Water Framework Directive
Western River Basin District

Programme of Measures and Standards

For

Forest and Water

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1. Executive Summary

1.1 Forest and Water Working Group

The National Summary Characterisation Report identified forestry as one of the key pressures which should be addressed in the Water Framework Directive River Basin Management Plans and Programme of Measures. The task of identifying impacts and possible measures was assigned to the Western River Basin District (Western RBD) by the National Technical Coordination Working Group as part of a suite of National Programmes of Measures studies. A Forest and Water Working Group has steered the project, chaired by a Director of Services from Mayo County Council and comprising representatives from the Department of the Environment, Heritage & Local Government (NPWS), Central Fisheries Board (DCMNR) Marine Institute (DCMNR), Regional Fisheries Boards, The Forest Service (DAFF), Coillte, COFORD, The Environmental Protection Agency and The Environment Agency Northern Ireland (formerly Environment and Heritage Service (Northern Ireland). Local Authorities and other River Basin Districts also provided input.

1.2 Primary Objectives of the Study

Primary objectives were:

- to assess the potential impact of afforestation and forest operations on status in river and lake water bodies
- to develop risk assessment methods to allow further national characterisation
- to inform and develop Programme of Measures thereby complying with the WFD.

The scope for the development of measures and standards relates to acidification, eutrophication, sedimentation and dangerous substances with the last of these covered in a separate report. The major legislative drivers considered are the Water Framework Directive (2000/60/EC; WFD) and, to a lesser extent, the Habitats Directive (92/43/EEC).

1.3 Background

This document outlines the place of forestry in the Irish environment. It reviews potential pressures on water from forests and forest activities together with the pathways and possible receptors involved. The document lists the existing guidance and codes of practice relating to forests and forestry management in Ireland and recommends a suite of further mitigating measures that could be incorporated. These measures will be particularly applicable to older plantations established prior to current guidance documents. The issues and measures discussed relate mostly to the postulated effects of forestry in Ireland

There are two fundamental perspectives relating to forests and forestry in the Irish landscape

- Forestry may give rise to negative pressures on aquatic ecosystems
- Forestry and forest management can provide an opportunity for delivering programmes of measures with positive benefit in achievement good ecological status over extensive land areas.

Two field research studies formed part of this project: by UCD into Forestry and Acidification (Reference Report) and by UCC into Forestry Eutrophication and Sedimentation (Reference Report). Comprehensive peer-reviewed literature surveys informed these studies. The study areas were confined principally to first and second order streams with some third order stream catchments included. Biological impacts and water quality were determined at multiple control and forested sites on varying soil types nationally.

The acidification study showed that there is a risk of acidification under closed-canopy forests on some base-poor rocks and soils with impacts on river organisms. Peat soils were most affected (including blanket peat, fen peat, raised bog and cutaway peat), along with peaty podzols on metamorphic and igneous rock (Granites) and, to a lesser extent, peat on sedimentary rock (Old Red Sandstone). Among the possible processes driving acidification in Ireland are organic acid addition, base cation dilution, organic sulphur oxidation to sulphate, nitrate and marine derived chloride, acid deposition of non marine sulphate and ammonium deposition derived from animal production .

The eutrophication and sedimentation studies suggests that impacts are more limited in extent and generally related to forest roading, harvesting and replanting rather than forest extent within a catchment. Any impacts are probably related to conifer forests on peat type soils (blanket bog, fen peat, raised bog and cutaway), but the confounding effects of acidification render interpretation of biological impact more difficult.

A National Forestry Inventory (NFI) involving a detailed nationwide field survey of the forest estate was published by the Forest Service in 2008. This confirms that the total forest area in Ireland stands at 10% of the total land area of which 57% is in public ownership and 43% in private ownership. An estimated 43% of the total stocked forest estate is on peat soils (basin peat, raised bog, blanket peat and cutaway peat).

The GIS-based National Forestry Inventory and Planning System has been updated to include forests grant aided by the Forest Service (Forest Premiums database) and Coillte Forest data updated to March 2008. It now provides a more comprehensive picture of forest cover in Ireland.

1.4 Pressure – Pathway Receptor Concept

The Programme of Measures follows the general principle of the Water Framework Directive in linking Pressures, Pathway and Receptors. The key potential pressures from forests and forestry activites have been identified, the pathways described and the receptors identified in terms of their sensitivity to potential impacts.

The timing of potential impacts has been considered, recognising that forests have a long life cycle with key stages. Commercial conifer forests in Ireland have a typical crop rotation period of 40 years, from establishment to harvesting. Impacts can occur, for example, at establishment through site preparation and fertilisation after crown closure (usually between 15 to 20 years for coniferous crops) where acidification impacts may manifest due to pollutant scavenging, prior to first thinning stage when

road construction is required; at harvesting when clearfelling occurs; and at replanting stage, if site preparation and pesticide application are required.

1.5 Receptor Sensitivity

Surface water bodies (rivers, lakes, estuaries and coastal waters) have different sensitivity to forest effects dependent on their hydro-geology and chemistry, aquatic species composition, existing status and designations under national and international legislation, such as the Freshwater Fish Directive, Habitats Directive and Birds Directive and location with respect to forest pressure in the catchment. Sensitive areas include protected areas designated under the WFD, acid sensitive areas, eutrophication sensitive areas, sediment sensitive areas and areas sensitive to hydrological change.

1.6 Programme of Measures

Under the Water Framework Directive, River Basin Management Plans must include a set of management measures aimed at achieving the default objectives within the 15-year time frame from the date of entry into force of the Directive, i.e. by 2015, unless alternative objectives are established. The required Programme of Measures (POM) (Water Framework Directive Article 11) can be divided into two broad categories, Basic Measures and Supplementary Measures.

Basic Measures are listed in Annex VI, Part A of the WFD These are "obligatory" and include measures required to implement existing Community legislation for the protection of water, (EU Directives and statutory obligations associated with their implementation), they may also require new additional legislation. Supplementary measures are optional but not exhaustive. Examples are provided in the directive (Annex VI, Part B), such as; administrative arrangements, economic or fiscal instruments, environmental agreements, emission controls, codes of good practice, re-creation and restoration of wetlands and rehabilitation projects.

Supplementary actions identified which are applicable to afforestation and to re-establishment of forest stands include:

FM - Management related Instruments: Identified to improve the flow of information, to ensure that all regulations and guidance are cross referenced. And to ensure that issues identified and proposed measures are incorporated into revisions of controlling legislation. These instruments also include education and awareness programmes.

- to improve the flow of information across all sectors to ensure good governance,
- to ensure that all regulations and guidance are cross referenced.
- to ensure that issues identified and proposed measures are incorporated into revisions of controlling legislation.
- education and awareness programmes.
- To ensure any revision of the Forestry Act 1946 takes account of the recommendations of the Forest and Water Working Group as appropriate.

FA – Acidification measures: Acidification appears on current evidence to be a management problems with Irish forest on some soil types, notably peat soils and to lesser extent peaty podzols on metamorphic and sedimentary rock. Measures include the following:

- avoid or limit (to below critical thresholds) afforestation on 1st and 2nd order stream catchments in acid sensitive catchments;
- restructure existing forests to include open space and structural diversity through age classes and species mix, including broadleaves.
- mitigate acid impacts symptomatically using basic material (e.g. limestone or sand liming);
- manage catchment drainage to increase residence times and soil wetting, including no drainage installation in some areas;
- Implement measures to increase stream production – for example with native woodland in riparian zones.
- Revise the Acidification Protocol to ensure actual minimum alkalinities are detected (i.e. ensure sampling under high flow conditions) and the revision of boundary conditions for afforestation in acid sensitive areas.

FE- Eutrophication measures/FS -Sedimentation measures: Eutrophication and sedimentation pressure are identified primarily with forestry activities, principally clearfell, roading, and, in certain circumstances, aerial fertilisation occurring on peat soils. In some instances the impacts may be confined to the headwaters of streams and can be critical where sensitive catchments are involved with sensitive habitats and species further downstream. Measures to control nutrient and sediment load from forestry operations include.

- avoid or limit forest cover on peat sites;
- change the tree species mix (e.g. broadleaves) on replanting
- limiting felling coup size
- new forest structures on older plantation sites (including new riparian zones, drainage layouts, species mix, open areas)
- establishing riparian zone management prior to clearfelling
- enhance sediment control
- manage catchment drainage to increase residence times and soil wetting, including no drainage in some locations
- Consider prohibition of aerial fertilisation on sensitive/ protected sites
- No replanting on certain hydrogeological settings (peat soils) on sensitive sites.

FH – Hydromorphological measures: Hydromorphological impacts can occur both from reduced water flow in catchments, due to increased evapotranspiration, in dry weather periods and from enhanced peak flood events increased flow from forested areas with large drainage networks established before the introduction of environmental guidelines. Further research is necessary in this area to quantify the potential impacts. Measures which have been recommended include

- auditing of existing drainage networks in forest catchments
- enhanced drainage network management – minimise drainage in peat soils

FP- Pesticide use measures: Pesticide use is generally associated with forest establishment (herbicide) and with re-establishment post clearfelling (herbicides and insecticides). Measures which have been recommended include:

- reduction in pesticide usage
- pre-dipping of trees in nurseries prior to planting out
- development of biological control methods
- maintaining registers of pesticide use (it is acknowledged that this is a national issue relating to pesticide use in general across all sectors)

It is envisaged that for a given area the most appropriate measures will be adopted from the suite of measures proposed as these will tend to be site specific

1.7 Recommendations for Further Research

During the course of discussions and arising from the findings of the current research project, past research and literature surveys additional research topics were identified which would benefit further the understanding of the forest and water relationship and would help refine measures in the future. The research and trialling of measures recommended by the Working Group include

Research/Trial Topic

- Elucidation of the dominant acidification mechanism in Ireland
- Application of native riparian woodland scheme to conifer forest on peat soils. Evaluate contribution of riparian woodland to stream productivity and degree of compensation achieved.
- Research into the hydromorphological impacts
- Evaluation of liming options for Irish catchments, including pre-liming, broadcast liming aerial application, silo based, grinding mills, base hardcore material for roading.
- Trialling out identified methodologies in some target catchments.
- Catchment scale trialling of native riparian woodlands in enhancing stream productivity and offsetting potential impact of forest on acid sensitive areas.
- Research into buffer zones
- Trialing different methods for timber/brash extraction
- Research into drainage control
- Test the effectiveness of conifers/other trees versus natural regeneration.
- Evaluate application and effectiveness of Decision Support System in development by Coillte for the Western Peatlands forested areas.

2. Introduction

2.1 Forest and Water Working Group

The National Summary Characterisation Report[1] identified forestry as a one of the pressures which should be addressed in the Water Framework Directive River Basin Management Plans and Programme of Measures. The assessment of potential impact from forests and forestry operations and identification of appropriate measures was assigned to the Western River Basin District (Western RBD) by the National Technical Coordination Working Group as part of an overall National Programmes of Measures studies. A Forest and Water Working Group was established to steer the project chaired by a Director of Services from Mayo County Council and comprising a representative from each of the following organisations, agencies and departments: National Parks and Wildlife Service (NPWS), Department of the Environment, Heritage & Local Government, Central Fisheries Board (DCMNR), Marine Institute (DCMNR), Regional Fisheries Boards, The Forest Service, Department of Agriculture, Fisheries and Food (DAFF), Coillte , COFORD, The Environmental Protection Agency and The Environment Agency Northern Ireland (formerly Environment and Heritage Service (Northern Ireland). Representatives from Local Authorities and other River Basin Districts also provided input to the working group.

The aim of the group was to steer the associated field research projects into acidification, eutrophication and sedimentation undertaken by University College Dublin and University College Cork, to assist in the evaluation and applicability of the research output in identifying potential impact from forests and forestry practices and to provide input into the programme of measures to mitigate potential impacts to the receiving waters.

2.2 Primary Objectives of the Study

The primary objectives of the study were to

- to assess the potential impact of afforestation and forest operations on water quality in river and lake water bodies
- to develop a risk assessment methodology to allow further characterisation at national level
- to inform and develop a suitable Programme of Measures to achieve compliance with the WFD.

2.3 Background

This document broadly outlines the scope of forestry in Ireland and its place in the Irish environment. A review of potential pressures on water from forests and forest activities is undertaken together with the pathways through which such pressures may impact and the type of receptors which may be affected by such potential pressures. The document lists the existing guidance and codes of practice relating to forests and

[1] WFD Article 5, Ireland's National Summary Characterisation Report, www.wfdireland.ie

forest management which have already been introduced to mitigate against potential pressures in Ireland and recommends a suite of mitigating measures, where applicable, to be incorporated into existing or new guidelines. These measures will be particularly applicable to older plantations, whose establishment predated the introduction of the current guidance documents.

The issues and measures discussed relate mostly to the postulated effects of forestry in Ireland on acidification, sediment release and nutrients in stream systems, and the consequences for aquatic biota. The major legislative drivers considered are the Water Framework Directive (2000/60/EC; WFD) and, to a lesser extent, the Habitats Directive (92/43/EEC). The document has been informed by the studies undertaken as part of the Western RBD Project by UCD into Forestry and Acidification (Reference report[2]) and by UCC into Forestry Eutrophication and Sedimentation (Reference Report[3]). Comprehensive peer reviewed literature surveys were undertaken as part of these studies. Although relevant to the WFD, less emphasis is placed on any possible effects on hydrology, hydromorphology or priority substances although issues related to these are discussed in the document. A separate report has been prepared on the use of priority substances in the Irish Forest Sector.

There are two fundamental perspectives relating to forests and forestry in the Irish landscape

1. Forestry may give rise to negative pressures on aquatic ecosystems
2. Forestry and forest management can provide an opportunity for delivering programmes of measures with positive benefit in achievement good ecological status over extensive land areas.

Through the WFD process an opportunity exists to shift the balance from negative to positive benefits with the caveat that climate change in the coming decades may exacerbate adverse effects and needs consideration.

2.4 Forest and Water Studies

Two field research studies were undertaken as part of the overall project, by UCD into Forestry and Acidification (Reference Report[4]) and by UCC into Forestry Eutrophication and Sedimentation (Reference Report[5]). The study areas were confined principally to first and second order streams with some third order stream catchments included. Biological impacts and water quality chemistry were determined at multiple control and forested sites nationally, including a spread of forest cover on varying soil types. Data on forest cover was derived from the updated Forest Inventory and Planning System (comprising updated Coillte data and Forest Premiums data provided by the Forest Service). Data on forestry activities (harvesting) within the target catchments was provided by Coillte. Soil type in the upstream catchments of monitoring locations was derived from the National IFS soils map (often referred to as the Teagasc/EPA soils map) and through a field sampling programme to verify soil type in forest stands.

[2] Forest and Water Acidification Study Report
[3] Forest and Water Eutrophication and Sedimentation study
[4] Forest and Water Acidification Study Report
[5] Forest and Water Eutrophication and Sedimentation study

The results of the acidification study suggest that there is a risk of acidification on certain acid geology settings. Impacts are observed on the biology of river systems where coniferous forest stands with closed canopies are located on acid geology soils and bedrock. Impacts are associated with with closed canopy conifer forest stands on peat soils (including blanket peat, fen peat, raised bog and cutaway peat) or peaty podzol soils on metamorphic and igneous rock (typically granites) and to a lesser extent peat soils on sedimentary rock (Old Red Sandstone Areas). Data from the study suggests that the impact becomes significant at elevated forest cover; greater than 25% catchment conifer forest cover for these hydrogeological settings on peat's and more markedly above 50% and at higher levels for peaty podzols. Among the possible processes driving acidification in Ireland are organic acid addition, base cation dilution, organic sulphur oxidation to sulphate, nitrate and marine derived chloride, acid deposition of non marine sulphate and ammonium deposition derived from animal production.

The results of the study on eutrophication and sedimentation suggests that impacts from these pressures are limited in extent and generally related to forestry operations such as roading, harvesting and replanting rather than extent of forest cover within a catchment. Data suggest these impacts are related primarily to conifer forests on peat type soils (blanket bog, fen peat, raised bog and cutaway). However, sites studied for impact from eutrophication and sedimentation may also exhibit confounding effects of acidification with a potential cumulative effect rendering interpretation of data more difficult.

2.5 National Forest Inventory

Official Government forest policy is set out in "Growing for the Future – A Strategic Plan for the Development of the Forestry Sector in Ireland" published in 1996. The plan envisages the expansion of the industry to establish a critical mass that would allow competition, operation of market forces and support a range of processing industries. This plan considers that a minimum domestic production level of 10 million m^3/annum and ideally 12-15 million m^3 would be necessary to achieve this objective. This should see an increase of current output from 3.0 million m^3 per annum currently to 5 million m^3 by 2035.

A National Forestry Inventory (NFI)[6] was undertaken by the Forest Service to provide an assessment of the extent and status of existing forest cover in Ireland. The results provide an assessment of growing stock volume in both public and private forest estates. It involved a detailed nationwide field survey of the forest estate, which began in November 2004 with the publications of the findings in 2007.

The results of the Inventory confirm that the total forest area in Ireland now stands at 10% of the total land area of which 57% is in public ownership and 43% in private ownership.

The main results to date are:

[6] National Forest Inventory, Republic of Ireland, Results, Forest Service, Department of Agriculture, Fisheries and Food, 2007

Forest area	10% of total area
Species composition	25% broadleaf
Volume	70 million m^3
Age structure	More than 60% of the total stocked forest area is less than 20 years old.

In addition the bulk of the forest estate is broadly of coniferous type Table 1

Table 1 Forest Estate by broad species group[6]

Broad Species Groups	Ownership/area			
Species (conifer/broadleaf)	**Public %**	**Private (grant aided) %**	**Private (other) %**	**Total %**
conifer	80.7	84.4	18.7	73.9
broadleaf	16.5	15.2	80.8	24.3*
temporarily unstocked	2.8	0.4	0.5	1.8

* This figure does not include broadleaves growing in hedgerows, shelter belts, groves, parklands, local authority amenity areas and roadside planting.

An estimated 43% of the total stocked forest estate is on peat soils (basin peat, raised bog, blanket peat and cutaway peat), Table 2. Peat soil is defined in the National Forest Inventory as peat with a depth of greater than 30cm on drained and 45 cm on undrained land.

Table 2 total stocked Forest Area by Soil Grouping and Ownership[6]

Total Stocked Forest Area by Soil Group and Ownership

	Ownership/Area							
Soil Group	**Public**		**Private (grant aided)**		**Private (other)**		**Total**	
	Ha	%	Ha	%	Ha	%	Ha	%
basin peat	31,230	8.7	22,830	12.2	12,820	16.2	66,880	10.(
blanket peat	130,650	36.3	60,950	32.6	5,200	6.5	196,800	31.4
brown earth	19,230	5.4	13,210	7.1	20,030	25.1	52,470	8.3
brown podzolic	16,460	4.6	7,610	4.1	4,830	6.1	28,900	4.(
gley	85,700	23.8	63,590	33.9	14,010	17.7	163,300	26.1
grey brown podzolic	5,230	1.5	6,000	3.2	4,020	5.1	15,250	2.4
lithosol	8,800	2.4	2,000	1.1	3,590	4.5	14,390	2.3
podzol	53,280	14.8	8,400	4.5	4,830	6.1	66,510	10.(
regosol	1,200	0.3			2,820	3.6	4,020	0.(
rendzina	2,000	0.6			6,410	8.1	8,410	1.3
cutaway peat	5,220	1.5	2,000	1.1			7,220	1.1
sand	400	0.1	400	0.2	400	0.5	1,200	0.1
limestone pavement					400	0.5	400	0.(
	359,400	100	186,990	100	79,360	100	625,750	1(

2.6 Forest Inventory and Planning System

FIPS (Forest Inventory and Planning System) was initially developed by the Forest Service in the mid to late 90's when it was a part of the Department of Agriculture and Department of Marine and Natural Resources. FIPS is a GIS platform designed to act as an aid for the long term strategic planning of the national forest resource as set

out in the Government's 1996 Strategic Plan for the Development of the Forestry Sector in Ireland.

In 1995 a national forest inventory was developed using a combination of satellite imagery and GIS technologies, funded by the Forest Service with EU support. The vector forest cover generated in the initial FIPS project is now referred to as FIPS98 and comprised a total forest cover area of 570,951 hectares. It was comprised of two main data sets:

1. A Forest cover map with polygons digitised to 2 meter accuracy derived from automated classification of satellite imagery and onscreen interpretation of Landsat TM Imagery (1993-1997) enhanced by interpretation of panchromatic ortho-photos and Ordnance Survey (OS) 1:2500, 25" Mapping (c. 504, 000 hectares)
2. Digitised forest plot and plantation areas captured from OS 25" and 6" maps and hand drawn boundaries up to 1998 (c. 65,000 hectares).

Since 1998 no update of the FIPS98 vector layer had been produced. Official Forest Service published statistics indicate that some 87,813 hectares of Forest Service approved woodland was planted between 1999 and 2005 or an average of 12,544 hectares per annum. An estimated 8,000 hectares of approved afforestation occurred in 2006. Most of the attribute and spatial information related to these 95,813 hectares has been captured digitally by the Forest Service GPAS and IFORIS systems. An Oracle database is used to store the GPAS/IFORIS attribute and spatial information. Planting activities by Coillte Teoranta since 1998 are confined in the main to the reforestation of harvested sites.

In 2006 the Forest Service began working towards an update of the FIPS vector forest cover layer. The GIS mapping of forest areas under the Forest Service Premiums extract was completed with the assistance of the WFD Western RBD Project. The updated forest inventory and planning system FIPS forest cover layer now comprises three primary spatial data sets:

1. Forest Service Premiums extract,
2. Updated Coillte Teoranta sub-compartment database.
3. Other legacy FIPS98 polygons not included in the Premiums extract or Coillte sub-compartment database. These include forest owned by NPWS, old estates, County Councils' lands and natural succession woodland. It is estimated that approximately 120,000 hectares of FIPS98 polygons fall into this category

It is envisaged that the three data sets will be merged to produce a final National Forest Inventory and Planning System. GIS mapping and attribute information has now been completed but some boundary issues remain to be resolved. This process is ongoing.

The mapped data includes information on species and year planted. Figure 1 illustrates the type of mapped data available. The area indicated is to the east of Lough Cutra in County Galway and above Lough Graney in County Clare. Dark green areas relate to Coillte properties and light green areas to private forest

properties. More detailed information is available as to species mix, year of planting etc.

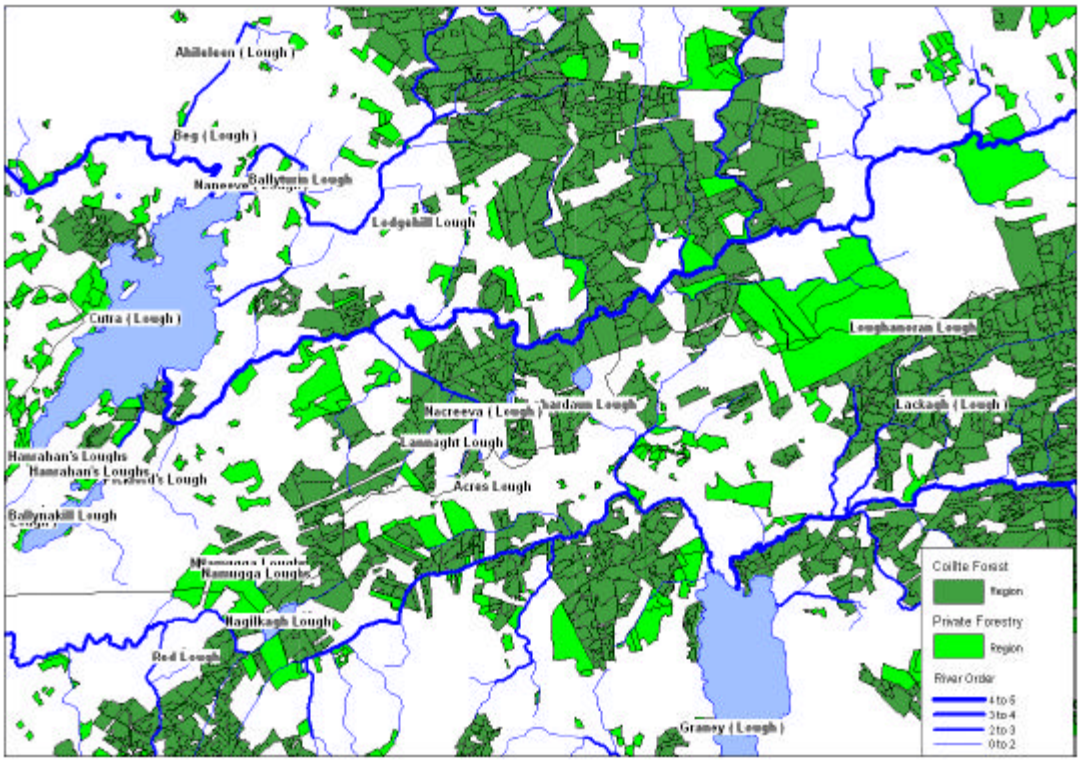

Figure 1 FIPS Mapped areas

The updated FIPS data has been mapped to the national river water body database. Table 3 provides an indication of the number of water bodies associated with different forest cover levels. Total stream length (all stream orders) associated with each band, level of forest cover (all forest stands) is also indicated.

Table 3 Total Forest cover and river water bodies.

RWB total forest cover	No of WBs	% Water body in forest cover band	Total WB River length (Km)	Total WB River length (Km) as a % of total national river length	Total Area (ha) Forestry	Total Area (ha) Forestry as a %
No Forestry	572.00	13	3,495.09	5	0.	0.00
0-5%	1,552.00	34	23,836.99	34	62,827	10.06
5% - 25%	1,865.00	41	34,221.87	49	352,975	56.50
25% - 50%	427.00	9	6,521.99	9	156,988	25.13
> 50%	112.00	2	1,254.31	2	51,919	8.31

All forest types are included, both coniferous and broadleaves

In addition data has been extracted in relation to the number of smaller 1st and 2nd order stream subbasin catchments and level of forest cover, Table 4.

Table 4 Forest cover and subbasin (1st and 2nd order) stream catchments

RWB forest cover	No of Stream Subbasins (1st and 2nd Order)	% Subbasins by forest cover	Stream length (Km) of 1st & 2nd Order Streams Subbasins	% Length of 1st & 2nd Order Streams in Subbasins	Area Forestry (ha) in 1st & 2nd Order Subbasins	% Forestry in 1st 2nd Order Subbasins
No Forestry	6,159.00	33.6				
0-5%	4,444.00	24.2	18,120	36.4	54,344	10.4
5% - 25%	5,021.00	27.4	25,542	51.4	298,862	57.1
25% - 50%	1,726.00	9.4	5,021	10.1	130,888	25.0
> 50%	988.00	5.4	1,029	2.1	39,547	7.6

All forest types are included, both coniferous and broadleaves

The data indicates that some 15% of subbasins have more than 25% forest cover (all forest types included) with just over 5% having greater than 50% forest cover. Some of these locations will have been clearfelled and replanted under the Forest Service Guidelines

FIPS Updates

Updating of the FIPS database is essential for forestry management and for the management of potential forestry pressure acting on water bodies. It is also essential for the interpretation of water quality information where forest properties exist upstream of a monitoring location.
The Forest Service will update the FIPS on an incremental basis. Afforestation captured in the IFORIS system and updated Coillte sub compartment data base information will be imported into FIPS. The following Management actions (Table 4) are recommended to support the Forest Instruments.

Table 4 Instruments related to management

	Actions in Support of Instruments	**Actioned by:**	**Comment**
FM1.	Finalise the Forestry Inventory and Planning System	Forest Service Department of Agriculture, Fisheries and Food	All boundary resolutions need to be completed.
FM2.	Maintain an updated FIPS database	Forest Service Department of Agriculture, Fisheries and Food	Subject to availability of data collect updated data from Coillte, NPWS, and integrate into FIPS
FM3.	Publish an updated FIPS database on an annual	Forest Service Department of	Consider web enabled access to

	basis. Provide database to all Statutory Authorities and make available to the public	Agriculture, Fisheries and Food	FIPS. This action is critical to the future management of River Basin Districts.
FM4.	Data sharing: All data to be accessable in an agreed common GIS tool common to all stakeholders.	River Basin District Boards EPA through EDEN Project	A basic requirement of good governance
FM5	All data to be accessible in an agreed common GIS tool common to all stakeholders	EPA	A basic requirement of good governance

3. Pressure – Pathway – Receptor Concept

The Programme of Measures follows the general principle of the Water Framework Directive in defining the Pressure -Pathway - Receptor concept. The key potential pressures from forests and forestry activity have been identified, the pathways described and the receptors identified in terms of their sensitivity to potential impacts. It is important to note that for an impact to occur on a receptor both a significant pressure and a pathway must be present. Measures to reduce the pressure or limit or remove the pathway will reduce or eliminate potential impact on a receptor.

Furthermore, consideration should be given to the timing of potential impacts, particularly in the case of forestry which has a long life cycle. Commercial conifer forests in Ireland have a typical crop rotation period of 40 years, from establishment to harvesting. Impacts can occur at key stages, e.g. at establishment through site preparation and fertilisation after crown closure (usually between 15 to 20 years for coniferous crops) where acidification impacts may manifest; at thinning stage where road construction is required; at harvesting when clearfelling occurs; and at replanting stage, where site preparation works and pesticide application may be required. Therefore impacts may only occur at key lifecycle stages.

4. Pressure Considerations

Potential Pressure from Forests and Forestry

The potential pressures from forest stands and from forestry operations are set out below. Note that these are potential pressures which could manifest into impacts if proper measures are not in place or are not adhered to.

4.1 Forest Life Cycle

The life cycle of coniferous forests spans about 40 years in Ireland but with the planting of significant areas of broadleaf species the lifecycle of forests may extend beyond 60 years especially when growing long rotation crops such as Oak.
In general the life cycle of forests includes the following phases:

- Approval for forest planting, including site selection and characterisation[7]
- Establishment, including species selection, ground cultivation and drainage, pesticide use (herbicides)
- Fertilisation (if required)
- Roading (which can occur at establishment and/or prior to thinning)
- Thinning
- Harvesting of final crop
- Restocking (may involve ground preparations, pesticide use, planting with the same or alternative species)

The forest life cycle extends from afforestation to restocking with some areas of semi natural development or other areas occasionally left fallow (Table 5). Reforestation includes both restocking (replanting) and natural regeneration from seed and coppice.

Table 5 Total Stocked Area by Rotation Type[6]

Rotation Type	Area / Ha	%
Afforestation	406,720.00	65.0
Reforestation	126,060.00	20.1
semi-natural	81,750.00	13.1
temporarily unstocked	11,220.00	1.8
Total	625,750.00	

Note these figures constantly change due to e.g. felling, afforestation and reforestation.

Broadleaf species are generally perceived to constitute less of a pressure on the aquatic environment than conifer species. Planting of native broadleaves in native riparian zones may also benefit the aquatic environment through bank side stabilisation and habitat improvement. Some broadleaf species may also contribute to acidification but to a lesser extent than conifers.

Pressures with potential to impact on water quality come from

- Established forests (physical presence and location in the landscape)
- Forestry operations, (site preparation, planting, fertilisation, road construction, thinning, harvesting and restocking)

Historical Background

Prior to the mid 1980s, forests were established, in compliance with best knowledge and practice at that time before the publication of the current Forest Service Environmental Guidelines. The current Guidelines have evolved based on scientific research and consultation between the forest sector and water regulatory bodies into the cause and effect of water quality issues related to forests and forest operations in general. As evidence, knowledge and understanding increased new guidance was introduced to mitigate against observed pressures. For example, historically forests were established on lands considered marginal for agricultural purposes such as deep peats (blanket and raised peat), which may have been of natural or semi natural habitat, with no allowance for an unplanted buffer zone between the trees and the stream bank. The use of phosphate fertiliser was also often required for impoverished

[7] Forestry Schemes Manual, Forest Service, Dept. of Communications, Marine and Natural Resources

marginal sites due to their poor nutrient properties. Additionally these areas were drained directly to existing watercourses providing a direct conduit for silt and nutrient loss to water bodies. Subsequent guidance required the use of buffer zones at establishment and replanting stage to mitigate against silt and nutrient loss and reduce light occlusion to watercourses. However, published Guidance documents have only been available since 1990 with the publication of the Forestry and Fisheries Guidelines and other Guidelines in response to the expansion of the private forest estate. Prior to this, silvicultural directives and standard operational procedures developed by the Forest and Wildlife Service (currently the Forest Service, Department of Agriculture, Fisheries and Food) for District and local forest management were in place since the early 1980s. The Forest Service Guidelines of the 1990s were revised and expanded in 2000 and in subsequent years. In some cases the practice was to install buffer zones prior to this date following agreement between Local Management and Fisheries. Buffer zones were also established in some areas of the country as part of specific schemes and projects. In reality a gradual introduction of buffer zones occurred since the mid 1980's.

Total stocked forest by age class is shown in Table 6.

Table 6 Total Stocked Forestry by Ownership and Age Class[6]

	Ownership/Area			
Age Class (10 years)	**Public %**	**Private (grant aided) %**	**Private (other) %**	**Total %**
Temporarily unstocked	2.8	0.4	0.5	1.8
1-10	26.3	56	14.2	33.7
11-20	25.5	39.9	20.3	29.1
21-30	18.4	2.4	20.2	13.8
31-40	16.2	0.4	15.3	11.4
41-50	7.3	0.03	9.4	5.4
51+	3.5	0.9	20.1	4.8

This indicates that about 35% of total stocked forestry exceeds 20 years in age and as such was planted prior to the introduction of the environmental guidance documents that were published in 1990. However this figure of 35% may be an overestimate and does not take into account forests where buffer zones were included as a result of good environmental forest practice introduced since the early 1980s that preceded these publications. It also does not take account of forests established on lands with no aquatic zones, such as the forests established on the Old Red Sandstones. Thus, a more accurate estimate may be less than 30% of forestry being planted without buffer zones complying with current standards in place[8]. Furthermore, much of this older estate was established on blanket peat and raised bog. Planting on blanket peat increased significantly in the early 1960's and peaked in the early 1980's; subsequently the trend was for the planting of gley soils.

Given the normal 40 year rotation cycle for commercial forestry it is primarily forest stands planted in the 1960's and 1970's which are now at harvestable stage and which supply the timber related industry in Ireland. The Forest Service, recognising that

[8] Source Forest Service

these areas, particularly those on peat soils, were established without the benefit of environmental guidance documents and pose a threat of sediment and nutrient loss in the absence of mitigation measures, issued new Guidelines, 'Forest Harvesting and the Environment Guidelines'[9] (which includes roading) in 2000 to specifically address this matter.

The area of forest established before the publication of guidelines and that has not been felled and restocked is a potential source of nutrients, acidification and sedimentation. The potential risks are compounded by the fact that the forests were mainly planted on peat soils, often on sloped lands and in catchments with sensitive water receptors.

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4.2 Potential Pressure from Established (Standing) Forests

This section deals with potential pressure from established forests, regardless of whether they were planted prior to the introduction of Forest Service Guidelines or not..

Forests by their physical presence have the potential to impact on water ecology through the following mechanisms:

- Acidification
- Sedimentation
- Eutrophication
- Shading and light occlusion
- Hydrological flow changes

but the degree to which this occurs depends on the effectiveness of controlling legislation, adherence to Forest Service Guidelines and Codes of Practices to mitigate impacts and to the effectiveness of the current guidelines
It should be noted that shading and light occlusion may also impart possible positive benefits to watercourses in the management of stream thermal regime, providing cooler refuges for fish species for example.

The degree to which this occurs depends on the effectiveness of controlling legislation, adherence to Forest Service Guidelines and Codes of Practices to mitigate impacts and to the effectiveness of the current guidelines.

4.3 Acidification Pressure:

Forests may exert an acidifying pressure[10] on surface waters (a) indirectly, through the enhanced transfer of atmospheric pollutants and in some instances sea salts to the catchment or (b) directly, through natural processes which occur within the

[9] Forest Harvesting and the Environment Guidelines, Forest Service Department of the Marine and Natural Resources July, 2000
[10] Forest and Water Project Acidification Literature Review

ecosystem, changes to the drainage pattern of the site and through scavenging of airborne pollutants.

There is a major need to understand the sources of acidity and acidifying mechanisms – particularly during high stream flow episodes. In general a primary cause is the deposition of acidifying sulphur and nitrogen compounds derived in part from combustion of fossil fuels and also from agriculture (ammonia). In addition, it has been shown that sea salts are a contributory source of acidifying ions in base poor catchments in the West of Ireland. Seasalts, being neutral, are not acidifying in themselves but through the interaction of sodium with soil acidity can drive a temporary exchange/release of acidity. This does not lead to long-term acidification. Allott *et. al*. (1997)[11] and Allott & Brennan (2000)[12], provide a detailed analysis of a number of acid events from catchments in the Galway - Mayo area. Of twelve events, one is described as being entirely driven by sea salts and is linked to a severe storm in the Atlantic. A further five events are described as having marine salts as a contributory factor. There is also strong evidence that pollutants occur in remote western catchments, both associated with easterly airflow and outside of severe easterly weather patterns in the form of dry deposition, which contribute to acid events during subsequent high rainfall periods.

Acidification is associated with the presence of closed canopy forests planted on acid sensitive areas. Elevation, rainfall intensity and type are also contributing factors Drainage network may also contribute but further research is required to fully understand its role. Acid sensitive areas are generally defined as base poor areas; typically acidic subsoil's overlying acid bedrock geology, with poor buffering capacity. Increased flow during rainfall events also dilutes and may bypass available bedrock and subsoil buffering capacity[13]. Tree species type is also important with acidification from evergreen coniferous forests higher than from broadleaf plantations.

Climate change effects could exacerbate some drivers of acidification. Climate Change Models suggest that the type of stormy weather which gives rise to sea spray events is likely to become more common in the future. So while the prevalence of atmospheric pollutants is likely to continue decreasing, the presence of acidifying ions from marine salts may become even more common, particularly along the western seaboard. In contrast increased temperature could promote soil weathering with the

Based on international studies, a number of processes have been suggested to explain the role of forests in increasing acidity and/or aluminium concentration in acid-sensitive surface waters[10]. These include:

[11] Allott, N., Brennan, M., Cooke, D., Reynolds, J., and Simon, N. (1997) AQUAFOR Report 4 Stream chemistry, hydrology and biota Galway-Mayo region. In: A study of the effects of stream hydrology and water chemistry in forested catchments on fish and macroinvertebrates. 4), Dublin, Ireland: COFORD.

[12] Allott, N. and Brennan, M. (2000) Nature and origin of acid episodes in western Ireland . I*nternationale Vereinigung für Theoreische und Angewandte Limnologie*, **27**, 2471-4

[13] WATERAC, Forestry and the potential for surface water acidification, Kelly-Quinn et al., EPA ERDTI study

1. interception by the canopy resulting in the enhanced transfer of atmospheric pollutants and in some instances sea salts to the catchment
2. uptake of base cations by trees and subsequent removal by harvesting
3. oxidation and mineralisation of organic matter resulting in the production of organic acids, sulphate and nitrogen compounds
4. alterations to site hydrology resulting in the reduced residence time of water and reduction in base-flow contribution
5. dissolution of aluminium in a highly toxic monomeric form depending on soil and subsoil type
6. the short-term release of nitrate following the large-scale felling of forest sites in acid-sensitive catchments. Studies in Ireland have shown that this is insignificant in Irish waters in terms of acidification (pEnrich[14], [15]Cummins & Farrell)

Evidence from the current study suggests that there is a risk of acidification where forests occur on peat soils in Ireland. The likely possible processes driving acidification under Irish forest areas are organic acid addition (derived from peat degradation), base-cation dilution, organic sulphur oxidation to sulphate, nitrate and marine-derived chloride. In Wales and Scotland, biological effects have been shown to vary between these acidification sources.[16] Understanding the exact process is important as there are consequences for management actions to be taken with potential implications for recovery.

A Protocol exists in relation to afforestation on sites potentially sensitive to acidification. This is described in the Forestry Schemes Manual (Appendix 19)[7] and precludes the establishment of forestry in areas of low buffering capacity based on periodic water chemistry analysis.

However, the protocol is confined to afforestation after 2002. It does not apply for example to replanting on acid sensitive sites but forest design does take this into account..

The magnitude of the pressure exerted by the scavenging effect of forests depends on the pollutant load (a measure of atmospheric pollution derived from anthropogenic sources), the percentage of forest cover in the catchment, tree species, stand age and structure, climatic conditions, rainfall volume and type and site characteristics, such as geology, soil type, elevation and aspect[10]. Drainage network may also play a role.

4.4 Sedimentation

The EU working group on Analysis and Monitoring of Priority Substances (AMPS) has proposed the following definition for sediment: particulate material such as sand,

[14] Machava, J., McCabe, O., O'Dea, P. Cabral, R. and Farrell, E.P., (2007) Forestry Operations and Eutrophication, PEnrich

[15] Cummins, T., & Farrell, E. P. (2003) Biogeochemical impacts of clearing and reforestation on blanket peatland streams II. Major ions and dissolved organic carbon

[16] Kowalik et al. 2007; Global Change Biology, 13, 2439–2452,

silt, clay or organic matter that has been deposited on the bottom of a water body and is susceptible to being transported by water (Stronkhorst *et al.* 2004)[17].

The European Environment Agency (EEA) provides a definition of sediment as "any material transported by water which will ultimately settle to the bottom after the water loses its transporting power. Sedimentation is defined as deposition of material of varying size, both mineral and organic, away from its site of origin by the action of water, wind, gravity or ice[18]. The EEA also provides a definition of silt as "the fine mineral material formed from the erosion of rock fragments and deposited by rivers and lakes. Its particles are the intermediate form between sand and clay. The particles can range in size from 0.01-0.05 mm in diameter".

The main potential sources of sediment from forests are as follows;

1. disruption of the soil surface, causing the soil and subsoil to be exposed to erosion and eventually, the transportation of the finer particles by overland flow;
2. weathering of parent material resulting in particle movement by overland flow (parent material comprising non-consolidated material represents a high risk);
3. the transportation of loose or decaying organic particles;
4. drainage systems, which reduce the length of overland flow paths and, thereby, the settlement of sediment on land. Drains can also potentially be a source of sediment by means of erosion;
5. removal of crop cover resulting in the exposure of unvegetated soil surface
6. windthrow of forest stands leading to the exposure of soil surface and is often preceded by soil pumping activity;
7. creation of forest roads;

Particles from any of these sources are referred to as sediment while in suspension and their accumulation on a streambed is referred to as sedimentation. Sediment can carry nutrients either adsorbed or chemically bound to the particles; some of which is bio-available or can become available depending on changes in the chemical environment. Soil erodability related to soil type and slope are also key elements in the degree of potential sediment loss and where certain soil types (e.g. peaty soils, sandstone derived soils) see Table 7 and steep slopes occur together, there is a greater risk of soil erosion and subsequent sedimentation. Rainfall intensity and the drainage network are also important factors.

Table 7 Assessment of Soil Erodability[19]

	Soil Erodability		
Soil type	Even to 1 in 7 (<15% slope)	1 in 7 to 1 in 3 (15–30% slope)	1 in 3 or greater (>30% slope)
Less erodable (e.g. gleys)	Low	Low	Medium

[17] Stronkhorst J, Brils J, Batty J, Coquery M, Gardner M, Mannio J, O'Donnell C, Steenwijk J, Frintrop P (2004): Discussion document on Sediment Monitoring Guidance for the EU Water Framework Directive. Version 2. EU Water Framework Directive expert group on Analysis and Monitoring of Priority Substances. May 25th, 2004

[18] http://glossary.eea.europa.eu/EEAGlossary/S/sedimentation

[19] Forestry and Freshwater Pearl Mussel Requirements – Site Assessment and Mitigation Measures, Forest Service, DAFF, 2008

Erodable (e.g. brown earths)	Medium	High	High
Very erodable (e.g. podzols, most peats)	High	High	High

The main potential for sediment loss in forest operations occurs at ground preparation stage for afforestation and replanting, at clearfelling and at the roading stage and is generally not associated with other stages of the forest lifecycle. However, when such operations occur forests have the potential to impact on water.

The magnitude of the potential for impact arises from factors such as site characteristics (area of operation, elevation, soil/subsoil type, erodability, rainfall intensity, drainage network, slope, catchment hydrology), age of plantation, degree of forest cover, forestry activities within a catchment and distance from receiving waters.

4.5 Eutrophication

Eutrophication is the process whereby a body of water becomes over-enriched with nutrients, in particular nitrogen (N) and phosphorus (P)[20]. This over-enrichment results in accelerated growth of algae and other plant life which in turn can deplete oxygen levels in the water, leading to the loss of aquatic biota. Forests in general provide a relatively small contribution to the overall N and P loading to running waters. Irish forests potentially have a high eutrophication impact as they are often located in upland areas draining into small headwater tributaries. These plantations generally receive applications of N and P at the establishment phase, they may then be subject to aerial fertilisation prior to canopy closure and are finally clear-felled. At all of these phases receiving waters could potentially receive significant nutrient inputs. These headwaters are normally very oligotrophic or nutrient poor and even small increases in N and P can produce significant changes in aquatic ecosystems. Headwaters may also provide a source of high quality water for public and private supply, support important salmonid fisheries and are often of a high conservation value.

For existing forest stands some P and N loss will occur to waters due to needle and leaf decay but this will be largely taken up by the existing forest crop root system. Low levels of nitrogen and phosphorus enter freshwaters through the natural supply from catchments, natural and semi-natural forests tend to be very economical with nutrients – releasing very little.

In undisturbed catchments, N and P originate from atmospheric deposition, rarely significant, and by leaching from soils and rocks. Undisturbed forests tend to exhibit tight nutrient cycling with only small exports to downstream sites[20].

[20] Eutrophication and Sedimentation Literature Review

4.6 Shading and light occlusion

Proximity of forest stands to stream courses, particularly with closed forest canopies can give rise to shading or light occlusion from headwater streams and from smaller rivers. Such shading can give rise to:

- Reduced temperature in the shaded areas.
- Reduced productivity in the shaded areas.

This can have both beneficial and negative effects. Shading leads to the modification of the regime by the riparian canopy and can potentially provide refuge for salmonid species and also offset potentially high temperature effects. Reduced temperature and light penetration can lead to reduced overall productivity in shaded streams. This in turn can lead to reduced fish productivity in the smaller 1st and 2nd order streams in forested areas which could potentially translate into reduced fish stock in a catchment where such streams form part of the spawning or nursery areas. Some shading of such streams is desirable to provide cooler refuge areas for fish during warm weather conditions. Native riparian woodland, with its lighter canopy, rate of application, providing dappled shade affords bank stabilisation and good stream productivity.

The issue of shading by existing forestry is largely a historic one, where trees were planted right down to the stream edge. In 1990[21] initial guidance on establishing buffer zones for forest establishment was introduced and with the introduction of the Code of Best Forest Practice[22], the Forestry Schemes Manual[7] and the Forestry and Water Quality Guidelines[23] requirements to establish buffer zones were introduced which effectively determine the light/shade ratio on the adjacent waters. Prior to 1990 buffer zones were provided in some areas by local agreement.

Woodlands of Ireland and the Forest Service have published Native Woodland Information Notes in support of the Native Woodland Scheme. Note No. 4 provides guidance on native riparian woodland design, establishment and management. There is a strong emphasis in this document on the use of native broadleaved trees in buffer zones to provide, among other things, a certain level of shading which will provide "dappled shade" and cooler refuges while not preventing light penetration altogether.[24] The document also deals with restoring native woodland on conifer plantation sites (under Element 1: Conservation) where appropriate.

The potential magnitude of shading due to existing forest stands is dependent on proximity to watercourses, degree of forested area adjacent to a stream bank, age and extent of canopy closure and species type. It is primarily an issue for forests planted prior to the issuing of Forest Service Guidelines and without buffer zones.

[21] Forest Service, 1990. *Forestry and Fisheries Guidelines.* Forest Service, Dept. of Energy, Leeson Lane, Dublin 2.
[22] Code of Best Forest Practice, Ireland, Forest Service, Department of the Marine and Natural Resources, 2000
[23] Forestry and Water Quality Guidelines, Forest Service, Department of Agriculture, Fisheries and Food
[24] Native Woodland Scheme Information Note No. 4, Native Riparian Woodlands – A Guide to Identification, Design, Establishment and Management, Little et al, June 2008

4.7 Hydromorphological Change

Forest canopies may alter the hydraulic balance of a catchment acting as effective precipitation interceptors absorbing moisture and increasing evapotranspiration losses due to their extensive foliage surface area. This may reduce the effective rainfall runoff within the forested area leading to lower stream flow. In the UK reduced water yield, in comparison to moorland or grassland areas, generally increases with forest height and canopy cover. Interception is greater in windier and wetter areas. In less windy drier areas interception loss is less but tree transpiration rates become more dominant, through tree roots reaching deeper soil water layers, and may have greater impact on such lower yielding areas[25]. Coniferous plantations tend to exert greater pressure than broadleaves, which have a lower evapotranspiration effect.

At the forest edge the forest stand may effectively intercept rainfall giving rise to increased precipitation in these areas increasing stream flow with potential hydro-morphological impacts.

Afforestation may bring about fundamental changes in the hydrology of catchments (or sub catchments) with subsequent alteration of flood regimes and durations and in the overall ecological balance of catchment streams. The low flow impacts are ameliorated when forest stands are felled and increase in water yields can be observed but impact from flow pressure may increase. Overall research suggests that the contrasting effects of different stages of the forest cycle on water yield will even out on a large catchment scale. [26]
Where forests are established in the catchment area of water abstractions or water dependent habitats and species potential impacts on the water resource may occur both with reduced flow levels and reduced water table and also through washout with increased and more rapid flood peak height.

The potential magnitude from hydraulic flow change due to existing forest stands is dependent on extent of catchment area forested, size of catchment, extent of canopy closure and species type, presence of felling operations, drainage network, slope rainfall intensity and beneficial uses of the catchment.

4.8 Potential pressures associated with forestry operations.

The previous section dealt primarily with existing forests and how they may interact with the aquatic environment. This section looks at forestry operations which include establishment, fertilisation, thinning, clear fell and restocking. Some of the pressures arising from such operations have been described above.

4.9 Establishment

Site suitability for afforestation

[25] Forests and Water Guidelines, Fourth Edition, Forestry Commission, UK
[26] Significant Water Management Issues, Digest of Comments, Environment and Heritage Service, Northern Ireland. (2007)

Afforestation in the catchment may introduce either a positive or negative pressure on water quality in that catchment.

Criteria for suitability of sites for afforestation are set out in the Forestry Schemes Manual[7]. The term afforestation means the planting of land not previously under forest. Silvicultural standards are set out which specify suitable tree species, provenance, soil requirements, species mixes, drainage requirements, ground cultivation options, stocking densities, fertiliser application and weed control measures amongst others.

The site assessments required and development of an afforestation plan provides an early stage for identifying and managing potential pressures from afforestation.

Site Preparation.

The initial site preparation involves

- Delineation of buffer/exclusion zones and areas for biodiversity enhancement
- Ground cultivation
- Drainage
- Herbicide use (if required)
- Roading

All are subject to Forest Service approval.

Buffer zones and biodiversity enhancement

Areas for biodiversity enhancement (ABE) which comprise open spaces and retained habitats are aimed at encouraging the development of diverse habitats, native flora and fauna and biodiversity. There is a requirement to treat up to 15% of the forest area with particular regard for biodiversity, comprising 5-10% open space and/or 5-10% retained habitat.[27] The requirement to establish ABEs applies to replanting areas also leading to restructuring of the older forest areas.

The buffer zone which forms part of the ABE, is not restricted to the riparian zone. It is an area adjacent to the aquatic zone which is managed for the protection of the water quality and aquatic ecosystems[25]. Ground preparation is prohibited within the buffer zone. Research work is still required to quantify optimum buffer design and management with respect to size, specific species mix and soil erodability to benefit hydromorphology, stream energetics and thermal regime.

The Forestry and Water Quality Guidelines[23] sets out required buffer zones which are based on slope, soil erodability, landscape and management considerations. These Guidelines coupled with the adherence to good forest practice and the Forest Biodiversity Guidelines provide the basis to conserve and enhance the biodiversity value throughout the entire forest.

[27] Forest Biodiversity Guidelines, Forest Service, Department of the Marine and Natural resources, July 2000.

Ground Cultivation

Ground cultivation is required to provide a suitable medium for the planting of young trees. Methods of soil cultivation are dependent on slope, soil and subsoil type and are set out in the Forestry Schemes Manual (Chapter 9, Section 9.9)[7]. The primary methods are the following:

Mounding	Blanket peat Carboniferous surface water gleys, Peaty gleys and Podzolised gleys with <20cm peat, slopes < 5 degrees
Ripping	Peaty podzols, peat depth less than 20cm. Brown earths and other free draining materials with indurated iron pan Brown earths and other free draining materials
Scarify	Brown earths and other free draining materials
Agricultural ploughing	Brown earths and other free draining materials.

Note: Mounding includes scrap mounding and inverted mounding which would not have associated drains. Double Mould Board ploughing has been utilised in the past but currently is no longer practiced.

The main potential pressure from ground cultivation is the release of sediment from the site. In the case of mounding, mound drains are also constructed which provide a pathway for soil and subsoil loss to watercourses if interceptor drains, sediment traps and other mitigation measures are not employed

The magnitude of the pressure will be dependent on extent of area afforested in relation to the area of the total catchment, the presence of vegetated buffer zones, site characteristics, ground cultivation method used, extent of area and proximity to the receiving waters.

Drainage

Drainage is required on some sites to lower the water table thereby encouraging tree growth. A site drainage and cultivation plan is mandatory for areas of 10 hectares or greater and optional below this threshold. Site drainage consists of a number of drain types as follows:

Collector drains	Collect water from mound drains and generally discharge via sediment traps to interceptor drains or in flat sites via sediment traps to the aquatic zone.
Interceptor drains	Constructed along the edge of aquatic buffer zones they collect drainage from the sub-catchment and allow it to overflow across the buffer zone
Cutoff drains	Constructed upslope of site to divert water away from site.

Adherence to mitigation measures in the establishment of the drainage network minimises the risk of nutrient, soil and subsoil transport to the aquatic zone.

Drainage generally involves opening drains that intersect rather than follow the natural contours of the landscape as equipment currently utilised for this purpose and for subsequent thinning and harvesting is unable to operate across steep slopes.

The main pressure from drainage is due to hydrological flow which may contribute to acidification, eutrophication and sedimentation pressures.

The potential magnitude is dependent on soil type and erodability, the presence of vegetated buffer zones, slope and ground cultivation method, extent of area afforested in relation to the area of the total catchment, rainfall, topography and proximity to the receiving waters.

Roading

Road construction is required both for management and harvesting purposes (Forestry Schemes Manual, Chapter 19). Management roads are constructed generally prior to planting or first thinning stage and are subsequently used for harvesting operations. In practice road construction is often left to the first thinning stage for economic reasons. A comprehensive set of mandatory specifications for forest road construction across all site conditions found in Ireland has been produced by COFORD in conjunction with the Forest Service[28].

The main pressure from roading arises from suspended matter loss leading to sedimentation in aquatic ecosystems during the construction and maintenance of the road network. Road construction on sloping sites or where soil erodability is high leads to higher risk.

The potential magnitude is dependent on soil type and erodability, slope, length of the road in relation to the area of the total catchment, the presence of vegetated buffer zones, road network density, drainage network, rainfall and proximity to the receiving waters.

Herbicides

Herbicides may be used where existing vegetation needs to be controlled prior to planting on fertile soils or where weed control is necessary post planting. Pit planting without cultivation generally need's a longer period of weed control around trees than mounded sites.

Conifers rarely require the use of herbicides at establishment stage while broadleaves require greater control of weed growth from competing vegetation and therefore may require the use of more herbicides.

[28] Forest Roads Manual, Guidelines for the design, construction and management of forest roads, COFORD, Ryan *et al*, 2004

All pesticides used are approved by the Pesticide Control Service[29] of the Department of Agriculture, Fisheries and Food. Guidance on the use of herbicides in forestry is provided in the Guidelines for the Use of Herbicides in Forestry (published by Coillte[30] on behalf of the Forest Service) and also set out in the Forest Protection Guidelines[31].

The potential impact is dependent on site hydraulic characteristics, herbicide used, rate of application, extent of usage in relation to the area of the total catchment, area afforested, persistence and behaviour of the herbicide and its formulation used and proximity to the receiving waters.

4.10 Fertilisation

On sites, such as those where afforestation or replanting occurred on marginal soils such as peats, the application of P and/or N, has been required to achieve economic growth rates or yield class. Yield class is a measure of the potential productive capacity of forests measured in cubic metres of timber per hectare per year (m^3/ha/yr)[32]. Generally sites of yield class potential less than 14 (m^3/ha/yr) require fertilisation.

Phosphorus is generally the main nutrient limiting factor for tree growth in Ireland. The need for fertilisation is dependent on previous land use and is related to the soil P reserves. Fertiliser is generally applied at establishment stage using a ground based method [mechanical or by hand]. An application may also be necessary at thicket stage, 12 to 15 yrs old. If a fertiliser application is necessary in a forested site which, because of tree and ground vegetation growth, is inaccessible to manual or mechanical application, the preferred method of application is by aerial means, which is subject to regulation[33] and is licensed by the Forest Service and must be supported by a foliar analysis.

Concerns have been expressed by Fisheries Boards over the practice of aerial fertilisation in salmonid catchments and it has been demonstrated that under certain circumstances, loss of phosphorus, ammonia and nitrogen to adjacent water courses can occur subsequent to such operations. The possibility of loss through runoff during subsequent rainfall is also an issue of concern for fisheries. To address these and other concerns the Forestry and Aerial Fertilisation, the European Communities (Aerial Fertilisation) (Forestry) Regulations 2006, S.I. No. 592, 2006 (as amended) and later the Forestry and Aerial Fertilisation Requirements have been published. Full

[29] http://www.pcs.agriculture.gov.ie

[30] Ward, D. (ed.) 1998. Guidelines for the Use of Herbicides in Forestry. 2nd Edition. Coillte, Forest Protection, Newtownmountkennedy, Co. Wicklow. Commissioned by the Forest Service

[31] Forest Protection Guidelines, Forest Service, Department of Communications, Marine and Natural Resources, Johnstown Castle estate, Co. Wexford, Ireland.

[32] http://www.coillte.ie/forests/forest_facts/glossary/

[33] European Communities (Aerial Fertilisation) (Forestry) Regulations 2006, S.I. No. 592, 2006 and as amended

enforcement of the regulations is critical to ensuring their effectiveness in controlling nutrient loss.

It has been suggested that afforestation should be restricted in areas where manual fertiliser application is inadequate to bring the crop to full maturity and for peat sites adjacent to sensitive water bodies, where it is required to bring a crop to full maturity, fertiliser should only be applied by hand . If a site's topography and soil is unsuitable to forestry development without recourse to aerial fertilisation, the site should not be afforested.

The normal fertiliser used is granulated rock phosphate (11% to 16% P). This is very effective on acid soils but super phosphate has been used on soils with pH > 6 and potato fertiliser (7:6:17) has been used successfully on broadleaf sites. The rate of application of rock phosphate can vary from 250 kg/ha (former agricultural lands not recently worked) to 350 kg/ha (unenclosed lands) and on more impoverished sites two applications may be made (350 kg/ha initially followed by 250 kg/ha at a later stage)[7]. Forest stands on deep peat and peaty mineral soils generally require higher P application rates than mineral soils due to their inherent infertility and poor nutrient retention characteristics. These rates are based on phosphorus requirements for Sitka spruce and are used to guide requirements for other species. On recently farmed improved lands no application may be required.

The main pressure from fertilisation is due to nutrient loss to the receiving aquatic environment. This has the potential to occur in a number of ways:

1. Leaching of applied fertilisers.
2. Wind drift into the aquatic zone during aerial fertilisation.
3. Sediment loss with adhered nutrient.

The magnitude of the pressure is dependent on the size of the area to be fertilised in relation to the area of the total catchment, presence of vegetated buffer zones, tree species, application rate, type of application, site characteristics including slope, drainage, soil type and nutrient retention capacity, rainfall and proximity to the receiving waters.

4.11 Thinning

Thinning is carried out to enhance the quality of the final crop, maintain its health status and ensure correct ecological balance. The first thinning occurs about year twenty when the trees are 10 to 15 m in height. The material harvested is used for pulp and pallet wood. A second thinning is undertaken about four years later to remove weak or malformed trees. Felling of the trees is done by mechanical means by a specially designed harvester. A second machine is used to extract the harvested logs to forest roadside.

The main pressures that arise from thinning operations are:

- Nutrient loss from decaying brash mats; and/or
- Particulate release from the roading operations pre thinning

Nutrient loss from decaying brash may not be significant at thinning stage as the standing forest is likely to absorb the available nutrients. The main pressure at this stage is from roading operations with the potential to release soil particles particularly on steeper slopes and on soils/subsoil's with high erodability.

The magnitude of the pressure from thinning operations will depend on the size of the forest area in relation to the area of total catchment, the presence of vegetated buffer zones, the extent of thinning area, the site characteristics particularly soil type, slope, erodability, hydraulic characteristics and proximity to the receiving waters.

4.12 Clearfell

Clearfelling of forests involves the removal of trees using specially designed harvesters (Figure 2) and forwarders (Figure 3). In some cases manual felling, using chainsaws, of selected areas is undertaken. As in the case of thinning operations, the brash mats created by the harvesting process are used as tracks for passage of the equipment. The forwarders move the felled timber, transporting it to the forest road for collection and transport to the processing plant . Clearfelling usually occurs at year 35 plus when trees have reached felling stage. At clearfell stage small quantities of urea are applied automatically to the tree stumps by the harvester to prevent infection by *Heterobasidion annosum* (syn *Fomes annosus*) a butt rot of coniferous trees.

The age of the forest crop and year of establishment needs to be considered when assessing the potential impacts from forest harvesting. Initial environmental guidance was introduced by the Forestry and Wildlife Service in the 1980s which set out protection buffer zones for water courses, followed by the publication of the Forestry and Fisheries Guidelines in 1990. This was followed by the suite of Forest Service Guidelines which was published a decade later.

Consequently forest stands since 1990, have been established in compliance with these environmental guidelines with some forest stands established with buffer zones and environmental controls prior to this date (e.g. under the EU funded Western Package Scheme some 24,000 ha were afforested between 1982 and 1990[34]) and arising from consultation with the Fisheries Boards. These stands will have established buffer zones and curtailed drainage networks (terminating prior to the buffer zone). By contrast, in older plantations trees will have been planted to the stream bank with drainage networks often connecting directly to the aquatic zones. It is these latter stands that are primarily being harvested at present. The restocking of these sites must comply with current guidelines.

[34] A Survey of Western Package Afforestation Scheme Plantations in Relation to Thinning Needs John Redmond, Áine Ní Dhubháin and Gerhardt Gallagher, COFORD Connects

Figure 2 Harvester in operation

Figure 3 Forwarder removing timber from site

Data from the National Forest Inventory[35] suggests that approximately 30% of the forest estate was planted prior to the introduction of environmental guidelines requiring buffer zones or drainage management.

The primary pressures acting on the aquatic zone from harvesting operations may arise from:

- Particulate loss
- Nutrient losses as a result of brash decay releasing phosphorus and nitrogen
- Physical impact on streams from brash debris
- Hydromorphological impact as a result of canopy cover loss

The magnitude for all pressure at harvesting is heavily dependent on the scale of the felling operation. Increased trafficking on brash mats and roads provides the potential for increased soil particle loss. The more extensive (in terms of volume of material) brash mats used on site the greater potential for nutrient loss over prolonged periods to the aquatic zone. Studies show that P losses vary widely in Ireland from 0.05 to 0.07 kg P/ha per annum observed in a peatland Ballinagee catchment in Wicklow up to 7.2 kg P/ha per annum from a clearfelled site of mature conifers on the previously fertilised Owenriff catchment in Connemara.[36] The ability of soils to store P is also a factor. High organic matter soils exhibit lower P sorption capacity than mineral soils. In high organic matter soils P tends to stay in the soil solution phase indicating that these soils may be unsuitable for heavy applications of P.[37] On these peat areas the main source of phosphorus will arise from fertilizer application, brash and root decay post clearfell.

The increased hydraulic flow (may be of the order of 15%) from the clear felled site can give rise to stream surge resulting in physical (hydro-morphological) impacts in

[35] National Forest Inventory, Republic of Ireland, Proceedings of NFI Conference, Forest Service, Department of Agriculture, Fisheries and Food, 2007, p 49.
[36] Forestry And Freshwater Pearl Mussel In The Owenriff Catchment, Owenriff Working Group, in press
[37] K. Daly1*, D. Jeffrey2 & H. Tunney, Soil Use and Management (2001) 17, 12±20, The effect of soil type on phosphorus sorption capacity and desorption dynamics in Irish grassland soils,

receiving streams leading to bank erosion and stream widening. The pressure potential may be more pronounced for older forest stands which are clearfelled due to the absence of buffer zones and drainage networks extending into the aquatic zone.

The magnitude of this pressure is dependent on factors such as coup size to be felled, in relation to the area of the total catchment, the presence of vegetated buffer zones, site characteristics (slope, soil, subsoil, and erodability), rainfall, drainage network, tree species and proximity to the receiving waters.

4.13 Restock of felled sites

Reforestation may occur through natural regeneration of a site or through restocking. The Forestry Act of 1946 stipulates the requirement for restocking of areas cleared under either a Limited Felling Licence (section 41 of the Act) or a General Felling Licence (Section 29 of the Act) within a specified time frame, after the clearfelling operations[38]. The restocking condition may be waived by the Minister in the case of a Limited Felling Licence.

Restocking generally requires some initial site preparation. This may involve windrowing of brash, upgrading of former drainage systems to comply with current guidelines and appropriate cultivation of the sites where necessary. Scrap mounding between windrows is sometimes practised to provide a planting medium. Planting is generally by hand at a density of 2,500/3,300 trees per hectare but mechanical planting is also practised to a limited extent. Restocking is carried out in accordance with the principles set out in the Forest Service suite of Guidelines, the Code of Best Forest Practice and the Forestry Schemes Manual, which includes the establishment of buffer zones along all aquatic zones.

The National Forest Inventory indicates that about 20% of the existing forest stock is on reforestation sites which include both restocked and natural regeneration areas. The main pressures arising from restocking are similar to those for afforestation sites but to a lesser extent, because less ground preparation and drainage will generally be required and roading will already have been established.

Pesticide.

Both insecticides and herbicides are used in forestry practice in Ireland. The use of such pesticides is authorised by the Pesticide Control Service (PCS) of the Department of Agriculture, Fisheries and Food, which is the Regulatory Authority with respect to plant protection products in Ireland. The authorisation of use for such plant protection products is regulated by Council Directive 91/414/EEC[39] concerning the placing of plant protection products on the market. Insecticides and herbicides by their nature can impact significantly on aquatic ecology reducing insect and plant abundance if they reach the aquatic environment.

[38] Irish Statute Book, Acts of the Oireacthtas, Forestry Act, 1946

[39] COUNCIL DIRECTIVE of 15 July 1991concerning the placing of plant protection products on the market (91/414/EEC) (OJ L 230, 19.8.1991, p. 1)

Insecticides on restock sites are used to manage the threat of pine weevil (*Hylobius abietis*) attack. The use of insecticides is associated almost entirely with clearfelling and replanting activities. The main insecticide used by Coillte (2006) for this purpose is cypermethrin, a synthetic pyrethroid..[40,41] The Report of the Dangerous Subnstances working Group has not indicated detectable levels of pesticides from forested areas. The use of pre-treated plants minimises the need for on site application of insecticides. Herbicides are used to control weeds which are the most common and persistent threat to young tree crops. Typical pesticides used by Coillte in 2006 are listed in Table 8.

Table 8 Pesticides used by Coillte 2006[40]

Type	Active ingredient	Product	Amount of active ingredient (g/l)
Insecticide	alpha-cypermethrin	Agromethrin	40
Insecticide	alpha-cypermethrin	Bestseller	100
Insecticide	cypermethrin	Forester	100
Insecticide	carbosulfan	Marshal suSCon granules	10%*
Herbicide	asulam	Asulox	400
Herbicide	atrazine	Atrazine	500
Herbicide	glyphosate	Roundup	360
Herbicide	glyphosate	Biactive	360
Herbicide	glyphosate	No-Mix Hilite	144
Herbicide	imazapyr	Arsenal	250
Herbicide	triclopyr	Garlon 2	240

* applied as a solid

The use of vigorous plants, coupled with site preparation may reduce the effects of competing vegetation and reduces the requirement for herbicide application, but where weed control is required the use of herbicides is generally the most economically efficient and effective method of crop protection. Allowing the site to remain fallow for a period of two to three years reduces the threat of pine weevil attack (provided adjacent sites are not clear felled in this period) thereby reducing the need for insecticides. However, this may require more herbicide use to suppress vegetative growth and also reduces the potential for nutrient uptake from decaying brash by newly planted trees.

The main potential pressures arising from restocking activity include

- Particulate loss leading to sedimentation in the aquatic environment
- Pesticide losses (both insecticide and herbicide) impacting on aquatic ecology
- Nutrient losses impacting on aquatic ecology

It is unlikely that artificial fertiliser will be required at reforestation sites at planting stage but may be required at a later stage depending on tree growth and foliar analyses

[40] Western River Basin District, Measures and Standards , Forest and Water Report, Priority action, relevant pollutant and general component candidate substances for surface waters in Ireland, Nov 2006
[41] Personal communication, Michael Keane ., Coillte.

The magnitude of this pressure will depend on area of restocking, method of establishment, in relation to the area of total catchment, the presence of vegetated buffer zones, site characteristics (slope etc), species mix, time interval between clear felling and planting, type and quantity of pesticide/herbicide use if any and proximity to the receiving waters. Reforested sites will subsequently progress through the entire forest rotation cycle but the inputs may be different (e.g. nutrients from decaying brash may be sufficient for the establishment of the new crop).

5. Pathway Considerations

Potential pressures from forestry can act on the aquatic environment through different pathways. The key potential pressures identified are as follow:

- Acidification Pressure
- Nutrient enrichment pressure
- Sedimentation pressure
- Hydromorphological pressure
- Dangerous substances

The main pathways for each pressure are discussed briefly below.

5.1 Acidification pressure pathway

The potential for ecological damage by forests depends on the sensitivity of the catchment (buffering capacity) which is expressed primarily by a measure of either the alkalinity or acid neutralising capacity or critical load of the run off water. Alkalinity is imparted to the water through contact with the soils and bedrock. In general run off from poorly buffered soils and subsoil's overlying poorly buffered bedrock has the potential for acidification. Presence of non acidic soils/subsoil's and bedrock material within such areas may also impart significant buffering capacity to receiving waters. In many areas in Ireland geology is mixed. Catchment size, extent of drainage network and hydrology also has a bearing on the susceptibility of running waters to acidification. Studies have shown that during increased rainfall events alkalinity levels and consequently buffering capacity are reduced.[42,2]

Under an existing Protocol for the determination of the acid sensitivity of surface water in the context of afforestation[7], between the DEHLG and the Department of Agriculture, Fisheries and Food, assessment of the buffering capacity of receiving waters in specific mapped areas designated as acid sensitive is required for grant approval of afforestation. The original mapped areas were drawn up largely on the basis of expert knowledge. New GIS based mapping of potential acid sensitive areas is being produced under the Water Framework Directive, based on bedrock and

[42] Environmental RTDI Programme 2000-2006, Evaluation of the use of the Sodium Dominance Index as a potential measure of acid sensitivity (2000-LS-3.2.1-M2) , WATERAC, Cruikshanks R. et al, 2006

subsoil acidity to provide a more scientific mapped basis for designation of potential acid sensitivity. This will provide an indication where field sampling would be required to establish actual buffering capacity. Field studies, including chemical, biological and fish sampling, have also been undertaken to provide a better understanding of the relationship between buffering capacity and acid impact and to identify areas where acid impact has already occurred. The output of the studies will be used to inform a new protocol for acid sensitive areas in Ireland and will include recommendations as to chemical parameter thresholds which will indicate potential for acidification to occur due to poor buffering capacity. Critical loads may also be utilised.

The critical pathway factors for acidification impact to occur are in relation to available buffering capacity and acid load.

- Acid neutralising capacity of surface waters (related to bedrock and subsoil geology)
- Elevation
- Rainfall
- Soil type
- Site hydrology, including drainage and altered hydrological pathways
- Climatic conditions
- Location of and proportion of forests in the catchment
- Quantity of ambient pollution
- Geographic location (proximity to source of sea salts)
- Degree of degradation of organic matter

5.2 Nutrient enrichment pressure pathway

Nitrogen and phosphorus have different sources, different routes to a watercourse, and different temporal and spatial dynamics. P inputs display a higher degree of fluctuation in comparison to N inputs[20].

The amount of supplied phosphorus and nitrogen reaching a stream will be affected by a number of factors including soil type, sorption capacity of the soil particles, P concentration in the soil, permeability and porosity of the soil, soil disturbance (drainage and ground preparation), water pathways to streams (including drainage patterns), subsurface drainage patterns (groundwater can be important for lakes and rivers), vegetation (absorption capacity), rainfall patterns, slope, buffer width and on site buffering capacity. The pattern of flooding and drying of soils can be very important for P release also. P is predominantly lost from catchments through surface run-off during, and post, high rainfall events either in dissolved form or as a non soluble particulate fraction. It can also be lost through aerial fertilisation operations.

Nutrient loss from clearfelled sites, arising from brash decay, on peat soils (peat depths greater than 30 cm) has been identified as a significant cause for concern in published literature[20] and by field studies carried out under the Forest and Water Research Project[3]. Peat soils have limited ability to bind P, see above and forest stands on deep peat soil have the potential to release significant P loads to the aquatic environment through brash decay.

5.3 Sediment pressure pathway

Sediment comprises particulate material such as sand, silt, clay or organic matter that has been deposited on the bottom of a water body and is susceptible to being transported by water. These particulates may be brought into suspension in water through disturbance of soil layers, hydraulic flow across sites and through the associated drainage networks. The primary pathway for particulates to enter water, giving rise to sedimentation, is through water carrying soil and sediments either overland or through the drainage networks to freshwaters. Some pathways occur through highly permeable soils such as brown earths and brown podzols. The degree to which this occurs is dependent on factors such as rainfall and runoff, soil erodability, slope gradient and length and vegetation cover. In particular rainfall intensity is important for initial mobilisation of soil particles, as well as the % of precipitation which runs off the surface. The nature and length of the hydraulic pathway is obviously also critical.

Rainfall can break down soil aggregates and disperse the aggregate material. Lighter materials such as very fine sand, silt, clay and organic matter can be mobilised by the runoff water. More intense rainfall events can result in the movement of larger sand and gravel particles. Soil movement is usually greatest and most noticeable during short-duration, high-intensity rainfall but significant soil loss can occur through erosion caused by long-lasting and less-intense storms. Runoff can occur whenever there is excess water on a slope that cannot be absorbed into the soil or trapped on the surface, e.g. low permeability soils such as peats overlying low permeability bedrock.

The ability of soils to resist erosion, erodability, is related to the physical characteristics of each soil. Generally, soils with higher infiltration rates, higher levels of organic matter and improved soil structure have a greater resistance to erosion. Sand, sandy loam and loam textured soils tend to be less erodable than silt, very fine sand, and certain clay textured soils. Subsoil's on eroded sites tend to be more erodable than the surface soils due to their poorer structure and lower organic matter. Increasing slope leads to a greater potential for soil loss from erosion by water. Soil erosion by water also increases as the slope length increases due to the greater accumulation of runoff.

Vegetative cover also plays an important role in the prevention of soil erosion. Lower vegetative cover leads to increased erosion whereas increased vegetative cover tends to slow down the movement of surface runoff and allows excess surface water to infiltrate. The extent to which this occurs depends on the type, extent and quantity of cover. Vegetation and leaf residue combinations that completely cover the soil, and which intercept rainfall at and close to the surface, are the most efficient in controlling soil erosion. Closed canopy forests reduce erosion potential through rainfall interception and through channelling rainfall though root systems.

In older plantations (planted before environmental guidelines) drainage networks, where installed, may be linked directly with watercourses providing direct connectivity for soil particulate transport when forests are harvested or roading takes place. The establishment of effective buffer zones, for example along the lines of the

Native Woodland Scheme[24], prior to clearfelling coupled with sediment traps, would reduce sediment and nutrient loss to watercourses.

5.4 Hydromorphological pressure pathway

In addition to acting as a transport mechanism for other pollutants increased episodic flow in itself can have significant hydro–morphological impact on water courses, widening stream width, eroding banks, stripping bank side vegetation and removing substrate. It can also cause washout of streams in forested areas with loss of spawning areas. The main pathways for hydromorphological pressure are overland flow, interstitial flow, groundwater flow, drainage network density and stream density. Overland flow predominates in areas with poorly productive bedrocks such as granites and where subsoil's have moderate to low permeability. The more rapidly precipitation leaves a site the greater potential for impact that exists with changes to the overall hydrology of the catchments and the alteration of flood regimes and durations. For example, draining peat leads to loss of water storage capacity of this soil type.

Whereas erosion is probably the most important factor here, the catchment-wide changes in hydrology brought about by increased evapotranspiration and extensive drainage of peatlands for forestry development, also results in reduced low flows which may become major issues for loss of biodiversity, salmonid production and water balance in areas designated for the abstraction of waters.. See Section 3.7 above.

5.5 Pesticides

Pesticides are not routinely used in forestry practice. They are generally applied as spot application to trees for insect control or to specific areas for competing vegetation control. The main pathways are through overland flow, interstitial flow, groundwater flow and drainage to receiving waters.

6. Receptor Sensitivity

Surface water bodies (rivers, lakes, estuaries and coastal waters) will have different sensitivity designations dependent on their hydro-geology and chemistry, aquatic species diversity, existing status and designations under national and international legislation, such as the Freshwater Fish Directive, Habitats Directive and Birds Directive and location with respect to forest pressure in the catchment.

For the main forestry pressures the sensitivity of receptors to acidification is described in the Acidification Literature Review[10] and to eutrophication/sedimentation in the Eutrophication/Sedimentation Literature Review[20].

6.1 Protected areas sensitivity

Article 6 of the Water Framework Directive (2000/60/EC)[43]requires each Member State to establish a "register or registers of all areas lying within each river basin district which have been designated as requiring special protection under specific Community legislation for the protection of their surface water and groundwater or for the conservation of habitats and species directly depending on water"

In Ireland, this Register has been compiled on a national basis by the Environmental Protection Agency (EPA). The Irish Register of Protected Areas is based exclusively upon existing national and EU legislation regarding the protection of waters for economic, recreational and ecological purposes

- Areas designated for the abstraction of water intended for public consumption
- Areas designated for the protection of economically significant aquatic species (fish, shellfish)
- Areas designated as recreational and bathing waters
- Nutrient-sensitive areas
- Areas designated for the protection of habitats (including birds)

In particular the requirements of habitats and species are that they must achieve favourable conservation status and any standards and objectives for such areas must be met. Examples of highly sensitive areas include designated Freshwater Pearl Mussel (Margaratifera margaratifera) river catchments, salmonid catchments, and oligotrophic lakes. In addition water bodies classified as High status under the WFD must be protected to ensure no loss of status. These water bodies would include Arctic char (Salvalenus alpinus) lakes and areas with high EPA Biological Q assessment values (Q 4-5 and Q 5).

6.2 Acid sensitive areas

These are described briefly below. The ability of a stream or lake to neutralise acid inputs is expressed primarily by a measure of either the alkalinity or acid neutralizing capacity of the run off water. Surface waters with alkalinity values of less than 10mg/ as $CaCO_3$ are regarded as being acid-sensitive (Bowman, 1991)[44]. This is reflected in the Forestry and Water Quality Guidelines which designates sensitive areas to acidification as having alkalinity for surface waters of 10mg/l as $CaCO_3$. In the Forestry Schemes Manual 2004, Appendix 19, it indicates that

- no afforestation will be approved where the minimum alkalinity of the run-off water is < 8mg/l as $CaCO_3$.
- Full, partial or no afforestation will be allowed where the minimum alkalinity is between 8mg/l as $CaCO_3$ and 15mg/l as $CaCO_3$ subject to discussion with the EPA and
- afforestation is allowed where the minimum alkalinity is above 15 mg/l as $CaCO_3$.

[43] DIRECTIVE 2000/60/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 23 October 2000 establishing a framework for Community action in the field of water policy

[44] Bowman, J. (1991) Acid sensitive surface waters in Ireland, Dublin: Environmental Research Unit, pp 321.

The measurement of minimum alkalinity must be made with sufficient accuracy for these criteria to be used. Minimum alkalinity values are flow dependent and sampling should ensure high flow conditions prevail at time of sampling. Recently, an index of buffering capacity, the Sodium Dominance Index (SDI), has been evaluated as an alternative measure of susceptibility of streams to acidification under diverse flow conditions. The Forestry Commission in the U.K. currently uses a catchment based critical loads assessment when designating areas of acid sensitivity. Critical load is the measure used to quantify sensitivity of specific biological elements to inputs of air pollutant. It is defined as 'a quantitative estimate of the 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'. Upland streams are important nursery areas for salmonids in Ireland and as such are sensitive.

Acidification, accompanied by high concentrations of H+ and elevated levels of labile monomeric aluminium, impoverishes fish communities to varying degrees and has the potential to impact these areas (Driscoll *et al*., 1980)[45]. In Ireland, areas along the Western seaboard and Wicklow Uplands are sensitive to acidification.

6.3 Eutrophication sensitive areas

Waters vary in their sensitivity to nutrient enrichment from forestry. Upland waters that are naturally nutrient-poor (oligotrophic) and where biological activity is usually phosphorus-limited may be particularly sensitive, nitrogen can also be important in nitrogen limited systems. In extreme cases, P and N enrichment can produce excessive algal growths, resulting in dissolved oxygen fluctuations and disruption of the ecosystem (Correll, 1997[46]; Chambers *et al*., 2006[47]). P on its own is rarely important, although it may be toxic in some cases. N, however, can be directly toxic, in the form of ammonia and nitrite.

Salmonid rivers supporting salmonid fish species such as salmon and trout, particularly the younger life stages, are sensitive as these juvenile have a relatively weak tolerance to low oxygen concentrations and are thus particularly vulnerable to organic pollution.

Upland lakes with forested or partly forested catchments without adequate vegetated buffer zones may be adversely affected by nutrient load with increased deposition of sediment and P load.

Some water bodies with habitats and species designated under the Habitats Directive may be particularly sensitive to eutrophication such as the Freshwater Pearl Mussel (*Margaritifera margaritifera*).

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[45] Driscoll, C.T., Baker, J.P., Bisogni, J.J., and Schofield, C.L. 1980 Effect of aluminium speciation on fish in dilute acidified waters. Nature, 284(5752): 161-164.

[46] Correll, D.L. 1997. The role of phosphorus in the eutrophication of receiving waters: a review. *Journal of Environmental Quality*, **27**: 261–266

[47] Chambers, P.A., Meissner, R. F., Wrona, J., Rupp, H., Guhr, H., Seeger, J., Culp, J.M. and Brua, R.B. 2006. Changes in nutrient loading in an agricultural watershed and its effects on water quality and stream biota. *Hydrobiologia*, **556**: 399–415

6.4 Sediment sensitive areas.

Erosion and siltation resulting from cultivation, harvesting, drainage and road building operations associated with forestry can have detrimental effects on both macroinvertebrates and salmonid spawning sites due to sediment smothering the streambed and decreasing oxygen levels. Oligotrophic upland waters, salmonid spawning and nursery areas and sites designated for specific species, especially the freshwater pearl mussel under the Habitats Directive are particularly sensitive to sedimentation pressure.

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6.5 Areas sensitive to hydrological change

Upland oligotrophic waters, fish spawning and nursery areas and species and habitats dependent on water flow and water level are highly sensitive to hydrological change.

7. Programme of Measures

Under the Water Framework Directive[43], River Basin Management Plans must include a set of management measures aimed at achieving the default objectives within the 15-year time frame from the date of entry into force of the Directive, i.e. by 2015, unless alternative objectives are established. The required Programme of Measures (POM) (Water Framework Directive Article 11) can be divided into two broad categories, Basic Measures and Supplementary Measures.

Basic Measures are listed in Annex VI, Part A of the WFD and are set out in Section 7.1 below. These are "obligatory" and include measures required to implement existing Community legislation for the protection of water, (EU Directives and statutory obligations associated with their implementation), they may also require new additional legislation.

"Obligatory" means they are enforced through National Legislation which sets specific objectives and standards or which have designated specific areas, e.g. areas designated as Special Areas of Conservation under the Habitats Directive.

Basic Measures may be target specific, such as the control of pesticides under the Plant Products Directive (91/414/EEC) (also draft "sustainable use of pesticides" Directive) and protection of specific designated species under the Habitats Directive and/or may have spatial application such as the Habitat designated areas (SACs) with water dependent habitats and species, catchment areas of designated species such as the Freshwater Pearl Mussel (*Margaritifera margaritifera*) or catchment areas of water abstraction locations or bathing waters.

Any actions or new legislative instruments supporting the implementation of the "Basic Measures" or which are applicable to specific targets or spatial areas

designated by the basic measures are considered as basic measures themselves. For example, the Department of Agriculture, Fisheries and Food, Forest Service, Forestry and Freshwater Pearl Mussel Requirements – Site Assessment and Mitigation Measures are an action to ensure protection of the species under the Habitat Directive and are therefore an action to support a basic measure. The Aerial Fertilisation Regulations are designed to control diffuse pollution in the forestry context and are therefore a further action in support of a basic measure (Controls on point source and diffuse source discharges with an impact on the status of water).

Supplementary measures are optional but not exhaustive. Examples are provided in the directive (Annex VI, Part B), such as; administrative arrangements, economic or fiscal instruments, negotiated environmental agreements, emission controls, codes of good practice, re-creation and restoration of wetlands and rehabilitation projects.

Actions in support of basic measures can also be seen as supplementary measures if they are applied to areas outside of the basic measures. For example, Freshwater Pearl Mussel populations exist outside of the designated SAC populations of this species. The application of the Forest Service, Forestry and Freshwater Pearl Mussel Requirements – Site Assessment and Mitigation Measures to forestry in the catchment of these areas is not obligatory. However, it may be prudent to manage forestry in such catchments in accordance with the requirements of this document, hence a supplementary measure action, as these locations may be designated under the Habitat's Directive in future.

Supplementary measures may also become Basic Measures through obligatory requirements. For example, the Forest Service, Forestry and Aerial Fertilisation Guidelines introduced in December 2001[48] have effectively become obligatory with the publication of the Aerial Fertilisation Licensing Regulations, 2006, SI 592 of 2006 (as amended) which is an action to support a basic measure.

The designation of actions for forests and forestry as either Basic Measure or Supplementary Measure will be dependent on the location of forests, afforestation sites or re-establishment sites with respect to areas designated under the Basic Measures or associated with specific target controls under such measures.

7.1 Basic Measures

This section discusses the basic measures and their relevance to forests and forestry activities. These measures which are obligatory and which must be complied with are set out in Table 9.

Table 9 Basic Measures under the WFD and relevance to forestry

Basic Measure	Transposing Legislation	Relevant to Forests and Forestry Activities	Comment

[48] Forestry and Aerial Fertilisation Guidelines, Forest Service, Department of the Marine and Natural Resources, December 2001

Basic Measure	Transposing Legislation	Relevant to Forests and Forestry Activities	Comment
New EU Bathing Water Directive (Directive 2006/7/EC of 15 February 2006)	Bathing Water Quality Regulations 2008, S.I. No. 79 of 2008	Yes	May be relevant where forest exist within the catchment area of bathing waters, particularly for freshwater areas
The Habitats Directive (92/43/EEC) and Birds Directive (79/409/EEC)	The European Union (Natural Habitats) Regulations, S.I. 94/1997 (which have been amended twice with S.I. 233/1998 & S.I. 378/2005) transpose the requirements of both directives	Yes	If operation/activity is likely to have a significant impact on a designated area it requires an appropriate assessment regardless of whether or not the operation/forest is in the designated area (ex-situ effects). Relevant where surface water and groundwater dependent habitats and species exist within forested catchments. Cumulative effects must also be taken into account.
The Drinking Water Directive (80/778/EEC) as amended by Directive (98/83/EC)	Drinking Water Regulations (S.I. 278 of 2007)	Yes	Where forests are within the zone of contribution of water abstraction area
The Major Accidents (Seveso) Directive (96/82/EC)	European Communities (Control of Major Accident Hazards Involving Dangerous Substances) Regulations (SI 74 of 2006)	No	
The Environmental Impact Assessment Directive (85/337/EEC	Planning and Development Acts 2000 and 2001 and the Planning and Development Regulations 2001 to 2002.	Yes	Afforestation above 50 ha comes within the planning and EIS requirements. All afforestation applications are assessed for subthreshold EIAs Deforestation of areas greater than 10 hectares of natural woodlands and 70 hectares of conifers is also subject.

Basic Measure	Transposing Legislation	Relevant to Forests and Forestry Activities	Comment
The Sewage Sludge Directive (86/278/EEC)	Waste management (Use of Sewage Sludge in Agriculture) Regulations (S.I. No. 183 of 1991, S.I. No. 148 of 1998 and S.I. No. 267 of 2001).	Yes	Where sewage sludge may be used as a fertiliser source for forestry (e.g. coppice willow.)
The Urban Waste-water Treatment Directive (91/271/EEC)	Environmental Protection Agency Act 1992 (Urban Waste Water Treatment Regulations (S.I. No. 419 of 1994, S.I. No. 208 of 1999, S.I. No. 254 of 2001 and S.I. No. 440 of 2004). Waste Water Discharge (Authorisation) Regulations, 2007, S.I. No. 684 Of 2007	No	
The Plant Protection Products Directive (91/414/EEC) (also draft "sustainable use of pesticides" Directive (proposal of 2006))	S.I No. 320 of 1981 as amended, S.I. No. 83 of 2003 and S.I. No. 624 of 2001.	Yes	Relevant to pesticides used in forestry
The Nitrates Directive (91/676/EEC	European Communities (good agricultural practice for protection of waters) Regulations (S.I. No. 526 of 2007).	No	Although forestry is listed in the definition of agriculture in the Regulations, the net farmed area excludes forestry and woodlands.
The Integrated Pollution Prevention Control Directive (96/61/EC	Environmental Protection Agency Acts of 1992 and 2003 and the associated licensing	No	

Basic Measure	Transposing Legislation	Relevant to Forests and Forestry Activities	Comment
	regulations		
Other Basic Measures			
Practical steps and measures taken to apply the principle of recovery of costs for water use and measures to promote efficient and sustainable water use	National Water Pricing Policy Framework (1998)	No	.
Measures taken to protect drinking water sources	groundwater and surface water bodies that are used, or may be used in the future, as a source of drinking water for 50 persons or more, or where the rate of abstraction is more than $10m^3$ per day	Yes	Where forests exists within the zone of contribution of water abstraction location.
Controls on abstraction and impoundment with an impact on the status of water	register or registers of water abstractions and a requirement of prior authorisation for abstraction and impoundment	No	
Controls on point source and diffuse source discharges with an impact on the status of water	IPPC, LA Section 4 and 16 Waste Water Discharge (Authorisation) Regulations 2007 (SI No. 684 of 2007). Unsewered areas - Water Services Act 2007 Aerial Fertilization (Forestry) Regulations, 2006 SI 592 of 2006 and as amended by the Aerial Fertilization	Yes	Aerial Fertilisation Regulations

Basic Measure	Transposing Legislation	Relevant to Forests and Forestry Activities	Comment
	(Forestry) (Amendment) Regulations, 2006 SI 592 of 2006		
Authorisations of direct discharges to groundwater	Waste Water Discharge (Authorisation) Regulations 2007 (SI No. 684 of 2007)	No	
Measures to deal with priority substances	33 priority substances and 8 other pollutants. Eliminate and phase out priority hazardous substances. Regulations are expected to be made in early 2008	Yes	Where such substances are used in forestry
Controls on physical modifications to surface waters with an impact on the status of water	considering the introduction of regulations to control physical modifications to surface waters	No	Likely to be confined to large scale physical modifications
Controls on other activities with an impact on the status of water	Introduction of regulations under Section 52(6)(a) of the Wildlife Act, 1976, for the purpose of prohibiting the possession or introduction of any species of wild bird, wild animal or wild flora or any part, product or derivative of such wild bird, wild animal or wild flora which may be detrimental to native species" .	No	May be relevant to some tree species
Measures taken to prevent or reduce the impact of accidental pollution incidents	“Framework for Major Emergency Management” was published by the Office of Emergency Planning (an agency of the Department of defence) in 2006	No	

In addition to the basic measures there are specific pieces of national legislation which bring effective control to forestry as follows:

7.2 Forestry and National Legislation

Forestry Act 1946, Forestry Act 1988

The development of forestry in Ireland comes under the Forestry Acts, 1946, 1956 and 1988.

The 1946 Act reaffirmed the power of the Minister to undertake the collection, preparation, publication and distribution of statistics relating to forestry and promote and develop instruction and training in forestry. It also strengthened the legal position in relation to the felling of trees in the State. Felling of trees is subject to licence and a limited or general felling licence may be granted.

In the case of a limited felling licence, the Minister with responsibility for forestry can attach a replanting (reforesting) condition, a condition to protect and fence off such replanting (reforesting), as well as, a condition to preserve in accordance with the general practice of good forestry not only newly planted trees, but also any natural regeneration which might arise as a result of the felling and fencing. Alternatively the Minister with responsibility for forestry may waive the replanting obligation.

In the case of a general felling licence, it became compulsory to replant.

The Draft Scheme of a new Forestry Bill, which will replace the Forestry Act 1946, has been prepared by the Department of Agriculture, Fisheries and Food and will shortly be submitted to Government for approval to send to the Office of the Parliamentary Counsel for drafting.

The 1956 Act was enacted to facilitate acquisition of land for forestry and was repealed in 2000 by the Wildlife (Amendment) Act. The 1988 Act was enacted to establish Coillte Teoranta with responsibility for development of the State forests.

Recommendation for revision of the Forest Act 1946

Felling Licences issued under the Forestry Act 1946 establishes the requirement to replant where felling has occurred in accordance with the licences issued. This requirement may be waived by the Minister.

It is apparent from Table 8 below that prior to the early 1980s no documented environmental guidance was provided to ensure sustainable environmental forestry management for Irish forestry. Research into forestry development initially focused on identifying suitable species, growing conditions and growing requirements. Ongoing research into forest and waters resulted in the introduction of the current guidance documents and codes of practice. This is significant in terms of reducing any

potential impact of forests and forestry activities on the aquatic environment given the long life cycle of forests. Figure 4 provides a general indication of the percentage forests planted on each soil type by planting period[49]. This indicates generally that planting on peat or peaty soils predominated from the mid 1960's to mid 1980's, predating the guidance documents, and declined as the percentage planting on gleys increased. The data also suggests that planting on both peats and gleys declined since this period. Overall up to 43% of all forests, including some natural and semi natural woodland, are growing on peat soils (Blanket peat, Raised Bog, Fen peat and Cutaway peat) and this includes all species (coniferous and broadleaves). For coniferous species with an average 40 year rotation period it is these forests that are currently at the harvesting stage. As these forests, comprising less than 30% of the forest estate, were largely established without the benefit of the current guidance documents and codes of practice they will represent the most significant risk to waters as

- they will generally have been planted for the most part to the stream edge
- will not generally have buffer zones
- may have drainage channels leading directly to stream and river water courses

Guidance should also be produced by the Forest Service on the future management of these areas.

Current practice is to restock areas which may be acid sensitive and on which forest stands were established prior to the Protocol on acidification between the DEHLG and the DAFF Forest Service.

Consideration should be given in the revision of the Forestry Act to allow for the making of regulations, which could be brought in to enforce the Guidance documents and Codes of Practice and to provides a more statutory legal basis for such documents where required..

The requirement to replant under the Forestry Act on some of the earlier forested sites particularly where such sites are of low yield class, where phosphorus retention is low and where forests will not develop without significant artificial fertilisation may need modification. Options for these sites include no replanting, limited replanting with alternative species and no artificial fertilisation.
Where the replanting requirement relates to acid sensitive areas then options exist to not replant, replant limited areas, replant with more suitable species mix, buffer the neutralising capacity of key areas or provide compensatory biological enhancement through creation of buffer zones.

European Communities (Aerial Fertilisation) (Forestry) Regulations 2006, S.I. No. 592 of 2007 and the European Communities (Aerial Fertilisation) (Forestry) (Amendment) Regulations 2007, S.I. No. 790 of 2007

The Ministry for Agriculture and Food introduced the aerial fertilisation forestry regulations in 2006. Under these regulations a person shall not engage in the aerial

[49] Data provided by the Forest Service, Department of Agriculture, Fisheries and Food, March 2008

fertilisation of forests other than under and in accordance with a licence ("aerial fertilisation licence"). The form of the licence is set out in the regulation which requires site specific information and justification to be provided as part of the application. The regulation allows for consultation
"if it appears to the Minister that the proposed application might have significant effects in relation to water quality – to the appropriate local authority, the appropriate Fisheries Board and the appropriate River Basin District Board"

It also allows for the protection of European sites (notified for the purposes of Regulation 4 of the European Communities (Natural Habitats) Regulations 1997 (S.I. No. 94 of 1997), subject to any amendments made to it by virtue of Regulation 5 of those Regulations, and for which details have been submitted.

A licence may be granted by the Minister with conditions and with a specified time period.

The regulation provides powers to authorised officers to carry out inspections and maintain strict controls on aerial fertilisation practices.

The time period for which aerial fertilisation is allowed is set out in Section 13. Aerial fertilisation may only take place between 1 April and 31 August in any year. The Minister may, if he or she is satisfied that exceptional circumstances so warrant, grant an aerial fertilisation licence valid for a period outside of the specified period.
A person engaged in aerial fertilisation shall not, in respect of the fertiliser type used, exceed the parameters set out in the Schedule.

Detailed exclusion zones and land conditions are also set out in the Regulation (Section 14).

Local Government (Planning and Development) (Amendment) Regulations, 2001 (S.I. No. 539 of 2001) and European Communities (Environmental Impact Assessment) (Amendment) Regulations, 2001. (S.I. No. 538 of 2001) and European Communities (Environmental Impact Assessment) (Forestry Consent System) (Amendment) Regulations 2006 (S.I. No. 168 of 2006)

The European Communities (Environmental Impact Assessment) (Amendment) Regulations, 2001 (S.I. No. 538 of 2001) introduced the Forest Consent System.

The Forest Consent System is a statutory approval and environmental screening procedure for initial afforestation and it's introduction coincided with initial afforestation being taken out of the planning control system by virtue of the Local Government (Planning and Development) (Amendment) Regulations, 2001 (S.I. No. 539 of 2001).

The Forest Consent System provides for a mandatory environmental impact assessment (EIA) in respect of all afforestation developments in excess of 50 hectares and provides for the possibility of a sub-threshold EIA where a project is likely to have significant effects on the environment.

Under the Forest Consent System, the approval of the Minister for Agriculture, Fisheries and Food is required in respect of afforestation. All applications for

approval to afforest are subjected to an environmental screening procedure in order to assess the potential environmental impact of the proposed development. The environmental screening procedure examines the potential impact of the proposed afforestation development across a range of factors including, water quality, designated habitats, archaeology, landscape or other environmental considerations. Where it appears that a proposed afforestation development might have significant environmental impact, the Minister must consult with the appropriate prescribed body and may also undertake public consultation, before a decision is made to approve or refuse approval for the proposed development.

7.3 Actions in support of Supplementary Measures

7.3.1. Non-binding policy and guidelines

Under the Forestry Act, 1946 the Minister with responsibility for forestry is empowered to approve, and where appropriate, grant aid forestry developments by private individuals with conditions. Currently the Forest Service provides grant aid to many forestry developments including afforestation, forest road developments, urban woodland schemes and woodland improvement schemes. Grant aid is given subject to the adherence of the applicant to a suite of environmental guidelines and the Code of Best Forest Practice. Most of these are not legally binding but the financial incentives coupled with the licensing requirements serve as a control mechanism. The development of the current suite of forestry related environmental guidelines parallels the extent of research into the link between forests, forestry and the environment. As the potential for impact on the environment from forests and forestry was researched, founded on a solid scientific basis, new guidance' aimed at ensuring sustainable forestry management was developed and introduced. These form a series of policy instruments primarily addressing forestry related research, environmental issues and sustainable forest management and include the Irish National Forest Standard. The historical development of this guidance is outlined in Table 10.

Increasing awareness of the forest sector to water quality is evidenced by the research notes developed in the 1980's as the decade progressed and which culminated in publication of the Forestry and Fisheries Guidelines in 1991 (after the formation of Coillte in 1989) and the increasing level of private afforestation from the early 1980s. The major driving force for the initiation of private forestry in Ireland was the introduction of the Western Package Afforestation Scheme (WPS) in 1980. It was the first EU co-funded afforestation scheme (EU Regulation 1820/80) to be launched in the country and initially focused on eleven western counties where land was considered as 'disadvantaged' by the EU. Under the scheme an estimated 23,000 ha were afforested between 1982 and 1992 with plantations varying in size from 0.25 to over 100 hectares[50] [ref].
With the advent of the WPS, concern soon arose amongst the Fisheries Boards about the potential of forest operations on water quality, particularly on the environmentally sensitive areas that are prevalent in the West of Ireland. In response to concerns raised by Fisheries, Operation Directives were developed and issued by the Forest and Wildlife Service (F&WS) dealing with aerial fertilisation, water pollution and forest

[50] COFORD Connects - Socio-Economic Aspects No. 2

operations. In addition local agreements between the F&WS (and subsequently Coillte) local management and the relevant Fisheries Boards were made in regard to the protection measures to be adopted when planting some environmentally sensitive sites. More comprehensive and uniformly applied guidelines were developed by a Working Group in 1989, comprising of representatives from the Department of Energy (Forest Service), Central Fisheries Board, Coillte, Irish Timber Growers Association and the Department of Marine. This culminated in the publication of the Forestry and Fisheries Guidelines by the Forest Service in 1991. The new Guidelines dealt with all forest operations and included for the first time the concept of designating (acid) sensitive areas, leaving unplanted buffer zones adjacent to water courses, harvesting and road making.

Cultivation techniques were also rapidly changing during the 80's and better silvicultural methods to establish forest plantations at lower cost became available. Mounding, which was first introduced in 1982/3, soon became the cultivation method of choice by the late 1980s with the added benefit that it had a much lower potential impact on water quality in comparison to more traditional methods.

Table 10 Forestry Environmental Guidelines and Codes of Practice timeline

Guideline	Reference	Year of Introduction
Operation Directive 1/82	Forest and Wildlife Service	1982
Aerial fertilisation, Standard Contract 1982-84, Terms and Conditions for contractors	Forest and Wildlife Service	1982 - 1984
Annual Research Report 1982 - page 15-16 - Water quality in relation to afforestation	Forest and Wildlife Service	1982
Annual Management Conference 1983 - Abstract of presentation entitled 'Water quality in relation to afforestation'	Forest and Wildlife Service	1983
Research Note 3/84 - The Acid Rain Debate	Forest and Wildlife Service	1984
Operation Directive 3/86 - Aerial Fertilisation, 1986	Forest and Wildlife Service	1986
Site cultivation for reforestation, Research Note, 1987 (mounding in afforestation was already gaining popularity at this time and was the method of choice for a majority of establishment sites from 1988-9 onwards)	Forest and Wildlife Service	1987
Operation Directive 6/87 - Water Pollution and Forest Operations, 1987	Forest and Wildlife Service	1987
Fertiliser in watercourses, Research findings, 1988	Forest and Wildlife Service	1988
Forest Service, Forestry and Fisheries Guidelines (This included for the first time the concept of designating (acid) sensitive areas, leaving	Forest Service, Dept. of Energy, Leeson Lane, Dublin 2.	1991. (superseded by subsequent guidance)

Guideline	Reference	Year of Introduction
unplanted buffer zones adjacent to water courses, harvesting and road making)		
Forest Service, Irish National Forest Standard	Forest Service, DAF, Johnstown Castle Estate, Co. Wexford.	2000
Forest Service, Code of Best Forest Practice – Ireland	Forest Service, DAF, Johnstown Castle Estate, Co. Wexford.	2000
Forest Service, Forest Biodiversity Guidelines	Forest Service, DAF, Johnstown Castle Estate, Co. Wexford	2000
Forest Service, Forestry and Water Quality Guidelines	Forest Service, DAF, Johnstown Castle Estate, Co. Wexford	2000
Forest Service, Forestry and Archaeology Guidelines	Forest Service, DAF, Johnstown Castle Estate, Co. Wexford	2000
Forest Service, Forestry and the Landscape Guidelines	Forest Service, DAF, Johnstown Castle Estate, Co. Wexford.	2000
Forest Service, Forest Harvesting and the Environment Guidelines	Forest Service, DAF, Johnstown Castle Estate, Co. Wexford	2000
Forest Service, Native Woodland Scheme Manual	Forest Service, DAF, Johnstown Castle Estate, Co. Wexford	2001
Forest Service, Forestry and Aerial Fertilisation Guidelines	Forest Service, DAF, Johnstown Castle Estate, Co. Wexford	2001 (non binding until 2006) and now replaced by the Forestry and Aerial Fertilisation Requirements (2007)
Forest Service, Protocol for the determination of the acid sensitivity of surface water in the context of afforestaion	Forest Service, DAF, Johnstown Castle Estate, Co. Wexford	2002
Forest Service, Forest Protection Guidelines	Forest Service, DAF, Johnstown Castle Estate, Co. Wexford	2002
Forest Service, Forestry Schemes Manual	Forest Service, Department of Agriculture & Food (DAF), Johnstown Castle Estate, Co. Wexford	2003.
Forestry and Aerial Fertilisation Requirements	Forest Service, Department of Agriculture & Food (DAF), Johnstown Castle Estate, Co. Wexford	2007.
Forest Service, Forestry and	Department of Agriculture,	2008 obligatory in

Guideline	Reference	Year of Introduction
Freshwater Pearl Mussel Requirements – Site Assessment and Mitigation Measures	Fisheries and food	support of Basic Measure (SAC designated areas under Habitats Directive)

It should be noted that as new regulations, guidance or new codes of practice are introduced the implications for content of previous guidance needs to be reviewed and these documents will need to be updated. Some examples of this are as follow:

Forest Service, Forestry and Water Quality Guidelines

- Reconciliation of Areas Sensitive to Acidification with appendix 19 of Forestry Schemes Manual
- Updating of example in Appendix to reflect WFD classifications for water.

Forestry Schemes Manual

- Updating Chapter 11 Environmental Protection and Controls Consultation Process to reflect Freshwater Pearl Mussel Requirements

Table 11 lists additional management actions to be taken in support of measures.

Table 11 Management actions in support of the measures

	Actions in Support of Measures	Actioned by:	Comment
FM6	Revision of the Forestry Act 1946	Department of Agriculture, Fisheries and Food, Forest Service.	Revision to allow provision for the making of Regulations
FM7	Comprehensive review of all Codes of Practice, Guidance Documents and Forestry Schemes Manual to ensure cross referencing, reflection of developments in legislation, policy, environmental objectives and environmental findings as appropriate	Forest Service Department of Agriculture, Fisheries and Food	
FM8	Establish a scheduled review process with predetermined time intervals (annually, biannually etc) to maintain this suite of documents in an up to date state.	Forest Service Department of Agriculture, Fisheries and Food	

7.3.2. Voluntary Measures

Forest Certification

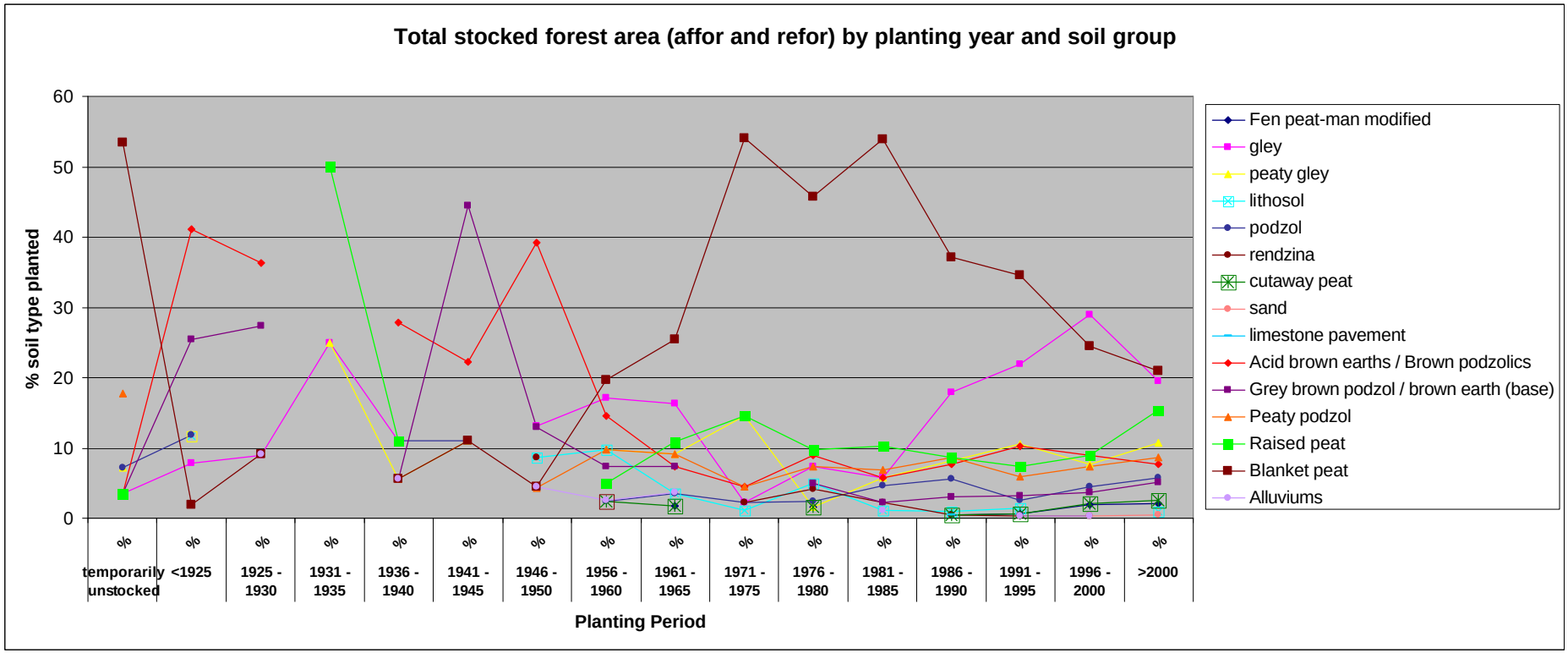
The Forest Service issued the Irish National Forest Standard in 2000[51] which sets out the framework for the sustainable management of forests in Ireland. It is based on six criteria for sustainable forest management, which were adopted at the Third Ministerial Conference on the Protection of Forests in Europe in Lisbon 1998. While the national standard is not a certification standard, it identifies appropriate forest practices and provides for the basis of forest certification. While there are many international forestry standards and certification schemes worldwide, in Europe two schemes dominate: Forest Stewardship Council (FSC) and the Pan European Forest Certification (FEFC). The latter was developed to address the certification needs of the small scale private owners, who considered the FSC scheme inappropriate for the size of the forests. In Ireland, the Coillte estate is subject to Forest Stewardship Council (FSC)[52] certification which is independently audited by professional auditors on an annual basis with stakeholder input. FSC is an international, non-profit association whose membership includes environmental and social groups and progressive forestry and retail companies working in partnership to improve forest management. The FSC International Standard, which was modified by the Irish Forest Certification Initiative to make it relevant to Ireland, requires Coillte to comply with 10 Principles and 56 Criteria that describe how forests should be managed if economic, environmental and social sustainability are to be achieved. This Standard goes beyond the statutory requirements and environmental impact is a key element in the Standard. This has given rise to Coillte (internal) guidelines on forest operations, which include the Forest Services Guidelines and additional measures which have been instituted arising from the findings of previous audits.

Riparian Woodland Scheme

Woodlands of Ireland and the Forest Service have published an information note entitled Native Riparian Woodlands – A Guide to Identification, Design, Establishment and Management. There is a strong emphasis in this document on the use of broadleaved trees in buffer zones to provide, among other things, a certain level of shading which will provide "dappled shade" and cooler refuges while not preventing light penetration altogether to support fish life.

[51] Irish National Forest Standard, Forest Service, Department of the Marine and Natural Resources, 2000
[52] http://www.fsc.org/en/

Figure 4. Total stocked forest area by planting period and soil type



7.4 Specific actions in support of measures

Potential specific actions to mitigate against the key pressures associated with forest stands and forestry are set out in Table 12 below. Actions outlined are site specific and will be based on a GIS based analysis of forest locations, acid sensitive areas mapping, forest soil type (on peat soils for example), where research has indicated potential for pressure impact. The obligatory nature of the actions will be determined by location of the pressure within a Basic Measure designated area or specific requirement and also by the sensitivity of the water body receptor.

All of the measures are technically feasible. The measures are expected to be used in combination in any one location with the most appropriate measures been selected on a site by site basis.

Measures have been divided in sub categories as follows:

FM - Management related Instruments: Identified to improve the flow of information, to ensure that all regulations and guidance are cross referenced. And to ensure that issues identified and proposed measures are incorporated into revisions of controlling legislation. These instruments also include education and awareness programmes.

FA – Acidification measures: Acidification appears on to be a management problem with Irish forests on some soil types, notably peat soils and to lesser extent peaty podzols on metamorphic and sedimentary rock. The mechanism for acidification effects under forest in Ireland is critical to the selection of appropriate measures which may include the following:

- avoid or limit afforestation on 1st and 2nd order stream catchments in acid sensitive catchments;
- restructure existing forests to include open space and structural diversity through age classes and species mix, including broadleaves.
- mitigate symptomatically using basic material (e.g. limestone or sand liming) – further research may be require to determine effectiveness of this measure;
- manage catchment drainage to improve residence times and soil wetting, including no drainage installation in some areas– further research may be require to determine effectiveness of this measure;
- Implement measures to increase stream production – for example with native woodland in riparian zones.
- Revise the Acidification Protocol to ensure actual minimum alkalinities are detected (i.e. ensure sampling under high flow conditions).

FE- Eutrophication measures/FS_ Sedimentation measures: Eutrophication and sedimentation pressure are identified primarily with forestry activities, principally clearfelling, and, in certain circumstances, aerial fertilisation occurring on peat soils. In some instances the impacts may be confined to the headwaters of streams but may be critical in others where sensitive catchments are involved with sensitive habitats

and species further downstream. Measures to control nutrient load from forestry operations include.

- avoid or limit forest cover on peat sites;
- change the tree species mix (e.g. broadleaves) on replanting
- limiting felling coup size
- new forest structures on older plantation sites (including new riparian zones, drainage layouts, species mix, open areas)
- establishing riparian zone management prior to clearfelling
- enhance sediment control
- manage catchment drainage to increase residence times and soil wetting, including no drainage in some locations
- Consider prohibition of aerial fertilisation on sensitive/ protected sites
- No replanting on certain hydrogeological settings (peat soils) on sensitive sites.

FH – Hydromorphological measures: Hydromorphological impacts can occur both from reduced water flow in catchments, due to increased evapotranspiration, in dry weather periods and from enhanced peak flood events increased flow from forested areas with large drainage networks established prior to environmental guidelines. Further research is necessary in this area to quantify the potential impacts. Measures which have been recommended include

- auditing of existing drainage networks in forest catchments
- enhanced drainage network management – minimise drainage in peat soils

FP- Pesticide use measures: Pesticide use is generally associated with forest establishment (herbicide) and with re-establishment post clearfelling (herbicides and insecticides) although some afforested sites may require insecticide application if situated close to recently felled coniferous stands. Measures which have been recommended include:

- reduction in pesticide usage
- pre-dipping of trees in nurseries prior to planting out
- development of biological control methods
- maintaining registers of pesticide use (it is acknowledged that this is a national issue relating to pesticide use in general across all sectors)

The suite of measures set out in Table 12 set out the recommended actions, water body objective target supported, specific objective of the action, implications of the action (deforestation may allow invasive species for example), targeted water bodies, body responsible for the action and comments.

It is envisaged that for a given area the most appropriate measures will be adopted from the suite of measures proposed as these will tend to be site specific.

7.5 Updated Guidance and Proposed New Guidance –Management of Older Forest Estates.

7.5.1. Updating existing Forest Service documents

It is recommended that a comprehensive review of the existing Forest Service Guidance documents and Codes of Forestry Practice be undertaken both to ensure cross referencing with up to date information and to incorporate measures recommended in Table 10 as appropriate.

7.5.2. Revised Forest Service Guidance document

It is also recommended that a revised guidance document on the management of older forest stands planted pre guidelines be developed by the Forest Service. Figure 4 indicates that a significant percentage of forests at harvestable stage are located on peat type soils. Their potential for phosphorus loss from decaying brash post harvest stage will be high due to the poor retention properties for P on these soils an dtheir direct connectivity with the aquatic environment. Sediment losses may also be an issue.

The management of these forest areas planted prior to the introduction of documented guidance and codes of practice will be critical to minimising the potential impact on the aquatic environment. The potential for forestry on these sites to impact on water quality will be very much site specific and will be dependent on factors outlined above (slope, species, size of area planted, soil type, hydrological aspects, weather conditions, location in river catchment and sensitivity of receptor). As such sites are managed under existing or modified guidelines and codes of practice, the potential overall forest pressure reduces.

Measures to mitigate potential pressure impacts from these older forest sites will, of necessity entail a combination of existing and additional forest management techniques. They will be attached as conditions to a felling and/or replanting licence issued for a specific site. It is recommended that a revised guidance document for the management of these older forest stands be developed by the Forest Service. This document will include a suite of optional management techniques which can be utilised as appropriate on a site by site basis drawn from the specific actions outlined in Table 11 below.

The potential impact of this proposed suite of management techniques on the requirements of other environmental legislation must also be assessed. For example allowing natural re-vegetation of buffer zones or of unstocked sites will need to ensure compliance with the Wildlife Act, Habitats or Birds Directive and measures to prevent invasion by alien species. These considerations may have further management and resource implications.

7.6 Effectiveness of Forest and Water Measures

The measures proposed have been developed by an expert working group with extensive environmental knowledge related to forestry and water in Ireland and with

extensive forestry management background. They have been developed based on research into pressures from forests and forestry, extensive literature surveys, best international practice and assessment as to their practicality and applicability in Ireland to the extent possible.

Some of the measures proposed, such as liming of catchments or establishment of buffer zones prior to felling for older forest plantations on peat, are technically feasible but have never been implemented on a large scale basis in Ireland although liming has been trialled in the UK.. They will require substantial catchment scale validation before widespread adoption. The selection of appropriate measures from the suite of measures available must be flexible to allow for site specific circumstances.

For acidification sites, complexities can arise where the implementation of measures under acidification, for example clearfell and no or limited replanting, could generate a nutrient enrichment pressure from the brash on site if no uptake crop were planted or natural regeneration was limited.. The magnitude of the nutrient pressure created would be dependent on the size of the felling coup. Hence, this could dictate the time period for clearfell of forest stands in a water body which subsequently may exceed one or more river basin management plan timeframe.

Research has shown that acid impact does occur in forested areas on certain geological settings in 1st and 2nd order streams. Whether this impact is significant in terms of the status of the entire water body will obviously be related to the percentage of the catchment forest cover on acid geology and the presence of alkaline geology providing buffering capacity within the water body also.

It is recommended that the significance of the acidification impact on the water body as a whole be determined through a full WFD status assessment, including chemistry, biology and fish, at a location on a third order stream selected to represent the status of the water body. If the status assessment indicates acidification impact leading to loss of good status then the measures must be implemented and could require reduced forest cover and/or the implementation of costly measures. The status assessment would include assessment of the favourable conservation status of relevant habitats or species in the catchment as a whole. A separate status assessment would need to be carried out on any lakes in the downstream receiving water. This process is set out in Figure 5 below.

In addition the mechanism of acidification is also not fully known.. Further research is needed in this area as it is critical to determining the most effective combination of measures required.

Eutrophication and sedimentation effects appear to be limited in extent and confined to recently felled sites, key forestry activities and to older forest plantations mainly on peat soils. Measures applicable to sediment control also have a beneficial effect on nutrient transport and associated pressures. These pressures derive from operational issues. Measures related to their controls have been identified. The effectiveness of some of these may be linked to the control of the drainage network in the forested area and may require a more prolonged time scale for implementation.

Hydromorphological measures may take some time to implement effectively, over several RBMP cycles. For example, modification of forest area drainage network will largely only become possible post clearfell. Given the long rotation cycle of commercial forests it is possible that time periods exceeding three RBMP cycles could occur to fully implement this measure.

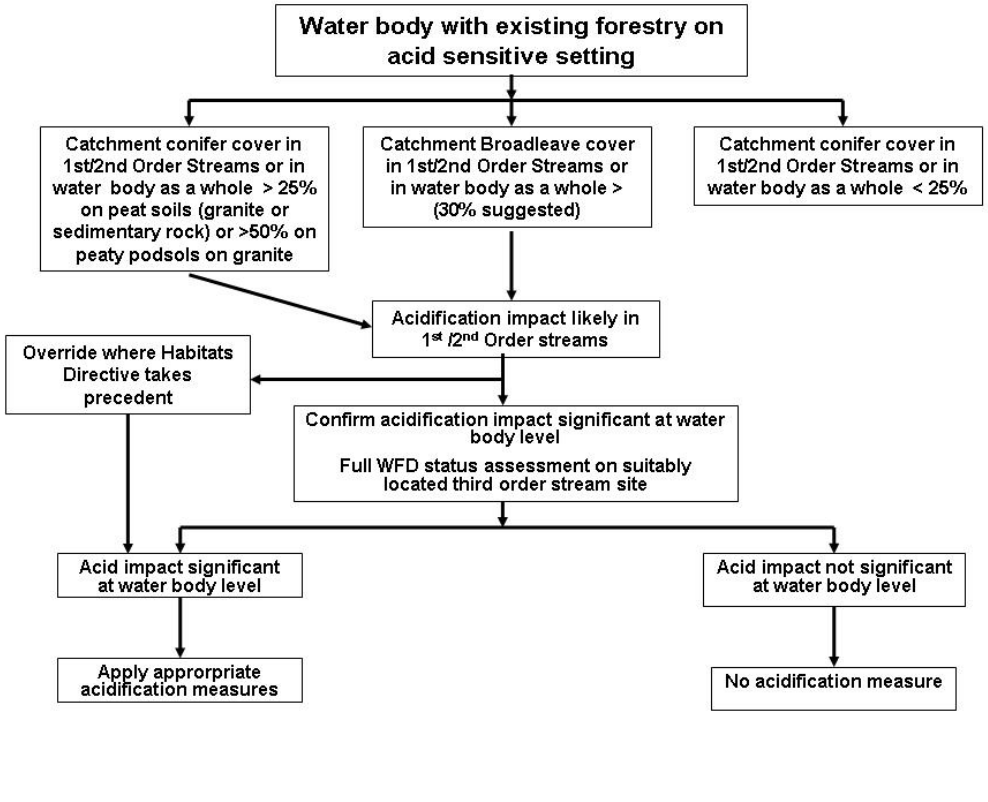


Figure 5 Decision tree for significant acid impact in a water body.

Table 12 Actions in Support of Basic and Supplementary Measures for Forest and Water

Action Item	Pressure	Forest Forestry setting/activity	Action	WFD water body Objectives	Specific Objective of action	Secondary Considerations	Alternative action	Target water bodies	Pressure targeted	Actioned by	Feasible	Time period required	Cost	Research Required
M	**Policy and Management Instruments**													
M1	Policy and Management		Finalise the Forestry Inventory and Planning System		Ensure up to date consistent National Forestry Inventory and Planning System			All	All	Forest Service Department of Agriculture, Fisheries and Food	Y	Medium Term	High	
M2	Policy and Management		Maintain an updated FIPS database		Ensure regular period updating of the National Forest Inventory and Planning System			All	All	Forest Service Department of Agriculture, Fisheries and Food	Y	Low	High	
M3	Policy and Management		Publish an updated FIPS database on an annual basis. Provide database to all Statutory Authorities and make available to the public		Ensure consistent national use of National Forest Inventory and Planning system			All	All	Forest Service Department of Agriculture, Fisheries and Food	Y	Short Term	High	
M4	Policy and Management		Data sharing: All relevant data to be shared among the stakeholders		Ensure all national data is available to all relevant agencies in the interest of good planning and management.			All	All	River Basin District Boards or EPA as the central data repository	Y	Medium Term	Low	

M5	Policy and Management		All data to be accessible in an agreed common GIS tool common to all stakeholders		Ensure all national data is available to all relevant agencies in the interest of good planning and management			All	All	EPA	Y	Medium Term		
M6	Policy and Management		Revision of the Forestry Act 1946		Take account of and incorporate recommendations from the Forest and Water Working Group			All	All	Department of Agriculture, Fisheries and Food, Forest Service.	Y	Medium Term	Low	
M7	Policy and Management		Review of all Codes of Practice, Guidance Documents and Forestry Schemes Manual		Ensure consistency across all guidance documents and Codes of practice			All	All	Department of Agriculture, Fisheries and Food, Forest Service.	Y	Short - Medium Term	Low	
M8	Policy and Management		Establish a scheduled review process with predetermined time intervals (annually, biannually etc) to maintain this suite of documents in an up to date state.		Maintain consistency across all guidance documents and Codes of practice			All	All	Department of Agriculture, Fisheries and Food, Forest Service.	Y	Medium Term	Low	
M8	Acidification impact tool		Develop biological metrics to detect acidification impact - inverts and fish		Provide an up to date national acidification impact tool			All	All	EPA, NPWS				
ED	**Education and awareness**													

'ED1	Education and awareness measures	All Forestry operations	Prepare public awareness and educational information for the forestry in general and the measures in place to protect the aquatic environment.	Protect	Increase awareness in Forest owners and the public re forest and water issues			All	All	Forest Service/NPWS/Fisheries/Coillte/COFORD/EPA	Y	Short term	High	
'ED2	Education and awareness measures	All Forestry operations	Host public awareness and educational information for the forestry in general and the measures in place to protect the aquatic environment	Protect	Increase awareness in Forest owners and the public re forest and water issues			All	All	Forest Service/NPWS/Fisheries/Coillte/COFORD/EPA	Y	Short term	High	

Table 12 Actions in Support of Basic and Supplementary Measures for Forest and Water

Action Item	Pressure	Forest Forestry setting/activity	Action	WFD water body Objectives	Specific Objective of action	Secondary Considerations	Alternative action	Target water bodies	Pressure targeted	Actioned by	Feasible	Time period required	Cost	Resea
A	**Acidification Measures**													
A1	Acidification	Afforestation	Strict adherence to Updated Protocol on planting in Acid Sensitive Areas	Protect	Ensure no acidification impact in areas designated as extremely or highly sensitive to acidification from forest cover			Water bodies with forest cover within the acid sensitive areas map	Source/Pathway	Forest Service and EPA	Y	Medium Term	Low	
A2	Acidification	Afforestation		Protect			Allow afforestation up to a specified threshold in headwaters of a water body provided canopy cover of coniferous species does not exceed 25% water body area overall and 25% in any second order stream catchment. For sensitive receptors catchment area to be delineated to the receptor.	Water bodies with forest cover within the acid sensitive areas map	Source/Pathway	Forest Service and EPA				

Table 12 Actions in Support of Basic and Supplementary Measures for Forest and Water

Action Item	Pressure	Forest Forestry setting/activity	Action	WFD water body Objectives	Specific Objective of action	Secondary Considerations	Alternative action	Target water bodies	Pressure targeted	Actioned by	Feasible	Time period required	Cost	Resea
FA3	Acidification	Existing forest stands	Identify existing forest stands on acid sensitive areas identified under the updated Protocol as being liable to acidification	Protect/Restore	GIS based mapping of forest stands on acid sensitive areas indicating potential impact risk	Confirm acid impact or likely acid impact by.	Assume area impacted significant in terms of water body status	Water bodies with forest cover in acid sensitive mapped areas with evidence of acidification impact	Source/Pathway	EPA/Local Authorities	Y	Short - Term	Medium cost	
						· Examining status classification of water body (monitoring results etc).								
						· Field sampling to determine acid impact at water body level before further action								
FA4	Acidification	Existing forest stands where acid impact likely or confirmed by field monitoring	No action option (leave trees standing)	Restore	No action taken to mitigate acidification	Assess % of water body catchment affected and determine likely impact on status.	Confirm acidification impact on status	Water bodies with forest cover in acid sensitive mapped areas with evidence of acidification impact		EPA/Local Authorities	Y	Short - Term	Low	

Table 12 Actions in Support of Basic and Supplementary Measures for Forest and Water

Action Item	Pressure	Forest Forestry setting/activity	Action	WFD water body Objectives	Specific Objective of action	Secondary Considerations	Alternative action	Target water bodies	Pressure targeted	Actioned by	Feasible	Time period required	Cost	Resea
A5	Acidification	Existing forest stands where acid impact confirmed or likely by field monitoring	Harvest forestry and no replanting where scavenging effects occur. Drainage alteration.	Restore	Remove pathway for acidification to occur	Produces potential eutrophication, sedimentation and hydraulic change pressure. Management issue of clearfelled area. May need to restore water table if the primary mechanism for acidification is dissolved organic carbon from peat degradation.		Water bodies with forest cover in acid sensitive mapped areas with evidence of acidification impact	Source	DAFF - Forest Service amendment to replanting requirements	Y	Short Term	Very High	
A6	Acidification	Existing forest stands where acid impact confirmed or likely by field monitoring	Harvest forestry with replanting of alternative non broadleave species.	Restore	Reduce potential impact through alteration of species mix in catchment. Drainage alterations may be required to establish alternative species.	Replanting may reduce nutrient loss through uptake by new plants	Identify suitable species mix for these areas which will minimise potential acid impact.	Water bodies with forest cover in acid sensitive mapped areas with evidence of acidification impact	Source/Pathway	DAFF - Forest Service amendment to replanting requirements.	Y	Shorrt Term Affor. Long term refor	Very High	

Table 12 Actions in Support of Basic and Supplementary Measures for Forest and Water

Action Item	Pressure	Forest Forestry setting/activity	Action	WFD water body Objectives	Specific Objective of action	Secondary Considerations	Alternative action	Target water bodies	Pressure targeted	Actioned by	Feasible	Time period required	Cost	Resea
						Acidification impact likely to occur when canopy closes				Possible support through Native Woodland scheme.				
A7	Acidification	Existing forest stands where acid impact confirmed or likely by field monitoring	Harvest forestry to provide a reduced % forest cover in catchment	Restore	Reduce potential impact through limited forested area in catchment (e.g. less than 25% of total water body catchment and less than 25% of second order stream catchments.	Acidification impact reduced to a level where status is not impaired		Water bodies with forest cover in acid sensitive mapped areas with evidence of acidification impact	Source	Possible support through Native Woodland scheme.	Y	Shorrt _Medium Term	Very High	
						Harvested areas may produce nutrient, sediment and some hydraulic change.								
A8	Acidification	Existing forest stands where acid impact confirmed or likely by field monitoring	Drainage curtailment	Restore	Reduce rate of flow across forested catchment to maximise uptake of acid neutralising base cations			Water bodies with forest cover in acid sensitive mapped areas with evidence of acidification impact	Pathway	Private Forest owner, Coillte, Forest Service Grant support?	Y	Medium Term	High	

Table 12 Actions in Support of Basic and Supplementary Measures for Forest and Water

Action Item	Pressure	Forest Forestry setting/activity	Action	WFD water body Objectives	Specific Objective of action	Secondary Considerations	Alternative action	Target water bodies	Pressure targeted	Actioned by	Feasible	Time period required	Cost	Resea
A9	Acidification	Afforestation	Buffer the forested area using alkaline based roading material	Protect			Plant acid sensitive areas to a specific threshold with less acidifying tree species if possible.	Water bodies with forest cover within the acid sensitive areas map	Source/Pathway	Forest Service and EPA	Y	Short Term	Very High	**Resea**
A10	Acidification	Existing forest stands where acid impact confirmed or likely by field monitoring	Buffer the forested area using lime	Restore	Provide additional buffering capacity to forested areas.	Significant impact from liming may occur to designated species such as Freshwater Pearl Mussel	Use of slow release alkaline material such as limestone rock.	Water bodies with forest cover in acid sensitive mapped areas with evidence of acidification impact	Source	Private Forest owner, Coillte, Forest Service Grant support?	Y	Medium Term	High	**Resea**
A11	Acidification	Existing forest stands where acid impact confirmed or likely by field monitoring	Buffer critical areas at strategic locations at critical flow outputs	Restore	Provide targeted additional buffering capacity to forested areas.	Some impact from liming may occur to designated species such as Freshwater Pearl Mussel	Alternative liming options include slow release lime based materials, lime silos (investigated by Environment Agency Wales) or lime grinding mills (investigated by EA Midlands, UK	Water bodies with forest cover in acid sensitive mapped areas with evidence of acidification impact	Source/pathway	Private Forest owner, Coillte, Forest Service Grant support?	Y	Medium Term	High	**Resea**

Table 12 Actions in Support of Basic and Supplementary Measures for Forest and Water

Action Item	Pressure	Forest Forestry setting/activity	Action	WFD water body Objectives	Specific Objective of action	Secondary Considerations	Alternative action	Target water bodies	Pressure targeted	Actioned by	Feasible	Time period required	Cost	Resea
FA12	Acidification	Existing forest stands where acid impact confirmed or likely by field monitoring	Buffer the forested area using alkaline based roading material	Restore	Provide additional buffering capacity to forested areas	Some impact on downstream species may occur.	Use of slow release alkaline material such as limestone rock as base road material.	Water bodies with forest cover in acid sensitive mapped areas with evidence of acidification impact	Source/Pathway	Private Forest owner, Coillte, Forest Service Grant support?	Y	Short Term	Very High	**Resea**
FA13	Acidification	Existing forest stands where acid impact confirmed or likely by field monitoring	Partial felling of existing stand to reduce canopy cover. Target forest cover to achieve less than 25% of 1st and 2nd Order Streams and water body as a whole.	Restore	Reduce potential impact through reduced forested area in catchment whwre scavenging is an issue. May need drainage measures also.	Reduced potential eutrophication, sedimentation and hydraulic change pressure. Management issue of clearfelled area	Partial felling to reduce canopy cover	Water bodies with forest cover in acid sensitive mapped areas with evidence of acidification impact	Source	DAFF - Forest Service amendment to replanting requirements				**Resea**
FA14	Acidification	Existing forest stands where acid impact confirmed or likely by field monitoring	Harvest forestry with replanting of broadleaved species. Possible up to a maximum of 30% broadleaved species.	Restore	Reduce potential impact through alteration of species mix in catchment.		Replant with broadleaved species. National native Woodland Scheme	Water bodies with forest cover in acid sensitive mapped areas with evidence of acidification impact	Source/Pathway	DAFF - Forest Service amendment to replanting requirements. Possible support through Native Woodland scheme.				**Resea**

Table 12 Actions in Support of Basic and Supplementary Measures for Forest and Water

Action Item	Pressure	Forest Forestry setting/activity	Action	WFD water body Objectives	Specific Objective of action	Secondary Considerations	Alternative action	Target water bodies	Pressure targeted	Actioned by	Feasible	Time period required	Cost	Resea
A15	Acidification	Existing forest stands where acid impact confirmed or likely by field monitoring	Enhance stream productivity through development of native riparian buffers adjacent to water courses in forested areas for example.	Restore	Provide compensatory biological productivity to offset acidification damage.	On older forest sites this action will also reduce % forest cover with acidifying species.	consider extending enhancement of stream productivity to water body level.	Water bodies with forest cover in acid sensitive mapped areas with evidence of acidification impact	Receptor	Private Forest owner, Coillte, Forest Service Grant support., NPWS, Fisheries. Possible support through Native Woodland scheme.	Y	Shorrt _Medium Term	High	Resea
A16	Acidification	Existing forest stands where acid impact confirmed or likely by field monitoring	Infilling drains and re-wettng soils in existing forests to stop decomposition of peat and losses of organic acids and sulphate	Restore	Reduce decomposition of peat and reduce potential organic acid impact				Receptor	Private Forest owner, Coillte, Forest Service Grant support., NPWS, Fisheries				Resea

ıction tem	Pressure	Forest Forestry setting/activity	Action	WFD water body Objectives	Specific Objective of action	Secondary Considerations	Alternative action	Target water bodies	Pressure targeted	Actioned by	Feasible	Time period required	Cost	Resea
'E	**Eutrophication Measures**													
'E1	Eutrophication Pressure	Afforestation	Afforestation strictly in accordance with the Forest Service suite of Environmental Guidelines, Code of Good Forestry Practice and Forestry Schemes Manual	Protect	Ensure sustainable forestry on correct geological setting to minimise potential impact on water quality	All documents need to be updated to ensure cross referencing and reflection of WFD requirements and standards and the requirements of the WFD Basic Measures. Significant compliance monitoring of forestry activities.	Prepare comprehensive new Forest Service Guidance or manual for Afforestation, Roading, Thinning, Clearfell and replanting.		Source	DAFF Forest Service	Y	Short Term (in place)	Low	
'E2	Eutrophication Pressure	Afforestation	No afforestation on soils classed as Peat under the IFS system (these include intact and/or unenclosed Blanket peat, Raised Bog, Fen peat, wet heath)	Protect	Prevent future nutrient loss from forestry on these soil settings	May be modified to include Yield Class considerations without artificial fertilisation..		Water bodies with exclusion area on certain hydro geological settings (deep peats) -	Source	DAFF Forest Service	Y	Short Term	Low	
						Make a condition of grant assistance								

ıction tem	Pressure	Forest Forestry setting/activity	Action	WFD water body Objectives	Specific Objective of action	Secondary Considerations	Alternative action	Target water bodies	Pressure targeted	Actioned by	Feasible	Time period required	Cost	Resea
E	**Eutrophication Measures**													
E3	Eutrophication Pressure	Afforestation	Allow afforestation on cutaway enclosed and improved peat following sub threshold EIA. No subsequent aerial fertilisation.	Protect	Ensure potential impacts are assessed prior to approval for afforestation			Water bodies with exclusion area on certain hydro geological settings (deep peats) -	Source	DAFF Forest Service	Y	Short Term	Medium cost	
E4	Eutrophication Pressure	Afforestation	Allow afforestation on cutaway, enclosed and improved peats using broadleaved and other suitable species only without artificial fertilisation.	Protect	Reduce potential future nutrient loss.			Water bodies with exclusion area on certain hydro geological settings (deep peats) -	Source	DAFF Forest Service	Y	Unlikely scenario		
E5	Eutrophication Pressure	Existing Forestry established post introduction of Forest Service guidelines	Harvesting and replanting strictly in accordance with the Forest Service suite of Environmental Guidelines, Code of Good Forestry Practice and Forestry Schemes Manual	Protect	Prevent future nutrient loss from forestry on these soil settings	Sensitive nature of the catchment may need to be taken into account in determining whether replanting should occur. For example replanting in some areas in freshwater Pearl Mussel catchments may be		Water bodies with forest stands established since the introduction of Forest service Guidelines (approx post 1990)	Source	Coillte/Private Forestry/Forest Service	Y	Short term (in place)		

ıction tem	Pressure	Forest Forestry setting/activity	Action	WFD water body Objectives	Specific Objective of action	Secondary Considerations	Alternative action	Target water bodies	Pressure targeted	Actioned by	Feasible	Time period required	Cost	Resea
E	**Eutrophication Measures**													
						excluded.								
E6	Eutrophication Pressure	Forestry on peats established without buffer zones, pre guidelines (includes forest stands on blanket bog, raised bog, fen peat, cutaway peat and wet heath)	Minimal management/ no harvesting	Protect	No harvesting of existing forestry in some locations	Windthrow risk high in specific situations likely to lead to nutrient and sediment loss	Partial harvesting with long term cover retention as shelter belts on some stable sites.	Water bodies with Forestry on peats established without buffer zones, pre guidelines (includes forest stands on blanket bog, raised bog, fen peat, cutaway peat and wet heath)	Source	Coillte/Private Forestry/Forest Service	Y	Short term	Low	
E7	Eutrophication Pressure	Forestry on peats established pre guidelines with no buffer zones (includes forest stands on blanket bog, raised bog, fen peat, cutaway peats and wet heaths)	Partial harvesting with long term cover retention as shelter belts on some stable sites an dincluding buffer zones.	Protect	Selective harvesting only maintaining buffer zones to reduce nutrient loss.	Windthrow risk high in specific situations likely to lead to nutrient and sediment loss		Water bodies with Forestry on peats established without buffer zones, pre guidelines (includes forest stands on blanket bog, raised bog, fen peat, cutaway peat and wet heath)	Source	Coillte/Private Forestry/Forest Service	Y	Medium term	Very High	

ıction tem	Pressure	Forest Forestry setting/activity	Action	WFD water body Objectives	Specific Objective of action	Secondary Considerations	Alternative action	Target water bodies	Pressure targeted	Actioned by	Feasible	Time period required	Cost	Resea
'E	**Eutrophication Measures**													
'E8	Eutrophication Pressure	Forestry on peats established pre guidelines with no buffer zones (includes forest stands on blanket bog, raised bog, fen peat, cutaway peats and wet heaths)	Harvesting strictly in accordance with Proposed New Guidance document on the Management of Older Forest estates (see section 6.2 below)	Protect	Minimise potential nutrient and sediment release from harvested areas on deep peats established prior to the mid 1980s			Water bodies with Forestry on peats established without buffer zones, pre guidelines (includes forest stands on blanket bog, raised bog, fen peat, cutaway peat and wet heath)	Source	Coillte/Private Forestry/Forest Service	Y			
'E9	Eutrophication Pressure	Forestry on peats established pre guidelines with no buffer zones (includes forest stands on blanket bog, raised bog, fen peat, cutaway peats and wet heaths)	Establish buffer zones or Native Riparian Woodland, where possible, at least three years prior to the general clearfelling of the adjacent crop as detailed in the Forestry and FPM Requirements and in accordance with Native Woodland Information Note 4[14,] using mechanical felling and	Protect	Provide a developed buffer zone in advance of clearfelling	May require roading to be established in advance of main crop felling		Water bodies with Forestry on peats established without buffer zones, pre guidelines (includes forest stands on blanket bog, raised bog, fen peat, cutaway peat and wet heath)	Pathway	Coillte/Private Forestry/Forest Service	Y	Short term	Very High	

ıction tem	Pressure	Forest Forestry setting/activity	Action	WFD water body Objectives	Specific Objective of action	Secondary Considerations	Alternative action	Target water bodies	Pressure targeted	Actioned by	Feasible	Time period required	Cost	Resea
E	**Eutrophication Measures**													
			removal[?]			If established using mechanised harvesters and forwarders impact from sediment may occur								
E10	Eutrophication Pressure	Forestry on peats established pre guidelines with no buffer (includes forest stands on blanket bog, raised bog, fen peat, cutaway peat and wet heaths) by hand	Establish buffer zones or Native Riparian Woodland at least three years prior to the general clearfelling of the adjacent crop as detailed in the Forestry and FPM Requirements and in accordance with Native Woodland Information Note 4	Protect	Provide a developed buffer zone in advance of clearfelling with minimal impact on watercourses	Health and Safety Considerations	Remove trees in Riparian zone by hand (motor-manual) felling to limit sediment impact. Consider for extremely sensitive sites.	Water bodies with Forestry on peats established without buffer zones, pre guidelines (includes forest stands on blanket bog, raised bog, fen peat, cutaway peat and wet heath)	Pathway	Coillte/Private Forestry/Forest Service	Y	Short term	Very High	

ıction tem	Pressure	Forest Forestry setting/activity	Action	WFD water body Objectives	Specific Objective of action	Secondary Considerations	Alternative action	Target water bodies	Pressure targeted	Actioned by	Feasible	Time period required	Cost	Resea
'E	**Eutrophication Measures**													
'E11	Eutrophication Pressure	Forestry on peats established pre guidelines with no buffer (includes forest stands on blanket bog, raised bog, fen peat, cutaway peat and wet heaths)	Establish buffer zones or Native Riparian Woodland at least three years prior to the general clearfelling of the adjacent crop as detailed in the Forestry and FPM Requirements and in accordance with Native Woodland Information Note 4	Protect	Provide a developed buffer zone in advance of clearfelling with minimal impact on watercourses	Health and Safety Considerations	Remove brash from the Riparian Zone. Recycle or dispose off at suitable location.	Water bodies with Forestry on peats established without buffer zones, pre guidelines (includes forest stands on blanket bog, raised bog, fen peat, cutaway peat and wet heath)	Pathway	Coillte/Private Forestry/Forest Service	Y	Short - medoum term	High	
'E12	Eutrophication Pressure	Forestry on peats established pre guidelines with no buffer (includes forest stands on blanket bog, raised bog, fen peat, cutaway peat and wet heaths)	Establish buffer zones or Native Riparian Woodland at least three years prior to the general clearfelling of the adjacent crop as detailed in the Forestry and FPM Requirements and in accordance with Native Woodland Information Note 4	Protect	Provide a developed buffer zone in advance of clearfelling with minimal impact on watercourses		Redistribution of brash from riparian zone across site.	Water bodies with Forestry on peats established without buffer zones, pre guidelines (includes forest stands on blanket bog, raised bog, fen peat, cutaway peat and wet heath)	Pathway	Coillte/Private Forestry/Forest Service	Y	Short - medoum term	High	

ction tem	Pressure	Forest Forestry setting/activity	Action	WFD water body Objectives	Specific Objective of action	Secondary Considerations	Alternative action	Target water bodies	Pressure targeted	Actioned by	Feasible	Time period required	Cost	Resea
E	**Eutrophication Measures**													
E13	Eutrophication Pressure	Forestry on peats established pre guidelines with no buffer (includes forest stands on blanket bog, raised bog, fen peat, cutaway peat and wet heaths)	Establish buffer zones or Native Riparian Woodland at least three years prior to the general clearfelling of the adjacent crop as detailed in the Forestry and FPM Requirements and in accordance with Native Woodland Information Note 4; vary buffer zone width	Protect	Provide a developed buffer zone in advance of clearfelling with minimal impact on watercourses		Increased buffer zone width and variable buffer zone width in areas of preferred flow	Water bodies with Forestry on peats established without buffer zones, pre guidelines (includes forest stands on blanket bog, raised bog, fen peat, cutaway peat and wet heath)	Pathway	Coillte/Private Forestry/Forest Service	Y	Short - medoum term	Very High	
E14	Eutrophication Pressure	Forestry on peats established pre guidelines with no buffer (includes forest stands on blanket bog, raised bog, fen peat, cutaway peat and wet heaths)	No replanting on peat sites. Incorporate into new forest design. Encourage natural regeneration of site.	Protect	Encourage? natural regeneration	No potential nutrient uptake by new trees increases potential for nutrient loss to waters	Nutrient deficient sites could be left as areas of open space in the redesign plans of forested stands	Water bodies with Forestry on peats established without buffer zones, pre guidelines (includes forest stands on blanket bog, raised bog, fen peat, cutaway peat and wet heath)	Source	Coillte/Private Forestry/Forest Service	Y	Short - medoum term	Medium cost	

ıction tem	Pressure	Forest Forestry setting/activity	Action	WFD water body Objectives	Specific Objective of action	Secondary Considerations	Alternative action	Target water bodies	Pressure targeted	Actioned by	Feasible	Time period required	Cost	Resea
'E	**Eutrophication Measures**													
'E15	Eutrophication Pressure	Forestry on peats established pre guidelines with no buffer (includes forest stands on blanket bog, raised bog, fen peat, cutaway peat and wet heaths)	No replanting on peat sites in targeted areas (sensitive areas, areas requiring aerial fertilisation to achieve commercial yield class).	Protect		Allows replanting on productive peats with minimal fertilisation		Water bodies with Forestry on peats established without buffer zones, pre guidelines (includes forest stands on blanket bog, raised bog, fen peat, cutaway peat and wet heath)	Source	Coillte/Private Forestry/Forest Service	Y	Short Term	Low	
'E16	Eutrophication/Sedimentation Pressure	Forestry on peats established pre guidelines with no buffer (includes forest stands on blanket bog, raised bog, fen peat, cutaway peat and wet heaths)	Replant with commercial species strictly in accordance with current FS Guidelines, etc	Protect/Restore				Water bodies with Forestry on peats established without buffer zones, pre guidelines (includes forest stands on blanket bog, raised bog, fen peat, cutaway peat and wet heath)	Source	Coillte/Private Forestry/Forest Service	Y	Short Term	Low	

ıction tem	Pressure	Forest Forestry setting/activity	Action	WFD water body Objectives	Specific Objective of action	Secondary Considerations	Alternative action	Target water bodies	Pressure targeted	Actioned by	Feasible	Time period required	Cost	Resea
'E	**Eutrophication Measures**													
'E17	Eutrophication Pressure	Forestry on peats established pre guidelines with no buffer (includes forest stands on blanket bog, raised bog, fen peat, cutaway peat and wet heaths)	Limited replanting on deep peat sites with variation or reduction in stocking level and where tree growth acceptable without fertilisation	Protect		Size and scale of buffer zone important		Water bodies with Forestry on peats established without buffer zones, pre guidelines (includes forest stands on blanket bog, raised bog, fen peat, cutaway peat and wet heath)	Source	Coillte/Private Forestry/Forest Service	Y	Short Term	Low	
'E18	Eutrophication/Sedimentation Pressure	Forestry on peats established pre guidelines with no buffer (includes forest stands on blanket bog, raised bog, fen peat, cutaway peat and wet heaths)	Extension of statutory replanting time frame. Defer planting for two to three year period.	Protect				Water bodies with Forestry on peats established without buffer zones, pre guidelines (includes forest stands on blanket bog, raised bog, fen peat, cutaway peat and wet heath)	Pathway	Coillte/Private Forestry/Forest Service	Y	Short Term	Low	

ction em	Pressure	Forest Forestry setting/activity	Action	WFD water body Objectives	Specific Objective of action	Secondary Considerations	Alternative action	Target water bodies	Pressure targeted	Actioned by	Feasible	Time period required	Cost	Resea
E	**Eutrophication Measures**													
E19	Eutrophication Pressure	Forestry on peats established pre guidelines with no buffer (includes forest stands on blanket bog, raised bog, fen peat, cutaway peat and wet heaths)	On re-stock sites, only apply fertiliser required and do not apply until vegetation has re-established. No aerial fertilisation	Protect		An agreed sampling protocol exists for foliar analysis		Water bodies with Forestry on peats established without buffer zones, pre guidelines (includes forest stands on blanket bog, raised bog, fen peat, cutaway peat and wet heath)	Source	Coillte/Private Forestry/Forest Service	Y	Short Term	Low	
E20	Eutrophication Pressure	Forestry on peats established pre guidelines with no buffer (includes forest stands on blanket bog, raised bog, fen peat, cutaway peat and wet heaths)	Consider no planting on very sensitive sites where aerial fertilisation would be required to grow trees, e.g. Arctic Char Lakes, FPM	Protect			All fertiliser application should use slow release granulated fertiliser where optimum. Reduction or no fertiliser application. Staggered application on specific areas	Water bodies with Forestry on peats established without buffer zones, pre guidelines (includes forest stands on blanket bog, raised bog, fen peat, cutaway peat and wet heath)	Source	Coillte/Private Forestry/Forest Service	Y	Short Term	Very high	

ıction tem	Pressure	Forest Forestry setting/activity	Action	WFD water body Objectives	Specific Objective of action	Secondary Considerations	Alternative action	Target water bodies	Pressure targeted	Actioned by	Feasible	Time period required	Cost	Resea
'E	**Eutrophication Measures**													
'E21	Eutrophication Pressure	Forestry on deep peats established pre the mid 1980s (includes forest stands on blanket bog, raised bog, fen peat and cutaway peat)	Reduced felling coup size and operational coup size where appropriate to limit nutrient loss	Protect		Windthrow may occur.	Limit % of catchment to be treated - felling, replanting over extended time periods. Progressive Felling Plan for whole catchment. 5yr plan	Water bodies with Forestry on peats established without buffer zones, pre guidelines (includes forest stands on blanket bog, raised bog, fen peat, cutaway peat and wet heath)	Source	Coillte/Private Forestry/Forest Service	Y	Short Term	Medium cost	
'E22	Eutrophication Pressure	All forestry	Windrows should not be formed until the brash has shed its needles and should be strategically placed away from watercourses	Protect				Water bodies with Forestry on peats established without buffer zones, pre guidelines (includes forest stands on blanket bog, raised bog, fen peat, cutaway peat and wet heath)	Source	Coillte/Private Forestry/Forest Service	Y	Short Term	Low	

ıction tem	Pressure	Forest Forestry setting/activity	Action	WFD water body Objectives	Specific Objective of action	Secondary Considerations	Alternative action	Target water bodies	Pressure targeted	Actioned by	Feasible	Time period required	Cost	Resea
'E	**Eutrophication Measures**													
'E23	Eutrophication Pressure	Forestry on peats established pre guidelines with no buffer (includes forest stands on blanket bog, raised bog, fen peat, cutaway peat and wet heaths)	Research the use of cabling to extract trees from buffer zone an dmain foreststands.	Protect		Technically possible but needs to be demonstrated as in peat areas may cause significant damage to soils.	Use cabling on sensitive sites only to extract timber.	Water bodies with Forestry on peats established without buffer zones, pre guidelines (includes forest stands on blanket bog, raised bog, fen peat, cutaway peat and wet heath)	Source	Coillte/Private Forestry/Forest Service				**Resea**

ıction tem	Pressure	Forest Forestry setting/activity	Action	WFD water body Objectives	Specific Objective of action	Secondary Considerations	Alternative action	Target water bodies	Pressure targeted	Actioned by	Feasible	Time period required	Cost	Resea
'S	**Sedimentation Measures**													
'S1	Sedimentation Pressure	All forestry	Roading strictly in accordance with the COFORD Roading Manual.	Protect	Limit site disturbance and soil loss production			Water bodies with Forestry on peats established without buffer zones, pre guidelines (includes forest stands on blanket bog, raised bog, fen peat, cutaway peat and wet heath)	Source	Coillte/Private Forestry/Forest Service	Y	Short Term	Low	
'S2	Sedimentation Pressure	All forestry	Crossing of watercourse. Review of COFORD Manual and FS Guidelines to ensure Fisheries culvert requirement adequately covered.	Protect	Limit site disturbance and soil loss production. Dovetail with Fisheries guidance on construction near watercourses			Water bodies with Forestry on peats established without buffer zones, pre guidelines (includes forest stands on blanket bog, raised bog, fen peat, cutaway peat and wet heath)	Source	Coillte/Private Forestry/Forest Service	Y	Short Term	Low	

ıction tem	Pressure	Forest Forestry setting/activity	Action	WFD water body Objectives	Specific Objective of action	Secondary Considerations	Alternative action	Target water bodies	Pressure targeted	Actioned by	Feasible	Time period required	Cost	Resea
'S	**Sedimentation Measures**													
'S3	Sedimentation Pressure	All forestry	Maintain brash mats during the harvesting process	Protect	Limit site disturbance and soil loss production			Water bodies with Forestry on peats established without buffer zones, pre guidelines (includes forest stands on blanket bog, raised bog, fen peat, cutaway peat and wet heath)	Source	Coillte/Private Forestry/Forest Service	Y	Short Term (in place)	Low	
'S4	Sedimentation Pressure	Forestry established pre the mid 1980s (includes forest stands on blanket bog, raised bog, fen peat and cutaway peat)	Establish effective sediment controls away from the stream with multiple locations through forested catchment during clearfelling	Protect	Provide more effective sediment control	Undertake slope and soil assessment before felling to determine location and number of sediment traps		Water bodies with Forestry on peats established without buffer zones, pre guidelines (includes forest stands on blanket bog, raised bog, fen peat, cutaway peat and wet heath)	Pathway	Coillte/Private Forestry/Forest Service	Y	Short Term (in place)	Low	

ıction tem	Pressure	Forest Forestry setting/activity	Action	WFD water body Objectives	Specific Objective of action	Secondary Considerations	Alternative action	Target water bodies	Pressure targeted	Actioned by	Feasible	Time period required	Cost	Resea
'S	**Sedimentation Measures**													
'S5	Sedimentation Pressure	Forestry established pre the mid 1980s (includes forest stands on blanket bog, raised bog, fen peat and cutaway peat)	Establish large sediment traps at strategic locations above buffer zones where preferential flow is an issue.	Protect	Provide more effective sediment control	Undertake slope and soil assessment before felling to determine location and number of sediment traps		Water bodies with Forestry on peats established without buffer zones, pre guidelines (includes forest stands on blanket bog, raised bog, fen peat, cutaway peat and wet heath)	Pathway	Coillte/Private Forestry/Forest Service	Y	Medium term	Very high	
'S6	Sedimentation Pressure	Forestry established pre the mid 1980s (includes forest stands on blanket bog, raised bog, fen peat and cutaway peat)	No re-establishment of sediment traps when filled. establish new sediment traps upslope from old trap	Protect	Avoids need to remove sediment from traps and redistribute on site			Water bodies with Forestry on peats established without buffer zones, pre guidelines (includes forest stands on blanket bog, raised bog, fen peat, cutaway peat and wet heath)	Pathway	Coillte/Private Forestry/Forest Service	Y	Short Term	Low	

ıction tem	Pressure	Forest Forestry setting/activity	Action	WFD water body Objectives	Specific Objective of action	Secondary Considerations	Alternative action	Target water bodies	Pressure targeted	Actioned by	Feasible	Time period required	Cost	Resea
'S	**Sedimentation Measures**													
'S7	Sedimentation Pressure	Forestry established pre the mid 1980s (includes forest stands on blanket bog, raised bog, fen peat and cutaway peat)	Research use of vegetated silt trap at reestablishment phase	Protect				Water bodies with Forestry on peats established without buffer zones, pre guidelines (includes forest stands on blanket bog, raised bog, fen peat, cutaway peat and wet heath)	Pathway	Coillte/Private Forestry/Forest Service				**Resea**
'S8	Sedimentation Pressure	Forestry established pre the mid 1980s (includes forest stands on blanket bog, raised bog, fen peat and cutaway peat)	Further design development, research and demonstration projects	Protect	Enhanced sediment management techniques.			Water bodies with Forestry on peats established without buffer zones, pre guidelines (includes forest stands on blanket bog, raised bog, fen peat, cutaway peat and wet heath)	Source/Pathway	DAFF-Forest Service/Coillte/ COFORD/EPA/ NPWS/Fisheries	Y	Short term	Very high	**Resea**

ction tem	Pressure	Forest Forestry setting/activity	Action	WFD water body Objectives	Specific Objective of action	Secondary Considerations	Alternative action	Target water bodies	Pressure targeted	Actioned by	Feasible	Time period required	Cost	Resea
H	**Hydro-morphological Measures**													
H1	Hydraulic Load	Forestry on deep peats established pre the mid 1980s (includes forest stands on blanket bog, raised bog, fen peat and cutaway peat)	Audit existing drainage network before harvesting (part of existing application)	Protect	Forward planning of drainage management and buffer zone requirements			Water bodies with Forestry	Pathway	Coillte/Private Forestry/Forest Service	Y	Short term (in place)	Low	
H3	Hydraulic Load	Forestry on deep peats established pre the mid 1980s (includes forest stands on blanket bog, raised bog, fen peat and cutaway peat)	Redesign of drainage network on sites for restocking	Protect	Minimise contribution to peak flow and increase time period to peak flow. Reduce risk of washout.			Water bodies with Forestry on soils liable to erosion or sediment release including deep peats (> 3 metres) established pre the mid 1980s (includes forest stands on blanket bog, raised bog, fen peat and cutaway peat)	Pathway	Coillte/Private Forestry/Forest Service	Y	Short term (in place)	Low	

H4	Hydraulic Load pressure	Afforestation	Research control of flow regime changes from forest cover for sensitive receptors (FPM, salmonid spawning areas,)	Protect	Limit impact on water balance which could effect habitats, species or uses associated with protected areas			All Water bodies	Pathway	DAFF-Forest Service/Coillte/ COFORD/EPA/ NPWS/Fisheries	Y	Medium term	Very high	**Resea**

ıction tem	Pressure	Forest Forestry setting/activity	Action	WFD water body Objectives	Specific Objective of action	Secondary Considerations	Alternative action	Target water bodies	Pressure targeted	Actioned by	Feasible	Time period required	Cost	Resea
'P	**Pesticide Measures**													
'P1	Pesticide Use	Afforestation and replanting	Minimise pesticide usage on site	Protect	Minimise potential impact from pesticide use			Water bodies where afforestation or replanting occurs (initially all water bodies are potential areas)	Source	Coillte/Private Forestry/Forest Service	Y	Short term (in place)	Low	
'P2	Pesticide Use	Afforestation and replanting	Pre-dipping of trees.	Protect	Minimise potential impact from pesticide use		Move to non pesticide controls if possible (e.g. biological)	Water bodies where afforestation or replanting occurs (initially all water bodies are potential areas)	Source	Coillte/Private Forestry/Forest Service	Y	Short term (in place)	Low	
'P3	Pesticide Use	Afforestation and replanting	Delay replanting if possible	Protect	Reduce risk of attack by pine weevil (Hylobius abietes)			Water bodies where afforestation or replanting occurs (initially all water bodies are potential areas)	Source	Coillte/Private Forestry/Forest Service	Y	Short term	Medium cost	
'P4	Pesticide Use	Afforestation and replanting	Establish and maintain register of pesticides use in forestry - National register not specifically related to forestry	Protect		Pesticide use by the Private sector is largely unrecorded or reported		Water bodies where afforestation or replanting occurs (initially all water bodies are potential areas)	Source	Coillte/Private Forestry/Forest Service	Y (with difficulty)	Short term	High	

P5	Pesticide Use	Afforestation and replanting	Move to non pesticide controls if possible (e.g. biological)	Protect	Reduce need for pesticide use			Water bodies where afforestation or replanting occurs (initially all water bodies are potential areas)	Source	Coillte/Private Forestry/Forest Service			High	**Resea**

7.7 Recommendations for further research and field trials.

The work to date of the Forest and Water Working Group has attempted to establish the relationship between standing forests and forestry operations and water quality. During the course of discussions and arising from the findings of the current research project, past research and literature surveys further research topics were identified which would benefit further the understanding of the forest and water relationship and would help refine measures in the future. In addition, some of the measures proposed, although technically feasible, have not been fully demonstrated at catchment scale in Ireland. Field trialling of some key measures is being recommended to be undertaken to demonstrate the effectiveness of the measure and the scope of its use in Irish Forestry. The research and trialling of measures recommended by the Working Group are set out in Table 12.

Table 12 Recommended Research and Measures Trialling

Research/Trial Topic	**Reason**	**Implementing Agency**
Elucidation of the dominant acidification mechanism in Ireland	The Forest and Water Research project on acidification has suggested that acidification from dissolved organic carbon and soil-derived sulphate may be the dominant mechanism in the west of Ireland as opposed to non marine sulphate and chloride which are more prevalent in the east. Understanding the mechanism is important in the selection of the most appropriate measures.	EPA Forest Service
Application of native riparian woodland scheme to conifer forest on peat soils. Evaluate contribution of riparian woodland to stream productivity and degree of compensation achieved.	To provide evidence of the ability to establish and maintain native riparian woodland in upland catchments and quantify their contribution to stream productivity particularly in acid sensitive areas.	Forest Service COFORD Coillte CFB EPA NPWS
Research into the hydromorphological impacts	Increased water flow from forested areas giving rise to increase peak flood height and decreased time to peak flood may cause loss of spawning areas, salmonid ova and juveniles an dmay impoact on freshwater pearl mussel juveniles. Important to establish the relationship between size of forested area, slope factors, drainage network etc and washout effect.	Forest Service COFORD Coillte CFB EPA NPWS OPW
Evaluation of liming options for Irish catchments, including pre-	Liming may be the only alternative to reducing forest cover in some critical locations. Practicality and effectiveness	Forest Service COFORD Coillte

liming, broadcast liming aerial application, silo based, grinding mills, base hardcore material for roading. Trialling out identified methodologies in some target catchments.	of options should be demonstrated at catchment scale.	CFB EPA NPWS
Catchment scale trialling of native riparian woodlands in enhancing stream productivity and offsetting potential impact of forest on acid sensitive areas.	Published material indicates that broadleaf forest cover with a total catchment area of greater than 30%[Error! Bookmark not defined.] is indicative of likely acid impact occurring, based on the work of Gagkas et al in the UK. Trialling using Irish broadleave species should be undertaken.	Forest Service COFORD Coillte
Research into buffer zones	To identify optimum buffer zone design and timing to enhance nutrient and sediment interception to water courses and enhance stream productivity	Forest Service COFORD Coillte
Trialing different methods for timber/brash extraction	To identify alternatives methods for timber extraction which would minime nutrient and sediment release.	Forest Service COFORD Coillte
Research into drainage control	To identify options to direct and slow the flow of water off the forest site, e.g. wetlands and the blocking of existing drains with the aims of producing prescriptions based on soil types, slopes etc.	Forest Service COFORD Coillte
Test the effectiveness of conifers/other trees versus natural regeneration.	To verify whether natural regeneration as opposed to replanting would be effective in reducing nutrient an dsediment loss form clearfelled sites.	Forest Service COFORD Coillte
Evaluate application and effectiveness of Decision Support System in development by Coillte for the Western Peatlands forested areas.	To verify whether the measures proposed by the DSS are appropriate in minimising impacts of forests and forestry operations on peat soils.	Forest Service COFORD Coillte

7.8 Note on "No Active Management"

This scenario addresses the issue of existing forests and of leaving the trees standing and not actively managing the area in any way. It has the advantage of avoiding ground disturbance by machinery and the associated sediment and phosphorus release. However, this scenario could result in windthrow and trees falling in an uncontrolled way, possibly resulting in large scale soil disturbance over considerable areas.

Windthrow could result in trees falling across riparian zones, streams and other water bodies with the potential for exposing large areas of soil. Fallen trees could also impede vegetation colonisation.

The probability of windthrow occurring was examined by COFORD (Ní Dhubhain *et al.*, 2000)[53] In the COFORD funded study five factors were found to contribute significantly to the probability of windthrow occurring, namely:

- Top height
- Location of the stand in the country
- Soil type on which the stand was established
- Compass bearing of the plough ribbons where the site has been ploughed
- Thinning status

A GIS based windthrow risk model was developed by the authors, which indicated that the greatest risk of windthrow was on gleyed soils, followed by peat soils. However the risk increased across all soil types examined as top height increased while thinning also significantly increased the risk of windthrow. The windthrow model software is available to download from the COFORD website but it has some limitations which are discussed on the website (e.g. developed for pure Sitka spruce stands).

Although adopting the "do nothing" scenario would avoid the potential effects of silt and phosphorus release caused by harvesting operations, in the longer term, such runoff might be greater and uncontrollable if large-scale windthrow occurs, potentially representing the risk of serious negative impacts on freshwater pearl mussels and salmonids.

Removal of the timber once it is blown would be difficult and potentially damaging to the soil. Forest sites could become more difficult to manage increasing the risk of increased negative nutrients and sediment loading to the receiving waters.