

The Natural Capital Value of Native Woodland in Ireland

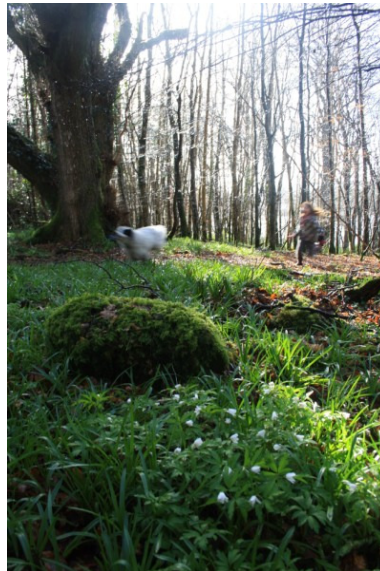
An abbreviated report of the full report prepared for
Woodlands of Ireland

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Executive Summary

Extensive native forest once covered most of Ireland. Today only about 100,000 hectares of this lost forest remain, equal to approximately 1.2% of land area. At present, native woodlands form 14% of our total forest cover - the rest is made up mostly of exotic conifer plantations. These woodlands are generally much richer in natural capital than exotic plantations.

Ireland's native woodlands are not just a natural asset, but a *natural capital asset* that provides a range of benefits in the form of *ecosystem goods and services*. This report quantifies, for the first time, the economic value of the natural capital of Ireland's native woodlands.

Failure to include natural capital values in national accounting systems incurs high but hitherto invisible costs. 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 (see box below). This requirement is recognised in Ireland's 2nd National Biodiversity Plan. Accounting for natural assets will present substantial economic opportunities. This report is presented as a small but significant contribution to this process.

In this report it is demonstrated that Ireland's existing area of native woodland has an economic value of at least €100 million and possibly €143 million/yr. Some key values include amenity use, which is worth at least €35 million/yr, while 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 in that it typically provides a higher output of public goods compared to equivalent areas of plantation forest comprised of exotic conifer species.

The values established in this study are obviously significant, but 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 and the restoration of existing woodland under three scenarios. Expanding current native woodland cover from 14% 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 and overlap 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 alternative countryside amenities.

Furthermore, these benefits are entirely compatible with a prosperous timber sector. 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

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 its bogs, lakes, rivers and hill tops².



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 potentially 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 could 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 native woodland areas.

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 [66] 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 but with much former wildlife and flora having already been lost. [67]

The Status of 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. The distinctiveness of this woodland is evident from any visit, 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 are 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.

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.

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 2003². 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 contains 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.

Around 11,000 ha of native woodlands are protected by statutory designations, mainly as Special Areas of Conservation (SACs) and as National Heritage Areas (NHAs). The latter 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: old oak woodlands, bog woodland, alder and yew woodland. 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

² www.noticenature.ie

damaging trees, shrubs and ground flora. As a result the future viability of heavily grazed woodlands is seriously compromised.

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 values 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 Ecosystems 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

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

- 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 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 value of protecting a resource or future use or natural capital that has not yet been recognised - for example, a plant that holds the undiscovered cure to a major 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 decision-making and 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, an ability to accurately value natural capital and ecosystem services demonstrates that investment in woodland, on all

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>.

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 below, 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 mitigate 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 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 using 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.

Box 2: Summary of Recommendations
<ol style="list-style-type: none">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 scale4. 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 valuation.8. Promote awareness of natural capital accounting, starting with this report, to maximise its impact on public opinion and policy makers.

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 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, Native Woodland Conference, GMIT, Galway. Woodlands of Ireland.
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. Christie, M., et al., *Valuing the diversity of biodiversity*. Ecological Economics, 2006. **58**(2).
12. Fitzpatrick Associates, *Economic value of trails and forest recreation in the Republic of Ireland*. 2005: Dublin.
13. 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**.
14. 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.
15. van Rensburg, T.M., et al., *Preferences and multiple use forest management*. Ecological Economics, 2002(43): p. 14.
16. Elvik, R., *Which are the relevant costs and benefits of road safety designed for pedestrians and cyclists*. Accident Analysis and Prevention, 2000. **32**(1): p. 37-45.
17. Health, *National Taskforce on Obesity Ireland*. 2005.
18. 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.
19. Ni Dhubhain, A., et al., *The socio-economic impacts of afforestation on rural development: Final Report CAMAR*. 1994, European Community.
20. Winson, A. *Flourishing trees, flourishing minds*. In: *Trees, People and the Built Environment*. In *Urban Trees Research Conference*. 2012. Birmingham: Forestry Commission, Edinburgh.
21. 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.
22. 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.
23. Kilfeather, P. *Fisheries and the aquatic environment*. In *Forests and Water*: 2000. Cork.

24. 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.
25. 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.
26. 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.
27. Indecon, *An economic/socio-economic evaluation of wild salmon in Ireland*. 2003, Indecon International Economic Consultants for Central Fisheries Board.
28. Norton, D., et al., *Benefit Transfer for Irish Water, in STRIVE Programme 2007-2013*. 2012, Environmental Protection Agency.
29. 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.
30. Cannell, M.G.R. and R. Milne, *Carbon pools and sequestration in forest ecosystems in Britain*. Forestry, 1995. **68**(4): p. 361-375.
31. 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.
32. 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.
33. 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(75): p. 227-243.
34. 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.
35. Black, K. and E.P. Farrell, *Carbon Sequestration in Irish Forests*. 1999, COFORD.
36. Xenopolou, S., *Market review of the technical performance of Irish hardwoods*. 2004, COFORD: Dublin.
37. Casey, J. and M. Ryan, *Situation and Outlook for Forestry 2011/2012*. 2012, Teagasc.
38. Forestry Commission, *A woodfuel strategy for England*. 2008.
39. Dimitriou, I., et al., *Quantifying environmental effects of short rotation coppice (SRC) on biodiversity, soil and water*. 2011, IEA Bioenergy.
40. Harrington, T. and M. Cullen, *Assessment of wild edible fungi production in Irish woodlands*. 2008, COFORD.

41. Weisbrod, B.A., *External benefits of education*. 1964, Princetown University.
42. Walsh, R.G., J.B. Loomis, and R.A. Gillman, *Valuing Option, Existence and Bequest Demands for Wilderness*. Land Economics, 1984. **60**(1).
43. Conrad, J.M., *Quasi-option value and the expected value of information*. Quarterly Journal of Economics, 1980. **94**: p. 7.
44. Fossitt, J.A., *A Guide to Habitats in Ireland*. 2000, Heritage Council: Kilkenny.
45. Little, D.J, Boyle, G.M., and Ryan, D., Intensive Monitoring of an Oak Woodland in Western Ireland. 2001, COFORD.
46. Cunningham, D., *Brackloon. The Story of an Irish Oak Wood*. 2005, Dublin: COFORD.
47. Peterken, G., *Reversing the habitat fragmentation of British woodlands*. 2002, WEF-UK.
48. 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.
49. Barron, C., *The Control of Rhododendron in Native Woodlands*, D. Little, Editor, Forest Service NWS Information Note No. 3.
50. Purser, P., F. Wilson, and R. Carden, *Deer and Forestry in Ireland: A Review of Current Status and Management Requirements*. 2009, Woodlands of Ireland.
51. Dunne, S. *Broadleaves: What's out there? In: Managing our broadleaf resource to produce quality hardwood timber*. 2002. Carrick-on-Shannon: COFORD.
52. Valatin, G. and J. Starling, *Valuation of ecosystem services provided by UK woodlands*. 2010, UK National Ecosystem Assessment Economic Analysis Report.
53. Bullock, C., *The Economic Value of Forest Wilderness at Nephin*, in *Draft report for Coillte Wild Nephin Feasibility Study*. 2011, Coillte.
54. IMPACT, *Save Our Forests. The Social, Economic and Environmental Case against selling Coillte Assets*. . 2013.
55. Pithon, J.A., R. Moles, and J. O'Halloran, *The influence of conifers on lowland farmland birds*. Land Use Policy, 2004.
56. Foulkes, N., et al., *Hedgerow Appraisal System. Best Practise Guidance on Hedgerow Surveying, Data Collation and Appraisal*. . 2013, Woodlands of Ireland: Dublin.
57. EPA, *Water quality in Ireland*, M. McGarrigle, J. Lucey, and M.E. O'Cinneida, Editors. 2010, Environmental Protection Agency: Dublin.
58. Posthumus, H., et al., *Impacts of the summer 2007 floods on agriculture in England* Journal of Flood Risk Management, 2009: p. 1-8.
59. Penning-Rowsell, E., et al., *Estimating injury and loss of life in floods: A deterministic framework*. Natural Hazards, 2005. **36**: p. 43-64.

60. Chatterton, J., et al., *the Costs of the Summer 2007 Floods in England*. 2010, Environment Agency.
61. Murphy, C. and R. Charlton, *Climate Change and Water Resources in Ireland in Sweeney (ed), Report submitted to the EPA Johnstown Castle, Wexford, in press.*, in *Climate Change: Refining the Impacts*, J. Sweeney, Editor. 2007, Environmental Protection Agency, Johnston Castle, Wexford.
62. NTMA, *Carbon Fund. Annual Report 2010*. 2011, National Treasury Management Agency, Government of Ireland: Dublin.
63. Edwards, P.N. and J.M. Christie, *Yield Models for Forest Management*. 1981. Forestry Commission: Edinburgh.
64. Phillips, H., *Economic analysis of broadleaf afforestation*, I.F.I. Chain, Editor. 2006.
65. Little, D. and J. Cross, *Realising Quality Wood from Ireland's Native Woodlands*. 2005, Woodlands of Ireland: Dublin.
66. Weber, J.L., *Implementation of land and ecosystem accounts at the European Environment Agency*. *Ecological Economics*, 2007. **61**(4): p. 695-707.
67. 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.
68. Collier, M. and E.P. Farrell, *The environmental impact of planting broadleaved trees on acid-sensitive soils*. 2007, COFORD: Dublin.
69. DAHG, *A National Landscape Strategy for Ireland. Strategy Issues Paper for Consultation*. 2011, Department of Arts, Heritage and the Gaeltacht.
70. Purser, P., Wilson, F. & Carden, R. 2009. *Deer and Forestry in Ireland: A Review of Current Status and Management Requirements*. A report prepared for Woodlands of Ireland. Woodlands of Ireland, Dublin.
71. Tourism Development International (2013). *Socio-economic study of recreational angling in Ireland*. A report prepared on behalf of Inland Fisheries Ireland. Dublin