Opportunities for biodiversity enhancement in plantation forests

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Foreword

Ireland's forest cover has increased almost nine-fold over the past century, from 1% at the turn of the 20th century to over 9% at present. Almost all of the increase is due to a state policy of undertaking afforestation and, more recently, through grant and premium payments to farmers. Plantation forestry has been the norm in both cases.

In the past, the services required by society from plantations focused mainly on employment generation and the supply of home-grown timber to the domestic market. Such expectations were more a reflection of Ireland's level of economic development in the 1950s and 60s and shortages in wood supply following the Second World War than current conditions of near full employment and global trading in wood products. In reality, society now places a far wider range of demands on forests, such as carbon storage, recreation, conservation of native flora and fauna, and water protection.

The Forest Service has responded to this changed focus; its procedures and conditions for grant-aid now reflect the desire to, *inter alia*, use plantation forests to protect and enhance biodiversity. However, many unknowns exist on how best to achieve this in Ireland. Having identified this knowledge gap, COFORD and the Environmental Protection Agency (EPA) are co-funding a major research study on the interactions between forests and biodiversity. This project, BIOFOREST, is being undertaken by University College Cork, Trinity College Dublin and Coillte.

In addition to this work, it is important to benchmark the Irish approach with best practice overseas. To address and highlight these, COFORD organised the seminar *Opportunities for biodiversity enhancement in plantation forests* in Cork in October 2002. The proceedings, which are presented here, are an important insight into current thinking, both in Ireland and abroad. Not only did the event provide an opportunity for the BIOFOREST team to present preliminary findings to an international peer group, but it also showcased examples of biodiversity enhancement in other European countries to policy makers and practitioners in Ireland.

In conclusion we thank the speakers, now authors, who made the seminar more than worthwhile and, of course, the BIOFOREST team for their close co-operation in organising the seminar.

David Nevins
Chairman

Dr Eugene Hendrick
Director

February 2004

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Biodiversity opportunities in plantations managed for wood supply

Orla Fahy[2] and Noel Foley[3]

INTRODUCTION

The Forest Service of the Department of Communications, Marine and Natural Resources is the Irish forest authority. Its responsibilities include the national forestry strategy, the Irish National Forest Standard, development of public and private forestry, administration of forestry grants and premiums and control of tree felling. In 1996 the Forest Service published *Growing for the Future - A Strategic Plan for the Development of the Forestry Sector in Ireland*. This states that Irish forest policy is 'to develop forestry to a scale and in a manner, which maximises its contribution to the national economic and social well being on a sustainable basis and in a manner which is compatible with the protection of the environment' (Department of Agriculture, Food and Forestry 1996).

At present, approximately 680,000 ha or 9.8% of the total land area of Ireland is under forest (Forest Service pers. comm.). It is estimated that more than 90% of current national forest cover (9% of the land cover) is plantation forest. Plantation forests are defined as 'forest stands established by planting and/or seeding in the process of afforestation or reforestation. They are either of introduced species or intensively managed stands of indigenous species which meet all of the following criteria: one or two species at plantation, even age class and regular spacing' (UN-ECE/FAO 2000).

The national afforestation target is 20,000 ha per annum from 2001 to 2030. A major portion of afforestation to 2006 will be under the Common Agricultural Policy (CAP) Afforestation Programme (Forest Service 2000a) where the primary objective is wood supply. The other main afforestation schemes are the Native Woodland Scheme (Forest Service 2001a), the primary objective of which is the development of native woodland and its biodiversity, and the NeighbourWood Scheme (Forest Service 2001b) which places most emphasis on forests as local amenities.

THE HISTORY OF FOREST COVER IN IRELAND

Deforestation has been a constant feature of Ireland's history. By the start of the 20th century forest cover had reduced to just over 1% of the land area. Since that time forest cover has increased more than six fold, to reach the current 680,000 ha or 9.8% of the land area. Most afforestation has occurred post 1950 (Figure 1).

Initially, state planting was responsible for the increase in forest cover in which land was purchased and afforested. Most of these lands were transferred to Coillte (The Irish Forestry Board) which was established under the 1988 Forestry Act, which gives it a mandate to manage state forests on a commercial basis.

Private afforestation was minimal until the late 1980s when various schemes and CAP reform measures were introduced to encourage private afforestation. As a result, private planting increased from 5% of the total planting in 1984 (Tree Council of Ireland 1999) to over 81% in 2000 (Department of Marine and Natural Resources 2001) (Figure 2). Individuals and institutions have, and have had, many

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reasons and objectives for establishing plantations. These include amenity and landscape as well as planting for game management and establishment of native woodlands. However, by far the greater number of plantations has been established to supply wood as a raw material for the processing sector. Wood is a renewable and a versatile raw material and a revenue earner for the landowner.

IRISH FORESTRY AND BIODIVERSITY

Although this paper focuses on issues relating to biodiversity in the design and management of plantation forests where wood production is the primary objective, there are other influences on forestry and biodiversity including:

- Ireland's obligation to biodiversity having ratified the Convention on Biological Diversity in 1996;
- European Union legislation in the form of the Birds Directive (1979) and the Habitats Directive (1992) have mandated the creation of Special Protection Areas (SPAs) and Special Areas of Conservation (SACs) respectively – known collectively as Natura 2000 sites. In addition to these designations, Natural Heritage Areas (NHAs) give protection to sites of national importance;
- Ireland's National Biodiversity Plan (Dúchas 2002) is government policy and devotes considerable attention to forestry;
- Forest health measures, such as monitoring of imports and of the forest estate, ensure that Ireland's forests remain healthy and free from damaging exotic pests and diseases;
- EU Directives on Forest Reproductive Material govern the collection and

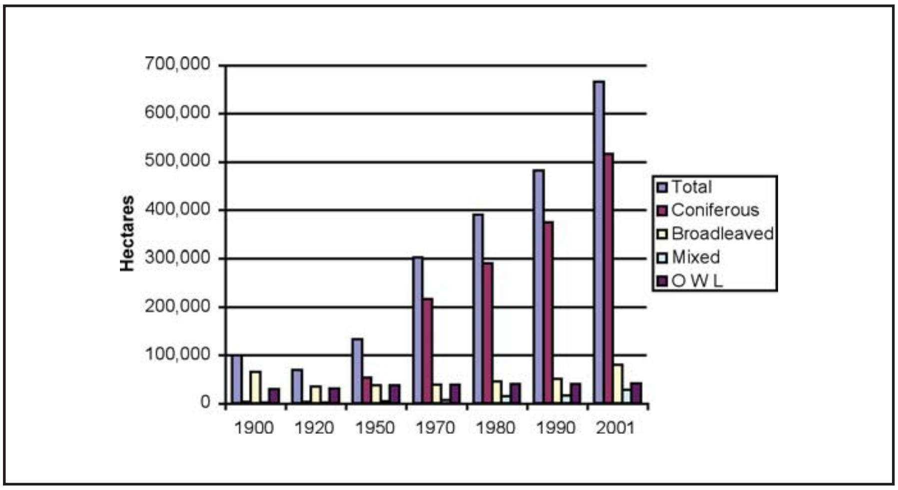

FIGURE 1: Forest cover by forest type – 1920 to 2001 (OWL = other wooded land).

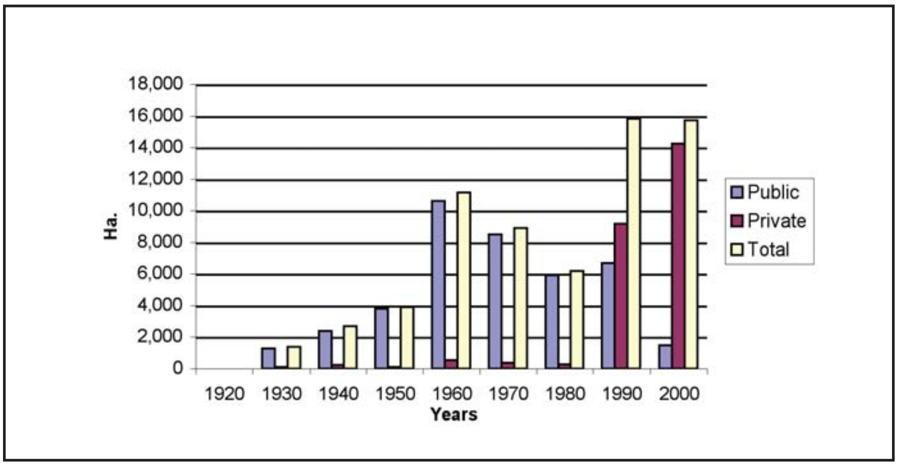

FIGURE 2: Public and private afforestation from 1920 to 2000.

distribution of seeds and transplants of approved genetic stock;

- The Native Woodland Scheme promotes the conservation and establishment of native woodlands;
- The procedures and standards that apply to afforestation (and other grant aided schemes) as well as to felling licenses, ensure that the associated operations are compatible with the protection of the environment;
- Research, such as the BIOFOREST research project co-funded by the EPA and COFORD (COFORD 2001), aims to address the gaps in knowledge of biodiversity and forestry;
- The Forest Service has recently recruited an ecologist to its permanent staff.

Other relevant issues include the biodiversity component in a future inventory of the forest estate, future reporting on the biodiversity elements of the criteria and indicators of the Irish National Forest Standard and of those of the Ministerial Conference for the Protection of Forests in Europe (MCPFE). However, Sustainable Forest Management (SFM) is a predominant issue for all forestry activity. Since the United Nations Conference on Environment and Development (UNCED 1992) in Rio de Janeiro, biodiversity issues and SFM have been visible on the international agenda. Ireland has signed the Lisbon Agreement (1998) which commits it to SFM. The Lisbon Agreement sets out six criteria for SFM which have been adopted in the Irish National Forest Standard (Forest Service 2000b). Criterion 4 of the Standard is the 'maintenance, conservation and appropriate enhancement of biological diversity in forest ecosystems'.

IRELAND'S PLANTATIONS

Plantations are not uniform but vary depending on their age, size, stage of development, species composition, place in the landscape, ownership and the habitats (both woodland and non-woodland) present. In Ireland, most forest plantations are young by forestry standards with less than 80% of the forest land being under woodland for more than 50 years. This is a short time when compared with natural forests and European plantations. The State plantations that were established in the period from c.1950 to c. 1990 were, for the most part, on the most marginal land for agriculture. Land holdings on these land types tend to be large and so land acquisitions for afforestation were in large blocks on hilltops, the upper slopes of mountains and on blanket peats. Single acquisitions of 200 hectares and more were not unusual in those years. In many cases these acquisitions joined and formed large forest blocks. Examples include the large forest blocks in the Slieve Aughties, around Lough Derg in Co Donegal, and in counties Wicklow, Cork, Mayo and Galway as well as in the Slieve Blooms. Many of these large plantations are now being clearfelled and the felling coupes are much smaller than the original plantations, resulting in more uneven aged and greater fragmentation within large blocks. Plantations established in the last 10 years are much smaller in area than before (their average size is approximately 10 hectares) and are widely scattered. This change has been dictated by the increase in private afforestation, a higher growth potential being necessary to qualify for grant aid, the move away from the more marginal lands and environmental issues.

In the past, when afforestation was on the most marginal lands for agriculture, Sitka spruce and lodgepole pine accounted for up to 80% of species composition. There is a greater diversity of species planted today due to the availability of more fertile lands for afforestation and to changes in the conditions for grant aid and premium payments[4].

[4] Current afforestation grant conditions require that each project contains no more than 80% of non-diverse conifer species (Sitka spruce/lodgepole pine). As a result, non-diverse species are planted in mixture with diverse conifers such as larch or with broadleaves. There is also a requirement that 10% broadleaves are planted in these sites (site permitting). Species composition of afforestation in 2001 was 82% conifers and 18% broadleaf species with a target of 30% broadleaves by 2006.

The life cycle of a typical plantation starts with establishment. Trees are small and the area invariably has more herbaceous than woody vegetation. Usually the vegetation is a reflection of the habitat prior to planting. In the years following canopy closure less light (in the case of broadleaf species) and in the case of most conifers very little light penetrates the canopy, consequently the higher plants are often non extant apart from some specialists. Thinning creates gaps, usually temporary, in the canopy and is usually followed by a recovery in ground vegetation. As the trees grow taller, near the end of the rotation, more light penetrates and the ground and shrub layers may develop. The plantation is eventually felled and the cycle recommences but the vegetation after reforestation may not reflect that of the original habitat. The plantation increases in height and in volume as it grows and its biodiversity changes with these stages. It is usual to find all stages of plantation development in forested landscapes and to find that this matrix 'moves' across the landscape over time.

FORESTRY GUIDELINES

In general, the larger plantations tend to be older, monocultures on more exposed and marginal lands but as pointed out these areas are changing through clearfelling and subsequent reforestation. Plantations also vary in the additional woodland and non-woodland habitats present, such as scrub, hedgerows, bare ground, water, deadwood and buildings. The Forest Service has published several guidelines to ensure that forestry is carried out to the best silvicultural and environmental standards. These include *Forest Biodiversity Guidelines, Forestry and Water Guidelines, Forestry and Archaeology Guidelines, Forestry and the Landscape Guidelines, Forest Harvesting and the Environment Guidelines, Forest Protection Guidelines, Irish National Forest Standards* and the *Code of Best Practice – Ireland* (Forest Service 2000b – i). These guidelines and the Code describe a range of measures that are mandatory conditions to qualify for grant-aided schemes and for the issuing of felling licenses.

FOREST BIODIVERSITY GUIDELINES

The *Forest Biodiversity Guidelines* recognise that afforestation and reforestation provide unique opportunities to design and plan a plantation so that the best existing habitats are conserved. The Guidelines state that local biodiversity factors (habitats, flora or fauna) should be identified and incorporated in the site development plan. The influence of the selection of tree species, age and structural diversity on the habitat value and biodiversity of a forest is also recognised. The guidelines recommend favouring broadleaf species, the use of native species, the retention of scrub and hedgerows and planting of a range of species. Old trees and deadwood are important features in plantations and provisions should be made to ensure, if possible, that they are left on site.

While good forest practice and adherence to the Guidelines must be practised, approximately 15% of the forest area must also be treated specifically for biodiversity. These areas are termed Areas for Biodiversity Enhancement (ABEs) and comprise open spaces and retained habitats. The ABEs are aimed at encouraging the development of diverse habitats, native flora and fauna and biodiversity. Areas for Biodiversity Enhancement are composed of 5 – 10% open space and 5 – 10% retained habitats, giving a total area of 15%.

On sites less than 10 hectares, the open space can be designed in conjunction with neighbouring land-use and the percentage required may be reduced. Open space can include ridelines, buffer zones around aquatic zones, exclusion zones around archaeological features and areas left unplanted for landscape purposes. They should be designed to maximise the edge effect between the forest and the open area and management should encourage a gradual transition from open ground to scrub to forest.

Retained habitats includes both woodland and non-woodland elements and management should aim to conserve and enhance these throughout the current rotation and into subsequent rotations. These areas should be clearly designated on relevant maps and on the ground during planting, thinning and harvesting (sensitive times).

The level, be it project level or a wider landscape or forest management unit (FMU) level, at which the ABE requirement applies varies with circumstances. It applies at the individual project level in the case of afforestation but in the cases of, for example, harvesting and reforestation it can apply at the FMU level provided the ABE element is identified at that level.

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Implementation of the biodiversity guidelines in current Irish afforestation

***Ian Wright*[5]**

I would like to thank COFORD for giving me the opportunity to present this paper. I am not a forester and have no scientific training - I happily admit that. What I hope I have got to offer is a good measure of common sense and my observations from creating wildlife habitats over the last 15 years.

I am one of a group who edit and produce the weekly *Forest Network Newsletter* - a newsletter that I know is eagerly awaited every Wednesday morning by many involved with forestry in Ireland, and I hope I am speaking for the majority of the NGOs today. The Friends of the Irish Environment asked me to make this presentation. However, I should stress that the observations I make are my own.

I have been asked to talk about the implementation of the biodiversity guidelines. I think first we have to look at why the biodiversity guidelines exist and why abiding by them are so important in the Irish context.

As the recent conference on sustainable forestry in Ennis illustrated so clearly, Ireland is totally out of line with international forest practices. Other European countries have accepted the disastrous environmental and economic consequences of plantations of non-native trees designed for clearfell. At Ennis, the Polish delegation apologised for the fact that because of earlier mistaken policies they still have to clearfell areas of up to 4.5 ha, while Ireland is still advocating clearfell coupes of 25 ha.

I know this is not the forum to discuss these policies but because the Forest Service is obsessed with planting plantations of trees to achieve its strategic plan, the areas retained and managed for biodiversity have far more importance and significance than anywhere else in Europe.

The Forest Service *Forest Biodiversity Guidelines* state that good forest practice coupled with adherence to the guidelines will conserve and enhance the biodiversity value through the whole forest. Initially the Forest Service stated that, as the guidelines had been explained to the Forest Service inspectors, they were confident the guidelines were being adhered to. However, Hugh Scanlon, writing in the *Farmers Journal*, made it very clear to what extent they had been ignored when he stated that: ‘the guidelines published over a year ago will be strictly implemented for the first time in the current planting season’.

Following the introduction of the guidelines there seemed to be a broad consensus among most contractors about their spirit and meaning, but they were not incorporated into practice for fear that most Forest Service Inspectors would not approve such plans. The confusion over the interpretation of these plans was obvious in that every representation we made to the Forest Service returned different answers. In the end, the Chief Auditor admitted that the mapping protocols used by the Department meant that ‘some single or some linear features are too small to be relevant on a 6 inch map’ and that their maps ‘do not facilitate showing biodiversity plot data’. (So too for landscaping.) How do you record rock outcrops, ponds, marshes, bogs, scrub, watercourses, or even pockets of existing broadleaves on a 6 inch map? If these features cannot be mapped, then how can they be monitored? Since the conference, new mapping procedures and legends for biodiversity were introduced. I will talk later on about whether these are adequate.

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During the information day on the *Forestry Environmental Guidelines* the Chief Environmental Officer of the Forest Service illustrated how they would impact on a theoretical 100-acre diverse conifer site. Fifteen percent of the site must be identified for biodiversity, 10% for broadleaves, and 20% of the remaining 75% to be planted with diverse conifers.

In response to the dismay of the Irish Farmers' Associations delegate who asked : 'no commercial return from 25% of the site?' the Chief Forestry Inspector, insisted that it wasn't as bad as it looks, because it has always been assumed that roads, turning bays, ridgelines and firebreaks have accounted for 15% of the site, and to remember that it is only sites over 10 hectares that have to conform with the 15% ruling, and with the average site at 8 ha this shouldn't be a major concern.

The 1995 Jakko Poyyry report on which the strategic plan is based recommended that 25% of every site should remain unplanted. Dr Susan Iremonger, who prepared the *Forest Biodiversity Guidelines*, writes: 'The point of having Nature Conservation Areas is to provide an area where the trees are allowed to grow old and a forest ecosystem develop, like that of a natural forest'. She recommended keeping 5% to 10% of each forest as open spaces for the feeding of birds and bats, and for shrub and herb species that are intolerant to dense shade but can flourish in the open spaces within a forest. She used the term 'Nature Areas'. The fact that this was changed to 'Retained Habitat and Open Space' in the guidelines speaks volumes. She goes on to say 'Nature Areas are parts of the forest that are not subjected to the same forestry operations as the rest of the forest area … they should not be logged or subject to other forestry operations and so cannot form part of any commercial broadleaf component of a plantation. The management of these areas is critical to their success'.

Surely the open spaces of Iremonger's Nature Areas cannot include ridgelines, forest roads, turning bays, landing bays and their associated margins - let alone firebreaks, which are scraped clear of all living vegetation every two years. To Coillte's credit, they say they don't include roads etc. in the open spaces. Coillte initially stated they were not bound by these guidelines, and intended to 'define' 15% of an FMU (Forest Management Unit) as Retained Habitat, arguing it would be uneconomic to plan for 15% biodiversity in each site. The Forest Service has confirmed to us and Coillte that Coillte do in fact have to abide by the guidelines.

These days Coillte state that they must be interpreting the biodiversity guidelines correctly as the Forest Service is passing their Farm Partnership sites.

Many private contractors planting for farmers have told me they feel they are at a disadvantage as they have to put in 15% ABE while others are allowed to plant 'every damn inch!" I have been shown sites where this does seem to be the case. However, without the maps and legends from the application it is impossible to work out whether this non-compliance with the guidelines is being approved by the Forest Service or the site maps are being ignored when planting. In the absence of transparency, we have issued a Freedom of Information (FOI) request for the maps which to date have not been made available by the Forest Service. People within the Forest service have made it very clear to me that they do not feel NGOs have any right to check on these sites.

An Taisce (Ireland's oldest and largest environmental organisation) has recently been given a monitoring role under the Forest Service new consent procedures in relation to some afforestation applications. This is An Taisce's assessment of the consent system to date: the new legislation has a provision for consultation with the general public and also with prescribed bodies. Under this new legislation, introduced last December, An Taisce has approximately 10% of the new forestry applications referred to it. Although An Taisce's specific brief is for sites with amenity and archaeology considerations, it does not limit its comments to these two areas. They have commented on acid-sensitive areas, water quality, designated nature conservation areas, cumulative impacts of forestry plantations, as well as the compliance of the application with the forestry guidelines themselves.

Initially, applications received from the Forest Service generally omitted page 3 of Form I, which would have allowed them to determine fairly quickly the key points to be examined in relation to individual applications. This page detailed silvicultural and environmental considerations and answers to questions on water quality, nature conservation designations, landscape considerations and archaeology. It was only following a face-to-face meeting with representatives from the Forest Service in July that they agreed to send this page.

The Forest Service were upset that An Taisce intended to take its monitoring role seriously, that it expected responses to its suggestions and details of the decisions the Forest Service made. The Forest Service stated they hoped they could have an arrangement as they have with Dúchas and the Water Authorities.

Very few of the applications received before July had areas of ABE marked. Of the 48 applications received in the last three months, only ten had the map and legend for ABE and most of those had no more than a tick - no breakdown of open spaces, no description to help identifying ABEs on the map. A six inch map gives little opportunity to identify small features so the legend is essential.

An Taisce is worried that so many applications are coming in without ABEs marked. The Forest Service comments give no indication that it is insisting on these before passing the applications. With no transparency it is impossible to monitor these.

The guidelines also recommend occasional cutting on retained areas of unimproved grassland, to encourage wildflower development. I would love to be proved wrong but I have yet to see an area of unimproved grassland left, let alone managed for wildlife.

They also recommend gap planting and layering to rejuvenate declining hedgerows. Again, I would love to be proved wrong but none of the contractors I have spoken to have ever planted hedges or for that matter planted any of the woodland trees and shrubs like wayfaring tree, spindle, guelder rose dogwoods or even whitethorn or blackthorn.

To me one of the most important elements for biodiversity has to be water. Unfortunately there seems to be an obsession with draining all the water off sites. The guidelines recommend creating small ponds and areas over 60 ha should be served by reservoirs. In the thousands of acres of plantations around Rock Chappell I have yet to discover a reservoir or pond. The guidelines are there, I believe the will is there from most of the contractors, and I know there are many digger drivers who would love the chance to create ponds and lakes. The costs would be minimal. All that is lacking is the will of the Forest Service to both encourage and enforce compliance with the guidelines.

At a meeting I had with An Taisce and the Forest Service in July this year, a Forest Service inspector stated that ‘on sites less than 10 ha you retain what biodiversity there is but you do not have to enhance any of the area for biodiversity. This is adequate for such small areas’. I stated that: ‘On a green field site with no existing hedges, a percentage must be set aside for biodiversity’. He replied: ‘No, the farmer is already losing 10% for broadleaves. I would not ask him to lose more of the site for biodiversity’.

I asked him to confirm his interpretation of the biodiversity guidelines in writing. By a strange coincidence, I received his reply the day before I left to talk to the EC commissioners last week. (Good to know the jungle drums are still working!) He stated: ‘In sites less than 10 ha in area, the open space element should be designed in conjunction with neighbouring land-use. Such small sites surrounded by open ground (non-forested land) consisting of grazing or tillage fields do not require open space for biodiversity purposes in addition to that which is normally provided for watercourses, roadways or rides.'

He is suggesting that the green field surrounding a forest negates the need for allowing areas for biodiversity within the plantation. Let us look at this green field. It more than likely has three cuts of silage taken of it each year with the circus of heavy machinery that modern harvesting requires, it will have at least three applications of fertiliser and more than likely at least one application of weedkiller, and just to make sure the field is as nature intended, the cows will have been worm drenched just before they are put to pasture which will wipe out the few remaining earthworms in the soil. This is the area the Forest Service are saying allows us to ignore the biodiversity guidelines and plant every square inch of a site.

At the conference in Ennis, a representative of Irish Timber Growers' Association stated that a recent study has proved that a Sitka spruce plantation has more biodiversity than the green field I have just described. I am sure he is right. A Sitka spruce desert supports more than a green desert, but surely the question that should be being asked and the comparisons that should be made should be between the richness and variety of biodiversity and habitat that are being lost forever and plantation forestry. I think it is safe to assume that by far the majority of planting is on the species rich marginal lands - our remaining reserve of biodiversity.

I would like to talk briefly about the Native Woodland Scheme. Although the Native Woodland Scheme is not immediately tied up with the biodiversity guidelines, it is about preserving and enhancing our remaining biodiversity. One of its aims is the phased long-term conversion of mixed and conifer forests to native woodland status. It states that all management inputs to the site must be kept to a minimum, avoiding unnecessary operations and blanket prescriptions, sensitively implemented to minimise disruption and disturbance.

Bearing this in mind I would like to talk briefly about Shippool Wood, just down the road from here at Innishannon on the banks of the Bandon River. It is an ancient woodland that was clearfelled in the 40s and replanted with Norway spruce and Scots pine in the early 50s, adjoining NHAs and a proposed SAC. Coillte had originally planned to clearfell this site, leaving the broadleaves, and replanting with Sitka spruce. Following public representations they have now stated they intend to clearfell (leaving the broadleaves) and apply for the Native Woodland Scheme. The Coillte company secretary said it could take many months if not years to be passed for this grant, and that Coillte currently had hundreds of hectares of clearfelled wood sites awaiting this grant. This suggests this not an isolated case. Once again it seems that, at the expense of biodiversity, the guidelines are being manipulated to allow a predominantly coniferous site to be clearfelled and then apply for the Native Woodland Scheme.

The fact that this could have a serious negative impact on the biodiversity of ancient woodland sites is borne out by a recent research led by Oxford University Forestry Institute. They found that if conifers (on ancient woodland sites) are felled and replaced with more conifers, then the wildlife dependent on ancient woodlands will not survive. They go on to say 'if we shift our understanding of restoration to mean creating conditions that will conserve and enhance ancient-woodland communities, it becomes clear that continuous-cover forestry is generally better. Restructuring the wood by degrees avoids sudden, dramatic change, and allows the sensitive woodland species to survive and expand under the protective embrace of the tree canopy'. Which, of course, is what the Native Woodland Scheme guidelines advocate.

To conclude: enforce and abide by Forest Service guidelines. I would also like to appeal to the Forest Service to simplify the guidelines, get rid of the loopholes so that all sites have to have 15% Area of Biodiversity. The biodiversity guidelines have made a difference. Riparian zones are for the most part being respected. Scrub is being retained. All guidelines are bound to have weaknesses and potential loopholes but if the guidelines are taken on board and implemented with the vision that Dr Susan Iremonger had when drafting them, if the Forest Service's Chief Environmental Officer's interpretation of them could be seen to be applied through the whole process from mapping and legends to planting, if a transparency were introduced into the system that would allow monitoring of these guidelines without having to resort to FOI for every scrap of information, the country as a whole would benefit from the expertise of the scientists gathered here today.

Enhancing biodiversity in commercial forestry – Coillte's approach

Dr Aileen O'Sullivan[6]

BACKGROUND

In adopting Sustainable Forest Management (SFM) in 1998, Coillte recognised the need to strengthen the environmental and social aspects of the management of its forests. Nature conservation was seen as an important area where the company could contribute to protecting and enhancing environmental quality in the countryside. Work in this area had been ongoing prior to 1998, but at a low level. SFM, and its verification through certification, required the company to put in place tangible policies and to develop systematic nature conservation practice on a more widespread scale, as appropriate, across its estate.

The framework for Coillte's biodiversity programme was provided by the requirements for FSC Certification. Certification is an internationally recognised process whereby forestry companies and forest landowners can have their forest management practice audited to a standard, and certified for the implementation of SFM. There are many forest certification schemes in existence, but Coillte has opted for that of the Forest Stewardship Council (FSC) (Forest Stewardship Council 2003). An example of an FSC-approved framework for SFM, including the protection and enhancement of biodiversity, is the UK Woodland Assurance Scheme (UKWAS 2000). An equivalent Irish framework is in second draft stage, but has not yet achieved FSC endorsement (Mannion 1999).

COILLTE APPROACH TO NATURE CONSERVATION

Broadly, the approach Coillte is taking in its nature conservation programme comprises two elements:

- Identification and appropriate management of biodiversity areas. These are areas within the Coillte estate that support a habitat or species of particular nature conservation value. In these areas, enhancement of biodiversity (or nature conservation) is the primary management objective. The appropriate treatment of these areas may require management that is considered unorthodox in terms of standard forestry practice. Depending on the site, timber production may also feature as a management objective in biodiversity areas.

- Adoption of wider forest measures. These are to be implemented, through good forestry practice, at the level of the standard forest operations site. These are sites that hold no outstanding nature conservation interest, and where timber production is the main objective of management. On such sites, good forestry practice is aimed at: a) ensuring the protection of relatively small features of conservation value; and b) enhancing the general habitat value of commercial forest stands. Wider forest measures include the following:

  - o Forest design and restructuring – aimed at: breaking up large, even-aged conifer stands, to diversify species composition and age structure of forests; incorporating riparian zones; protecting features of biodiversity, archaeological and cultural value on operations sites;

  - o Brief, non-statutory impact appraisal carried out by Coillte staff before forest operations commence – includes an assessment of environmental and social impacts.

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This paper focuses on progress to date with the identification of biodiversity areas. Wider forest measures are not covered further here, but information is available on from Coillte Teoranta (Coillte 2000, 2001, 2002, 2003a).

BIODIVERSITY AREAS

Context

Guidelines for SFM certification indicate that a minimum of 15% of the forest unit should be managed with nature conservation as a primary objective (Mannion 1999, UKWAS 2000), i.e. overall, Coillte's biodiversity areas should comprise at least 15% of the estate.

The scale at which this '15%' is identified is a very important consideration. The certification guidelines imply that each forest stand should have 15% identified and managed for biodiversity. But, in reality, the land under Coillte's stewardship – like the rest of the country – consists of a pool of sites which represent the complete spectrum, from outstanding to minimal nature conservation interest, with the majority of sites occupying the broad middle ground. Depending on their intrinsic value, different sites will merit a different management approach. Thus, Coillte is identifying the '15%' at sub-regional level, i.e. at the level of the Forest Management Unit.

The Coillte estate is divided into 36 Forest Management Units (FMUs) (Figure 1). The FMUs were delineated based on topographical and management criteria. A FMU typically includes about 15,000 hectares of Coillte land, ranging from just over 3,000 ha (Eastern Border FMU or FMU 702) to just under 34,000 ha (Slieve Aughty's FMU or FMU 405).

Because site types occur across a spectrum, as mentioned above, it can be difficult to know where the biodiversity areas – the '15%' – should begin and end. But despite its shortcomings, this sub-regional, FMU-based approach provides a framework for the identification of sites that require special treatment and it has proved useful.

Included in the '15%' biodiversity areas in each FMU will be all of the Coillte land proposed for designation by Dúchas, under national and international nature conservation legislation, i.e. Natural Heritage Areas (NHAs), Special Areas of Conservation (SACs) and Special Protection Areas (SPAs). This ensures that Coillte's biodiversity programme is linked to national objectives, as reflected in the Wildlife Act (Anon. 1976, Anon. 2000) and the EU Birds and Habitats Directives (Anon. 1979, Anon. 1992). Nature conservation designations in 2001 covered approximately 4.6% of the Coillte estate (Garrett 2001a).

The remainder of the target area will be made up of: areas of good quality semi-natural habitat; areas that should be restored to semi-natural habitat; long-term retentions (forest stands retained beyond the normal commercial rotation or felling age) (UKWAS 2000).

Site Survey and Assessment

In order to properly identify biodiversity areas, Coillte is engaged in a process of site survey and assessment. This survey programme commenced in 2001 and is due for completion in 2005. The surveys are carried out by freelance ecologists, while engaged on contract to Coillte, who work closely with local Coillte staff. The ecologists typically visit up to about 20% of the Coillte land within the FMU, assess the nature conservation interest of each site, and recommend whether it should be a biodiversity area.

Since it is not feasible to have every Coillte-owned site visited and surveyed by an ecologist, a process of preliminary site selection was carried out by Coillte for each FMU during 2000 and 2001. Four avenues of information provided a list of potential biodiversity areas for each FMU:

a) Coillte Forest Inventory and GIS provided a list of subcompartments recorded as having, for example, broadleaved high forest, mixed high forest, scrub, open

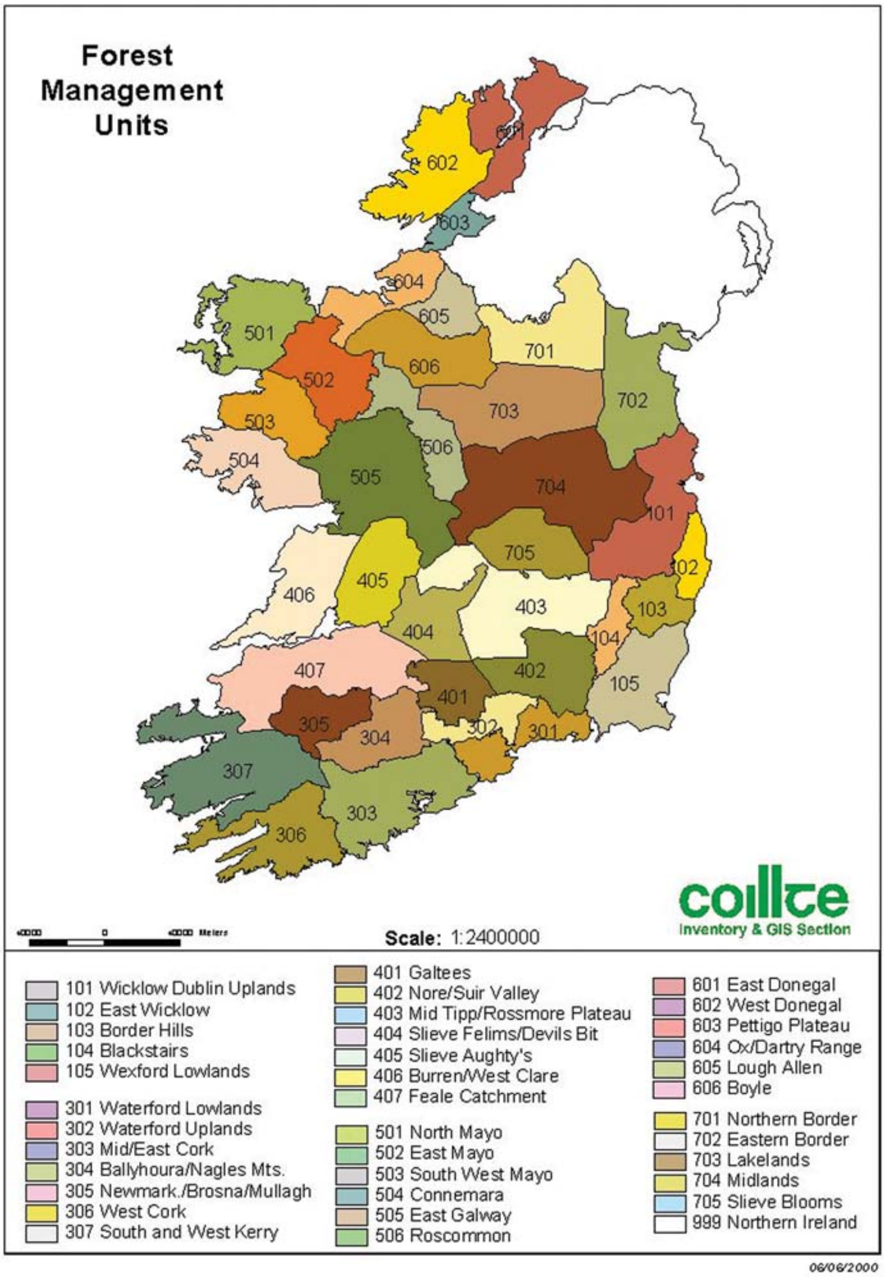

FIGURE 1: Location of Coillte Forest Management Units (FMUs).

conifer stands, swamp, lake, unplanted land.

b) Woodland History Survey of the Coillte estate (Garrett 2001b).

c) Dúchas archive of sites proposed for nature conservation, i.e. NHAs, SACs, SPAs (Dúchas The Heritage Service 2001).

d) Local Coillte staff knowledge of sites on the ground.

The first three sources identified a large number of sites in each FMU with potential nature conservation value. Local knowledge of sites has proved invaluable in refining and/or expending the lists of potential sites provided by the first three sources.

All of these data combine to produce for the ecologists a target list of sites to be surveyed. At each site visited, habitats present are recorded, using the habitat classification system published by The Heritage Council (Fossitt 2000). Habitats are not mapped, but habitat codes are assigned to each forest subcompartment as mapped by the Coillte inventory, and the area of each habitat present is estimated and recorded. Any available information on the presence of rare habitats or species is included in site descriptions. The ecologists also recommend suitable management for each biodiversity area, in discussion with Coillte staff. Photographs are taken to support site descriptions.

Preliminary Results

By the end of 2002, 14 FMUs were surveyed by ecologists. So far, survey data have been compiled only from the 7 FMUs surveyed in 2001. Summary data from 2001 are presented in Figure 2. In these 7 FMUs, a total of 11,359 ha of Coillte land has been proposed for inclusion in biodiversity areas.

Forests are the dominant habitat type, comprising 57% of the biodiversity areas identified (Figure 2; Table 1). Forests here include broadleaved, mixed and conifer high forest and scrub. The remainder is made up of open habitats, primarily peatlands (20%) and heaths (20%). Peatlands here include raised bog, blanket bog, cutaway bog and fen, i.e. sites on deep peats, where peat depth is generally >50 cm (Fossitt 2000). Heaths include wet heaths (peat depth 15-50 cm) and dry heaths (peat depth usually <15 cm) (C. Douglas, Dúchas, pers. comm.). Small pockets of other habitats were also recorded.

The most abundant habitat types represented in Coillte biodiversity areas are conifer forest, dry heath and mixed woodland (Table 1). Some of the habitat types recorded in the FMU surveys are considered 'rare' in a national and European context, e.g. yew woodland, calcareous springs, native wet woodland, limestone pavement and unimproved (species-rich) grassland. These 'rare' habitats, by their nature, tend to be small in size, but they are,

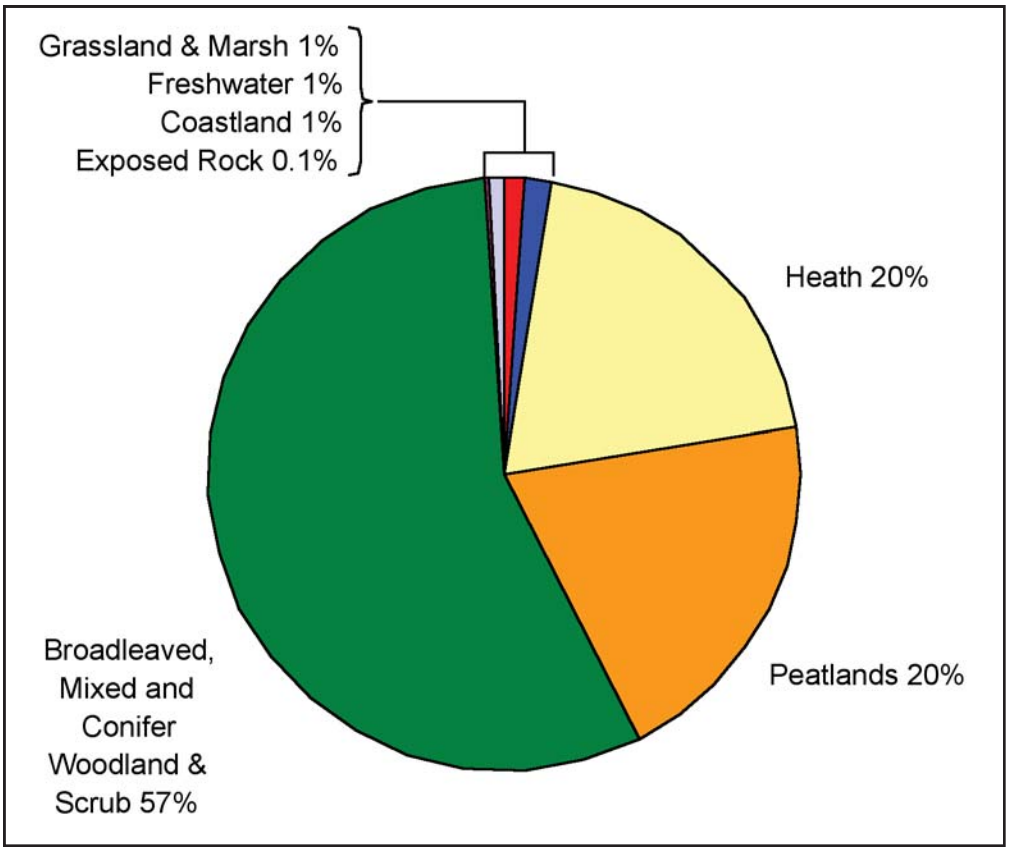

FIGURE 2: Summary of habitat types recorded in biodiversity areas recommended from surveys of 7 FMUs in the Coillte estate, completed in 2001. Habitat definitions follow Fossitt (2000) habitat classification, and are explained in the text.

TABLE 1: Habitats recorded in ecological survey of biodiversity areas in Coillte estate – data from 7 Forest Management Units surveyed in 2001.

NOTE 1: Habitat Names and Codes follow Fossitt (2000);
NOTE 2: Area values of 0 hectares denote values of <0.5 ha.

HABITAT NAME	HABITAT CODE	AREA (HA)	TOTAL (HA)
Woodland and Scrub			6413
Oak-birch-holly woodland	WN1	258	
Oak-ash-hazel woodland	WN2	156	
Yew woodland	WN3	2	
Wet peduculate oak-ash woodland	WN4	36	
Riparian woodland	WN5	11	
Wet willow-alder-ash woodland	WN6	76	
Bog woodland	WN7	128	
(Mixed) broadleaved woodland	WD1	543	
Mixed broadlved/conifer woodland	WD2	1319	
(Mixed) conifer plantation	WD3	335	
Conifer plantation	WD4	2933	
Scattered trees and parkland	WD5	2	
Scrub	WS1	355	
Immature woodland	WS2	220	
Recently-felled woodland	WS5	40	
Peatlands			2278
Raised bog	PB1	266	
Upland blanket bog	PB2	869	
Lowland blanket bog	PB3	417	
Cutover bog	PB4	411	
Eroding blanket bog	PB5	241	
Rich fen and flush	PF1	22	
Poor fen and flush	PF2	27	
Transition mire and quaking bog	PF3	24	
Heath, Dense Bracken			2258
Dry siliceous heath	HH1	1333	
Dry calcareous heath	HH2	7	
Wet heath	HH3	743	
Montane heath	HH4	125	
Dense bracken	HD1	51	

Table 1 continued

HABITAT NAME	HABITAT CODE	AREA (HA)	TOTAL (HA)
Grassland and Marsh			149
Amenity grassland (improved)	GA2	0	
Dry calcareous and neutral grassland	GS1	28	
Dry meadows, grassy verges	GS2	5	
Dry-humid acid grassland	GS3	38	
Wet grassland	GS4	74	
Marsh	GM1	5	
Freshwater			138
Dystrophic Lakes	FL1	2	
Acid oligotrophic lakes	FL2	29	
Mesotrophic lakes	FL4	7	
Eutrophic lakes	FL5	4	
Turloughs	FL6	16	
Other artificial lakes and ponds	FL8	3	
Eroding/Upland rivers	FW1	23	
Depositing/Lowland rivers	FW2	7	
Calcareous springs	FP1	1	
Reed and large sedge swamps	FS1	41	
Tall-herb swamps	FS2	6	
Coastland			110
Lower salt marsh	CM1	23	
Upper salt marsh	CM2	28	
Marram dunes	CD2	26	
Fixed dunes	CD3	17	
Dune scrub and woodland	CD4	10	
Dune slacks	CD5	6	
Exposed Rock			13
Exposed siliceous rock	ER1	9	
Exposed calcareous rock	ER2	2	
Siliceous scree and loose rock	ER3	1	
Spoil and bare ground	ED2	2	
Active quarries and mines	ED4	0	
Cultivated and Built Land			1
Buildings and artificial surfaces	BL3	1	
GRAND TOTAL (Area classified, hectares)			**11,360**

nonetheless, extremely important in terms of their nature conservation value. Other habitats that appear, from Table 1, to be 'rare', e.g. lakes, exposed rock, are possibly under-recorded and are likely to be more widespread outside biodiversity areas. It is important to bear in mind that time on these surveys does not permit a complete inventory of the habitats present in biodiversity areas. Table 1 should be seen as only indicative of the habitats present.

The large area of conifer forest in biodiversity areas comprises a wide range of site types – both in terms of stand type and in terms of the management objectives for these areas. Some conifer forest is included because it is intended to convert it to a different habitat type, e.g. convert to open ground or to native woodland. This is only proposed where there is a clear nature conservation benefit to be gained from such a conversion. Some conifer forest is included because it is of conservation value in its own right – management will be aimed at maintaining a particular species composition or age structure.

Follow-up actions

The identification of biodiversity areas forms the basis of a nature conservation strategy for each FMU, which Coillte staff will be responsible for delivering over the next few years. Management of these areas will involve a range of objectives, depending on site type. In some cases, all that will be required is simply to retain what is already present, while other sites may require more active management, e.g. reflooding wetlands, conversion of forest to open ground or conversion of conifer stands to native woodland. Coillte is actively pursuing financial support for these special actions, e.g. under the EU LIFE-Nature programme (Anon. 2003) and The Forest Service (2001) Native Woodland Scheme. Work has already commenced on a major nature conservation project, funded jointly by the EU under the LIFE-Nature programme and by Coillte, which is aimed at restoring afforested land to open blanket bog in SACs where this is deemed appropriate, i.e. where the afforested blanket bog habitat has good restoration potential (Coillte 2003b).

WOODLAND HISTORY SURVEY

Context

Woodland sites that have a continuous history of woodland cover have special significance in nature conservation. This is because there are some species of plant and animal that are specially adapted to woodland habitat conditions. They cannot readily colonise new or first rotation forests (Hermy *et al*. 1999). Because Ireland lost almost all of its forest cover, we have already lost many of these woodland specialist species, but nonetheless, some survive. The immense importance of old or ancient woodlands to species conservation is reflected in the attention these sites are now receiving in nature conservation programmes within the forestry sector (Mannion 1999, UKWAS 2000, Spencer 2002).

Survey Methodology

To address this issue, a complete review of available old maps was carried out, to trace the woodland history of all Coillte land. The earliest available standardised set of maps available for the whole of Ireland is the 6':1 mile series, the first edition of which was produced by the British Ordnance Survey between 1833 and 1844 (Table 2). These maps were periodically updated by the Ordnance Survey (O.S.). A full coverage for the country is again available in the third edition of the series, which was published between 1900 and 1954 with the majority having been published in the period 1900-1915. These old maps show the boundary of woodlands extant at the time, and symbols drawn in on each site indicate roughly the composition of woodland cover.

For every portion of the Coillte estate, the former woodland boundaries, as shown on the 1st and 3rd Edition O.S. maps, were digitised

TABLE 2: Summary of recording technique employed during a map review of woodland history for the entire Coillte state (Garrett, 2001b). O.S. = Ordnance Survey maps; Scale 6':1 mile.

1st Edition O.S. 1833-1844 A.D.	3rd Edition O.S. 1900-1915 A.D.	Coillte Inventory 2000 A.D.	Site Type Recorded
Wooded	Wooded	Wooded	old woodland site
Wooded	Open Ground	Wooded	interrupted old woodland
Very Open Woodland	Very Open Woodland	Very Open Woodland	parkland
Open Ground	Wooded	Wooded	long-established plantation
Open Ground	Open Ground	Wooded	recent plantation

and entered into the Coillte GIS, and the woodland types shown on the old maps were recorded. This allowed a comparison with today's forest coverage, as provided by the Coillte Forest Inventory. The Woodland History Survey was completed in 2001 (Garrett, 2001b).

Summary Results

According to their history of woodland cover, sites were categorised into five categories (Table 3; Garrett 2001b). Of the total Coillte estate, over 88% consists of 20th century plantations on sites that, at the time, were open ground – these are termed 'recent plantations'. 'Old woodland sites' account for 6.3% of the estate – these are sites that appear to have been continuously wooded since the 1830s. A further 4% of the estate consists of 'long-established plantation', i.e. sites where forest was established on open ground some time between 1830s and 1910s. A small number of sites (1% of the total estate) were classified as 'interrupted old woodland', i.e. forest was present in the 1830s, but was then cleared by the 1910s and was subsequently reforested. Finally, a small proportion of sites (0.6% of the estate), classified as 'parkland', formerly consisted of very open stands of trees, on land that was probably also used for grazing.

The data from the woodland history survey have not yet been fully analysed, however, some preliminary points have emerged. In general (though not always), the old woodland sites – i.e. sites that have been continuously wooded since the 1830s – are the most important category from a nature conservation point of view. Taking the old woodland sites as a dataset in themselves, Figure 3 shows a size distribution graph of the old woodland sites. As expected from looking at the Irish landscape today, the vast majority of old woodland sites are small and fragmented. The largest size category is 2-4 hectares. The majority of old woodland sites are <20 hectares in size.

TABLE 3: Summary results of woodland history survey of entire Coillte estate (Garrett, 2001b), as recorded from Ordnance Survey maps (Scale 6':1 mile).

Woodland History	Area (hectares)	Area (% Coillte Estate)
Old woodland site	27,785	6.4%
Interrupted old woodland	4,325	1%
Parkland	2,471	0.6%
Long-established plantation	16,733	4%
Recent plantation	386,310	88%
TOTAL survey area	437,341	100%

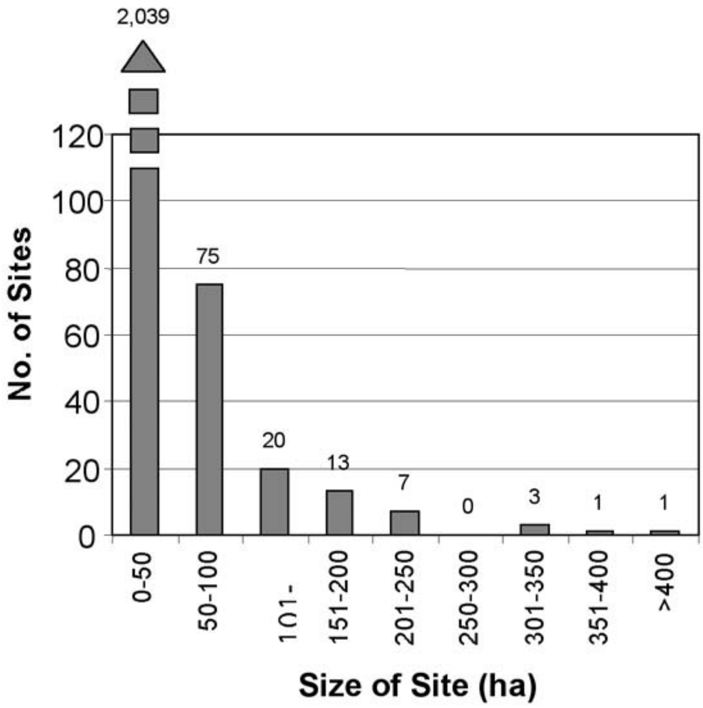

FIGURE 3: Size distribution of old woodland sites on the Coillte estate (Garrett 2001b).

However, there are five old woodland sites larger than 300 hectares. The larger an old woodland site, the greater the chance that at least parts of the site are much older than the 170 years covered by the Woodland History Survey. Consequently, these large old woodland sites may in future be found to support interesting plant and animal communities.

Application of results

Old woodland sites are, as far as possible, included in the survey of biodiversity areas by ecologists. Not all old woodland sites are included as biodiversity areas in each FMU. Inclusion in the biodiversity '15%' depends on the habitat value of each site. On most old woodland sites, the objective will be to balance nature conservation and timber production objectives.

CHALLENGES

The pace of development of Coillte's nature conservation programme has been challenging. This rapid pace of change is also seen in the wider forestry sector, as well in other spheres such as agriculture and the heritage and nature conservation sectors.

Particular challenges include:

- Achieving a balance between commercial and nature conservation objectives.
- Creating an awareness among foresters of management requirements for biodiversity areas, which are often at variance with the requirements of commercial timber production. Usually the management of biodiversity areas is required to be much less intensive than that of commercial stands.
- Achieving clarity in nature conservation policy and practice among non-specialist staff. A significant problem here is the lack of availability of clear interpretative material to assist in conveying nature conservation concepts and objectives, which often appear obscure to non-specialists.
- Lack of availability of biological data. Records of plant and animal species can be difficult to obtain. Coillte is supportive of The Heritage Council's initiative to

address the need for a biological records centre in Ireland (McGowan *et al*. 2002).

CONCLUSION

The initiatives described above will make a significant contribution to Ireland's national nature conservation efforts. Biodiversity areas constitute a significant expansion of the national area of lands managed for nature conservation. The Woodland History Survey is the first systematic survey of its kind at national level.

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Examining the effects of land-use, particularly afforestation, on biodiversity

Thomas Bolger[7]

THE NEED FOR IRISH STUDIES

Although the fauna and flora of Western Europe are comparatively well known and a large volume of literature exists on the biodiversity of European forests, it is apparent that specific studies of biodiversity in Ireland are necessary. The existing literature, both Irish and international, provides only a basis for such studies. This is because of the rather unusual composition and history of the Irish flora and fauna. For example, in the Foreword to his encyclopaedic book on Ireland, Cabot (1999) writes that upon his arrival in Ireland 'the first arresting ornithological surprise was a hooded crow frisking on some rubbish….They were a rarity where [he] had come from'. This crow, which is so familiar in Ireland, is absent from most of Western Europe where it is replaced by the carrion crow (c.f. Mullarney 2000, p.336).

This unique composition of Ireland's flora and fauna is the result primarily of its island status and the history of recolonization of the island following the ice ages. However, human activities have also had a large impact. For example, D'Arcy (1999) describes how habitat destruction and predation are likely to have led to the loss of species such as the golden eagle and the bittern while many other animal species such as the rabbit, frog and sika deer are known to have been introduced by humans (Hayden and Harrington 2000).

It is also clear that the roles and population dynamics of many species of animal and plant are contingent on the situations in which they find themselves. This is particularly obvious when we consider the situations with invasive species, such as rhododendron and Japanese knotweed, which have been introduced by humans. Thus when considering the effects of human activities on biodiversity it is generally not appropriate to simply extrapolate from one set of circumstances to another.

THE POTENTIAL UNIQUENESS OF THE FAUNA AND FLORA OF IRISH FORESTS

Afforestation is one of the main forms of land use change currently taking place in Western Europe. For example, in Ireland, following centuries of deforestation and subsequent agricultural development, the total forested area of the country was only 1.4% in 1905 (OCarroll 1984). However, with the advent of state and European Community sponsored planting programmes, the forested area has reached approximately 10% of the country and the government envisages an expansion in tree planting of 30,000 ha per annum (Lowery 1991). In addition, much of the planting is made up of non-native conifers, particularly Sitka spruce (*Picea sitchensis* (Bong.) Carr.) and lodgepole pine (*Pinus contorta* var *latifolia* Watson) (Cabot 1985). Thus, following a period of almost total deforestation, a new, man-made, environment of exotic coniferous forest has replaced the natural woodland habitat.

Due to the history of Irish forests one might expect that many of the species relying on forests would have disappeared when deforestation virtually eliminated forest cover from Ireland and that the composition of forest communities would have an unusual composition because many of the species occurring in these habitats would not have coevolved with the tree species which make up most of the forest area. This expectation is already known to be true for certain taxa. For example, 20 of the 52 bird species, which Fuller

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(1995) lists as breeding and feeding within closed-canopy schrub and woodland, do not occur in Ireland and birds, such as the great spotted woodpecker, which once bred here, has gone to extinction presumably due to deforestation (D'Arcy 1999). In addition, many woodland plant species, common in the rest of Europe, are either not present or are rare in Ireland (e.g. Clabby and Osborne 1999). There is also a reduced richness of *Elateridae*, *Bupresidae* and *Cerambycidae* which one might expect in association with a native species, Scots pine (Speight 1985, 1988, 1989).

Some studies have been carried out of the biodiversity present in Irish forests. There is a considerable literature available on birds, summarised in O'Halloran *et al*. (2002), carabid beetles (e.g. Day and Carthy 1988, Day *et al*. 1993, Coll *et al*. 1995, Coll 1998, Faky and Gormally 1998), other insects (e.g. Breen 1977, 1979a, b, c, Speight 1985, 1988, 1989) and soil and litter fauna (e.g. Little and Bolger 1995, Heneghan and Bolger 1996 a, b, O'Hanlon and Bolger 1997) of Irish woodlands and hedgerows. However, although the flora and vegetation of semi-natural woodlands has also been extensively studied (e.g. Kelly 1981, White 1985, Cross 1987, Kelly and Kirby 1982, Kelly and Iremonger 1997) there is very little information on the flora of coniferous plantation forestry (e.g. Doyle and Moore 1982).

An important question is whether the biota of forests is any more depauperate than the biotas of other habitat types in Ireland. For example, in the case of one relatively well studied group of insects, the carabid beetles, Ireland's fauna is impoverished relative to Europe and only contains about 60% of the species which occur in Greet Britain. In addition, the carabid fauna of Irish forests is distinct from those of other European forests due to the absence of many large woodland species and the relatively rarity of species such as *Pterostichus oblongopunctatus* (Fabricius) which are common in woodlands elsewhere (Coll *et al.* 1995). However, the fauna appears to be equally depauperate in other habitat types (Table 1). This may not be the case for other groups.

HOW SHOULD WE ASSESS BIODIVERSITY? WHAT BIODIVERSITY ARE WE INTERESTED IN?

A need is frequently expressed for indicators of biodiversity and other methods of 'rapid biodiversity assessment' to assess overall biodiversity (Oliver and Beattie 1993). This arises because a programme to assess changes in all components of biodiversity is clearly impossible. There are too many species present in any place [e.g. 1000 species of soil invertebrates in a single square metre of a beech forest (Schaefer and Schauermann 1990)] which in turn requires a logistically unreasonable number of experts. It has been suggested that single groups of plants and

TABLE 1: Comparisons of number of carabid species found in Ireland and Great Britain based on various habitat features. Habitat preferences based on Lindroth (1974).

Habitat Affinity	Ireland	Britain	Proportion
Forest	24	43	0.56
Open	60	118	0.51
Bog	4	8	0.50
Altitude	12	17	0.71
Coastal	21	48	0.44
Dry	22	56	0.39
Hygrophilous	98	142	0.69

animals may serve as indicators for overall biodiversity, e.g. Scarabeidae (Halffter and Favila 1993). However, many studies have shown that different groups have highly variable responses to disturbance (e.g. Lawton *et al.* 1998). Others have proposed 'predictor sets' of taxa (Kitching 1993, Stork 1995), the 'shopping basket' approach (Niemelä and Baur 1998) or synthetic indexes such as those proposed to assess the quality of running freshwaters based on their diversity and the identity of the taxa.

However, to select the components of biodiversity to be assessed it is necessary to have a clear view of the biodiversity that one needs, or wishes, to assess. For example, in many biodiversity assessment programmes either species richness or species diversity (where the relative abundance of the species is taken into account) are used and the system which harbours the largest diversity is often implicitly assumed to be the best in some sense. However, this is not always the case. If fauna or flora occurring in habitat patches of varying sizes are sampled and the cumulative number of species occurring in habitat patches plotted, in the first instance starting with the largest habitat fragment and gradually adding the smaller ones, in the second starting with the smallest and gradually adding the larger ones then in virtually all cases, it is found that many more species are present in several small patches than in a single large patch of equivalent area. This is illustrated for a study of springtails and mites on fungal fruiting bodies in Figure 1 (O'Connell and Bolger 1997). Thus it could be argued that the most appropriate way to maintain high biodiversity is to have a large number of small patches. The problem with this idea is that it ignores the identity of the species found in the patches. When this is examined, it is usually found that the species in the small patches are widespread or weedy species and that the habitat specialists or species requiring complex community structures are absent. This arises because of a feature of many communities called nestedness (e.g. Honnay *et al.* 1999). Therefore it is obvious that we also have to consider the identity of the species and know which species are most 'valuable' to us.

We have to be clear about the components of biodiversity that are of interest. Interest in the detection and preservation of keystone species would be important from the sustainability point of view, flagship species, e.g. red grouse in Mayo, are often used when the integrity of habitats is of particular interest and birds and butterflies when aesthetic and public relations exercises are of importance.

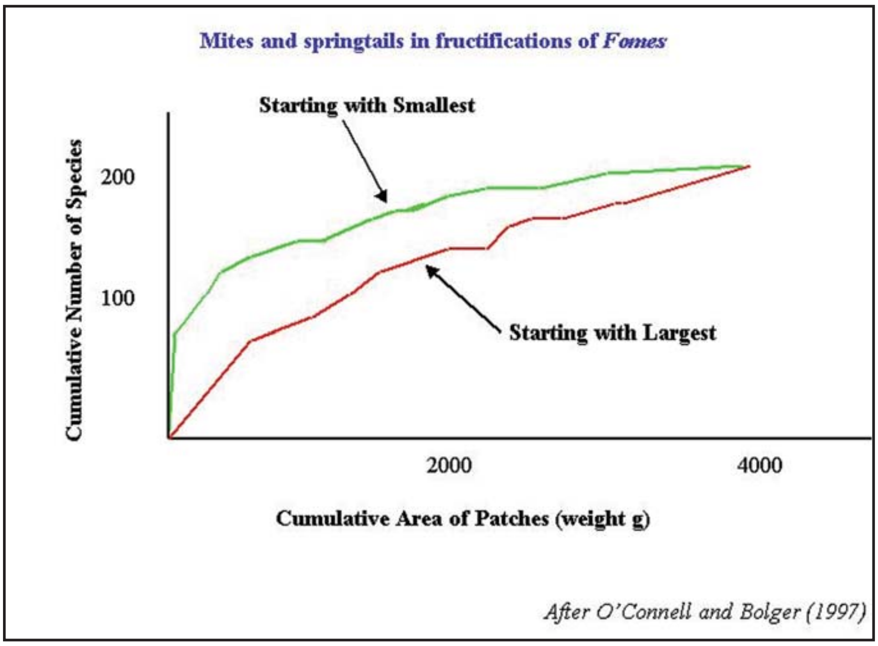

FIGURE 1: Relationship between cumulative number of species and cumulative habitat size in one instance starting with the largest patch, in the other starting with the smallest.

SAMPLING DESIGN

A study carried out by Coll (1998) shows that sampling design is critical when comparing the biodiversity of open and forested habitats. Several previous studies showed that distinct carabid assemblages occur in forested and open habitats (e.g. Butterfield *et al.* 1995, Heliölä *et al.* 2001) and in this study the species composition and biodiversity of Carabidae in coniferous forests and unafforested habitats were compared.

In 1995, the carabid assemblages were sampled in a series of randomly selected open and afforested sites and significantly more species were found in the open sites. However, when the data were re-examined, it was found that the greatest amount of variation in the data was not related to forestry but to altitude. In fact, the difference which had been detected was potentially an artefact of random site selection because forested sites were on average at slightly higher altitudes. In 1996 a similar study was carried out but, on this occasion, a paired design was used comparing adjacent open and forested sites. On this occasion no difference in number of species was detected but there was a change in species composition. For example, six species were found exclusively in heathland: *Notiophilus germinyi* Fauvel, *Notiophilus palustris* (Duftschmid), *Olisthopus rotundatus* (Paykull), *Patrobus assimilis* Chaudoir, *Pterostichus adstrictus* (Eschascholtz) and *Pterostichus cupreus* (L.), while four species were found uniquely in the forest plots adjacent to these: *Amara familiaris* (Duftschmid), *Leistus fulvibarbis* Dejean, *Leistus rufomarginatus* Duftschmid and *Trechus micros* (Herbst). Thus, diametrically opposite conclusions can be drawn from inappropriate experimental design.

INFLUENCE OF LANDSCAPE

The landscape in which a particular habitat patch is located will influence the species composition of many taxa in the patch. Forest fragments surrounded by managed open habitats contain elements of the field fauna (Halme and Niemelä 1993). There is a similar indication that a proportion of the Carabidae present in Irish forests reflect the surrounding habitats and landscape. This is perhaps not surprising given the fragmented nature and small size of many Irish forests stands. Usher *et al.* (1993) point out that small patches have a large edge to interior ratio and are therefore likely to be greatly influenced by surrounding habitat. However, Heliölä *et al*. (2001) have found that carabid assemblages at the edges of forests were more similar to those of the forest interior and that open-habitat species did not penetrate into the forests from clearcuts.

In our studies we have found that the surrounding habitats can affect the penetrability of a landscape for particular species. For example, *Abax parallelepipedus* is a carabid beetle found in most woodlands which have been studied in Ireland. It is also found in heathland, rough grassland and hedgerows. However, it is virtually absent from most intensively managed pastures and tillage areas. Thus the presence of this species in the woodland is likely to be influenced by the habitat types surrounding the forests, the presence or absence of hedgerows and the distance between forest patches sites.

CONCLUSION

From the examples cited above it is obvious that:

i) many aspects of biodiversity are context dependent and therefore studied in have to carried out in the Irish landscape;

ii) sampling design is critical if unbiased results are to be achieved from surveys;

iii) biodiversity can have several different meanings and the aspect of biodiversity which is being assessed needs to be identified explicitly; and

iv) both habitat and landscape features need to be taken into account when assessing the effects of a land use on biodiversity.

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Biodiversity of plantation forests in Ireland: BIOFOREST project

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INTRODUCTION

Currently across the globe there is unprecedented interest in the earth's biodiversity (e.g. EWGRB 1997). In 1993, one hundred and fifty countries (including Ireland) signed the Convention on Biological Diversity. Other related conventions include the Convention on Sustainable Development. Forests have come under particular scrutiny, with the UN setting up intergovernmental panels to agree on procedures for forest planning and management.

Each country is now obliged to work towards establishing a legal and institutional framework for Sustainable Forest Management (SFM) (Forest Service 1999). The importance of biodiversity and its assessment has taken centre place in this process. Forestry is becoming increasingly important in Ireland, with the industry intending to have up to 15% of the Irish landscape planted by the year 2010 (Anon. 1996). There is a need to determine national (and European) indicators of sustainable forest management. The trees being planted are mostly exotic conifers, though there is a shift to plant more deciduous broadleaves in the last number of years, with a national target of 20% (Department of Agriculture Food and Forestry 1996). One of the great driving forces for sustainable forest management is the need for Environmental Certification to demonstrate that timber is produced in a sustainable way without damaging the environment.

Plantation forest provides a habitat for elements of Ireland's biodiversity. While there has been some work on birds (O'Halloran *et al*. 1998), these data and those for other taxa are rather limited. The dramatic habitat changes that occur over the forest cycle can be expected to influence biodiversity positively or negatively, but much work is needed to try to assess structure, composition and management practices most optimal for the maintenance and enhancement of biodiversity. New areas of forest (broad-leaved or coniferous) will potentially provide support for or encourage recolonisation by some components of biodiversity. Potential losses of open-country biota, dependent on the 'traditional' cultural landscape of much of Ireland (Aalen *et al*. 1997), must also be considered however.

Assessment of biodiversity in any habitat or landscape is a difficult task to achieve on a comprehensive scale, given the range of components of biodiversity (different biota) that could be measured if logistics allowed. At most, studies aimed at assessing biodiversity directly can expect to measure the occurrence and diversity of only a small proportion of biota, whether animal, plant, fungal or microbial. Choosing the appropriate groups to study raises questions of subjectivity, and the diversity of different groups may respond differently to habitat and other environmental factors. An additional approach is to try to identify features that can be used to predict biodiversity, at least in relative terms for comparisons over space or time. In some cases, particular components of biodiversity (e.g. species diversity of 'group X') may vary in tandem with 'overall biodiversity' (or, at least, with our perceived notion of overall biodiversity). Recent studies involving members of BIOFOREST have identified a number of potential indicators of forest

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biodiversity (Larsson *et al*. 2002), which can be broadly divided into three classes as follows:

- Structural indicators (e.g. area of forest from national through landscape down to stand scales, field boundary connectivity between forests or other habitats on a landscape scale, or amount of dead wood on a stand scale).
- Compositional indicators (measurements of actual components of biodiversity, e.g. number or diversity of tree species on different scales, numbers or diversity of species of particular animal groups, etc., if these are considered likely to reflect or predict overall biodiversity).
- Functional indicators (e.g. frequency and intensity of natural or human activities, including land management).

The BIOFOREST project aims to: 1) study biodiversity and its assessment in afforestation sites, 2) assess biodiversity at different stages of the forest cycle, and 3) investigate experimental methods to enhance biodiversity in plantation forests. Fundamental to our approach is the identification of structural, compositional and functional indicators of biodiversity. These indicators can then be used to enhance the assessment and management of biodiversity at all stages of forest development. In addition, the outputs of the project can be used to guide the development of sustainable forestry policy in Ireland.

Here we provide some information on the BIOFOREST project, and we present some preliminary data and some details of our proposed work on biodiversity enhancement of plantation forests.

THE BIOFOREST PROJECT

The BIOFOREST project is a five year project which started in 2001 and will be completed in 2005; it is divided into three sub-projects as follows:

Sub-project 1: Biodiversity assessment of afforestation sites;

Sub-project 2: Assessment of biodiversity at different stages of the forest cycle, and

Sub-project 3: Investigation of experimental methods to enhance biodiversity in plantation forests.

Sub-project 1 Biodiversity assessment of afforestation sites

Afforestation in Ireland is no longer confined to the poorer uplands, and the types of sites being planted are quite diverse, ranging from bog and heath to different types of grassland. The changes in the landscape that are being brought about by afforestation activities are quite significant, and have led to questions about their implications for biodiversity. Scientific data showing how land use change affects biodiversity are scant, and there is debate about how to optimise the landscape for biodiversity. There is currently no protocol for on-site assessment of the biodiversity of areas to be afforested, and for projecting how afforestation activities may affect them.

Previous biodiversity studies of Irish habitats of the type currently being afforested have been somewhat uneven, but some (heathland, unimproved grassland, etc.) contain distinctive and highly localized plant communities (e.g. lowland heath, a rare vegetation type away from coastal areas); collectively they include several major elements in Ireland's plant and animal diversity. Each habitat may include a number of scarce and rare species, including legally protected species. Because of the absence of a functioning biological records centre in Ireland, standard inventory data that would normally underpin strategic planning are not available. For this reason, the development of the forest industry and conservation of biological diversity may come into conflict. If biodiversity were to be assessed for potential sites, such conflict might subside as decisions could be based on objective scientific data.

Main Objectives

- Develop methodologies for biodiversity assessment and identify indicator species in important habitats that might be subjected to afforestation.
- Compare species composition between a range of recently afforested sites representing different habitats, and non-afforested equivalent habitats.
- Assess the efficacy of the *Forestry Biodiversity Guidelines* (Forest Service 2000) and recommend improvements.

Methods

The approach taken here is a comparison of the biodiversity of recently afforested sites with adjacent, closely comparable sites that have remained unplanted. The sites are selected from four frequently-afforested habitat types: wet grassland, improved grassland, cutover blanket bog and wet heath, with balanced replication among the habitat types. In addition, before/after surveys of five sites afforested in the winter of 2002/2003 are being carried out.

A comprehensive in-depth inventory of all taxa is outside the scope of this project: instead a targeted approach will be used, with three avenues:

- Literature searches and consultation with forestry and biological institutions internationally have been used to draft a suitable methodology for assessing the biodiversity of afforestation sites in Ireland (Gittings *et al*. 2002).
- Current knowledge on the biodiversity of habitats most usually used for planting is being assembled and used to reinforce the choice of indicators of biodiversity in each habitat type.
- The outputs from these reviews will guide surveys of flowering plants, ferns, mosses, liverworts, birds, and selected invertebrate fauna in a number of study sites. Rare and threatened species will be highlighted.

The first season of fieldwork for this project has been completed (Figure 1), and another two seasons are planned.

Sub- project 2: Assessment of biodiversity at different stages of the forest cycle

This sub-project examines the current gaps in knowledge about how forest biodiversity changes during the forest growth cycle. Most plantation forests in Ireland are managed under a clearfelling regime, which means that they have distinct stages of development from the planting stages, up through thicket and pole stages, to finally harvesting and re-planting, or ‘overmature’ (where the forest is left to grow beyond the commercial optimum). It is essential to have a picture of biodiversity that represents not only one stage in the forest cycle, but a series of pictures that can be put together to provide a better picture of biodiversity in the complete forest system.

Forest biodiversity will not only be affected by growth stage but by the forest type. Most of the plantation forest in Ireland is coniferous, mainly Sitka spruce, and the biota of these forests will differ both from each other and from other forest types, such as those dominated by broadleaves. These latter were very uncommonly planted in the past but are gaining in popularity due to changes in policy by the Forest Service. In addition to the differences between forests due to tree species dominance, there are differences due to variations in the environment, even within forests of a particular tree species type.

Main objectives

- Assess the range of biodiversity in representative forests at key stages of the forest cycle
- Review and recommend opportunities for enhancement of biodiversity in plantation forests

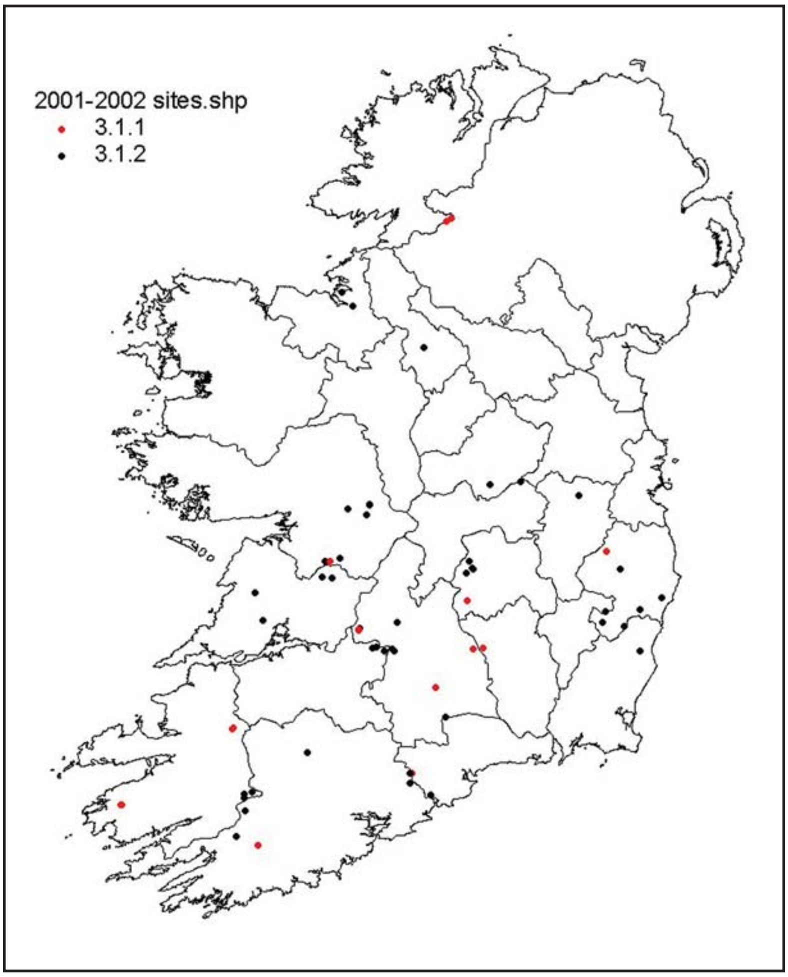

FIGURE 1: Locations of BIOFOREST study sites sampled in 2001 and 2002 for Sub-projects 1 and 2.

- Assess the effectiveness of the *Forest Biodiversity Guidelines* (Forest Service 2000).

Methods

Study sites were selected according to tree species dominance and growth stage, and covered as broad a geographical area as was practicable. Fieldwork was conducted in 2001 and 2002 and included sites sampled in Sitka spruce forests, ash forests and non-intimate mixtures of Sitka spruce and ash. Pre-thicket, thicket, mid-rotation and mature stands were sampled (Figure 1).

Using standard survey methods, field data were collected on particular components of biodiversity, including specialists on dead wood. Vascular plants, mosses and liverworts were recorded from 142 botanical quadrats in 39 sites, Syrphidae (hoverflies) and Lepidoptera (butterflies and moths) were sampled in 65 malaise traps from 35 sites, spiders were recorded using 1575 pitfall traps sampled over three periods in 35 sites, and birds were sampled using 4-9 point-counts for each of 40 sites, with two or three visits to each site (total 380 data sets).

Preliminary results from Sub-project 2

Plants:

The 2002 field survey for plants covered the pre-thicket (about 5 years old) stage of all forest types. Pure Sitka spruce sites were the most species-rich forest type: on average 25 species were observed in the 10 x 10 m quadrats. However, there appears to be no significant difference in total richness between the forest types ($p>0.05$) (Figure 2). Although the pre-thicket ash forests were the most species-poor, a 10 x 10 m quadrat on these sites still supports an average of 22.7 species.

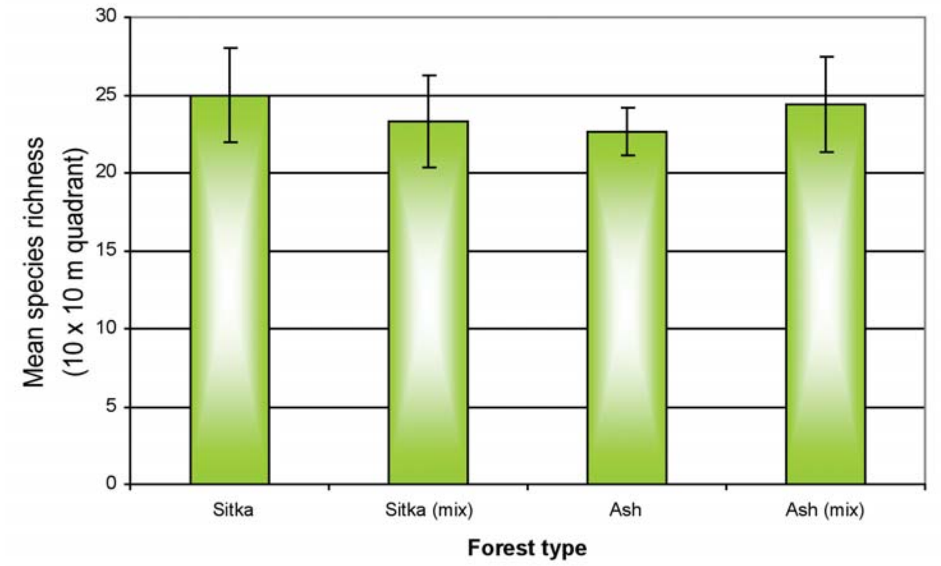

FIGURE 2: Mean plant species richness of the Sitka spruce and ash forests at the pre-thicket stage (bars show SE).

The average species richness of each pre-thicket forest is displayed in Figure 3. The ash compartment of the mixed Lurgan Great study site was the most species-rich forest, where an average of 35 species were found in each quadrat. A mixed site was also found to be the most species-poor: only an average of 9.7 species were identified in the 10 x 10 m quadrats in the Sitka spruce compartment of Kilmacow.

The pre-thicket Sitka spruce forests were more species-rich than the thicket, mid-rotation and mature pure spruce forests (Figure 4), and they have comparable levels of richness to the thicket and mature ash forests. Any differences in species richness between the Sitka spruce and ash forests becomes more apparent as the forest cycle progresses.

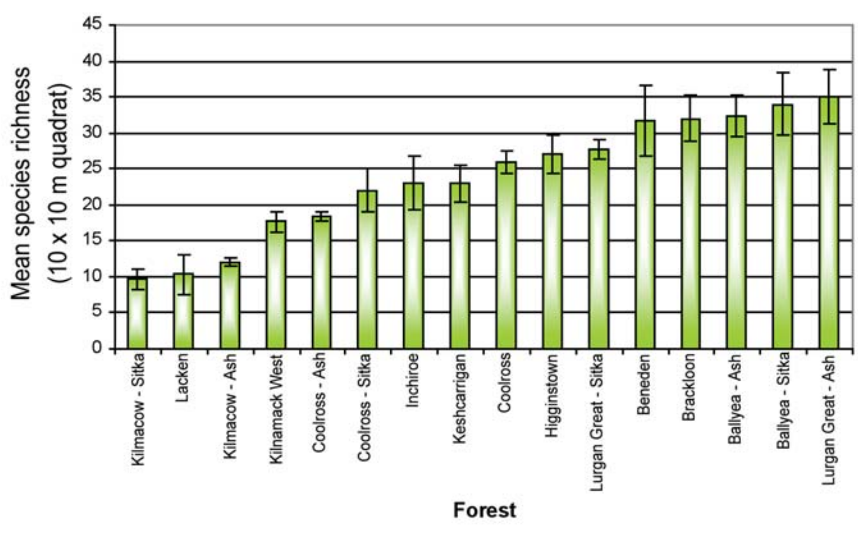

FIGURE 3: Mean plant species richness of the pre=thicket forests (bars show SE).

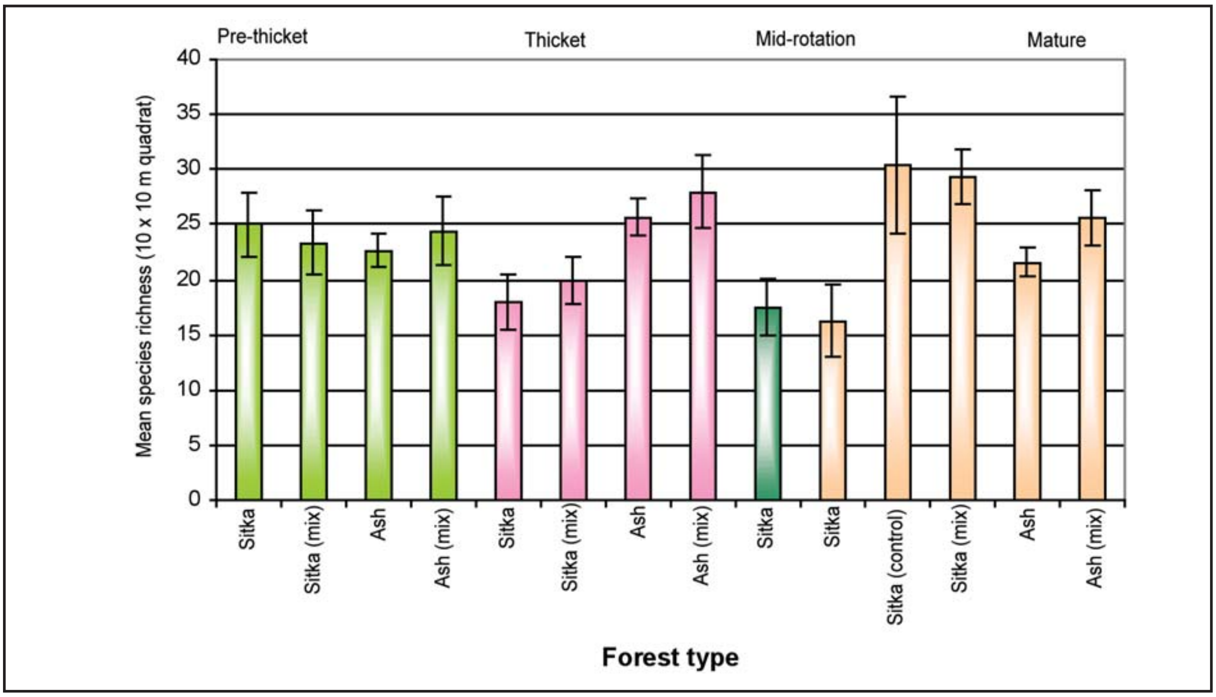

FIGURE 4: Mean plant species richness of the Sitka spruce and ash forests at different stages of the forest cycle (bars show SE).

Birds:

More than fifty-five bird species were recorded during 2001 fieldwork. Preliminary analyses indicate clear differences between the bird communities of young plantations (in which willow warblers and redpolls are abundant) and older forests (in which goldcrests and coal tits are more numerous). Some of the variation in the data appears to be related to tree species composition as well as to age (see Figure 5). The two bird species recorded most frequently were wren and chaffinch. Wrens were recorded twice as frequently as chaffinches in all ages and types of forest except for mature Sitka, where approximately twice as many chaffinches as wrens were recorded, and mid-rotation Sitka, where numbers of chaffinches and wrens were approximately equal. Species richness and total numbers of birds also appear to vary with forest type and age. Further analyses will be based on bird species densities.

Hoverflies:

Some preliminary data analyses are shown in Figure 6. This compares the composition of the syrphid fauna in paired forest road and forest interior samples from four mature Sitka spruce forests. All the forest interior samples were from small (< 200 m^2) clearings. The number of hoverflies in the set analysed was 1120 individuals of 39 species. The categorisation reflects the habitat type(s) that the species are typically associated with. Supplementary open space refers to species which only occur in conifer forests when there are at least some small areas of open space habitat present. The figure shows that samples from forest roads and within the forest had similar numbers of forest specialist species, but the road samples had lower abundances. The forest road samples had greater species richness and abundances of generalists, supplementary open space and open space specialists.

Sub-project 3: Investigation of experimental methods to enhance biodiversity in plantation forests

According to Peterken (1996), ‘the treatment of the open spaces is the single most important factor in the success or failure of nature conservation within plantations’. The

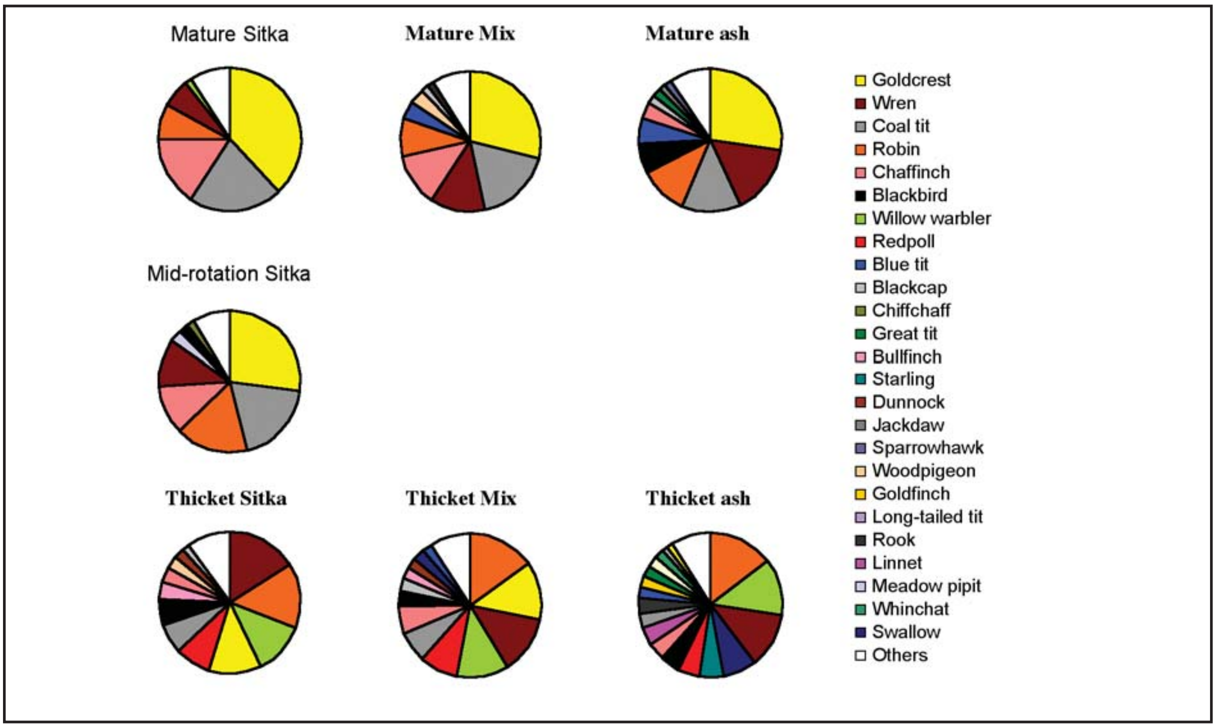

FIGURE 5: Effect of tree age and species on bird communities in some Irish forest types.

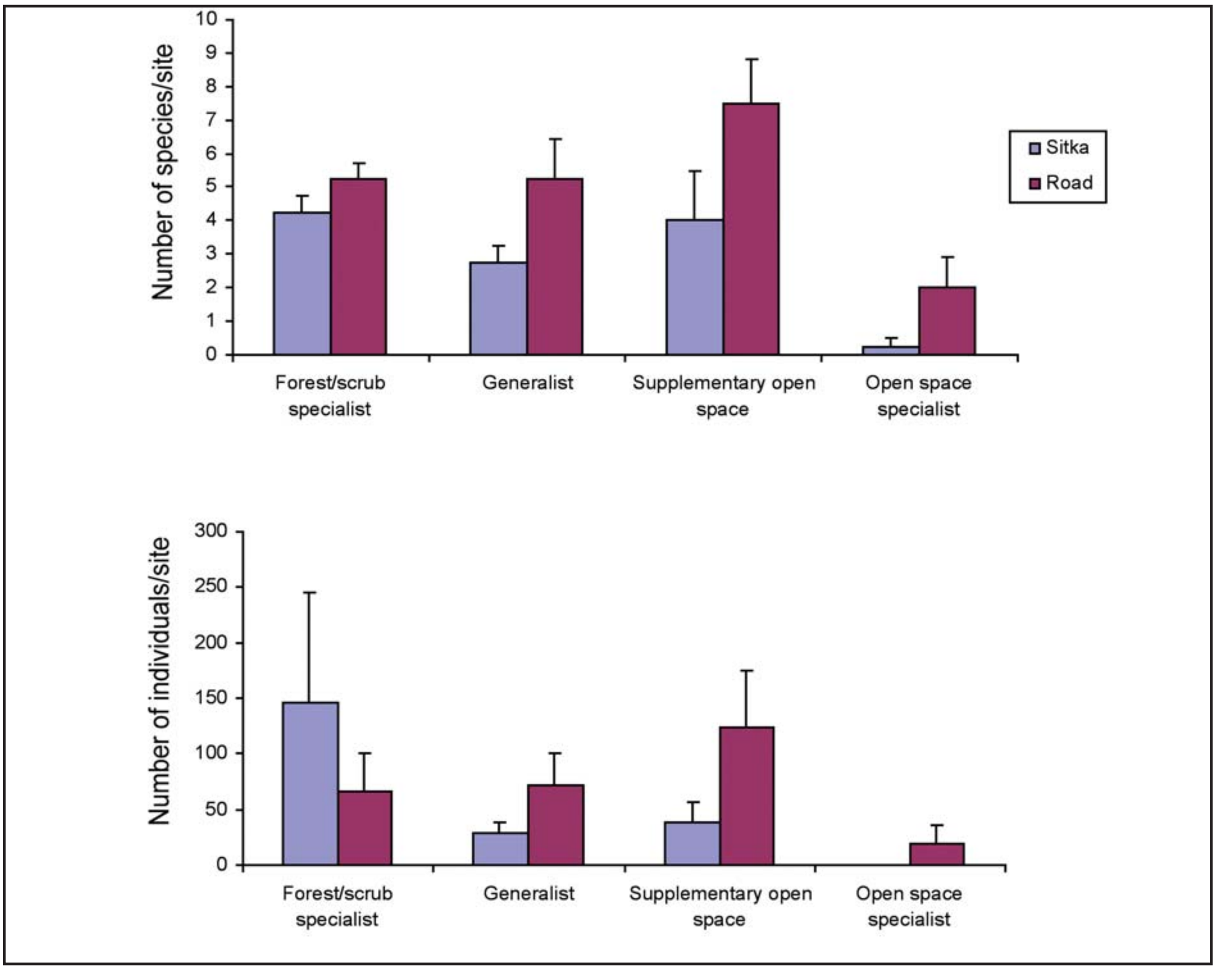

FIGURE 6: Habitat associations of hoverflies in malaise samples from forest roads and Sitka spruce forest interior (bars show SE).

distribution, composition and management of open space within forests is a factor that is acknowledged to be important by the requirement under the Forest Biodiversity Guidelines (Forest Service 2000) for 15% open space and retained habitats in new plantations. It is a factor that is amenable to intervention for biodiversity enhancement, both at the forest planning stage, and through the subsequent treatment of the open space during the forest cycle. Afforestation can affect the species composition of adjacent habitats of biodiversity importance (Cameron 1994). Management of open space, following its incorporation into a forestry plantation, can affect its biodiversity (Humphrey and Patterson 2000). Therefore, research on the biodiversity of open space in plantations would contribute significantly to biodiversity enhancement of plantation forests.

Objectives

The objective of this sub-project is to identify the optimum configuration and management of open space within plantation forests for enhancement of biodiversity.

- Determine the effects of different configurations of open space on biodiversity within forested areas.
- Determine the effects of experimental manipulations regarding open space in forests.
- Make recommendations as to how management practices can positively affect biodiversity in forests.

The project will involve both an extensive and intensive survey, as well as supplementary work on birds of conservation concern.

Extensive Survey

The extensive survey will examine forests with a variety of different configurations of open space. The variables to be examined will include some, or all, of the following:

- Total percentage of open space.
- Composition of open space (rides, retained habitats, firebreaks, etc.).
- Distribution of open space.
- Management of open space.

To allow adequate replication, the survey sites will be restricted to Sitka spruce stands of a limited range of ages. The survey design will be based upon matched clusters of sites. Within each cluster, factors such as geographical location, soil type and altitude, will be as similar as possible and open space configurations will vary. Sites with more than the currently recommended 15% unplanted land will be included where possible.

Vegetation

Environmental conditions, such as light, humidity and wind speed, in open spaces within a forestry plantation and in stand interiors differ considerably. Therefore, terrestrial vegetation will be evaluated using a transect approach, where quadrats will be sampled in given open space, at the forest edge and within the adjoining plantation. In addition, there will be a particular focus on epiphytes for the floral survey, which will be innovative and informative. The ecological distribution of epiphyte species is governed by a complex of gradients, notably: (i) host tree species, (ii) position on host tree, (iii) stage of the forest cycle, (iv) rainfall and humidity regime, (v) air quality. Similar to the terrestrial survey, the epiphyte survey will compare trees in (a) dense stands, (b) open spaces and (c) at intervals on a gradient from forest interior to margins and gaps. All sampled trees will be permanently marked, with a view to downstream monitoring. The effects of large and small gaps will be compared. Epiphyte sampling may be based on the methodology of Johannson (1974), as modified by Cornelissen and ter Steege (1989); viz. a division of the tree into six zones: BT: base of trunk, LT: lower trunk, UT: upper trunk, LC: lower/inner canopy, MC: mid-canopy, UC:

upper/outer canopy. A standardised methodology will be used for recording within each zone. Sampling of upper/outer canopy may be curtailed in the light of time and safety constraints.

Invertebrates

The invertebrate sampling will focus on hoverflies (Syrphidae) and spiders (Aranae), as in the other sub-projects. Malaise traps will be used to sample hoverflies, and the results will be interpreted using the Syrph The Net database (Speight *et al*. 2001) to determine the relative contribution of various types of open space habitat components to the overall syrphid biodiversity. Pitfall traps and vacuum sampling will be used to sample spiders. Plots of pitfall traps will be located in a range of open space microhabitats, and vacuum sampling will be carried out near to each pitfall plot, based upon trial work (pitfall trapping and sweep-net sampling) carried out in 2001.

Birds

We propose to sample bird communities in the open spaces and the closed forest canopy using standard survey methods.

Experimental Manipulations

The experimental manipulations will involve creation of new open space and/or widening of existing open space. The manipulations will be carried out in association with Coillte. Post-manipulation surveys will be carried out using the same methodologies as the extensive surveys. The before/after comparison would be between the biodiversity of the open space in the forest before and after, not between the biodiversity of the area physically manipulated.

Birds of Conservation Concern

The scale of interest for forest management for birds is much larger than it is for plants and invertebrates. Therefore, additional bird survey work will be also carried out which will be focus on bird species of conservation importance which could benefit from large-scale management of plantation forests. This will involve targeted survey work and review of existing data. For example, the hen harrier breeds in young plantations. In the same way the size of clearfells and the subsequent management of restock, e.g. application of herbicide to control the development of ground vegetation may be important for endangered species, e.g. nightjar (Ravenscroft 1989), a red listed species in Ireland (Whilde 1993, Newton *et al*. 1999). Hen harrier and nightjar distribution will be analysed in conjunction with the Coillte and FIPS databases to identify associations with particular forest management practices.

Further information on the project can be obtained on http: http://bioforest.ucc.ie

ACKNOWLEDGEMENTS

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Enhancing biodiversity in UK plantation forests: future perspectives

***Jonathan Humphrey*[11]**

INTRODUCTION

UK forestry has changed considerably over the last 20 years. As the demands of society have evolved, so there has been a shift in the ethos of forestry from a focus purely on timber production, to an embracing of sustainable forest management and the delivery of social and environmental benefits (Rollinson 2003). Biodiversity is a key component of sustainable forest management and through national and international political processes such as the 1985 Amendment to the Wildlife and Countryside Act, the 1992 Convention on Biological Diversity (The Rio Earth Summit), the EU Habitats and Species Directive, and the 1993 Helsinki Agreement, is now firmly enshrined in British forestry policy and practice (Stevenson 2000). In the 1990s, management for biodiversity was driven largely by: statutory requirements (such as protection of Sites of Special Scientific Interest); the implementation of the UK Biodiversity Action plan with its focus on the protection of priority species and habitats (Anon. 1995); and the adoption of the UK Forestry Standard with its associated guidelines (Anon. 1998). A number of measures were put in place including:

- A reduction in the rate of upland afforestation;
- Expansion, restoration, and improvement in the condition of priority native woodland habitats and conservation of the species they support;
- Conservation of genetic resources;
- Restructuring of forests at the landscape scale to reduce visual impact;
- Increasing open space and broadleaved planting both within new woodland and during restocking;
- Removal of dense conifer stands along streams to reduce shading.

Guidance has been produced to help managers implement these measures (Table 1). Much of this guidance remains relevant to management at the current time. Initiatives such as the restoration of native woodland on planted ancient woodland sites, and the establishment of new native woodlands have been, and will continue to form a significant part of sustainable forest management for the foreseeable future (Spencer 2002; Thompson *et al*. 2003). However, the pace of change in commercial forestry has increased considerably in recent years leading to profound changes in the way UK forests as a whole will be managed both for biodiversity and other objectives in the future. A number of key drivers of change can be identified:

1. Devolution of biodiversity and forestry policies and practices from the UK level to individual countries (Scotland, England, Wales and Northern Ireland), leading to the development of separate biodiversity (e.g. Anon. 2003) and forestry strategies (Anon. 1999, Anon. 2000a, Anon. 2002) for each country.
2. Increased emphasis on the social benefits of forestry at the country level especially in relation to improving community involvement in forest design and management and enhancing recreation facilities (O'Brien 2003).
3. A greater focus on management at the landscape scale with increasing recognition that there should be better integration of forestry and agriculture to help rationalise public expenditure, and

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TABLE 1: Examples of recent guidance relating to biodiversity management.

GENERAL THEME	TOPICS	PUBLICATIONS
Needs of special species and habitats	Genetic conservation	Conservation of genetic resource (Ennos *et al*. 2000)
		Use of local origins (Herbert *et al*. 1999)
	Special habitats	Restoration of native woodland on planted ancient woodland sites (Thompson *et al*. 2003)
		Peatland restoration (Patterson and Anderson 2000)
	Special species	Red squirrel (Pepper and Patterson 1998)
		Forest birds (Currie and Elliot 1997)
		Raptors (McGrady *et al*. 1997; Petty 1998)
Habitat management and enhancement	Tree species diversity	Inclusion of broadleaves (Humphrey *et al*. 1998)
	Impacts of herbivores	Grazing (Mayle 1999; Gill 2000)
	Encouragement of structural diversity	Deadwood (Humphrey *et al*. 2002a); Silvicultural systems (Kerr 1999); edge management (Ferris and Carter 2000)
General	All aspects of biodiversity	Forest Nature Conservation Guidelines (Forestry Commission 1990)
	Forests and water	Forests and Water Guidelines (Forestry Commission 2000)

produce diverse landscapes of greater value to wildlife (Anon. 2002a).

4. Raised awareness of the value of plantations of introduced conifer species as habitats for native flora and fauna including some endangered species (Humphrey *et al*. 2002b, Forestry Commission 2003), and the need for improved integration with native woodland (Mason *et al*. 1999) and other habitats at the landscape scale (e.g. through Forest Habitat Networks, Peterken 2003).

5. The development of certification schemes for sustainable forest management. The UK woodland Assurance Scheme (UKWAS - Anon. 2000b) sets out detailed guidance and requirements for managers seeking to meet the desired management standards, including a number of challenging criteria for biodiversity protection and enhancement.

6. Continuing low economic return from timber production (Forestry Commission 2002). External economic factors have pushed down timber prices (Figure 1) such that in some parts of the UK the cost of felling and restocking operations is not being met by timber revenues, with many owners and managers seeking radical alternatives to traditional production forestry based on Sitka spruce.

Quine *et al*. (2003) reviewed the value of conifer plantations in the UK for biodiversity and concluded in broad terms, that highest species-richness and diversity occurred either in the early successional stages of the forests cycle (for 10-20 years after planting) or in stands retained beyond economic maturity (over 40-60 years in the case of Sitka and Norway spruce). These findings supported earlier proposals by Peterken *et al*. (1992) that biodiversity was best maximised in production forests by adopting a strategy of increasing the amount of early and late successional habitat at the expense of mid-rotation habitat.

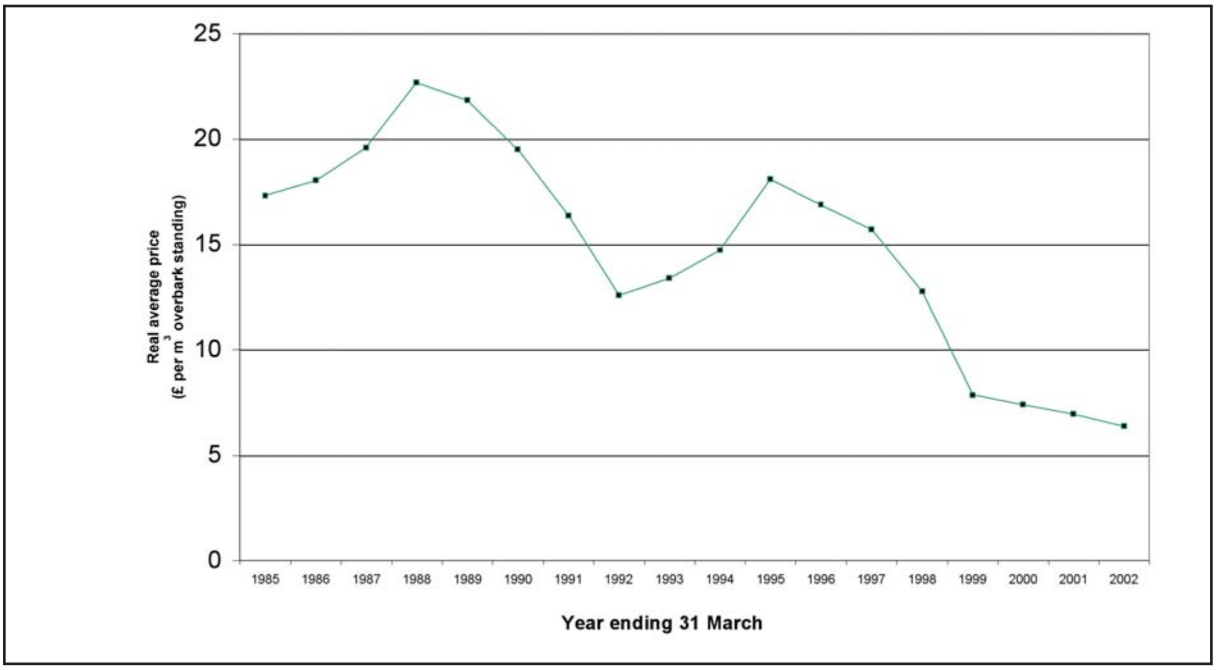


FIGURE 1: Coniferous standing sales price index in Great Britain (data from Forestry Commission 2002). The real average price is converted to a 'constant price' (using 1996 prices) to remove the effects of inflation.

Early successional forest stands provide niches for open ground and scrub species of particular conservation importance in upland Britain (Humphrey *et al*. 2002c, Fuller 2003). Linked to this is the need to maintain a fine grain mosaic of both permanent and transient open space within young forests connected to external open space thereby enhancing movement of organisms around the forest (Quine *et al*. 2003). Quine *et al*. (2003) also suggest a number of other measures to enhance open ground and early successional communities such as: ensuring that regeneration (planted or natural) is widely spaced; thinning and keeping rotations short to enhance survival of non-forest organisms and the soil seed bank etc.; and maximising the occurrence of edges. Substantial areas of spruce forests in the north and west of the UK are becoming increasingly unproductive economically and the conversion of conifer stands to open, mixed conifer broadleaved stands is being considered, together with deforestation and the creation of varied edge habitat.

Whilst the development of open ground and early successional habitat within forests is an important issue, the aim of this paper is to consider the benefits to biodiversity of retaining conifer stands beyond normal economic felling age, together with advising on the best location for these stands and how to manage them. The focus is primarily on commercial upland spruce plantations and the role that mature woodland conditions might play within these forests in providing habitats for native flora and fauna.

WHY FOCUS ON CREATING MATURE WOODLAND CONDITIONS IN UPLAND FORESTS?

UKWAS requires owners and managers to protect and enhance key plantation habitats and features, such as old stands and deadwood, and maintain populations of threatened conifer-dwelling species that use plantations (e.g. red squirrel and capercaillie). Increasingly, these requirements are being addressed through the mixed bag of 'continuous cover' forestry measures (Mason *et al*. 1999). The political pressure to increase the amount of plantation area managed under continuous cover silviculture is gathering strength. The Welsh forestry strategy (Anon. 2002) states that in 20 years time, 50% of state forest areas should be managed as continuous cover, using alternatives to clear-felling such as group selection, shelterwood and selection systems [see Mathews (1992) for definitions of these systems].

Recent research (Humphrey *et al*. 2002b) has emphasised the importance of creating mature woodland conditions in plantations for some aspects of biodiversity. The term mature woodland includes areas of continuous cover where stands are retained beyond 'normal clear fell' economic maturity and stands where management intervention is minimal. This latter group are termed 'natural reserves' within UKWAS and are intended to provide 'old-growth' conditions (sensu Oliver and Larson 1996) comprising large veteran trees and deadwood habitats. The UKWAS standard requires that owners and managers set aside at least 1% of the plantation forest area as old-growth natural reserves.

DEFINITION OF 'OLD GROWTH' STANDS AND THEIR OCCURRENCE IN THE UK

Stands of ancient trees associated with wood pasture, parkland and undisturbed ancient represent the last fragments of primary old growth forests in Britain (Peterken 1996). Although these forests have all been modified by man to some degree, significant examples of old growth occur in places such as the ancient broadleaved forests of the New Forest and Windsor Great Park in England, and in the Caledonian Scots pinewoods in the Scottish Highlands (e.g. Glen Affric). However, the term old-growth can also apply to non-ancient woodland which has developed the requisite structural characteristics. A definition of old growth as it might apply to UK spruce forests is shown in Box 1. This definition of old-growth is based on current understanding of the term in Scandinavia and the Pacific Northwest (Franklin *et al*. 2002) where semi-natural stands of Norway spruce and Sitka spruce (respectively) offer clues as to the possible development of such stands in the UK. There are considerable areas of spruce and fir plantations in the UK that are over 150 years old (termed 'Long-established plantations') but few where the trees are actually of that age or more. Many of these stands have been managed on a low intensity basis for centuries, so whilst mature woodland conditions have been retained, large old trees have generally been removed. In contrast, some currently unmanaged 60-80 year-old spruce and fir stands are beginning to develop old growth characteristics such as structural variety and deadwood. These stands are often on very productive sites where growth is rapid, and Sitka spruce in particular can obtain heights of 30 m or more and diameters in excess of 1 m in less that 80 years (Figure 2). These stands are also often affected by windthrow which can create considerable volumes of standing and fallen deadwood (Humphrey *et al*. 2003a).

A database of notable planted conifer stands over 60 years old has been complied. Currently over 220 stands have been identified (Figure 3) and these provide a resource for further study.

Box 1: Definition of 'old-growth' stands as applied to spruce forests in the United Kingdom.

Areas of forest >150 years old with:
- a significant proportion of trees > 80-100 cm diameter
- a mix of trees of different ages and sizes including native broadleaves
- variability in vertical and horizontal structure
- occurrence of a shrub layer
- large volumes of standing and fallen deadwood
- veteran trees, and trees with deep crowns
- continuity of habitat conditions over a long time period

Figure 2. Eighty year old Sitka spruce stand developing old growth features (deadwood, vertical structure, large girth trees). (L. Poulsom)

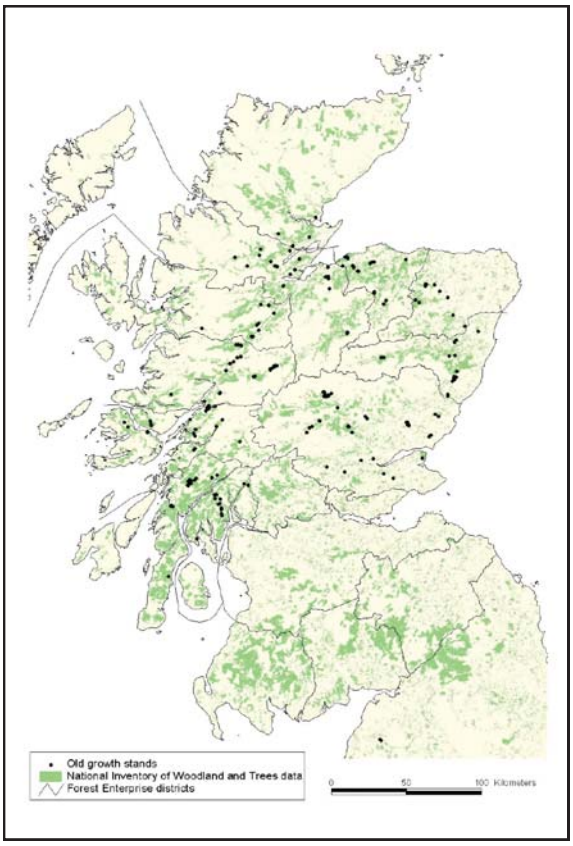


Figure 3. Map showing location of old growth conifer stands in plantations

VALUE OF OLD-GROWTH SPRUCE STANDS FOR BIODIVERSITY

Survey work reported by Humphrey *et al*. (2003b), suggests that mature conifer stands can provide important habitat for species normally associated with native woodland. Twenty-nine Red Databook species were recorded in upland Sitka spruce stands, a considerable number of these being fungal species normally associated with native pinewood. Mature stands had a higher proportion of 'woodland specialist' species than the younger stand stages. These specialist species included bryophytes, woodland herbs, and carabid beetles. One of they features of these mature spruce stands is the occurrence of decaying wood habitats (Figure 4). In comparison to the younger stand stages, the over mature stands had much higher deadwood volumes, comprising standing deadwood (snags), stumps and fallen deadwood (logs).

Deadwood in these stands supported diverse populations of wood saprotroph fungi, lichens and bryophytes.

Bryophyte species-richness was positively related to increasing diameter of logs and to decay class (Figure 5), with classes 4 and 5 having significantly higher species numbers than classes 1, 2 and 3. Other species also benefit from the retention of old conifer stands such as red squirrels (Lurz *et al*. 2003) and uncommon woodland birds such as redstart or pied flycatcher (Currie and Elliot 1997).

LOCATION AND SIZE OF OLD GROWTH RESERVES

The current distribution of old conifer stands has to an extent been influenced by management, often unplanned. Stands have survived near recreation facilitates to provide amenity benefits, or on sites with poor access where extraction would not have been cost effective. However, one of the major abiotic factors affecting the current distribution of old stands is windiness. In UK forestry, a system

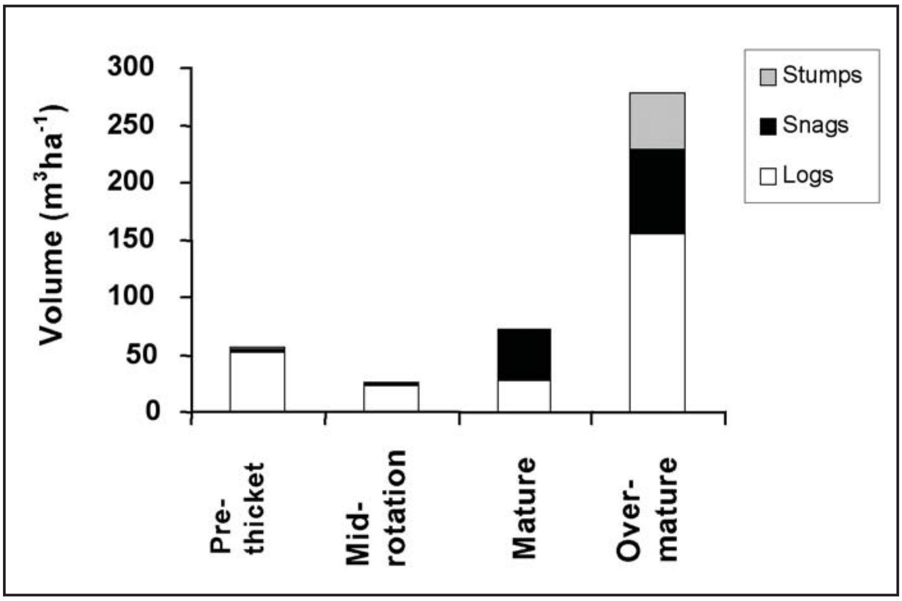
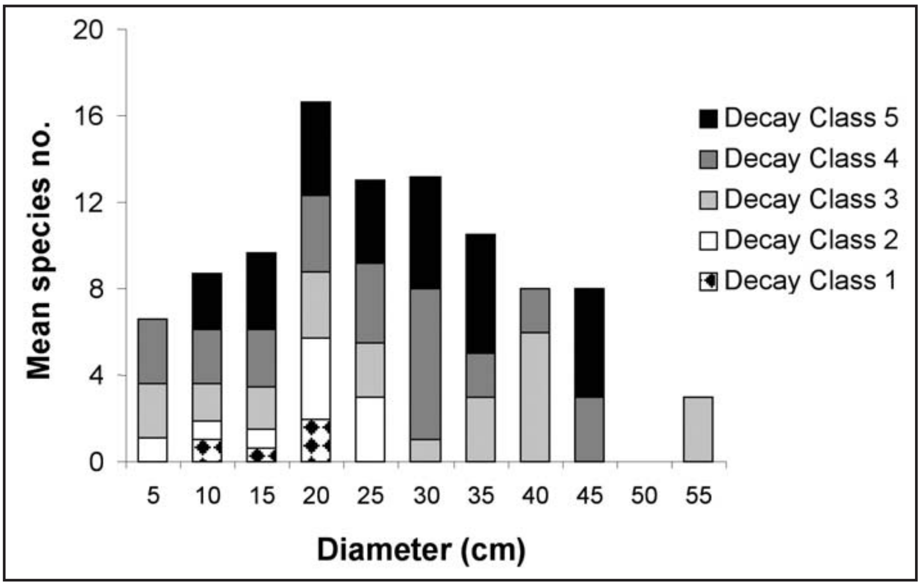


Figure 4 Volumes of deadwood in different stages of upland spruce stands. Pre-thicket stands were 8-10 years in age; mid-rotation 20-30 years, mature 40-50 years, and over-mature 60-80 years. From Humphrey *et al*. (2003a).

Figure 5. Mean number of bryophyte species recorded on different sizes and decay stages of logs. Decay stages are 1-intact to 5-fully decomposed. From Humphrey *et al*. (2003c).



called DAMS (Detailed Aspect Method of Scoring - Quine and White 1993) is used to measure windiness and risk of windthrow. DAMS values are available for the whole of the UK at 50 m resolution and analysis of the current distribution of old stands held within the database (Figure 3) revealed that the majority occurred on sites with DAMS values of 16 or less. This suggests that above DAMS 16 there is a higher probability of catastrophic windthrow occurring at a periodicity of less than 80 years, and hence the scope for developing stands with old and large trees may be less than in more sheltered locations.

Even if old-growth development was restricted to localities with DAMS scores of 16 or less, the potential area available is large as the map of northern Britain illustrates (Figure 6). Of course there are other restrictions on the development of old-growth which were not included in the preparation of the map (e.g. occurrence of urban areas, open water etc.) and a strategic approach to locating old-growth needs to be developed at the regional and landscape scales. Part of this strategic approach would take into account the degree of connectivity between the intended old-growth stand and other ancient and long-established woodland. Humphrey *et al*. (in press) found that bryophyte species-richness in planted stands was positively correlated with the amount of semi-natural woodland within 1 km, with species such as woodland vascular plants,

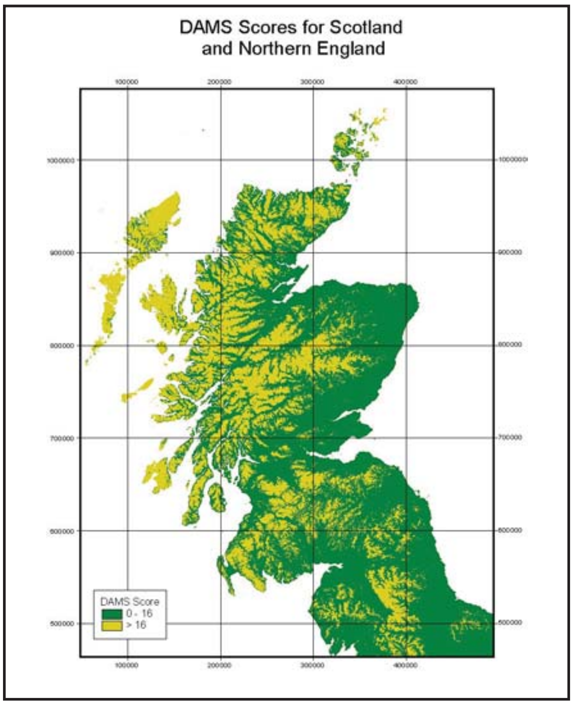


Figure 6. Classification of northern Britain according to DAMS. Areas with DAMS score of 16 or less (green) are suitable for development of old-growth reserves

beetles and mycorrhizal fungi showing similar relationships with other measures of connectivity. The implications of these findings are that old-growth natural reserves would be best placed in already well-wooded landscapes with plenty of linkages, such as hedgerows and riparian zones, between areas of woodland (Peterken 2003).

However, stands of old trees are likely to be retained for other reasons as well as biodiversity enhancement. Groves of large trees have aesthetic value and provide excellent recreational facilities. Increasingly there is an emphasis on retaining permanency of forest structure in areas with high visual sensitivity, such as within popular view sheds and in landscapes with high aesthetic value. Within state forestry in Scotland, England and Wales there is a drive to create large (200+ ha) areas of continuous cover in low wind risk zones. These areas could provide scope for developing mosaics of non-intervention old-growth and stands managed by low impact silviculture; the low impact stands acting as 'buffer' for the old growth stands in terms of maintaining a constant microenvironment.

In contrast there will also be some scope for retaining smaller patches of old-growth reserves in higher wind risk areas where clear-felling regimes are maintained. In Scandinavia this approach to management is termed the 'green tree retention system' (Vanha-Majammaa and Jalonon 2001) and in North America the 'variable retention system' (Franklin *et al*. 2002). Various recommendations have been made as to the size and distribution of retained patches/clumps of trees on clear-fells. On average, it is suggested that between 15-40% of the area could be retained, with patches in the range of 0.25-2 ha.

Taking both continuous cover areas and retentions on clear-fells together, one approach might be to aim for a 'reverse J' size-class distribution of old-growth patches across the forest landscape as a whole. There would therefore be a few large (50 ha+) reserves for species requiring interior forest conditions and a large number of small patches, providing 'habitat stepping stone' type linkages between the larger patches. This type of approach would mimic the landscape patterns generated by natural disturbance in large forest landscapes (Wimberly 2002), and allow substantial parts of the landscape to remain free for other forest management operations. A stylised example of this type of landscape structure is shown in Figure 7, in this case with a focus on creating and connecting deadwood habitats within the landscape

MANAGEMENT OF OLD-GROWTH RESERVES

The simplest approach to managing old-growth is simply to allow natural processes to generate variability in stand structure and promote higher volumes of dead and dying trees. Evidence from near-natural Sitka spruce-western hemlock stands in South-east Alaska (Ott and Juday 2002) and from Norway spruce-dominated stands in western Scandinavia (Ohlson and Tryterud 1999) suggest that both species of

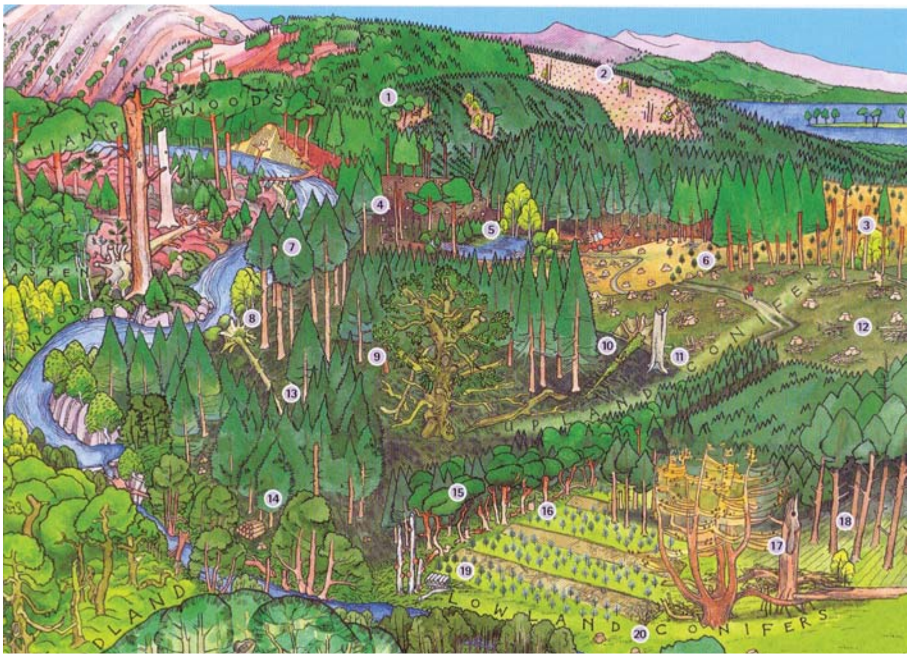


Figure 7. Stylised view of a forest landscape showing distribution of different deadwood habitats (numbered 1-20). Reproduced from Humphrey *et al*. (2002a).

spruce can self-perpetuate in stands subjected to small-scale ‘gap-phase’ disturbance. These stands typically have naturally created gaps (usually by wind) of < 50 to 1000 m^2 with and average of 5-12% of the forest area in ‘gap’’ at anyone time. Typically the size class distribution of trees within these stands in ‘reverse-J’ in shape with a few large dimension trees and many smaller ones. Dead and dying trees make up about 10-20% of total stand volume.

Work in British upland spruce stands suggests that the ecological behaviour of Sitka spruce in this country is similar to that in south-east Alaska, with a minimum gap size of 150-200 m^2 needed to establish natural regeneration in stands of 30-40 m in height (Quine 2001). However, Nixon and Worrell (1999) suggest that gaps of 4000 m^2 (equating to about 50% full sunlight) or more may be necessary to allow development of good timber trees. The general consensus is that Norway spruce is more shade tolerant than Sitka and will grow successfully in 30% full light (equating to gap sizes of 400-1000 m^2 in a 40-year-old stand). Given the climatic characteristics of north-western Britain, with its windy, oceanic conditions (Quine *et al*. 1999) it seems safe to assume that both Sitka and Norway spruce are capable of self-perpetuation in upland conifer plantations given protection of regeneration from excessive browsing (Nixon and Worrell 1999).

There is also no reason why some old-growth reserves could not be subject to low intensity management. Evidence from Alaska (Deal and Tappeiner 2002) and from Norway (Storaunet *et al*. 2000) suggests that selective logging in spruce stands is not detrimental to the maintenance of old-growth structures and associated species provided that the stand is given time to ‘’recover’ between interventions. An average time between interventions might be around 80 years. It is likely that these stands will become progressively more naturalised in terms of composition as native broadleaves trees and shrubs colonise (Thompson *et al*. 2003; Humphrey *et al*. 1998). However, there is also a risk that shade tolerant species such as western hemlock may invade, creating much more shaded conditions and loss of understorey diversity. Conversely the creation of large gaps (> 0.25 ha) may exacerbate weed problems, if too much light is let into the stand (Thompson *et al*. 2003). As with all new ventures, a period of trial and error (i.e. adaptive management) will be needed to seek the best approach to management.

Finally, if it is intended to manage these reserves in some way on a non-clearfell system, it may be necessary to identify potential stands at an early stage of development, so that preparatory management can be undertaken (Mason and Kerr 2001). For example, variable densities of thinning could be used to transform regularly structured stands into stands with an irregular structure, allowing large trees with deep crowns to develop to provide adequate seed for future regeneration.

CONCLUSIONS

Over the past century, the UK has pursued an active policy of forest restoration. Although the rationale for reforestation has evolved considerably over the last few decades, and will continue to do so in line with the changing demands of society, the fact remains that the vast majority of the wooded area in the UK comprises relatively young forests of non-native conifer species. Despite considerable effort to restore and expand native woodland fragments (Humphrey *et al*. 2003d) substantial gains for biodiversity at the country level will only be made if planted forests are included as potential new habitat (Humphrey *et al*. 2002b). We should be in no doubt that the public wish managers to pursue this course of action. The vast majority of people cite wildlife conservation as the principal reason for continuing with public support for forestry in the UK (Forestry Commission 2003). The creation of old-growth reserves in conifer plantations appears to be one of many promising strategies for improving biodiversity value. However, these old stands are still very young in biological terms and research into management techniques is still in its infancy. Considerable monitoring work, linked to stand modelling will be needed to validate biodiversity gains over the longer time period.

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Key habitat designation in plantation forests: a Scandinavian tool for biodiversity conservation

***Flemming Rune*[14]**

INTRODUCTION

The woodland key habitat (WKH) concept emerged in Sweden during the early 1990s. Inspired by Landres *et al*. (1988) and Noss *et al.* (1990), the national Swedish Forest Agency (Skogsstyrelsen) initiated a project on the development of inventory methods for WKH designation in 1990, introducing the Scandinavian term 'nyckelbiotop' (key habitat) for small biotopes valuable to the biological diversity of woodlands (Nitare and Norén 1992). During the period 1993-1998 a full-scale national inventory of WKHs was completed in Sweden at a cost of € 10 million (Norén *et al*. 1999). The experiences from this inventory have formed the basis for development of national inventory models in all other Scandinavian and Baltic countries.

Parallel with this process, DeMaynadier and Hunter (1997) introduced the concept of keystone ecosystems to cover biotopes with greater importance to the biological structure and function than average for the landscape and to sustain natural ecological processes and scarce resources. The first steps towards locating such 'hot spots' were probably made in Great Britain by Peterken (1974) and Rose (1976), using the occurence of certain vascular plants and lichens to identify forest biotopes with a long history of moderate cuttings and especially continuous forest cover. The importance of these habitats was presented to both forest owners and the general public through large information campaigns in the three Scandinavian countries, under the name 'Rikare Skog' (richer forests) in 1990-1995 (Skogsstyrelsen 1990 (Sweden), Anonymous 1991 (Norway), Hübertz and Kristiansen 1995 (Denmark)).

The WKH designation process is an extension of those efforts – an attempt to elaborate more distinct inventory methods to locate these areas in modern plantation forestry, and to prescribe sufficient management modifications to protect them. In all three Scandinavian countries active NGOs have contributed significantly to the process, creating a trilateral co-operation between government agencies, research institutions and the NGOs themselves. This paper presents an overview of the WKH process.

THE WKH CONCEPT – DEFINITIONS AND LIMITATIONS

The main philosophy behind the WKH concept is that structures and (rare) species of special importance to the forest ecosystem are not evenly distributed, and that areas with high concentrations of these features can be located through an inventory. In plantations established on old forest ground this is undoubtedly true in many cases, but there are certain limitations to the general rule. Gjerde (2002) demonstrated that 20-25% of all red-listed species were found on just 5% of the total forest area in Norwegian old-growth forest, and that this 5% of the area contained 4-5 times more red-listed species than the surroundings. However, the historical forest management and silvicultural practices in the landscape determine to a large extent the patchiness of potential WKHs, and the selection of indicators to support their designation is encompassed by numerous methodical problems (e.g. Lindenmayer *et al.* 2002, Sætersdal 2002).

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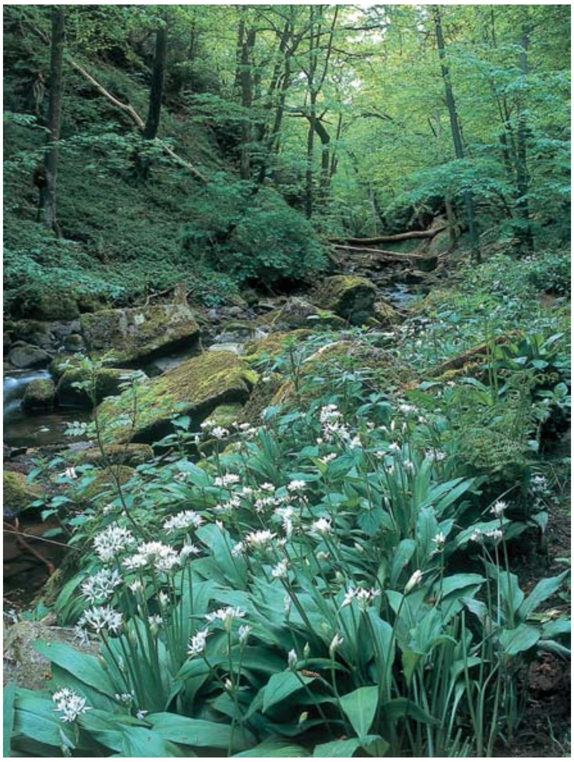
The Swedish WKH concept relies on the presence of red-listed species, i.e. threatened, vulnerable, rare or care-demanding species. In 1993 the Swedish Forest Agency defined the WKH concept as: ‘a quality concept determining forest areas where red-listed species occur or are expected to occur’. Throughout the Swedish inventory this defininition was sustained, even though the main focus in the inventory in practice was put on various structural indicators.

Species are included in the red-list by a group of specialists, based on empirical knowledge of the occurence of each species. The red-listed status is not permanent, but is generally reappraised every 5-10 years, when the red-lists are revised. This may cause a problem in time. An efficient protection of key habitats may change the red-listed status of species, which were the very justification for the designation of many key habitats.

Perhaps that paradox led other countries to elaborate different defintions of key habitats, not focusing distinctly on rare species, but rather on structures, processes and patterns expected to be favourable to sustain biodiversity. The Norwegian Association of Foresters (Norskog) suggested a definition of key habitats based more on the ecosystem than on individual species: ‘biotopes with special nature conditions or with special communities of great importance to species diversity. The concept is linked to the function of the biotope/locality as an element in a large woodland system’ (Aasaaren and Sverdrup-Thygeson 1994). The ‘keystone ecosystem approach’ of DeMaynadier and Hunter (1997) was somehow forestalled by this definition.

In Denmark, the Forest and Nature Agency, under the Ministry of Environment and Energy, decided to use a management-oriented definition of key habitats, probably due to the intensive silviculture applied to almost any part of the Danish forest area: ‘areas important to biodiversity conservation, because they contain or could expectedly contain habitats, structures or species which have difficulties in surviving conventional forestry and thus require special management prescriptions’ (Rune 2000). The aim of key habitat designation in Denmark is explicitly stated as ‘to elaborate a tool that the forest owner himself can benefit from’ in sustainable and multiple-use forest management. The Swedish, Norwegian and Danish definitions represent the range of key habitat concepts, and Finland and the three Baltic countries have used definitions that are mere composites of these.

The WKH definitions – no matter if they focus on species, ecosystems or management prescriptions – are not accurate and incontrovertible. In Denmark, the Forest and Nature Agency has tried to establish a practice where at least three certain categories of important structures should be present in a key habitat, but in any case the decision to designate a key habitat must rely on local or regional biological experience. This opens up the possibility of designating any percentage of the forest area as key habitat, but in practice between 1% and 3.5% of the total forest area



▲ A gurgling watercourse through a patch of semi-natural forest is an obvious woodland key habitat. The stream is fringed by mosses, rare ferns and groups of ramson (*Allium ursinum*).

Photo: F. Rune, Döndalen (Bornholm), Denmark.

Large diameter dead wood of indigeneous tree species left for natural decay is a rare sight in the managed forests of Western Europe. It is considered an important key element for woodland key habitat designation by all Nordic and Baltic countries.

Photo: F. Rune, Strödam (Hilleröd), Denmark.

has been designated in the Scandinavian inventories. When the methodology is elaborated and tested in each country or region, it is quite easy to agree on a general way of using it, leaving room for specific biological arguments at any forest site in question.

WKH DESIGNATION METHODOLOGY

The WKH designation methodology is very uniform in the seven countries that have carried out WKH inventories so far. The basic methodology is based on the Swedish WKH designation model, and it is nationally adapted only as regards selected important structures and species. The method is designed for use in a managed and fragmented forest landscape. In large areas of natural forests, specific survey methods have had to be designed, and in newly afforested areas on agricultural land it may take several decades before key habitats develop – or the development of potential key habitats may be planned from the very start of the afforestation.

The WKH surveyors have usually received an education in forestry or biology, and, especially in Denmark, participation by the local forest administration is encouraged. All surveyors, irrespective of their education and background, receive special training in conservation biology, in the recognition of special valuable habitats, and in the knowledge of indicator species. In Sweden more than 150 surveyors were trained in the years 1993-1998 and went through repeated ‘calibration courses’ to ensure maximum consistency in their field work and designation practice (Norén *et al*. 1999). Some degree of subjectivity is unavoidable, but as far as the WKH designation is not linked directly to any legal limitations in future forest management, the incongruity has been acceptable.

The total inventory of WKHs falls into three phases: 1) preparatory work, 2) field survey, and 3) data processing.

The preparatory work consists of collecting and compiling information from a large variety of sources, written or verbal. Depending on the age of forest management in the area, written sources should include: old and new forest management plans, forest maps, historical maps, soil maps, aerial photographs, and botanical or zoological surveys or records of any kind. The primary verbal sources are: forest owners, employees, neighbours, frequent forest guests, and knowledgeable NGOs. All the information is recorded, and potential WKHs are marked on detailed working maps to be used during the field survey. In the Danish WKH designation model the field work focuses almost exclusively on these ‘nominated’ areas, due to the very detailed knowledge about many forest areas, with several generations of forest management plans and matching maps at scale 1:10,000 of all stands and surrounding topography.

The field survey has several objectives: 1) to verify the information collected during the preparatory phase, 2) to carry out an extensive survey of the rest of the forest, 3) to designate, delimit and describe WKHs, and 4) to consider all necessary management prescriptions in order to conserve the special values of the WKHs. As a general rule, all locations found in the preparatory phase must be visited, and normally the route through the forest is planned to ensure the most efficient survey of the forest between these locations. An inventory form is completed for all locations and they are categorised as WKHs or not in the field. In some countries, e.g. Sweden, a category of less important habitats is used, 'objects with certain nature values'.

The most important tools in the field survey are designated structures expected to be of importance for biodiversity, key elements, and selected indicator species, signal species, indicating that certain favourable ecological conditions exist, or – as in Sweden – indicating that red-listed species are present or could be present. Normally 50-70 key elements are designated in the field work manuals, e.g. within the categories very large trees, old or dying trees, dead wood, rare stands, hedges with shrubs and trees with berries, breeding localities, special terrain structures, water, etc. There are large overlaps in key elements between the seven countries involved.

Signal species include vascular plants, mosses, lichens as well as fungi. In Sweden close to 300 species have been selected as signal species in one or another part of the country. About 75% of these species are not vascular plants. There are large differences in signal species between different regions of Sweden (covering almost 14 degrees latitude), and even more between the involved countries. In Denmark only about 70 signal species (or groups or species) are included in the field work manual due to the much smaller size of the country (covering not much more than 3 degrees latitude). Only a few of the signal species are red-listed. Due to their scattered occurence they seem to be of limited use in pointing out biologically diverse areas. All signal species are fairly common and some are found in multitude when the conditions are right.

The signal species were not selected in any scientific way, but only from the experience of a forum of field specialists. Generally, the signal species indicate rare ecological conditions, e.g. in Denmark with its intensive silviculture: tree species continuity on the same area, undrained wetland areas, undisturbed forst soil etc.

The lack of scientific consistency in the selection of signal species may seem controversial, but recent attempts at numerical selection of such indicators (old-growth species), even when based on a very large number of test plots in various forest types, were not satisfactory (e.g. Lawesson *et al.* 1998). Statistically selected indicator species seem to be of limited geographical use (Lindenmayer *et al*. 2002, Sætersdal 2002).

The third and final phase of the total WKH inventory is the processing of field data. The information is evaluated and the data are made available to the forest managers and are, as much as possible, integrated in digital maps, management plans and working schedules. All information should be ready for use in the daily management operations and when management plans and monitoring programmes are being prepared or revised.

NATIONAL IMPLEMENTATION AND FUNDING IN THE NORDIC AND BALTIC COUNTRIES

The following status of the Nordic and Baltic implementation of WKH inventories is summarised from a four-day conference in Bialowieza Forest, Poland, October 2002:

Sweden: A WKH pilot project was initiated in 1990, and during the years 1993-1998 a state financed full-scale inventory of private forests

<5,000 ha was completed, in total covering 11.7 million ha at a cost of about €10 million. Continued inventories are being carried out from 2001 to 2003, at a cost of additional €3.2 million. Forests greater than 5,000 ha were surveyed at the expence of the forest owner on a voluntary basis. A general interest in certification has been the driving force, prompting most forest owners to carry out their WKH inventory before 2000. Financial compensation to forest owners for management restictions has only been paid for non-intervention WKHs, in total 2,600 areas (7,500 ha). Now, about 141,000 ha of WKHs (46,000 sites) have been designated, covering 1.2% of the total forest area. Preliminary results show that the total number of WKHs in Sweden may exceed 60,000. Only a few percent of the forest area remain to be surveyed.

Finland: A full-scale WKH inventory was initiated in the state forests in 1995, covering 6.4 million ha at a cost of €23 million. About 168,000 ha of 'valuable habitats' were designated. The key habitat terminology in Finland is not quite comparable to the rest of Scandinavia, but reflects nevertheless the same principles. In 1996-1997 a WKH pilot project was completed for the private forests, covering 1.1 million ha, and this was followed by a full-scale inventory of 10 million ha, at a cost of €13.4 million. Another 5 million ha were extensively surveyed through the forest management planning. Until 2003, 38,000 ha of 'habitats of special importance' and 41,000 ha of 'other valuable habitats' (60,000 sites) have been designated. The practical WKH inventory in the private forests was financed by the Ministry of Agriculture and Forestry, and it was supervised by the Finnish Forestry Development Centre, Tapio. Almost all forest areas in Finland will have been surveyed by the end of 2003.

Norway: Of the total forest area in Norway, only about 50% is used for production. A nation-wide research project, *Environmental monitoring in forests*, was carried out by the Norwegian Institute of Forest Research during the period 1997-2001 at a cost of close to €3 million, providing important information on the potential of WKH designation in Norway. A full-scale WKH inventory was initiated in 2001, and about 1 million ha were surveyed during the first year. The state finances about 60% of the inventory costs, and pays full compensation to private forest owners for non-intervention WKHs in production forests.

Denmark: A WKH pilot project was initiated in 1998 on 2,135 ha of private or other non-state owned forest. In early 2000 a state subsidy scheme was introduced for private forest owners, but during the following three years only 4,820 ha forests were surveyed voluntarily under the subsidy scheme, or about 1.5% of the total private forest area. The state covers 50-100% of the inventory expenses, and runs a parallel compensation scheme for non-intervention areas in production forests. In the state forests (29% of the total forest area) no WKH inventories have been initiated yet, but a number of habitats (e.g. all wetlands irrespective or their size) are statutory protected.

Latvia: A WKH pilot project was initiated in 1998 and was immediately followed by a full-scale inventory of all state forests (1.43 million ha) during the period 1999-2002. More than 120 surveyors were trained under Swedish supervision, and 18,681 WKHs were designated, covering 34,367 ha or 2.4% of the total state owned forest area. No subsidy schemes for inventories or financial compensation for non-intervention WKHs in private forests were introduced, and consequently WKHs have only been designated in state forests so far.

Estonia: A WKH pilot project was initiated in 1999, covering 167,511 ha, and it was followed by a full-scale inventory of the remaining almost 2 million ha during the period 2000-2003. Twenty-two surveyors were trained under Swedish supervision, and until 2001 15,330 ha of WKHs were designated, or close to 2% of the surveyed area. All inventories are fully paid by the state, and there is full compensation to private forest owners for non-intervention WKHs. By the end of 2001, 105 contracts of non-intervention WKHs were signed between the state and private forest owners.

Lithuania: A WKH pilot project was completed in 2001-2002, covering 237,000 ha, and followed by a full-scale inventory in the period 2002-2005. Twenty-five surveyors were trained under Swedish supervision. In the pilot project 6,346 ha of WKHs and potential WKHs were designated, corresponding to about 3.5% of the surveyed forest area. The average size of WKHs and potential WKHs in the pilot project was 3.48 ha. There will be full compensation to private forest owners for non-intervention WKHs, but at the end of 2002 no contracts of protection had been signed.

MANAGEMENT CONSEQUENCES AND CONCLUSION

Many resources have been allocated to WKH designation in the Nordic and Baltic countries since 1990, with Sweden and Finland in the lead. Consequently these two countries are advanced with certification of forests products, representing more than 70% (almost 50 million ha) of the total forest area in the Nordic and Baltic region. The Baltic countries have initiated and partly completed their full-scale WKH inventories under Swedish supervision, while Norway and Denmark have still only surveyed less than 10% of their forest areas for WKHs.

WKH designation seems to be a rational and practical tool for forest management to support biodiversity protection in plantation forestry, despite all local and national inconsistencies and lack of scientific basis for the selection of indicator species. Generally, the inventories only cover a fraction of the total forest area, and large nature values will inevitable be missed during the survey. A forest may contain a wide variety of natural values which will not be registered if their habitats do not qualify as key habitats. Biological corridors, often not WKHs, may be crucial for the dispersal and long-term survival of many species in the forest, and the patchiness of nature values is completely disregarded in the WKH designation process. The use of indicators in the WKH surveys is not scientifically based, and a certain amount of subjectivity from each field worker is tolerated.

Nevertheless, it is believed that the 1-3.5 % of the forest area designated as WKHs with this methodology accommodates a large number of organisms that cannot survive conventional forestry. The WKH designation process gives the forest manager an option of practising active biodiversity conservation with management restrictions on only a small fraction of the total forest area.

A large element of volunteering is incorporated in the WKH philosophy. Basically, designation of WKHs does not imply non-intervention. In Sweden only about 5% of the total WKH area were appointed non-intervention areas with full economic compensation from the state. Most often the silvicultural system is continued even in the WKHs, possibly modified or restricted to a certain degree, and always ultimately decided and put into practice by the forest owner himself.

In the years to come, WKH designation may by introduced to countries other than Scandinavia and the Baltic States, and gradually become a natural part of modern forest management there. The WKH philosophy, however, requires support from several stakeholders to be implemented successfully in a country, including first of all the forest authorities and the forest owners themselves.

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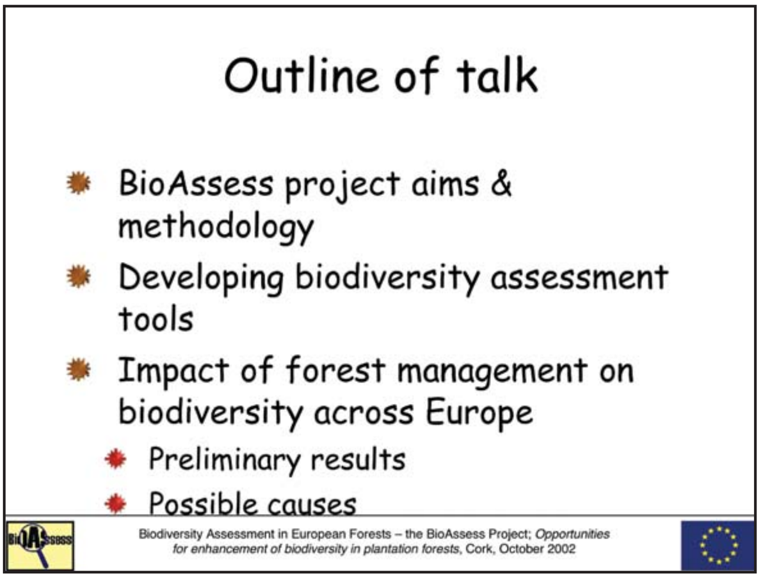
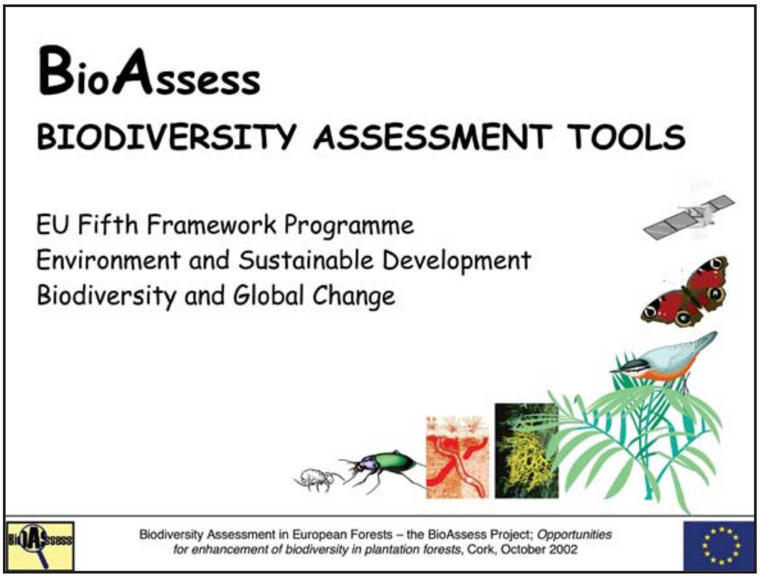
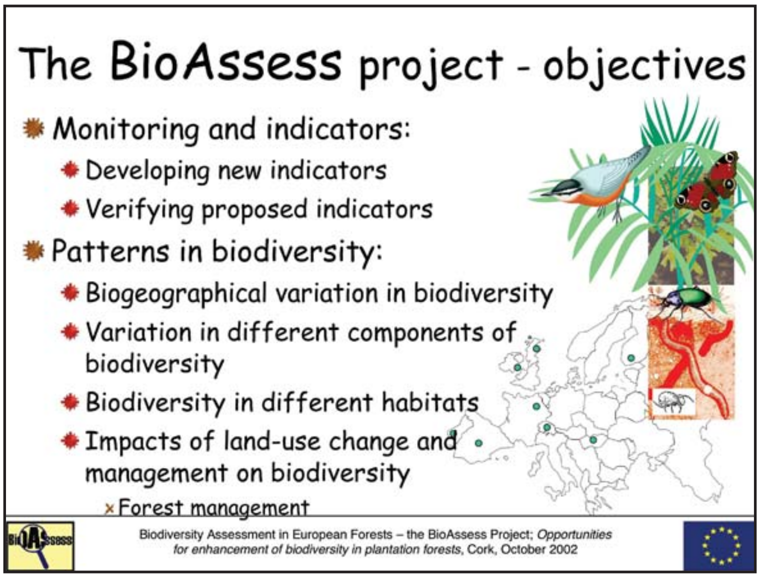
Biodiversity assessment in European forests within the BioAssess project

Allan Watt[12]





12 Centre for Ecology and Hydrology, Hill of Brathens, Glassel, Banchory, Aberdeenshire AB31 4BW, Scotland, UK. Email: adw@ceh.ac.uk


The BioAssess project - objectives
Monitoring and indicators:
Developing new indicators
Verifying proposed indicators
Patterns in biodiversity:
Biogeographical variation in biodiversity
Variation in different components of biodiversity
Biodiversity in different habitats
Impacts of land-use change and management on biodiversity
Forest management
Biodiversity Assessment in European Forests – the BioAssess Project; Opportunities for enhancement of biodiversity in plantation forests, Cork, October 2002


Partners:
Partner 1. Centre for Ecology and Hydrology, United Kingdom
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Partner 3. National University of Ireland, Dublin, Ireland.
Partner 4. The British Trust For Ornithology, United Kingdom
Partner 5. The Natural History Museum, London, United Kingdom
Partner 6. Department of Remote Sensing and Land Information Systems, FELIS, Freiburg, Germany
Partner 7. The Ministry of Environment - Government of Catalonia, Spain.
Partner 8. Dutch Butterfly Conservation / De Vlinderstichting, The Netherlands
Partner 9. Swiss Federal Institute For Forest, Snow and Landscape Research (WSL), Zurich, Switzerland.
Partner 10. IRD/Universite De Paris VI, France
Partner 11. Universidad Autónoma De Madrid, Spain
Partner 12. Universidad De Castilla-La Mancha, Spain
Partner 13. Universidad De Murcia, Spain
Partner 14. University Complutense of Madrid, Spain
Partner 15. New University of Lisbon, Portugal
Partner 16. Institute of Environment and Life Sciences, University of Coimbra, Portugal
Partner 17. Mãe D'água, Consultoria Técnica Em Áreas De Interesse Natural
Partner 18. Centro De Ecologia E Biologia Vegetal, Univeristy of Lisbon - Po
Partner 19. The Institute of Agronomy, Technical University of Lisbon, Portu
Partner 20. Hungarian Natural History Museum, Hungary
Partner 21. The Finnish Forest Research Institute (METLA), Finland
2. CNRS, University Paul Sabatier, France
3. CNRS, Museum
5. Parc Naturel Regional Du Morvan, France
Biodiversity Assessment in European Forests – the BioAssess Project; Opportunities for enhancement of biodiversity in plantation forests, Cork, October 2002


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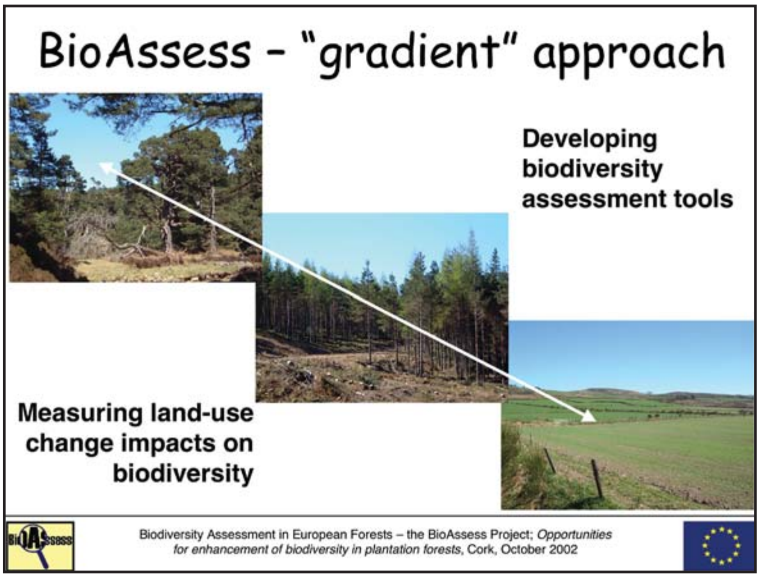
BioAssess – "gradient" approach
Developing biodiversity assessment tools
Measuring land-use change impacts on biodiversity
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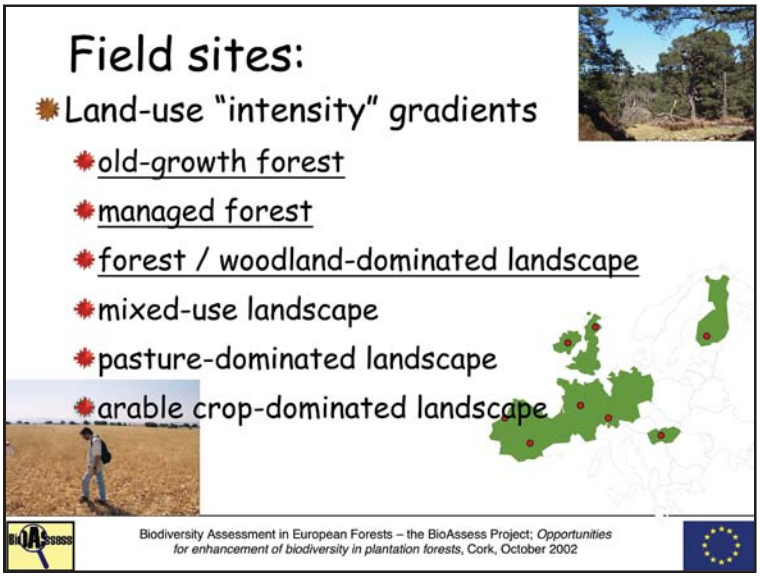
Field sites:
Land-use "intensity" gradients
old-growth forest
managed forest
forest / woodland-dominated landscape
mixed-use landscape
pasture-dominated landscape
arable crop-dominated landscape
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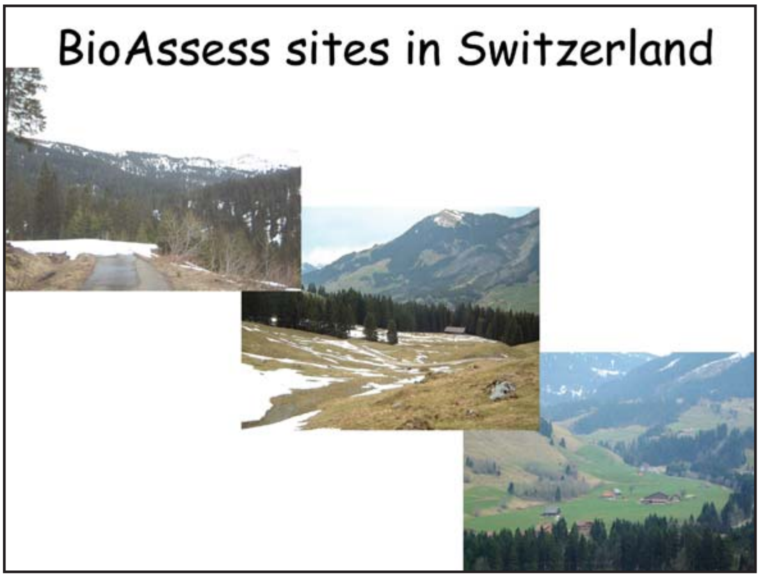
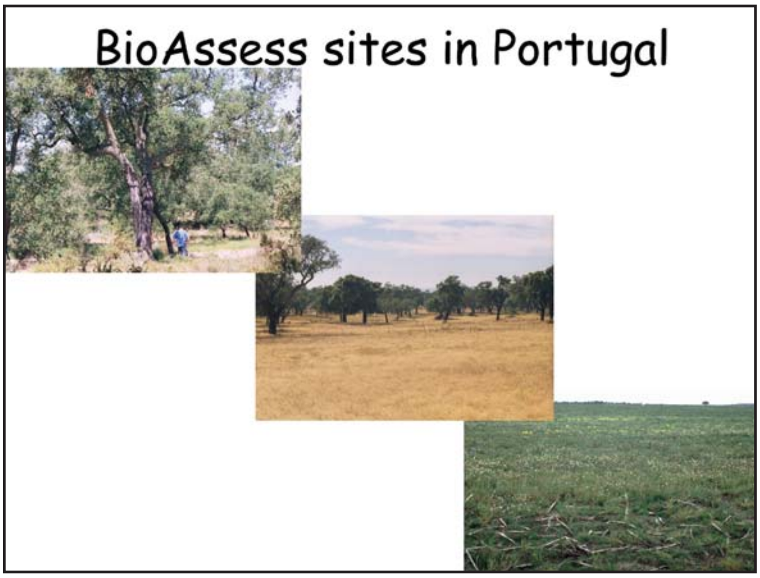
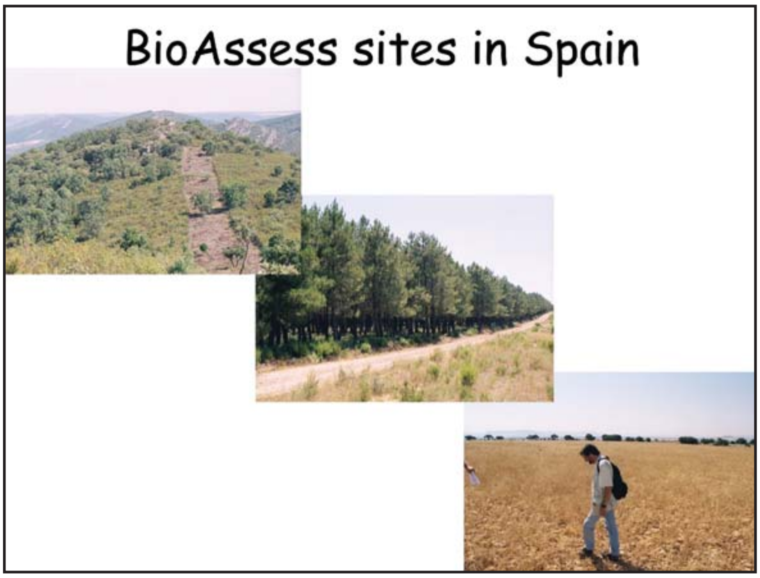
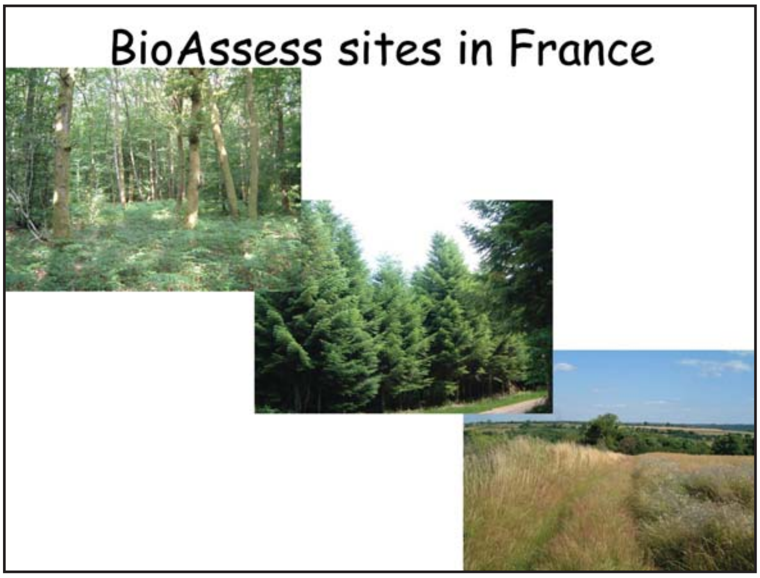

BioAssess sites in Switzerland


BioAssess sites in Portugal


BioAssess sites in Spain

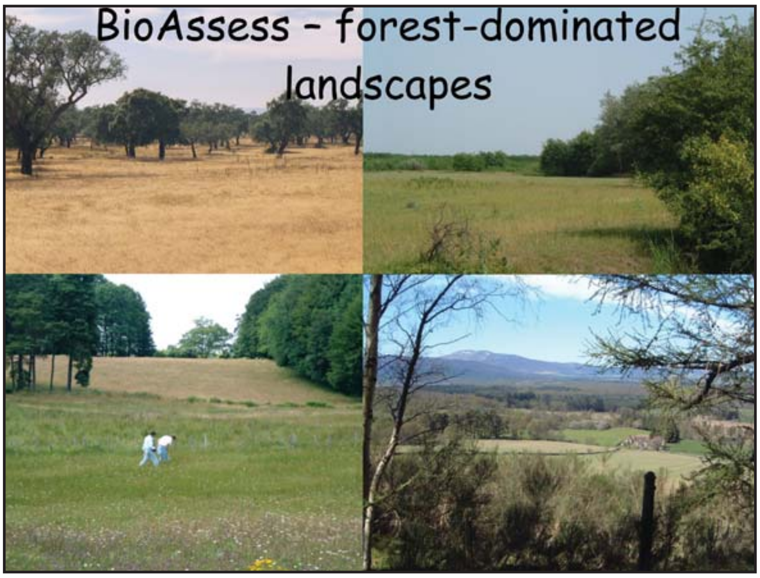

BioAssess sites in France

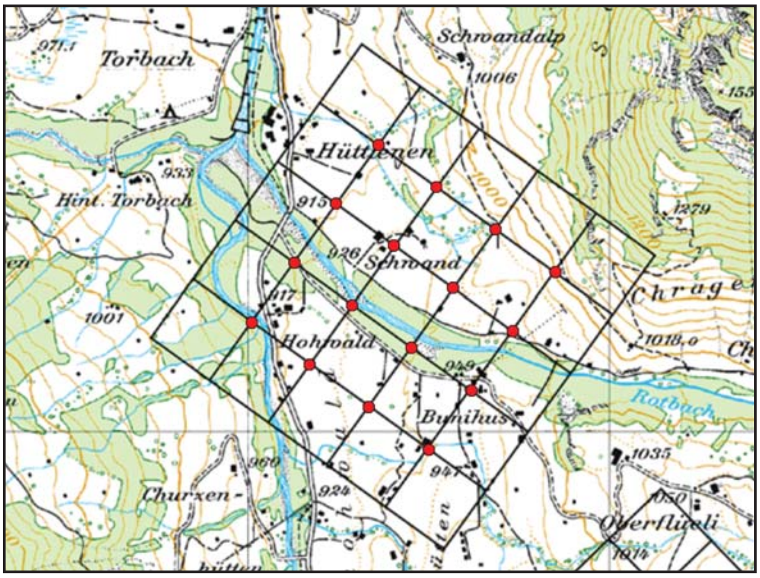

BioAssess sites in Hungary

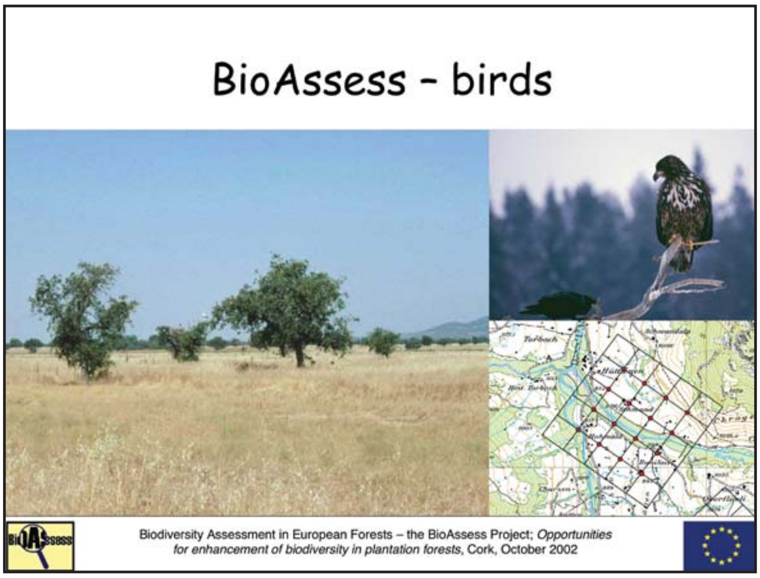

BioAssess sites in Finland


BioAssess – unmanaged forests


BioAssess –
managed forests


BioAssess – forest-dominated
landscapes


Torbach
Schwandalp
1006
933
Hint. Torbach
915
1279
Schwand
1001
Rotbach
1035
924
Churzen-


BioAssess – birds
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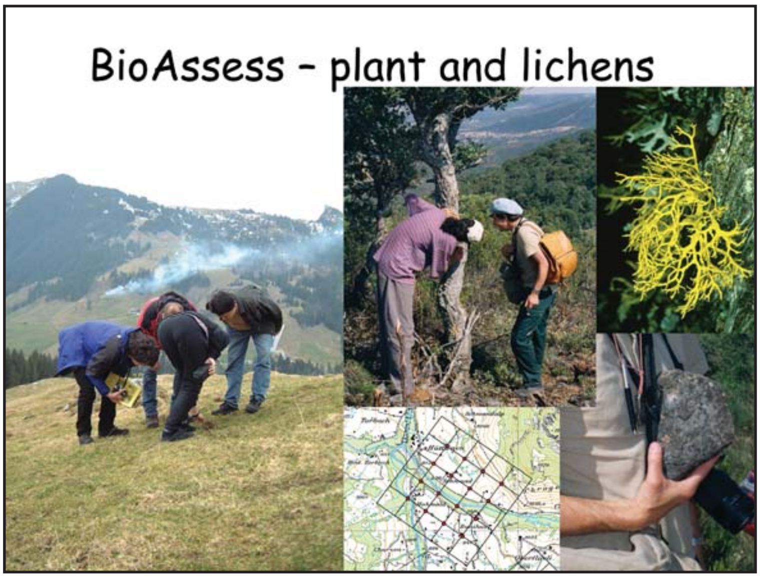
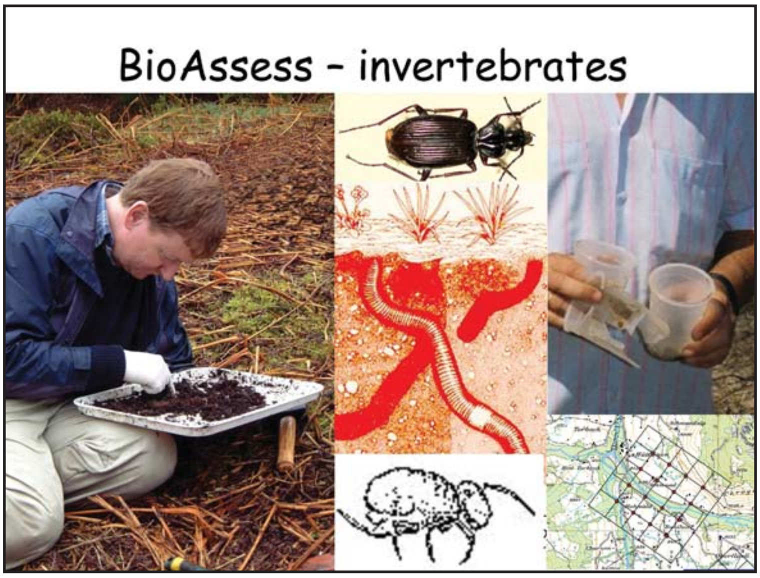
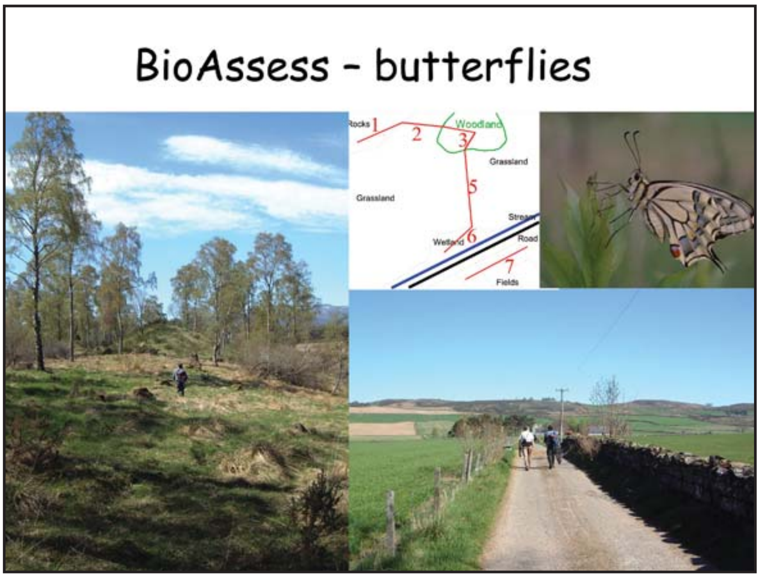
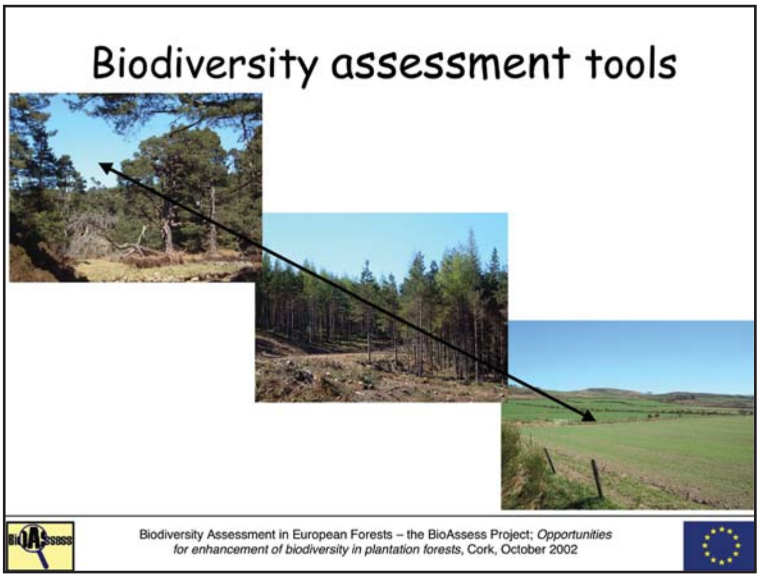

BioAssess – plant and lichens


BioAssess – invertebrates





Biodiversity indicators

- Functional / process indicators
- Structural indicators
  - Landscape / remote sensing
- Compositional (biological) indicators
  - Plants?
  - Birds?
  - Indicator sets

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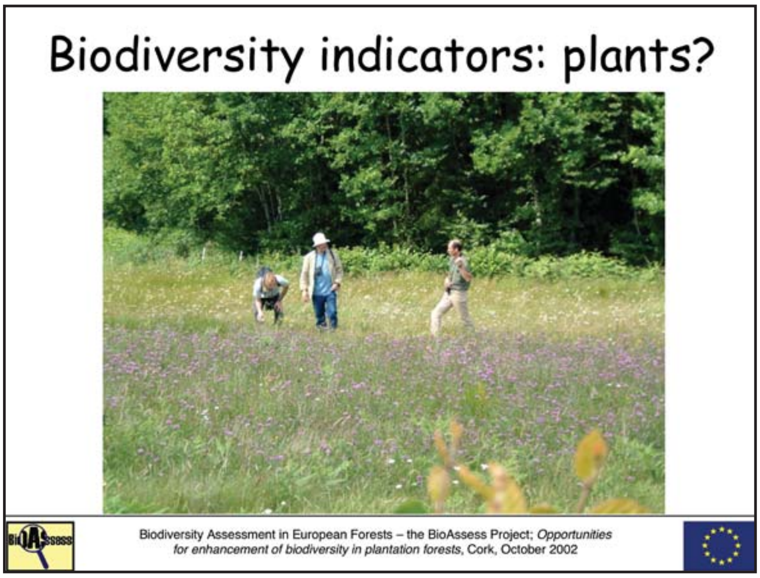
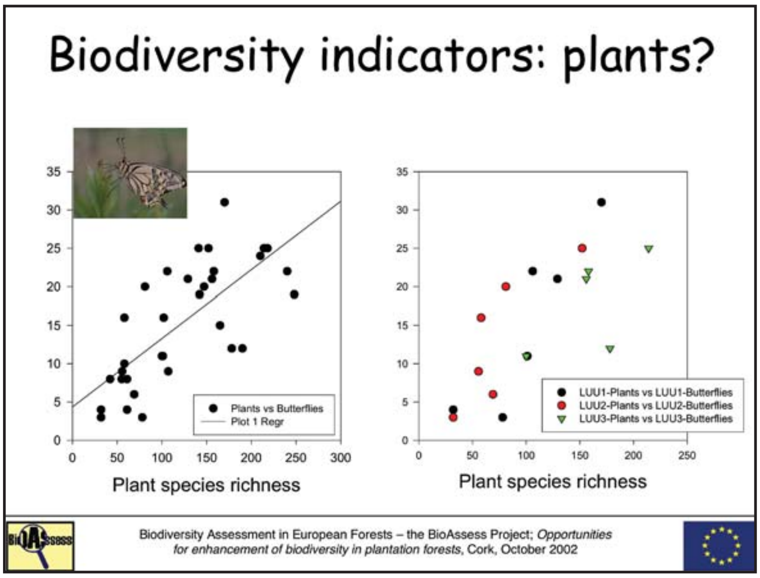

Biodiversity indicators: plants?
Biodiversity Assessment in European Forests – the BioAssess Project; *Opportunities for enhancement of biodiversity in plantation forests*, Cork, October 2002


Biodiversity indicators: plants?
0
5
10
15
20
25
30
35
0
50
100
150
200
250
300
Plant species richness
Plants vs Butterflies
Plot 1 Regr
LUU1-Plants vs LUU1-Butterflies
LUU2-Plants vs LUU2-Butterflies
LUU3-Plants vs LUU3-Butterflies
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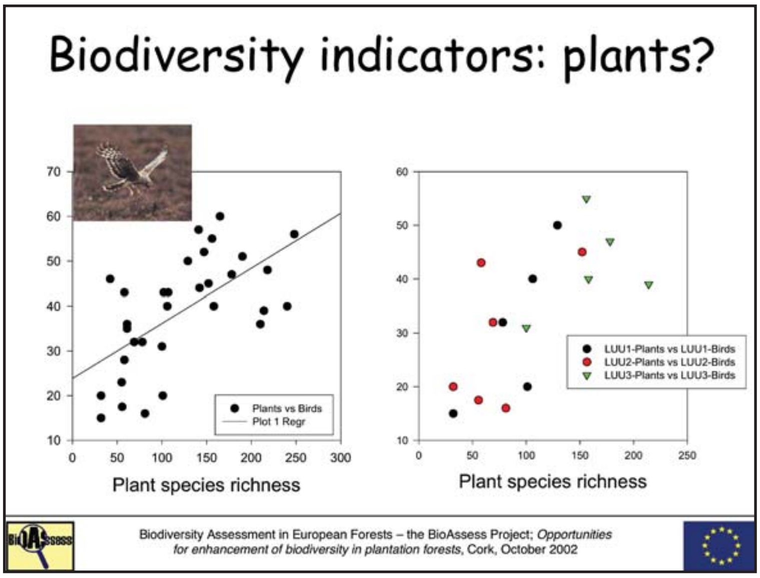
Biodiversity indicators: plants?
10
20
30
40
50
60
70
0
50
100
150
200
250
300
Plant species richness
Plants vs Birds
Plot 1 Regr
LUU1-Plants vs LUU1-Birds
LUU2-Plants vs LUU2-Birds
LUU3-Plants vs LUU3-Birds
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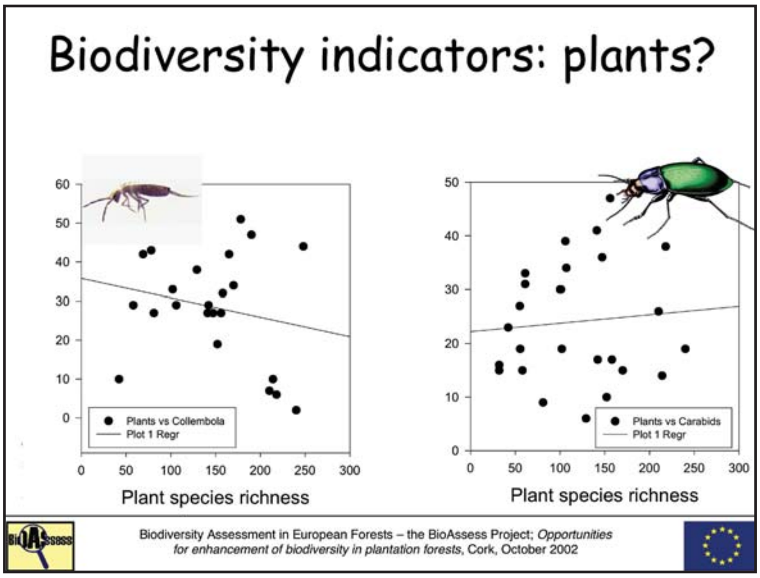
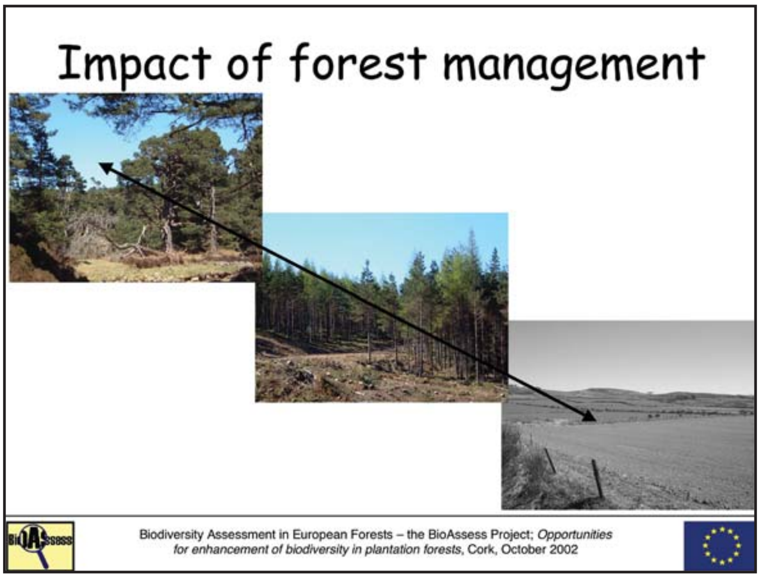
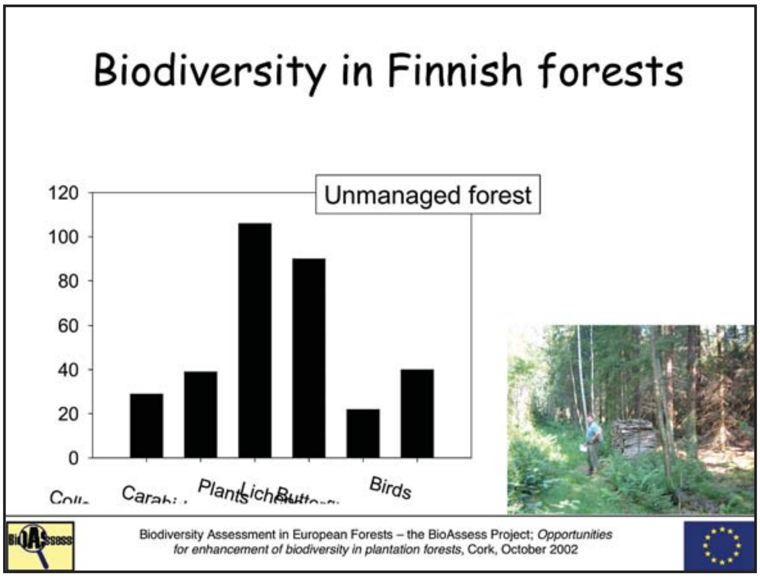
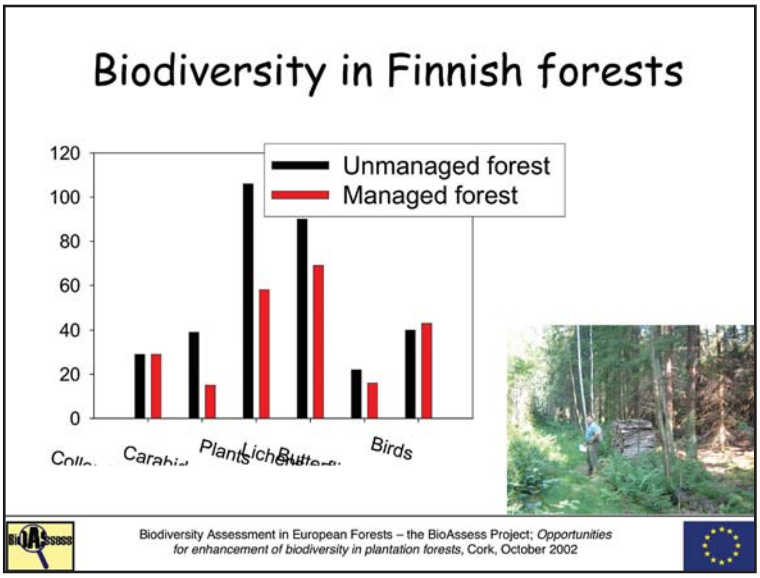
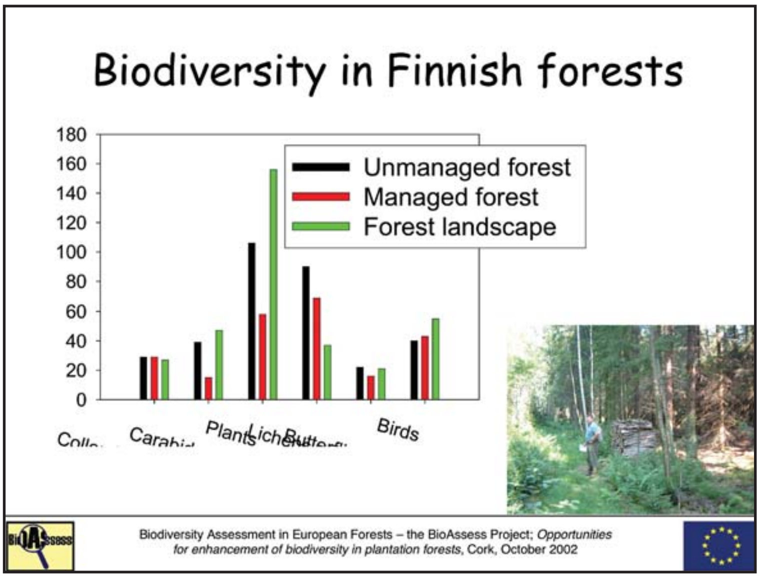
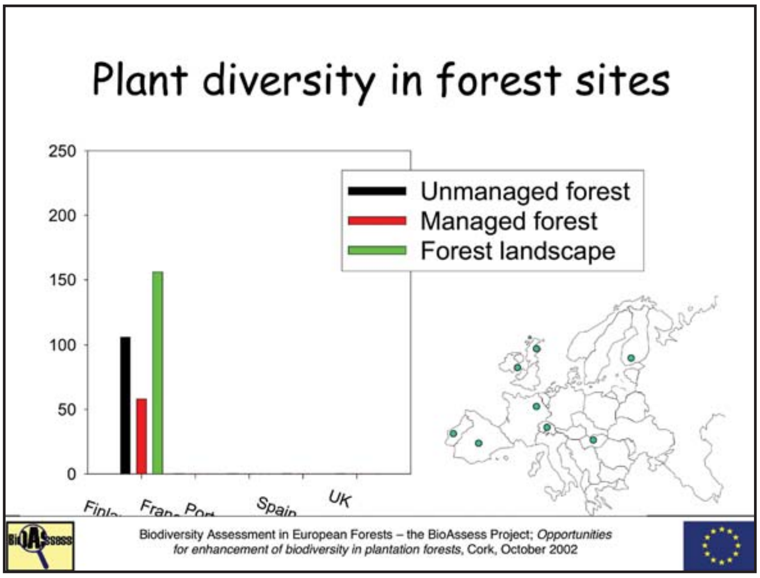

Biodiversity indicators: plants?
Plants vs Collembola
Plot 1 Regr
Plant species richness
Plants vs Carabids
Plot 1 Regr
Plant species richness
Biodiversity Assessment in European Forests – the BioAssess Project; Opportunities for enhancement of biodiversity in plantation forests, Cork, October 2002

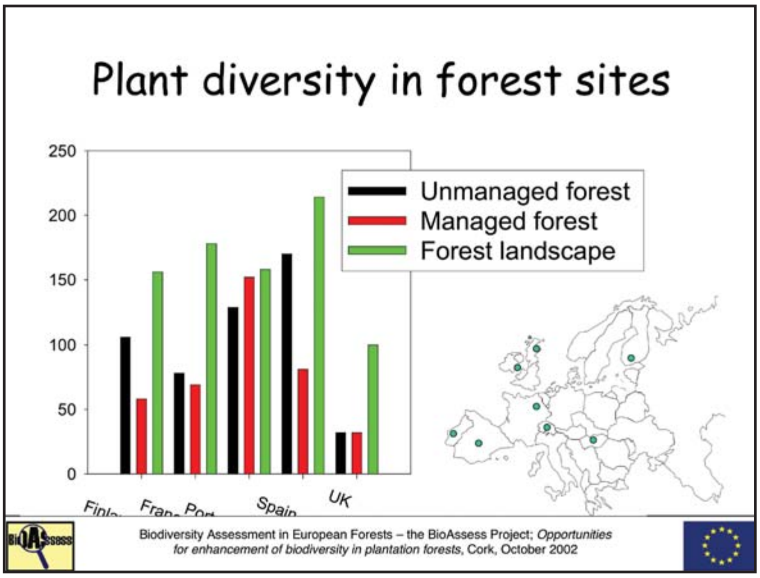

Impact of forest management
Biodiversity Assessment in European Forests – the BioAssess Project; Opportunities for enhancement of biodiversity in plantation forests, Cork, October 2002

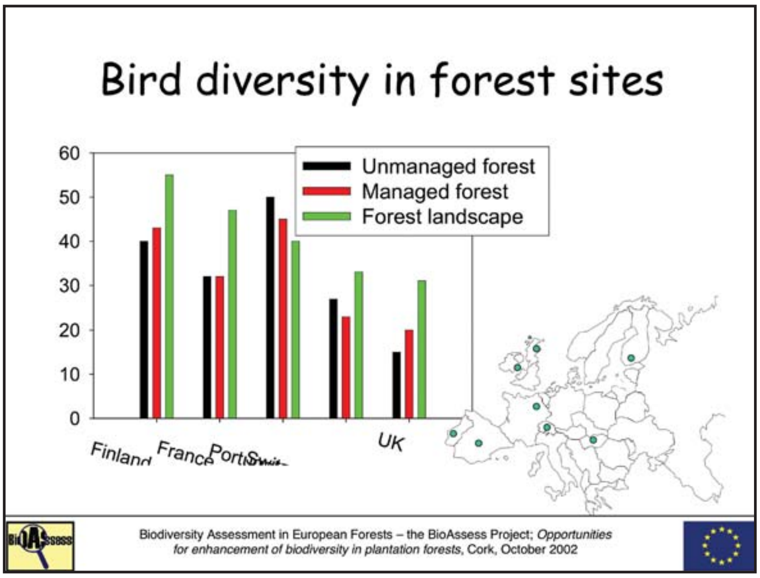

Biodiversity in Finnish forests
Unmanaged forest
Plants
Birds
Biodiversity Assessment in European Forests – the BioAssess Project; Opportunities for enhancement of biodiversity in plantation forests, Cork, October 2002

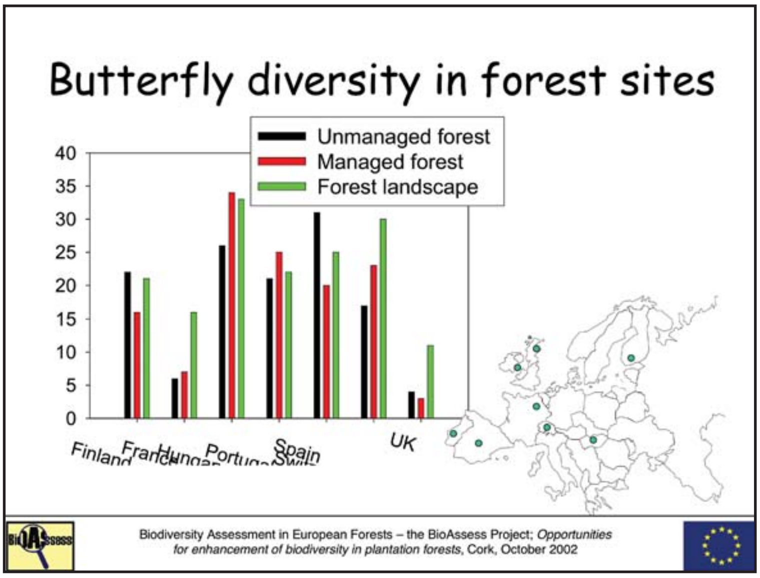

Biodiversity in Finnish forests
120
100
80
60
40
20
0
Unmanaged forest
Managed forest
Plants
Birds
Biodiversity Assessment in European Forests – the BioAssess Project; Opportunities for enhancement of biodiversity in plantation forests, Cork, October 2002

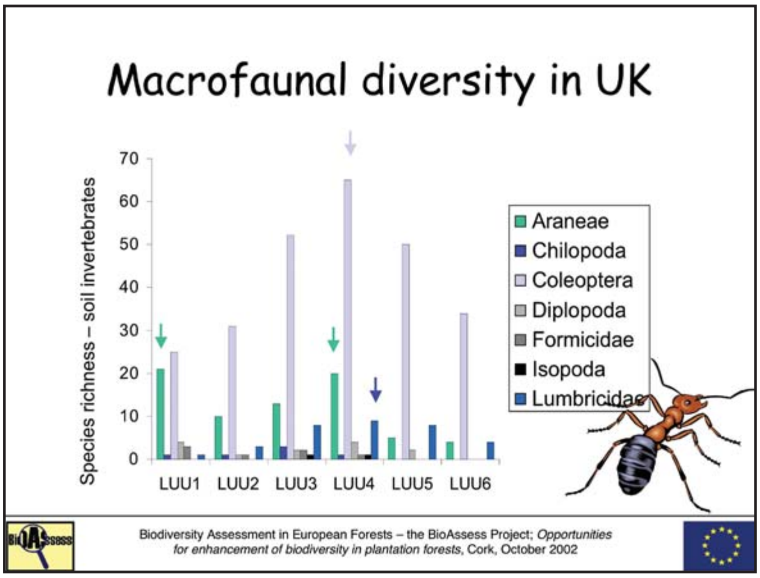

Biodiversity in Finnish forests
180
160
140
120
100
80
60
40
20
0
Unmanaged forest
Managed forest
Forest landscape
Plants
Birds
Biodiversity Assessment in European Forests – the BioAssess Project; Opportunities for enhancement of biodiversity in plantation forests, Cork, October 2002


Plant diversity in forest sites
250
200
150
100
50
0
Unmanaged forest
Managed forest
Forest landscape
Spain
UK
Biodiversity Assessment in European Forests – the BioAssess Project; Opportunities for enhancement of biodiversity in plantation forests, Cork, October 2002


Plant diversity in forest sites
250
200
150
100
50
0
Unmanaged forest
Managed forest
Forest landscape
Spain
UK
Biodiversity Assessment in European Forests – the BioAssess Project; Opportunities for enhancement of biodiversity in plantation forests, Cork, October 2002


Bird diversity in forest sites
60
50
40
30
20
10
0
Unmanaged forest
Managed forest
Forest landscape
UK
Biodiversity Assessment in European Forests – the BioAssess Project; Opportunities for enhancement of biodiversity in plantation forests, Cork, October 2002


Butterfly diversity in forest sites
40
35
30
25
20
15
10
5
0
Unmanaged forest
Managed forest
Forest landscape
Spain
UK
Biodiversity Assessment in European Forests – the BioAssess Project; Opportunities for enhancement of biodiversity in plantation forests, Cork, October 2002


Macrofaunal diversity in UK
Species richness – soil invertebrates
70
60
50
40
30
20
10
0
LUU1 LUU2 LUU3 LUU4 LUU5 LUU6
Araneae
Chilopoda
Coleoptera
Diplopoda
Formicidae
Isopoda
Lumbricidae
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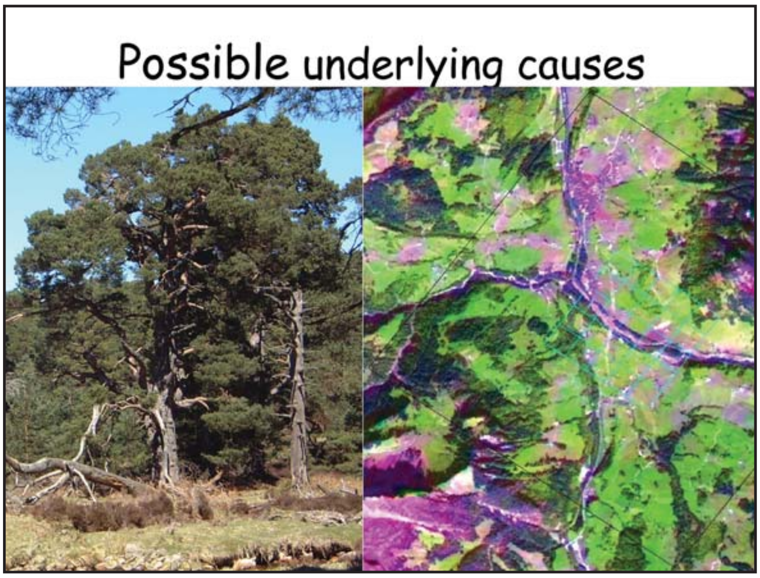
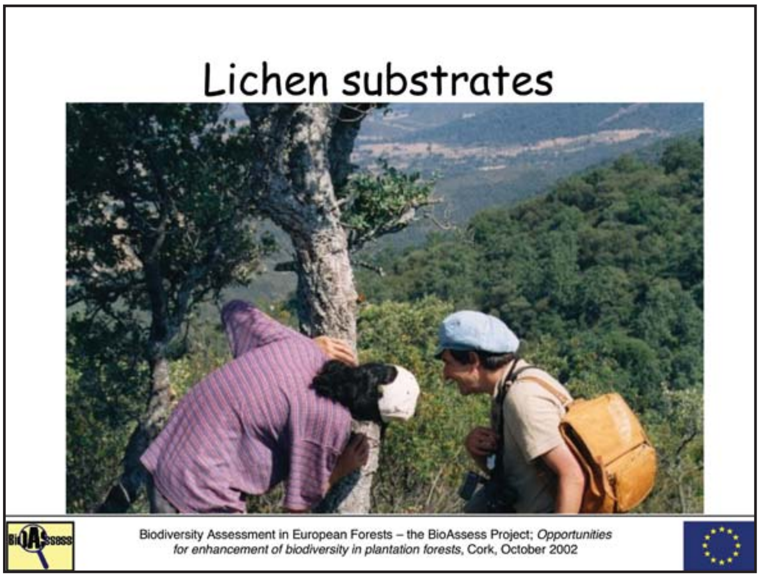

Possible underlying causes


Lichen substrates
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Lichen substrates
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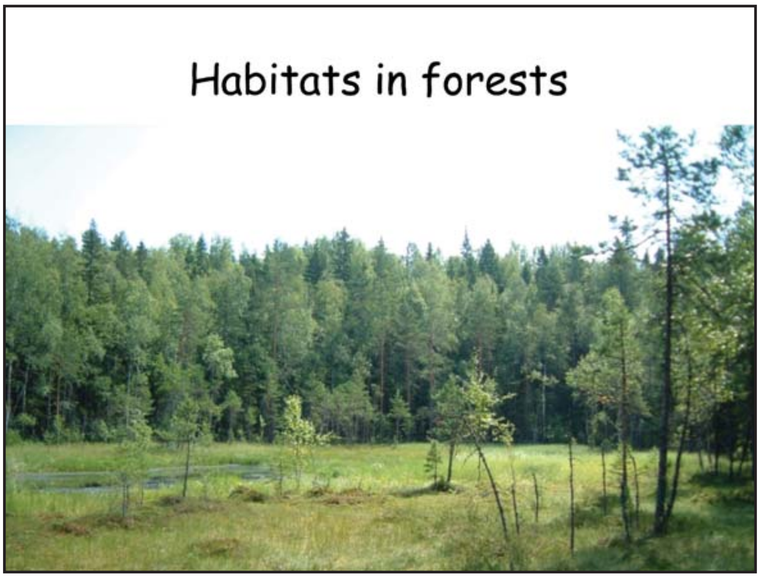
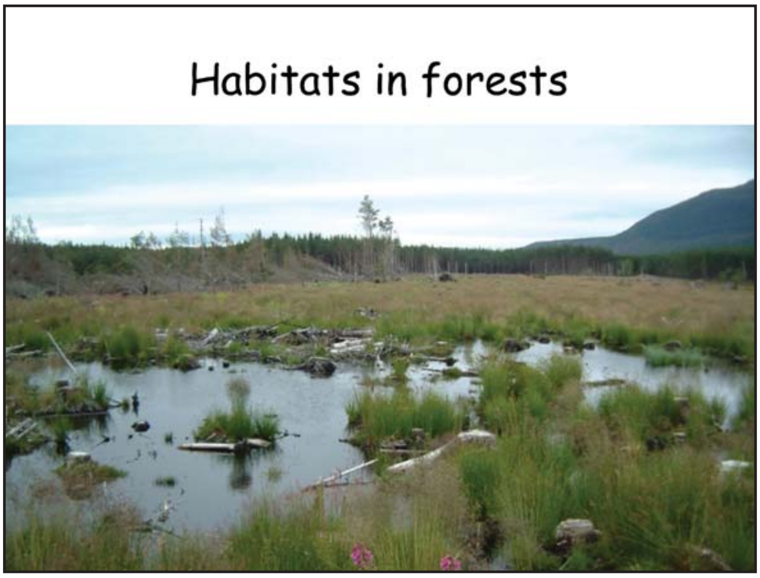
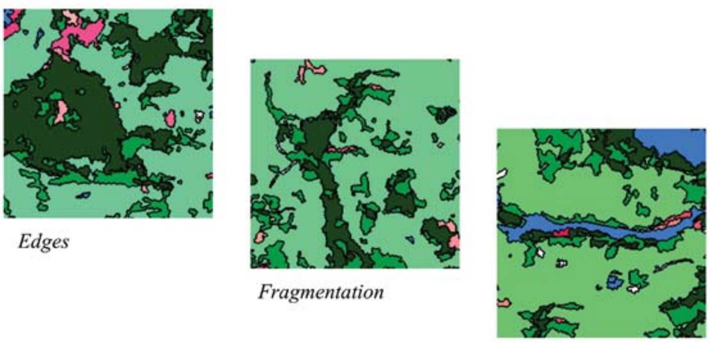

Habitats in forests


Habitats in forests

Trees in the landscape

Trees in the landscape

Forest & landscape characteristics



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