The Natural Capital Value of Native Woodland in Ireland

Prepared for Woodlands of Ireland

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Executive Summary

Extensive native forest once covered most of Ireland. Today only about 100,000 hectares of this lost forest remains or approximately 1.2% of the land area. This remnant forest is not just a natural asset, but a *natural capital asset* that provides a range of benefits in the form of *ecosystem goods and services*. At present, native woodlands form 14% of our total forest cover - the rest is made up mostly of exotic conifer plantations. Native woodlands are generally much richer in natural capital than exotic plantations.

This report quantifies, for the first time, the economic value of the ecosystem goods and services provided by the natural capital of Ireland's native woodlands.

Failure to include natural capital values in national accounting systems incurs high but hitherto invisible costs: a sound business axiom warns that assets that are not clearly accounted for cannot be managed well, and may not be managed at all. Recent international studies, especially the Millennium Ecosystem Assessment and The Economics of Ecology and Biodiversity (TEEB), have led to increasing recognition of the economic damage done by this hidden deficit. It is often said that nature is priceless, and that is true in some respects. But if we fail to price natural capital and ecosystem goods and services, then we will continue to treat critically important aspects of nature as if they were worthless. This failure is now being addressed by the European Union. The EU 2020 Biodiversity Strategy requires Member States to integrate these values into national accounting and reporting systems by the end of this decade.

This requirement is recognised in Ireland's 2nd National Biodiversity Plan (Actions for Biodiversity 2011 – 2016), but progress to date has been slow. Accounting for natural assets will present substantial economic opportunities, and it is recommended a full national assessment of all our natural capital wealth should proceed without further delay. This report on native woodland's natural capital value is presented as a small but significant step in this process.

A fundamental natural capital element of native woodland is biodiversity: many specialist flora and fauna species are the foundation for potentially significant economic and social benefits. Core services are also provided by ecosystem structure: for example, forests mitigate flooding and prevent erosion by reducing the speeds at which water moves through landscapes.

In this report it is demonstrated that Ireland's existing area of native woodland has an economic value of between €100 million and €143 million/yr. The amenity use of native woodland is worth at least €35 million/yr, woodlands-related domestic and international tourism expenditure brings in €50 million/yr and carbon sequestration up to €8 million/yr. These baseline estimates have principally been derived by proportionately relating the area of native woodland to estimates of the public goods value of the total forest area in Ireland. However, native woodland has a premium value in that it typically provides a higher output of public goods compared to equivalent areas of plantation forest comprised of exotic conifer species.

The economic and social benefits outlined in this report are derived from the provisioning, regulating, cultural and supporting ecosystem services that flow from the natural capital of native woodlands. This assessment will inform and coordinate decision-making and provide the foundation for incentives and forest policies necessary to unlock natural capital values for the purpose of sustainable economic growth.

The values established here are obviously significant, but they are only a fraction of the benefits that could be realised through an expansion of native woodland to – and beyond -- the targets envisaged in the National Biodiversity Plan. The report quantifies the value of expanding native woodland, through new woodland creation/restoration, in three scenarios. Native forest at present makes up 14% of total forest cover in Ireland. Expanding this to 25%, 50% and 100% of current total forest cover could yield to €274, €436m and €650 million respectively. For example, an expansion to 25% of the current total forest cover would result in at least the following annual scale of ecosystem service benefits and values:

• Amenity (non-market value)	€65 million per year
• Tourism expenditure	€60 m
• Health	€4 m
• Biodiversity utility value	€60 m
• Water quality, flood and erosion control	€3 m
• Carbon storage and sequestration	€45 m
• Timber and wood fuel	€37 m
Total	€274 million per year

Some of these economic benefits are market values; others are public goods. There is a relationship between the two: the public good of amenity contributes to tourism income, and to savings on the public health budget.

This report reveals that the natural capital value of Ireland's native woodland resource is depleted, and that efforts to augment it are faltering due to funding problems. The Native Woodland Scheme (NWS) has created 1,100 hectares of new native woodland over the past decade. However the conservation element of the NWS, which has contributed to the management of 2,550 hectares of existing woodland and is the scheme's cornerstone, is currently suspended. A realistic expansion target of 2,500 hectares/yr should be set now, increasing to 5,000 hectares/yr when resources allow. Continuous, uninterrupted public funding linked to payments for ecosystem services (PES) is recommended as it is vital to achieve targets and maintain confidence amongst landowners and the forest sector.

A strategic, targeted expansion of native woodlands would maximise all its inherent values and provide valuable ecosystem services in terms of habitat, landscape, protection of water quality, flood mitigation and erosion control. In addition, to realise the full amenity, tourism, health and biodiversity utility benefits from publicly funded initiatives such as the NWS, it is necessary to promote public amenity use, particularly in areas close to urban centres or where there are few other countryside amenities.

Furthermore, these benefits are entirely compatible with a prosperous timber sector. Native woodlands can supply a profitable hardwood market, in turn producing very significant spinoffs related to wood products, biomass/fuel and associated exports, local development, new business opportunities and sustainable employment. At present, this element of the native forestry sector has a modest value of €2-3 million/yr, but it could be worth twenty times this sum given the strong and growing demand for quality, indigenous timber and renewable energy.

To realise the true economic value of Ireland's native woodland potential, with all the associated social benefits, consistent and targeted stimulus funding is required. Natural capital requires investment if it is to maximise the 'interest' it produces in terms of ecosystem goods and services, just as financial capital requires investment in order to expand. In challenging economic times, investment in the natural capital of native woodlands would represent a courageous and productive strategy for the future.

The Natural Capital Value of Native Woodland in Ireland

1. Introduction

Report objective

Ireland is one of the least forested countries in Europe. Just under 11% of the land area is forest, most of which comprises exotic conifer species. Just over one per cent of the total land area of the Republic still supports the kind of native woodland that once covered most of Ireland (except for bogs, lakes, rivers and hill tops)[2].

This report strongly makes the case that the protection and expansion of Ireland's remaining area of native woodland is of critical economic importance. It demonstrates that this woodland holds multiple and often hitherto unrecognised economic values due to the services it supplies in the form of, for example, biodiversity, amenity and carbon sequestration, in addition to being a productive timber resource. The report describes and quantifies these economic values. It describes the various measures and forestry projects that have been introduced to protect and enhance the area of native woodland. It broadly evaluates its economic contribution to date and outlines how this can be further improved. It also quantifies the economic consequences of further loss in native woodland cover, the benefits of protecting existing areas and the additional significant benefits that would arise from expanding the native woodland area.

Ireland's native woodlands

The area of forest cover in Ireland has increased substantially in recent years, but remains low relative to other European countries. It is mainly a homogeneous resource, comprised primarily of non-native conifer plantations focused almost exclusively on commercial timber production, albeit occasionally ameliorated by attractive parklands, remnants of old estates and visitor facilities. Within this total area of forest, some modest pockets of native woodland remain, comprised mainly of deciduous broadleaf species. A visit to the woodland confirms its distinctiveness, particularly in spring or autumn when its varied colour, abundant ground flora, wildlife and birdsong is most apparent. Unlike exotic conifer plantations, native woodlands have a distinctive and complex biodiversity that has developed since the advent of the Post-glacial period some 13,000 years ago.

Unfortunately, the opportunity to visit native woodland, and consequently Irish people's familiarity with this native resource, is limited by its scarcity. Estimates by the National Forest Inventory (NFI)[1] put the total area of broadleaf woodland at 152,000 hectares (ha), a proportion of which would be non-native broadleaf plantations. The National Parks and Wildlife Service (NPWS) estimate a figure of 100,000 ha of native woodland based on its specific native

woodland classification system.[1] This is equivalent to 14% of the current total forest area. However, most native woodlands have been modified by past management and the presence of non-native species. Only a fraction (around 20,000 ha) comprises 'ancient woodland' or 'old growth forest' (dating from before 1650AD), and this is the category that is most rich in flora and fauna.[2]

A National Survey of Native Woodlands was initiated in 2003[2]. The survey generated a database for 1,320 sites. It reported the presence of four main types of woodland. Much of this area has been heavily modified and most woodlands are highly fragmented and are less than five ha in size.[3-5] Fortunately, some connectivity is provided by Ireland's 300,000km of hedgerow.[2] This network consists mainly of native tree and shrub species.

Strictly speaking very little of the remaining woodland can be described as purely native, but rather as 'semi-natural'. Semi-natural woodland is dominated by native trees and shrubs but also non-native trees and shrubs that have been introduced by people. They are also modified by human intervention, especially management and felling, so that natural evolutionary processes are interrupted and altered. Three of Ireland's six National Parks, Killarney, Glenveagh and Wicklow, contain substantial areas of native semi-natural woodland. On a county basis, County Cork has the largest area of native woodland and County Waterford the highest density. The National Survey of Native Woodlands noted that 25% of forest stands contain three or more tree species, although only 5% contains five or more species. The NFI estimated that 40% of native forest is publicly owned, while grant-aided privately owned native woodland makes up 19% and private (other) 41%.

'Old' woodland sites -present on the first Ordnance Survey (OS) maps of 1830-1844 - amounting to 27,000 ha have been identified on the Coillte estate (see [6, 7]). These, along with other sites owned privately or by NPWS, are described as being of higher conservation value than more recently established woodlands, including new commercial plantations. However, 'ancient' woodland is very rare. The NPWS inventory of long-established and ancient woodlands identifies 481 ancient woodlands in the Republic of Ireland.[8] Although all these sites are likely to have been managed and/or exploited at some time in the past, they contain communities of animals and plants that are associated with the original forest cover.

Although around 11,000 ha of native woodlands are protected by statutory designations (i.e. mainly SACs and NHAs), Natural Heritage Areas (NHA) currently lack full legal protection. In addition, these and many other sites are vulnerable to under-management and invasive plants or deer. For example, the National Survey of Native Woodlands describes an old oak-dominated woodland at the much-visited Kylemore Abbey in County Galway that is so infested by rhododendron that it can no longer be classified as native woodland. The last NPWS report on the status of EU Protected Habitats and Species (2008) gives a disturbing account of the condition of the four main types of native woodland designated under the EU Habitats Directive. Bog woodland fares best, but is still rated as "poor", while Old Oak woodlands, Alluvial forests and Yew woodland are each allocated an assessment of "bad" on the basis of fragmentation, threats from invasive species and uncontrolled grazing. Invasive alien understory species such as rhododendron, laurel and dogwood are inhibiting regeneration at many sites, as are naturalised sycamore and beech. Excessive grazing pressure from domestic livestock and from wild deer (which lack any natural predators in Ireland) is also suppressing regeneration and damaging trees, shrubs and ground flora. As a result the future viability of heavily grazed woodlands is seriously compromised.

[1] The National Survey of Native Woodland (Perrin et al 2008) prepared for NPWS comments on the NFI figure and a lower figure of 82,321ha from the Forest Inventory Planning System (1995). The NFI figure includes areas of ash plantation and mixed woodland that includes non-native beech, etc.

[2] www.noticenature.ie

Woodlands as Natural Capital

People often think of our environment as 'priceless', but it is often treated as though it were 'worthless' precisely because it has not been given a market value. Far from protecting the environment, this failure to appreciate its economic value often leads to its unsustainable exploitation and, in many cases, its heedless destruction. This results in the depletion of natural capital with often serious, negative consequences for both biodiversity and the human race.

The natural capital asset represented by native woodlands provides ecosystem goods and services, for example, commercial timber, clean water and carbon storage. These goods and services have been described as the return, or interest, which derives from this stock of natural capital.[9] The wise management of natural capital, like the wise management of financial capital, demands that core capital stocks are not depleted, but rather are augmented and enhanced. In order to translate this principle into practical policies, it is necessary to first find ways to attribute accurate economic values to natural capital and associated ecosystem goods and services. This is the purpose of this report.

Internationally, there are various initiatives underway to ensure that the value of natural capital and ecosystem goods and services are fully recognised. Some of the most recent and comprehensive work has been carried out by The Economics of Ecology and Biodiversity (TEEB), a study financed by the UN and eight industrialised nations. Its findings have been produced in different formats appropriate to the needs of business, policy-makers, and scientists.[3] The TEEB studies are an advance, in structure and detail, on the pioneering research carried out for the UN Millennium Ecosystem Assessment (MA). A text-book has also been produced on the theory and practice of natural capital valuation, the augmentation of natural capital through ecological restoration, and its application for the benefit of business and society in general.[4]

These initiatives represent a major paradigm shift in the perception of our relationship with the environment. However, like many ground-breaking ideas, once it is communicated and understood, the arguments seem logical and self-evident.

Ecosystem services

The Millennium Ecosystem Assessment [10] identified four main classes of ecosystem services:

- Supporting services (soil formation, nutrient cycling etc) that underpin other ecosystem services
- Regulating services (climate regulation, flood protection, water purification etc) that protect the quality of the environment
- Provisioning services (ecosystem goods) that supply products such as food or raw materials
- Cultural services (recreational, educational, aesthetic, health and well-being, spiritual etc), some of which have direct economic value, while others have indirect economic value through the social benefits they bring.

These categories are not set in stone, but rather are being subjected to a rapid process of refinement, as one would expect in a new field of study. Many of their benefits are clear, though often unaccounted for by the markets. Others are obscured due to lack of knowledge of ecosystem functions, for example, of species relationships or soil microbial populations, or of the space or time over which ecosystems function. Natural capital may contribute external benefits - in economic language *externalities* - at a downstream location or to another population group, far from the ecosystem where the capital has been generated. Conversely, losses of natural capital can impose adverse impacts on distant locations or communities. The implications of ecosystem loss are generally not appreciated in the short term and longer term benefits may be discounted by conventional accounting procedures. These uncertainties often

[3] see www.teebweb.org and http://bankofnaturalcapital.com.

[4] Restoration of Natural Capital: Science, Business and Practice, edited Aronson, Blignaut and Milton, Island Press, 2008

provide tacit justification for policy inaction. A pertinent example is the role of forests and peatlands in climate change mitigation, where the value of the regulating service of carbon storage or sequestration they provide will only be fully realised in the decades to come. Therefore, a mismatch between our awareness of natural capital's value and its use, or between this use and its social costs and benefits often results in mismanagement of environmental resources.

Some environmental economists and scientists distinguish a further valuation category, i.e. *option value.* This refers to the values of protecting a resource for future use or because it is likely to have natural capital value that we have not yet recognised – for example, a plant that holds the undiscovered cure to a disease. Clearly, an option value is hard to quantify, but it should be acknowledged, not least as a reminder that the extinction of an apparently insignificant species today may have significant costs in the future.[5]

An understanding of the valuation of natural capital and ecosystem services is critical to policy development and land use planning. It is also essential to any comprehensive economic assessment of national and sectoral resources. A full cost-benefit analysis must identify all the streams of private and social benefits and costs, including the public good benefits to wider society. Without them, we cannot accurately measure trade-offs between competing land uses, nor make well informed decisions on the best use of investment capital.

Many native woodlands have survived only because they are located either on land of little agricultural value or are located on estates that have had a relatively stable management history and a cultural tradition of appreciating native trees. Conservation policy has struggled to protect even those relatively small woodland areas that are of highest biodiversity value, since they require ongoing injections of finance for proper management. However, the ability to accurately value natural capital and ecosystem services demonstrates that investment in woodland, on all types of land (from fertile to very infertile) brings a return that rivals, or can exceed, that from other land uses.

The key ecosystem services provided by native woodlands include:

1) Supporting services

Supporting services have biodiversity as their bedrock, and involve ecosystem functions like soil formation and nutrient cycling. They are distinct from the other three ecosystem services because they are at a remove from contributing directly to human wellbeing. But they are nonetheless very valuable, because they are the sine qua non for those other services. Ancient woodlands, with their exceptional biodiversity including remnant populations of specialist fauna and flora, contribute very significant supporting services.

2) Regulating services

Forests regulate water quality and the volume of water run-off. They also protect against soil erosion and stabilise riverbanks. Carbon sequestration is of increasing value given the need to reduce emissions in strategies attempting to mitigate against climate change.

3) Provisioning services

The provisioning services of native woodlands provide us with ecosystem goods: not only timber, wood products and wood fuel, but also wild foods such as berries, mushrooms, and venison. These are valued and utilised in many other European states and have considerable potential in Ireland too. An additional provisioning service, much utilised in Ireland, is the

[5] Gretchen Daily, founder of the Natural Capital Project, describes option value in some detail in http://www.smartplanet.com/blog/pure-genius/q-a-gretchen-daily-ecologist-on-quantifying-natures-value/9728.

forage and shelter forests accord to farm animals, realising a significant benefit in reduced agricultural input costs.

4) Cultural services

Forests make an important contribution to landscape quality. Their presence is valued for amenity use, providing physical and mental well-being, aesthetic and spiritual pleasure, and opportunities for the appreciation of birds and other wildlife. Ancient woodlands, in particular, also provide historical landscape value as they often contain archaeological features and evidence of past agriculture and settlement.

In some parts of the world various ecosystem services, for example regional climatic modification, water storage and erosion control, are recognised and accounted for due to their very significant value. For Ireland, this report identifies and quantifies some of the principal economic benefits of native woodland, particularly in the next chapter and through the example of Brackloon Wood in County Mayo (chapter 4). The ecosystem services benefits of native woodland are typically rather different from, and generally more complex than, those of commercial forest, which contains a relatively limited range of tree species and ages. However, the value of native woodland ecosystem services is at present restricted by the small area that remains. Consequently, the report describes and evaluates not only the current level of services provided, but also the much more substantial level of economic returns that could flow from continued rehabilitation of the native woodland resource and from an active policy of native woodland expansion.

Natural Capital Values and Environmental Accounting

By 2020, the EU Biodiversity Strategy requires Member States, including Ireland, to integrate ecosystem services values into national accounting and reporting systems. The mapping and assessment of ecosystem services in all sectors will inform and coordinate the management of natural resources. This process should encourage the government to explore incentives and policies that unlock natural capital for the purpose of sustainable economic growth. It is in the national interest to begin this process as soon as possible. This report is a modest early step in this direction.

Box 1 Environmental Accounts

Conventional measures of economic development such as Gross Domestic Product (GDP) present a partial and selective estimate of a country's wealth and its citizens' well-being. Rather perversely, GNP treats expenditure to clean up environmental damage as a contribution to economic growth. Environmental accounting is used to adjust measures of GDP or to complement these measures. It provides a more balanced description of well-being and of the sustainability of current paths to development. The circumstances by which Ireland descended from the Celtic Tiger Era to the current financial malaise are a timely reminder of what is meant by sustainable economic growth and development.

New economic frameworks, based on the UN System of Environmental and Economics Accounts (SEEA), present a more accurate or comprehensive picture of well-being by accounting for natural capital assets and the balance between environmental protection and degradation. In these accounting systems, natural capital is recognised as a stock and ecosystem services as a flow. Material, energy and waste flows can also be estimated. An acknowledged challenge is presented by the difficulty of quantifying many ecosystem services in monetary terms, including many social and environmental benefits, e.g. biodiversity. In particular, there is a need to integrate output from the disciplines of biology, geography and economics, along with the incorporation of remote sensing data to gauge gains and losses of natural capital.

The UN accounting system has been further progressed by the EEA to include information on ecosystem integrity and ecosystem services at a spatial level. This system [11] has selected a number of approaches by which to measure ecosystem integrity. The approaches relevant to forests include:

- Structure and morphology of the landscape including potential connectivity
- Fragmentation of ecosystems and landscapes
- Water stress based on stocks, flows and abstractions
- Water quality including the ability to assimilate waste
- Biodiversity as measured by monitoring of species and habitat.

Based on these and other indices, the EEA arrived at four classes of ecosystem health:

- Homeostasis (no change)
- Resilient state
- Reversible process (degradation)
- Irreversible change

Much of Ireland's native woodland falls within the third and fourth of these classes with some woodland capable of restoration notwithstanding that a lot of its former fauna and flora has already been lost. [12]

2. Estimating the Value of Our Native Woodlands

Methods of economic valuation

The approach proposed in this report identifies the value of natural capital and the ecosystem goods and services that flow from this asset. This approach allows natural resources to be treated in an equal manner to other resources and flows in the economy, thereby facilitating sound, information-based policy making for sustainable development.[9]

A principal challenge to natural resource accounting is to find the most appropriate mix of valuation methods, using both market prices and non-market values, to apply in each case. Box 2 below summarises several of the more common methods used currently.

Requirements for Environmental Economic Valuation

Environmental Economic valuation has three fundamental stages

1. Understanding the role of an ecological function in the production of an ecosystem service
2. Identification of the role of the ecosystem service in the production of a product or 'good'.
3. Valuation of this service in proportion to the good's market price or non-market value.

Often, precise information on ecosystem functions is not available. For example, it may be impossible to identify the regulating role of soil fauna in the production of marketable timber. If however, the standing value of the timber is known, this can be used as an indicator of the regulating service value. In this way, the natural capital value of forest outputs can be estimated as the value of the ecosystem services, even though the ecological inputs to the production of forest products are numerous and varied. However, when combining ecosystem services values it is important not to double-count individual values, particularly with final ecosystem outputs such as timber.*

Valuing Native Woodland

The recent UK National Ecosystem Assessment (NEA 2011) draws a distinction between stocks of natural capital and flows of ecosystem services. For Ireland it must be acknowledged that the absolute value of ecosystem services from native woodlands is small because the remaining stock of native woodland is small.

However, because there is so little native woodland left, the natural capital value of what remains can be expected to be proportionately high even before a service-by-service estimation of ecosystem service values is calculated. For instance, using a CVM survey, Upton et al (2012) identify a threshold at which increasing forest cover in Ireland appears to exhibit diminishing returns in terms of the benefits people perceive. However, the forest cover is primarily made up of commercial plantations. The stock of native woodland is too small to exhibit diminishing

***Note on Marginal Value** - As this report is concerned with the management of natural capital, the relevant measure of value is *marginal value*, i.e. the incremental value of each ecological input that contributes to the total rather than the absolute worth of each value separately. This is because values are inter-dependant and hence a change in one may affect another. This approach allows the value of ecosystem services to be calculated at any one time or under altered conditions. It does, however, require information on how ecosystem functions vary under different conditions.

returns. Rather, its value is enhanced by its rarity and vulnerability, as is typically the case for all scarce resources.

Therefore, there is ample reason to believe that the benefits of native woodland are much greater per unit area than for non-native, exotic coniferous woodland. Nevertheless, by virtue of being more prevalent and less complex, commercial, forest can be valued more easily and there are more examples of past valuation to draw upon. Consequently in this report, the relative values of native and non-native woodland are distinguished where possible and demonstrate just how significant the value of native woodland would be if the area were to be increased appreciably. The approach employed in this report is to:

1. Identify the value of native woodland where specific values have been identified by previous studies of deciduous or other forest.
2. Where this is not the case, to draw upon values that have been - or can be - calculated for the total forest area.
3. To take as a proportion of this value the area that is represented by native woodland.
4. To factor up this proportion by available evidence of the relative value of native species.
5. To indicate the value of a three stage incremental expansion of native woodland to an area equal to that currently occupied by forest of all types, including conifer plantation.

In using this approach it must be acknowledged that 'native woodland' comprises many woodland types. As discussed above, the most valuable is ancient woodland of which very little remains. This represents 'critical natural capital' of both intrinsic and economic value whose loss would be irreplaceable.

In this chapter the report addresses the valuation of ecosystem services, moving from the very familiar – provisioning services like the supply of timber – to the less familiar - regulating services such as flood control, cultural services such as amenity, and supporting services, including biodiversity and soil formation, and finally option values. However, readers of this report may be surprised to find that the more familiar market values, such as timber, are sometimes exceeded by less familiar ones, such as amenity. This underlines the importance of eliminating the gaps that currently exist in accounting systems for environmental wealth.

Box 2 Economic valuation methods

Various direct and indirect valuation methods are available to quantify the value of ecosystem services in monetary terms. These include:

The **production function approach** is ideally suited to the quantification of provisioning services, but can also potentially be applied to regulating and supporting services. It can be applied in cases where natural capital provides an input to a final output, the value of which can be identified through a market price. The challenge is to separate the natural capital input from other inputs and to identify the nature of the ecological contribution, i.e. the character of the ecosystem function.

Averted expenditure values an ecosystem service through costing the creation of an artificial substitute. For example, coastal defence structures provide substitute storm protection formerly provided by a dune system and/or a salt marsh. This method does not directly give the value of the ecosystem service, but rather of its alternative. However, this enables us to price the benefits provided by conserving or restoring natural capital, benefits that usually come at a significantly lower cost than artificial alternatives.

Revealed preference methods examine people's behaviour as a measure of the benefits (utility) they receive from the use of non-market goods, including natural resources. Common examples are travel cost methods, which measure the cost people are willing to incur in visiting a natural site, and hedonic pricing, which measures the contribution of a natural feature to property prices. The challenge is to identify the nature of the relationship with the natural good. These methods do not capture the person's full consumer surplus, i.e. the maximum price they would be willing to pay to experience the natural capital.

Stated preference methods attempt to identify the maximum 'willingness-to-pay' (WTP) through surveys in which respondents are presented with a scenario of protection, loss or enhancement of an environmental good. In this case the challenge is to secure accurate responses and to avoid hypothetical bias in which respondents treat the questions hypothetically or without due seriousness. One of the two principal stated preference techniques is the contingent valuation method (CVM) in which a respondent is asked directly how much they would be willing-to-pay for a good (or willing to accept for a loss) using either open ended or more sophisticated dichotomous choice approaches. Alternatively, discrete choice experiments (DCE) are used to establish values for discrete attributes or levels of provision, outputs that are frequently sought by environmental managers. Related conjoint approaches include contingent ranking or rating.

Provisioning Ecosystem Services

Timber and Wood Products

In the early years of the last decade the outlook for Irish hardwood products was positive. Xenopolou (2004)[13] reported that Irish products were in demand by the furniture and crafts sector, which represented 45% of the market at the time, followed by sawn timber at 36% and wood turning at 27%. These businesses were mainly small in size but numbered 250 and together employed around 8,000 people, approximately 1,000 of whom worked with hardwoods. Purchases by such businesses amounted to 3,298m^3, although it was thought that actual hardwood output could have exceeded twice this amount. The main species sought were ash (30%), beech (26%) and oak (24%), with demand exceeding supply for oak.

However, hardwood prices had been falling in recent years. In 2009, standing prices averaged £18-£22 per m^3 in the UK, although higher grades were selling at £55/m^3. Overcapacity in overseas processing of hardwoods is a major factor. This problem is compounded by the loss of a large number of private furniture businesses that have been unable to compete with the price of imports. Partly as a consequence, Coillte are in the process of closing the country's only mill dedicated to the processing of hardwood. Therefore, while Ireland's hardwood resource is valued by the domestic processing sector, this sector has diminished in size.

Nevertheless, hardwood is fundamentally a desirable product in the market place. Traditionally millers have used American and European products because so little Irish hardwood was available. However, they argue that Irish timber offers a more complex colour and texture.[6] The sector has significant potential if the Forest Service Native Woodland Scheme, the Broadleaf

[6] From discussion with Irish timber millers. See also Heaney (2002).

Afforestation Scheme and the Woodland Improvement Scheme can deliver more regular supplies from a larger area that is adequately managed for timber production. Recent price rises for firewood are providing an incentive for improved silviculture, especially as firewood is a large proportion of output from all woodlands irrespective of whatever silvicultural system is applied.

The NFI estimated that the broadleaf growing stock amounted to 11 million m^3. However, values based on standard yield models bear little resemblance to reality. Much of the resource is in privately-owned woodlands which are undermanaged to such an extent that total sawlog output is estimated at 20,000 m^3.[7] A few estates are producing timber at the highest quality grade, selling at between €100/m^3 and €300/m^3, but hardwood from all other grades is currently selling at €60/m^3. Altogether, the standing value of sawlog output is approximately €1.36 million per year.

Native woodlands – Timber and Wood Products

The total value of forestry output prior to processing was €378 million in 2010. The total value of the sector, including expenditure generated by wood products, was €2.2 billion (Casey and Ryan, 2011). Ireland is the largest supplier of softwood based particleboard in the EU.[14] By comparison, around 20,000m^3 of native broadleaf roundwood is harvested each year at a value of approximately €1.4 million.

Wood Energy and Firewood

Wood for energy is both a product of the forest ecosystem and is of value for the mitigation of climate change. The EU has set targets of cutting greenhouse gas emissions by 20% and establishing an equivalent percentage share for renewable energy by 2020. National policies have set a target of 30% for co-firing in power stations by 2015 and increased demand for biomass by more than 4 million tonnes. This biomass target, particularly as it relates to power generation, is proposed to come mainly from short-rotation forest. Although this type of forest (mainly willow) has some potential benefits for small mammals and birds,[15, 16] it is essentially an intensively managed monoculture whose environmental benefit is mainly related to climate change mitigation, but with some risk of some adverse impacts, especially eutrophication. By contrast, net environmental benefits are realised where trees are grown according to the principles of traditional coppice. As advocated by the Coppice Association of Ireland, coppicing is a form of woodland management for an array of wood products rather than wood fuel alone (although fuel and charcoal are also by-products). Many surviving ancient and old woodlands were once coppiced and some woodland species are specifically associated with this silvicultural practise. Unlike short rotation plantation forestry, coppiced woodlands are physically accessible and, being endowed with floral diversity and colour, are also biodiverse and attractive places to visit.

Wood-burning has a carbon intensity of 0.35 kg CO_2 compared with 0.49 kg CO_2 for the average grid mix and is also carbon neutral.[8] Current energy demand for biomass is estimated at close to 2 million cubic metres of which fuelwood is estimated at 200,000 m^3, an increase of 35% in five years.[9] The fuelwood market is estimated to be worth €29 million per year. There is nonetheless, considerable potential for market growth given the rising costs and high carbon emissions of oil-based heating systems. An acre of woodland can produce 3.3m^3 of thinnings or a tonne of dry firewood per year.[10] In addition, fuelwood represents over half the output of

[7] The Native Woodland Survey 2003-08 put the proportion of merchantable timber at just 3.8% (68,000 stems) from 82,000 ha of which oak contributed 60%.
[8] Figures taken from the Carbon Trust (2005) and Forestry Commission (2007).
[9] Roundwood Demand Group (COFORD 2011)
[10] See (www.coedcymru.org.uk).

commercially managed hardwood forests when thinnings and waste is subtracted from quality grade timber. Increased demand has led to the creation of some market initiatives such as the Clare Wood Energy Project (http://www.ccwep.ie).

The market for brash, timber offcuts and thinnings is providing an incentive for improved forest management. Given the potential for 3.3m^3 per hectare, the current area of native woodland could supply 315,000m^3 of fuelwood per annum However, while an additional 10,000 ha of new broadleaf woodlands have received their first thinning, most of the existing area has rarely been thinned despite current fuelwood prices of €50/m^3. Assuming one fifth of the total area is thinned, the value derived would be between €1 and €3 million per year. In addition, firewood collected by farmers or woodland owners or purchased directly by others could yield savings of perhaps €3 million per year on the cost of heating oil or coal thereby substituting fossil fuels with wood.

Native woodlands – wood fuel

A provisioning service is apparent in the capacity of woodlands to provide fuelwood with benefits too for climate change mitigation. This market is growing and estimated to be worth €29 million per year with thinnings from native woodlands potentially worth €3.3 million per year. In addition, rural households save over €3 million per year on purchases of alternative non-renewable fuel, including marketed and non-marketed peat. The demand is encouraging improved woodland management and a renewed interest in forestry, including broadleaves.

Wild Foods

The collection of fungi and berries is a common activity in continental European, countries where a woodland culture exists. Collections of wild foods do occur in Ireland on a limited basis by individuals, often non-nationals, and for the restaurant trade, and foraging is currently receiving increasing media and public attention. However, most forest wild foods, valued at approximately €1.4 million, is imported. COFORD established a project (FORESTFUNGI) to explore the potential market of woodland fungi alone, which is very underdeveloped. Around 29 edible species occur in Ireland.[17] Wild venison also has considerable potential, supplies of which could be more actively exploited if supported by food standards and marketing underpinned by a national deer management strategy.[70]

Regulating Ecosystem Services

Water – Quantity, Quality and Prevention of Bankside Erosion

Ireland has 16,000km of main river channel and an equal length of tributaries, along with approximately 5,000 lakes covering 200,000 ha. Native woodland provides a regulating ecosystem service by moderating run-off, reducing impacts from flooding, erosion and siltation, and absorbing pollutants.

Regarding run-off, the more constant base flows in forested catchments represents about 60% of total flows compared with 20% in non-forested catchments.[18, 19][11] However, good natural capital accounting requires that losses as well as gains are registered: there are generally reductions in groundwater recharge due to canopy interception and root uptake/transpiration, which could exacerbate water deficits should these arise as a consequence of climate change due to lower rainfall. But the balance is still positive for woodlands in these accounts: flooding presents a greater risk to life and property than ground-water deficits following the heavy rainfall events that are predicted to become more frequent in Ireland in future climate change scenarios. Native woodland increases the *roughness* of channels holding back river flow by 15%-70% while the duration of peak flow is extended and moderated by 20-140 minutes.[20] The economic benefits of damage avoidance due to peak flow moderation by woodland depends on the severity of weather events, the nature of the catchment, the type and area of forest and the value of property at risk. An application of a monetary estimate to this benefit would be very place-specific. However, it is worth recalling that the 2009 floods in County Cork cost the city authorities €35 million, with a total cost to affected homes and businesses estimated at between €80-€100 million.[12]

The mitigation of excessively high river flows is beneficial to wildlife too, including nesting waterbirds and salmonids. Native riparian woodland provides shade, food supply, erosion control and protection from polluted run-off. When riparian woodland is created in a mosaic with open areas and wetland habitats it enhances valuable salmonid habitat and has been shown to increase fry survival. [21, 22] Returning salmon numbers have been declining nationally, hence the natural capital value of good quality rivers with appreciable numbers of returning salmon is very high. For example, each salmon caught on the River Moy in County Mayo is estimated to add €2,000-€8,000 in capital value through fishing rights, equivalent to as much as €500,000 per kilometre for the best sections of the river.[23] The Moy is one of the premier salmon rivers in Ireland and indeed Europe. There are a number of other rivers that are comparable, and many more important angling rivers and tributaries whose value could be enhanced, by a significant amount if protective riparian woodland strategically planted and appropriately managed. On average, each rod-caught salmon is currently worth €1,000 as well as being a significant driver of the tourism economy, amounting to at least €11.5 million nationally as of 2003.[23] Angling on the River Tweed in Scotland, which is comparable to the Moy, contributes £13 million annually to the local economy.

Forest ecosystems also protect potable water quality through the filtering effect of soil and ground flora on surface and groundwater. Riparian woodland provides a buffer against diffuse agricultural pollution including nutrients released from slurry spreading and fertiliser that contribute to eutrophication, arguably Ireland's most prevalent adverse environmental impact. New York City is commonly presented as an example in this context: the city committed $700 million to forest catchment protection in the Catskill Mountains, which is reckoned to have saved very significant capital and current costs, as the alternative would have been the construction and ongoing operation of new water treatment plants. In Britain too, tens of millions of pounds are being invested by water companies in woodland protection and peatland conservation, for example at Lake Vyrnwy in Wales. Economic benefits are realised through the utility value that people attach to clean water and freshwater habitats and through savings on the level of water purification built infrastructure that would otherwise be needed. Various scenarios related to achieving the good quality status required under the Water Framework Directive (2000/60/EC) have been included in public surveys across Europe. A transfer of European values calibrated to the Irish context has estimated small and large improvements in water quality to be worth €32 and €66 per household per year respectively.[24, 25]

[11] Flows are also moderated by the effect of soil porosity and subsurface movement (Neary et al, 2008).
[12] Mr. Eamon Downey of Owens McCarthy insurance assessors as quoted in The Irish Times (18/7/02)

Native woodland – water

Native woodland cover provides a regulating ecosystem service by reducing the incidence of damaging floods and by maintaining good water quality. Although, in principle, the economic benefits are very sizeable, those provided by the current small area of native woodland are slight, though not irrelevant where native woodlands are located adjacent to watercourses. To date, most habitat improvement on angling rivers has involved basic rehabilitation, rather than riparian woodland establishment. Shade and woodland do make an economic contribution in terms of enhancing salmon angling potential, but its current contribution to water quality and to fish habitat is marginal. None of these values can be reliably quantified at present, but there is clearly the potential to realise much more significant economic returns from this service.

Soil protection and Prevention of Erosion

In many parts of the world deforestation has led to enormous problems of erosion and flooding. In Ireland, woodland can be strategically planted to secure hillside soils that have been subjected to overgrazing. River bank erosion can be reduced by strategically planting native riparian woodland at catchment level, especially at vulnerable locations. New and existing riparian woodland not only bind soil via tree roots but also intercepts nutrients. Hence, losses of agricultural land can be reduced while reductions in sedimentation also benefit aquatic fauna, especially freshwater pearl mussel habitats and the spawning grounds of fish. Even narrow riparian exclusion zones can reduce bank erosion caused by livestock in the vicinity of watercourses.[13]

Native woodland - erosion

The potential economic benefits of reduced hillside and river/stream bank erosion are significant in principle, but currently modest in practice due to the small area of native riparian woodland. The value of agricultural land in many vulnerable areas is variable, but in some catchments exceeds €11,000 per acre. In these catchments the loss of income due to soil erosion may be very considerable.

Carbon sequestration

Forest is a significant resource in terms of the mitigation of climate change, both in terms of the absorption - or sequestration - of CO_2 from the atmosphere and as a long-term store of carbon. Net sequestration can be estimated in terms of its marginal economic value. It occurs during tree growth and varies with species. Sequestration by willow is typically high, but the length of its rotation and the lifetime of its products are short so that carbon is quickly returned to the atmosphere. Sequestration by conifers is high as they grow quickly, but broadleaves generally accumulate even more carbon due to longer rotations, e.g. oak, ash and cherry. For commercial conifers, the accumulated carbon storage from planting to harvest is only approximately one third that of a broadleaf forest at full maturity.[26, 27]

While sequestration diminishes as trees mature, many broadleaf trees will remain in situ as a long-term carbon store. Hardwoods are cut for durable purposes such as furniture and construction as well as for low value pulp and pallets. Both hardwoods and softwoods also displace energy intensive products, for example concrete in buildings. When used for energy to replace fossil fuels, displacement amounts to 100%.

Estimates of carbon sequestration must take account of carbon cycles in the leaf litter and soils. In a newly planted forest, it may take several rotations before soil carbon reaches a stable,

[13] Coed Cymru woodland project in Wales. See http://www.coedcymru.org.uk/

maximum level. Ancient woodland is a far greater carbon store than younger forest life cycle stages.

Table 1 provides estimates of annual carbon sequestration based on the influential work by Cannell and Milne (1995). More recent estimates have been revised upwards by over 40% to between 4 to 8 tonnes carbon/ha per year for younger plantations on the basis of new models.[28] The carbon storage capacity of broadleaves accumulates as the trees mature, particularly on higher yield class soils where it can reach 115 tC/ha. The total carbon reservoir can amount to as much as 298 tC/ha when soils are included.[29, 30] Planting broadleaves, particularly for amenity, protection and/or biodiversity, can involve little disruption to soils and therefore, to the existing carbon store.

Table 1 Carbon sequestration and storage

Species	YC	Rotation Years	long-term carbon storage tC/ha^{-1}		annual sequestration tC/ha/yr.
			trees & products	plus litter and soils	
Sitka Spruce *	16	55	86	192	3.6
Sitka Spruce *	8	65	61	146	2.4
Scots Pine	10	71	79	178	2.7
Beech	6	92	85	200	2.4
Oak	4	95	67	154	1.8
Willow coppice	-	8	22	93	5.9

* Assumes thinning has occurred (which reduces C by 15%). Sources Dewar and Cannell (1992) and Cannell & Milne (1995).

Annual sequestration by Ireland's forests is estimated at up to 2.4 million tonnes of CO_2. Noting that much of Ireland's native woodland is low density on poor quality soils, and assuming that only around one fifth of this area is comprised of young trees,[14] annual sequestration is estimated at 30,000 tonnes (approximately 110,000 tonnes of CO_2) after allowing for net emissions from bog woodland. This figure could, however, amount to 42,000 tonnes (154,000 tonnes CO_2) or more given higher recent estimates of sequestration.[31] In addition to sequestration, total carbon storage (trees, soils, litter and deadwood) by Ireland's native woodlands could amount to as much as 80 million tonnes.

Various methods are available to price this regulating ecosystem service. Typically, the long-term traded price of carbon on the European Emissions Trading Scheme (ETS) is used as a measure of value. Current prices are €15-€20 per tonne. Discounted at 5%, the present value of sequestration from oak (yield class 6) is €200-€270. In principle though, the social value of sequestration should depend on its impact in reducing future climate change costs. Recent official advice from the UK (DECC, 2009) suggests that sequestration should be valued in relation to the abatement cost of meeting mitigation targets using other renewable energies. This implies a cost of £50 per tonne of CO_2 equivalent, a figure that is expected to rise to £70 by 2030.[15] On the basis of these figures annual sequestration of CO_2 in Ireland would be worth between €2 million and €6 million per year. A discounted value of the carbon store could be worth substantially more assuming future climate damage can be estimated.

[14] Upper range of total forest estimates is taken from Black and Farrell Eds. (2006).
[15] This for UK abatement targets of 12.5% below 1990 emissions levels requiring an annual emissions reduction of 16%.

Native woodlands – carbon sequestration

Most of the current stock of native woodland is mature, but assuming that 20% is in an active growing phase, sequestration of between 110,000 and 154,000 tonnes CO_2 is possible. At current prices this ecosystem service would be worth an average of €2 million per year, but probably closer to €8 million depending on the estimated rate of sequestration and future carbon price assumed.

Cultural Ecosystem Services

Amenity and Recreation (utility)

At least 18 million visits are made to Irish forests each year.[16] In the UK, the numbers involved in forest recreation have more than doubled since the 1980s[32] and it is likely that a similar trend has occurred in Ireland.

Various public surveys have been undertaken to determine the value that forest visitors place on these trips. As discussed in the methodology (Box 2 above) the contingent valuation method (CVM) is commonly used to measure the income that people are prepared to forego, i.e. what they would be willing-to-pay, in return for continuing to enjoy the experience of visiting woodlands. Measuring people's utility as an indicator of economic welfare is now accepted practice for the non-market valuation of natural resources internationally.

Based on a number of surveys, people's willingness-to-pay for forest visits varies between €4 and €10 per trip depending on the frequency of trips and the nature of the visit. A median figure of around €7 per trip represents an approximate average since regular visitors will generally place a relatively low value on an individual trip compared to less regular visitors, including trips to more remote forests. In addition, up to 5% of visits are likely to comprise more specialist activities such as bird watching, horse riding or mountain biking. Specialist forest users in the UK have been estimated to value each such trip at almost €20[12].

On the basis of these estimates it can be assumed that adult visitors to Irish forests value these trips at an aggregate minimum of €126 million per year (i.e. €7 x 18m), but it is more likely to be above €165 million per year based on the frequency of adult visits to *all* forest areas and types of use as reported in national surveys (approx 38m visits in total).[33][17] Furthermore, this utility gain is not confined to use, but extends to everyone in Ireland through non-use values too, which reflect how people value the existence of forests for landscape enhancement

[16] The figure is given by Coillte (www.coillte.ie/aboutcoillte/recreation) for visits to the Coillte estate, which represents the bulk of accessible forest in Ireland. The figure equates to that given by Fitzpatrick Associates (2005) based on the median number of visits (6) made by people interviewed in forests.

[17] Based on an average willingness-to-pay (WTP) of €7 per visit (more frequent visits valued at half of this value) and the relative median frequency of visits taken from the wider postal survey undertaken by Fitzpatrick Associates (2005) for the Coillte and the Irish Sports Council, i.e. 14% of the population never visiting woodland, 41% 1-6 visits, 11% 7-12 visits, 26% 13-52 visits, and 8% > 52 visits, less 740,000 visits for specialist activities. This study has valued less frequent trips at €7 per adult, more frequent (13-52+) at €3.64 and specialist trips at €20. These figures are quite conservative compared with the cost of other priced leisure activities. The total is reduced on the assumption that around one half of trips are by individuals and one half by couples/groups.

and use by other people. If it is conservatively estimated that non-use value is the same as a single woodland trip by every Irish adult, the cumulative amenity value rises to €188 million per year.

These figures provide an indication of the amenity value of all types of forest in Ireland. Native woodland comprises just over 14% of the total forest area and most of the native woodland area of 100,000 ha is over 15 years old. Curiously, no study of amenity values has been conducted in Ireland or the UK that is specific to native woodlands. However, a few surveys have included tree species amongst the attributes of forests that respondents were asked to consider [34-36]. These studies report a range of results including a preference for spaciousness and mixed species.[18] In a survey by Upton et al (2012), broadleaf woodland was valued 30% more than a standard baseline scenario of conifers, and mixed species woodland was valued at 43% more.[19] This suggests that the proportion of Irish forest that is represented by native woodland is valued at least at €30 million per year by forest users based on the averages used above for forest in general. If this equation is extended to a total utility value, including non-users' valuation of woodland access and landscape, the amenity value of native woodland is likely to be worth at least €35 million per year.[20]

In principle, the number of trips to native woodlands could be expected to be in proportion to their relative value. However, the more scenic Coillte forest parks attract significant use, while many native woodlands are located on private land or are in less accessible, remote locations. It therefore seems appropriate to consider the above figures as a basis for projecting the value of a larger area of accessible native woodland.

Table 2 Current forest amenity values under various assumptions.

	Original aggregate estimate for all forests	Of which a proportionally higher value of broadleaf	Relative amenity value of larger conifer forest area
Visitor values	€165m	€30m	€135m
Non-use values [17]	€23m	€5m	€15m

Native woodland amenity value

The amenity value of forest makes a very significant contribution to economic welfare. Given its proportional area and relative value, existing native woodland attracts an annual value of at least €35 million per year based on total amenity value by Irish nationals**.**

Amenity and Recreation (tourism and expenditure)

As forests attract visitors their non-market value extends to a market return through tourism. This includes trips by Irish visitors (both day-trips and over-night visitors) and trips by overseas tourists. Both groups spend money on accommodation, food and local services. Like all tourism

[18] It is possible that the higher value that people place on mixed species woodland is due to variety and landscape considerations (Neilsen et al, 2007). Although it is equally possible that this is due to the desire to express a compromise between all broadleaf and all conifer.

[19] Upton et al (2012) applied Discrete Choice Experiments (DCE) to a hypothetical expansion of forest area rather than the existing area. In DCE, the coefficient represents probability of choice for broadleaf woodland. This was 30% higher than that for the baseline of conifers. The coefficient can be divided by the coefficient on price to indicate willingness-to-pay.

[20] Including values based on the estimate for numbers of irregular visitors drawn from the Fitzpatrick Associates (2005) postal survey.

expenditure, this can make a significant contribution to local economies, especially in rural areas that often lack a diversity of employment sectors. Tourism expenditure can also have a significant multiplier effect as the sector is a buyer of services and is labour intensive. This ensures that a considerable portion of expenditure is recycled back into the economy through local suppliers and employees. Regular forest users, including overseas visitors, also purchase outdoor clothing and equipment, as is evident from the presence of numerous specialist clothing shops in tourism hot-spots.

The Coillte/Irish Sports Council survey of 2005 found that Irish forest and trail users spent an average of just under €15 per trip, or €64 per trip when staying overnight.[21] On the basis of figures from this survey, forest-related expenditure would amount to €135 million per year with most of this remaining in the local economy. On top of this figure, the most frequent forest users spent €70 million on equipment such as boots. Forest parks attract most visitors and, while comprised largely of conifers, often contain pockets of native and mixed species woodland. Consequently, the proportion of expenditure associated with native woodland is tentatively estimated proportionately to be €30 million per year.

International tourists, including visitors from Northern Ireland, contribute around €4 billion to the economy. Along with domestic tourism this contributes 3.7% of GNP and employs 322,000 people. Although Ireland has many attractions, native woodland is a key feature of popular destinations such as Glendalough and Killarney National Park, which both attract one million visitors each, every year.[22] Assuming that half of the visits to these key sites is by overseas tourists and that native woodlands account for only 10% of the attraction (almost certainly an underestimate), this suggests a value of nearly €20 million per year. Furthermore, scenery is consistently the main reason given by tourists in Failte Ireland surveys for visiting Ireland. Native woodlands are therefore not just destinations in themselves, but integral elements of landscape quality, particularly in counties Kerry, Cork, Waterford, Carlow and Wicklow. Therefore, they are also integral elements of Ireland's identity and are of considerable value to Irish people and foreign visitors alike.

Native woodland – tourism value

Domestic visitor expenditure associated with native woodlands is conservatively estimated at €30 million per year. Popular forested tourist destinations such as Glendalough and Killarney National Park are together likely to contribute comparable returns on their own. Expenditure of €20 million or more by overseas tourists can almost certainly be attributed to native woodland. Indeed, both figures are likely to be very low estimates given the indirect attraction of forested landscapes to tourists, both domestic and overseas.

[21] Based on the survey by Fitzpatrick Associates (2005) for Coillte/ISC. These figures relate to *both* forest trails and way marked trails so forest-related expenditure is distinguished here from the estimates given for all trial users expenditure, e.g. €161m in the case of equipment.. The figure of 18 million trips is used here assuming these to involve more formal visits.

[22] www.npws.ie/publications/archive/KNPMP.pdf. www.wicklowmountatainsnationalpark.ie

Health

Forest recreation contributes to public health in many ways. Visitors often say that they experience physical and mental health benefits from exercise in woodland. Physical exercise is vital in combating obesity, cardio-vascular and musculo-skeletal diseases, stroke and cancer [37]. The woodland environment also has a role in relieving stress and depression. Consequently, there are public savings on healthcare expenditure and there is increased productivity due to reduced absenteeism. The healthcare savings can be very significant: the cost of rising levels of obesity in Ireland, for example, has been estimated at €370 million per year.[38]

If applied to Ireland, figures for the UK suggest that just a 1% reduction in the 24% of the population who are physically inactive would reduce premature deaths and morbidity amongst people under 75 years by 715 cases per year and save €37 million in annual healthcare costs and productivity losses. While it is almost impossible to demonstrate a direct link between forest recreation and health, we can indicate the benefits based on the average number of forest trips per person per year (i.e. between 23 and 27).[33, 39] If just 1% of the 37% of Irish people regularly visiting forests had previously been inactive (i.e. 3,800 people), the immediate benefit would be €15 million per year.

Even if these figures were reduced by two-thirds[23] to account for the effect of other exercise opportunities, they suggest that the benefits applicable to all types of forest would be €5 million per year and €1 million per year for the native woodland component. However, this is a modest figure in comparison with the economic value of amenity and, while there is some overlap, it can argued that the true benefits to health are likely to be much higher given the role of forests in family recreation and general wellbeing, the benefits to psychological health, and the value that people attach to their personal health. Children gain additional benefits from exercise, like spatial skill development. None of these benefits has yet been fully quantified, but a range of evidence is presented by Winson (2011) and others. [37, 40]

Native woodlands – health

Woodland recreation contributes to public health and reduced health expenditure. A direct link is impossible to estimate precisely, but UK figures based on participation in woodlands activities by previously inactive individuals suggest a minimum economic benefit in Ireland of €1 million per year. Once other benefits are taken into account, the real value could be 2-3 times this figure. The real opportunity however, is presented by the potential to accelerate the reduction in inactivity to more than 1% per year (refer to Chapter 5 and the benefits of an expansion of native woodland).

Biodiversity

Biodiversity can be argued to have an inherent or intrinsic value, which is arguably infinite because it is irreplaceable. However, it is possible to identify an element of biodiversity's cultural ecosystem service value in terms of how it is valued by human beings. Applying CV methods (see Box 2 and also the Amenity and Utility section), Christie et al (2006) report values of €55 per household per year for habitat creation in the UK while Garrod and Willis (1997)[41] found that biodiversity objectives increase willingness-to-pay for woodland by 70% over a basic conservation scenario.[24]

There is reason to suspect that these utility values could be higher in Ireland due to the smaller area of broadleaf woodland. Based on a survey of public attitudes in Ireland to future planting,

[23] Regneris (2009) reduce their estimate by three-quarters on the same basis. In either case, the reduction is rather arbitrary as no data exists to guide the estimates.
[24] Both surveys used CVM to estimate average willingness-to-pay.

Upton et al (2012) found that a scenario of 30% forest area being set aside for wildlife was valued at 53% more than for a scenario with no such areas. Nonetheless, it would be inappropriate, and risk double-counting, to simply add this proportion to the aforementioned amenity values given that many forest users' interest in visiting native woodlands derives from enjoyment of the surroundings and opportunities to see wildlife. At the very least, it is evidence for the earlier estimate of the relatively high amenity value obtained for broadleaf woodland including the non-use amenity component of €5 million per year.[25] More likely, based on the UK estimates above, a dedicated Irish survey of woodland biodiversity values would demonstrate aggregate annual utility values of €30 million or more per year. Note that this would be for cultural ecosystem service values only and not an estimate of biodiversity's inherent value or of its contribution to other ecosystem services.

Native woodland – Biodiversity

Biodiversity has an inherent value in its own right, to which it is almost impossible to ascribe an estimated value. Biodiversity is a factor in woodland amenity, but is also of value as a cultural ecosystem service that contributes directly to people's well-being. On the basis of UK studies, this value alone amounts to at least €40 million per year.

Supporting Ecosystem Services

Biodiversity, soil formation, nutrient cycling etc

Supporting ecosystem services are those ecological qualities and functions that underpin the provisioning, regulating and cultural ecosystem services. Biodiversity, as well as providing a cultural ecosystem service, plays a key role here. The functions provided by diverse woodland species are vital to a healthy forest ecosystem. At one level or another, biodiversity provides support for all the ecosystem services listed in this chapter and therefore contributes to all of the economic value estimates. While we have not found it possible at this stage to separate out this contribution and quantify it, it is nonetheless clearly significant.

Biodiversity directly contributes to the key supporting services of nutrient cycling and soil formation upon which overall forest health depends. Forests and hedgerows provide a habitat for predators of farmland pests, providing a significant ecosystem service especially in arable areas, recognised by the recent emphasis on integrated pest control. Compounds from forest biodiversity are continue to reveal potential pharmaceutical value, for example the development of the cancer drug Taxol, derived from the yew tree. In summary, the supporting ecosystem service value of biodiversity underpins all the regulating, provisioning and cultural services described in this report.

Since unit value increases with scarcity, the biodiversity of Irish native woodlands should be highly valued at present. The scarcity of remaining native woodland (and Ireland's island status) are principal reasons why there are fewer woodland flora and fauna indicator species compared and continental Europe. Ancient woodlands represent a time capsule of biodiversity from the period when forest covered much of Europe. For example, it is only in ancient woodlands that we find significant instances of the fissured bark, hollowed trunks, decay holes and large volumes of deadwood that provide niches for the survival of many specialist species.

[25] Upton et al (2012) used DCE. An addition of biodiversity values to broadleaf values implies a linear model without substitution between the two attributes. However, Upton et al found no significant interaction between the two attributes.

Although woodlands are often isolated in the modern Irish landscape, ancient woodlands are a core of 'critical natural capital' with species assemblages that have a vital role in habitat restoration, expansion and adaptation to climate change. The valuation of that capital is a challenge for the future.

Option values

An option value arises when a person is not currently using a resource, but nevertheless values – and is willing to pay for - the preservation of that resource in the expectation of possible future use.[42][26] Option values are now an accepted component of economic value (i.e. Total Economic Value). They are present where the future of an environmental good is uncertain and especially if its loss would be irreversible, at least in the short term, as is the case for ancient woodland sites and their inherent complex biodiversity, or in the long-term, as in the case of species extinction.

Option value is clearly difficult to quantify, and is typically not a large component of the value attributed to forests associated with present day needs such as recreation in forest parks.[43][27] Nevertheless, in economic terms, option values are income elastic and can be expected to grow if indeed personal incomes – and therefore willingness to pay - rise in real terms over time.

Ancient woodland is the product of many centuries of ecological evolution in which the forest ecosystem has had the opportunity to mature. In this context, the concept of quasi-option values becomes relevant. This describes a situation in which preservation has an added value in the expectation of future information.[44] The value of woodlands in-situ as reserves of biodiversity or as stores of carbon are examples of quasi-option value. Until recently, these benefits were not credited. Hence, while wildlife conservation has long been valued, the principle of ecosystem services was not. As the loss of ancient woodland is essentially irreversible (except in the very long term), the option value is greater than for other goods for which substitutes may exist. Quasi-option values have received much attention in relation to adaptation to climate change because it cannot be predicted with any certainty what challenges climate change will present in future.

[26] The concept was first articulated by Weisbrod (1964).
[27] Walsh *et al* (1984) provided an early attempt to quantify option values. Using surveys they found option value to be equivalent to 15% of preservation value (i.e. excluding per visit use values) and those values were very dependent on household income.

3. Schemes Promoting Native Woodland

Support for Native Woodland Planting and Restoration

The multifunctional value of forestry is increasingly recognised in forest policy and by the forest sector. As well as the conventional benefits attributed to forestry, such as timber, employment and local development, its amenity value is also being recognised, along with values related to biodiversity, water and climate change.

The period since 2001 has represented the most significant direct financial investment in native woodland in the State's history. Government policy is to plant 20,000 ha of new forest per year. While much of this planting is comprised of commercial conifer species, it also includes amenity, protective and biodiversity forest.[28]

All commercial plantations are now expected to comprise 10% broadleaf species and Areas of Biodiversity Enhancement. Although this does not equate to native woodland, all broadleaves provide some valuable outputs in terms of landscape and biodiversity. Most of the dedicated broadleaf component is planted under the Native Woodland Scheme (NWS) and the Broadleaf Afforestation Scheme. The first National Biodiversity Plan (NBP) 2008-2012 set a target of 15,000 ha for the Native Woodland Scheme. In addition, funds were made available for the management and improvement of existing native woodlands in public and private ownership. The new NBP 2011-2016 reiterates the Government's national broadleaf component target in the afforestation programme of 30%. However, funding constraints have caused afforestation targets to fall behind.

The planting of native species has been addressed by the following publicly financed forestry Schemes implemented by the Forest Service. Some of these Schemes have been suspended and cease to provide financial support for planting and/or management, but nonetheless maintain a profile along with a legacy, i.e. the physical presence of the trees and woodlands created and/or managed.

- Afforestation Scheme
- Native Woodland Scheme -Element 1: Native Woodland Conservation: no funding currently available
- Native Woodland Scheme – Element 2: Native Woodland Establishment
- Woodland Improvement Scheme (restricted)
- Reconstitution of Woodland Scheme
- Neighbourwood Scheme (restricted)
- Forest Environmental Protection Scheme (FEPS) (restricted)

Additional native woodland projects and support measures include:

- The People's Millennium Forests Project
- Coillte LIFE-Nature 'Restoring Priority Woodland Habitats in Ireland'
- NPWS National Survey of Native Woodlands
- NPWS woodland restoration programme
- Native Woodland Trust native woodland properties

[28] Growing for the Future (1996)

In addition, 22,000 ha of the Coillte estate (i.e. 5%) is designated as Natura 2000 under the EU Habitats Directive. A further 32 woodlands, amounting to 5,500 ha, are managed by the NPWS as Nature Reserves. Three of the largest NPWS-managed native woodlands totalling 1,700 ha are located in Co. Kerry (Killarney National Park, including Muckross, Tomies, Derrycunnihy, Glenna, etc.), Co. Wicklow (Wicklow National Park, Vale of Clara) and Co. Cork (Glengarriff). All of these are popular tourist destinations.

In this chapter, the key aspects of these schemes are set out, and a sample assessment is used to demonstrate their level of effectiveness in creating and augmenting natural capital value.

Afforestation Scheme

The Afforestation Scheme is the principle mechanism used for promoting afforestation of all species, although fast-growing conifers comprise the majority of new forests. Its stated objectives are timber, biomass and rural development, along with climate change mitigation, amenity, biodiversity and water quality. The Scheme supports planting with capital grants and annual premiums. New conifer plantations must include a mix of at least 10% broadleaves and an Area for Biodiversity Enhancement equal to 15% of the area that may include pre-existing broadleaves, scrub or open ground.[29] A management plan is required when the planted area is more than 10 ha of conifers (or 5 ha of broadleaf) and an environmental impact assessment is required where the area is more than 50 ha.

For new plantations, first instalment grants (i.e. 75% of the total) are payable immediately after planting with a second final instalment (i.e. 25% of the total) paid after four years once the woodland has been established and maintained successfully to the satisfaction of the Forest Service. In addition, income is received through annual premium payments for up to 20 years (Table 3).

Table 3 State supports available to Grant Premium Categories in 2013.

GPC	Forest Type	Total grant	Fencing allocation[1]	Premium (farmer)	Premium (non-farm)
GPC1	Unenclosed or unimproved land (max 20% area)	€2,000	€400	€155	€126
GPC2	Sitka Spruce or Pine	€2,900	€400	€369	€181
GPC3	10% Diverse mix (Spruce & Pine plus diverse species)	€3,000	€400	€427	€181
GPC4	Diverse (non Spruce & Pine plus diverse)	€3,200	€400	€454	€181
GPC5	Broadleaf, non-oak or beech	€4,700	€500	€481	€195
GPC6	Oak	€5,000	€500	€515	€195
GPC7	Beech	€5,000	€500	€515	€195
GPC8	Alder	€3,200	€500	€481	€195

[1] Alternatively maximum payments are available for deer fencing of €975 per hectare for upgraded fencing and €1,800 per hectare for new fencing (€1,950 for additional rabbit fencing).

Native Woodland Scheme (NWS)

The NWS was launched in 2001 and, for the first time, provided funding for native woodlands in public and private ownership.[30] The Scheme consists of two elements, i.e. NWS1 Conservation (for the improvement of exiting native woodland), and NWS2 Establishment (for the

[29] Where more than 10 ha are planted.

[30] For a time, the NPWS and Coillte could both avail of funding to enhance native woodlands, but funds for publicly-owned woodlands has ceased since 2007.

establishment of new native woodland). Existing woodlands are eligible under NWS1 where the existing overstorey is dominated by native species or where the herb layer is typical of native woodland. New woodlands are eligible under NWS2 on improved and marginal greenfield sites.

The Scheme is primarily aimed at protecting biodiversity and, where compatible, for promoting the supply of quality hardwood. There is a focus on sites that are sensitive from the perspective of environmental and landscape criteria, which are adjacent or close to existing designated sites (SACs, NHAs) or which can demonstrate connectivity, particularly with designated habitats or woodlands. As with the Afforestation Scheme, planting may include an ABE equal to 15% of the planted area to encourage a diversity of habitat, including glades, which would typically occur in natural woodland. Planting on unenclosed land is permitted up to a ceiling of 20% of the total application area.

Funding is available for management planning, the purchase of indigenous planting stock, site preparation, natural regeneration works, maintenance, clearance of invasive species, protection and fencing, and re-spacing. Since 2011, an ecological survey is no longer mandatory under NWS2 and has been replaced by a site appraisal framework which relates location, landscape, existing habitats and soils to the woodland classification system used in the NWS to determine the appropriate species to be established under GPCs 1, 5, 6 or 8.[31]

Woodland Improvement Scheme

The latest version of this Scheme was introduced in February 2008 and aims to improve existing woodland through active management and thinning for timber production. The Scheme is presently focused on the thinning and maintenance of broadleaves. The WIS differs from NWS1 in that its primary purpose is to realise a commercial crop and includes non-native broadleaf woodlands, i.e. beech and sycamore. In common with some other Schemes, additional objectives include landscape enhancement, soil and water protection. A maximum grant of €750 per hectare is available.

Reconstitution of Woodland Scheme

This Scheme was designed to allow for the restoration of plantation woodland following damage from disease, fire and deer browsing. The Scheme is not restricted to broadleaves but includes the objectives of maintaining landscape, biodiversity and the ecosystem. Grants are available to cover costs to a maximum of €7,604 per hectare for broadleaves.

Forest Environmental Protection Scheme (FEPS)

FEPS was open to farmers in the Rural Environmental Protection Scheme (REPS) at the time when new applications were still being accepted into the latter, i.e. REPS 4. Newly-established woodlands were intended to encourage marketable timber but also included the objectives of enhancing biodiversity, landscape and water quality, and the protection of archaeological heritage. In part, the productive element was intended to counter the common perception of farm forestry as being appropriate only for infertile or 'boggy' parts of the farm. Likewise, above the basic premium of €200 per hectare, grant payments were based on the GPCs but at higher rates than apply to the Afforestation Scheme. The Scheme requires a minimum of 15% broadleaves and 18% ABE together with a mix of mandatory and discretionary elements in this respect. Although FEPS is now closed it made a considerable impact in terms of environmental and landscape awareness at farm level amongst the farming community. In 2010 3,301 ha were planted, corresponding to 289 applications while, in 2011, 1,386 ha were planted, corresponding to 142 applications.[32]

[31] As tailored for the NWS by Cross et al (2010).
[32] Forest Service figures (2011)

NeighbourWood Scheme

The NeighbourWood Scheme is targeted at the development of both new and existing woodlands for public amenity in the vicinity of towns or villages. As such, it is focused particularly on realising social benefits such as recreation and education, as well as environmental benefits. Applications from community groups are encouraged. The Scheme publicity identifies the value of NeighbourWoods for broad sustainable planning, including greenbelts, greenways, buffers between residential and industrial areas, for the protection of watercourses and reclamation of former landfill or industrial brownfield sites. Maximum grants for Element 1 'Enhancement' are €4,500 per hectare (plus the standard fencing allowance). Element 2 'Establishment' allows for maximum grants of €5,000 per hectare. Provision for up to 30% open space is permitted within the Element 2 area and, aside from space for recreational purposes, should include an ABE. In addition, a third Element involves payments of up to €4,000 per hectare for recreational facilities (up to €2,500/ha 10-40 ha). After a period of suspension due to budgetary constraints, the NeighbourWood Scheme was re-opened for a limited period in July 2012.

People's Millennium Forest Project (PMF)

As the name suggests this project was developed at the onset of the new Millennium in 2000, proposed by Woodlands of Ireland. The PMF received financial support from Allied Irish Bank, the National Millennium Committee and the Forest Service. Over 600 hectares of native woodland were restored, mainly through planting on 16 existing semi-natural woodland sites countrywide. The project included a 'Family Tree Scheme' where a tree was planted for every household in Ireland, amounting to 1.3 million in total. The project also included an extensive ancillary programme, including a countrywide 'road show' for community engagement, information dissemination and education. The project was managed by Coillte in partnership with Woodlands of Ireland, and includes a draft Memorandum of Understanding that the woodlands be set aside in perpetuity for the nation as a public resource.

Coillte woodlands

A modest proportion of the Coillte estate is comprised of native woodland. Old woodland sites that have been wooded since the 1830s comprise 27,780 ha (6.4%) of Coillte's estate. Coillte has invested in the conservation of the highest quality biodiversity woodlands with biodiversity objectives and conservation as priority goals. From 2006-2009, Coillte managed an EU LIFE project 'Restoring Priority Woodland Habitats in Ireland'. Funded jointly by Coillte and EU DG-Environment, the project restored four priority woodland types (i.e. calcareous, alluvial, bog and yew woodlands) which are 'critically rare', not just in Ireland, but also in Europe. A total of 551 ha of woodland was restored at nine sites, all designated as Special Areas of Conservation (SACs) within the EU Natura 2000 network.

National Parks and Wildlife Service (NPWS) woodland programme

NPWS is responsible for implementing nature conservation legislation such as the EU Habitats Directive and the Wildlife Act. Native woodland forms part of this brief. There are 10,700 ha of native woodland designated as SACs on public and private land in Ireland. NPWS manages 45 native woodlands, 2,628 ha of which are located within 32 Nature Reserves and 2,854 ha within National Parks. Most of these native woodlands are also designated as SACs. State investment in native woodland conservation during the 20th century has focused primarily on these woodlands via NPWS and its predecessor, the Office of Public Works (OPW). District budgets for ongoing investment in native woodland conservation are required to meet Ireland's obligations under the EU Habitats Directive. Examples of ongoing woodland restoration include Glenveagh, Co. Donegal, Killarney, Co. Kerry, and the Vale of Clara, Co. Wicklow, which primarily involves the removal of invasive rhododendron, cherry laurel and under-planted conifers. However, no definite figures are available on the total woodland restoration costs involved.

The lack of detailed information on the character and condition of native woodlands nationwide was the rationale for the first National Survey of Native Woodlands, undertaken by the NPWS between 2003 and 2008, jointly funded by the NPWS and Forest Service (Perrin et al 2008, Cross 2012). It examined the distribution, flora, ecology, structure and conservation value of 1,320 sample woodlands and also gathered limited information on the quality and quantity of timber.

Table 4. State investment in native woodlands management in the last 15 years

Project	One-off expenditure per year	Annual expenditure	15 year 1997-2012 actual
Woodlands of Ireland			€1,215,000
People's Millennium Forests	€5,013,000		
NWS Element 1			€8,900,000
NWS Element 2			€7,211,000
Coillte LIFE	€1,475,000		
Coillte: district budget spend on native woodland		€750,000	€11,250,000
NPWS		no precise figures	no precise figures
Sub-totals:	€6,488,000	€750,000	€28,576,000

Coillte expenditure for 2011 native broadleaf is given less plant purchases. No NPWS broadleaf budget is available, although around €1000 per hectare is spent each year in Glenveagh NP on rhododendron clearance alone. Therefore the total figure above is an underestimate.

The ongoing investment in native woodlands made by the Coillte and NPWS is as significant as all other native woodland projects and Forest Service Schemes in the private sector. In Coillte's case this investment is a fundamental element of national Sustainable Forest Management (SFM) policy which underpins the company's Forest Stewardship Council (FSC) certification requirements with respect to international timber trade.

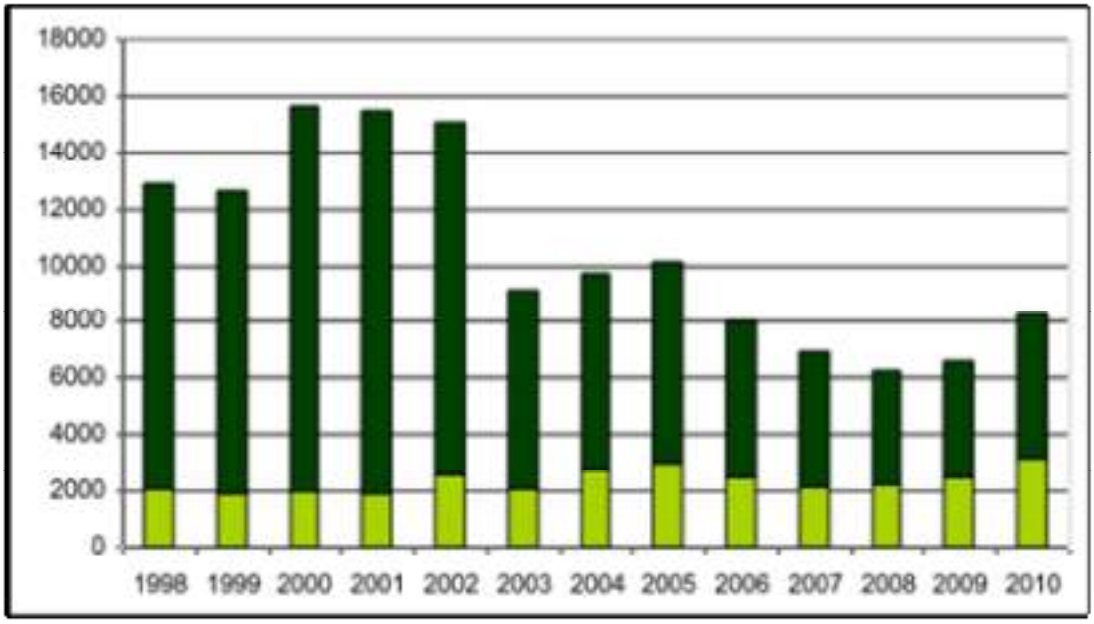
Performance of Forest Service Schemes

Total afforestation of broadleaves and conifers between 2002 and 2010 amounted to 30,982 and 105,954 ha respectively (Figure 1). Planting data by GPC and species has been available since 2008. The total area of broadleaf planting in 2010 was 3,149 ha compared with 5,164 ha for conifers. [33]

Between 2002 and 2011, 2,542 ha of existing native woodland were restored and 1,054 ha of new native woodlands created. Over €16 million has been spent on grants and €3 million on premium payments under the NWS. Although Establishment grants were first paid out in 2005, this element of expenditure had risen to over 40% by the end of 2011 on 1,054 ha. To date, more sites have been funded under the Conservation element (i.e. 165 sites in total under NWS1) than under the Establishment element (107 sites under NWS2), which reflects the initial focus of the NWS and the readiness of woodland owners to embrace the Scheme in the early years. Average grant expenditure per site is approximately €46,000, being slightly higher for Element 1 - Conservation.

[33] Ash accounted for 865 ha, oak for 704 ha and other or mixed broadleaves for nearly 1,500 ha.

Figure 1 Planting of broadleaves (light green) **and conifers** (dark green)



Grant payments are designed to cover the capital costs of establishment and initial management. Establishment costs are typically higher for broadleaves compared to conifers. For example, for oak (GPC6), costs are estimated to range between €3,990 and €5,420 per hectare. Premium payments are higher for Establishment as new woodland is substituting for agricultural income and permanently takes land out of agricultural production. Along with FEPS, the NWS differential between rates for farmers and non-farmers is designed to make tree planting more attractive, particularly for farms eligible for REPS.

The elimination in 2011 of the need for an ecological assessment under NWS2 – Establishment removed a disincentive for applicants to enter the NWS. Landowners were concerned that, in the event of their application being refused, they would still have to pay the significant up-front cost of the ecological survey. In addition, the new requirements for Appropriate Assessment have largely superseded the need for an ecological assessment in proximity to areas with environmental designations, i.e. SACs.

In practice, the success of projects is related to the landowner's motivations and the extent to which these meet the objectives of the Forest Service/NWS. Landscape, biodiversity, a desire for self-sufficiency in fuel wood and some additional income from timber sales feature among the motivations of most landowners, and are areas of public/private commonality.

Overall, there has been a positive trend towards more sustainable forest management and the concept of multifunctional forestry, of which broadleaf planting is a component. The potential financial and ecological value of native woodland is also being increasingly recognised in the forestry profession. Native trees are now also promoted within national road schemes. The public too is becoming more aware of the value of forests and the planting of native species. The PMF helped to kick-start this process through the restoration and planting of new forest areas, many close to urban areas. Surveys provide evidence of rising awareness of the environmental benefits of native woodland amongst the general public, particularly schoolchildren (i.e. surveys before and after PMF showed a 70% increase in awareness of forestry generally[34]). Awareness has also been maintained through annual events held at native woodlands during National Tree Week, National Tree Day and due to a small number of high profile native woodland NeighbourWood Schemes.

[34] Lansdowne Marketing Research (2002)

Unfortunately, state support has shown less continuity and commitment than is required given the current level of demand. Support for new applications for Element 1 of the NWS has now been suspended since 2008 and more recently, has been suspended for the Woodland Improvement Scheme. Although state finances are now much depleted as a result of the current financial crisis, suspension has also occurred in the past (e.g. in 2001), and this lack of funding continuity deprives the forest sector of the confidence needed to develop the native woodland and hardwood resource effectively. New applications for FEPS have also been suspended along with the closure of REPS. Funding is continuing only through the Establishment element of NWS along with occasional limited funds being made available for the NeighbourWood Scheme. For the time being, investment in the management of designated sites owned by the NPWS represents virtually the only state support for native woodland conservation.

Sample evaluation of Schemes

An evaluation of the performance of the NWS and other broadleaf projects with respect to their objectives is beyond the scope of this study. However, to complement the consultations undertaken and to assist with recommendations regarding the future management of native woodlands, ten NWS sites were sampled in order to assess the extent to which natural capital values are being realised.

The sample includes six existing woodlands (NWS1) and four new native woodlands (NWS2). The sites encompass upland and lowland locations in the West and Northwest, and lowland sites in the Midlands and East. Large woodlands close to urban areas (with high amenity value) as well as small rural woodlands are included in the sample. One existing woodland site is in public ownership, another is owned by an environmental NGO (Table 5).

The NWS2 establishment sites include upland and lowland plantations, with low and high timber quality potential respectively. Likewise, the existing NWS1 conservation woodlands include upland and lowland woodland sites with low and high timber quality potential. In the sample examined, the existing woodlands ranged in size from 5 ha to 107 ha. New woodlands ranged in size from 5.7 ha to 20 ha.

Although the sample size of ten sites is small, it helps to introduce the arguments that will be developed in the next chapter with regard to the realisation of potential natural capital values. For instance, half of the sites are located close to urban areas. They have the capacity to realise amenity values which, as noted in the previous chapter, are amongst the highest value outputs of native woodlands. There is potential to advance this value; three of these sites have a moderate value for public, passive recreation while one other is judged to be of more minor value for this purpose. A couple of these sites include interpretive signage and one is regularly used for education. Landscape benefits are observed for most sites; these are judged by the authors to be more significant at two locations.

Seven of the sites include some riparian habitat and three have potential to contribute to local river water quality. Each of the woodlands performs strongly as existing and future wildlife habitat, some within a diverse habitat mosaic. In some of these woodlands, broadleaves have replaced conifers. Other sites have at least some potential to produce small amounts of firewood and saleable timber, while two have high commercial hardwood potential. Timber output is not an objective in the sites managed by NGOs. Nonetheless timber production is compatible with conservation and wildlife objectives and, as an added incentive for the expansion of woodland habitat, increases biodiversity at a strategic level.

The sample does reveal problems with deer and invasive plant species. The latter have been removed on five sites, but rhododendron remains a problem at two others. Competitive weed growth persists at three sites, and this is compromising planted tree and shrub saplings. Five sites are experiencing problems with deer, one to a very serious degree.

In summary, the ten sites demonstrate how biodiversity benefits are being realised through the funding that has been made available for native woodlands and the importance of maintaining this support. The evaluation also indicates how a more strategic or targeted approach to planting could be used to increase natural capital values by realising biodiversity objectives along with amenity values, augmented - in some cases - with returns from timber or wood sales. The sample also highlights the threat presented by invasive plant species and deer, which have the capacity to undermine the potential value of new areas of woodland planting in particular. Although grant payments currently allow for the management of invasive plants and deer fencing, difficulties arise where both are present or where these are compounded by a lack of motivation among neighbouring forest landowners to reduce/control these problems. A comprehensive, strategic approach must therefore be applied to pursue maximum economic values in terms of the various market and non-market natural capital values described in the preceding chapter, while ensuring that these are not undermined by invasive plant species and/or deer.

Table 5. The sample of NWS woodlands assessed in this study.

Location	Sligo	Galway	Central Mayo	West Mayo a	West Mayo b	West Mayo c	West Mayo d	Wicklow	Leitrim	Offaly
Initiated	2003	2005	2011	2008	2004	2008	2005	2008	2003	2003
	public	private	private		**Private**	private				
Close to an urban area	✓	X	X	X	✓	X	X	✓	✓	✓
Grant Scheme	NWS1	NWS1	NWS2	NWS2	NWS2	NWS1	NWS2	NWS1	MWS1	NWS1
Woodland type	WN1	WN1	WN2	WN1	WN1	WN2	WN2	WN6	WN1	WN2
Area (ha)[45]	60	24	5.7	7.8	20	5	8	20	40	107
Natural capital value *										
Biodiversity	5	5	3	5	5	5	4	5	5	5
Recreation / educ. public	4	-	4	1	-	3		3	-	2
Private use	-	3			3	-	4	-	-	-
Water quality / angling	2	2	1	3	1	1	-	1		1
Timber potential	1	2	4	1	4	1	2	1	3	5
Challenges										
Deer	✓	X	X	X	X	✓	✓	✓	✓	✓
Goats									✓	
Grey squirrel										✓
Invasive species	✓	✓	X	X	X	✓		X	✓	✓
Poor growing conditions	X	X	X	✓	X	X		X	X	
Weeds	X	X	✓	✓	✓	X	✓	X	X	X

* benefits on a scale of 1 (low) to 5 (high)

Conclusions

This chapter demonstrates that there is a demand for broadleaf planting and that Forest Service schemes can be effective in expanding the area of native woodland and augmenting its natural capital value. However, it also demonstrates how inconsistent funding can undermine the potential of the schemes. Although forestry publications persistently make reference to the public good, this needs to be backed by a more tangible recognition of the various public good benefits and their respective value. For example, if the public amenity value of woodland is to be respected, this means either enhancing accessible woodlands that already exist or ensuring that the prevailing policy of expansion though private afforestation also delivers public amenity one way or another, particularly in the vicinity of urban areas. The NeighbourWood Scheme is a good mechanism to achieve these objectives, but is funded in an intermittent fashion. Realising public good values also requires pro-active targeting to support national objectives on biodiversity, long-term carbon storage, and the protection of water quality and provision of flood mitigation through strategic, appropriately sited riparian woodland. Rather than responding to applications when they are made on the basis of available funds, this requires a strategic area approach that promotes implementation in the short, medium and long term.

4. Case study - Brackloon Wood, County Mayo

Description

Brackloon Wood is an example of how the natural capital - augmented and created through native woodland restoration - can contribute ecosystem service benefits, even though the woodland is of modest size.[46, 47] It also demonstrates the economic and social benefits that could potentially be realised by a policy of significant native woodland expansion in parallel with strategies that seek to develop wider amenity, tourism and biodiversity objectives.

Brackloon Wood is located 7km southwest of Westport, Co. Mayo. This 74-hectare woodland comprises remnants of oak and birch with ground flora species characteristic of ancient native woodland, but was until recently, underplanted and interspersed with conifers, planted in the 1950s (Cunningham, 2005). The woodland is managed by Coillte and, commencing in 1999 all of the non-native conifers were removed and the woodland restored with native broadleaf species over a five-year period. Today, it comprises a rich mix of native trees and shrubs including sessile oak, downy birch, ash, willow and rowan, with an understory of holly and hazel. Ground cover consists of woodrush, hard fern and bilberry. There is also a wide variety of mosses, liverworts and lichens. The site is designated as an SAC under the EU Habitats Directive. In addition, there are areas of other habitat such as marsh and freshwater (the adjacent Owenwee River, which contains Priority species such as Atlantic Salmon).

The woodland is popular for amenity use and there is an internal looped forest road that is regularly used by locals and tourists alike.

Restoration

Prior to restoration, Brackloon Wood was in a depleted state, with fragmented stands of ancient woodland areas. There was little natural regeneration and very poor scope for native woodland expansion due to the adjacent conifer blocks. In common with most long-established native woodland in Ireland, active hands-on management is necessary to ensure the woodland can become more viable, thereby ensuring its long-term survival.

The wood was restored in the late 1990s under the Woodland Improvement Scheme at a cost of around €200,000. This rehabilitation project acted as a forerunner for the Native Woodland Scheme (NWS) and earned a Forestry award from the Royal Dublin Society. Excepting small areas of Scot's Pine (an 'honorary' native species[35], all other conifers were removed along with sycamore and some beech. A large-scale clearance programme of rhododendron was also undertaken. The seed source for oak locally was very limited and a seedling nursery was established with support from LEADER, which produced approximately 10,000 one-year old seedlings for planting in order to provide connectivity between the areas of mature oak. Other

[35] i.e. it almost certainly became extinct c. 1000 years ago, but was re-introduced subsequently.

sections of the wood contained soils more suited to ash, which was also planted, while natural regeneration of birch and willow proved to be quite prolific, especially in very wet areas. Indeed, the regeneration of birch has demonstrated the value of using it as a pioneer to create diversity at this early stage of restoration, in contrast to the oak-dominated 'climax' woodland. Some of this birch has now been thinned and this has had the effect of providing new habitat niches as a result of opening up parts of the woodland.

Tree regeneration has also benefitted tremendously from the absence of deer. If deer were present, expensive fencing and greater use of tree tubes would have been essential. Indeed, it would have been difficult in practice to erect fencing along the river and its absence would have left important alluvial trees and plants vulnerable to grazing. It would also have had an adverse impact on accessibility for people. While not preventing visitor access, deer fencing sometimes creates a negative psychological barrier.

Ecosystem services

The primary objective behind the restoration of Brackloon has been to establish a reserve for biodiversity. As a result of the necessary management that has been applied to date, the wood will in time develop into a mixed-age woodland, dominated by deciduous species with glades and areas of deadwood. Its rich floral community already includes Wood millet (*Milium effusum*) and Lungwort (*Lobaria pulmonaria*), species typical of long-established or ancient woodland. These species now have the potential to spread to new areas of woodland created in recent years. Pine marten, stoat and badger are also present along with wood warbler, a rare breeding species in Ireland (NPWS site description, 2009).

The woodland provides cultural ecosystem services of amenity value and is a popular destination, mainly for local people from the Westport area. A primary school is located beside the woodland and is occasionally used as an education resource for field studies. It is also contains various features of historic value, including a former woodsman's cottage and the remains of a mill race, as well as much older archaeology, including a standing stone, enclosures and a Late Christian souterrain.

The Owenwee River runs alongside the entire northern edge of the wood and supports trout and salmon. In addition, freshwater pearl mussel (an endangered Priority 1 listed species under the Habitats Directive) is found in the river adjacent to the woodland (NPWS, 2009). Hence the woodland plays an important regulating ecosystem service role in maintaining water quality along the length of the river. In addition, existing mature trees are a permanent carbon store, and the rate of carbon sequestration is increasing rapidly as younger trees grow in the restored zones that occupy c. 60% of the woodland area. The overall carbon balance is positive, as natural regeneration has avoided the need for extensive ground/soil preparation and consequent carbon emissions. Future thinnings may be used for firewood, an end-use that has the advantage of being carbon neutral.

Brackloon is managed for biodiversity and amenity, but could also have some limited future provisioning service values for sustainable timber production. The mature oak is of limited

timber value but has enormous biodiversity value. However, the newly planted oak and ash can provide the basis a harvestable crop in time, using continuous cover silviculture. Recently, the birch thinnings supplied a wood product and will also continue to provide a return in the context of the current buoyant market for firewood.

The Option Value of Woodland Expansion

At present, the attraction of Brackloon for amenity use is largely local and sign-posting is low-key. However, the wood could make a significant contribution to the integrated development of facilities for sustainable tourism. Potentially, Brackloon could act as a core area for a significant expansion of native woodland locally, along with supplying a corresponding range of valuable ecosystem services. An increase in native woodland to 30% of the land area locally could provide significant dividends. Expansion on this scale would certainly result in a more forested landscape, but much of this could be achieved by reversing centuries of fragmentation of former wooded areas. Planting that links existing pockets of native woodland, hedgerows, stream edges and other areas of semi-natural vegetation to a core woodland area like Brackloon would represent a strategic approach towards habitat connectivity. Peterken (2002), in describing a strategy for woodland expansion in the UK, outlines the benefits of ancient and large old woodlands in providing core areas for biodiversity.[48] He argues that expansion would not be characterised by trees alone, but would involve a mosaic of woodland and other habitats, with open areas containing wooded heath, wetlands and semi-natural grassland.

Brackloon is well placed to provide a core biodiversity hotspot for a possible woodland expansion project. In recent years, significant areas of new woodland and scrub have become established on lands to the north and east. There is potential to target support for a network of woodlands in the area, integrated physically or spatially. Biodiversity generally would gain tremendously from this connectivity at a landscape scale.

The existing wooded areas in the vicinity (circled in red on the map below - Figure 2) currently amount to approximately 20% of the area to the northeast, between Brackloon and the R336 Louisburgh to Westport road. A few of these areas are conifer plantations that could potentially be converted to deciduous or mixed woodland. While the eastern flanks of Croagh Patrick form part of an SAC of montane and blanket bog value, much of the lighter brown area consist of marginal grazing land that could potentially be converted to native woodland. The Figure 2 also shows the course of the Owenwee River, which snakes through areas of improved, and marginal grazing land, and existing woodland. A municipal water supply is located on the river adjacent to Brackloon Wood. Expansion of the riparian woodland area would further protect and enhance water quality and potentially enhance the river's reputation for angling.

Croagh Patrick is a major visitor destination and the Western Way walking route passes beside Brackloon and provides one of the most attractive routes to the summit ridge. Indeed, the entire area of West Mayo is very popular for tourism and amenity. The recently developed Great Western Greenway has attracted very considerable positive publicity and considerable numbers of cycling/walking visitors. It has had the effect of reinforcing Mayo's rapidly developing reputation for activity tourism. A recently designated cycle route runs alongside Brackloon wood and ties into the Croagh Patrick Loop.

In 2009, 800,000 foreign visitors went hiking in Ireland. Their total spend was €183 million. Those for whom walking was a major element of their stay spent

over twice the average amount. Around 25% of all walking visitors and holidaymakers spent their time in the West of Ireland. Tourism and local community amenity could benefit significantly from a coordinated strategy of woodland expansion and the provision of recreational facilities (i.e. signage, walks, etc.).

Brackloon not only has the capacity to act as a core forest area for woodland biodiversity, but could also act as a hub for a major expansion of amenity tourism. This could begin with a modest investment to promote awareness of its location, along with directional and interpretative signage, picnic facilities and publicised links to adjacent cycle and walking trails. Ultimately, amenity expansion could result in significant dividends in terms of biodiversity, tourism, amenity, angling, water quality and landscape values. There is no reason why similar projects could not be developed elsewhere in Ireland around core native woodland hotspots.

Figure 2: Map of Brackloon (arrowed centre right) and local woodlands
(Note: Areas circled in red are woodlands, predominantly regenerating 'scrub comprised of native trees and shrubs)

5. The Potential Benefits of an Expansion of Native Woodlands and the Negative Economic Consequences of their Neglect and Decline

Introduction

Ireland has some beautiful native broadleaf woodlands and a handful of ancient woodlands that are especially valued for their contribution to biodiversity. However, a considerable number of our woodlands have been neglected for so long that their future viability is compromised. Most are small in size, dispersed and/or highly fragmented. In addition, most are unmanaged and over-mature in terms of providing a valuable timber supply.

This chapter first describes the threats to Ireland's existing native woodland area, and the economic losses they incur. Subsequently, the economic benefits of a three-stage expansion of native woodland are explored. The proposed expansion would ultimately bring an equivalent area of land under native forest to that currently under all types of forest, including existing native forest, commercial conifer and non-native broadleaf plantations. That is, an increase of native forest from 100,000 ha to 650,000 ha, which equates to the current total forest area in the Republic of Ireland.

Box 3 Scenarios of native woodland expansion

The three phases of native forest expansion explored in detail in this report are:

Scenario A: An expansion to 25% of current total forest area, i.e. to 160,000 ha
Scenario B: An expansion to 50% of current total forest area, i.e. to 325,000 ha
Scenario C: An expansion to 100% of current total forest area, i.e. to 650,000 ha.

The report also considers a fourth scenario, Scenario D, which envisages expansion of native woodland to cover 30% of the total land area of the State, (approximately 2,000,000 ha). It is most unlikely that this scenario could be implemented in the foreseeable future, but it does offer a vision of the values that could be achieved through a truly substantial restoration of native forest.

Building on the example of Brackloon Wood, the potential benefits of a significant expansion of the native woodland area, combined with a selective, strategic targeting of supports with respect to the location of new woodlands and accompanying infrastructure are outlined. In line with the proposals of Peterken (2002) for the UK, some of the potential benefits of a more sizeable expansion of woodland cover up to 30% of the land area are also examined (see Box 3 above). An expansion on this scale would be undisputedly very ambitious. It could be more easily achieved in some locations than others, for example in the immediate vicinity of Brackloon where there are numerous pockets of regenerating secondary native woodlands. Nevertheless, even where native woodland is currently sparse there are opportunities to strategically expand native tree cover along rivers, streams and adjacent lakes, beside existing (including coniferous) woodland, and in tandem with the extensive hedgerow network already present in Ireland.

Threats to the native woodland estate

In many woodlands, current biodiversity value and regeneration potential is being diminished by an understorey of rhododendron, cherry laurel and other invasive plant species. Depending on location, deer, rabbits, goats and uncontrolled grazing by livestock are a severe impediment to regeneration and tree growth. Elsewhere, good silvicultural management is being hindered by damage from grey squirrels. The recent spread of ash die-back disease in the UK and its appearance in County Leitrim represents a further threat to ash-dominated woodlands nationally.

Invasive plant species

Rhododendron has spread rapidly in woodlands on peaty soils especially in the West of the country, while cherry laurel is a particular problem in drier areas on better soils. In the National Survey of Native Woodlands (Perrin et al, 2008) rhododendron was found on 25% of sites and laurel on 22% of sites respectively. Other invasive species include Himalayan balsam and giant hogweed, as well as naturalised beech and sycamore. Very few native insect species are associated with rhododendron and its litter is broken down mainly by fungi and bacteria. As a consequence, bird numbers are much lower in woodlands where this shrub dominates.[49] More pertinently, the heavy shade it casts leads to the loss of native herb and moss flora and prevents regeneration of trees and shrubs.[50] Furthermore, mature rhododendron is also capable of shading out woodland streams. As a consequence, the biodiversity value of woodlands is much reduced and heavily infested woodlands are potentially heading on a terminal course of decline due to their incapacity to regenerate sufficiently.

The rapid spread of rhododendron and laurel make these shrubs difficult to manage, especially in rough terrain. Eradication is an expensive operation as both readily re-sprout from cut stems. Removal typically costs €2,500 to €3,500 per hectare depending on degree of infestation.[36] The profuse seeding of rhododendron means that regular inspections are required following removal, preferably supported by cooperation from neighbouring landowners. Realistically, rhododendron can only be managed to acceptable levels as it is virtually impossible to eradicate completely.

Deer

Heavy grazing by deer and livestock was recorded on only 12% of sites in the National Survey of Native Woodlands, but numbers of deer are anecdotally estimated to be increasing nationally. Deer browsing prevents regeneration while bark stripping causes serious damage to growing trees, with resultant losses in timber value. According to a report compiled for Woodlands of Ireland (Purser et al., 2009)[51], the deer population could reach very serious proportions within ten years. The authors estimate that a 50% timber value downgrade due to deer would result in a loss of €18 million compared to a gain of €56 million that could

[36] NPWS

otherwise be earned from timber derived from broadleaves planted between 1998 and 2007. Serious damage would result in a €34 million loss of income. In heavily deer-populated areas broadleaf planting is becoming untenable. Indeed, for this reason, the Forest Service has stopped funding broadleaf projects in much of Co. Wicklow.

Although there are some native red deer populations in the south-west, most deer populations were introduced for sport in the past. Red deer numbers are estimated to have increased substantially by 565% between 1978 and 2008, while Sika and Fallow deer have increased by an estimated 354% and 174% respectively over this same period. Red and Sika deer are found in the south-west, north and east, with Fallow deer present through central Munster and parts of the east and north-west.

There is no national body charged with monitoring or controlling deer numbers, as there is, for example, in Scotland. Deer control is not practiced to any significant extent. Foresters often place a misguided reliance on hunters to control numbers. Shooting rights are often held by previous or neighbouring owners who may have little or no motivation to hunt systematically. Neither is there any quality control system in place that could form the basis of a market for wild venison. Protective tubes are used for smaller discrete groups of planted broadleaves, often at a very high cost. The NWS provides grants for fencing, but this is a very expensive option and its effectiveness is disputed. Fencing does not reduce the deer population and trespass by deer can occur if the fencing is not regularly maintained. It even sometimes accidentally results in deer being confined *inside* fenced areas, with disastrous results.

Grey squirrel

Since its introduction to Ireland in the early twentieth century, the grey squirrel has spread throughout the country, especially east of the River Shannon, and is gradually displacing the native red squirrel. Browsing and bark stripping by grey squirrel can cause serious damage to broadleaf trees, most especially to beech and sycamore, but also to native broadleaf species. There are various methods of control, including trapping. However, control requires persistence that is often lacking in woodlands that are not managed for timber.

Lack of management and undeveloped markets

Problems with invasive flora, grey squirrel and deer are serious enough to impact negatively, even on well-managed woodlands. However, a major threat to the potential value of Irish native woodlands is the lack of silvicultural management, especially by forestry contractors more accustomed to managing softwoods. Many of Ireland's native woodlands are over-mature with trees that have passed through periods of ownership change, cycles of depression in the rural economy and/or selective exploitation. Many old woodlands have been neglected since the Napoleonic period, after which timber prices collapsed, particularly for oak. The National Forest Inventory reported in 2007 that the oak resource has not been pruned: almost all of the mature broadleaf estate has never been shaped through the removal of competing side branches. The result is often poor stem form with a high incidence of forks and knots. Indeed, the National Survey of Native Woodlands found that, of the 3.8% of stems of merchantable quality, 64% had one or more defects. Because of the state of these woodlands, yield class models bear little relevance to the actual timber output. Prices of €10m^3 and returns of as little as €100 per hectare (excluding extraction costs) were not uncommon before the recent rise in firewood prices. The problems of management and changing ownership are further compounded by a poorly

developed supply chain from which only small volumes emerge, often following storm damage or after direct approaches to landowners from saw millers or timber merchants. Of an estimated annual growth increment of 80,000m^3 (as of 2002) about 35,000m^3 is harvested [52].

For new plantations the picture is more positive. Phillips (2006) refers to management costs of between €2,620 and €4,998 per hectare, the lowest being for ash. These costs are roughly twice those of conifer mixes and arise from the longer rotations and more demanding silvicultural management required by hardwoods. Using a discount rate of 5%, Phillips estimates internal rates of return (IRR) of less than this threshold and, consequently, negative annual equivalent values. However, a satisfactory IRR of 6.5%-13.3% is achieved with the inclusion of establishment grants. Premium payments further improve the financial margins.

Nevertheless, inconsistent state support casts uncertainty over the prospect of Ireland developing a sustainable supply and market for hardwoods. Prices fell internationally by one third between 1989 and 2008 due to oversupply, a decline estimated to be equivalent to a fall of three-quarters in real terms in the case of the UK [53]. Saw millers currently report good demand for quality Irish hardwood with prices for premium quality timber holding up well, but the overall market situation has suffered due to the demise of the domestic furniture industry. These factors particularly impact on established woodlands where grant support has been suspended. Also, these woodlands continue to be especially vulnerable due to mismanagement, invasive flora and deer. For new woodlands, returns depend on the quality of management and on the objectives of the owner for whom proper silviculture might not be the priority. In 2006, Phillips (2006) reported that hardwood thinnings did not break even until stem volume reached c.0.3m^3 whereas equivalent conifer thinnings sold for over €10m^3. However, this situation is changing as a buoyant firewood market for hardwood thinnings has seen roadside prices rise of late to €35–45m^3. This provides an incentive for better management.

The threats outlined above, from invasive species to poor management, all impact on the multiple natural capital values of Irish native woodland and incur economic losses. If these threats are addressed, however, and native woodland cover is expanded, there is potential for very significant increases in these values.

Opportunities for an Expansion of Native Woodland Natural Capital Values

This section describes the consequences for the natural capital values of native woodland subject to the expansion scenarios described in Box 3 above.

Scenario A (to 160,000 ha) is eminently achievable within ca 20 years. Progress is already being made on the annual planting target for broadleaves of 30% of new forest area as specified in the National Biodiversity Plan. Scenario A could be supported by forest industry timber objectives as well as providing biodiversity, amenity and ancillary benefits. A realistic target of 2,500 ha per year should be set now, which could be increased to 5,000 ha per year when resources allow. To date, approximately 1,500 ha of new native woodland have been planted since the inception of the NWS. This is in stark contrast with the target of an additional 15,000 ha set when the NWS was introduced in 2001. However, 23,000 ha of broadleaves have been planted under all schemes since 2002.

Scenario B (to 325,000 ha) and Scenario C (to 650,000 ha) are more ambitious and would require a substantial increase in the planting of native tree and shrub species. However, these expansions can be justified by the value of the increased ecosystem service benefits that would accrue, as described in previous chapters.

Scenario D, an expansion to 30% of *total land area* would be a 'game changer' in terms of biodiversity, tourism, water quality, flood protection and the forestry/timber industry. Peterken (2002) identifies 30% cover as the threshold at which a forest ecosystem is sustainable *vis-a-vis* biodiversity optimisation. He acknowledges that much can be achieved at lower levels of woodland cover, especially where woodlands contain a diverse composition of habitats, and where fragmentation is overcome through wooded links of riparian woodland or species diverse hedgerows. Biodiversity value would be enhanced by establishing woodlands 25-50ha in size, or by targeting locations contiguous with existing woodland, especially old or ancient woodland.

As discussed in Chapter 4 using the example of Brackloon Wood, the biodiversity benefits would be accompanied by ecosystem service benefits that are of potentially significant economic value, in particular the benefits to water quality, flood mitigation, recreation and timber supplies to the forestry industry.

Cultural Ecosystem Services – Amenity, Tourism and Health

a) Expanding native woodlands

Chapter 2 estimated the amenity value of Ireland's native woodlands at €30 million per year in terms of visitor benefits, or at least €35 million per year once irregular user and non-use values are included.

As discussed in chapter 2, closer examination of the responses to public surveys suggests that the actual number of annual visits to publicly accessible woodlands and forest of all types could be worth as much as €38 million per year. Furthermore, there is evidence that people value broadleaf woodland and mixed species woodland more than conifer plantations. Many towns in Ireland are devoid of a nearby accessible broadleaf (or even conifer) forest for recreation. Therefore, it is likely that an increase in the number of accessible forests will result in higher amenity values. Indeed, the amenity values elicited by Upton et al (2012) (see chapter 2) are related to the Forest Service's programme of new afforestation and, hence, are an indicator of the value of expanding exclusively with broadleaves compared with the composition of the existing area of

predominantly conifer forest. An expansion of native woodland to an area equal to that of the current forested area could result in at least a 15%-20% increase in the total number of visits to all forest areas (excluding the most frequent visitors, but including half the previous non-user population). Allowing for some displacement from trips to conifer forest, the higher social value (preference) attached to native woodland means that its amenity value would rise proportionally more, to around €65 million with an increase to 25% of the total forest area, €120 million with an increase to 50% of the total forest area and €150 million per annum if equal to the total forest area. Higher benefits could be realised earlier if expansion were targeted to areas of amenity value and areas where there is low woodland cover presently.

The relative attractiveness of native woodland for visitors suggests that annual domestic visitor expenditure could rise from the €30 million per year estimated in Chapter 2 to €50 million per year with an increase to an area equivalent to that of current forest area. Some of this expenditure would represent displacement from visits to coniferous forest, although the lower proportional increase arises from the presence of existing facilities in forest parks (which are predominantly coniferous). However, new opportunities are likely to arise from the expansion in native woodland area. As previously noted, these estimates omit the direct and indirect attraction of native woodlands to both residents and tourists, both as destinations in their own right or as an attribute of a heritage-rich landscape. Although tourists might continue to be attracted to honey-pot destinations such as Killarney National Park, a planned new mixed species wilderness forest in the Nephin Beg Mountains in County Mayo would attract tourist visitors, and potentially tourist expenditure estimated at up to quarter of a million euro per annum [54]. Across the country similar ecotourism opportunities combined with the landscape impact could add €10 million per year to the estimate of current forest related international tourist expenditure (€20m), which would result in total expenditure related benefits of €80 million per year.

Taking the average baseline estimate from chapter 2, the benefits to health of Scenario C (proportionate to the value of visits) could rise to €7 million per year. Given that the total number of visits may increase by 15%-20% to all types of forest, this increase is a proportion of an overall increase in health benefits of between €6 million to €9 million per year. Indeed, the true benefits are likely to be much higher. The greater availability of an appealing native woodland resource, especially in areas that are lacking in native woodlands such as in Co. Meath, would encourage more recreational activity. As indicated previously, the health value estimate excludes factors that cannot currently be reliably measured or attributed to forest recreation; net total health benefits of more than €9 million per annum are likely.

There are, nonetheless, problems in simply extrapolating benefits estimated on the basis of the existing area of native woodland to a notional expanded area. The first is related to diminishing returns. This has been allowed for in the assumption of a modest increase in total forest visits despite the much larger proportional increase in the area of native woodland. As discussed, the figure

assumes that some of this increased number of visits to native woodland would arise from displaced visits to coniferous woodland so that the total amenity value of all forest areas increases by less than 25%. This displacement would be less if broadleaf planting is targeted to areas where there is currently little forest cover and hence, recreational choice. On the other hand, the existing area of native woodland is *so* small that it can reasonably be assumed that the 600% increase implied by the Scenario C would not encounter any diminishing returns in terms of the relative public valuation of native woodland. Preferences can be presumed to apply mostly to mature woodland so that newly-planted woodlands will increase in amenity value over time.

A more critical proviso is that these estimated amenity values relate to public access.[37] Many of Ireland's existing woodlands are accessible, notably public-sector woodlands managed by Coillte and the NPWS. However, support for new planting is currently being provided primarily to the private sector. In addition, the possibility of some degree of privatisation of Coillte lands is raising fears in relation to continued and future access[55]. The evaluation in Chapter 3 identified that public access was only available in a minority of NWS sites. If the above estimates of potential public good amenity benefits are to be realised, it is imperative that the public have access to native woodlands, especially through publicly-funded grant schemes, which would defray the costs of public access for private owners. If access were provided to only one quarter of the new native woodlands the total amenity use benefits could be reduced from potentially €150 million per year to perhaps €55m per year, and tourism-related benefits would be reduced to €50 million. Of course, native woodlands do contribute amenity in ways that are not entirely associated with accessibility, i.e. biodiversity appreciation and landscape. Nonetheless, if most of the estimated potential amenity value of woodland expansion is to be realised, public access is essential.

The value of woodland cover at 30% of total land area

Extrapolating the estimates of amenity benefits to an expansion of woodland to Scenario D, 30% of the *total land area* of the State, would be unique in that it would strategically target key areas at a landscape level in order to optimise woodland biodiversity while at the same time addressing other ecosystem service values such as amenity, water quality, timber production and climate change-related measures. In this case, native woodland would become a much more familiar feature of the landscape. However, the risk of diminishing returns associated with this scale of increasing woodland area could be counter-balanced by the values derived from enhanced landscape and biodiversity attributes (see "Biodiversity" below). A spatial configuration of either linked networks or larger woodlands would, in principle, generate a greatly enhanced recreational resource. If this were to simply double current levels of use by all but the most regular current users, this could support amenity and recreation use worth over quarter of a billion euro per year. This assumes that access objectives feature in state support for new native woodland.

Perhaps the merit of strategic support for access may be realised only in particular areas in association with local tourism initiatives. However, it is worth returning to the potential health benefits in this respect. On the basis of the above estimate, the public benefits to health at first appear to be modest. It is worth contemplating the additional health benefits that would arise from a connected network of woodlands with access routes that have the capacity to support a variety of outdoor activities. This would increase this economic value of

[37] i.e. vicarious and bequest values are included in non-use values, but are related to forest recreation.

health enormously to many millions of euro as the forest resource invites a greater proportion of the population to become engaged in healthy, active pursuits.

b) The converse – the cost of the neglect of native woodlands

The suspension of funding for the Conservation Element of the NWS impacts negatively on the management of existing privately and publicly-owned woodlands. According to the NFI, privately-owned native woodlands comprise 60% of the total native woodland resource and without State support they are likely to suffer ongoing neglect.

The presence of invasive plant species such as rhododendron, and their capacity to spread rapidly, places the integrity and future viability of affected woodlands at serious risk. Much of the attraction of these woodlands is contributed to by their wildlife communities, which will be greatly diminished by an understorey of invasive species. This particularly applies to the most valuable native woodlands, i.e. ancient woodlands. The survival of these woodlands is affected by the prevention of regeneration due to either invasive plants or deer, or both. A loss of economic and biodiversity value would follow, for the want of very modest state support.

Supporting Ecosystem Services – Biodiversity

a) Expanding native woodlands

At present, Ireland possesses a rather limited range of specialist forest fauna with some notable exceptions such as pine marten and red squirrel that are equally at home in coniferous and mixed woodlands. Rather, the presence of scattered small woodlands within the landscape mosaic supports more generalist species [56].

The NWS expresses a preference for the siting of new woodland beside existing or designated woodland sites to create connectivity with other habitats. However, in practice, targeting has been rather imprecise and responsive to applications wherever they occur in the landscape. More pro-active targeting would increase the likely protection of isolated species within woodlands and also add a significant *option value* by allowing biodiversity to adapt and migrate in response to climate change. Scenario C would do much to secure the future of woodland biodiversity and vulnerable areas of ancient woodland. In the absence of primary data, chapter 2 postulated the cultural ecosystem service value of woodland biodiversity to be at least €40 million per year. However, while biodiversity values could not be expected to rise in the same proportion as area, the overseas studies referenced in Chapter 2 suggest that an expansion in line with Scenario C could double these values to €80 million per year. It is important to be aware that biodiversity contributes in one way or another to all the ecosystem services identified in this report and that the estimate of cultural ecosystem value excludes the substantial intrinsic, value of woodland biodiversity.

An expansion to up to 30% of land area based on a mixture of Core Forest Areas and wooded links as proposed by Peterken (ibid) would dramatically enhance woodland biodiversity and hence, biodiversity values. The siting of new woodland close to mature or ancient woodland would assist many species whose natural population variability reduces their resilience to exogenous changes, including climate change. Larger woodlands (or wooded landscapes) of 25-50 ha would also be better placed to facilitate deadwood, natural glades and the mosaic of habitats

found in natural forest. This would bolster the small native populations of woodland specialist species such as wood warbler and great spotted woodpecker, while possibly attracting new woodland species (especially birds). This would also enhance amenity value.

Box 4 Hedgerows

Hedgerows are a characteristic element of the Irish landscape. Fortunately, Ireland still has an extensive hedgerow network typical of extensive agricultural landscapes. However, while REPS has helped to preserve some hedgerows that might otherwise have been lost, current management in many counties remains lamentable with hedgerows either having been allowed to deteriorate due to lack of management or otherwise poorly and inappropriately managed. Although many hedgerows have been lost in recent times through clearance and removal, 300,000km remain, many of which are long established and even ancient, i.e. Heritage Hedgerows, with a varied mix of species.[57]. This includes native species such as ash, hawthorn and blackthorn. Hedgerows provide benefits as stock-proof barriers and shelter for livestock, and also protect streams and ditches from trampling by livestock. They are of value for fuel and can potentially be managed to provide a sustainable crop of firewood. In particular, hedgerows are valuable to nesting and wintering birds. They also provide corridors for mammal, bird and insect movement, an option value that strengthens links between fragmented areas of woodland. This linkage benefit will almost certainly become more relevant if species need to migrate in the event of climate change.

b) The neglect of native woodlands

The neglect of native woodlands through poor management and the spread of invasive plants and/or herbivores could ultimately lead to the demise of much of what remains of Ireland's woodland flora and fauna. It would severely hamper recent re-colonisation by woodland species and prevent the realisation of its full potential in the future. It would also mean that the conservation status of designated habitats would continue to be classified as "poor" or "bad". Ireland would therefore fail in its obligations to meet its EU commitments under the Habitats Directive to manage these species and habitats to achieve 'favourable conservation status', with the potential added consequence of regular fines to the Irish taxpayer from the European Court of Justice. The future capacity to realise the benefits of ecosystem services from both forest and forest species would also be undermined. It would also leave woodland biodiversity unprotected to the vagaries of climate change.

Regulating Ecosystem Services – water, erosion control, carbon sequestration

a) Expanding native woodlands

Native woodlands, in particular riparian woodlands, provide very significant benefits, moderating flooding risk and impacts, and maintaining or improving water quality. In Chapter 2 it was shown that, at present, these benefits are not being realised to any great extent due to the paucity of native riparian woodland and the lack of a fully developed strategy to protect aquatic zones at catchment level using riparian native woodland.

Although conifer planting is now subject to guidelines that minimise acidification or sedimentation impacts from land preparation and harvesting, conifer

plantations do not replicate the ecosystem services of native woodlands to any significant degree – especially regarding water quality protection - because of their ecological structure, and the inherent commercial remit.

In terms of gross area, an expansion of native woodlands would not in itself have an inevitable positive impact on or water quality. Much would depend on where planting occurs. The Forest Service recognises that the impact could be multiplied by the targeting and coordination of new planting projects. Indeed, targeting to maximise public good values is already recognised in the Native Woodland Scheme's objectives, but requires coordination between government department's vis-à-vis policy (i.e. Forest Service, NPWS, River Basin Districts, Water Services/Local Authorities, Agriculture, Fisheries, OPW and Planning) and bottom-up promotion amongst landowners. Some coordination is already occurring. For example, in County Kilkenny, landowners have come together with the support from NPWS to examine options for riparian woodland planting to reduce the impacts of autumn and winter flooding that result in the significant erosion of quality grazing land.

An increase to 30% of land area (Scenario D) would present be a very different scenario. At this level of strategically targeted cover, significant benefits would follow from improved water quality and flood mitigation.

i. Fisheries

The potential for coordination between forest and fisheries managers regarding new riparian woodland establishment applies particularly to freshwater game fisheries, which is an appreciable proportion of total recreational angling. Inland Fisheries Ireland (IFI) has prioritised river rehabilitation through the removal of impediments to salmon migration, and spawning. Although there are good examples of riverside habitat improvement in Ireland, the Tweed Foundation in Scotland provides an example of how bankside improvements, including native tree planting schemes, can contribute to increased catches of salmon and trout, thereby increasing angling value.[38] Ireland has its own quality angling rivers, of course, such as the Moy and Blackwater, but if more rivers were to provide the kind of higher end angling associated with the Tweed, their value *per river* could approach that of this Scottish competitor, a figure equal to approximately the annual €11.5 million value[39] for angling currently estimated for Ireland as a whole. Although the proportion of high quality rivers has been in long-term decline for a number of reasons, there is a good platform for habitat improvements given that 59% of the rivers/sites sampled by the IFI were classified as having water quality sufficient for 'good salmonid status'.

If habitat improvements were to be replicated on a targeted sample of angling rivers with high salmonid potential, as part of a package of national improvements, the economic returns per river would be very significant in terms of the local economy. Greater participation in angling would address the recent decline in returning tourist anglers and provide a wider geographic spread of angling opportunities, thereby increasing the total tourism value of angling to perhaps

[38] "http://www.treedfoundation.org.uk"

[39] The national figure is provided by Indecon (2003). Salmon population dynamics are complex and subject to exogenous factors such as changes in ocean conditions.

three times its current level. IFI lists 60 principal salmon rivers compared with 90 systems in Scotland. However, salmon and trout angling in Scotland is worth around €96 million per year, despite some environmental problems there.[40] Although Ireland has roughly only two-thirds of the angling potential of Scotland, there is still considerable scope for increasing revenue to perhaps €60 million per year. Spatial targeting and coordination of native tree and shrub planting as envisaged under all the scenarios of native woodland expansion could include native broadleaf afforestation in key catchments and along spawning tributaries to improve the quality of game fisheries.

ii. Water quality

The benefits of targeting new woodlands also apply to the economic value of a clean aquatic environment, to clean water supplies and to flood mitigation. Regarding the first of these, the EU's Water Framework Directive (WFD) sets an objective for all rivers achieving "good ecological status" by 2015. In Ireland, just 52% of rivers achieved the required status in 2010, with a further 19% being of "poor" quality status [58].

A recent survey by Stitou *et al* (2011) found that households in the Boyne catchment were willing to pay between €23 and €66 per year more in taxation to achieve medium and high improvements towards good water status respectively.[41] The context is realistic as a national water utility is now proposed along with household water charges. The figures are comparable to those derived from international studies referenced in Chapter 2 of between €32 and €66.[42]

To date, the State response to issues regarding forestry and water quality has been reactive rather than proactive, for example, the development of guidelines to avoid damage from coniferous forestry. While the first priority is to reduce pollution at source, riparian woodland does provide an inexpensive buffer to diffuse pollution. If the 48% of Irish rivers that are not currently of good status were matched by the above willingness-to-pay figure of 48% of the nation's households (i.e. 0.79m), a conservative estimate of the water quality benefits would amount to €35 million per year based on the mid-range of the willingness-to-pay estimates from the above survey.

In fact, a figure of €35 million appears modest and results from the relatively low Irish population density compared to other EU countries. However, the benefits people were being asked to value apply principally to improvements in source water quality and to the biodiversity and amenity of rivers. There are potential additional benefits of cost-efficiency savings in water purification, including reduced potential liability to cryptosporidium and carcinogenic trihalomethanes, avoidance of productivity losses due to gastroenteritis[43], and avoidance of potential EU fines for non-compliance with WFD targets. A modest, targeted expansion of riparian woodland in line with Scenario C could account for up to one quarter of these benefits, complementing control of point and diffuse sources of water pollution. A 30% native woodland cover expansion scenario could account for benefits of at least €16 million per annum using the same assumptions. In both cases the benefits would be higher if targeted at the most vulnerable water

[40] http://www.scotland.gov.uk/Publications/03/19079/34371
Includes problems with salmon farms.
[41] The authors emphasise the presence of wider confidence intervals around these means.
[42] Norton et al (2012).
[43] Costs estimated by Rodrigues et al (2007) at €135m/pa, although mostly due to food hygiene.

bodies. They are also worth more in principle, if they facilitate Ireland's compliance with the WFD.

iii. Flood mitigation

Benefits of flood mitigation are most likely to derive from targeted afforestation of catchments with broadleaves along riparian corridors and on floodplains. In Chapter 2 it was estimated that the current contribution of native woodland is marginal. However, benefits could be realised through an expansion in line with Scenario C, if this is targeted towards riparian corridors and upland areas sensitive to erosion. Riparian woodland would decrease flows, increase stream roughness, reduce land erosion and protect banks.[44] More significant downstream benefits could be realised through an ambitious programme of native broadleaf afforestation to mitigate flood damage.

Many floods affect agricultural land. Damage to grazing land is estimated at between €100 and €750 per hectare per event depending on season and intensity.[59] Nevertheless, if targeted riparian woodland planting of as little as 1,500 ha were to mitigate summer flooding of an area equivalent to the Shannon Callows SAC - the cost avoided would amount to between €500,000 and €1.25 million. If such areas were targeted each year, the annual benefits in terms of cost avoidance would generate cumulative benefits over time.[45]

More significant gains would follow from a major expansion in line with the 30% woodland cover scenario, especially if targeted at vulnerable catchments. For example, based on UK figures, a property with a 1% annual risk of flooding is estimated to have an annual equivalent damage risk of £84.[60] Assuming that a similar proportion of private properties are at risk in Ireland as in the UK, this equates to an annual cost of €39 million. Broadleaf and riparian afforestation can never completely mitigate the risk of flooding, not least because a chronic flood event may overwhelm any moderating effect woodland could have on overland flow, but an estimated one fifth reduction in risk with 30% woodland cover would save €8 million per year. Even a targeted increase in areas of greatest risk could avoid damage of around €2 million per year.

As with the maintenance of water quality, woodland establishment, along with other soft engineering options such as wetland creation, can only be one part of a catchment-based flood risk management strategy. The precise benefits are impossible to attribute without a detailed assessment of vulnerability in each catchment. Current thinking is that wetland areas may be of value for small areas at risk.[46] Riparian woodland would also reduce local erosion risks, while larger scale planting projects would have benefits at a greater spatial scale. The intervention costs are considerably less than many hard engineering solutions and would exchange the negative impacts on biodiversity that result from canalisation, with positive impacts in terms of new habitat and amenity.

iv. Option values (Water)

The regulating ecosystem services of targeted native woodland planting, including riparian woodland establishment and management has an additional *option value* in terms of its potential contribution to both mitigation and adaptation to climate change. Under a medium to high emissions scenario, flood frequencies are

[44] Roughness refers to bankside vegetation, debris, etc.
[45] For example, by avoiding a one in ten year flood event at each such location equivalent to this amount each year.
[46] Pers comm. Mark Adamson, OPW.

predicted to increase to such an extent that events with a 50-year return period are likely to occur every 12.6 years[81]. The magnitude of flood events is also predicted to increase. From UK data, the average damage per flood event has been estimated at €34,000 and €94,000 for domestic properties and businesses respectively.[61] Given that the floods of November 2010 affected 8,000 homes and 800 businesses in Ireland, the cost of a single serious event could amount to as much as €300 million. These are costs that could occur in future more than once a decade.

Some of the largest increases in flood risk are anticipated on the Rivers Blackwater, Moy and Suck.[62] These rivers are also amongst the country's best angling rivers. Higher temperatures will also place additional pressures on the maintenance of water quality and salmonid stocks. Forest ecosystems and shade from riparian woodland can make a significant contribution by moderating water temperatures. This correlates with current thinking on 'robust adaptation' to climate change. This low cost strategy also benefits amenity and biodiversity.

v. Carbon sequestration

As outlined in Chapter 2, native woodlands also contribute to climate change mitigation directly through carbon sequestration. The benefit of planting forests for carbon sequestration is realised with respect to the €270 million set aside by the government for the purchase of carbon credits to meet Ireland's commitment to the Kyoto Protocol in the period 2008-2012.[63][47] As most native woodlands in Ireland are mature, carbon sequestration from actively growing young trees was estimated (see Chapter 2) to be modest at up to 42,000 tonnes of carbon (147,000 tonnes CO_2) per year. However, ten years after establishment, newly-emerging native woodlands will begin to contribute significantly to sequestration. Expansion in line with Scenario C could ultimately increase sequestration of carbon to as much as 1.4 million tonnes of carbon per year (mt/C/pa) (equivalent to 5.1 mt/CO_2/pa.) at an annual value of €100 million or as much as €255 million in terms of reduced abatement cost (average €178m).[48] Expansion to an area 25% or 50% of current forest cover would achieve proportionate values. It should be taken into account that some of these new woodlands will be rotationally harvested under continuous cover silvicultural principles so that net sequestration would stabilise at a lower level over time.

Adopting the scenario of native woodland expansion to 30% of the land area (Scenario D) would not run the risk of diminishing returns and could result in sequestration of around 15 mt/C/yr (56 mt CO_2) if it were to occur over a period of 50 years. Such a large expansion could cause the value of sequestration to revert to the price levels of the Emission Trading Scheme rather than the opportunity cost of mitigation. Nevertheless, this additional sequestration could still ultimately be worth over €1 billion per year before falling back as net new planting ceases.

b) The neglect of native woodlands

The neglect of native woodlands would result in economic losses through resultant declining water quality and flood mitigation capacity. The loss, particularly of mature trees/woodland, will also result in losses of carbon storage and of opportunities for sequestration from newly planted trees. The biggest cost

[47] NTMA (2010) Carbon Fund Annual Report 2010. Reference to purchase of Certified Emission Reductions equivalent to one tonne CO^2.
[48] Reducing over time as trees mature assuming half the tree stock is unharvested.

would be the failure to realise the very significant opportunity cost. There would also be the lost opportunity to adopt a cost-effective approach to climate change mitigation and adaptation by protecting both young and remnant woodland and to realise a double dividend from the preservation of its flora and fauna. Ultimately, Ireland would fail to realise much of the potential annual return from the carbon sequestration of younger trees, but also experience the gradual loss of the more sizeable extant native woodland carbon store amounting to upwards of 80 million tonnes.

Provisioning Ecosystem Services

a) Expanding native woodlands

Although much of the existing native hardwood stock is over-mature in terms of timber production and has been poorly managed in the past, recently established new native woodland offers the potential to realise a valuable timber resource in the future. About 40,000 ha of planted broadleaves (native, naturalised and non-native) are yet to enter the mature, productive phase. If well managed, this area could produce an additional cumulative volume of 20 million m^3 in the first rotation period [64].[49] Alternatively, based on an average NPV of €4,200 per hectare for hardwoods (Phillips, 2006) [65], the value of these new plantings could amount to as much as €150 million.

Should the area of native woodland be expanded as per Scenario C this could add a further 280 million m^3 over the full rotation if predominantly comprised of yield class 4 oak. In gross terms this would be worth around €200 million in roundwood per year or €60 million in thinnings at current prices before consideration of costs and transfer payments in the form of grants and premiums. In reality, lower values species would also be planted and other woodland set aside purely for amenity, protection or biodiversity so that the actual value of round wood could be half this amount and thinnings/firewood around two-thirds. The increase in standing value would be significant in itself, but could be greatly augmented by the added value of a hardwood processing industry that would provide guaranteed timber supplies and stimulated market development. Market development and the provision of continuous timber supplies is co-dependant if utility values are to be maximised. In Wales, where the broadleaf area amounts to 145,000 ha, Coed Cymru (www.coedcymru.org.uk) has shown how market development can be achieved through strategic cooperation and an exchange of information between landowners, contractors and timber users. An expansion to 30% of total land area (Scenario D) would certainly provide a continuity of supply and could account for saw log output of over 1 billion m^3 over the rotation period, depending on how much is set aside for amenity, biodiversity and other public goods.

While the international hardwood sawlog market is depressed, quality Irish timber is scarce and receives good prices. Oak and ash have always been highly-prized and demand for shorter rotation species such as birch and alder is also increasing. Little and Cross (2005) demonstrated that with good silvicultural management commercial returns of 5%-9% can be realised without undermining ecological integrity [66]. In addition, the buoyant market for firewood is providing demand for thinnings. This demand is likely to continue given Ireland's Kyoto commitments, the growth in wood energy and the rising cost of oil. This, in turn, will improve silvicultural practices and provide the incentive for good management and higher timber values in the future.

[49] Based on standard yield models, e.g. Edwards and Christie (1981).

b) The neglect of native woodlands

Any reduction in new woodland planting will deny the broadleaf sector the prospect of providing greater future timber supplies and therefore, the capacity to develop a viable and valuable economic market for native hardwoods. Net present values for recently established new native woodlands could fall closer to the €21-38 million estimated by Purser *et al* (2009) if poor management and ongoing deer damage prevail. Demand for fuelwood is likely to increase, but without the promotion of a forestry culture with a diverse range of silvicultural systems, Ireland will fail to realise the value of a future forestry industry based on both quality hardwood and softwood.

6. The Economic Value of Native Woodlands

The Economic Returns

The preceding chapters have revealed the natural capital value of Ireland's native woodlands. The current area of native woodland is calculated to have a total approximate value of at least €100 million per year and perhaps more than €143 million per year. However, while the area has increased in recent years, it remains a small proportion of the state's total forest area and an even smaller fraction of the total land area. The benefits that the current area of broadleaf woodland provides in terms of amenity, biodiversity, timber output and carbon sequestration/storage are significant, but modest in scale. The benefits are modest because the area of woodland is small, i.e. circa 100,000 ha. They are boosted in value because of their scarcity or rarity value. The benefits to water quality, flood mitigation, climate adaptation and the downstream timber/wood processing industry are severely under-realised at present, as these require a strategic expansion in the area of broadleaf cover, together with appropriate management and investment. Only an ambitious expansion programme can secure maximum benefits.

This report describes how an expansion of native woodland up to Scenario C could eventually realise annual economic benefits in excess of €650 million per year. Returns from thinnings would be realised first followed by a gradual rise in the level and value of carbon sequestration, amenity and related benefits before a renewable harvest income is achieved after 40-140 years depending on tree species. There is also reason to suspect that the value estimates that are attributed to health and water quality in particular, are a fraction of their true potential value.

Table 6. Economic benefit flows of native woodland - current and projected, the latter on expanding native woodland cover under Scenarios A, B, and C (€ millions per annum).

	Amen-ity	Tour-ism	Health	Biodiv-ersity #	Water/ flood	Carbon	Wood products	Wood fuel	TOTAL
Existing woodland									
Best estimate	€35m	€50m	€2m	€30m	Slight	€2m	€0.5m	€3m	€102m
Upper estimate	€35m	€50m	€3m+	€40m	Slight	€8m	€1.4m	€6m	€143m
Possible future area									
Scenario A (160,000 ha)	€65m	€60m	€4m	€60m	€3m	€45m	€25m	€12m	€274m
Scenario B (325,000 ha)	€120m	€70m	€6m	€70m	€6m	€90m	€50m	€24m	€436m
Scenario C (650,000 ha)	€150m*	€80m	€7m	€80m	€10m	€178m**	€100m***	€46m	€650m

valued as a cultural ecosystem service only.
* based on total forest amenity value of €236m, or a net €48m addition after displacement from conifer plantations.
** representing an average of values while increased area is in growing phase and excluding carbon storage value.
*** minimum roadside value after ca100 years, assuming that half the area is un-harvested or contains lower value species.

Natural Capital Values, Environmental Accounts and Payments for Ecosystem Services

The multiple benefits of native woodlands demonstrate why government should consider these woodlands as an economic resource, i.e. as natural capital. The benefits are realised as flows over time in the form of provisioning, regulating and cultural ecosystem services. As discussed in Chapter 1, the UN Environment Programme and European Environmental Agency (EEA) are encouraging Member States to formally recognise the contribution of ecosystem services to national well-being by accounting for natural capital balances in economic indicators like GDP. Conventional accounting indices not only fail to provide a measure of sustainable development, they offer a very incomplete and dangerously misleading impression of economic realities.

Payments for ecosystem services (PES) are a means of 'operationalising' the value of the natural capital recorded in environmental accounts. Although often pitched as compensation measures for opportunity costs foregone with respect to alternative land uses (for example, payments to farmers/landowners for loss of agriculture income in set-aside schemes), PES are distinctly positive in that, where properly designed, they have the capacity to provide incentives for the sustainable management of ecosystem services. PES may occur between private interests, but typically there is recognition by government that maximising the flow of ecosystem services provides economic and/or social benefits of the types described in this report. These may be direct returns, or savings on other costs such as the purchase of carbon credits, hard engineering flood protection measures and health expenditure.

For native woodland, the question is: what policies would most efficiently maximise natural capital values? Certainly, the NWS is supplying grants and premium payments to cover the cost of woodland management, including an element of income. FEPS clearly provides an equivalent to PES in the form of annual payments that compensate farmers for forestry costs and for allocating land for this purpose, most of which has an alternative productive value for agriculture.

Through PES there is potential for greater targeting in response to the relative contribution of native woodland for multiple ecosystem services. This is already realised in the objectives of the NWS, which has proceeded, albeit in a piecemeal fashion, with the support, cooperation and synergy between government departments and native woodland stakeholders via the Woodlands of Ireland umbrella. There are already examples of cooperation amongst landholders with the assistance of local Forest Inspectors and NPWS Wildlife Rangers, like the County Kilkenny example outlined in Chapter 5.

The benefits of native woodland for water quality, flood mitigation and the adaptation of biodiversity to climate change can best be realised through more systematic targeting using a landscape ecological approach that maximises the spatial interactions of new planting projects. A diverse native woodland resource requires planting on most soil types, including in Acid Sensitive Areas (ASAs) that are typically found in marginal landscapes.[67] This should be backed by PES to reward forest owners for the supporting and regulating services of native woodland. For the purposes of cost effectiveness, these may need to be directed to certain locations or even factored in where the regulating value is highest.

At the same time, the value of native woodland for amenity has to be recognised as a true economic asset. Native woodland is supplying public good benefits at a variety of levels. Some are site-specific such as biodiversity, landscape, erosion

control, climate change adaptation and timber. Others are less so, such as water quality, fisheries, flood mitigation, carbon sequestration and species movement or migration. However, amenity is strongly linked to access and hence, there are benefits in providing accessible new native woodlands close to populated areas akin to the PMF project. Here also, there is potential for targeting with PES premiums to aggregate woodlands into single or connected accessible areas. There is also potential to supplement this funding with biodiversity offsets or finance from developers or others responsible for environmental impacts or losses elsewhere, e.g. on new road schemes and industrial developments.[50]

The natural capital benefits of woodland expansion

Table 6 omits figures for individual ecosystem services regarding native woodland cover at 30% of total land area because such an expansion is, strictly speaking, outside the scope of this report. However, the benefits would undoubtedly be very considerable. Such an expansion would provide the basis for a very profitable hardwood sector with knock-on gains for employment, regional and rural development, and the trade balance and government revenue. An expansion of this order would also save the state money by providing for the sequestration of atmospheric carbon, thereby facilitating Ireland's capacity to meet emission obligations under the Kyoto Protocol and reduce the millions of Euro that would otherwise have to be spent on carbon credits.

Investment in native woodland expansion also has the ability to reduce Ireland's vulnerability to climate change and to enhance capacity for adaptation and resilience. Existing ancient woodlands provide a vital refuge for specialist forest flora and fauna, but new woodland, including connecting forest, will strengthen species' resilience and their capacity to move in response to climate change. Broadleaf forest will also help reduce the public and private cost of flooding and erosion in the face of an expected increase in extreme rainfall events. Riparian woodland would also reduce the pressure that higher temperatures will place on water quality and recreational fisheries.

An increase to 30% of the land area would be a very significant change, though it is difficult to contemplate such an expansion and cultural shift at this point in time. However, targeted expansion of this order would not be inconceivable or out of place in particular areas where woodland cover is already present in small fragmented patches, for example in West Mayo or parts of Counties Cork, Wicklow, Monaghan and Waterford. A consolidation of existing woodlands would greatly strengthen the survival prospects of Ireland's woodland biodiversity and permit its gradual expansion into the wider countryside. The variety of fauna and flora would increase as a larger woodland resource would result in a richer complex mosaic of ecosystems, including other habitats such as clearings, meadows and mixed age stands. Connecting strips of woodland could be developed along suitable topographical corridors, including roads or watercourses and by combining and enhancing Ireland's network of hedgerows. These connections could also allow for recreation by means of trails for walking, cycling or horse riding, facilitating access to the countryside while minimising perceived conflicts with farming. It would allow for the development of a localised critical mass of green or activity tourism business and wood product enterprises. It would absorb the visual impact of scattered residential development and provide

[50] Biodiversity offsets seek to compensate for losses of habitat that have occurred elsewhere through unavoidable or unforeseen impacts on the environment. Although controversial in some respects, they have potential to extend nature conservation away from exclusively protected areas and are being used as a tool in North America, Australia and some EU states, including the UK.

a landscape that can contribute positively to the quality of life of local communities and visitors alike. This is also in line with the aims of the proposed National Landscape Strategy.[68]

7. Conclusions

This report sets out the rationale for valuing native woodlands as a natural capital resource. Indisputably, native woodland and its rich biodiversity have an inherent value, but they also have an economic value in terms of the multiple ecosystem services that they provide. The natural capital value of the current native woodland resource is estimated to be conservatively worth in the region of €100 million per annum and is derived mainly from its biodiversity, amenity, carbon storage, firewood and downstream wood product values. At first glance it might appear surprising that the public good value of amenity use of native woodland by citizens is estimated to be amongst the highest economic values. Far from being made up of vague or intangible benefits, however, native woodlands contribute substantially to the quality of life of Irish people. They also supply tangible knock-on returns in terms of activity expenditure, tourism, and personal health benefits that reduce State and private medical expenditure. The EU requirement for Member States to integrate environmental accounting into conventional GDP measures from 2020 presents a key opportunity to undertake a critical assessment of the benefits of payments for ecosystem services (PES) and other incentives to realise natural capital values through sustainable development.

While there has been a modest increase in the area of broadleaf woodland in recent years, Ireland has yet to grasp this opportunity, and indeed there are still threats to Ireland's remaining oldest and most valuable native woodlands. Sporadic stop-start funding of otherwise very positive State schemes to support and expand this resource has undermined their undoubted successes. True, government must now operate under serious financial constraints, but this discontinuity in funding engenders little confidence in the private and public forestry sectors and hinders investment in a diverse wood-processing industry with a profitable hardwood element.

The discontinuity in funding has now been compounded by the suspension of the Conservation Element of NWS (NWS1) since 2008 and of FEPS (new entrants) since 2010. The suspension of the NWS1 has completely removed the incentive to restore and rehabilitate existing native woodlands, especially in the private sector. These forests are primarily of value for biodiversity and amenity but have some significant timber values too.

The integrity of native woodland as natural capital is also endangered by the rapid spread of non-native plants and animals (e.g. grey squirrel, Sika and Fallow deer). Non-native invasive plant species such as rhododendron have negative biodiversity value, or to put it more bluntly, they cost a lot of money. They prevent regeneration of native woodland flora and compromise the future viability of affected woodlands. Meanwhile, increasing deer populations will deny future generations a chance to experience native woodland in many areas, by preventing regeneration and woodland perpetuity through over-browsing. The establishment of new native forests is not possible in many areas without costly fencing and constant vigilant management.

These problems threaten to undo much of the good work that has been achieved under the NWS. The resultant neglect of native woodlands makes no economic sense given the actual and potential economic returns that this resource provides. Indeed, there is a double dividend from maintaining and increasing funding for native woodlands. Firstly, their protection will ensure conformance to the EU Habitats Directive, saving the State money on future fines. Secondly, opportunities to create forest amenity not only contribute to quality of life, but

also to the income of woodland owners and local businesses. A strategic expansion of native woodland would protect water quality – saving even more money - and help reduce the impact -and the increasing costs of flooding and erosion. Such an expansion both strengthens adaptation to climate change, and simultaneously mitigates this threat through carbon sequestration. This, in turn, reduces State expenditure on carbon credits. Furthermore, all these economic benefits go hand in hand with the provision of the raw material for a profitable hardwood industry.

The report estimates that an increase in the area of native woodland to an area equal to one quarter (Scenario A) and half (Scenario B) of that currently occupied by forest of all types would ultimately be **worth up to €274 million** and **€436 million per year** respectively, in added capital value due to the extra ecosystem services provided. An increase as per Scenario C could be **worth around €650 million per year**.

Value of native woodland expansion	
Current area of native woodland	**€100m+ per year**
Scenario A (increase to one quarter present forested area)	**€274m per year**
Scenario B (increase to one half present forested area)	**€436m per year**
Scenario C (increase to 100% of present forested area)	**€650m per year**

A further and very ambitious increase in native woodland cover to 30% of land area would represent a considerable policy and cultural change. At this level, very significant benefits emerge from the cumulative contribution of woodland to recreation, health, water quality and flood mitigation. An expansion of this magnitude, even if it were restricted to specific target areas, would greatly protect and enhance the environment, as well as contributing significantly to rural livelihoods and employment.

It is therefore recommended that native broadleaved planting be increased to at least 2,500ha/yr now, and to 5,000 ha/yr when resources allow, in order to reach at least the Scenario A target of 160,000 ha discussed in Chapter 5. New native woodlands should also be strategically targeted to concurrently maximise biodiversity, water quality and recreation values. Some woodlands should also be located close to urban centres, with public access and interpretative facilities in order to enrich and optimise the amenity experience.

The case study of Brackloon Wood indicates how native woodland can contain a variety of habitats, be contiguous with existing woodlands in the locality and follow natural topographical corridors such as streams and roads, so as to advance connectivity and enhance landscape, water quality, amenity and tourism values. In the short term, local woodland expansion could spearhead opportunities for tourism, artisanal businesses and local entrepreneurism. Brackloon Wood is therefore a good example of what could be achieved in the future if there is a commitment to maximising the natural capital values of the native woodland estate.

Box 5: Summary of Recommendations

1. Implement the commitment in the EU Biodiversity Strategy to integrate natural capital and ecosystem goods and services valuation into all national accounting indicators by 2020.
2. Expand native forest cover to at least Scenario A (160,000 ha), by setting an annual afforestation target of 2,500 ha, and subsequently increasing this target to 5,000 ha/yr in order to attain Scenarios B (325,000 ha) and C (650,000 ha).
3. Evaluate the costs and benefits of strategically expanding native woodland cover to Scenario D, in particularly appropriate regions, i.e. to 30% of the total land area of the State, in order to optimise woodland cover at a landscape scale
4. Regarding 2 & 3 above, focus on targeting woodland to maximise benefits, i.e. create woodlands close to populated areas to increase public access, and therefore maximise amenity value; focus on planting beside rivers, streams and lakes to minimise flood damage and erosion, and to enhance and protect water quality; maximise biodiversity by planting adjacent to existing old native woodlands.
5. Actively promote forest activities to further increase amenity and health values.
6. In order to achieve these targets, restore the conservation element in the Native Woodlands Scheme. Provide and maintain consistent, carefully targeted stimulus funding to restore private forest investor confidence using the Native Woodland Scheme and payments for ecosystem services, the latter under the Rural Development Programme.
7. Conduct further research to more accurately quantify the value of the natural capital and ecosystem goods and services provided by native woodlands, especially in the field of amenity, health and water.
8. Promote awareness of natural capital accounting, starting with this report, to maximise its impact on public opinion and policy makers.

8. References

1. Forest Service, *National Forest Inventory*. 2007, Department of Agriculture, Fisheries and Food: Wexford. p. 271.
2. Rackham, O., *Ancient Woodland (revised edition).* 2003, Dalbeattie: Castlepoint Press.
3. Gallagher, G., et al., *Ireland's forest inventory and planning system.* 2001, Department of the Marine and Natural Resources.
4. Higgins, G.T., *National Survey of Native Woodland in Ireland - Interim Report.* 2004, National Parks and Wildlife Service.
5. Perrin, P.M. and O.H. Daly, *A provisional inventory of ancient and long-established woodland in Ireland*. 2010, BEC Consultants for the Department of the Environment, Heritage and Local Government.
6. Garrett, W., *Woodland History of the Coillte Estate.* 2001, Coillte Teoranta: Newtownmountkennedy.
7. O'Sullivan, A., *Woodland history of the Coillte estate - a survey and policy developments*, in *Ireland's native woodlands, theme 2: the ecology and current status of Ireland's native woodlands*. 2004, Proceedings of the Native Woodland Conference, GMIT, Galway. Woodlands of Ireland, Dublin.
8. Perrin, P.M., et al., *National Survey of Native Woodlands 2003-2008 - Volume 1; Main Report*. 2008, BEC Consultants for National Parks and Wildlife Service.
9. Voora, V.A. and H.D. Venema, *The Natural Capital Approach. A Concept Paper*. 2008, International Institute for Sustainable Development (IISD) and Environment Canada.
10. MEA, *Ecosystems and Human Well Being: Synthesis Report.* 2005, Millennium Ecosystem Assessment: Washington.
11. Weber, J.L., *Implementation of land and ecosystem accounts at the European Environment Agency*. Ecological Economics, 2007. **61**(4): p. 695-707.
12. NPWS, *The Status of EU Protected Habitats and Species in Ireland*. 2008, National Parks and Wildlife Service, Department of the Environment, Heritage and Local Government.
13. Xenopolou, S., *Market review of the technical performance of Irish hardwoods*. 2004, COFORD: Dublin.
14. Casey, J. and M. Ryan, *Situation and Outlook for Forestry 2011/2012*. 2012, Teagasc.
15. Forestry Commission, *A wood fuel strategy for England.* 2008.
16. Dimitriou, I., et al., *Quantifying environmental effects of short rotation coppice (SRC) on biodiversity, soil and water*. 2011, IEA Bioenergy.
17. Harrington, T. and M. Cullen, *Assessment of wild edible fungi production in Irish woodlands.* 2008, COFORD.
18. Neary, D.G., G.G. Ice, and C.R. Jackson, *Linkages between forest soils and water quality and quantity.* Forest Ecology and Management, 2008. **258**: p. 2269-2281.
19. Kilfeather, P. *Fisheries and the aquatic environment.* In: *Forests and Water*, 2000. Cork.
20. Thomas, H. and T.R. Nisbet, *An assessment of the impact of floodplain woodland on flood flows.* Water and Environment Journal, 2007. **21**(2): p. 114-126.
21. Broadmeadow, S. and T.R. Nisbet, *The effects of riparian forest management on the freshwater environment: A literature review of best management practice.* Hydrology and Earth System Sciences, 2004. **8**(3): p. 286-305.
22. Malcolm, I.A., et al., *The influence of riparian woodland on stream temperatures: implications for the performance of juvenile salmonoids.* Hydrological Processes, 2008(22): p. 968-979.

23. Indecon, *An economic/socio-economic evaluation of wild salmon in Ireland*. 2003, Indecon International Economic Consultants for Central Fisheries Board.

24. Norton, D., et al., *Benefit Transfer for Irish Water*, in *STRIVE Programme 2007-2013*. 2012, Environmental Protection Agency.

25. Stithou, M., *Estimating the value of achieving 'good ecological status' under the Water Framework Directive in the Boyne River Catchment*, in *Stirling Management School, Economics Division*. 2011, University of Stirling.

26. Cannell, M.G.R. and R. Milne, *Carbon pools and sequestration in forest ecosystems in Britain.* Forestry, 1995. **68**(4): p. 361-375.

27. Dewar, R.C. and M.G.R. Cannell, *Carbon sequestration in the trees, products and soils of forest plantations: an analysis using UK examples.* Tree Physiology, 1992(11): p. 49-71.

28. Black, K.G., K.A. Byrne, and G. Gallagher, *Implications for National Reporting*, in *Carbon sequestration and Irish Forest Ecosystems*, K.G. Black and E.P. Farrell, Editors. 2006, COFORD: Dublin. p. 61-66.

29. Bailey, N., J.T. Lee, and S. Thompson, *Maximising the natural capital benefits of habitat creation: Spatially targetting native woodland using GIS.* Landscape and Urban Planning, 2006(75): p. 227-243.

30. Bailey, N., J.T. Lee, and S. Thompson, *Maximising the natural capital benefits of habitat creation: Spatially targeting native woodland using GIS.* Landscape and Urban Planning, 2006: p. 227-243.

31. Black, K. and E.P. Farrell, *Carbon Sequestration in Irish Forests*. 1999, COFORD.

32. Christie, M., et al., *Valuing the diversity of biodiversity.* Ecological Economics, 2006. **58**(2).

33. Fitzpatrick Associates, *Economic value of trails and forest recreation in the Republic of Ireland*. 2005: Dublin.

34. Upton, V., A. Ni Dhubhain, and C. Bullock, *Preferences and values for afforestation: the effect of location and respondent understanding on forest attributes in a labelled choice experiment.* Forest Policy and Economics, 2012. **In press**.

35. Nielsen, A.B., S.B. Olsen, and T. Lundhede, *An economic valuation of the recreational benefits associated with nature-based forest management practices.* Landscape and Urban Planning, 2007. **80**(1/2): p. 63-71.

36. van Rensburg, T.M., et al., *Preferences and multiple use forest management.* Ecological Economics, 2002(43): p. 14.

37. CJC Consulting, *Economic Benefits of Accessible Green Spaces for Physical and Mental Health*, in *CJC Consulting with Prof Ken Willis and Dr Liesl Osman*. 2005. Final report for the Forestry Commission.

38. Health, *National Taskforce on Obesity Ireland*. 2005.

39. Ni Dhubhain, A., et al., *The socio-economic impacts of afforestation on rural development: Final Report CAMAR*. 1994, European Community.

40. Winson, A. *Flourishing trees, flourishing minds. In Trees, People and the Built Environment.* In: *Urban Trees Research Conference*. 2012. Birmingham: Forestry Commission, Edinburgh.

41. Garrod, G.D. and K.G. Willis, *The non-use benefits of enhancing forest biodiversity: A contingent ranking study*. Ecological Economics, 1997(21): p. 17.

42. Weisbrod, B.A., *External benefits of education*. 1964, Princetown University.

43. Walsh, R.G., J.B. Loomis, and R.A. Gillman, *Valuing Option, Existence and Bequest Demands for Wilderness.* Land Economics, 1984. **60**(1).

44. Conrad, J.M., *Quasi-option value and the expected value of information.* Quarterly Journal of Economics, 1980. **94**: p. 7.

45. Fossitt, J.A., *A Guide to Habitats in Ireland*. 2000, Heritage Council: Kilkenny.

46. Little, D., et al., *Intensive Monitoring of an Oak Woodland in Western Ireland*. 2001, COFORD.

47. Cunningham, D., *Brackloon. The Story of an Irish Oak Wood*. 2005, Dublin: Coford.

48. Peterken, G., *Reversing the habitat fragmentation of British woodlands*. 2002, WEF-UK.

49. Becker, D., *Control and removal of Rhododendron ponticum on RSPB Reserves in England and Wales.* . 1988, Unpublished report. Royal Society for the Protection of Birds.

50. Barron, C., *The Control of Rhododendron in Native Woodlands*, D. Little, Editor. 2007, NWS Information Note No. 3. Woodlands of Ireland, Dublin.

51. Purser, P., F. Wilson, and R. Carden, *Deer and Forestry in Ireland: A Review of Current Status and Management Requirements*. 2009, Woodlands of Ireland. Dublin.

52. Dunne, S. *Broadleaves: What's out there?* in *Managing our broadleaf resource to produce quality hardwood timber*. 2002. Carrick-on-Shannon: COFORD.

53. Valatin, G. and J. Starling, *Valuation of ecosystem services provided by UK woodlands*. 2010, UK National Ecosystem Assessment Economic Analysis Report.

54. Bullock, C., *The Economic Value of Forest Wilderness at Nephin*, in *Draft report for Coillte Wild Nephin Feasibility Study*. 2011, Coillte.

55. IMPACT, *Save Our Forests. The Social, Economic and Environmental Case against selling Coillte Assets.* . 2013.

56. Pithon, J.A., R. Moles, and J.O. Halloran, *The influence of conifers on lowland farmland birds.* Land Use Policy, 2004.

57. Foulkes, N., et al., *Hedgerow Appraisal System. Best Practise Guidance on Hedgerow Surveying, Data Collation and Appraisal.* . 2013, Woodlands of Ireland: Dublin.

58. EPA, *Water quality in Ireland 2007-2009*, M. McGarrigle, J. Lucey, and M.E. O'Cinneide, Editors. 2010, Environmental Protection Agency: Dublin.

59. Posthumus, H., et al., *Impacts of the summer 2007 floods on agriculture in England* Journal of Flood Risk Management, 2009: p. 1-8.

60. Penning-Rowsell, E., et al., *Estimating injury and loss of life in floods: A deterministic framework.* Natural Hazards, 2005. **36**: p. 43-64.

61. Chatterton, J., et al., *The Costs of the Summer 2007 Floods in England*. 2010, Environment Agency.

62. Murphy, C. and R. Charlton, *Climate Change and Water Resources in Ireland*, in *Climate Change: Refining the Impacts*, J. Sweeney, Editor. 2007, Environmental Protection Agency, Johnston Castle, Wexford.

63. NTMA, *Carbon Fund. Annual Report 2010.* 2011, National Treasury Management Agency, Government of Ireland: Dublin.

64. Edwards, P.N. and J.M. Christie, *Yield Models for Forest Management*. 1981, Forestry Commission: Edinburgh.

65. Phillips, H., *Economic analysis of broadleaf afforestation*, I.F.I. Chain, Editor. 2006.

66. Little, D. and J. Cross, *Realising Quality Wood from Ireland's Native Woodlands* 2005, Woodlands of Ireland: Dublin.

67. Collier, M. and E.P. Farrell, *The environmental impact of planting broadleaved trees on acid-sensitive soils*. 2007, COFORD: Dublin.

68. DAHG, *A National Landscape Strategy for Ireland. Strategy Issues Paper for Consultation*. 2011, Department of Arts, Heritage and the Gaeltacht.

69. Tourism Development International. *Socio-Economic Study of Recreational Angling in Ireland.* 2013. Inland Fisheries Ireland: Dublin.

70. NPWS, *Actions for Biodiversity 2011-2016. Ireland's National Biodiversity Plan.* 2011.Department of Arts, Heritage and the Gaeltacht, Dublin.