Forests and Water

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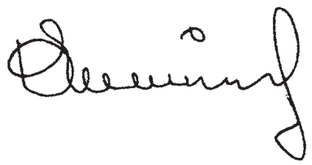
FOREWORD

Water is one of the most precious resources available to mankind. Access to clean, unpolluted drinking water and the use of watercourses and lakes for fishing and water-sports has been almost taken for granted in Ireland. However, in recent years we have come to value our water resource to a far greater extent, not only for human consumption and use, but also for the aquatic communities and biodiversity that it supports. This realisation has come about for a number of reasons, but principally because of the threats that water resources are increasingly coming under from pollution and ever-encroaching development.

At the European level, the importance of water resources has been given expression in a number of Directives, including the Nitrates Directive and the more recent Framework Directive on Water Policy. When these policies come fully into force they will have a profound effect not only forestry but on all land-use activities in Ireland. In this context, it is worth bearing in mind that in many parts of the world forests play a vital role in watershed management, by preventing soil erosion and siltation and by providing much of the food input essential to aquatic life. In Ireland, however, the situation is somewhat different; forest cover is low and we are in the process of creating a forest resource. We need to stand back and consider the impacts that this process has on water quality and yield and how best to site and manage forests to protect and enhance water quality. Having considered the impacts, we need to take appropriate action (such as the Water Quality Guidelines of the Forest Service) based on the best available information and science, drawing on best practice in countries with similar climate and growing conditions.

These are the reasons why COFORD organised its Forests and Water Seminar in Cork at the end of 2000, and why we are now bringing the presentations together in this important publication – Forests and Water. It summarises many of the water quality issues that face forestry in Ireland at present, both from the industry and regulatory perspectives, and what is being done about them. Findings from COFORD-funded water quality research are presented, work that continues in a jointly-funded COFORD/EPA programme of work. In this publication, and in our R&D endeavours, the aim is to find ways to conserve and improve water quality in forested catchments in Ireland. An additional product of the research is information on the role of riparian woodlands in improving water quality.

As I write, the World Conference on Sustainable Development in Johannesburg is coming to an end. Once again, water has come to the fore as an issue of the highest importance. It is no exaggeration to say that access to clean water for human consumption is a life-and-death issue for many on this planet. We are indeed fortunate in Ireland to have an abundant water resource but, as I have pointed out, it is coming under pressure. COFORD has an important role to play in ensuring that this priceless resource is protected and developed. I am confident that this publication and COFORD's research programme will contribute to the achievement of that vitally important objective.



David Nevins

Chairman
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September 2002

Forestry and Water: Finding the Best Fit

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ABSTRACT

Regulatory, control and development procedures relating to forestry in Ireland are the responsibility of the Forest Service, the national forest authority. These include a national forest standard, guidelines and a Code of Best Forest Practice. The objective of these is, *inter alia*, to protect and enhance water quality as well as aquatic and riparian habitats in forest areas. These and other procedures provide the means to achieve a balance between social, environmental and economic interests at national and local levels so that water quality is one of the products of correct forest placement, good forest design and appropriate forest management practices.

INTRODUCTION

Forestry in Ireland is generally a commercial land-use activity. It is not a stand-alone, self-contained sector but has linkages to, and has to find a fit with agriculture, rural development, industrial policy, leisure and tourism, trade and the protection of the environment.

A forest is a renewable resource with a relatively long life cycle. Forestry is an alternative to agricultural land-use, an agent of landscape change, a wildlife habitat, a carbon sink, an environment for recreation and not least the source of raw material for wood-based industries.

Water quality and the quality of the aquatic and riparian environments are of the utmost importance. Not alone is water used for human and industrial consumption but our rivers, lakes and streams are among the attractions of the leisure and tourism industry and those associated with inland fisheries and other leisure and sporting activities. Aquatic and riparian habitats are important ecotypes and are significant contributors to our biodiversity.

Traditionally forestry was confined to the more marginal agricultural lands and this is where water quality is most pristine, valuable and vulnerable.

A forest and its environment are undisturbed for the greater part of its long life cycle. Disturbances come in relatively short periods of intense activity such as afforestation (new planting), road making, harvesting (tree felling) and reforestation (regeneration after felling).

BALANCING THE INTERESTS

It is necessary to balance social, economic and environmental interests in order to ensure that forestry is sustainable. Protection and enhancement of water quality will be achieved by:

- correct forest placement in the landscape,
- good forest design which will maximise the benefits of forestry (both tangible and intangible),
- appropriate forest management and controls at the strategic, tactical and operational levels.

REGULATORY, CONTROL AND DEVELOPMENT MECHANISMS

Forestry is a regulated and controlled activity in Ireland. The Forest Service of the Department of the Marine and Natural Resources is the national forest authority. Given the large number of linkages which forestry has with other sectors it is not surprising that a great part of the governance of forestry and the forest industry is a result of the participation of many organisations and individuals.

In relation to forestry and water quality the participants include the Central and Regional Fisheries Boards, as well as the County Councils and Dúchas, and of course the players within the forest industry such as the landowners, forest companies and the training, education and research organisations.

The mechanisms currently in use include the following:

- Forest legislation
- National forest strategy
- Irish National Forest Standard and sustainable forest management (SFM)
- Research
- Education and training

- Grant aid and felling conditions
- Consultation
- Site inspections
- Code of Best Forest Practice
- Environmental guidelines.

All forest activity is guided by and strongly influenced by mechanisms 1 to 5. The remaining mechanisms govern at an operational level and at the level of the individual forest block.

Forest legislation

There are two forestry acts of relevance:

- the Forestry Act 1946 controls forest harvesting/tree felling through Felling Licences and Prohibition Orders; it also authorises the Minister to purchase land and grant aid forestry developments;
- the Forestry Act 1988 established Coillte (the Irish Forestry Board) to manage state forests on a commercial basis.

Forestry is also covered by legislation relating to Planning, Health & Safety, Water Pollution, Roads, Owner's Liability etc.

National forest strategy

The Irish national forest strategy was adopted by government and published in 1996 (Department of Agriculture, Food and Forestry 1996). The overall aim is "to develop forestry to a scale and in a manner which maximises its contribution to national economic and social well being on a sustainable basis and in a manner which is compatible with the protection of the environment". The targets up to 2030 are:

- to achieve a critical mass in wood harvesting of 10 million cubic metres annually,
- to expand forest cover from 9% to 17% of the land area.

Irish National Forest Standard and sustainable forest management (SFM)

Sustainable forest management principles and processes are the result of international agreements. Ireland is a signatory to the Lisbon Resolution of the Ministerial Conference on the Protection of Forests in Europe, where six criteria and accompanying indicators for SFM were adopted.

The Irish National Forest Standard (Forest Service 2000a) outlines these criteria and relates them and their appropriate indicators and measures to the national implementation of SFM. The ***criteria*** define the essential elements or outputs of SFM, the ***indicators*** provide a basis for assessing forest or forest industry conditions for each criterion and the ***measures*** describe the type of information needed to evaluate or measure how indicators change over time. It is neither a stand-alone document nor a set of operational prescriptions. It must be understood in the context of its supporting instruments which are the Code of Best Forest Practice (Forest Service 2000b), the environmental guidelines (Forest Service 2000c-g), the legal framework and the Forest Service inspection and monitoring systems (Forest Service 2000h).

Forest research

Forest research has a pivotal role to play in SFM. Society's understanding of sustainable forest management is as yet incomplete. Research is underway to refine the measures by which it is evaluated. Results from this work will be transferred into practical and cost-effective protocols, which in turn will be incorporated into future codes and guidelines. Current forest research is dealt with more fully in other papers at this seminar.

Education and training

Forestry is professional qualification. Coillte, Teagasc and other organisations provide forestry training for non-foresters.

Grant aid and felling licence conditions, consultation and inspection procedures

These will be illustrated with reference to the afforestation grant and premium scheme (Forest Service 2000h). The procedures involved also apply in general to other grant aid schemes and to Felling Licences.

Any project which is grant-aided or any harvesting or tree felling operation which receives a felling licence must meet the following conditions (among others):

- it must have written approval or, in the case of harvesting, have received a Felling Licence before any work commences,
- the work must be compatible with the protection of the environment,
- it must be in accordance with good forest practice.

All such work is subject to regular inspection by the Forest Service inspectorate. The stages of the afforestation grant aid and premium payment processes are as follows:

- prior approval must be obtained before any work commences (this involves the submission of an afforestation plan and is dealt with in more detail below),
- afforestation grant payment is only made after satisfactory completion of afforestation,
- maintenance grant payment is usually made four years after afforestation, provided the plantation has been maintained so that satisfactory establishment has been achieved,
- premium payments are made annually provided the plantation is maintained and managed in a satisfactory manner.

Prior approval

The Forest Service has responsibility for issuing afforestation approval. (Areas greater than or equal to 70 ha require planning permission including an EIA[2].) In order to apply for afforestation approval a landowner must submit an afforestation plan and a map prepared by a professional forester. This plan addresses silvicultural and environmental issues.

Silvicultural issues include the potential of the site to produce a commercial tree crop, as well as suitability of access and its suitability for taking a minimum of 10% broadleaf species. The plan also includes a description of the proposed ground preparation, fertiliser type and rate, species selected, fire protection measures and weed control.

The afforestation plan and map identify the following environmental issues for each site:

- if fishery or other water quality issues pertain to the site,
- if the site contains or adjoins a proposed National Heritage Area pNHA, (Special Area of Conservation (SAC) or Special Protection Area (SPA),
- if the site contains archaeological sites and/or monuments,
- if the site lies within a landscape outlined in the County Development Plan or in the Inventory of Outstanding Landscape (An Foras Forbatha 1977),
- if the site contains areas of other environmental importance.

Prior to issuing afforestation grant approval the Forest Service issues notification to, and undertakes consultation with, the bodies identified in Table 1 in relation to these environmental considerations. The notification consists of a map of the site together with a synopsis of the afforestation plan.

[2]S.I. No. 538 of 2001 European Communities (Environmental Impact Assessment) (Amendment) Regulations 2001 require an E.I.A. for proposed afforestation projects greater than or equal to 50 ha.

TABLE 1: FOREST SERVICE AFFORESTATION NOTIFICATION PROCEDURES[3].

	Environmental consideration	***Referral body/action taken***
1	Water quality	
1.1	Area designated as potentially acid sensitive by the Department of the Marine and Natural Resources	Subject to protocol (acid neutralising capacity is measured and assessed against predetermined limits)
1.2	Proposed planting area greater than 5 ha and sensitive for fisheries	Fisheries Board
1.3	Proposed planting area non-sensitive for fisheries and greater than 40 ha	Fisheries Board
1.4	Proposed planting area greater than 10 ha and within the catchment of a Local Authority designated water scheme	Local Authority
2	Designated habitats	
2.1	Proposed planting area within a pNHA, SAC, SPA or National Park	An Taisce, Dúchas, public notification
2.2	Proposed planting area less than 3 km upstream of a pNHA, SAC, SPA or National Park	Dúchas
2.3	Proposed planting area contains a current REPS plan habitat	Dúchas
3	Archaeology	
3.1	Proposed planting area contains an archaeological site or feature with extensive public usage	An Taisce, Dúchas, public notification
3.2	Proposed planting area contains or adjoins a listed archaeological site or monument	Dúchas
4	Landscape	
4.1	Proposed planting area is within a prime scenic area in the County Development Plan or within an area listed in the Inventory of Outstanding Landscapes	An Taisce, Bord Fáilte, public notification, Local Authority
4.2	Other high amenity landscape considerations	Local Authority
	Area of planting proposal Greater than 25 ha	Local Authority
5	Other environmental considerations	As appropriate

[3]Updated to end 2001.

Forest Service inspections

Forest Service inspections occur at each stage of the afforestation grant and premium scheme, i.e. at prior approval, at afforestation grant and maintenance grant payments stages and during the period of premium payments. Likewise Forest Service inspections occur in relation to other grant-aided projects and in relation to tree felling and the application for and issuing of Felling Licences and any subsequent reforestation.

These inspections are to ensure that all relevant work has been carried out in accordance with approval or licence conditions and that issues such as water quality are addressed at the development, maintenance and harvesting stages of the forest life cycle.

The Code of Best Forest Practice

The Code of Best Forest Practice is the first of its kind in Europe. It is designed to ensure that forest operations in Ireland are carried out so that environmental, social and economic standards are met.

It identifies forest values in Ireland which need to be safeguarded. These values can be broadly classified as social, environmental and economic. It identifies water quality as an important constituent of forest environmental values. Within this context, water values are concerned with protecting water quality, ecology and stability, and controlling onsite and downstream impacts.

It outlines an Impact Appraisal System whereby forest operations can be audited in relation to their impacts, if any, on the various forest values. For example, operations such as afforestation, road making and harvesting can impact on the hydrology, chemistry and level of sedimentation in aquatic zones through compaction by heavy machinery, soil displacement, increased run-off through drainage and contamination with fertilisers, chemicals and fuels.

The focus of the Code of Best Forest Practice is on forest operations such as seed collection, nursery operations, establishment and maintenance of forests, road making, harvesting, transport, specialised woodlands, training and forest planning.

Each operation is described under the following headings:

- Mission statement
- Key factors
- Objectives
- General description and discussion
- Potential adverse impacts
- Best practice.

The section covering the site preparation for afforestation will illustrate the level of detail pertaining to each operation.

Mission statement

Site preparation can take place on the basis that the necessary planning, identification of constraints and consultation have all been carried out.

Key factors

Ten key factors are listed including soil preparation and drainage systems, drainage and water impacts, fertilisers and water and requirements for aerial fertilisation.

Objectives

Three objectives are listed including "to minimise environmental disturbance".

General description

The general description and discussion outline the operation by its constituent parts such as the provision of access roads, woody vegetation clearance, ground preparation and drainage, initial fertiliser application (including appropriate fertiliser rates) fencing, gates and stiles, firebreaks and shell marl[4] (high pH) sites.

Potential adverse impacts

The potential adverse impacts relating to water quality listed for this operation include:

- damage due to aquatic zone crossings by machinery and equipment,
- failure to implement appropriate operational procedures,
- sedimentation from poorly designed and/or executed ground preparation and drainage,
- incorrectly timed fertiliser application or application under inappropriate weather and/or ground conditions,
- excessive fertiliser application,
- careless or otherwise inappropriate storage of materials and fuels,
- failure to notify authorities of damage.

Best practice

Having identified the potential adverse impacts, the Code of Best Forest Practice then identifies how best to avoid these. Best practices are also contained within the environmental guidelines.

Environmental guidelines

The following environmental guidelines have been developed through extensive consultation with a wide range of relevant parties:

- Forest Biodiversity Guidelines
- Forest Harvesting and the Environment Guidelines
- Forestry and Archaeology Guidelines
- Forestry and the Landscape Guidelines
- Forestry and Water Quality Guidelines.

Apart from the Forestry and Water Quality Guidelines, those most relevant to water quality are the Forest Biodiversity Guidelines, Forest Harvesting and the Environment Guidelines and the Forestry and the Landscape Guidelines.

It is a condition of all the guidelines that machine operators have contact phone numbers on-site for all relevant agencies in case of accidental damage to aquatic zones or other environmental damage.

Forestry and Water Quality Guidelines

These relate to water quality protection and enhancement for the full forest cycle, including ground preparation, planting, fertiliser and chemical application, thinning, harvesting and road making. They identify numerous protective measures. These include:

- the provision and management of buffer zones adjoining aquatic zones,
- distance of operations and planting distances for conifers and broadleaves from aquatic zones,
- the need for cut-off drains and sediment traps,
- timing, weather and ground conditions and type of fertiliser application (including split applications on peat sites),
- application and storage and of chemicals,
- limits on machine operations and refuelling,
- suspension of operations during times of high erosion risk,
- provision and maintenance of brash mats during harvesting,

[4] A layer of calcium carbonate, comprised in the main of snail shells, that originates in shallow lakes on limestone and occurs beneath some raised bogs and reclaimed fen peats in the Midlands and parts of east Galway and Mayo. Its high pH generally precludes its use for conifers.

- forest road, bridge and culvert location, construction types and timing,
- the protection of river gravel.

Areas sensitive to acidification and to erosion are described.

An aquatic zone is defined in these guidelines as "a permanent or seasonal river or stream or lake shown on an Ordnance Survey 6 inch map".

These guidelines define a buffer zone as "an area adjacent to an aquatic zone managed for the protection of water quality and aquatic ecosystems".

Buffer zone management

The functions of a buffer zone are to:

- physically stabilise banks,
- protect against sedimentation by ensuring that drainage water flows through and is filtered by riparian vegetation,
- act as a source of leaf litter into aquatic zones,
- provide cover and dappled shade to enhance aquatic life.

The guidelines establish the width of buffer zones for each side of the aquatic zone. This width increases with slope and sensitivity to erosion, from 10 m on flat stable sites to 25 m on steep slopes with highly erodable soils. These minimum widths vary where landscape design warrants it.

Forest operations are curtailed within the buffer zone, vegetation is encouraged and allowed to develop, and additional planting of suitable riparian tree species is allowed, depending on the agreement of the Regional Fishery Board. The planting methods to be used are limited to pit planting or inverted mounding. Undesirable trees are to be removed or pruned where appropriate, in order to encourage riparian vegetation.

Exclusion zones

The differences between a buffer zone and an exclusion zone are also set out in the guidelines. The buffer zone is described as a biotope or habitat for the enhancement and protection of the aquatic environment and is to be managed as such. Operations such as cultivation, fertilisation or road making are not allowed in the exclusion zone (which is always equal to or greater than the width of the buffer zone). For example, the exclusion zone for fertiliser, fuel and chemical storage is 50 m, for manual fertiliser application is no less than 20 m, for aerial application over established crops it is 50 m and for roads it is normally 50 m.

These guidelines and the Forestry and Water Quality Guidelines, as well as the Code of Best Forest Practice and other environmental guidelines, apply to all grant-aided projects and to all activities associated with a Felling Licence. They are working documents and, as with the Irish National Forest Standard, will be subject to continuous improvement in the light of new research findings and additional consultations and participation.

CONCLUSIONS

Water and forests share the same landscape and environment to such an extent that they form a habitat. Water is part of the forest resource and the protection and enhancement of water quality has to be among the benefits of the forest and its management. Water quality is a tangible benefit and has economic, social and environmental impacts. It is an indicator which some use to judge the state of our environment.

Forestry is a science and an economic activity. Wise forest and ecosystem management is dependent on human knowledge, endeavour and creativity. These are fostered by mutual trust and co-operation between stakeholders. Irish forestry is fortunate in the interest taken in it and the contributions made to it by many organisations (both government and non-government) and by individuals, including landowners. The challenge for forestry and all these interested parties is to develop efficient communication and participation methods so that Ireland’s forests deliver the benefits of sustainable forest management and achieve the overall aim of the national forest strategy which is to "to develop forestry to a scale and in a manner which maximises its contribution to national economic and social well being on a sustainable basis and in a manner which is compatible with the protection of the environment".

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Fisheries and the Aquatic Environment

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ABSTRACT

From a Regional Fisheries Board perspective, there is still, despite publication of numerous research reports, guidelines and codes of practice, very significant variation in the type and quality of afforestation/reforestation development plans, particularly an absence of detail regarding proposed drainage networks. Concerns have also been raised regarding aerial fertilisation of areas where mound drains discharge directly to receiving waters. There are issues relating to reduced water yield within afforested catchments and possible implications for the free movement of migratory fish. Use of instream forest debris may have adverse impacts on angling, and contribute to bank destabilisation and downstream flooding/fouling of structures. The policy of continuing to plant areas which are acid sensitive because of geology and overburden is questionable. There is significant variation in the quality of afforestation applications referred to the Board by the Forest Service and contractors as part of a consultative process. Bridges are the preferred type of stream crossing. There have been water quality difficulties encountered during a number of operations involving both ground preparation and tree felling.

INTRODUCTION

This paper reviews a number of aspects of forestry practice and operations from the perspective of a Regional Fisheries Board. When carried out in a wholly sustainable manner, forestry operations can be beneficial to the well-being and development of the fisheries resource. However, it has to be recognised that where operations are carried out other than in accordance with best practice, and where there is non, or only partial compliance with the various guidelines and codes currently having effect, these can impact negatively on the fisheries environment. The issues discussed hereunder reflect those areas in terms of practice and operation which most frequently concern Regional Fisheries Boards at local level.

AFFORESTATION/REFORESTATION PROPOSALS - CONSULTATION

In recent years, and particularly since the publication in 1991 of the Forestry and Fisheries Guidelines (Forest Service 1991), there has been a very significant improvement in the level of consultation between the various forestry contractors and Regional Fisheries Boards insofar as afforestation, reforestation, felling, fertilisation and forest road construction proposals are concerned. In this regard, the role of the Department of the Marine and Natural Resources, which has been working with all of the stakeholders concerned to ensure improved consultation and co-operation, is acknowledged.

There are significant differences in the quality and content of afforestation and reforestation proposals bordering or adjacent to waters referred to us as a Regional Board as part of the consultation procedure where grant assistance is being provided by the State for proposed developments. For example, some applications come with colour coded, high quality Ordnance Survey map extracts, whereas in other situations very poor quality black and white copy maps are received, sometimes bearing no county name or map reference number, and often bearing numerous shaded/hatched areas without clear definition of what precisely is proposed to be planted. Obviously high quality maps make it very easy to identify the proposed area to be developed, whereas poor quality presentations make it difficult if not impossible.

It is essential that consultation procedures be efficient and effective, so that applications can be speedily processed. Contractors and all parties involved have a duty to ensure they forward comprehensive and legible applications to Fisheries Boards. Otherwise there will be unnecessary delays in the processing of applications, leading to criticism of state agencies perceived as responsible for delaying or frustrating the process. By way of further illustration of the variation in applications received by us, whereas many clearly identify all waters, others provide no information or detail as to waters likely to be affected. Likewise, many applications come with complete copies of the Department of the Marine and Natural Resources Form 1, thereby obviously containing very detailed information on issues of concern to ourselves such as ground preparation, method of planting, proposed fertiliser application etc. Obviously complete copies of Form 1 are particularly helpful, whereas applications without Form 1 are generally difficult to process, invariably lead to delays, and our having to issue requests for further information. Similarly, it is essential that afforestation/reforestation applications include details of proposed drainage layout, location of cut-off drains and settlement areas together with detailed ground preparation plans. While this information is

received in many cases, there are still regrettably instances where no such information is submitted. Indeed in some situations, memoranda are received at our offices from contractors using their own internal photocopied documents which neither provide the contractors name, address or contact number. In such instances we have no option but to embark on a time consuming process of enquiry, to establish whom precisely we are dealing with, leading as earlier described to delays involving all parties.

The essential point we would wish to communicate is that if attention is not given by contractors to initial planning and preparatory work, and then to regular site visits and supervision of ground preparation and planting, this is very likely to result in problems in the future.

Another area of concern is that often when site inspections are being carried out by ourselves during, for example the carrying out of planting operations, it is not uncommon to find a machine operator on site having no mounding plan, or to find that for reasons of economy of time, a machine operator excavating the longest possible mound drains that can be fitted within any one site. Training of machine operators is critical, and foresters concerned must prepare, taking account of issues such as soil type, drainage characteristics, site contours etc., a proper ground preparation/mounding plan.

Fertilisation/aerial fertilisation

Many of the applications received by the Fisheries Boards involving afforestation or reforestation typically provide for the application of 350 kg P/ha. At a typical purity of 14.3%, this corresponds to an application of 50 kg P/ha. In a typical mound drain situation, each ha with drains 0.6 m wide, positioned at 12 m centres, has an area of 720 m2 of open drains. While from a forestry perspective these drains may not appear significant, they are in fact watercourses, and in many situations discharge directly or indirectly to the receiving aquatic environment. From a fisheries viewpoint, and emphasising the precautionary principle, the application of 350 kg of phosphorus actually results in the distribution of 3.6 kg P/ha directly into watercourses. We are equally concerned at the spreading of fertiliser over forest road networks during the aerial fertilisation process, as these roads are typically bounded by drains/watercourses, again in many cases discharging directly or indirectly to the receiving aquatic environment. Is this sustainable development?

Until relatively recently, the perceived wisdom of soil chemists internationally was that phosphorus was so strongly held by soil particles, that movement and loss from soil to waters was minimal. Recent research, and in particular three factors arising from that research, have changed that perception.

1. It is now recognised that very low levels of phosphorus can cause environmentally significant enrichment. In other words, losses of phosphorus, which are insignificant in terms of the growth of trees, can have marked environmental consequences.
2. Considerably more phosphorus than was realised can move through soils to reach drains and surface waters, i.e. the phenomenon of by-pass flow or macropore flow occurs in a much wider range of soils than previously thought likely.
3. There is now a much greater recognition of the importance of soil erosion and surface run off as mechanisms in phosphorus transport.

The most recent assessment of aerial fertilisation proposals carried out by the Southern Regional Fisheries Board concerned the proposed programme for year 2000 by Coillte. As part of that assessment, we examined a number of sites throughout the fisheries region. (The Southern Region comprises mainly the catchments of the rivers Barrow, Nore, Suir and Munster Blackwater.) In many situations we found direct connections from mound drain networks to receiving waters. These findings were not confined to specific plantations, or within particular counties. Afforested areas covering parts of Cos Laois, Kilkenny, Tipperary and Waterford were examined and found to have such direct connections between mound drains and the receiving environment. Our concerns were brought to the attention of Coillte, and all sites of concern to the Board were deleted by them from their fertilisation programme. Coillte's co-operation in withdrawing these sites is acknowledged. However, this raises the question as to whether the sites should have been included in the first instance. It is not as if the whole process of enrichment of our inland waters has just come to light. Everyone surely knows at this stage that, as stakeholder, we must all do everything possible to minimise nutrient losses to waters.

The Board's concern regarding Coillte's fertilisation proposals were brought to the attention of the Department of the Marine and Natural Resources' Forest Service Inspectorate, and to the attention of SGS Qualifor, who were assessing Coillte operations as part of that organisation's application for certification under the FSC scheme. From a Regional Board perspective, whilst we accept that in certain situations

fertilisation is required, aerial fertilisation can only, in our view take place on mound drain areas, where drainage networks stop well short of receiving surface waters, and where there are well grassed/planted buffer zones in which all nutrients in drainage waters can be assimilated and incorporated into growing tree crops[2]. Also, the continued use by contractors of peat soils where fertiliser application is necessary in order to achieve a particular yield class must surely be questioned in a national context.

FISH MOVEMENT AND STREAM FLOW REGIME

This is an area where, in an Irish context, the amount of research data available is limited. Based on work carried out by research workers in University College Cork, it would appear that base flows in afforested catchments comprise up to approximately 60% of total stream flows, whereas in non-afforested catchments, base flow comprises only approximately 20% of total flow. Rates of evaporative loss can be up to 50% of annual rainfall for forested catchments, whereas in non-afforested areas the rate of evaporative loss is only up to 10%. The UCC research findings also suggest that peak flows in mature forested catchments are approximately 25% of those in non-afforested areas. From a fisheries perspective, these findings are of concern. A nett loss of surface water resources within a catchment has implications for the triggering of fish movement and response. Less water means, for example, less dilution in the case of entry of pollutants. It means that previously passable obstructions can be rendered no longer passable. Salmonids are attracted to migrate upstream for spawning purposes by what is termed a 'fresh', i.e. a flood type event bringing new and increased water flow from upstream. In terms of the well-being of fisheries, an issue that must be considered is whether there should be a limit on the area of any individual catchment/sub-catchment that is permitted to be planted.

IN-STREAM FORESTRY DEBRIS

Earlier this year there was a catastrophic flooding event in the catchment of the Glengarra River near Burncourt, Cahir, Co Tipperary. As a result of an extremely heavy rainfall event confined to a small area of the catchment, extensive areas of agricultural land were flooded, and serious damage occurred to bridge structures. At one stage during the flood event, the main Dublin/Cork road was barely passable to road traffic because of the partial blockage of a bridge with timber debris which had been carried down in what was a raging torrent from upstream. Locally the view was taken by landowners and others that Coillte were to blame, because of the amount of forest debris washed downstream. Issues such as compensation for damage to grasslands and responsibility for road and bridge repair works arose. Coillte could not, of course, be held responsible for the intensity of rainfall, nor indeed could they be termed accountable for the loss and movement downstream of the great majority of the timber debris. In fact, much of what was carried downstream originated well above those areas owned by Coillte.

The above incident is fortunately one which seldom occurs, but it does raise the whole issue of timber debris within river systems. University College Cork (UCC) has been carrying out research on the experimental use of instream forest debris in terms of improvements to the aquatic environment, with particular reference to increasing macroinvertebrate habitat and thus numbers/food supply, and with the intention of improving salmonid habitat/numbers. We are very anxious that the message must not go out that leaving all forestry debris in streams and rivers is to be encouraged in all situations. Extreme caution must be exercised regarding the placing of instream structures. It must be clarified and understood that improvements in terms of habitat quality and stock density can be achieved by using natural instream materials. It is essential that all water uses and all water users are considered insofar as the placing of such debris and structures are concerned.

Typically in the UCC experiments, structures made of woody debris were placed at a 900 angle to stream flow, were sized half of the stream width, were not fully submerged, and there was no bank protection placed either upstream or downstream of the structures. By way of contrast, in cases where similar work has been carried out by Regional Fisheries Boards, the type of deflector structures installed are typically less than one third of channel width, they involve the judicious use of natural instream materials (boulders and stones), are placed at a 1350 angle to river flow, are submerged in all flow conditions, and bank protection is provided both upstream and downstream. These concerns are raised not as criticisms of the work carried out by UCC, but to highlight the potential for downstream flooding, damage and undermining of bridge structures, river bank erosion, and the potential for interference with angling due to fouling of fishing tackle where woody debris might drift or progress downstream. We need to be aware, unlike for example the United States, where a considerable amount of work on the use of woody debris has and is being carried out, that we do not have large wilderness areas in this country. Very many of our rivers and streams are crossed by minor and major roads and associated bridges, and particular care must be taken insofar as advising on the use of instream debris. The essential point to note is that all such material when placed instream must be stable and not create difficulties for any water users.

[2]These considerations are addressed in the new Forestry and Aerial Fertilisation Guidelines (Forest Service 2001) – Eds.

ACID SENSITIVE WATERS

Table 1 summarises pH, alkalinity and conductivity values obtained as part of a sampling programme carried out by the Southern Regional Fisheries Board in 1991 in order to identify and designate, in the context of the then Guidelines for Forestry and Fisheries (Forest Service n.d.), fisheries waters as sensitive or non-sensitive on the basis of designation criteria set out in the guideline document. It is apparent therefrom (for example, pH values less than 4.5, negative alkalinity, i.e. positive acidity, and some very low conductivity values) that throughout the fisheries region there are areas that by virtue of a combination of geology and overburden, and perhaps to an extent afforestation practice, that are clearly acid sensitive. From a fisheries perspective, we wish once again to pose the question: should areas that are naturally acid sensitive because of their natural geology and overburden continue to be planted? Additionally, is not the broad conclusion from COFORD published research (Allot *et al.* 1997, Kelly-Quinn *et al*. 1997), carried out in Connemara and Wicklow, that coniferous plantations in particular will lead to increases in acidification with consequential adverse impacts on the fisheries resource? Can further forestry development of such sensitive areas truly be considered sustainable?

TABLE 1: ACID-SENSITIVITY OF SELECTED RIVERS IN THE SOUTHERN FISHERIES REGION (source: Southern Regional Fisheries Board, 1991).

River	***pH***	***Alkalinity mg/l***	***Conductivity* µS/cm**
Aherlow	6.13-8.40	1.28-280.0	61.3-651.0
Arglo	7.90-8.18	277.0-354.5	650.0-692.0
Arrigle	6.80-7.50	9.5-42.7	106.7-203.0
Clodiagh	6.75-8.11	6.0-106.0	57.2-350.0
Colligan	4.35-8.77	-0.06-92.0	57.9-392.0
Dalligan	4.23-8.11	-0.08-44.0	61.1-208.0
Delour	3.90-8.60	-0.01-154.5	120.9-398.0
Glenary	6.85-7.55	5.7-47.5	70.5-77.5
Glenshelane	7.21-7.84	16.0-38.0	95.1-192.0
Little Arrigle	7.03-8.51	29.0-303.5	144.8-776.0
Mahon	4.48-8.00	-0.05-66.0	49.2-387.0
Muckalee	7.36-8.53	16.0-204.0	102.9-472.0
Multeen	7.31-8.56	33.6-132.0	150.8-313.0
Nire	6.49-9.04	4.8-72.0	50.1-272.0
Tar	4.17-8.81	-0.27-205.0	51.9-502.0
Tay	6.25-7.92	5.5-71.5	76.5-310.0
Thonoge	4.90-8.15	1.5-223.0	73.9-495.0
Trib Dungarvan Bay	6.57-7.78	3.64-60.8	84.9-288.0

STREAM CROSSING STRUCTURES

Inevitably, be it afforestation, reforestation, tree felling, road preparation, etc., there are numerous instances where river/stream crossings are required. It is absolutely essential that consultation with Regional Fisheries Boards takes place at the earliest possible opportunity in advance of the placing of crossing structures. We do not claim to have a monopoly on either expertise or virtue, but by meeting and explaining our respective roles and requirements, better understanding can be achieved among all parties. For example, such consultation could ensure that a crossing structure could be located downstream rather than upstream of a particular sensitive aquatic species. Of special concern, is the issue of rutting adjacent to crossing structures due to the continuous use of the same route, for example, by forwarders. Rutted areas turn into watercourses themselves, and convey suspended solids, engine and lubricating oils directly to the receiving environment.

Stream crossing structures should not damage fish habitat or create blockages to fish and macroinvertebrate passage. Design and choice of structures must be based on the technical and economic feasibility of the structure to pass fish and macroinvertebrates, the requirement to protect critical fish habitats, e.g. fish spawning and overwintering areas, and prevention of erosion and sedimentation. The most frequently used crossing structures on small streams are culverts and these are associated with some of the most common passage problems. Fisheries Boards prefer the use of bridges or bottomless culverts on fisheries streams and rivers, as these have the least impact on fish and macroinvertebrate passage. Bridges and bottomless culverts are the best option for maintaining natural stream channel characteristics. These structures generally span an entire stream or are supported by a minimum number of piers in the stream channel. Clear span designs maintain the stream channel profile, do not alter stream gradients, readily pass sediment and debris, and provide unrestricted passage for all size classes of fish by retaining the natural stream bed and gradient.

Contractors must be made aware that stream size is misleading in relation to fish carrying capacity. Even the smallest streams and watercourses have potential in a fisheries context. Just because a river or stream does not appear on a 6-inch Ordnance Sheet, or has been recently man made, does not mean it is unimportant.

EXAMPLES OF DIFFICULTIES, RESOLUTION AND FOLLOW-UP ACTION

The following three examples are presented to illustrate at a practical level, the type of issues and problems which we have encountered in our day-to-day work on the ground.

The first example involved a felling operation in the middle of a large forest, which required the extraction of felled timber across a small and indeed what might not unreasonably, from the perspective of a forestry contractor, be termed a minor watercourse in the forest. The contractor concerned placed a number of timber poles in the watercourse parallel to its flow, and placed a brash mat type structure downstream of that crossing structure for the purposes of intercepting and trapping suspended solids disturbed during machine passage across the watercourse. Each evening, at the completion of felling and extraction, the contractor removed the timber poles and brash mat structure, probably because these were acting as a barrier to the movement of water, and the watercourse was ponding upstream of the crossing structure. As a result, a plug of material with a high suspended solids content was released which progressed downstream initially through the small watercourse, eventually entering a large river on which was located a commercial fish farm development. This interfered with the feeding of fish in the farm, as the water abstracted from the river was turbid and of high solids content. When the problem at the fish farm arose, the Southern Regional Fisheries Board received a complaint from the proprietor of the farm, as it was believed that a discharge was being deliberately made during the hours of darkness, i.e. in the early morning when personnel came to work at the fish farm, they found fish holding tanks to be turbid and with high solids content, whereas by mid-morning and certainly before mid-day, all such discoloration and turbidity apparently disappeared from the river system. On investigation, and taking account of travel time within the river, we were satisfactorily able to establish that the discoloration and turbidity at the farm was as a result of the removal of the poles and brash mat structure. This was an example of where a contractor appeared to be genuinely attempting to offset the effects of the blockage caused by the poles and brash mat. Following contacts between the Board and the contractor concerned, the matter was satisfactorily resolved. This illustrates that stream size can be extremely misleading, as in this case a very small and apparently unimportant watercourse acted as a direct conduit between the felling site and the fish farm. The solution in this particular case, and in similar cases, is obviously the installation of a permanent crossing structure, totally spanning the watercourse.

Very many afforestation operations within the Region involve the excavation of mound drains. In this second example, the Board during the course of inspections encountered a site (ca. 30 ha) wherein the great majority of mound drains discharged directly to tributaries forming part of the receiving aquatic environment, and there were very few interceptor drains or settlement areas within the site. Because of the seriousness of the situation, and the extent of erosion taking place, a formal complaint was made by the Board to the Forest Service. Grant assistance for the particular site was put on hold. In co-operation with the Forest Service Inspectorate, a rehabilitation plan for the site was prepared which involved considerable reworking of areas of the site, blocking of all mound drain outlets, back filling of mound drains with debris to act in the interception and slowing down of water flow and the settlement of solids, and installation of a number of settlement areas/settlement lagoons also took place. These works were costly and difficult. Clearly reworking and undoing damage is more difficult after the event.

A particularly bad example of site erosion because of poor planning at the ground preparation stage was encountered by the Board, again following routine on the ground inspections. The problem arose because only one main collector drain was installed in what was a severely sloping site, with all mound drains running thereto. The interceptor or main collector drain ran directly down, as distinct from across the slope/contour of the site. Extreme erosion took place, and in areas the main interceptor drain was up to 5 m in depth as a consequence of erosion. Also, eroded material was discharged over considerable areas of the plantation, up to 0.5 m deep in places. In practical terms, it is very difficult to undo the adverse effects of such severe erosion. The message obviously is to plan drainage layout at an early stage, taking account of soil type, land contour and expected run off. In this situation, the Forest Service Inspectorate advised the installation of a criss-cross series of interceptor drains in an attempt to ameliorate the situation. Following the carrying out of that remedial work, a site visit was arranged in conjunction with the contractor and Forest Service, which involved a large number of contractors working in the general Munster area. Visits such as this serve to create greater awareness of just what can go wrong, and the practical difficulties in retrospectively trying to rectify errors.

These examples serve to illustrate the importance of pre-planning and, in certain situations, direct contact with Fisheries Boards in advance of the commencement of operations. The Board would like to acknowledge the high level of co-operation which we received in dealing with each of these examples from the Forest Service of the Department of the Marine and Natural Resources. We would also like to acknowledge, since Coillte is the single largest contractor we deal with, that in recent years there have been very considerable improvements both in terms of communications and co-operation. However, there are still improvements to be made in a number of areas, and we look forward to co-operating with all parties concerned to ensure that in the carrying out of afforestation operations, these will be wholly sustainable and compatible with the well being and development of our inland fisheries resources.

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Forestry and Water Quality: A Washington State Experience

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ABSTRACT

In the United States, Washington state has used a committee-based consensus approach to identifying forest land management issues and mitigation approaches. Modules were developed to deal with resources, including water quality. While temperature is emphasised, other water quality parameters are also analysed. Information is synthesised from all modules and a management prescription prepared. Criticisms are that analyses are partial and that monitoring is not mandatory.

Keywords: *water quality, temperature, watershed analysis, consensus approaches, TFW (Timber, Fish and Wildlife).*

EARLY FOREST USE IN THE UNITED STATES

The first foresters in the United States were probably the Tribes, the aboriginal peoples who inhabited what is now the United States. They harvested various forest products for crafts (such as baskets) and accomplished habitat manipulation. They would start fires to clear brushy areas and open up timbered areas to increase game production and production of herbs and forbs that they used.

Europeans came to the United States' eastern seaboard in small numbers in the 1400's through the 1600's, with little appreciable effect on the landscape. Once they started settling, however, they started to influence their surroundings. In addition to viewing the forests as a source of raw materials, forests were often considered as being 'in the way'. The forests prevented people from farming.

As the East Coast of the US became settled, Europeans began spreading out across the continent. Forest use moved along with the people and slightly ahead of development – from the Northeast to the Ohio River Valley and on to the Great Lakes and the Big Pine Woods around the turn of the 19th century.

There had been some exploitation of timber resources in the Pacific Northwest, around 1900, but it hit its high point from the mid-30s through to the early 70s. As supplies in the other areas diminished, forestry moved to the Intermountain area and to the South East (Georgia).

About one third of the US is currently in forestland, 58% (100.9 million ha) of which is federally owned (US Forest Service, Bureau of Land Management, etc.) and 34% is private (in the Pacific Northwest owned by companies such as Weyerhaeuser, Plum Creek, and Boise Cascade).

CURRENT ISSUES

There are many issues one could highlight depending on one's perspective. Fragmentation of forest land is an issue for certain factors, particularly wildlife. Forested habitat - 'islands' - within urbanised areas often does not have sufficient area to sustain some species or functions (such as a watershed for water supply).

Conversion of forest lands to other uses is gradually reducing the overall supply of timber. According to the American Land Trust, in the US, we are losing our landbase at the rate of 160 ha per hour. Carbon sequestration goes hand-in-hand with land-use. We are losing trees at a rate that causes some concern in this regard.

Fire suppression policies have been an issue for decades. Policies of complete fire suppression have allowed for fuel buildup and when a fire does occur, it often is more intense and covers a larger area than if an alternative 'let burn' policy had been in place.

Water quality has deteriorated over the years, partially due to some forestry practices. We have logged in areas where we maybe should not have, where we are getting slumping and, with road maintenance dollars having been cut, causing things like road failures and culvert blockages.

WASHINGTON STATE FORESTRY

Forestry in Washington (according to 1998 figures) is responsible for 52,546 jobs (direct and secondary) and has a value of $11 billion. It is the second leading industry after transportation (i.e. Boeing Airplane Company). (Washington's data gatherers consider technology businesses, such as Microsoft, as services and not industry.)

Forestry in Washington State has two components – an east side and a west side, with the Cascade Mountain Range which runs north-south as the dividing line. The east side of the state is dry, lightly populated and relatively undeveloped. The west side has highly urbanized areas and most of the state's population. Pines dominate the east side while the west side has primarily Douglas fir, along with western hemlock, western red cedar, and Sitka spruce, along with red alder and bigleaf maple.

Forest land in Washington (8,651,610 ha) is 48% federal (US Forest Service, National Parks, Bureau of Land Management and others), 36% private, 10% state and 6% tribal. Activities on state and private lands are regulated by the state Department of Natural Resources while forestry on federal agencies' lands is generally self-regulated. Seventy-eight percent of the timber harvest is from private lands. Total harvest from all lands in Washington in 1998 was approximately nine and a half million cubic metres (Washington State Forest Protection Association 1999).

WASHINGTON'S MAJOR ISSUES

Growth and land conversions

Population growth and associated forest land conversion to other uses is an issue. The land base for growing tress is eroding. At statehood (1889), Washington had about one-third of a million people – now it has nearly six million. Along with that growth comes demand on resources, such as more drinking water, more landfills, less habitat, more impervious surfaces, etc.

Endangered Species Act

The Northern Spotted Owl was listed in 1989 as threatened under the federal Endangered Species Act. More recently, over the past three years, 17 salmonid species have been listed as either threatened or endangered. A significant influence on these fish species has been the quality of water.

Water quality[2]

In Washington state, there are about 1,000 water bodies that have substantial water quality problems. The federal Environmental Protection Agency, under the authority of the Clean Water Act, regulates water quality. Generally, and it is true for Washington state, that authority is delegated to the states for administration while EPA retains oversight.

TFW

TFW is the acronym for Timber, Fish and Wildlife. In the mid-70's, there were court cases that held that the treaties from the mid-1850's gave Tribes the right to 50% of the fish and also the right to have the habitat for those fish (and also wildlife) kept in a good condition to produce those fish. The litigation involved the Tribes, state agencies, timber companies, environmental groups, and probably others.

There was a court case that held that the state forestry agency had to examine all environmental impacts during its environmental assessments. The Endangered Species Act has a provision for third party lawsuits which says, in effect, that if a state agency does not adequately protect a resource, that it can be liable for the infraction. The same approach holds true for the Clean Water Act.

The traditional approach had been for the various parties to fight and sue one another. The traditional approach really did not work very well – it was costly to litigate, it often did not protect the resource and outcome was not predictable.

Prior to TFW, forestry was done on a case-by-case basis, essentially in a vacuum by the state forestry agency. The Tribes and environmental groups felt they were shut out of the process. Industry wanted consistency and predictability. The state agencies wanted resource protection and compliance with the laws.

In 1986, the Tribes, environmental groups, industry, and state agencies got together to try a consensus approach. A meeting was convened at a resort by a neutral facilitator and they divided the group into policy

[2]The website for Washington state's water quality programme, which includes regulations related to forestry, is: <http://www.ecy.wa.gov/programs/wq/wqhome.html>.

and working groups. The policy group consisted of the decision-makers and the working groups were just that – they met and developed approaches to dealing with the issues of timber, fish, wildlife, and water.

TFW ground rules

There were a couple of underlying precepts to the TFW agreement. One was that the process was voluntary – no-one was forced to participate. The motto for the group, as coined by the head of the industry group, Washington Forest Protection Association, Stu Bledsoe was, "Go where the truth leads"; or, to paraphrase – "What do the data say?" There were four basic ground rules that were agreed beforehand. The first was that weapons had to be left at the door. Essentially, this meant that the participants had to work together to try and achieve solutions rather than trying to figure out ways to confound those who had traditionally been on the opposite side of the table.

The second ground rule was that participants needed to truly listen. Preconceived notions had to be abandoned so that an understanding of different views could be developed. Just because someone's view differed from your own, did not make it wrong.

Third, any group had the freedom to walk away from the negotiating table. BUT, if a group decided they wanted to leave, they had to say what the issue was and give the other participants a chance to 'fix' it. A disgruntled group could not simply walk away without an explanation.

The final ground rule was that the negotiators were attempting to reach consensus. They defined consensus as no dissenting opinions (which meant that on some occasions some groups chose not to say anything.)

TFW organisation

After a final agreement in 1987, TFW retained the policy and working group approach. Additional working groups were established as issues arose and an administrative group for the day-to-day things was established. The Policy Committee continued to be the decision-makers, as it was during the initial stages. This group would set the strategic direction and work with the legislature for changes to the laws.

Directly under policy was the Administrative Committee. Acting much like a screening group, they formulated the questions and issues for the Policy Group and acted as intermediaries to the working groups.

The Field Implementation Committee (FIC) had oversight for how the various things TFW developed were actually being implemented in the field. For example, FIC worked with field personnel to see if the road management requirements made practical sense – could they be implemented? If they are implemented, did they work?

A cornerstone of TFW was the CMER committee. The Cooperative, Monitoring, and Research committee developed research proposals to answer management questions, developed the research projects (or reviewed proposals), set up quality assurance/quality control measures, and then developed reports on the results. The CMER sub-committees would actually develop the proposals or oversee projects and then report back to CMER, who would package them for presentation to Policy.

The CMER sub-committees vary over time. The most recent committees have been for fish, wildlife, monitoring and water quality. There used to be committees for other functions, like an information/education committee and a data committee. The idea has been that if a committee gets its work done, it can disband. CMER sub-committees also have the ability to establish subordinate sub-committees, such as what the water quality committee did in establishing the wetlands committee to look at wetlands and water quality interactions.

The way this system worked in a practical sense was that Policy would assign projects to a CMER sub-committee, CMER would set up the composition of the sub-committee, timelines, product expectations, etc. and then bounce that back to the Policy group who would approve, approve with modifications or disapprove. The CMER sub-committee would work on the issue providing periodic updates through CMER to Policy. Upon completion of the project, there would generally be a CMER-sponsored workshop where results were presented. A final report would be provided to CMER and then CMER would provide a management implications synopsis to Policy. Sometimes this process would go back and forth several times.

WATERSHED ANALYSIS (WSA)

An early product of TFW and CMER was the watershed analysis approach. Watershed analysis was (is) a holistic examination of the various factors that could interact with forestry activities. It addressed cumulative effects.

WSA is science-based and addresses seven areas in a 'module approach' – four process modules and three resource modules. The process modules are mass wasting, surface erosion, hydrology, and riparian. These modules look at resource interactions in the particular basin (catchment). The resource modules include fish habitat, public works/water supply, and water quality. Each of the modules has a team comprised of trained and certified experts who analyse the conditions for their module within the basin. After the various analyses are completed, the module team leaders get together for synthesis, where they examine module interactions, describe causes and outputs, along with a summary of hazards and vulnerable resources.

These leaders develop a report which describes the situation (a causal mechanism report – what is likely to happen and what can be done about it) and pass that report to a prescription team. The prescription team describes what and how to implement management measures. As an option, they can develop and implement a monitoring program to see if the prescriptions are appropriate.

What this process does is develop forestry rules to guide forestry activities within the assessed basin. Having a completed and approved watershed analysis allows departure from the standard 'cookie cutter' forestry rules. WSA is a voluntary programme; standard state-wide rules apply to those areas where watershed analysis has not been done.

Results of watershed analysis

The incentives to complete WSA are many. It develops a resource inventory and a map set that will assist mangers in forest management, as well as other activities. Watershed analysis brings standardisation of approaches and products. This allows scale economies and comparisons between basins.

WSA streamlines the forest practices permit granting process and brings predictability to industry operators – they know what to expect on a watershed basis rather than on a permit-by-permit basis.

Water quality module

The final and most controversial module for watershed analysis is for water quality. This section will be a case study of how the water quality module (WQM) was developed and what it was intended to cover, and what the issues surrounding it were.

The WQM was one of the three resource modules (the other two being fish habitat and water supply/public works). Its intent was to address those forestry impacts that influence water quality and to provide linkages to the other modules (for example, if shade is reduced under a management scheme developed under the riparian module, it could influence water temperature – a water quality parameter in Washington state.).

In Washington, "waters of the state" include streams, rivers, creeks, wetlands, lakes, ponds, and estuaries, all of which are subject to the state water quality standards (Water Quality Standards for Surface Waters of the State of Washington, Chapter 173-201A WAC). Forest management activities cannot legally degrade water quality. Through TFW, various committees had tried to develop a water quality module because people knew forestry was having a harmful effect on water in many cases but there was no consistent mechanism for avoiding or mitigating those effects.

After the five years of failed attempts, another water quality group was established. It was comprised of staff experts from the state forestry agency, an industry representative, a delegate from a Tribe, an environmental group envoy, and an agent from the state water quality agency.

The team accomplished their task of preparing a water quality module within about eight months by working together extremely well - this took place for several reasons.

Many people wanted to be on the committee. The committee's recommendations would be very important to all involved. It seemed that some wanted to be involved not to help develop the module, but to scuttle it. Participation on the committee was therefore limited to those who actually needed to be there and could contribute to its development. After a few months of working together, group psychology seemed to take over and we started acting as our own group with the prime objective being to develop an acceptable module

in the face of severe opposition that would address Endangered Species and Clean Water Act needs.

An additional factor that contributed substantially to completing the module was that we stripped it down to the bare essentials. We limited the things to be included to those things where we thought we could reach an agreement. (The logic used was something like, "Would you rather have a 50% efficient module or no module?" The Policy group accepted this logic.) We omitted many forest management factors that have an obvious influence on water quality. The prime example of an area omitted from the module was pesticides.

Water quality module project management

Project management follows a similar path for all the modules in watershed analysis.

The first step is to assemble available materials and maps. Relevant information would be gathered, including reports, US Geological Survey topographic maps, National Wetlands Inventory maps, Clean Water Act maps, administrative boundary maps, etc.

The water quality module analysts would get together after reviewing the information they have and decide what further information might be needed and start scheduling project tasks. An example of a project task might be taking temperature measurements through the summer in a wetland in order to determine what the impact of harvesting near that wetland might be.

The analysts would develop a set of base maps that would show all water bodies, water supply diversions, problems areas etc. The water quality module analysts would share this information with analysts for the other modules (riparian, hydrology, fish, erosion, water supply/public works) and seek what information those other analysts might have related to water quality.

A vulnerability assessment would be conducted. Hazards would be described and mapped, vulnerable resources would be identified and mapped and the potential for delivery of a ‘hazard’ to ‘vulnerable’ water would be assessed. The logic here is that there may be a hazard (a slump area, for example) and there may be a vulnerable body of water downhill from it (example- a wetland that could be filled with sediment), but if there is no way for the sediment to be delivered, the hazard is not really an issue.

The assessment addresses critical questions or information needs:

- waterbodies are identified,
- the vulnerability of those waterbodies is identified,
- indications of vulnerability are noted,
- the ability of the ‘hazard’ to be delivered to the vulnerable waterbody is noted.

During the development of the water quality module for a watershed assessment, certain assumptions are made. Those assumptions are:

- all surface waters are assessed,
- water quality standards identify key characteristics,
- changes in input variables can result in changes in water quality,
- water quality varies in space and time,
- waterbodies differ in their functional characteristics,
- a variety of land uses and natural processes affect water quality,
- a waterbody reflects its response to past and current watershed processes.

After this work is completed, there is a team meeting to bring all the information together and adjust it as needed. A report is produced which is taken to the synthesis meeting (where the module leaders get together.)

Water quality parameters included in the water quality module

As previously stated, the number of parameters addressed in the WQM was limited. The parameters covered are: temperature, sediments, nutrients, dissolved oxygen, and acidity. In Washington state, in most cases, the biggest water quality concern is temperature elevation after harvest. Because of that concern, this module emphasizes temperature. There is some justification that some practitioners have called it a "temperature module", as opposed to a water quality module.

Temperature

There is no temperature assessment above 1100 m (3600 feet) west of the crest of the Cascade Mountain range or 1400 m (4600 feet) east of the crest. The logic is that ambient air temperature is the determining factor, i.e. it is colder at higher elevation.

Shade is determined – what it is today and what it could potentially be. The vulnerability of the water body or bodies to shade loss is determined. Maps are completed. Generally, shade is determined using a densiometer.

Sediment

Waterbodies in Washington state are classified from AA (extraordinary) down to C (fair). The level of sediment allowed in each class is part of the standard for that class. In this module, the focus is on wetlands and their vulnerability to filling from sediment.

Nutrients

Phosphorus and nitrogen are generally not an issue for water bodies in the Pacific Northwest except for lakes, ponds and wetlands.

Dissolved oxygen

Most streams in Washington are at or near the saturation point for dissolved oxygen (DO). DO is generally associated with either slow-moving streams or with lakes and wetlands.

Acidity

Acidity standards are part of the water quality standards. All water bodies are assumed to have a low vulnerability to influence from acidity unless they fall outside the standards in the water quality standards.

Weaknesses of the water quality module

Some people who have worked with the module would probably say that this list is much too short.

We changed some of the terminology. The changed terms confused people. The most vivid example is that instead of talking about shade, we called it "view to sky". People were unsure what we meant.

In the temperature part, we assumed that lakes and ponds were round. This had more to do with modelling than anything else, and obviously, lakes and ponds are not round.

We omitted factors which might be important in a particular watershed. For example, an area may have been treated with chemicals, and, because pesticides are not addressed in the module, any influences on water quality from the pesticide may have been missed.

The federal Environmental Protection Agency came into the process late and had reservations about the approaches. They agreed the module would be sufficient to meet Clean Water Act requirements for the specific parameters addressed, but they held out conditional acceptance provided monitoring would be included in subsequent versions. (EPA’s concerns were satisfied when the "Forests and Fish" Legislation was passed in 1999.)

The WQM needs to be strengthened to include all those water quality parameters affected by forestry activities.

CURRENT SITUATION

Legislation (the so-called "Forests and Fish Report") was passed in 1999. It included many of the components of the water quality module. Since the federal fish and water agencies were involved in the Forests and Fish legislation, there is agreement from the federal agencies that requirements of the Endangered Species Act and Clean Water Act are met.

Industry is backing away from the entire watershed analysis process because they believe it is not paying off for them in a cost/benefit comparison. A watershed analysis costs tens of thousands of dollars and many forestry companies feel the pay-off for undertaking such an endeavour is not sufficient. Some companies are still in the process, but others are backing away, so the future of watershed analysis is not clear. Some of the pressure to complete a watershed analysis was relieved because the Forests and Fish legislation covered many of the same factors as did watershed analysis. (Forests and Fish applies state-wide and the regulatory effect was a raising of many of the standards for water quality, riparian, wildlife and other resources.)

Environmental groups and some Tribes left the process midway through the development of the Forests and Fish legislation because they felt that water and fish were not protected adequately. In fact, two law suits are pending from environmental groups against the state forestry agency – one for the Clean Water Act and one for the Endangered Species Act – each contending that those resources are not protected as they should be.

The watershed analysis process is slow, and it is unclear at this time if it will survive. Many participants are tired and have moved on to other challenges.

On the positive side, stakeholders and the general public are much more educated about the issues than they were previously. Ten years ago the federal agencies were not engaged – now they are prominent players and are helping to solve problems through staff expertise and some funding.

Other sectors are now seeing that they have a stake in public resources. For example, because forestry has stepped up to the mark and has made significant strides in how they are managed, other sectors, such as agriculture, are seeing that they need to make a contribution toward protecting public resources. An example would be in the forestry realm, buffers a minimum of 15 m (50 feet) wide are required, while currently, in agriculture, the buffer requirement is 3 m (10 feet). Disparity is becoming apparent.

All stakeholders need to be involved - those affected by a decision ought to be a party to its preparation. This is a difficult line to walk because if the groups are too involved, it becomes a conflict of interest situation where they are writing their own rules.

Governmental regulatory agencies need to value input from constituency groups. Work with people, not against them.

Do not be in a hurry. Consensus processes take time because newcomers need to be educated, people need to take issues back to their constituencies, negotiations need to occur, decision-makers need to agree, and the general public needs to be informed. Magic potions only exist in fairy tales.

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Studies on the Interactions Between Forests and Aquatic Ecosystems in South-West Ireland

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ABSTRACT

Some of the key conclusions of three studies on the interactions between forests and forestry practice on aquatic ecology in south-west Ireland are reported. Our studies of water quality across 16 clearfelled sites showed that many of the physicochemical changes were found to be short-term (within the time-frame of the study) and did not occur at all clearfelled areas. Overall water pH, total hardness or conductivity did not appear to have been influenced by clearfelling throughout the study period. In the majority of clearfell study catchments, no changes in stream macroinvertebrate community composition were found after felling when compared with reference stations. Seasonal effects overshadowed other environmental variables, indicating that at the majority of sites no short-term impact on macroinvertebrate community structure due to clearfelling was noted. Intensive studies at two stream sites in the Ballyhoura Mountains showed that the levels of nitrate (mg N/l) were broadly similar on all sampling dates at adjacent and downstream stations relative to the reference station following felling. Other hydrochemical parameters (e.g. total hardness, conductivity) showed a similar pattern at stations on both streams. It appears that relationships between fish metrics and environmental variables at regional level are swamped somewhat by inter-catchment variation; at the local catchment scale the habitat can explain more of the variation in trout metrics. Future analysis is thus probably better carried out over several years within catchments, with year on year variation taken into account in the analysis. There were significant increases in trout density and biomass in the debris sections relative to the control sections, one and two years after debris addition although trout condition was not modified by the addition of large woody debris.

INTRODUCTION

A number of recent studies have focused on the interactions between stream ecosystems and water quality in south-west Ireland. The AQUAFOR Study (Giller *et al*. 1997) focused on the interactions between forestry and stream water quality, hydrology and ecology. A detailed study of the freshwater ecology of the Araglin Catchment spanned over eight years (O'Halloran *et al*. 1999) and focused on the Kilworth catchment. Giller *et al*. (2001) have been studying the stream macroinvertebrates in relation to disturbance at Glennfinnish on the River Araglin for well over a decade. All of these long-term studies have provided valuable inputs into our understanding of the interactions between forest and aquatic ecology in Munster.

The expansion of the forest sector over the past decades has presented opportunities and challenges to the Irish landscape and the need for further research and the relevance of 'lessons from abroad' has to be determined, particularly in areas of low atmospheric pollution, such as south-west Ireland (O'Halloran and Giller 1993). Given the proposed further expansion of the forestry sector and the need to harvest forests, the Forest Service has developed guidelines for biodiversity, harvesting, archaeology, landscape and water quality (Forest Service 2000). These guidelines will need to be constantly reviewed and accordingly a number of studies have been supported by COFORD, Coillte and Enterprise Ireland to contribute to these revisions.

Three studies have been completed or are underway in the south-west area, namely: a study on the interactions between clearfelling operations and stream ecology (Johnson *et al*. 2000a), forest location and enhancement strategies for fish (Lehane 2000) and the impact of experimental tree-felling and subsequent restocking on water quality and stream ecosystems (Duggan *et al*. 2000). Here we present some preliminary findings for each project. More detailed analysis for each project are described elsewhere (Lehane *et al*. 2002, Johnson *et al*. 2000b, Duggan *et al*. 2000).

Stream macroinvertebrates tend to be most abundant around a particular set of optimum environmental conditions. The composition of communities of macroinvertebrate species thus changes along environmental gradients, both through natural variation (for example over time and through factors such as spate events) and through changes in environmental conditions from an activity such as clearfelling (Giller and Malmqvist 1998).

It is not known to what extent the results of research into the effects of clearfelling on stream ecosystems carried out abroad are applicable to the Irish situation. Factors such as climate, biogeography, pollution levels and scale of felling are different from elsewhere. Hence for environmental, as well as management, purposes it is important to establish what effects, if any, clearfelling has and how these effects might be minimised.

The aim of the clearfelling project was to examine the interactions between clearfelling operations and stream ecosystems, i.e. physicochemical parameters (water chemistry, stream morphology and habitat features), macroinvertebrate communities and salmonid populations. Here we present some preliminary results of the effects of clearfelling on macroinvertebrate structure based on a multivariate analysis, incorporating some of the major environmental variables examined. Canonical Correspondence Analysis (CCA) is a multivariate direct gradient analysis tool that can be used to relate community composition to known variation in the environment (Ter Braak 1986, 1987, 1990). This ordination technique detects the patterns of variation in community composition that can be explained by environmental variables. CCA analysis can also illustrate the degree of change in macroinvertebrate communities at sampling stations adjacent to or downstream of clearfelling from before to after felling, over and above natural variation and successional time reflected in samples from reference stations. We use this approach here to test whether clearfelling causes variation in the environment resulting in changes in species composition and community structure.

As part of the felling project described above, a small experimental site was established in April 1998 to monitor the effects of felling and replanting on streams with and without buffers in Mallow forest, Ballyhoura Mountains, north County Cork. The site was clearfelled in May 1998, with an area of approximately four ha felled adjacent to each stream. Felling was carried out up to the bankside at stream one while a 10 m buffer strip of coniferous trees and riparian vegetation was retained at stream two. Data were collected on water chemistry, in-stream habitat, macroinvertebrate communities and salmonid fish populations. Sampling was carried out at a reference station above and at treatment stations adjacent to and downstream of the felled areas on each stream. This experimental design allowed the testing of the impacts of felling and whether the presence of the buffer strip, as recommended in recently published Forestry and Water Quality guidelines (Forest Service 2000), has any impact on stream ecology and hydrochemistry during and following felling.

This study set out to track the impacts of forest clearfelling and subsequent restocking on stream ecology at a single experimental catchment. Monitoring of hydrochemistry and ecological parameters was carried out following clearfelling until April 1999. The current phase of this study, funded jointly by Enterprise Ireland and Coillte, began in March 2000 and aims to track both the longer term effects of felling and the immediate impacts of reforestation at the experimental site.

FORESTRY-FISH RELATIONSHIPS

It is well known that the nature of the surrounding landscape and catchment land-use adjacent to rivers is one of the primary factors governing the ecology of aquatic systems (Hynes 1977, Giller and Malmqvist 1998). Concern is often expressed about the potential negative effects of plantation forestry on fish, largely through hydrochemical changes, most notably acidification, although physical effects probably also play a role. Ireland and the south-west in particular, has relatively low levels of anthropogenic air pollution compared to other northern hemisphere countries. This offers the opportunity to investigate the influence of conifer afforestation plantations *per se* on fish populations. Previous work in this area has suggested that, in some situations, afforestation may enhance salmonid population densities within relatively buffered catchments. This unexpected finding was based on a limited number of sites and altitudinal bands (Wallace 1995). Confirmation of this trend could alter our understanding of the interactions between forestry and aquatic environments and provide objective information for management practices, particularly in terms of future location of forestry. Concern over the possible negative influences of conifer plantations on aquatic systems prompted this study into the spatial-temporal variation in hydrochemistry, trout metrics and habitat enhancement throughout the south-west of Ireland.

This COFORD-funded project investigated the relationship between forest location, fish populations and enhancement strategies in south-west Ireland over the period 1996-2000. The two main aims of this project were:

- to test the relationships between the level of afforestation, altitude and salmonid populations,
- to evaluate the potential for stock enhancement through manipulation of woody debris.

The second part of the salmonid project involved the experimental provision of large woody debris as a salmonid management technique. Large woody debris (LWD) is a natural component of unmanaged streams and rivers and its role in hydrological, chemical and biological processes is complex (Gurnell *et al*. 1995). Forest and water quality guidelines in Ireland (Forest Service 2000) dictate that woody debris should be removed from streams and rivers within forested catchments. A comprehensive survey of the in-stream large

woody debris in the Douglas River study area, carried out during 1996 and 1997, showed that the LWD loading in the catchment as a whole was low (O'Halloran *et al*. 1999), with debris dams confined to extreme headwaters of the various tributary streams. Given the recognised important role of LWD in steam ecosystems, we hypothesise that habitat quality in streams draining plantation forestry may be impaired by current forest-fishery practices and hence we experimentally manipulated woody debris to determine its influence on habitat configuration and fish distribution. This project aimed to quantify changes in stream habitat by examining physical characteristics of the stream channel before and after the installation of partial dams as stream rehabilitation structures, and to evaluate the potential for salmonid stock enhancement by manipulation of habitat structure in plantation forested streams using LWD.

METHODS

Felling project

Between 1996 and 1999 we monitored sixteen clearfelled areas located on predominantly old red sandstone in south-west Ireland under a wide range of felling conditions. Sampling stations, including a reference (usually upstream of felling), and at least one station adjacent to and/or one downstream of the clearfelling operation (depending on suitability) were sampled on each occasion. Each sampling station was 30 m in length and dominated by riffle habitat. All stations were sampled for physicochemical parameters and macroinvertebrates prior to felling, one and three months after and one year after felling.

Macroinvertebrates were collected semi-quantitatively using three one-minute kick samples in riffle habitat at each sampling station (500 µm mesh net). After collection, samples were returned to the laboratory and preserved in 70% ethanol. Since a large numbers of individuals were present in the majority of kick samples, sub-sampling was conducted as described in Johnson *et al*. (2000a). All macroinvertebrates were identified to the lowest operational taxonomic unit possible and relative abundance was calculated. For the analysis presented here 366 one-minute kick samples were used, which were pooled, resulting in 122 macroinvertebrate samples collected at reference, adjacent and downstream stations at different clearfelled areas and on different sampling occasions.

For each macroinvertebrate sample 48 different corresponding environmental parameters, including results from water chemistry and both in-stream and bankside physical habitat, were recorded or measured (methodology of data collection is described in Johnson *et al*. 2000a) and used for the CCA analysis. The CCA resulted in an overall ordination diagram of macroinvertebrate community composition of the 122 spatial and temporal samples and corresponding environmental parameters. Additionally we obtained ordination diagrams (on the same scale as the overall ordination diagram) for each of the thirteen individual clearfelled areas.

Single catchment clearfelling study

Reforestation of the experimental site began in May 2000, when ground preparation (windrowing/drainage and mounding) was carried out adjacent to both streams. Replanting took place in May/June with a mixture of species including Sitka spruce, Norway spruce, Japanese larch and sycamore. The site was then manually fertilised in early October.

The timing of biological sampling was related to on-site activities, and carried out in April (pre-cultivation and two years post-felling), June (one month post-cultivation) and August/September (three months post-cultivation). As in the previous study, the parameters studied included instream habitat (e.g. percentage cover of vegetation, sedimentation, substrate, canopy cover), macroinvertebrate communities (replicate Surber samples) and salmonid fish populations (sampled using an electrofisher and populations estimated by the removal method (Zippen 1958)).

Hydrochemical sampling was carried out in conjunction with biological sampling, during on-site activities and some flood events. Samples were analysed for pH/H+ ion concentration, suspended solids, total hardness, conductivity, nitrate and ortho-phosphate.

Salmonid project

Temporal and spatial variation in trout metrics, including fish condition, were assessed. Fish condition is a measure of the health of the fish in terms of a relationship between weight and length. It was calculated as:

$$Condition = \frac{weight\ (g) \times 100}{[length\ (cm)]^3}$$

All these metrics were analysed in relation to altitude, level of afforestation in the catchment, and the physical and chemical site characteristics, throughout the south-west of Ireland. This study was carried out between spring 1996 and autumn 1998 using electrofishing sampling techniques on a bi-annual basis at 144 sites in spring and 134 in autumn. Sites were categorised into four altitude bands and four levels of catchment afforestation giving sixteen treatment classes with internal class replication. A sample of 18 sites were refished every year to examine year–to-year variation. Subsequent analysis of trout density and biomass of these sites showed no significant differences across years, except for density between spring 1996 and spring 1998.

The salmonid investigations also involved a survey of the physical characteristics and fish stocks of 16 contiguous reaches on?. were surveyed in spring 1998 prior to the installation of 12 debris dams, installed on four reaches along 400 m of stream. Repeat surveys were undertaken in spring 1999 and 2000 (for further details see Lehane *et al*. 2002).

RESULTS

Clearfelling

Before presenting results of the CCA analysis, the physicochemical parameters which were influenced by felling are summarised in Box 1. Many of the physicochemical changes were found to be short-term (within the time-frame of the study) and did not occur at all clearfelled areas. Overall pH, total hardness and conductivity did not appear to have been influenced by felling throughout the study period. A detailed presentation of the effects of clearfelling on physicochemical parameters is given in Johnson *et al*. (2000c) and Gallagher *et al*. (2000).

BOX 1: PHYSICOCHEMICAL PARAMETERS INFLUENCED BY FELLING.

- Relative increases in magnitude of nitrate levels at some clearfell areas
- Increases in suspended solids at some areas, mainly centred around the period of the clearfelling activities
- Major peaks in suspended solids associated with the presence of machinery crossing points
- Increases in sedimentation on the streambed at some clearfell areas shortly after felling
- Soil inputs associated with bank collapses
- Increases in canopy opening where trees were felled close to the stream bank
- Relative increases in green algae and macroalgae at some sites which were previously shaded
- Increases in woody debris at some clearfell areas
- The formation of drainage channels running from some clearfell areas into the streams

The ordination diagram (Figure 1) displays sampling stations and environmental variables and shows the main pattern of variation in macroinvertebrate community composition as accounted for by the environmental variables. The closer the points are, the more similar are the communities. Arrows represent the direction of influence of environmental variables. Broadly speaking, the arrow points in the direction of maximum effect of that environmental variable across the diagram and its relative length is proportional to its strength of correlation to the main ordination axes. The longer the arrow the stronger is its influence on the pattern of community variation shown in the ordination diagram. All environmental variables that

explained a significant amount of variation in community structure were included in the analysis (using forward selected, a Monte Carlo permutation test). Variables such as altitude and distance from headwater, and, to some extent, nitrate and total hardness mainly defined the 1st axis, the seasons summer and winter defined the 2nd axis, with altitude and distance from headwater differentiating out further (Figure 1). Felling-related variables such as % soil on the streambed and % green algae also explained a significant, albeit relatively small amount of, variation in community composition on the 2nd axis. Other felling-related variables including area felled, % conifers in the riparian zone, % afforestation, % openness define the 3rd axis (not shown in Figure 1).

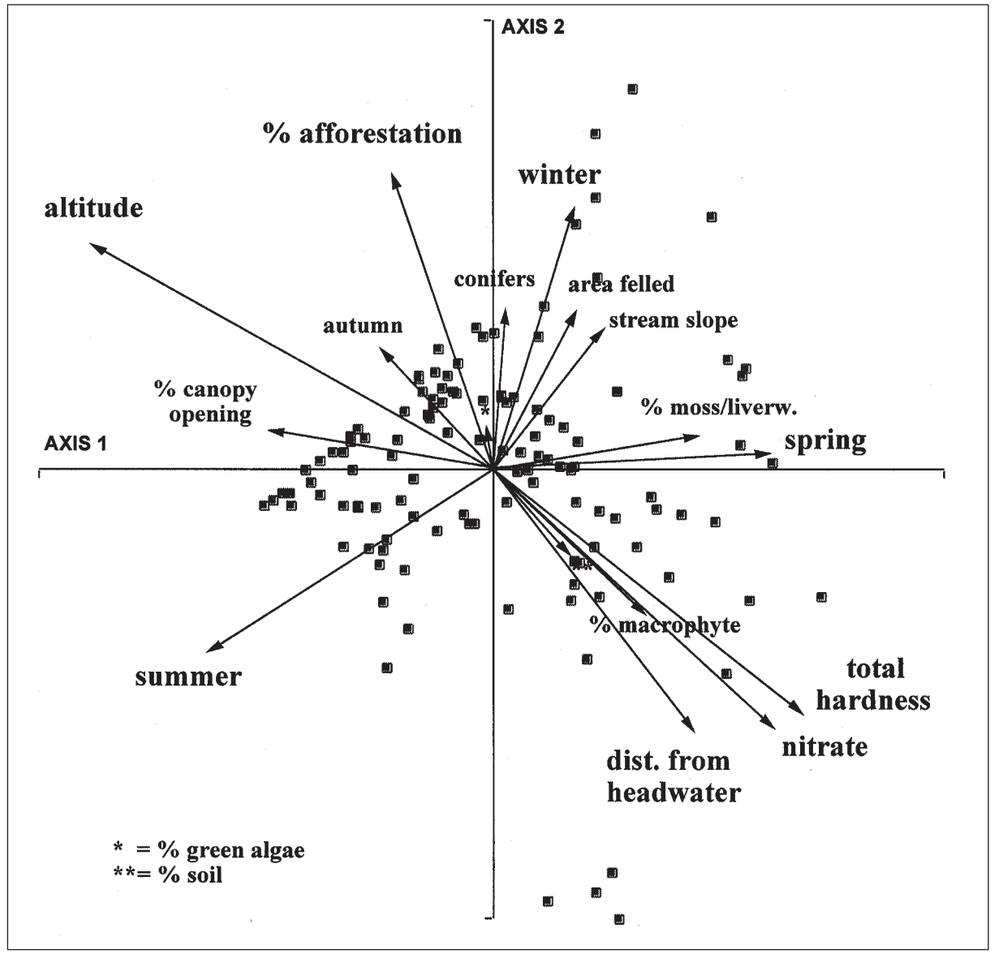

FIGURE 1: ORDINATION BIPLOT BASED ON A CANONICAL CORRESPONDENCE ANALYSIS OF MACROINVERTEBRATE COMMUNITIES SAMPLED FROM DIFFERENT STREAM SYSTEMS AND AT DIFFERENT IN-STREAM LOCATIONS AND TIME PERIODS IN RELATION TO CLEARFELLING IN SOUTH-WEST IRELAND.

Since the sampling stations are represented by 122 points in the ordination (with a large amount of overlap), it was difficult to visualise the changes in community composition after clearfelling from Figure 1. However, analysis of the individual ordination diagrams for each of the thirteen clearfell areas provided a clearer picture and a summary of the general findings is given below.

Overall, for the majority of clearfell areas, no relative changes in community composition were found post clearfelling when compared with reference stations. Seasonal effects were not overshadowed by other environmental variables, indicating that at the majority of sites no short-term impact on macroinvertebrate

community structure was due to clearfelling. There was some evidence of a change in community structure at four clearfell areas shortly after felling, but also evidence of subsequent recovery one year later. These sites were associated in the main with significant instream changes caused by river crossing and damage to banks and subsequent sedimentation problems.

Single catchment clearfelling study

At present the results for this project are preliminary and statistical analyses of the data are underway. No data on macroinvertebrate communities are available but some summary hydrochemical data are presented.

The levels of nitrate (mg N/l) are broadly similar on all sampling dates at adjacent and downstream stations relative to the reference station (Figure 2). Other hydrochemical parameters (e.g. total hardness, conductivity) exhibit a similar pattern at stations on both streams. Suspended solids increased in a tributary at stream two (with a buffer), immediately following ground preparation before planting (Figure 3).

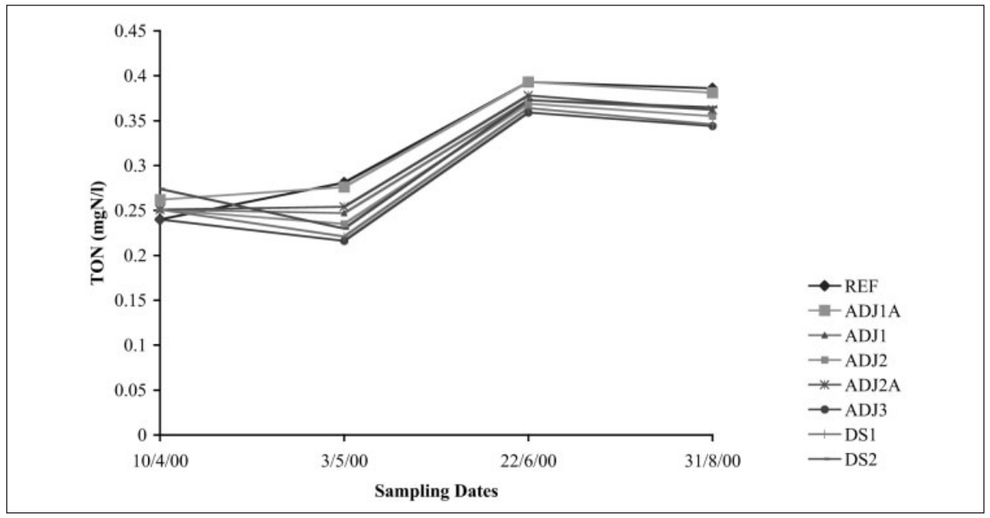

FIGURE 2: NITRATE VALUES AT STATIONS ON STREAM ONE (WITHOUT A BUFFER).

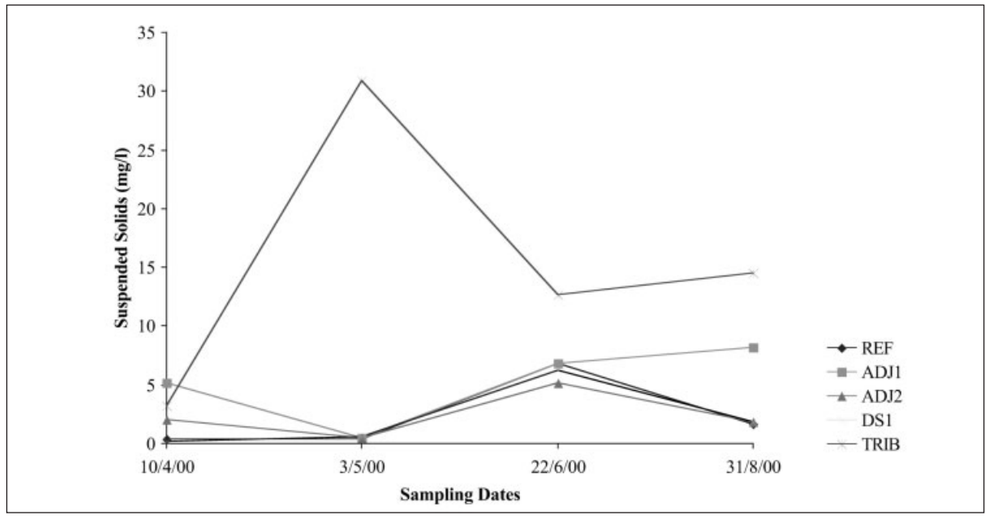

FIGURE 3: SUSPENDED SOLIDS (MG/L) IN THE TRIBUTARY AT STREAM TWO (WITH A BUFFER). THE INCREASE WAS OBSERVED IMMEDIATELY FOLLOWING CULTIVATION AT THE STATION TRIB, BUT NOT IMMEDIATELY DOWNSTREAM AT THE STATION DS1.

This small stream acted as a drain for the felled area and entered just below the buffer strip, upstream of the downstream station. This value decreased immediately following completion of operations. Instream vegetation showed an increase in green algae at adjacent stations, relative to the reference station, on stream one (without a buffer) in April 2000 where canopy cover had been removed during felling.

Salmonid fish were found at all sites and at greater densities at adjacent stations on stream one (without a buffer) than at the reference station. Characteristic increases in numbers and densities were also found at both streams during autumn sampling.

SALMONID STUDIES

Condition of fish was good (i.e. >1) in all seasons and in all study years, except at high altitudes with high catchment afforestation. Density and biomass of fish was higher in autumn than spring in all years. Density, biomass, age structure and condition of trout were related to habitat variables using principle component analysis for each season. Stepwise multiple regression analysis was used to determine the most influential environmental factors, using Principal Components Analysis (PCA), on trout metrics. A low percentage of variation in fish metrics was explained at this regional scale. Stream size (depth/width) and water velocity at sites accounted for a small but significant amount of variation in trout metrics across all seasons. Altitude, bankside cover, substrate and percentage forestry also contributed to the distribution of trout across sites. In the latter case, there was no evidence of negative effects of afforestation and some evidence of enhanced fish populations at sites of intermediate altitudes and degree of afforestation.

Eight separate catchments were examined in more detail using principle component and multiple regression analysis to investigate the effects of environmental variables at the local scale on trout metrics. A high proportion of the variation in fish metrics at this scale was explained by the environmental parameters measured with glide, minimum depth, cobbles and percentage catchment afforestation being most important. It appears that relationships between fish metrics and environmental variables at regional level are swamped somewhat by inter-catchment variation and at the local catchment scale the habitat can explain more of the variation in trout metrics. Future analysis would thus be better carried out over several years within catchments, with year-on-year variation taken into account.

Surveys of stream habitat conditions and large woody debris in autumn 1998, spring 1999 and spring 2000, showed that a change in stream morphology had occurred. This resulted in more suitable habitat for brown trout (*Salmo trutta*), creation of additional pools in which beds of fine sediment developed and constrained the main current, increasing the amount of eddies and slack water areas. There were significant increases in trout density (Figure 4) and biomass in the debris sections relative to the control sections one and two years after debris addition, although trout condition was not modified by the addition of LWD.

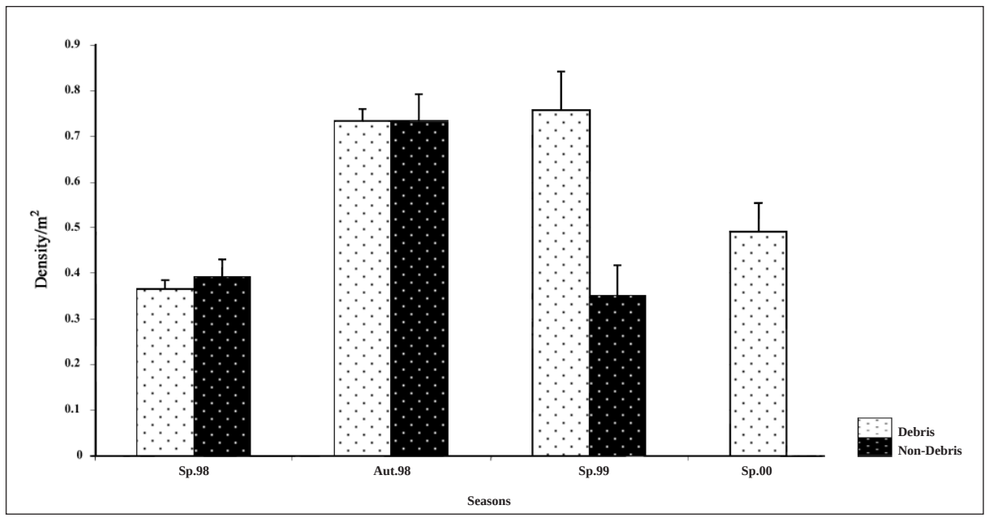

FIGURE 4: TROUT DENSITY IN THE DEBRIS SECTIONS RELATIVE TO THE CONTROL SECTIONS, ONE AND TWO YEARS AFTER DEBRIS ADDITION (TROUT CONDITION WAS NOT MODIFIED BY THE ADDITION OF LARGE WOODY DEBRIS).

CONCLUSIONS

The studies described here were undertaken to investigate the interactions between forestry and stream water quality and ecology. In this short paper it has not been possible to describe in detail each of the projects. A fuller discussion of each of the projects can be found elsewhere (Lehane 2000, Lehane *et al*. 2002, Johnson *et al*. 2000a-c, Duggan *et al*. 2000). Some key conclusions from each project are highlighted below.

Clearfelling project

Although sampling season and altitude/distance from headwater were the most important gradients in explaining the variation in macroinvertebrate community composition, some felling-related variables such as % canopy opening, % afforestation, area felled and % soil on the streambed were shown to be significant in explaining some of the variation in community composition (albeit a relatively small amount). This suggests that any change in these variables as a result of clearfelling can, in some instances, result in a change in macroinvertebrate community composition.

This preliminary multivariate analysis showed no major or long-term effects of clearfelling on macroinvertebrate community structure, although changes in physicochemical parameters due to clearfelling were evident. However, longer term monitoring may reveal more significant impacts of felling on macroinvertebrate structure, since the response of macroinvertebrate species to change in their environment may in some situations not take place until several years after felling (Growns and Davis 1991, Richards and Minshall 1992, Stone and Wallace 1998).

Single catchment clearfelling studies

The patterns observed to date are in line with the findings of the extensive study described earlier. Preliminary results support those of the earlier intensive study at this experimental site (Johnson *et al*. 2000b), indicating that the buffer strip plays a role in preventing any major changes in hydrochemistry and ecology at adjacent and downstream stations relative to the reference stations on each stream.

Statistical analysis of the data is currently underway and will provide us with more meaningful indications of patterns. It is anticipated that these results will contribute to the development of indicator criteria for sustainable forestry management and provide information about the key elements of best practice in relation to felling and restocking. However, it is clear even at this preliminary stage, that the time-scale of this project, while adding valuable information to the post-felling data set, is still too short to elucidate the complex impacts that clearfelling and forest operations may have on water quality and stream ecology. Further monitoring will be required to track the impacts of these practices throughout the forest cycle.

Salmonid studies

This work provided the most spatially extensive study on forestry-fishery interactions in the country to date and complemented previous work carried out in Ireland and elsewhere on forested catchments. A low percentage of variation in fish metrics was explained at the regional scale. However, stream size and water velocity at sites accounted for variation in metrics across seasons. Although altitude, bankside cover, substrate and percentage afforestation also influenced the distribution of fish across sites, there was no evidence of negative effects of afforestation. In fact there was some evidence of enhanced fish populations at sites of intermediate altitude and degree of afforestation (Lehane 2000). The results from the woody debris studies suggest that the addition of woody debris offers a positive and practical management technique for enhancing conditions for fish in forest streams. Careful planning and management of forestry activities will mitigate potential negative impacts while maximising the positive aspects of forestry. Furthermore, aquatic biodiversity can be maintained and enhanced through the protection of riparian ecosystems and continual research, monitoring and management at a catchment level.

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Forests and Water Quality: A Land User's Perspective

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ABSTRACT

Coillte's mandate is carry on the business of forestry and related activities on a commercial basis, in accordance with efficient silvicultural practices, with due regard to the environmental and amenity consequences of its operations. This paper outlines how Coillte is managing its operations to deliver on the economic, social and environmental imperatives implicit in its mandate. Coillte's core activities centre on growing and selling wood from its plantations in a sustainable manner, while enhancing the overall environment for the benefit of its customers, the company and society. Water quality monitoring has become a key part of Coillte's overall environmental programme. In addition to the development of process teams, Standard Operating Procedures (SOP) and water quality studies, Coillte has adopted the principles and criteria of sustainable forest management, certified to Forest Stewardship Council (FSC) standards by an independent third party certifier.

INTRODUCTION

Ireland once had extensive forests of pine and broadleaves, but from the early Middle Ages overexploitation for wood and extensive grazing substantially reduced forest cover. By the turn of the 19th century forest cover was down to just over 1%. However, in response to this situation a modest state afforestation programme was begun in the early years of the 20th century. This accelerated following independence and especially from the mid-fifties. Significant private afforestation began in the mid-eighties. The result is that the Republic of Ireland now has 626,000 ha of forest, comprised mainly (77%) of conifers with the balance (23%) consisting of broadleaves (including some scrub areas). Coillte owns and manages 72% or 436,000 ha of the forest area, of which some 376,000 ha are comprised of woodlands, mostly coniferous plantations.

When Coillte was vested on the 1 January 1989 it was given a mandate to carry on the business of forestry and related activities on a commercial basis, in accordance with efficient silvicultural practices, having due regard to the environmental and amenity consequences of its operations.

The purpose of my paper is to outline how the Coillte is managing its operations to deliver on the three imperatives implicit in its mandate: economic, social and environmental, but particularly the latter.

COILLTE ESTATE

As outlined, the total Coillte estate covers an area of 436,000 ha of which 376,000 ha are forested; the net stocked or production area being 345,000 ha. It is apparent that a substantial part of the estate, some 66,000 ha, is not forested and that within the forested area a further 31,000 ha does not have a full tree canopy.

Species composition

The predominant species in the estate is Sitka spruce (Table 1) followed by lodgepole pine and a range of other conifers.

TABLE 1: SPECIES COMPOSITION OF THE COILLTE ESTATE.

Species	*Area*	*Proportion total area*	*Proportion planted area*
	000 ha	*%*	*%*
Sitka spruce	218.5	50.1	63.0
Lodgepole pine	67.6	15.5	19.6
Norway spruce	17.8	4.1	5.1
Larch	8.8	2.0	2.5
Scots pine	8.6	2.0	2.4
Douglas fir	8.0	2.0	2.4
Other conifers	5.6	1.3	1.6
Broadleaves	11.6	2.5	3.4
Unplanted	89.5	20.5	0.0
TOTAL	436.0	100.0	100

Spatial distribution

By international forestry standards the Coillte estate is fragmented, being made up of some 7,500 blocks with an average size of 76.8 ha. Some relatively large concentrations of plantations do, however, occur in areas such as North Mayo, Slieve Bloom in Offaly and Laois, the Slieve Aughty mountains of south Galway and north Clare, and in the Cork Region on the Ballyhoura, Mullaghareirk, and Derrynasaggart ranges. Figure 1 illustrates the scattered nature of the Coillte forest estate in the south of the country.

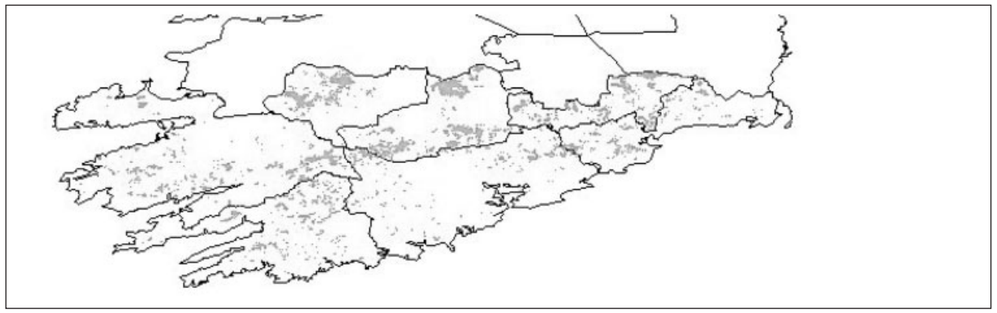

FIGURE 1: LOCATION OF COILLTE FOREST PROPERTIES IN THE MUNSTER REGION (highlighted in grey).

COILLTE'S ACTIVITIES AND ORGANISATIONAL STRUCTURE

Operations

Coillte's core activities centre on growing and selling wood from its plantations in a sustainable manner, while enhancing the overall environment for the benefit of its customers, the company and society. When translated into operations company-wide, it is about establishing 10,000 ha of forest annually, of which about 70% is made up of reforestation, managing and maintaining a 436,000 ha estate, producing and selling close on three million cubic metres of roundwood annually and constructing around 350 km of roads to access the resource. The size of these tasks in the Southern Region of 92,500 ha is shown in Table 2.

TABLE 2: COILLTE OPERATIONAL PROGRAMME FOR THE SOUTHERN REGION FOR THE YEAR 2000.

Operation	*Extent*
Forest establishment	2,306 ha
Afforestation	400 ha[2]
Reforestation	1,906 ha
Timber production and sales	640,000 m^3
thinning area	3,500 ha
clearfelling area	2,000 ha
Road construction	21 km
New	37 km
Upgrade	
Inventory survey	12,235 ha

ORGANISATION STRUCTURE

The Coillte forest management organisation structure is now based on five process teams (Figure 2), where each team is responsible for managing its process within a Region.

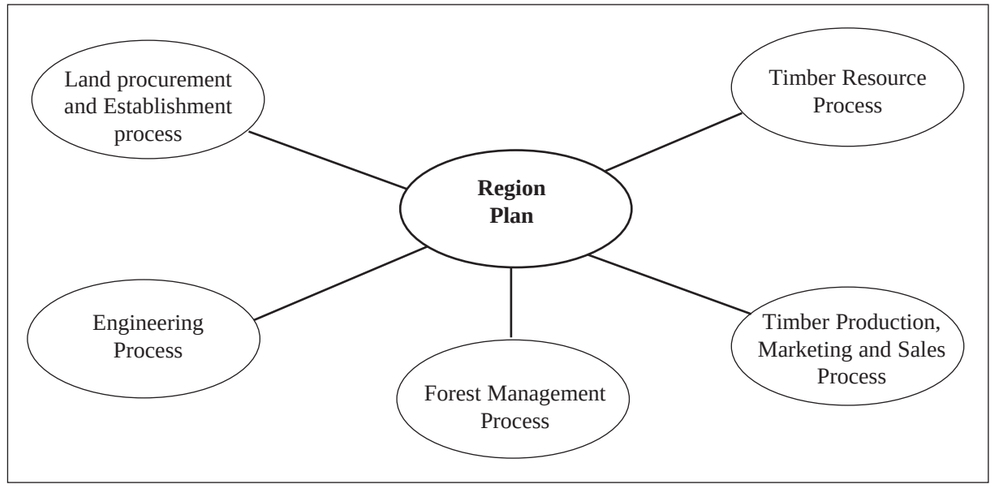

FIGURE 2: COILLTE PROCESS TEAMS STRUCTURE.

STANDARD OPERATING PROCEDURES

Each process team within the company has developed procedures to standardise best practice throughout the company in that process. These are called standard operating procedures (SOPs). They are broken down into a number of sub-processes. Establishment, for example, is broken down as follows:

- species selection,
- cultivation,
- fertilisation,
- fencing,
- planting,
- weevil control and
- cleaning.

[2]Sixty percent of afforestation was under the Coillte Farm Partnership Scheme, whereby Coillte undertakes forest establishment for farmers in return for a share in the income generated by the investment.

SOP's are based on company best practice and take into account the Forest Service's Code of Best Forest Practice (Forest Service 2000a) and guidelines (Forest Service 2000b-f). As well as the work specification, SOPs contain the quality standard, and monitoring and audit required to ensure the operation has been carried out according to the SOP.

IMPACT OF FOREST OPERATIONS ON WATER QUALITY

All forest operations can have an impact on water quality: from selecting the right tree in the right place to the transport of timber to the forest exit and to the railhead or to the processing mill. Water quality problems arise from poor forestry practice and not from forestry itself. The operations which potentially have the greatest impact on water quality if not managed correctly are:

- forest establishment: cultivation and herbicide/insecticide application,
- fertilisation: particularly aerial application,
- timber harvesting: size of felling coupe and timber extraction,
- road construction: water run-off, construction of culverts, bridges etc.

Over the years Coillte has developed its management structure to ensure its operational programme is planned and achieved based on best forest practice. Furthermore we have embraced the principle of sustainable forest management (SFM), which is dealt with later in this paper.

Fertilisation

There is an SOP covering fertiliser application. Company policy is minimum usage, which means that on reforestation sites we apply no fertiliser to sites of yield class 18 or over. On afforestation sites, which are mainly high yield class farm partnerships sites, the levels are agreed with the Forest Service. Overall fertiliser usage in Coillte has been declining since 1995 in both absolute terms and on a per ha basis (Table 3).

TABLE 3: COILLTE S FERTILISER USAGE BY TYPE AND AMOUNT OVER THE FIVE-YEAR PERIOD 1995 TO 1999.

Fertiliser type	*Year*				
	1995	*1996*	*1997*	*1998*	*1999*
	Fertiliser usage t				
Rock phosphate	4,163	4,396	4,226	3,621	2,899
Urea	1,120	1,770	1,194	678	466
Muriate of potash	42	65	117	250	65
0/10/20	39	41	7	4	13
10/10/20	14	164	108	38	22
TOTAL	5,378	6,436	5,652	4,591	3,465
Coillte afforestation and reforestation	11,734	10,548	*ha* 9,984	9,897	10,396

Where trees are 10-15 years old and manual application of fertiliser is not possible, aerial (helicopter) application is used. The SOP incorporates guidelines on management of aerial fertilisation. The main steps involved in aerial fertilisation are:

- foliar analysis,
- preparation of standard maps and plan of operation,
- consultation with statutory authorities (Fisheries Boards, County Councils and Dúchas - where adjacent to NHA or SAC),

• modification of plans to reflect consultation,
• operational control,
• monitoring.

A single individual within each Region co-ordinates the operation. A schedule of fertilising (between April and July) is agreed company-wide, which ensures the optimum tree growth response and minimum environmental impact. In addition the following steps are followed:

• all adjoining landowners are notified that the operation is to take place, together with dates of fertilising;
• the Garda are informed;
• the forest location, pilot, fertiliser type and rate of application are recorded;
• the operation is supervised at all times;
• operations cease prior to and during inclement weather;
• helicopters are not permitted to fly over waterbodies or reservoirs when the fertiliser bucket is attached;
• helicopters must be equipped with a global positioning system and print-outs are examined to determine flight paths;
• water sampling is carried out at selected sites before and after the application;
• sampling is carried out on the ground to determine the uniformity of application.

Water quality monitoring

Coillte short-term studies

Coillte water quality monitoring comprises of short-term studies and long-term water monitoring studies. In the period 1995-2000, 124 monitoring studies were initiated (see Table 4). Most of the studies (97) were concerned with investigating the effects of fertilisation on water quality, whilst 21 studies dealt with harvesting and six with establishment.

TABLE 4: WATER QUALITY STUDIES CONDUCTED BY COILLTE IN THE PERIOD 1995-2000.

Year	*Operation*		
	Fertilisation	*Establishment*	*Harvesting*
	Number of studies		
1995	4	0	1
1996	9	3	7
1997	7	0	1
1998	14	1	1
1999	20	0	2
2000	43	2	9
TOTAL	97	6	21

The approach is to conduct water sampling prior to, during and after forest operations. Since forest operations can be of variable and long duration, monitoring studies can take up to three years before completion, with the result that many of the studies are still ongoing.

Results from two studies dealing with P application are now presented. The first results are from a short-term water quality monitoring study, carried out in the Coillte Southern Region with the objective of determining the impact of forest fertilisation with granulated rock phosphate applied at a rate of 350 kg/ha on streamwater P levels.

As can be seen there was little or no impact of fertilisation on streamwater P levels in the vast majority of studies.

A further short-term water quality monitoring was carried out in the Coillte Western Region to determine the impact of forest fertilisation with non-granulated rock phosphate, applied at a rate of 500 kg/ha, on streamwater P levels (Figure 4).

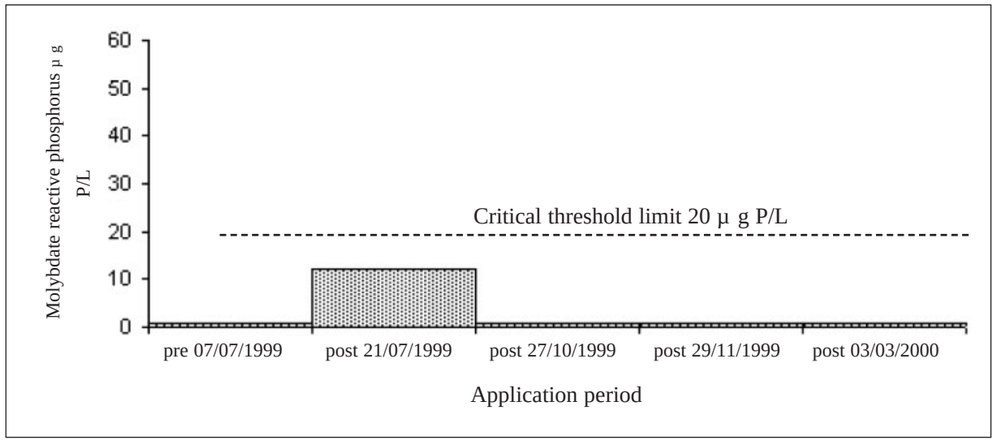

FIGURE 3: EFFECT OF FOREST FERTILISATION ON STREAMWATER P LEVELS IN THE COILLTE SOUTHERN REGION.

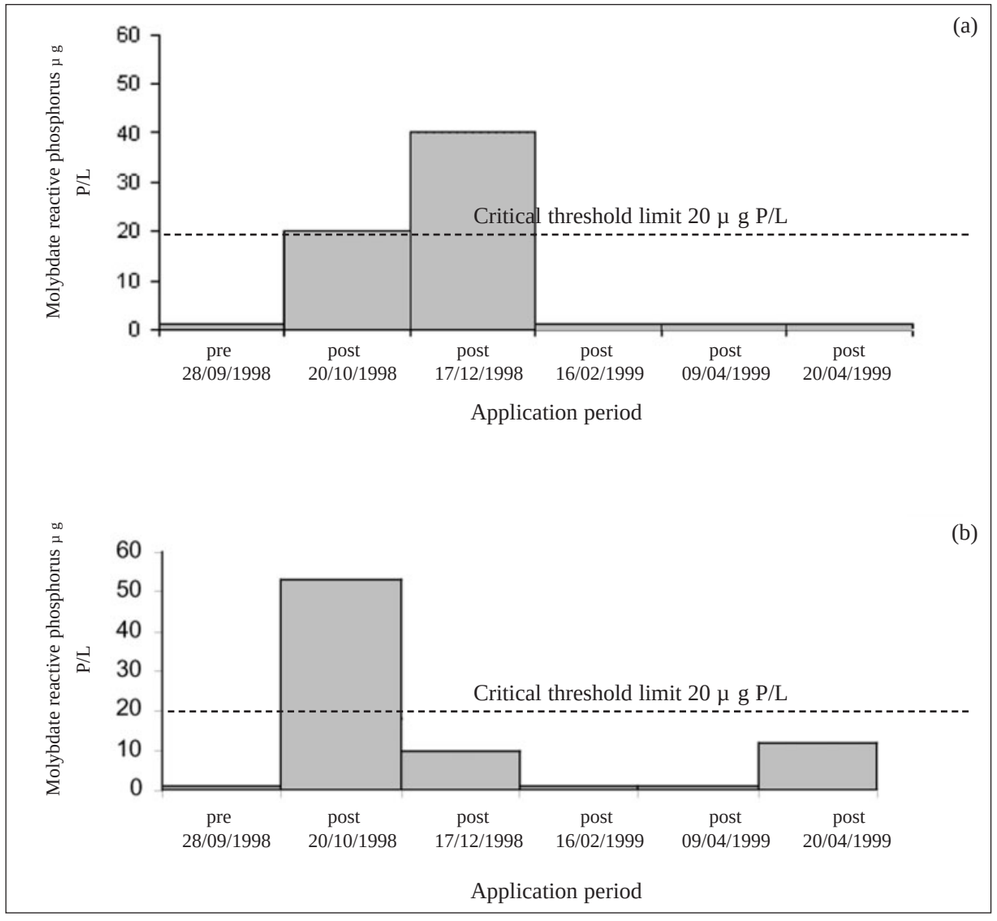

FIGURE 4: EFFECT OF FOREST FERTILISATION ON STREAMWATER P LEVELS (a) ABOVE AND (b) BELOW THE POINT OF APPLICATION IN THE COILLTE SOUTHERN REGION.

Where impacts have been detected they have been temporary in most cases. While increases in P levels following application were significant, bearing in mind the natural variation of P in the stream, use of non-granulated rock phosphate is contrary to current recommendations. Furthermore the application rate of 500kg/ha of P fertiliser exceeds current recommendations.

These water quality monitoring studies have become a key part of Coillte's overall environmental programme. They have become an important mechanism by which staff at all levels are continually reminded of the need for vigilance on environmental issues, and the need for local and environmental concerns to be the foundations on which forest work plans are formulated.

Long-term studies

There have been concerns for some time about the steady increase in eutrophication of Irish fresh water since the early 1970's. Eutrophication is now recognised as the greatest single threat to the quality of the country's rivers and lakes (Stapleton et al. 2000). To address this problem, the Department of the Environment and Local Government has issued a strategy document: Managing Ireland's Rivers and Lakes. A Catchment-based Strategy against Eutrophication (Department of the Environment 1997). The strategy prescribes environmental quality objectives and standards for phosphorus in rivers and lakes and obliges local authorities to take all necessary steps to ensure phosphorus concentrations do not exceed stated levels.

In order to develop water pollution control strategies for catchments, the sources of pollution need to be identified and their contribution to the pollution loading quantified. In July 2000 the strategy, which was based on catchments, was superseded by a new strategy, based on river basins.

Currently, a number of river catchment initiatives operate. Coillte is directly involved in two of these: the Three Rivers and Lough Leane Projects. These take a multi-sectoral approach to encourage ownership of results and recommendations. They involve intensive monitoring of water quality and the development of strategies to improve it.

Within these initiatives, pilot studies relating to forestry and other landusers are ongoing. For example, in the Three Rivers Project the forestry pilot study is located on the headwaters of the Kings river, whilst in the Lough Lane project, the forest pilot study is based in the Clydagh valley. The objective of these pilot studies is to estimate the contribution of the various landuses to P loading, with the ultimate objective of developing a nutrient management plan for the different land-uses of the various catchments.

COFORD- and EU-funded studies

In addition to the above studies, Coillte has also actively collaborated in a number of studies funded by outside agencies (Table 5).

TABLE 5: COILLTE COLLABORATION IN COFORD - AND EU - FUNDED WATER QUALITY STUDIES.

Collaborating organisation	*Project*	*Year of completion*
Salmon Research Agency of Ireland	Mitigation of streamwater acidity	2000
University College Cork	Riparian zone and stream ecology	1997
University College Cork	Araglin river catchment ecology	1997
University College Cork	Clearfelling and water quality	1998
University College Cork	Forestry and brown trout	1999
University College Cork	Effect of harvesting on blanket bogs on water quality	1999
University College Dublin	Clearfelling and reforestation effects on stream ecology	2001
University College Galway	Hydrological and water quality impacts of harvesting on peatlands	2000

TIMBER HARVESTING

The standard operating procedure for timber harvesting is to have in place an effective harvest site plan for all harvesting sites. This plan must comply with the Forest Service guidelines and the principles and criteria of Coillte's sustainable forest management programme.

Each harvest site plan has a standard map legend that incorporates the features listed in Table 6.

TABLE 6: FEATURES DESIGNATED ON COILLTE HARVEST SITE PLANS.

Feature	*Details*
Roads	Forest and county roads (designated routes if applicable)
Aquatic zones	Rivers, streams and lakes (buffer zones are also identified and are marked out on the ground)
Biodiversity	SAC, NHA, SPA, nature reserve, national forest parks
Archaeology	National monuments
Buildings	Houses and cultural features
Water supply sources	
Utility lines	
Wood stacking area and storage area for fuel	

CONSULTATION AND CONTINGENCY PLANNING

A felling licence application is submitted to and approved by the Forest Service for each harvesting sales proposal. Consultation also takes place with local authorities in respect of sites greater than 25 ha. If a sales proposal is either in or adjacent to a Dúchas designated area, consultation also takes place; and with local stakeholders (including the Fisheries Boards) for sensitive sites

All machine operators have a written contingency plan to deal with spillage or leakage of fuels, lubricants, coolants or urea. This also outlines procedures to be followed during inclement weather or where soil erosion is beginning to occur. All machines are equipped with a pollution control kit.

TRAINING

The key to the successful implementation of standard operating procedures on the ground is through the knowledge and skill of the operators. Coillte has undertaken a comprehensive training programme for all its operators over the last number of years, as well as ongoing refresher courses (Table 7). It is planned that by 2002 all machine operators operating on Coillte sites will hold a certificate of competence for that machine and operation.

TABLE 7: EXTENT OF TRAINING UNDERGONE BY COILLTE FIELD STAFF IN RELATION TO WATER QUALITY AND RELATED AREAS, 1998-2000.

Course	*Year*		
	1998	*1999*	*2000*
	Number of field staff trained		
Pesticides	124	138	156
Machine operators	34	25	23
Silviculture (for existing machine operators)	58	68	-
Pollution control	-	-	138

Sustainable forest management

Along with the development of process teams (Figure 2), Standard Operating Procedures and water quality studies Coillte has taken a further step of incorporating these work practices in its business processes by adopting the principles and criteria of sustainable forest management. This process is certified to Forest Stewardship Council (FSC) standards by an independent third party certifier. The FSC is non-governmental organisation, founded in 1993 as an offshoot of World Wildlife Fund (now known as WWF). It pioneered the development of forest certification based on ten principles consistent with good forest management. FSC-Ireland has adapted the International Principles, and developed an FSC Ireland Standard (Draft) - this is the standard against which Coillte was audited.

CONCLUSION

The forest industry has abided by the water quality regulations and best practices that have been in place since the early 1990s. It has protected environmental quality in general, and water quality in particular, through standard operating procedures based on best practice and Forest Service guidelines, water quality monitoring, involvement in collaborative research projects and through the FSC certification process.

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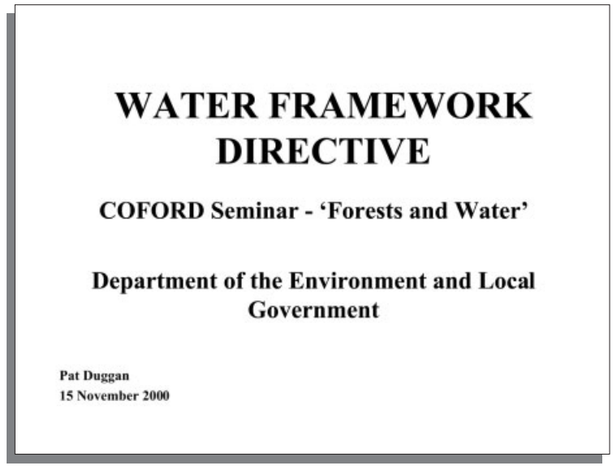
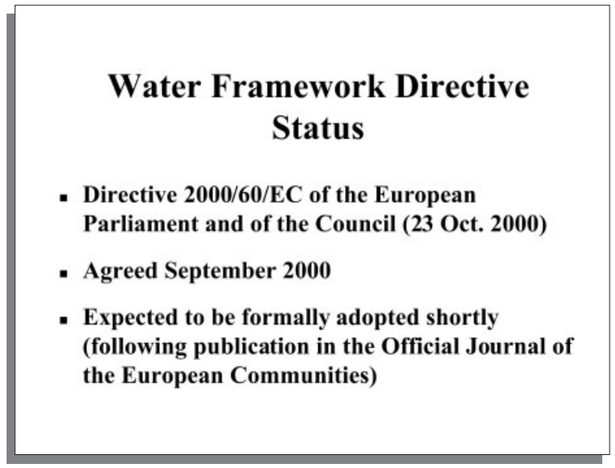
THE EU WATER FRAMEWORK DIRECTIVE

Pat Duggan[1]





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Water Framework Directive Overall Purpose

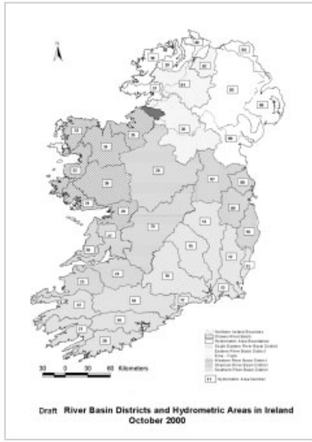
- Sets a framework for the comprehensive management of water resources within a common approach and with common objectives, principles and basic measures
- Generally aims to prevent deterioration of water status and to achieve good water status (as defined) within a 15-year timeframe
- Addresses inland surface waters, transitional and coastal waters and groundwaters

Water Framework Directive Management Unit (1)

- Based on the river basin as the natural unit for water management
- River basin is the area of land from which all surface run-off flows through a sequence of streams, rivers and (possibly) lakes into the sea at a single river mouth, estuary or delta
- Each river basin must be assigned to a River Basin District (RBD) comprising an individual river basin or group of (neighbouring) river basins(c. 400 river basins in Ireland)
- Cross-border river basins must be assigned to an international River Basin District (IRBD)

Water Framework Directive Management Unit (2)

- River Basin District (RBD) is the area of land and sea, made up of one or more neighbouring river basins together with their associated groundwaters and coastal waters
- Groundwaters to be assigned to the nearest or most appropriate RBD
- Coastal waters extend one nautical mile beyond territorial water 'baseline'



Draft River Basin Districts and Hydrometric Areas in Ireland
October 2000

Water Framework Directive Challenges

- Extremely demanding timetable
- Complexity of Directive
- Resource limitations (human and financial)
- Technical and scientific base not adequately developed
- High level of co-ordination required between many Government Departments and State Agencies

Water Framework Directive Timetable (1)- Year 2003

- Transpose Directive into national law
- Identify location and boundaries of RBDs
- Identify competent authorities
- Ensure that the requirements of the directive for the achievement of environmental objectives, in particular all programmes of measures, are co-ordinated for the whole of the RBD

Water Framework Directive Timetable (2) - Year 2004

- Characterisation of surface water body types (including artificial and heavily modified surface water bodies) and groundwaters
- 'Type-specific' reference conditions to be established for all surface water body types
- Review pressures and impacts on the status of surface waters and groundwater
- Establish register of protected areas
- Undertake economic analysis of water use

Article 5 – Characterisation of Surface Waters	
For each RBD, undertake 'Analysis of Characteristics' by not later than 2004 'Type-specific' reference conditions to be established for each surface water category by 2004	- Identify the location and boundaries of bodies of surface water and carry out an initial characterisation (as defined). Surface water bodies shall be identified as falling within the following categories: • Rivers • Lakes • Transitional • Coastal • Artificial • Heavily modified - An artificial body of water is a body of water created by human activity - A heavily modified body of water is a body of surface water which as a result of physical alterations by human activity is substantially changed in character

MS may designate a body of surface water as artificial or heavily modified, where

(a) The changes to the hydromorphological characteristics of that body which would be necessary for achieving good ecological status would have significant effects on:

- The wider environment
- Navigation, including port facilities, or recreation
- Activities for the purpose of which water is stored, such as drinking water supply, power generation or irrigation
- Water regulation, flood protection, land drainage; or
- Other equally important sustainable human activities

(b) The beneficial objectives served by the artificial or modified characteristics of the water body can not, for technical feasibility or disproportionate costs, reasonably be achieved by other means, which are a significantly better environmental option

Surface Water Characterisation

- Ecological status determined on the basis of biological, hydromorphological and physicochemical elements
- Type-specific biological, hydromorphological and physicochemical reference conditions to be established for each surface water body type (rivers, lakes, transitional and coastal waters), representing values consistent with 'high ecological status' (as defined) for each type
- In applying the procedures to heavily modified or artificial surface water bodies, reference to 'high ecological status' to be construed as reference to 'maximum ecological potential'
- Reference conditions serve as 'yardstick' against which water status is determined

Biological elements to be determined (by water category)

Element	Rivers	Lakes	Transitional Waters	Coastal Waters
Phytoplankton	–	–	–	–
Macroalgae and angiosperms			–	–
Macrophytes and phytobenthos	–	–		
Benthic invertebrate fauna	–	–	–	–
Fish fauna	–	–	–	

Groundwater Characterisation

- Initial characterisation of all groundwaters required : - - location and boundaries of groundwater bodies; pressures (diffuse and point source pollution, abstractions); general character of overlying strata; directly dependent surface water and terrestrial ecosystems
- Further characterisation required for groundwater bodies 'at risk': - geological and hydrogeological characteristics, characteristics of superficial deposits and soils, associated surface water systems, water exchange between groundwaters and surface waters, long-term annual rate of recharge, chemical composition

Register of Protected Areas

- Areas designated for the abstraction of drinking water
- Areas designated for the protection of economically significant aquatic species
- Designated recreational waters including bathing waters
- Nutrient-sensitive areas
- Areas designated for the protection of habitats and species (where water status is an important factor in their protection)

Water Framework Directive Timetable (3) - Year 2006

- Comprehensive monitoring programmes (as defined) to be operational
- For surface waters, this shall cover ecological and chemical status, and ecological potential; and the volume and level or rate of flow to the extent relevant
- Chemical and quantitative status for groundwaters
- Specifications of relevant Community legislation to (additionally) apply for 'protected areas'

Water Framework Directive Timetable (4) - Year 2009

- A River Basin Management Plan (RBMP) must be produced for each RBD (by 2009)
- Public consultation required in preparation of the Plan
- Active involvement of all interested parties to be encouraged
  - ➢ publish timetable and works programme including proposed consultation measures by 2006
  - ➢ publish overview of main water management issues by 2007
  - ➢ publish draft copy of RBMP by 2008

River Basin Management Plans

- A single co-ordinated RBMP to be produced for each RBD which will include (partial only)
  - ➢ description of characteristics of RBD
  - ➢ maps of waters and protected areas
  - ➢ reference conditions
  - ➢ monitoring network and results of monitoring
  - ➢ environmental objectives
  - ➢ economic analysis of water use
  - ➢ pressures and impacts (point and diffuse)
  - ➢ programmes of measures including supplementary measures
  - ➢ public information and consultation measures taken (including outcome)
  - ➢ list of competent authorities

Water Framework Directive Timetable (5) - Year 2009

- Co-ordinated programme of measures (included in RBMP) to be established for each RBD in order to achieve objectives
- 'Basic measures' to include those measures necessary to implement Community legislation for the protection of waters
- 'Supplementary measures' as appropriate

(Minimum) Lists of Measures to be Included in Programme of Measures

- Bathing Water Directive
- Birds Directive
- Drinking Water Directive
- Major Accidents (Seveso) Directive
- Sewage Sludge Directive
- UWWT Directive
- Plant Protection Products Directive
- Nitrates Directive
- Habitats Directive
- IPPC Directive
- EIA Directive

Supplementary Measures

- 'Supplementary' measures are those measures designed and implemented (in addition to basic measures) with the aim of achieving the environmental objectives of the directive (partial list only)
  - ➢ legislative instruments
  - ➢ negotiated environmental agreements
  - ➢ economic and fiscal instruments
  - ➢ codes of good practice
  - ➢ educational projects
  - ➢ rehabilitation projects

Water Framework Directive DELG Supported Initiatives

- Support for local authorities in the establishing RBD projects which are seen as a step towards implementing the WFD (Guidelines for the Establishment of RBMS, DELG July 2000)
- EPA study on organisational / resource needs
- EPA pilot studies to establish monitoring methodologies for the ecological assessment of Irish rivers and lakes (ERTDI Research Programme 2000-2006)

RBD Projects -Opportunities

- Promote water management (by local authorities) on the basis of RBDs
- Strengthen tools available to local authorities in the area of water monitoring and management
- Improved data handling, management and reporting
- Potential for improved efficiencies in the delivery of environmental management services by local authorities
- Address significant 'information gaps' (e.g., groundwater)
- Address water management in a co-ordinated and systematic manner
- Potential for improved inter-agency and cross sectoral co-operation in the delivery of water quality objectives

Some Perceived Weaknesses

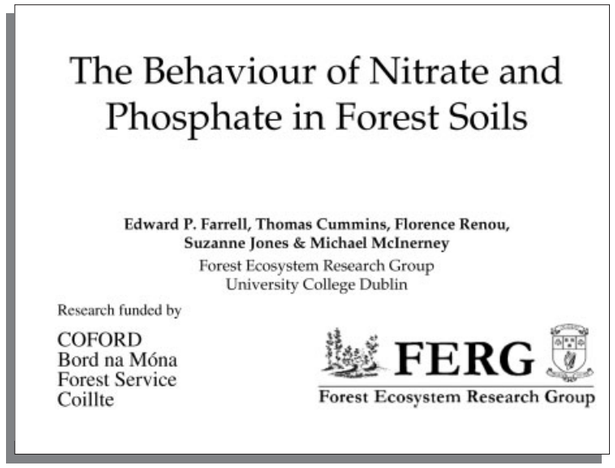
- Although systems for monitoring river and lake water quality are well developed, information on aquatic ecosystems has not been routinely collected; WFD requires development of 'ecosystem-based' methodologies for surface water management purposes
- Clear objectives have not been established for coastal and transitional waters, and groundwaters; some Irish estuaries are at risk from eutrophication due to inputs from agriculture and/or urban sources; progress on 'groundwater characterisation' has been slow to date
- Nature conservation and habitats objectives (dependent on water status) need to be developed
- Organisational cohesiveness (single RBMP)

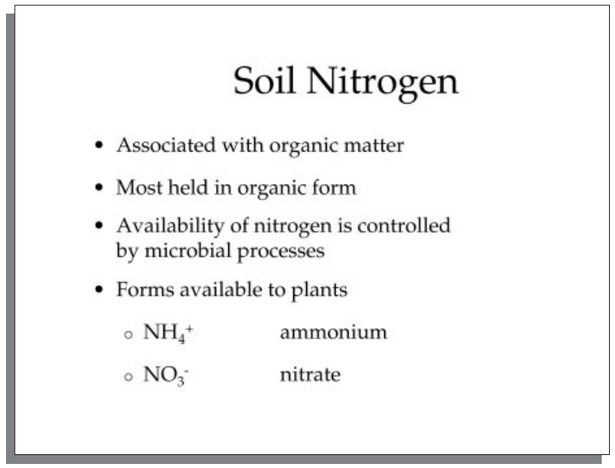
Water Framework Directive National Co-ordination

- Need to determine technical requirements for the 'characterisation' of all waters and establish reference conditions
- Co-ordination between Government Departments and State agencies (DELG, DMNR/CFB, EPA, Dúchas, DAFRD, OPW, GSI, Marine Institute, etc.) in developing monitoring methodologies (and implementation of same), and 'programmes of measures' (outside remit of local authorities)
- Agreed 'work plans' for delivery of products within WFD timeframe
- RBMPs must reflect/incorporate national policy and programmes of measures

THE BEHAVIOUR OF NITRATE AND PHOSPHATE IN FOREST SOILS

Edward P. Farrell[1]





[1]Forest Ecosystem Research Group, University College Dublin, Belfield, Dublin 4.
(Email: ted.farrell@ucd.ie).

Behaviour of Ammonium

- Nitrification
- Uptake
- Adsorption on exchange complex
- Fixation in clay minerals
- Denitrification

Behaviour of Nitrate

- Leaching
- Uptake
- Denitrification

Soil Phosphorus

- Availability controlled by physico-chemical processes
  - Sorption retention at soil surfaces
  - Precipitation formation of insoluble compounds

Factors Influencing P Retention Processes

- Soil texture
- Soil pH
- Soluble iron and aluminium

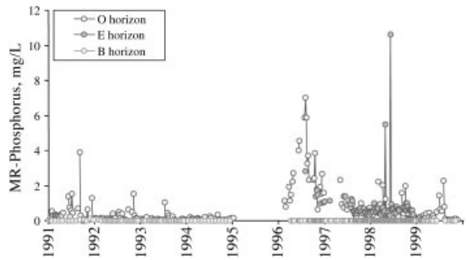
Mobility of Phosphate

- Highly immobile in mineral soils
- Potentially mobile in organic soils

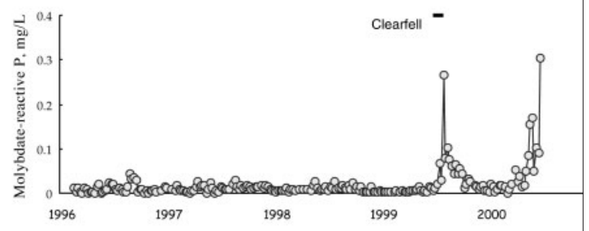
COFORD Funded Projects

- **MONSTAC;** Ballyhooly, Co. Cork
  - Clearfelling effects on surface waters and ecosystem pools
- **CATCHMENTS**; Cloosh, Oughterard, Co. Galway
  - Clearfelling effects on streams
- **BOGFOR;** Tumduff, Boora, Co. Offaly
  - Phosphorus runoff monitoring
  - Fertiliser trial

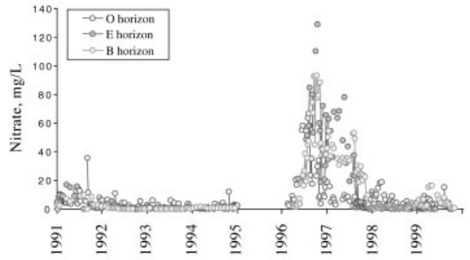
Ballyhooly: Phosphorus mobilised by clearfell is retained by mineral soil



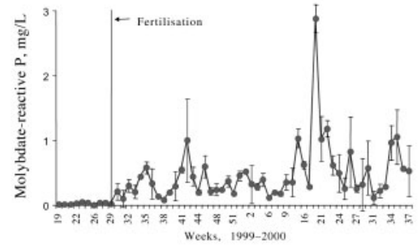
Cloosh: Phosphorus losses follow clearfelling, in the absence of fertilising



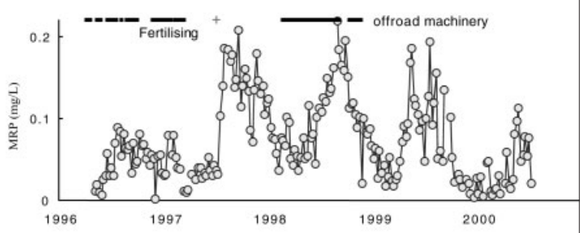
Ballyhooly: Nitrate is lost below root zone (B horizon) following clearfell



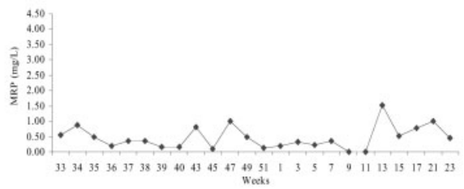
Tumduff: Phosphorus losses in surface runoff water follow P fertilising



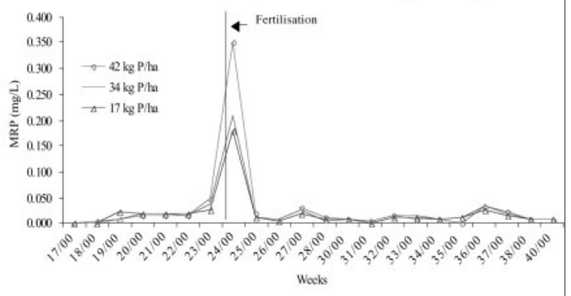
Cloosh: Phosphorus losses in stream water follow P fertilising (July 1997)



Tumduff: Reconstituted Area: Control plots



Mount-Lucas: phosphorus in soil water (shallow peat)



Conclusions: Nitrate

- Nitrate losses will occur following clearfelling
  - in soils which produce nitrate
  - when root system is eliminated or severely damaged

Conclusions: Phosphate

- Phosphate losses will occur following fertilisation or felling
  - on soils with poor sorption capacity *viz.* peat soils.

Eutrophication Potential

- Limiting Element
- Duration of Impact
- Magnitude of Impact

Options for Management:

Nitrate

- Restrict clearfell area on fertile soils
- Restrict proportion of catchment clearfelled in drinking-water carchments

Phosphate

- Minimise fertiliser use on peat soils
- Restrict clearfell area on peat soils
- Make use of phosphate-retaining seepage areas

Recommendations for Future Research:

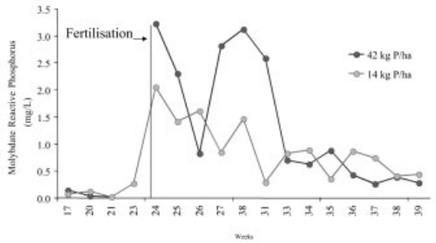
Nitrate

- Identify nitrate-producing soils
- Model effect of clearfell control in drinking-water catchments
- Develop continuous cover systems

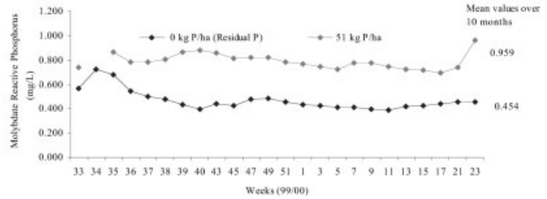
Phosphate

- Investigate phosphate losses to surface waters of biological significance
- Explore sorption potential of natural and artificial wetlands

Tumduff: phosphorus lost at normal and low fertiliser rates



Reconstituted Area: control plots and normal rate of P fertilizer



Microbial Denitrification

[V] NO_3^- nitrate *soluble ion*

[III] NO_2^- nitrite *soluble ion*

[II] NO nitric oxide nitrogen oxide *gas*

[I] N_2O nitrous oxide dinitrogen oxide *gas*

[zero] N_2 molecular nitrogen *gas*

ACIDIFICATION OF SOILS AND WATERS

Miriam Ryan[1]

Presentation overview

- Acidification of soils and waters - Processes
- Studies in Ireland
- COFORD/EPA funded research 2000-2006
- Conclusions

COFORD - progress through research

Acidification

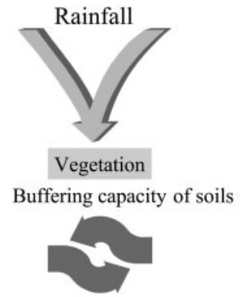
- Acidification - what is it?
- pH scale, logarithmic - pH 7.0 is neutral.
- 1……..7..…….. 14

  acidic Neutral basic
- Acidification of soils and waters.
- Rainwater is naturally acidic (pH ~ 5.9) due to dissolution of CO_2

COFORD - progress through research

[1]At the time of this presentation, Dr Miriam Ryan was Research Officer, COFORD. Her current contact details are: Enterprise Officer, Research and Graduate Studies, NUI Maynooth, Co Kildare. (Email: miriam.ryan@may.ie).

Water cycle and Acidification



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Acidification of soils and waters

- *Rainfall*
- 'Acid rain' -Acidity of rain increased by SO_2 and NO_x from fossil fuel combustion.
- 'Sea-salt' episodic acidification
- Ireland unique, westerly weather systems bearing high concentrations of sea salts. Sodium (Na^+) and Chloride (Cl^-).

COFORD - progress through research

Acidification of soils and waters

- *Vegetation*: scavenging of acidic ions.
- Interception of sea-salts by vegetation .
- *Soils* - negatively charged sites
- Buffering capacity of soils ~ cation exchange capacity
- High buffering capacity -' basic'/mineral soils -better able to deal with acidity
- Low buffering capacity -less sites and H+

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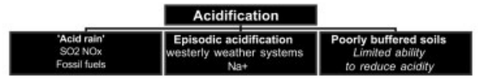
Acidification causes



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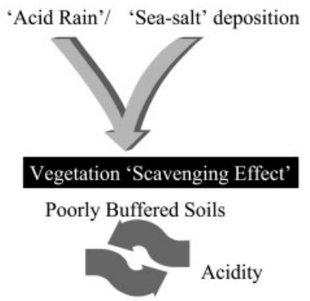
Acidification Processes



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Studies in Ireland

- Early 1990's Galway, Mayo & Wicklow N Allott *et al.*
- Aquafor Project: published by COFORD 1997. UCC, UCD and TCD.
- Two poorly buffered areas west Galway-Mayo and part of the Wicklow mountains & less sensitive Munster area.
- Interactions between forestry & aquatic ecology studied.

Aquafor study

- *Results:*
- Acidity essentially *episodic* in nature
- Sources of stream acidity included *sea salts* and high levels of *organic acids* in streams draining peatland.
- Acid episodes in poorly buffered streams at certain Wicklow and Mayo sites exhibited minimum pH values below recommended for Salmonid waters.

COFORD - progress through research

Aquafor Study II

- Acid episodes were more severe and long-lasting in certain forested catchments - occurred mostly in winter and spring.
- *Fish populations:* Fish were absent from a small number of streams in forested sites.
- In Munster, sites with low to medium forest cover tended to have larger fish stocks than corresponding sites with zero forest cover.

COFORD - progress through research

Aquafor Study III

- *Conclusions:*
- Overall negative effects were confined to some of the least favourable regions for future forestry development.
- Interactions between forestry and aquatic ecology are very complex.

COFORD - progress through research

Identification of acid -sensitive surface waters

- Catchment management
- Identify the effects of *all* land uses within the catchment.
- Use of acid-sensitivity maps.
- Use of critical load maps.
- Soil maps.

COFORD - progress through research

COFORD- EPA funded research 2000-2006

Forestry -Environment Impacts
Forestry and Water Quality
•Forestry and the potential for surface water acidification
•Forest operations and eutrophication
•Forest operations -quantification and management of erosion and siltation.

COFORD- EPA funded research 2000-2006

•Forestry and the potential for surface water acidification
•Recommend management practices that could prevent and lessen impacts of forest operations on acidification
•Development of the sodium dominance index
•Assess efficacy of current Forestry and Water Quality Guidelines.