the road surface in the area receiving heavy use by forwarders stacking timber at the roadside.

Buffer area
An area which protects the watercourse from pollutants and sediment off the adjacent land. The buffer area will usually include the riparian zone and may extend into the adjacent land.

Buffer capacity (buffer intensity; buffer index)
Measure of the resistance of a solution to pH change.

Bulk precipitation
The total input of wet and dry deposition measured by a horizontal gauge.

Bunded tanks
Tanks for fuel oils, lubricants or other chemicals that are protected by secondary containment such as an impermeable external or integral bund.

Cable-way crane extraction
A timber extraction method which uses a steel wire system to extract whole trees, logs or shortwood by means of moving cables, powered by a stationary winch. The produce is carried wholly or partially clear of the ground.

Coarse fish
Any freshwater fish other than salmon, trout (including rainbow trout and charr) or eels.

Continuous-acting mounders
Tractor-mounted or trailed machines which produce mounds by digging or scraping the soil surface as the machine moves over the site.

Controlled water
All streams, rivers, lakes, groundwaters, estuaries and coastal waters to three nautical miles from the shore.

Coupe
An area of woodland. A felling coupe is an area of woodland designated for felling.

Critical loads
A quantitative estimate of an exposure to one or more pollutants below which significant harmful effects on specified sensitive elements of the environment do not occur according to present knowledge.

Critical load exceedance
Critical load exceedance is where the estimated exposure to a pollutant exceeds the critical load.

Cross-drains/cut-off drains
Open ditches aligned slightly off the contour with a bed gradient not exceeding 2°. Their primary function is to control the volume of water moving down cultivation channels to prevent significant erosion. Drains can affect the water table on some wet peaty soils.

Cultivation channels
Any linear cultivation feature including plough furrows, mole drains and scarifier trenches.

Down flume
A permanent paved channel constructed below a culvert to conduct storm water run-off safely down slope.

Dry deposition
Pollutants reaching the ground in particulate form or as aerosols or gases, i.e. excluding the indirect input in aqueous solution or suspension (wet deposition).

Ephemeral stream
A watercourse that may not have surface flow throughout the year due to drought or abstraction.

Episode
An intensive, short-term surge of stream water or atmospheric pollution characterised by rapidly changing chemical composition. Episodes are usually associated with heavy rainfall or rapid snow melt.

Eutrophication
See Nutrient enrichment.

Excavator mounding
The technique provides small 30–50 cm high mounds on which to plant trees using soil excavated from an adjacent area of soil or trench. The trench spacing is controlled by the maximum reach of the machine.

Forwarders
Tractors which extract timber lifted entirely clear of the ground. The timber is carried on a linked trailer or integral platform.

Glide
A reach of river where the flow is slow and laminar.

Good ecological status
The target is defined in the Water Framework Directive as 'the values of the biological quality elements for the surface water body type show low levels of distortion resulting from human activity, but deviate only slightly from those normally associated with the surface water body type under undisturbed conditions'. Biological elements include phytoplankton, macrophytes and phytobenthos, macroinvertebrates, and fish.

Groundwater
Water stored in the soil and rock both above and below the water table.

Headwater source areas
Wet flushes, bogs or springs at the head of first-order streams.

Horizon
A layer of soil which differs in colour, texture and composition from other layers lying above or below.

Listed substance
Substances classed as either List I or List II under the EC Groundwater Directive. List I substances should be prevented from being discharged into groundwater while discharge of List II substances should be minimised.

Main River
On 'Main Rivers' in England and Wales, the Environment Agency has permissive powers for flood defence purposes to construct and maintain defences and to control the actions of others through Byelaws and the issuing of consents.

Metalliferous
Road construction material containing metals which may leach out in solution and which may lead to the pollution of watercourses. Some materials to avoid are mining spoil, opencast spoil, and oil shale.

Mineralization
Production of inorganic ions in the soil by the oxidation of organic compounds.

Moling
A cultivation method similar to ripping but with an additional device to open a conduit within the soil along which water may flow to cross-drains.

Nitrate leakage
Quantities of nitrate can leak into watercourses when the rate of supply of nitrate exceeds its utilisation.

Nitrification
Oxidation of ammonia, urea or other inorganic nitrogen compounds to nitrites and of nitrites to nitrates, as by action of bacteria.

Nutrient enrichment (Eutrophication)
A process that increases the nutrient concentration of water adversely affecting the diversity of the biological system, the quality of the water, and the uses to which the water may be put.

Occult deposition
The turbulent transfer of cloud, mist or fog droplets, which can contain large concentrations of pollutants, to vegetation.

Overland flow (return flow)
Water passing rapidly over or through the surface layer of soil.

Peat
A largely organic substrate formed of partially decomposed plant material. The FC defines peats as soils having an organic layer deeper than 45 cm.

Peaty gley
A wet, imperfectly draining soil type in which a peat layer less than 45 cm thick overlies a mineral soil which is periodically waterlogged.

pH
A logarithmic index for the hydrogen ion concentration of an aqueous solution. Used as a measure of acidity of a solution. Given by $pH = -\log_{10}[H^+]$ where $[H^+]$ is taken as the hydrogen ion concentration. A pH below 7 is considered to be acidic and one above 7 alkaline. pH measurements give no indication of how the hydrogen ion concentration of a water came about, or how it will change with the addition or removal of other substances.

Piped crossing
A length of corrugated plastic pipe placed in a watercourse as a temporary culvert to enable vehicles to cross during forest operations. The piped crossing often carries a brash mat.

Pipeflow
Water moving rapidly through the soil in natural cracks and channels.

Podzol
A soil type in which there is a surface layer of acid humus underlain by a severely leached mineral layer; typically found under coniferous forest and heathland.

Pollution climate
A phrase used to describe the mixtures of pollutants in the atmosphere that occur on a regional scale.

Precipitation
Rain, snow, hail or sleet. Occult precipitation (or deposition, see above) is the input of water from cloud, fog or mist.

Riffle
A habitat feature characterised by shallow, fast flowing water with a distinctly disturbed surface over unconsolidated gravel/pebble or cobble substrate.

Ripping
A cultivation method in which a tine pulled behind a tractor disturbs the soil.

Runnel
Minor channel depression conducting surface water after heavy rain.

Run-off
The gravity flow of water in open channels.

Salmonids
Fish belonging to the family Salmonidae, including salmon, brown trout, sea trout, grayling and charr.

Scarifiers
A tractor-mounted or trailed cultivation machine which scrapes away a shallow layer of harvesting debris, ground vegetation or soil to provide a clear weed-free planting site.

Skidding
The extraction of timber using a tractor to lift one end of the log or the base of the tree clear of the ground with the other end dragging on the ground.

Soil acidification
This may be defined in two ways: a process causing a decrease in soil solution pH or a process which reduces the acid-neutralising capacity of the soil. The former definition is the one adopted in these Guidelines.

Spaced furrow ploughing
A tractor-mounted or trailed plough used to create warm, weed-free, aerated planting sites on the plough ridge. Ridges are formed in ribbons spaced at distances suitable for the growth of trees.

Spoil
The soil material resulting from the excavation of open drains or trenches, or material excavated from silt traps.

Stemflow
Water that reaches the ground by flowing down the surfaces of stems.

Stream
Any river, or other inland watercourse, whether natural or artificial, above or below ground. In these Guidelines this term includes the channel or bed of a stream that is periodically dry.

Throughfall
Water that drips from plant surfaces (crown drip) or falls uninterrupted through gaps in the canopy (direct penetration also known as free throughfall).

Throughflow
Water passing relatively slowly through the subsurface layers of soil.

Water regulatory authority
In Scotland, the Scottish Environment Protection Agency (SEPA); in England and Wales, the Environment Agency; and in Northern Ireland, the Environment and Heritage Service (EHS) and the Rivers Agency. Contact details are given in Appendix 1.

Water undertaker
In Scotland, Scottish Water; in England and Wales, the water utility companies; and in Northern Ireland, the Department for Regional Development's Water Service. Contact details are given in Appendix 1.

Watercourse
Any natural or man-made channel through which water flows continuously or intermittently.

Wet deposition
Pollutants reaching the ground in rain, hail, snow or sleet.

APPENDIX 1: SOURCES OF ADVICE

In England and Wales forest managers should obtain advice on matters relating to the water catchments in their areas from the appropriate regional office of the Environment Agency, and also from the regional water utility or distribution company in the case of water supply catchments. In Scotland such advice can be obtained from SEPA, Scottish Water, Scottish Power, and Scottish Hydro-Electric. In Northern Ireland, advice may be obtained from the Environment and Heritage Service, the Rivers Agency and the Water Service. Appendix 2 gives an outline of the roles of these bodies. The local conservancy office is the contact point for advice from the FC.

Forest managers are strongly advised to contact the local office of their water regulatory authority and/or water undertaking to obtain the emergency telephone numbers applicable to their area of operations, and then to ensure that site supervisors know these numbers.

Water regulatory authories

Scotland

Scottish Environment Protection Agency (SEPA)

www.sepa.org.uk

Pollution hotline 0800 80 70 60
(open 24 hours a day, 7 days a week)

SEPA Corporate Office
Erskine Court
The Castle Business Park
Stirling
FK9 3TR
Tel: 01786 457700
Fax: 01786 446885

Dingwall Office
Graesser House
Fodderty Way
Dingwall Business Park
Dingwall
IV15 9XB
Tel: 01349 862021
Fax: 01349 863987

Aberdeen Office
Greyhope House
Greyhope Road
Torry
Aberdeen
AB11 9RD
Tel: 01224 248338
Fax: 01224 248591

Elgin Office
28 Perimeter Road
Pinefield
Elgin
IV30 6AF
Tel: 01343 547663
Fax: 01343 540884

SEPA Offices – continued

Fort William Office
Carr's Corner
Industrial Estate
Lochybridge
Fort William
PH33 6TL
Tel: 01397 704426
Fax: 01397 705404

Fraserburgh Office
Shaw House
Mid Street
Fraserburgh
AB43 9JN
Tel: 01346 510502
Fax: 01346 515444

Orkney Office
Norlantic House
Scotts Road
Hatston
Kirkwall
Orkney
KW15 1RE
Tel: 01856 871080
Fax: 01856 871090

Shetland Office
The Esplanade
Lerwick
Shetland
ZE1 0LL
Tel: 01595 696926
Fax: 01595 696946

Thurso Office
Thurso Business Park
Thurso
Caithness
KW14 7XW
Tel: 01847 894422
Fax: 01847 893365

Western Isles Office
2 James Square
James Street
Stornoway
Isle of Lewis
HS1 2QN
Tel: 01851 706477
Fax: 01851 703510

Edinburgh Office
Clearwater House
Heriot Watt Research Park
Avenue North
Riccarton
Edinburgh
EH14 4AP
Tel: 0131 449 7296
Fax: 0131 449 7277

Arbroath Office
62 High Street
Arbroath
DD11 1AW
Tel: 01241 874370
Fax: 01241 430695

Galashiels Office
Burnbrae
Mossilee Road
Galashiels
TD1 1NF
Tel: 01896 754797
Fax: 01896 754412

Glenrothes Office
Pentland Court
The Saltire Centre
Glenrothes
Fife
KY6 2DA
Tel: 01592 776910
Fax: 01592 775923

Perth Office
7 Whitefriars Crescent
Perth
PH2 0PA
Tel: 01738 627989
Fax: 01738 630997

Stirling Office
Bremner House
The Castle Business Park
Stirling
FK9 4TF
Tel: 01786 452595
Fax: 01786 461425

East Kilbride Office
5 Redwood Crescent
Peel Park
East Kilbride
G74 5PP
Tel: 01355 574200
Fax: 01355 574688

Ayr Office
31 Miller Road
Ayr
KA7 2AX
Tel: 01292 294000
Fax: 01292 611130

Dumfries Office
Rivers House
Irongray Road
Dumfries
DG2 0JE
Tel: 01387 720502
Fax: 01387 721154

Lochgilphead Office
2 Smithy Lane
Lochgilphead
PA31 8TA
Tel: 01546 602876
Fax: 01546 602337

Newton Stewart Office
Penkiln Bridge Court
Minnigaff
Newton Stewart
DG8 6AA
Tel: 01671 402618
Fax: 01671 404121

Glasgow Office
Law House
Todd Campus
West of Scotland
Science Park
Maryhill Road
Glasgow
G20 0XA
Tel: 0141 945 6350
Fax: 0141 948 0006

England

The Environment Agency

www.environment-agency.gov.uk

Emergency Hotline 0800 80 70 60
(24 hours a day, 7 days a week)

Pollution Prevention Guidelines and leaflets can be obtained from the website or by calling Customer Service Centres on 0845 933 3111

Head Office
Rio House
Waterside Drive
Aztec West
Almondsbury
Bristol
BS32 4UD
Tel: 01454 624400
Fax: 01454 624409

Anglian Region

Northern Area Office
Waterside House
Waterside North
Lincoln
LN2 5HA
Tel: 01522 513 100
Fax: 01522 512 927

Eastern Area Office
Cobham Road Lane
Ipswich
Suffolk
IP3 9JE
Tel: 01473 727712.
Fax: 01473 724205.

Central Area Office
Bromholme Lane
Brampton
Huntingdon
Cambridgeshire
PE28 4NE
Tel: 01480 414581
Fax: 01480 413381

Midlands Region

Upper Severn Area Office
Hafren House
Welshpool Road
Shelton
Shrewsbury
SY3 8BB
Tel: 01743 272828
Fax: 01743 272138

Lower Severn Area Office
Riversmeet House
Newton Industrial Estate
Northway Lane
Tewkesbury
GL20 8JG
Tel: 01684 850951

Upper Trent Area Office
Sentinel House
9 Wellington Crescent
Fradley Park
Lichfield
Staffs
WS13 8RR
Tel: 01543 444141
Fax: 01543 444161

Lower Trent Area Office
Trentside Offices
Scarrington Road
West Bridgford
Nottingham
NG2 5FA
Tel: 0115 945 5722
Fax: 0115 981 7743

North East Region

Northumbria
Tyneside House
Skinnerburn Road
Newcastle Business Park
Newcastle upon Tyne
NE4 7AR
Tel: 0191 203 4000
Fax: 0191 203 4004

Ridings
Phoenix House
Millshaw
Beeston Ring Road
Leeds
LS11 8PG
Tel: 0113 213 4600
Fax: 0113 213 4609

Dales
Coverdale House
Aviator Court
Amy Johnson Way
Clifton Moor
York
YO3 4UZ
Tel: 01904 692296
Fax: 01904 693748

North West Region

Central Area Office
Lutra House
Dodd Way
Off Seedlee Road
Walton Summit
Bamber Bridge
Preston
PR5 8BX
Tel: 01772 339882
Fax: 01772 627730

North Area Office
Ghyll Mount
Gillan Way
Penrith 40 Business Park
Penrith
Cumbria
CA11 9BP
Tel: 01768 866666
Fax: 01768 865606

South Area Office
Appleton House
430 Birchwood Boulevard
Birchwood
Warrington
WA3 7WD
Tel: 01925 840000
Fax: 01925 852260

Southern Region

Hampshire and
Isle of White Office
Colvedene Court
Wessex Business Park
Wessex Way
Colden Common
Winchester
Hampshire
SO21 1WP
Tel: 01962 713267
Fax: 01962 841573

Sussex Area Office
Saxon House
Little High Street
Worthing
West Sussex
BN11 1DH
Tel: 01903 215835
Fax: 01903 215884

Kent Area Office
Orchard House
Endeavour Park
London Road
Addington
West Malling
Kent
ME19 5SH
Tel: 01732 875587
Fax: 01732 875057

South West Region

Cornwall Area Office
St John Moore House
Victoria Square
Bodmin
Cornwall
PL31 1EB
Tel: 01208 78301
Fax: 01208 78321

South Wessex Area Office
Rivers House
Sunrise Business Park
Higher Shaftbury Road
Blandford Forum
DT11 8ST
Tel: 01258 456080
Fax: 01258 455998

North Wessex Area Office
Rivers House
East Quay
Bridgwater
Somerset
TA6 4YS
Tel: 01278 457333
Fax: 01278 452985

Devon
Exminster House
Miller Way
Exeter
Devon
EX6 8AS
Tel: 01392 444000
Fax: 01392 316016

Thames Region

North East Area Office
Apollo Court
2 Bishop Square
Business Park
St Albans Road West
Hatfield
Herts
AL10 9EX
Tel: 01707 632300
Fax: 01707 632500

South East Area Office
Frimley Business Park
Camberley
Surrey
GU16 5SQ
Tel: 01276 454300
Fax: 01276 454301

West Area Office
Isis House
Howbery Park
Crowmarsh Gifford
Wallingford
Oxfordshire
OX10 8BD
Tel: 01491 832801
Fax: 01491 834703

Wales

Environment Agency

www.environment-agency.wales.gov.uk

Emergency Hotline 0800 80 70 60
(24 hours a day, 7 days a week)

Pollution Prevention Guidelines and leaflets can be obtained from the website or by calling Customer Service Centres on 0845 933 3111

Head Office
Cambria House
29 Newport Road
Cardiff
CF24 0TP
Tel: 029 2077 0088
Fax: 029 2079 8555

South West Area Office
Glan Tawe
154 St. Helens Road
Swansea
SA1 4DF
Tel: 01792 645300
Fax: 01792 648652

South East Area Office
Rivers House Business Park
Fortran Road
St. Mellons
Cardiff
CF3 0EY
Tel: 029 2077 0088
Fax: 029 2036 2487

Northern Area Office
Ffordd Penlan
Parc Menai
Bangor
Gwynedd
LL57 4DE
Tel: 01248 670770
Fax: 01248 670561

Northern Ireland

The Rivers Agency

www.dardni.gov.uk

Pollution Hotline 0800 80 70 60
(24 hours a day, 7 days a week)

Headquarters
Hydebank
4 Hospital Road
Belfast
BT8 8JP
Tel: 028 9025 3355
Fax: 028 9025 3455

Eastern Region
Ravarnet House
Altona Road
Lisburn
BT27 5QB
Tel: 028 9260 6100

Fax: 028 9260 6111
Western Region
Woodside Avenue
Gortin Road
Omagh
BT79 7BS
Tel: 028 8225 4900
Fax: 028 8225 4901

Environment and Heritage Service (EHS)

www.ehsni.gov.uk

Water Management Unit
Calvert House
23 Castle Place
Belfast
BT1 1FY
Tel: 028 90 254754
Fax: 028 90 254865

Water undertakers

Scotland

Scottish Water

www.scottishwater.co.uk

Emergency Line 0845 600 8855
(24 hours a day, 7 days a week)
Customer Service Helpline 0845 601 8855

Headquarters
Castle House
6 Castle Drive
Carnegie Campus
Dunfermline
KY11 8GG
Tel: 01383 848200
Fax: 01383 622090

Edinburgh Office
55 Buckstone Terrace
Edinburgh
EH10 6XH
Tel: 0845 601 8855
Fax: 0131 445 5040

Dundee Office
Riverside Business Park
Dundee
DD1 9WL
Tel: 0845 601 8855
Fax: 0138 266 5515

Glasgow Office
419 Balmore Road
Glasgow
G22 6NU
Tel: 0845 601 8855
Fax: 0141 355 5146

England and Wales

Water Utility Companies

AWG
Anglian House
Ambury Road
Huntingdon
Cambs
PE29 3NZ
Tel: 01480 323000
www.anglianwater.co.uk

Northumbrian Water Ltd
Abbey Road
Pity Me
Durham
DH1 5FJ
Tel: 0191 383 2222
www.nwl.co.uk

United Utilities PLC
Dawson House
Liverpool Road
Great Sankey
Warrington
WA5 3LW
Tel: 01925 234000
www.unitedutilities.com

Severn-Trent Water Ltd
2297 Coventry Road
Sheldon
Birmingham
B26 3PU
Tel: 0121 722 4000
www.severn-trent.com

Southern Water Ltd
Southern House
Yeoman Road
Worthing
BN13 3NX
Tel: 01903 264444
www.southernwater.co.uk

South West Water
Peninsula House
Rydon Lane
Exeter
EX2 7HR
Tel: 01392 446688
www.pennon-group.co.uk

Thames Water Utilities Ltd
Reading Bridge House
Reading Bridge
Reading
RG1 8PR
Tel: 01189 640276
www.thameswater.co.uk

Welsh Water PLC
Dwr Cymru Cyfyngedig
Pentwyn Road
Nelson, Treharris
Mid Glamorgan
CF46 6LY
Tel: 01443 451888
www.hyder.com

Wessex Water Operations Centre
Claverton Down Road
Claverton Down
Bath
BA2 7WW
Tel: 01225 526000
www.wessexwater.co.uk

Yorkshire Water Services Ltd
Western House
Western Way
Halifax Road
Bradford
BD6 2LZ
Tel: 01274 691111
www.yorkshirewater.com

Northern Ireland

Department for Regional Development Water Service

www.waterni.gov.uk

Head Office
Northland House
3 Frederick Street
Belfast
BT1 2NR
Tel: 08457 440088

Hydro-electric generators

Scotland

Scottish and Southern Energy
Hydro Generating HQ
Clunie Power Station
Pitlochry
PH16 5NF
Tel: 01796 484034
www.hydro.co.uk

Scottish Power plc
Cathcart Business House
Spean Street
Glasgow
G44 4BE
Tel: 0141 568 2000
www.scottishpower.plc.uk

England and Wales

Innogy plc
Head Office
Windmill Hill Business Park
Whitehill Way
Swindon
SN5 6PB
Tel: 01793 877777
www.innogy.com

Power-Gen plc
Head Office
Westwood Business Park
Coventry
CV4 8LG
Tel: 02476 424 000
www.pgen.com

Other advice

Advice on fisheries is obtainable from a number of bodies including:

Scotland

Association of Salmon Fishery Boards
5A Lennox Street
Edinburgh
EH4 1QB
Tel: 0131 343 2433
www.asfb.org.uk

Association of West Coast Fisheries Trusts
c/o Sarah Bayley
23 Culduthel Court
Inverness
IV2 4FB
Tel: 07799 628666
sarah.bayley@speed-mail.co.uk

Fisheries Research Services
Freshwater Laboratory
Faskally
Pitlochry
PH16 5LB
Tel: 01796 472060
www.marlab.ac.uk

Scottish Fisheries Co-ordination Centre
c/o Hilary Anderson
Freshwater Laboratory
Faskally
Pitlochry
PH16 5LB
Tel: 01796 472060
Andersonh@marlab.ac.uk

England and Wales

National Salmon and Trout Fisheries Centre
Environment Agency
Rivers House/Plas-yr-Afon
St Mellons Business Park
Fortran Road
St Mellons
Cardiff
CF3 0EY
Tel: 02920 770088

Cambria House / Ty Cambria
29 Newport Road
Cardiff
CF24 0TP
Tel: 02920 770088

National Coarse Fisheries Centre
Environment Agency
Arthur Drive
Hoo Farm Industrial Estate
Worcester Road
Kidderminster
DY11 7RA
Tel: 01562 68975

Centre for Ecology and Hydrology
Lancaster Environment Centre
Library Avenue
Bailrigg
Lancaster
LA1 4AP
Tel: 01524 595800
www.ceh.ac.uk

Centre for Environment Fisheries and Aquacultural Science
Pakefield Road
Lowestoft
Suffolk
NR33 0HT
Tel: 01502 562244
www.cefas.co.uk

Environment Agency
(see local office address under WATER REGULATORY AUTHORITIES)

WRc plc
Medmenham Laboratory
Henley Road
Medmenham
Bucks
SL7 2HD
Tel: 01491 636500
www.wrcplc.co.uk

Northern Ireland

Department of Culture, Arts and Leisure
Inland Waterways and Inland Fisheries Branch
Interpoint
20–24 York Street
Belfast
BT15 1AQ
Tel: 028 9025 8825
www.dcalni.gov.uk

Loughs Agency
22 Victoria Road
Londonderry
BT47 2AB
Tel: 028 7134 2100
www.loughs-agency.org

Fisheries Conservancy Board (NI)
1 Mahon Road
Portadown
BT62 3EE
Tel: 028 3833 4666
www.fcbni.com

Wildlife

Advice on wildlife is obtainable from a number of organisations including:

Scotland

Scottish Natural Heritage
12 Hope Terrace
Edinburgh
EH9 2AS
Tel: 0131 447 4784
www.snh.org.uk

Scottish Wildlife Trust
16 Cramond Glebe Road
Edinburgh
EH4 6NS
Tel: 0131 312 7765
www.swt.org.uk

England and Wales

English Nature
Northminster House
Peterborough
PE1 1UA
Tel: 0845 130 6229
www.english-nature.org.uk

Countryside Council for Wales
Maes y Ffynnon
Penrhosgarnedd
Bangor
Gwynedd
LL57 2DN
Tel: 01248 385500
www.ccw.gov.uk

Royal Society for Nature Conservation
The Kiln
Mather Road
Newark
Nottingham
NG24 1WT
Tel: 0870 036 1000
www.rsnc.org

Northern Ireland

Environment and Heritage Service
Commonwealth House
35 Castle Street
Belfast
BT1 1GU
Tel: 028 9025 1477
www.ehsni.gov.uk

Forest management

Advice on forest management is available from:

The local FC office in Britain and the local Forest Service District Forest Office in Northern Ireland

The Institute of Chartered Foresters
7a St Colme Street
Edinburgh
EH3 6AA
Tel: 0131 225 2705
www.charteredforesters.org

Forest and Timber Association
5 Dublin Street Lane South
Edinburgh
EH1 3PX
Tel: 0131 538 7111
www.forestryandtimber.org

Scottish Native Woods
1 Crieff Road
Aberfeldy
PH15 2BJ
Tel: 01887 820392
www.scottishnativewoods.org.uk

APPENDIX 2: WATER REGULATION AND LEGISLATION

The water industry

Under the powers of the Water Resources Act 1991 and the Environment Act 1995 the Environment Agency is charged with regulating water quality and resources, fisheries, recreation and amenity (on water and land within its control) and flood defence. The water utility companies provide public water supply, sewerage and sewage treatment. In some parts of the country water is supplied by water distribution companies.

In Scotland, the Scottish Environment Protection Agency (SEPA) incorporates the duties of the River Purification Boards and their counterparts in the three Island Councils; Her Majesty's Industrial Pollution Inspectorate; and powers of the local authorities in terms of enforcing release of substances into the air and waste regulation. It is responsible for protection of the environment. Scottish Water is responsible for water supply and sewerage under the Water (Scotland) Act 1980 and the Sewerage (Scotland) Act 1968.

In Northern Ireland, the Environment and Heritage Service is responsible for enforcing the pollution requirements of the Water (Northern Ireland) Order 1999. It is responsible for protecting and improving the quality of air, water and land; enforcing relevant environmental protection legislation; developing and implementing catchment-based water quality management plans; monitoring discharges to the aquatic environment; monitoring water quality; and maintaining emergency response services for water pollution incidents. The Rivers Agency, acting on behalf of the Department of Agriculture and Rural Development, is the statutory drainage and flood protection authority for Northern Ireland. It exercises discretionary powers under the Drainage (Northern Ireland) Order 1973. Water supply, sewerage and sewage treatment are the responsibility of Department of Regional Development Water Service.

Public water supply

Under the Water Industry Act 1991, and preceding legislation, all water undertakers are required to supply wholesome water; standards of wholesomeness are prescribed by the regulations under the Act.

These regulations are the Water Supply (Water Quality) Regulations 1989 (S.I. 1147), the Water Supply (Water Quality)(Amendment) Regulations 1989 (S.I. 1384), the Water Supply (Water Quality) (Amendment) Regulations (1991) (S.I. 1837), and the Surface Waters (Abstraction for Drinking Water) (Classification) Regulations 1996 (S.I. 3001), and parallel regulations for Scotland. They prescribe bacteriological, chemical and aesthetic standards which incorporate and, in some instances, go beyond those set out in the EC directive relating to the quality of water intended for human consumption (80/778/EC).

Another relevant EC directive is that concerning the quality required of surface water intended for the abstraction of drinking water in member states (75/440/EC). It is implemented inter alia via the Surface Waters (Classification) Regulations 1989 (S.I. 1148), and by parallel regulations for Scotland. These standards are gradually becoming statutory, via Regulation.

Control of water pollution

In respect of water pollution, the Environment Agency acts under the powers of the Water Resources Act 1991, SEPA under the powers of the Control of Pollution Act 1974 as amended, and EHS under the powers of the Water (Northern Ireland) Order 1999. It is an offence to cause or knowingly permit the entry of poisonous, noxious or polluting material into any inland water (lakes, lochs and watercourses), specified underground waters or tidal waters within the three nautical miles limit; in Northern Ireland this is an offence whether discharges are allowed 'knowingly or otherwise'. Any discharge of sewage or trade effluent requires the consent of the Environment Agency, SEPA, or EHS. People storing potentially polluting substances should take precautions to prevent their entry into water. There are also provisions for regulations to prohibit or restrict particular activities in designated protection zones, e.g. around a water supply source or important aquatic habitat.

Regulations made under the Food and Environment Protection Act 1985 require prior consultation with the Environment Agency or SEPA before the use of herbicides or pesticides in or near water, and before the aerial application of chemicals. Where there is a risk of contamination of water, herbicides that have been cleared for use in or near watercourses and lakes should be used. These are listed in the MAFF publication Guidelines for the Use of Herbicides on Weeds in or near Watercourses and Lakes 1995.

Standards for metals and organic substances are increasingly being set in relation to EC directives, in

particular those on *Pollution caused by certain dangerous substances discharged into the aquatic environment of the Community* (76/464/EC) and its daughter directives, and *Quality of fresh waters needing protection or improvement in order to support fish life* (78/659/EC).

Fisheries

Freshwater fisheries are capable of being in legal ownership and anybody who negligently damages a fishery could be liable in damages to the owner or any other person having an interest in the fishery. Fisheries may be fished by their owners or let out to others and may be managed by individuals, companies, angling clubs or associations.

In England and Wales, under the Environment Act 1995 and the Salmon and Freshwater Fisheries Act 1975, the Environment Agency has a duty to maintain, improve and develop salmon, trout, freshwater and eel fisheries. The 1975 Act provides protection for fisheries and, for example, makes it an offence to render any water containing fish, or any tributary of that water, poisonous or injurious to fish, their spawning grounds, fish spawn or the food of fish.

In Scotland, under the Salmon Act 1986 local District Salmon Fishery Boards have powers to protect and improve salmon fisheries (though boards have not been set up in all districts). There is no statutory local administration for trout or other freshwater fisheries (except on the River Tweed where the River Tweed Commissioners have a statutory responsibility for trout) but, as in England and Wales, the legislation provides protection for all fisheries and, for example, prohibits the killing of fish with noxious substances, obstructing the passage of salmon, and damage to spawning gravel (Salmon Fisheries (Scotland) Act 1868 and Salmon and Freshwater Fisheries (Protection) (Scotland) Act 1951). Separate, but similar legislation applies to the River Tweed under the Tweed Acts 1857, 1859 and 1969. The right to fish for trout and other freshwater fish belongs to the owner of the riparian land, but salmon and sea trout fisheries are a separate heritable estate and may have a different owner.

In Northern Ireland, under the Fisheries Act (Northern Ireland) 1966 as amended, the Department of Culture, Arts and Leisure is responsible for policy relating to the supervision, establishment, development and protection of salmon and inland fisheries.

Under Section 25 of this Act, the Fisheries Conservancy Board for Northern Ireland is responsible for the conservation and protection of the salmon and inland fisheries of Northern Ireland, with the exception of the Foyle and Carlingford areas, which are the responsibility of the Loughs Agency of the Foyle, Carlingford and Irish Lights Commission (FCILC).

Abstractions

In England and Wales the abstraction of water from rivers and underground waters requires a licence from the Environment Agency under the Water Resources Act 1991. There are some exceptions, including water for fire-fighting. The impoundment of water also requires a licence, and in this case it includes storage for fire-fighting purposes when this is provided by a barrier constructed across a stream. The Salmon and Freshwater Fisheries Act 1975 requires the inclusion of a fish pass in any new dam or weir frequented by salmon or migratory trout.

In Scotland the right to abstract water from surface and underground sources is generally founded in the common law. There are, however, several statutes that govern abstractions for specific purposes. These are:

- Water (Scotland) Act 1980 – public water supplies.
- Electricity Act 1989 – water for hydroelectric development.
- Natural Heritage (Scotland) Act 1991 – covering all abstractions for irrigation, including spray irrigation, by commercially-based agriculture and horticulture.
- Acts of Parliament (usually Private Acts) – water for specific purposes. Such acts are now rare as water for industrial purposes is usually obtained through the agency of the statutory authority.
- Town and Country Planning Acts provide control over most developments that involve abstraction.

In Northern Ireland there is no water abstraction licensing scheme.

Flood defence

In England and Wales the Environment Agency, through its regional offices, exercises general supervision over all matters relating to flood defence under the provision of the Environment Act 1995. It has permissive powers to

undertake improvement and maintenance work on main rivers, designated by Defra, and on sea and tidal defences in relation to the prevention of flooding. Internal drainage boards have drainage powers on small watercourses within their designated districts (mostly in low-lying agricultural areas), while local authorities have similar permissive powers on other non-main rivers.

A consent from the Environment Agency is required before any structure affecting water flow in a main river is erected or modified. Bye-laws give detailed provisions for controlling many activities in or beside main rivers – including construction work in or over the river and on the banks, the tipping of matter, removal of debris, management of flood banks, planting of trees and access to the river. Consent is also required from the Environment Agency, or an internal drainage board where one exists, before the erection or modification of any dam, weir or other obstruction to flow in any watercourse. Likewise, no culvert likely to affect the flow of any watercourse should be erected or modified without consent. A copy of the Agency's Culverting Policy is available on request from local offices. It is also an offence to obstruct the passage of migratory fish.

Currently in Scotland, land drainage and the prevention of flooding of agricultural land are the responsibility of individual proprietors. However, when Section 24 of the Environment Act 1995 comes in force, SEPA must then be consulted on any drainage works (as defined under the Land Drainage (Scotland) Act 1958, in order to advise on any measures which should be taken to prevent pollution of water.

In Northern Ireland, functions associated with land drainage and flood protection are the responsibility of the Rivers Agency of the Department of Agriculture and Rural Development. The principal enabling legislation is the Drainage (Northern Ireland) Order 1973. Most of the drainage and flood defence functions undertaken in England and Wales by the Environment Agency, as previously defined, are executed in Northern Ireland by the Rivers Agency.

Conservation

The official bodies responsible for promoting nature conservation in the countries of the UK are the Countryside Council for Wales (CCW), English Nature (EN), the Environment and Heritage Service – Northern Ireland (EHS), and Scottish Natural Heritage (SNH). The Joint Nature Conservation Committee (JNCC) fulfils the UK and international functions of the country agencies.

While these bodies have many responsibilities in common, there are also differences. English Nature's remit covers the conservation of wildlife and geology throughout England but does not extend to other matters relating to the countryside. In contrast, the roles of SNH in Scotland and CCW in Wales are broader, encompassing not only the conservation of habitats, species and geological features, but extending to landscapes and to the promotion of responsible access to the countryside. In addition, CCW and SNH both have a specific responsibility to encourage environmental sustainability in all forms of economic activity.

In Northern Ireland, the Environment and Heritage Service, as part of the Department of the Environment, has still broader duties. Under the Water (Northern Ireland) Order 1999 it has a duty to promote the conservation of water resources, promote the cleanliness of water in waterways and underground strata, have regard to the preservation of amenity and the conservation of flora and fauna, and have regard to the conservation of geological or physiographical features of special interest and any feature of archaeological, historical, architectural or traditional interest.

These organisations work in various different ways to achieve their aims, including the notification of Sites (or 'Areas' in Northern Ireland) of Special Scientific Interest (SSSIs/ASSIs), making proposals to government on which sites should be designated as Special Areas of Conservation (SACs) under the EC Habitats Directive, and dealing with a wide range of practical site management issues. They may also provide grants to others, enter into management agreements with landowners and occupiers, licence activities relating to statutorily protected species, carry out survey and monitoring, commission research and development projects, and advise government on matters relating to conservation and the countryside.

In Scotland, SEPA under the Environment Act 1995 (Section 34) has a duty to promote the cleanliness of inland, ground and tidal waters, conserve so far as practicable the water resources of Scotland and promote the conservation of flora and fauna which are dependent on an aquatic environment.

Many Sites of Special Scientific Interest and other protected areas involve rivers and lakes. The Wildlife and Countryside Act 1981 also has schedules of plants and animals, including aquatic species, afforded special protection.

APPENDIX 3: PROTECTED SPECIES

A list of freshwater organisms found in the UK (excluding brackish-water and estuarine species, but including some which only spend a part of their life-cycle in water) protected (wholly or partly) under Schedule 5 (animals) and 8 (plants) of the Wildlife and Countryside Act 1981*, or the Wildlife (Northern Ireland) Order 1985** (and taking account of changes made during quinquennial reviews) is given below. Those species included in Annexes to the EC Habitats Directive are also listed, together with a note of the Annex in which they are listed (II = Species for which Special Areas of Conservation (SACs) may be designated; IV = Species in need of strict protection; V = Species for which management measures may be required). 'Priority species' under the Biodiversity Action Plan are also indicated (•).

Common name	Scientific name	Statutory protection	EC Habitats Directive	Priority species
Plants				
Adder's-tongue spearwort	*Ranunculus ophioglossifolius*	*		
Atlantic lejeunea	*Lejeunea mandonii*			•
Baltic stonewort	*Chara baltica*			•
Beaked beardless-moss	*Weissia rostellata*			•
Bearded stonewort	*Chara canescens*	*		•
Bog moss	*Sphagnum* – all species		V	
Cernuous bryum	*Bryum uliginosum*			•
Clustered earth-moss	*Ephemerum cohaerens*			•
Convergent stonewort	*Chara connivens*			•
Creeping marshwort	*Apium repens*	*		
Cut-grass	*Leersia oryzoides*			•
Derbyshire feathermoss	*Thamnobryum angustifolium*	*		•
Dwarf stonewort	*Nitella tenuissima*			•
Fen violet	*Viola persicifolia*	**		
Floating-leaved water-plantain	*Luronium natans*	*	II, IV	•
Grass-wrack pondweed	*Potamogeton compressus*			•
Great tassel stonewort	*Tolypella prolifera*			•
Hawkweeds	*Hieracium Sect Alpestria* (Shetland spp only)			•
Holly-leaved naiad	*Najas marina*	*		•
Irish lady's-tresses	*Spiranthes romanzoffiana*			•
Lesser bearded stonewort	*Chara curta*			•
Millimetre moss	*Micromitrium tenerum*			•
Mossy stonewort	*Chara muscosa*			•
Mudwort	*Limosella aquatica*	**		
Multi-fruited river moss	*Cryphaea lamyana*			•
Pear-fruited bryum	*Bryum turbinatum*			•
Pennyroyal	*Mentha pulegium*			•
Pigmyweed	*Crassula aquatica*	*		
Pillwort	*Pilularia globulifera*	**		•
Ribbon-leaved water-plantain	*Alisma gramineum*	*		•
River jelly-lichen	*Collema dichotomum*	*		•
River water-crowfoot	*Ranunculus fluitans*	**		
Scottish pohlia	*Pohlia scotica*			•
Shetland pondweed	*Potamogeton rutilus*			•
Slender naiad	*Najas flexilis*	*	II, IV	•
Slender stonewort	*Nitella gracilis*			•
Spreading-leaved beardless-moss	*Weissia squarrosa*			•

Spruce's bristle-moss	*Orthotrichum sprucei*			•
Starfruit	*Damasonium alisma*	*		•
Starry stonewort	*Nitellopsis obtusa*			•
Strapwort	*Corrigiola litoralis*	*		
Tarn lecanora	*Lecanora achariana*	*		
Tassel stonewort	*Tolypella intricata*			•
Three-lobed water-crowfoot	*Ranunculus tripartitus*			•
Tiny fern-moss	*Fissidens exiguus*			•
Triangular club-rush	*Schoenoplectus triqueter*			•
Violet crystalwort	*Riccia huebeneriana*			•
Water rock-bristle	*Seligeria carniolica*			•
Waterwort, eight stamened	*Elatine hydropiper*	**		
Water violet	*Hottinia palustris*	**		
Welsh mudwort	*Limosella australis*	*		
Yorkshire feather moss	*Thamnobryum cataractarum*			•

Animals

Apus	*Triops cancriformis*	*		
Atlantic stream crayfish	*Austropotamobius pallipes*	*	II, V	•
Beetle	*Hydrochus nitidicollis*			•
Beetle	*Meotica anglica*			•
Click beetle	*Synaptus filiformis*			•
Cranefly	*Lipsothrix nigristigma*			•
Cranefly	*Rhabdomastix laeta*			•
Depressed river mussel	*Pseudanodonta complanata*			•
Desmoulin's whorl snail	*Vertigo moulinsiana*			•
Diving beetle	*Agabus brunneus*			•
Diving beetle	*Bidessus minutissimus*			•
Diving beetle	*Bidessus unistriatus*			•
Diving beetle	*Hydroporus cantabricus*			•
Diving beetle	*Hydroporus rufifrons*			•
Fairy shrimp	*Cheirocephalus diaphanus*	*		
Fen raft spider	*Dolomedes plantarius*	*		•
Freshwater bryozoan	*Lophopus crystallinus*			•
Freshwater nemertean	*Prostoma jenningsi*			•
Freshwater pea mussel	*Pisidium tenuilineatum*			•
Freshwater pearl mussel	*Margaritifera margaritifera*	*	II, V	•
Glutinous snail	*Myxas glutinosa*	*		•
Ground beetle	*Badister peltatus*			•
Ground beetle	*Bembidion testaceum*			•
Ground beetle	*Lionychus quadrillum*			•
Ground beetle	*Stenus palposus*			•
Hoverfly	*Eristalis cryptarum*			•
Lesser silver water beetle	*Hydrochara caraboides*			•
Mayfly	*Heptagenia longicauda*			•
Medicinal leech	*Hirudo medicinalis*	*	V	•
Netted carpet	*Eustroma reticulata*			•
Norfolk aeshna dragonfly	*Aeshna isosceles*	*		
Reed beetle	*Donacia aquatica*			•
Reed beetle	*Donacia bicolora*			•
Rove beetle	*Thinobius newberyi*			•
Shining ram's-horn snail	*Segmentina nitida*			•

Southern damselfly	*Coenagrion mercuriale*	*		•
Spangled diving beetle	*Graphoderus zonatus*			•
Stiletto-fly	*Cliorisimia rustica*			•
Stiletto-fly	*Spiriverpa lunulata*			•
Stonefly	*Brachyptera putata*			•
Tadpole shrimp	*Triops cancriformis*			•
Water beetle	*Graphoderus zonatus*	*		
Water beetle	*Helophorus laticollis*			•
Water beetle	*Hydrochara caraboides*	*		
Water beetle	*Ochthebius poweri*			•
Water beetle	*Paracymus aeneus*	*		•

Fish

Allis shad	*Alosa alosa*	*	II, V	•
Atlantic salmon (only in fresh water)	*Salmo salar*		II, V	
Barbel	*Barbus barbus*		V	
Brook lamprey	*Lampetra planeri*		II	
Bullhead	*Cottus gobio*		II	
Burbot	*Lota lota*			•
Grayling	*Thymallus thymallus*		V	
Houting	*Coregonus oxyrhynchus*			•
Pollan	*Coregonus autumnalis*			•
River lamprey	*Lampetra fluviatilis*		II, V	
Sea lamprey	*Petromyzon marinus*		II	
Spined loach	*Cobitis taenia*		II	
Twaite shad	*Alosa fallax*	*	II, V	•
Vendace	*Coregonus albula*	*		•
Whitefish (powan, schelly, gwyniad)	*Coregonus lavaretus*	*	V	

Amphibians

Common frog	*Rana temporaria*	*	V	
Common toad	*Bufo bufo*	*		
Great crested newt	*Triturus cristatus*	*	II, IV	•
Natterjack toad	*Bufo calamita*	*	IV	•
Palmate newt	*Triturus helveticus*	*		
Smooth newt	*Triturus vulgaris*	*,**		

Mammals

Barbastelle bat	*Barbastella barbastellus*			•
Lesser horseshoe bat	*Rhinolophus hipposideros*			•
Otter	*Lutra lutra*	*, **	II, IV	•
Pipistrelle bat	*Pipistrellus pipistrellus*			•
Water vole	*Arvicola terrestris*	*		•

Birds

Bittern	*Botaurus stellaris*			•
Common scoter	*Melanitta nigra*			•
Marsh warbler	*Acrocephalus palustris*			•
Red-necked phalarope	*Phalaropus lobatus*			•
Reed bunting	*Emberiza schoeniclus*			•

(Additional plants or designations not added for NI)

APPENDIX 4: GUIDANCE ON THE PROCEDURE FOR CARRYING OUT A CATCHMENT-BASED CRITICAL LOADS ASSESSMENT

This edition of the Guidelines uses the critical loads exceedance map for total acidity for UK freshwater ecosystems based on 1995–97 pollutant depositions (ECRC, 2001) to indicate where the additional scavenging of atmospheric pollutants by trees could lead to further freshwater acidification. It is recognised that this map is indicative only since the 10 km square values are based on just one standing water body in that area (although originally selected in terms of size, altitude and geology to represent the most sensitive water body). A more detailed assessment at the catchment scale is therefore likely to be required for new planting proposals and restocking plans within those squares of the map where critical loads are exceeded. An assessment may also be required in some non-exceeded squares, particularly in those squares adjoining exceeded ones, including diagonally opposite. In exceptional circumstances, sites may be at risk even though they fall outside a critical load exceedance or adjacent square; in view of the requirement to protect candidate SACs, site-specific data where available should be used to assess acidification risks for designated river catchments. A decision tree for undertaking a catchment-based critical loads assessment is presented opposite.

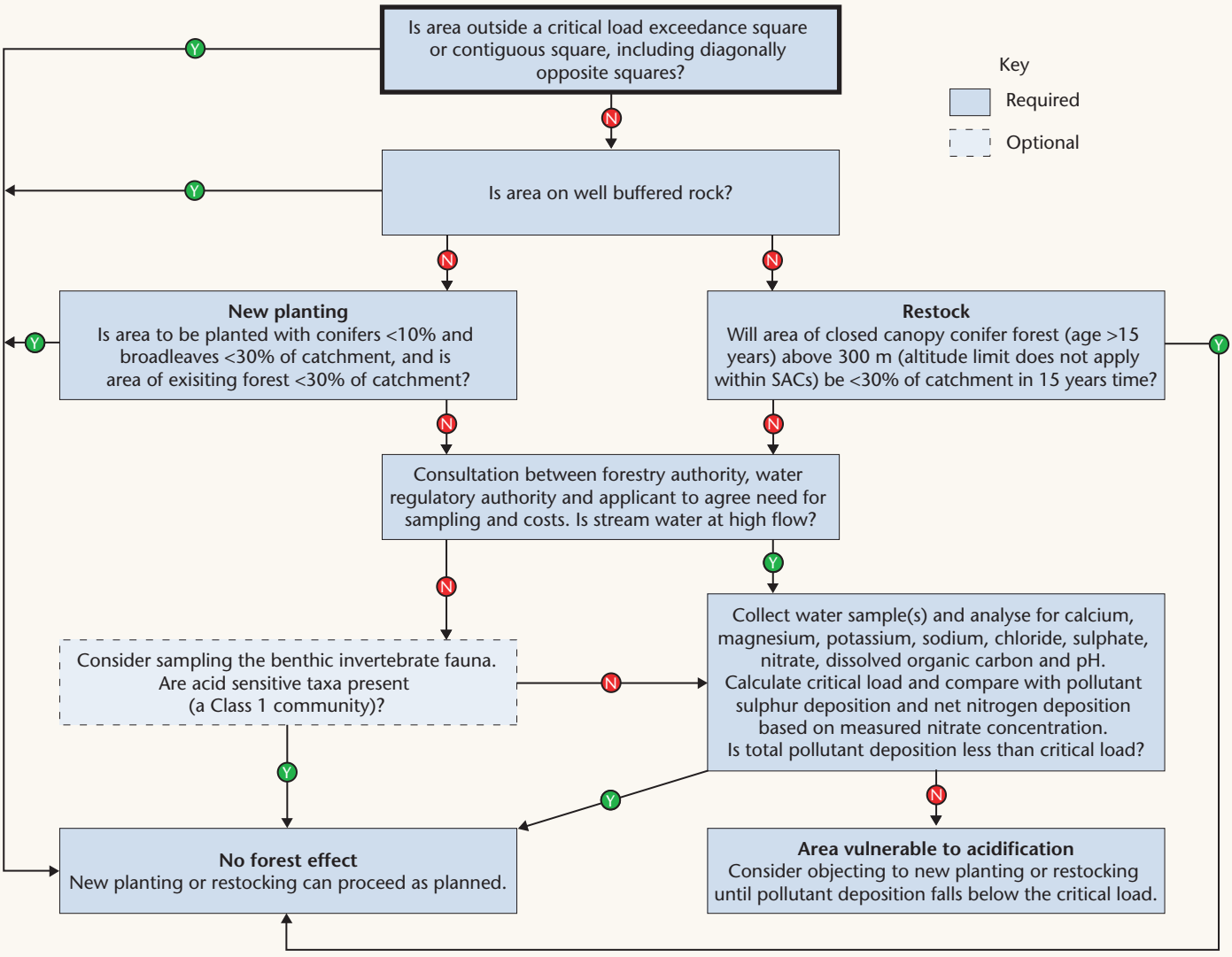
The forestry authority, taking advice as necessary from the appropriate water regulatory authority, will determine the need for an assessment. Factors that will be considered include the nature of the underlying geology; the size and species mix of a planting scheme; the age distribution, altitude and proportion of forestry already in the catchment; and the sensitivity of local water-uses. Some examples where an assessment is unlikely to be required include: areas with significantly better buffered geology to that of the sampling point in the exceeded square, small planting schemes within catchments with limited forest cover, most broadleaved planting schemes on account of their lower scavenging ability, and forest restocking at elevations less than 300 m (except where the area lies within an SAC or candidate SAC).

Where an assessment is required the forestry and water regulatory authorities will discuss details with the applicant or forest owner. In some cases, assessment will be possible on the basis of existing information. Where sufficient information is not already available, assessment is likely to involve the collection of one or more water samples at high flow from the principal watercourse receiving drainage from the area proposed for new woodland or for restocking. Stream flow conditions are likely to be most acidic and conducive to sampling during the period January to March inclusive, although it may be possible to collect samples outside this time. A principal watercourse should be taken to mean a perennial stream of sufficient size to support fish life. The appropriate water regulatory authority or a qualified contractor will usually carry out the sample collection and chemical analysis, and seek recompense for the cost.

The results from the chemical analyses will be used by the forestry authority or a qualified contractor to calculate the catchment's critical load, which will then be compared with the total pollutant deposition of S and N (estimated from the measured nitrate concentration in run-off) for the appropriate grid square. The previous edition of the Guidelines recommended that the total deposition figure should be the sum of the estimated additional pollutant capture by a planted forest and the predicted pollutant deposition at the time of canopy closure. However, due to the problem of estimating the proportion of nitrogen deposition that will reach forest streams and because pollutant depositions are expected to decline by a significant margin over the next decade, which is likely to exceed the forest scavenging effect, it is recommended that the published 1995–97 pollutant deposition data are used instead. Where the deposition total exceeds the freshwater critical load, approval of a grant or restocking plan is unlikely until there are further reductions in pollutant emissions. However, any decision against restocking would be subject to a wider Environmental Impact Assessment.

If the time of year is not conducive to sampling high flows, a stream biological assessment could help to determine whether a site is at risk of further acidification. This would usually involve the water regulatory authority or a qualified contractor sampling the macroinvertebrate fauna on the bed of the principal watercourse and determining the occurrence of acid-sensitive species. The presence of significant numbers of these species (a Class 1 community as defined by acidity indices developed by the water regulatory authorities) would be indicative of well-buffered conditions and thus forest planting or restocking could proceed without detriment to the freshwater ecosystem. However, the absence of acid-sensitive species would suggest that the site may be vulnerable to acidification and therefore there would need to be a delay until the chemical sampling and a full assessment could be undertaken.

Decision tree for undertaking a catchment-based critical loads assessment



APPENDIX 5: GUIDANCE ON THE PROCEDURE FOR CARRYING OUT A SITE IMPACT ASSESSMENT FOR FOREST HARVESTING WITHIN ACID SENSITIVE AREAS

The Guidelines recognise that the short-term release of nitrate that can follow the large-scale harvesting of some forest sites may pose an additional acidification threat within acid-sensitive areas. Depending on local circumstances, there may be a need to carry out a site impact assessment before issuing a felling licence or agreeing Forest Plans or Forest Design Plans. The forestry authorities, taking advice as necessary from the appropriate water regulatory authority, will determine the need for an assessment. Factors to be considered include local geology, catchment size, the presence of fish, the timing of felling operations, species mix and conservation designations. A decision tree for undertaking a site impact assessment is presented below.

The critical loads exceedance map for total acidity for UK freshwater ecosystems based on 1995–97 pollutant depositions will be used to define the acid sensitive area, which will include all adjacent squares. This will be supplemented by local geology maps and existing water chemistry data to exclude component areas with better buffered streams.

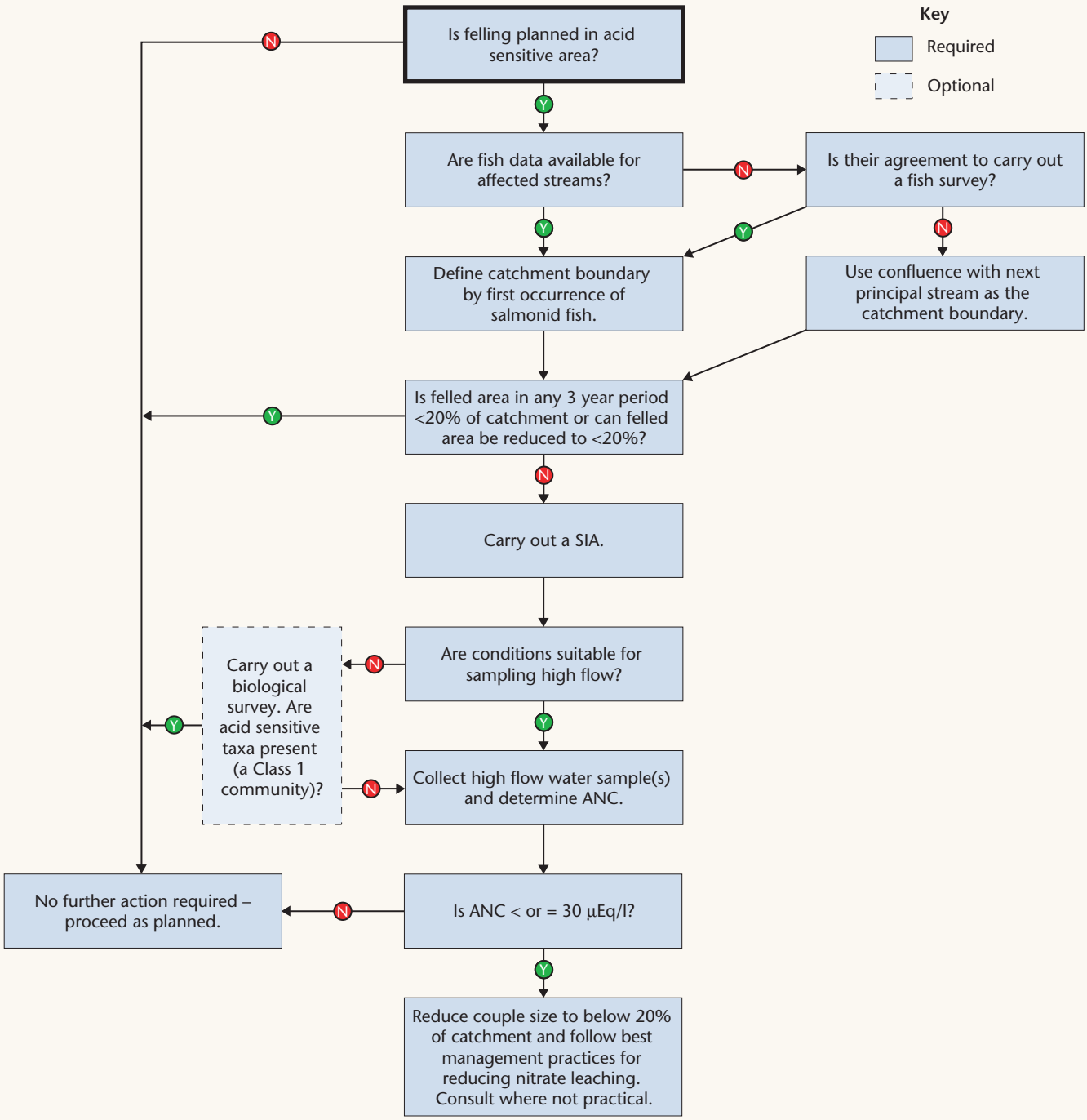
Recent research has suggested that the effects of harvesting on stream acidity are very hard to discern when 20% or less of a catchment is felled within any 3-year period (Neal & Reynolds, 1998). Consequently, where the rate of felling exceeds this figure it may be necessary for a site impact assessment to be carried out, unless the felling area can be reduced in size to meet the threshold.

For a site lying within an acid sensitive area, the forestry authority needs to determine the effective catchment boundary for applying the 20% criterion. This should be based on the nearest receptor at risk of damage from felling activity, which in most cases will be the presence of salmonid fish. For some catchment streams the water regulatory authority or fishery interests will have data on local fish populations. Where information is lacking, consideration should be given to undertaking a fishery survey. Details would need to be agreed with the water regulatory authority. If a survey is not feasible, the point at which the principal watercourse receiving drainage from the proposed felling joins another principal watercourse should be taken as the catchment outlet for the purpose of calculating catchment size.

The site impact assessment would normally involve the collection of between one and three water samples by the water regulatory authority or a qualified contractor from the catchment outlet during high flow conditions. Recompense will usually be sought for the costs associated with the sample collection and analysis. Stream flows are likely to be most acidic and conducive to sampling during the period January to March inclusive, although it may be possible to collect samples outside this time. Samples would be analysed to determine the acid neutralisation capacity (ANC) of the stream. If the minimum value measured is less than or equal to 30 $\mu Eq\ l^{-1}$, then the stream would be considered to be at risk from the planned scale of forest harvesting. In such cases, it would be necessary to reduce the area to be felled in any 3-year period to below 20% of the catchment, unless it is agreed with the water regulatory authority that other constraints such as tree stability or site conservation require a larger felled area. It would also be important to adopt site management practices that can help to minimise nitrate leaching. These include removing brash from riparian buffer zones to encourage revegetation and nitrate uptake, and avoiding the burning or chipping of brash, or the piling of it into spoil trenches formed by excavator mounding treatments.

If the time of year is not conducive to sampling high flows, a stream biological assessment could help to determine whether a site is at risk from forest harvesting. This would usually involve the water regulatory authority or a qualified contractor sampling the macroinvertebrate fauna on the bed of the principal watercourse and determining the occurrence of acid-sensitive species. The presence of significant numbers of these species (a Class 1 community as defined by acidity indices developed by the water regulatory authorities) would be indicative of well-buffered conditions and thus the size of felling area would not pose a problem. However, the absence of acid-sensitive species would suggest that the site may be vulnerable to acidification and therefore there would need to be a delay until the water sampling and full chemical assessment could be undertaken.

Decision tree for undertaking a site impact assessment



NOTES

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