Chapter 18: Status and changes in the UK's ecosystems and their services to society: a synthesis for Northern Ireland

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Key Findings*

There are many different factors that affect the environment, how it is used and what ecosystem services can be delivered[1]. Northern Ireland's history has meant that the environment has been given a low political priority relative to social and economic factors. This has been changing since the advent of the Northern Ireland Assembly in 2007. A large proportion of local environmental legislation is directly related to EU and UK legislation. The Common Agricultural Policy (CAP) has had significant impacts on land use, including through agri-environment schemes. Targets for the designation, protection and management of sites and species have repeatedly been delayed. The Programme for Government is a major driver for political action, supported by major strategies including the Sustainable Development Strategy, Regional Development Strategy and Biodiversity Strategy. Climate change, invasive alien species and diseases are having impacts on habitats and ecosystem services. Consumer preferences, international trade, the costs and availability of commodities and energy may also have impacts on the demands made on land and sea resources. There is a need for greater recognition of the ability of land to deliver many functions simultaneously under integrated management regimes.	[1] well established
Northern Ireland has a unique and important biodiversity[1]. Mechanisms to protect biodiversity are having beneficial outcomes[2]. The principal pressures on Northern Ireland's species diversity come from human activities such as agriculture, forestry, fisheries and building development which have led to significant habitat loss. Climate change has had little impact to 2010, but seasonal changes have been noted for both plants and animals. Non-native invasive species have considerable localised impacts and are becoming a problem in many habitats. There has been some loss of species and others are declining. Further information is required on trends in the conservation status of priority species and habitats.	[1] well established [2] established but incomplete evidence
The area, composition and ecosystem services delivered by Northern Ireland's habitats have changed over time and contribute to the delivery of a range of ecosystem services[2]. The Northern Ireland Countryside Survey provides the major source of information on habitat change since 1989. Key changes noted between 1989 and 2007 include increases in Improved Grassland, built-up land and broadleaved woodland and decreases in arable land, Neutral Grassland and peatland. Between 1998 and 2007, Improved Grassland increased at the expense of both Neutral Grassland and arable farmland, but there was considerable loss of both Improved and Neutral Grassland to building development. Smaller amounts of Neutral Grassland, Bog, fen, Coniferous Woodland and Improved Grassland were converted to broadleaved woodland.	[2] established but incomplete evidence
Mountains, Moorlands and Heaths contain the largest tracts of semi-natural habitats and cover an estimated 13% of Northern Ireland, with the vast majority being upland blanket bog (10% of Northern Ireland)[1]. The overall area has been relatively stable over the past 20 years, although changes between some of the constituent habitats have occurred due to changes in landuse.	[1] well established

Although most of the blanket bog has been physically modified, the majority is still capable of forming peat, and Northern Ireland has a large proportion of the UK and EU blanket peat resource. Peat has a high carbon content, and bogland vegetation sequesters carbon and represents a substantial carbon store, especially where the hydrology of pristine sites is maintained and that of degraded sites restored. Uplands are used for low-intensity livestock grazing and are of high scenic and recreational value. Water storage in intact peatlands can contribute to flood alleviation.	
Semi-natural Grasslands cover an estimated 18% of Northern Ireland and are composed predominantly of Neutral Grassland (16%)[1]. This habitat has undergone a major decline in the past 60 years due to fragmentation and agricultural intensification. There is some change in management between intensive and Semi-natural Grassland, with a high proportion of Neutral Grassland being highly productive agriculturally and species poor. Maintenance of these habitats requires very specific management regimes, with grazing intensity particularly important, both to avoid soil and plant damage and to halt scrub encroachment. Some of the associated flora and fauna are very important in both a UK and an EU context. Semi-natural Grassland is used primarily for low intensity livestock grazing. Perennial grassland is a valuable carbon store.	[1] well established
Enclosed Farmland is the largest of the UK NEA Broad Habitats and covers an estimated 44% of Northern Ireland, with the majority consisting of Improved Grassland (40% of Northern Ireland)[1]. Agricultural systems have changed markedly over the last century due to intensification, which has led to some loss of habitat and species diversity. Field boundaries, with their associated open wet drains, are important for biodiversity. Since the 1950s many field boundaries have been removed, but this trend is declining. Enclosed Farmland gives the countryside its characteristic appearance and provides most of Northern Ireland's agricultural output, largely from livestock and associated products. It is also a significant source of greenhouse gas emissions and pollutants in soil and water. Perennial grassland is a potential carbon sink and increasing amounts of land are used for energy production.	[1] well established
Northern Ireland is one of the least wooded countries in the EU, with coniferous plantations (predominantly Sitka spruce) covering about 4% of the land area and broadleaved woodland, including a small amount of ancient woodland, transitional scrub and recent plantings, covering another 6%[1]. There has been a large increase in total Woodland cover since the 1950s, with the last 10 years responsible for a major increase in broadleaved woodland. Woodlands dating to 1830 or earlier cover less than 1% of Northern Ireland's land area and are highly fragmented (most <2 ha). Woodlands provide many ecosystem services, often simultaneously, and these include timber production, carbon sequestration, biodiversity and recreational opportunities.	[1] well established
Northern Ireland is notable within the UK for its large area of freshwater habitats, their flow dynamics, their nutrient characteristics and their biodiversity, including internationally	[1] well established

important bird populations[1]. Open waters and Wetlands cover an estimated 7% of Northern Ireland (75,000 ha) and there has been little change in this area over the past 50 years. There are three large lakes of particular importance for recreation and tourism, but they are eutrophic. Lowland raised bogs cover 1.5% of Northern Ireland and are important in a UK context. These and many other minor wetland habitats have decreased over the past 10 years. Arterial drainage works carried out until the 1990s resulted in Northern Ireland having the highest percentage of modified rivers in the UK, with accompanying impacts on biodiversity. More recently, priority has been given to restoring riverine habitats and recognising their role in flood prevention. Open waters and wetlands provide the benefits of water, food, recreation and biodiversity as well as detoxifying pollutants and contributing significantly to flood control.	
The Urban habitat (settlements, roads and rural buildings) covers 7.5% of Northern Ireland; there was a 30% increase between 1998 and 2007[1]. Much of this is on the edges of existing built-up areas, but there is significant development in the countryside, principally of single dwellings with attendant issues concerning the provision of infrastructure. Urban areas generally rely on the countryside to provide ecosystem services including food, water, waste disposal and recreation. However, they provide greenspace and some sites of high conservation value. Greenspace in cities provides major health and well-being benefits to residents and helps to detoxify pollutants generated by the city.	[1] well established
Although Coastal Margin habitats (Sea Cliffs, Shingle, Sand Dunes, Saltmarsh, Coastal Lagoons) cover only 0.25% of Northern Ireland, they have high biodiversity value, with seabird populations and levels of insect diversity that are important from a UK and Irish perspective[1]. The overall area has remained relatively stable over the past 20 years. However, the quality of individual sites and the amount of scientific knowledge available are highly variable. About 75% of the coast is protected, much of it by multiple designations. Coastal Margins provide major benefits in terms of recreation, culture and tourism and help to alleviate flooding, as well as being major sites for biodiversity.	[1] well established
Northern Ireland waters to 12 nautical miles include 450,000 ha of the Irish Sea and Atlantic Ocean, of which about 11,000 ha are the intertidal zone[1]. The Marine habitat contains around half of its overall biodiversity, with Strangford Lough and Rathlin Island together containing 90% of the marine biodiversity. However, catches of many finfish have decreased and there is evidence of damage to habitats and deterioration of water quality, especially in coastal areas. Northern Ireland's fisheries are important locally and the development of marine renewable energy projects has begun. The Marine environment is valued for its cultural heritage, recreational value and tourism, and is a vital component of energy, nutrient and water cycles, with major roles in regulating carbon.	[1] well established
Northern Ireland's ecosystems contribute to provisioning, regulating, cultural and supporting services[3]. There is limited information available to enable assigning these outputs to specific	[3] competing explanations

habitats.

Provisioning services: Northern Ireland's agricultural outputs are livestock and dairy products. Large amounts of grain are produced, but most of this is for livestock feed rather than human consumption. Over the past 150 years there has been a shift away from producing grain and potatoes to raising livestock; the total area of land in production (crops and pasture) in 2009 was slightly above that of 1959, but much less than in 1859 and 1909. More livestock were produced in 2009 than in 1959 or earlier. In the past 30 years cattle have slightly and steadily increased in number, the number of pigs has decreased and sheep numbers have shown a moderate increase after a peak in the 1990s. Livestock (cattle, sheep and pigs) accounted for £407 million, the dairy industry an additional £514 million, and poultry and eggs £218 million of output in 2008.

Arable production has declined since 1981, with considerable change in the types of crops produced over the past 28 years. Potatoes, apples and mushrooms are the main crops for human use, with wheat, arable crop silage and other crops increasing in recent years. Crops and horticultural products accounted for £126 million of agricultural output in 2008.

The agriculture and food processing industries are major employers and significant contributors to the local economy. However, farm numbers and incomes have been declining for the past 28 years, while the value of farmland has been increasing rapidly since the mid-1990s to nearly £20,000/ha.

Marine fisheries from Northern Ireland waters accounted for some £25million in 2008 (4% of the UK catch) and have shown a shift from finfish to shellfish (primarily lobster) since about 2004. In 2008 the value of shellfish was nearly three times the value of finfish. There has been a decline in fish stocks over the past decade.

Freshwater fisheries for salmon and eels have decreased significantly since 2000. The eel fishery in Lough Neagh accounted for some £2 million in 2008, down from £5 million, and has been declining since 1983. Salmon has declined by some 85% since a peak in 1995 in terms of numbers caught, but the value per kg has increased.

Aquaculture (both marine and freshwater) was valued at nearly £11 million in 2009. Species farmed include mussels, oysters, salmonids and living trout ova.

Most forestry consists of exotic conifers, yielding relatively low-quality timber; this was valued at over £7 million in 2009. Production gradually increased to around 400,000 m^3/yr from 50,000 m^3 in the 1970s. There has been a recent shift to small-scale planting of broadleaved trees in lowlands, with emphasis on the many benefits of mixed woodlands.

Around 98% of drinking water is abstracted from rivers, lakes and reservoirs in Northern Ireland, unlike England and Wales, where 35% is extracted from groundwater. Annual water costs were over £186 million in 2007/8, an increase of one-third since 2004. The

water quality of Northern Ireland's rivers and lakes has a direct relationship to the cost of water treatment which, along with high overall annual water costs, is high in comparison to Great Britain. Historic underinvestment in the infrastructure is being addressed, with capital investment over 5 years to upgrade the system for piping, sewage treatment and drinking water treatment exceeding £1 billion. Low flow levels, particularly resulting from possible climate change impacts, are a concern. Peat is a traditional energy source, but levels of extraction and usage are now low following significant extraction in the 1980s and 1990s. However, the area of peat extraction for horticulture has increased since 1990. Peat extraction leads to major carbon losses from peatland. Extraction of major lignite deposits has been suggested. Upland areas are the main location for windfarms, an increasingly important source of electricity. Marine renewables (wind, tidal or wave power) have significant potential for development to meet renewable targets. Hydropower is mostly on a small scale, and there is more research into, and commercial interest in, short rotation coppice and anaerobic digestion. Renewable development has increased over the past 10 years and is likely to continue to expand to meet government targets.	
Regulating services[1]: An estimated 386 million tonnes of carbon is held in Northern Ireland's soils. Peat soils occupy 15% of the land area, but contain 42% of the carbon stock. The highest soil carbon densities (>5000 t carbon/ha) are in deep peat, and peaty soils account for a further 10% of the carbon stock. Northern Ireland's soils have much higher carbon content on average (5%) than those in the rest of the UK (2–3%). Total vegetation stores of carbon are relatively higher in agricultural soils in Northern Ireland than in Great Britain (36% versus 10%) and lower in woodland (55% versus 80%), due to differences in land cover percentages. Land use changes have affected these values over time. Agriculture accounted for 23% of greenhouse gas emissions in Northern Ireland in 2007, up slightly from 22% in 1990 and compared to 7% in the UK as a whole. Northern Ireland's territorial waters may contribute to cycling of nitrogen- and sulphur-based greenhouse gases indirectly through ocean temperatures and the activities of marine algae. The marine environment receives and processes nutrient pollution from the land, some sewage, much litter and all of the wastes from marine aquaculture. Although overall soil degradation is low in comparison to the situation in Great Britain, many agricultural soils have elevated nitrogen and phosphorus levels and are a source of these nutrients to surface waters. The Nitrates Directive and the Water Framework Directive have encouraged tighter control of nitrogen and phosphorus inputs from agriculture, resulting in decreased fertiliser use, and there have been improvements in soil phosphate levels in recent years. There is still a major surplus in most soils, especially	[1] well established

those under intensive grassland. Water quality problems in Northern Ireland are mostly due to diffuse nutrient pollution from agriculture; fewer than 6% of rivers show no nutrient enrichment. There have, however, been improvements in nitrate and phosphate pollution levels in rivers since 1994. Despite this, there is no evidence yet of any improvement in the biological aspects of water quality. River pollution incidents decreased in both number and average severity between 2001 and 2008. Water courses were affected by major drainage schemes and canalisation between the 1950s and 1980s. Air quality has improved in recent years and is good in general. Domestic heating and transport are the main sources, as there is relatively little industry. High levels of ammonia can occur in rural areas near intensive animal production facilities. Apples are the main crop pollinated by insects, 80% by honeybees; the market value of apple pollination is over £7 million/yr. Vegetables and soft fruit are also partially dependent on insect pollination, worth an additional £100,000/yr. There are several agricultural pests and diseases with variable economic impacts of up to many millions of pounds a year (bovine TB, New Zealand flatworm, *Phytophthora ramorum*), but there are few data on their control by natural systems. Flooding occurs sporadically in some parts of Northern Ireland and the human and financial cost can be high. In Urban areas, it is usually pluvial rather than from rivers. Investment in water and sewage infrastructure aims to address this, but increasing levels of hardstanding contribute to flooding. On floodplains, building development control is provided through the planning system. Flood maps have been prepared to help identify areas at risk (including under changing climatic conditions). There are some coastal defences, most of which were developed in the mid-20th Century; increasingly, emphasis is on managed retreat with recognition of the value of 'natural' flood defences for both the coast and rivers.	
Cultural services[1]: There is no public 'right to roam' in Northern Ireland and there are no National Parks. Public access is largely restricted to lands in public or charitable ownership, and both membership of, and volunteering for, organisations that provide access to their properties are popular. Parks, play areas, allotments and community gardens are important and facilities are provided for cycling and walking, which are encouraged as part of a healthy lifestyle. There is a strong appreciation of the social value of farming in relation to the agricultural landscape. Tourism is becoming increasingly important and is responsible for about 5% of Northern Ireland's economy: some £1.5 billion and 40,000 jobs. Northern Ireland has a rich cultural and archaeological heritage and some unique landscapes, but the history of violent conflict has restricted the willingness of tourists to visit over the past 30 years. In 2009 there were 3.3 million visitors; this is low	[1] well established

compared to the other countries of the UK. There is scope for expansion, especially in relation to unique and distinctive landscapes which are a major attraction for visitors. The Giant's Causeway, a World Heritage Site, is an especially important tourist destination. Coarse, game and sea/shore angling are popular among residents and visitors, with the former contributing about £40 million and the latter £3.5 million/annum to the local economy. Northern Ireland has a long history of literature, poetry, music and the visual arts and the landscapes have inspired many local artists. Religious traditions form an important part of local culture.	
Supporting services[1]: There is a wide variety of geological substrata and hence of soils. Soil degradation is generally lower in Northern Ireland than in other parts of the UK, partly due to the cool and wet climate, which slows down decomposition and results in soils that are high in organic matter and generally of good quality. Climatic conditions ensure a good supply of fresh water; however, levels of pollutants and changing patterns of temperature and rainfall are affecting water bodies. Basic nutrient and water cycles are functioning, but are affected by human activities in some areas.	[1] well established
Ecosystem services contribute significantly to the economy of Northern Ireland, but valuation of the direct and indirect benefits is still at its beginnings, with many conclusions speculative[1]. Little work has been done on the economic values of the final goods produced by ecosystem services in Northern Ireland, especially those that have no market price. The ecosystem services for which economic values exist tend to be those provisioning services for which there are markets, for example agriculture, fishing and timber. However, these may not reflect the full benefits or costs, as only the direct, private good aspects have been captured. The agricultural industry had a net output of £1.3 billion in 2008, with a gross margin of £615 million. Data presentation makes comparisons difficult, but fisheries, aquaculture and marine tourism together are valued at £135 million/yr. The net cost of agriculture to the environment in Northern Ireland has been calculated to be £34.2 million/yr. The market price of agricultural goods does not include external benefits and costs. A valuation of water quality in 2006 found a benefit of at least £8 million/yr which, if quality were improved, could rise to at least £13 million. A 2006 study estimated that the natural environment contributed £573 million to the economy. In 1996 the 'non-market benefits' of the Environmentally Sensitive Area scheme were estimated at £13 million/yr. Direct costs of controlling invasive alien species amount to well over £100,000/year.	[1] well established
Northern Ireland depends on external ecosystem services for basic food and other commodities[1]. Northern Ireland's ecological, carbon and greenhouse gas footprints are slightly lower than the UK per capita average. The ecological footprint of Northern Ireland's food consumption in 2006 was 1.2 global ha/capita, the largest	[1] well established

contribution of any sector. The value of food imports and exports is very similar (around £5 billion) but the make-up differs markedly. Exports consist largely of milk and meat products, whereas most fruit and vegetables and many processed food products are imported.	
There are limited data on the consequences of change to habitats and ecosystem services, so conclusions are speculative[2]. Natural ecosystems provide considerable value to the people of Northern Ireland through a wide range of ecosystem services, although the specific services change over time. Some benefits such as carbon sequestration and hazard resilience are not currently recognised as having financial value, but this may change. Data have been collected at differing scales, using different methodologies and for varying purposes. Changes to habitats, their current and past management, and the extent of knowledge concerning past trends all vary. In many cases, trends differ markedly between different sub-habitats and the direction of changes has shifted over the 20-year time frame. Qualitative and quantitative changes may complement or contradict each other.	[2] established but incomplete evidence
Sustainable management mechanisms have enhanced the delivery of ecosystem services from Northern Ireland's habitats[2]. The sustainable management of ecosystems is supported primarily through designations, the planning system and financial incentives for agricultural land management. The Northern Ireland government, Crown Estate and charities own considerable areas of land, much of it managed for conservation purposes. Most land, however, is owned by private landowners, primarily farmers. Land management is strongly influenced by government and EU policies and financial measures to support these objectives (specifically CAP measures). Land is subject to a complex of 'rights' including turbary (peat-digging), fishing, shooting, mineral and water rights, which may or may not correspond to land ownership. The network of Areas of Special Scientific Interest (ASSIs) is still some years from completion; 305 sites (amounting to about 7% of Northern Ireland) had been declared by the start of 2010. Area of Special Scientific Interest designation forms the basis of terrestrial Natura 2000 sites, Special Areas of Conservation (SACs) and Special Protection Areas (SPAs). There is one Marine Nature Reserve in Strangford Lough, and 10 of the 15 SPAs have a marine component. Designation alone does not ensure protection. In 2008, 916 features had been assessed on 195 ASSIs. The general results, focused on Natura 2000 sites, show that condition varied across the UK NEA Broad Habitats but that overall, fewer than half of the sites were in favourable condition, but a number were 'recovering'. 'Wider countryside' and 'landscape-scale' conservation are largely through Areas of Outstanding Natural Beauty (AONBs), which cover over 22% of Northern Ireland, but powers are limited. Sites of Local Nature Conservation Importance (SLNC), country parks, regional parks and forest parks also allow for sustainable management	[2] established but incomplete evidence

options. Planning is centralised but is scheduled to transfer to local authorities before 2015. A Regional Development Strategy, supported by a suite of Planning Policy Statements (PPSs) is delivered locally through Area Plans. Environmental Impact Assessments and Strategic Environmental Assessments are legal requirements for many major developments, plans and programmes. River Basin Districts (RBDs) serve as the administrative areas for coordinated water management. River Basin Management Plans use an integrated approach to the protection, improvement and sustainable use of the water environment. The Northern Ireland Countryside Management Scheme (NICMS) was introduced in 2008 to deliver on a wide range of targets and includes previous agri-environment schemes. By the end of 2010 the total area under agri-environment schemes reached 468,000ha, or 42% of the agricultural land area. The Woodland Grant Scheme encourages the creation of new Woodland to increase wood production, improvement of the landscape and woodland biodiversity, and the sustainable management of forests and Woodlands. Since 1988, it has supported the planting of almost 12,000ha. Almost 70% of farms in Northern Ireland are located on land designated as Less Favoured Areas (LFA).	
Considerable information is available on the state of Northern Ireland's habitats, but there is little work linking specific habitats to the delivery of ecosystem services, and understanding of the functioning of ecosystems as a whole is still incomplete[2]. Data and research issues centre on whether data exist, their accessibility and their comparability and compatibility. Baseline information on ecosystem services and their valuation is required. Integration across scientific disciplines and political boundaries is needed to fully understand and optimise management of ecosystems. Further study is required to develop practical management mechanisms to optimise delivery of multiple ecosystem services.	[2] established but incomplete evidence

***** Each Key Finding has been assigned a level of scientific certainty, based on a 4-box model and complimented, where possible, with a likelihood scale. Superscript numbers and letters indicate the uncertainty term assigned to each finding. Full details of each term and how they were assigned is presented in Appendix 18.1.

18.1 Introduction

18.1.1 Scope and Purpose

The Northern Ireland Ecosystem Synthesis provides an introduction to the habitats and ecosystems of Northern Ireland and how the various services provided by those ecosystems impact on Northern Ireland's people. Within the context of the UK National Ecosystem Assessment (UK NEA) it identifies unique aspects, issues and opportunities of particular relevance to Northern Ireland.

The document provides an assessment of the extent and condition of Northern Ireland's habitats. It looks at what ecosystem services they provide and at what information is available on the value of those services in economic, social and health terms. It goes on to identify existing and potential future drivers for change and to identify where additional work is required if the ecosystem approach is to realise its full potential. It provides a baseline of existing information in 2010, but it is not exhaustive due to timescale and resource limitations. Additional information on a variety of topics is included in a Technical Supplement. The Northern Ireland Synthesis document should be seen as a first step, an introduction to how the ecosystem approach can be used to inform policy development and management decisions to help Northern Ireland's environment continue to function efficiently and deliver a range of benefits to its residents and visitors.

Placing a financial value on ecosystem services is difficult and controversial. Recent work has attempted to address this issue (Rockström *et al.* 2009a; TEEB 2009; Comhar SDC 2010b; TEEB 2010a,b,c) and it is a major aspect of the UK NEA. In the past the tendency has been to assign a 'zero' or minimal value to functioning ecosystems, landscape and biodiversity when conducting economic valuations and assessments of alternative land use proposals. The ability to provide even general financial values for functioning natural environments is fundamental to ensuring that retention of ecosystem services is considered when land use decisions, or policy decisions to encourage shifts in land use, are being made. The assignment of values to ecosystems in Northern Ireland is still developing, but the value of regulating and cultural services in particular is increasingly recognised in government policy (Section 18.5.6).

The ecosystems approach provides a mechanism for the integrated management of land, air, water and living resources that promotes conservation and sustainable use, recognising that people and their culture are an integral part of ecosystems (Defra 2007b). It is a holistic, system-oriented approach looking at the interdependence and interactions of natural resources (physical, chemical and biological) and human (socio-economic) systems. A healthy ecosystem demonstrates resilience, a capacity to respond to disturbances without loss of functional capability (Bennett & Balvanera 2007; Petchey & Gaston 2009), which allows it to recover from and adapt to change. Resilience and functional capacity are the criteria for monitoring ecosystem health and assessing the sustainability of human uses of ecosystems (Defra 2007c; Comhar SDC 2010a).

The Economics of Ecosystems and Biodiversity (TEEB), a 2-year study sponsored by the United Nations Environment Programme (UNEP), was launched at the Convention on Biological Diversity (CBD) meeting in Nagoya in October 2010. It highlights the economic value of ecosystem services around the world and uses these figures to develop policy and business recommendations aimed at improving the global situation with regard to loss of biodiversity and consequent loss of ecosystem services (TEEB 2009; TEEB 2010a,b,c). Although many of the values are context-specific, the concepts can be applied to inform planning and policy decisions locally (Section 18.6.6).

A concept closely related to ecosystem services is green infrastructure, which seeks to address biodiversity loss by highlighting the value of biodiversity and ecosystem services to the economy and society and allowing the integration of that value into business decisions. A functioning green infrastructure enhances human well-being while improving resilience and adaptation to climate change and other perturbations. It can be defined as 'an interconnected network of green space that conserves natural ecosystem values and functions and provides associated benefits to human populations the ecological framework needed for environmental, social and economic sustainability – in short it is a nation's natural life sustaining system'

(Benedict & McMahon 2002). Striving to maintain effective green infrastructure should be incorporated into policy to get the best outcomes from ecosystems for human well-being. Comhar Sustainable Development Council has produced a Green Infrastructure report for the Republic of Ireland (Comhar SDC 2010b) highlighting the importance of the approach and its many benefits. The National Parks and Wildlife Service estimate that the current marginal value of biodiversity and certain ecosystems in the Republic of Ireland in terms of their contribution to productive output and human utility is over €2.6 billion per annum (DEHLG 2008). This is considered a conservative estimate because it does not include services such as food production and waste assimilation, so the true figure will be much higher (Comhar SDC 2010b). The recent Lawton report makes a strong case for the need for a coherent network of well-managed, planned and high quality wildlife sites underpinning wider countryside sustainable management in England (Lawton *et al.* 2010).

This document was compiled and collated by the authors between May and November 2010, with final editing and incorporation of reviewers' comments in December 2010 and January 2011. The process involved four major meetings, from which the Lead Authors compiled drafts which were circulated for comments to all contributors using an iterative process to develop the final document. It has had to be shortened and edited, and much important detail is provided in a Technical Supplement for those interested. The resulting document is variable in the degree of detail in different sections, depending on the information provided by the contributors.

Time constrained the depth of the literature search, so the chapter relies primarily on the information provided by the authors supplemented by available government data. It rapidly became clear that much of the information available for Northern Ireland is 'grey literature', primarily government publications, which has not been published in the scientific literature but nonetheless provides a significant body of information on the state of Northern Ireland's environment. The chapter is based on the information available at the time of compilation and provides pointers as to what data need to be collected to enable a comprehensive assessment. The document as a whole is intended as a reference document, providing a baseline of available information and an indication of the usefulness of the ecosystems approach. There are also numerous references to data which have been provided by scientists actively working as 'pers. comm.' or 'unpublished data'; this allows inclusion of the most up-to-date information.

18.1.2 Pen Picture of Northern Ireland

Northern Ireland shares many of its ecological and cultural features with the wider Atlantic region of Europe which stretches from Norway to Spain (Aalen 1997). However, traditional patterns of land ownership and management differ from other areas of the UK and the Republic of Ireland, with implications for land use and ecosystem services.

Northern Ireland is warmer than Scotland in winter and cooler than most of England and Wales in summer (Ratcliffe 1968; Section 18.3). It is in close proximity to the tracks of Atlantic depressions and generally experiences stronger winds than more southerly parts of the UK and Ireland (Betts 1982). Heavy falls of snow are relatively rare. Days with snow lying are fewest on the east coast of County Down and the lowlands of Lough Foyle and the valleys of the rivers Roe and Lower Bann, while the uplands have a snowfall frequency of over 30 days per annum (Betts 1982).

Northern Ireland also differs from other parts of the United Kingdom by virtue of its separation from Great Britain by the Irish Sea and the land border that it shares with another EU member state, the Republic of Ireland. The rise in sea level after the last Ice Age occurred before many species had colonised Ireland, although they had reached Britain. Northern Ireland is diverse in its natural habitats, although the island effect means that there is, overall, a lower level of species diversity than in Great Britain (Webb 1982). Intentional and accidental introductions are now significant components of the biodiversity in many taxa (Ian Montgomery pers. comm.).While biodiversity of species and habitats is independent of the political boundary, the border has profound impacts on ecosystems (EPA 2008). Legislation, policy, economic drivers and management practice differ between the two countries. The differences between the island's

ecosystems and those of the other countries within the UK require consideration when legislation and policy are developed on a UK basis and applied to Northern Ireland (Section 18.3).

The human population of Northern Ireland was 1.79 million in 2009 and is expected to reach 1.92 million by 2020 (NISRA 2005b). There are two major cities and 41 large towns which are home to about 65% of the population, with half of these living in the Belfast Metropolitan area (NISRA 2005b). The remaining people live in smaller settlements, many with fewer than 4,500 people, or in the open countryside (NISRA 2005b). Settlement patterns differ across Northern Ireland depending on local history and topography, but in the lowlands generally there is little truly 'open' country and even the marginal hill-lands retain evidence of fields and farms from the 19th and 20th Centuries. Settlements and farms are linked by a high density, well-maintained network of roads, many of them very narrow. There is high dependence on personal transport, which is seen as essential for rural areas due to the dispersed nature of the population. There are few places in Northern Ireland more than 2 hours by car from Belfast. The attachment to land and family and the dense road network mean that considerable numbers of people commute to work by car, often from large, new houses built on former farmland or semi-natural habitats in the open countryside (NIEL 2009b; Section 18.5.7).

Tertiary basalt lavas cover almost one-third of the landscape of Northern Ireland, representing the largest continuous unit of basic igneous rock in Britain and Ireland (Hamilton 1982). Northern Ireland has a wide variety of soil types, which helps to create a diversity of habitats and land uses. In spite of its small size, Northern Ireland exhibits at least 308 different soils on 97 parent materials (Cruickshank 1997). There has been little serious degradation of these soils through industrial processes, as industry has been focused mainly on a small number of towns and cities. Although there are many soil types, 60% of the land area has gleyed (poorly draining) soils (Cruickshank 1997). Many of the soils have been modified by farming and drainage operations; even grassland farming is only possible on the most gleyed soils because of field drainage. In addition, upland areas have predominantly peat or peaty soils, some of which have been drained for farming or forestry. Only a limited amount of the land is of sufficiently high quality to support profitable arable agriculture, primarily on the better drained soils of the Foyle valley, the Lower Bann and north Down (Cruickshank 1997). As recently as the late 1940s a larger area of Northern Ireland was under arable crops as part of general mixed farming. The present dominance of grass is a feature of agriculture since the Second World War (WWII) in response to national and later European agricultural policies. 'Lazy beds' and abandoned farmsteads provide evidence of potato and subsistence farming high into the upland margins in previous centuries. There is evidence of some alien species (tropical nematodes, New Zealand flatworms) having negative impacts on grassland (Murchie *et al*. 2003; Fleming *et al*. 2008; Sections 18.4, 18.6.2, 18.6.5).

Around three-quarters of the 1,351,000 ha land area of Northern Ireland is used for agriculture, primarily rough and improved grazing for cattle and sheep and for silage production. In 2008 agriculture supported roughly 24,000 full-time equivalent (FTE) jobs and provided £348 million gross value added (GVA), or 1.2%, of income to the regional economy (DARD 2009d). This rises to about £878 million GVA (3.1%) and 42,400 employees (5.5%) if the food and drinks processing sector is included (DARD 2009d). Key features include small farms, part-time farmers and conacre (Section 18.6.2.1), with a variety of farming practices and differing impacts on the environment. Most land is in private ownership with an average farm size of 40ha, which is smaller than the UK average of 54 ha (DARD 2010o). There is a strong attachment to the land (Alexander 1964). However, only about half of farms are entirely owner occupied, with around one-third of the land in conacre (DARD 2010o; Sections 18.5.3, 18.5.4 & 18.6.2.1).

Uplands include the Mournes in the south east, Cuilcagh and Slieve Beagh in the south west, the Sperrins in the North West and the Antrim Plateau in the North East. Slieve Donard in the Mournes is the highest peak in Northern Ireland at 852m (Met Office 2007). Upland moorland remains extensive despite some plantation of conifers, draining for farmland and extraction of peat, and most is used for rough grazing, primarily by sheep. Much of the peatland is degraded through agriculture, forestry and especially past peat cutting, with 47% cut-over at some time in the past, but some large tracts of intact bog remain in the

uplands, as well as some significant areas of lowland raised bog. Peat is a major carbon store, with over 50% of soil carbon stocks in peat and peaty soils (Sections 18.5.2, 18.5.6.3, 18.6.2 & 18.6.3).

Northern Ireland is the least wooded country in the EU, with only 6% cover as opposed to 12% in the rest of the UK, 44% being the EU average (McEvoy & McAdam 2004; Forestry Commission 2009a). Only 0.75% of the land area is covered with woodland that dates back to at least 1830. Around 0.04% of Northern Ireland is woodland that can be classified as ancient (continuously present since at least 1600) with a high degree of certainty, compared with 2% in Britain (Woodland Trust 2010a). While there have been significant increases in both broadleaved and coniferous woodland since 1986, and especially since 1998, some of this woodland is successional from a range of semi-natural habitats which had biodiversity value in their own right, including cutover bog margins (Section 18.5.5).

In Northern Ireland there are three major lakes within two lakeland areas and three key river basins. A total of 4.4% of Northern Ireland's surface area is water, four times more than that of Great Britain (Smith *et al*. 1991). Lough Neagh, in the centre, is the largest lake in the British Isles at 38,300ha, but is shallow (mean depth of 8.9m with a maximum of 30m; LNAC 2002). The Lough Neagh system is of international conservation importance, particularly for its populations of wetland and migrant birds. The Erne lakelands in the south west are similarly important for wetland birds and for the wet grasslands that surround the lakes. They are also a major focus for tourism, with links through to the Shannon river system that help encourage boating and angling holidays (Sections 18.5.6, 18.6.4.2 & 18.6.4.3).

Northern Ireland has an extremely rich coastal and marine biodiversity due to its location at the transition between cold northern waters from the north-east Atlantic and warmer southern waters from the Irish Sea. It is responsible for managing an estimated 450,000 ha of Marine environment, containing around half of Northern Ireland's total biodiversity (NIEA 2010h, AFBI & NIEA 2011). The coastline is an estimated 650km in length (DOE & NISRA 2010) and is punctuated by five major sea loughs. Strangford Lough is the largest (150,000 ha; EHS *et al*. 2001) and is Northern Ireland's only Marine Nature Reserve, containing almost three-quarters of the marine biodiversity of Northern Ireland and including many internationally important bird populations (Brown 1990). The Giant's Causeway World Heritage Site is Northern Ireland's major tourism attraction (Section 18.6.4.2). The largest offshore island is Rathlin Island, off the north coast, which rises steeply and is surrounded by waters exhibiting a high level of marine biodiversity. It is also the only permanently populated offshore island. There is a substantial fishing industry (mainly Dublin Bay prawn, *Nephrops*) concentrated on the County Down coast, responsible for roughly 5% of total UK landings and worth £34 million annually (2008 figures; MFA 2009; Sections 18.5.8, 18.5.9 & 18.6.2.2).

Approximately 430,000 ha of Northern Ireland have been designated for conservation purposes (NIEA unpublished data; see Table 18.21 for details). Designations include: Area of Special Scientific Interest (ASSI), Special Area of Conservation (SAC), Special Protection Area (SPA), Area of Outstanding Natural Beauty (AONB), although AONB is not primarily a conservation designation, Ramsar site (wetlands of international importance), and Marine Nature Reserve (there is one MNR: Strangford Lough). This area includes some very large sites which have multiple designations. In addition to the designated areas, the Environmentally Sensitive Areas (ESA) Scheme and Countryside Management Scheme (CMS) have provided a significant incentive to undertake sensitive land management on farms. Agri-environment schemes cover 42% of the agricultural land area (DARD 2008a; Sections 18.9.1 & 18.9.5).

There is more limited public access than elsewhere in the UK, with no 'right to roam' (EHS 2004c). In Northern Ireland the townland has been the basic system of land division since at least the medieval period (Proudfoot 1990; Aalen 1997). Turbary (bog turf or peat-cutting), water, mineral, shooting and other 'rights' are complex, rooted in history, and often do not correspond with land ownership. This can lead to time-consuming site designation practices (ASSIs, National Nature Reserves (NNRs), etc.) and complex land management arrangements. Tourism is a valuable local industry accounting for about 5% of the Northern Ireland economy. However, this is lower than in the rest of the UK (9.7%) and the Republic of Ireland (6.3%; Sections 18.6.4 & 18.6.4.2).

There has been a low level of mining and industry and consequently relatively little industrial pollution. Northern Ireland is geologically rich, with a wide diversity of construction aggregates providing an industry with a 2009 turnover of approximately £450 million, which has declined from £730 million (Bell 2008) since the economic downturn. Hard rock is quarried in all counties, and sand and gravel from glacial deposits are also dredged from Lough Neagh. At present no marine sand is extracted from Northern Ireland waters. Damage to ecosystems is localised, and many abandoned quarries have been used for waste disposal while others are providing valuable natural habitat (Section 18.6.2.13).

Pollution is primarily agricultural or urban in origin, including diffuse pollution from agricultural runoff. The impacts on aquatic ecosystems continue to be severe. Air pollution was traditionally primarily from solid fuel heating, but since the 1950s is now primarily from motor vehicle traffic (POST 2002; Section 18.6.3.10).

Northern Ireland had a 3.5% share of UK total net greenhouse gas emissions in 2008, with a decline of 11.2% since 1990. However, due to the significance of agriculture, it accounts for 13.5% of UK emissions for agricultural methane (AEA 2010; DOE 2010c). While carbon dioxide emissions decreased by only 6.7% between 1990 and 2008, the decrease in methane was by 23.8% and of nitrous oxides was 26.8%. However, hydro fluorocarbon emissions increased by 650% and sulphur hexafluoride by 261% (DOE 2010c). The energy sector as a whole (electricity, transport, domestic) is responsible for 73.2% of emissions of greenhouse gas (lower than the UK average of 85.1%) and agriculture is responsible for 20.8%, much higher than the UK average of 7%, but not as high as the Republic of Ireland at 27.7% (in 2006; EPA 2008). Northern Ireland is a small net sink of carbon dioxide from land use, land use change and forestry, with cropland a net source and grassland a net sink (DOE 2010c). While detailed targets have not yet been set for Northern Ireland, the Executive has committed to delivering on UK targets and, given the different profile for Northern Ireland's emissions, there are likely impacts on land use (Sections 18.6.3.1, 18.6.3.2, 18.6.3.3, 18.6.3.4 & 18.6.3.5).

18.2 Drivers of Change

This section reviews some of the major drivers affecting land use and ecosystem services in Northern Ireland at the beginning of the second decade of the 21st Century. Many factors impact on the way the land, sea, ecosystems and landscape are managed. Recognising the different outputs that can be obtained from ecosystems adds to the value of the land economically and socially, as well as environmentally. Increasing demands on land will add to the need for delivery of multiple benefits but it will also result in conflicts between different uses (Coates & Hadden 2010; Foresight 2010; Lawton *et al.* 2010; Section 18.2).

The high profile and political emphasis given to social and economic factors as a result of Northern Ireland's past has meant that the environment has generally not had a high political priority (Macrory 2004; Bell et al. 2007). Environmental action has increased in recent years, with AONBs declared in the 1960s and 1970s and the Convention on Biological Diversity (CBD), EU Directives and the Northern Ireland Biodiversity Strategy in the 1990s. An important driver has been EU legislation and the possible financial consequences of not meeting targets for water quality, waste management and site and species protection (Macrory 2004). However, Northern Ireland still lags behind other UK countries in designation, protection and management of sites and species (Macrory 2004; Bell et al. 2007). For example:

- Northern Ireland adopted the target of halting biodiversity loss by 2016 (NIBG 2009), in comparison with the international target of halting biodiversity loss by 2010 (although this target has since been revised to 2020);
- the target for ensuring features on designated sites are in or approaching favourable condition is 2016, compared to 2010 in the rest of the UK (NIBG 2009);
- the revised Sustainable Development Strategy, including biodiversity targets, only came into force in mid-2010;
- data on many aspects of biodiversity are still lacking and full designation of the ASSI network is not planned to be complete until 2016 (EHS 2003a); and,
- there are no National Parks.

Human health and well-being are dependent on ecosystem services, so land use must be actively planned and a long-term view of investment in environmental protection adopted (MA 2005a; TEEB 2009, 2010a,b,c).However, in Northern Ireland, as with the UK as a whole, the economic impacts of the 2009 recession may result in the environment receiving less attention, as limited available funding is targeted at health, education and social care. It is important to identify the factors which influence environmental attitudes, management and priorities if ecosystem services are to be understood, a prerequisite for their protection. The need for a healthy environment to underpin human health has direct impacts on spending in the health service, but such links are seldom made when funding decisions are taken (Comhar SDC 2010b).

Drivers of change can be either direct, with a clear causal relationship between the driver and the resulting environmental changes, or indirect, where change factors have a more general influence on the environment. In the UK NEA, drivers of change are considered under six major headings (Birnie *et al*. 2002; Miller *et al*. 2009) and the same general factors are identified in the Land Use Futures project (Foresight 2010). **Table 18.1** presents some of these drivers, the relevant manifestations and potential impacts in Northern Ireland and some relevant changes of the past 20 years.

Insert Table 18.1 here

These drivers interact and overlap and the overall impacts are often highly complex. The differences between private and public goods in terms of management costs and beneficiaries of investment in land management need to be considered. Another important consideration in future policies is the need to develop multifunctional use of land and sea to enable resilience. The potential for different policies to complement and/or conflict with each other (at all levels: local, Northern Ireland, UK and EU) requires forward planning in advance of implementation. Work such as the Foresight studies and the scenario work of the UK NEA provide mechanisms to identify such potential issues and devise ways to address them (Foresight 2010; Chapter 25). A schematic representation of the factors impacting on land use and ecosystem services is presented in **Figure 18.1**. Specific knowledge, skills and training of landowners or managers is essential for the delivery of integrated ecosystem services.

Insert Figure 18.1 here

In Northern Ireland the Programme for Government is the main driver for national action, supported by a number of other key strategies (including the Sustainable Development Strategy, Regional Development Strategy, Regional Transport Strategy, Waste Management Strategy, Biodiversity Strategy) and implemented through a programme of national legislation. A significant proportion of local environmental legislation and policy, delivered through regulation and funding schemes, is directly related to EU and UK legislation (Bell et al. 2007; Commission of the European Communities 2008). Major environmental matters are dealt with by a number of Government Departments and Agencies in Northern Ireland (**Table 18.2**). The Mid Term Evaluation of the NI Rural Development Programme 2007–2013 has stated that 'there is a strong belief that future Rural Development programmes will focus on greenhouse gases and climate change, with a clear focus on emissions' (NISRA 2010b) with clear implications for future land use. The recent recognition of the importance of food security, food traceability and food carbon costs should also be recognised as an important driver.

Insert Table 18.2 here

Underpinning, but often independent of, the policy, legislative and financial drivers, are environmental changes which can have major impacts. Climate change (Section 18.4.4), invasive alien species (Section 18.4.3) and pests and diseases (Section 18.6.3.12) are areas where impacts on habitats and ecosystem service delivery could be severe, unexpected and expensive to address. Ensuring that ecosystems have sufficient resilience to deal with these perturbations is an important role of policy and other drivers under

direct government control. Consumer preferences, international trade, costs and availability of commodities and energy sources also have impacts which could lead to major changes in the demands on land and sea.

There is research evidence that land is increasingly recognised as a valuable public resource and that it needs to be managed in ways which benefit the community at large. Research which attempts to quantify the environmental, economic and social benefits provided by ecosystem services is also increasing (Heal 2000; eftec 2005; Kremen 2005; Barbier 2007; Brauman et al. 2007; TEEB 2009; Comhar SDC 2010b; TEEB 2010a,b,c).

Some of the many functions which land can provide are water resource management, nature conservation, agriculture, woodland and forestry, flood defence, energy, residential and commercial development, transport, recreation, waste management and education. Not every piece of land is suitable for delivery of all ecosystem services but in total, the land of Northern Ireland delivers all of these benefits. In some areas there is significant delivery of many ecosystem services from single areas. By using a systems view of the environment, its functions and the drivers that affect it, the stakeholders are better able to understand and determine how best to manage it for future benefits to themselves and society at large (Sections 18.5.2, 18.5.3, 18.5.4 &18.5.5).

Most land is in private ownership so influencing its management must be through legislation, fiscal drivers and education. The Common Agricultural Policy (CAP) has demonstrated that financial incentives do impact on land management (sometimes having negative impacts on ecosystem service delivery) and therefore can be used to encourage landowners to manage land in ways which deliver public goods in exchange for payment. The Single Farm Payment's environmental conditions (Cross-Compliance; Good Agricultural and Environmental Conditions) do this to a limited extent. Future EU programmes should include ecosystem service delivery as a goal while addressing other issues including food and energy security and climate change adaptation and mitigation (NIBG 2009; SEL 2009; Comhar SDC 2010b; Godfray *et al.* 2010; Lawton *et al.* 2010).

18.3 Biodiversity in Northern Ireland

Biodiversity is the diversity and abundance of living things, including the visible plants, animals and fungi but also the bacteria and microscopic life which are particularly important to decomposition and nutrient cycles. Organisms are fundamental to the service delivery by an ecosystem and awareness of their health and vigour is essential to determining the overall health and resilience of any ecosystem (NIBG 2009; SCBD 2010). It is becoming clear from research on a range of taxa from algae to mammals that many Irish species have a unique genetic composition. Further, comparison of plant communities with their counterparts in Great Britain indicates differences that are important and should be maintained (QUB unpublished data).

Managing land in ways which maintains or increases natural biodiversity improves the delivery of all classes of ecosystem services, as well as improving the resilience of the area if it is subjected to stress (Foresight 2010). Natural flood control, pollination, erosion control and pollution abatement are all areas where the natural biodiversity of an area can greatly improve its ability to deliver benefits to people.

There are many examples where the decline of a key species or the introduction of a non-native, invasive species has led to severe declines of natural habitats and degradation of many ecosystem services (EHS 2008a; NIBG 2009). For example, the accidental introduction of zebra mussels in Lough Erne has altered nutrient cycling, increased water clarity and reduced the abundance of phytoplankton. This has led to significant changes in native fauna and flora, including loss of species and excessive weed growth (Minchin et al. 2002; Maguire & Sykes 2004). Furthermore, the phytoplankton species composition has recently shifted towards increasing prevalence of cyanobacteria (notably the potentially toxic *Microcystis*), causing surface blooms (Mooney *et* al. in press). Removing a species, or adding one which significantly changes the balance between organisms, can restrict the ability of any habitat to deliver the services which people require, be that cleaning up wastes, mitigating flooding, providing food or conserving carbon (Goldschmidt

1997; Foresight 2010; Section 3).

Biodiversity is of value to people. It provides protection from climate change and maintains soil fertility, clean water and fresh air; it is the source of commodities such as timber, paper and fibres for clothing and it provides the raw resources for developing new pharmaceuticals and many other potential products. Currently, many of these services are considered to be provided for 'free' because no financial value is put on them; their loss is seen as having no financial cost. Building the economic value of the natural world into accounting systems is essential to ensure that its value is recognised by governments, financial institutions and business, and is fully factored into management decisions. This is the principle behind The Economics of Ecosystems and Biodiversity approach (TEEB 2009, 2010a,b,c).

Northern Ireland has about 11,500 freshwater and terrestrial (CEDaR 2010c) and around 2,400 currently identified marine species (CEDaR 2010a,b), but this is likely to be a substantial underestimate, especially when fungi and microorganisms are considered. While Northern Ireland has fewer taxa than Great Britain, due partly to its smaller size and offshore position, it does host some species and subspecies that are endemic to the island of Ireland (**Table 18.3**).

Insert Table 18.3 here

The principal pressures on Northern Ireland's species diversity are human activities leading to habitat loss through agriculture, forestry, fisheries and building development. To date climate change has had relatively little impact, but phenological changes have been noted for both plants and animals (times of flowering, migration dates) which may result in wider ecosystem impacts (Woodland Trust 2010c). The impacts of non-native invasive species are second only to habitat destruction as a cause of global biodiversity loss (Pejchar & Mooney 2009). In Northern Ireland invasive species are becoming a problem in many habitats (Stokes et al. 2006; Arkell et al. 2007; Invasive Species Ireland 2008). For example, the grey squirrel (*Sciurus carolinensis*) has had significant impact upon the red squirrel (*Sciurus vulgaris*; O'Neill & Montgomery 2003), the New Zealand flatworm (*Arthurdendyus triangulatus*; Murchie *et al*. 2003; Fleming *et al*. 2008) and zebra mussel (*Dreissena polymorpha*; Minchin et al. 2002) have had major effects and numerous plants, especially aquatic ones, have become costly problems (ISI 2010).

Examples of species lost in Northern Ireland include the corn bunting (*Miliaria calandra*), small blue butterfly (*Cupido minimus*) and elegant feather-moss (*Eurhynchiastrum pulchellum*), and threatened species include the Irish damselfly (*Coenagrion lunulatum*), white-clawed crayfish (*Austropotamobius pallipes*), freshwater pearl mussel (*Margaritifera margaritifera*), chough (*Pyrrhocorax pyrrhocorax*) and Irish hare (*Lepus timidus hibernicus*; Habitas 2002; EHS 2005m; NIEA 2011).

18.3.1 Priority Habitats and Species

The western oceanic climate of Ireland, its island biogeography (isolated from Britain and Europe) and the varied geology, soil topography, long coastline and varied landscapes, contribute to the unique species composition and structure of the ecosystems of Northern Ireland.

In 2002 the Northern Ireland Biodiversity Strategy noted that Northern Ireland has a target to halt biodiversity loss by 2016 (NIBG 2009; NI Executive 2008) which compares with the international target of 2010. Priority habitats and species have been identified on a UK basis as part of compliance with the EU Habitats and Species Directive. All those that exist in Northern Ireland are priorities for Northern Ireland. However, some habitats and species require particular attention because of their status in Northern Ireland, or jointly with the Republic of Ireland.

At the start of 2011 there were 51 Northern Ireland priority habitats and 481 priority species following the UK and Northern Ireland priority habitats and species reviews (lists available from Northern Ireland Environment Agency, www.doeni.gov.uk/niea/). Prior to the reviews there were 40 Northern Ireland priority habitats, including three unique to Northern Ireland (crowfoot rivers, marl lakes and montane

heath), and 271 priority species. The Northern Ireland Environment Agency has published 35 Northern Ireland Habitat Action Plans (HAPs) and 33 Northern Ireland Species Action Plans (SAPs), as well as seven all-Ireland SAPs. Habitat or Species Action Plans contain information on the habitat or species, its management and status. Reviews of the status of priority habitats and Species have been undertaken in 2002, 2005 and 2010 (NIBG 2009; NIEA 2011; **Figures 18.2**; **Figure18.3**). It is envisaged that SAPs will not be required for most of the new priority species. However, it is intended that Species Statements will indicate the conservation action required for each. Information on over two-thirds of the new priority species is available on the Habitas website and progress is being made in providing the full set of Species Statements.

Insert Figure 18.2 and 18.3 here

Progress towards the achievement of the objectives of the Northern Ireland Biodiversity Strategy was reviewed in 2005 (NIBG 2005) and 2009 (NIBG 2009). Progress has been made, for example the introduction of 21 SAPs, 35 HAPs, local biodiversity officers within 11 out of 26 local authorities in 2009, the development of local Biodiversity Action Plans (BAPs) at both administrative and natural resource area levels, and the introduction of Biodiversity Implementation Plans (BIPs) in most government departments (NIBG 2009). However, overall the data indicate that fewer than half of the priority species or habitats reported on are stable or increasing, with data lacking or unavailable in many areas. The Northern Ireland Biodiversity Group Report (2009) made a series of recommendations covering the ecosystem approach, policy and legislation, planning and implementation, implementation tools, communication, awareness and engagement, local authorities, industry and commerce, monitoring, measurement and evaluation, all-Ireland measures for biodiversity, biodiversity indicators, habitats, species, rare breeds and cultivars, and climate change drivers for biodiversity action.

Biodiversity Delivery Groups (BDGs) were set up by the Northern Ireland Environment Agency and the Department of Agriculture and Rural Development to co-ordinate delivery of HAPs and arrangements for monitoring and reporting on priority habitats through partnerships between government and other relevant groups. Current trends in the area of priority habitats in Northern Ireland are available in The Second Report of the Northern Ireland Biodiversity Group 2005–2009 (NIBG 2009).The assessment, with only 17 habitats increasing or stable, caused the Northern Ireland Biodiversity Group concern (NIBG 2009; **Figure 18.2**). To date, only priority habitats with ASSIs are monitored for their condition (**Figure 18.59**). The condition of some priority habitats in the wider countryside will be able to be determined through further analysis of the Northern Ireland Countryside Survey data (NIEA pers. comm.).

Exemplar priority species were selected by the Northern Ireland Biodiversity Group in agreement with the Northern Ireland Environment Agency to cover the range of habitats represented by the BDGs (NIBG 2009). While the exemplar species represent a limited sub-set of priority species, the trends observed caused the Northern Ireland Biodiversity Group concern as, based on available data, over half of the exemplar species are declining, are at an extremely low level or, in the case of the small blue butterfly, feared extinct in Northern Ireland (NIBG 2009; **Figure 18.4**). Of the 18 Biodiversity Exemplar Species reported on to the Northern Ireland Biodiversity Group, five have a Species Action Plan, five were included within a HAP, three were subject to an All-Ireland Action Plan and five had no Action Plan (NIBG 2009).

Insert Figure 18.4 here

18.3.2 Other Biodiversity Indicators

A number of biodiversity indicators are available. Populations of wild birds may be a good indicator of the broad state of biodiversity as they move between a wide range of habitats. However, in Northern Ireland there is a lack of data, especially for the west, compared to that available in Great Britain, which reduces the effectiveness of this indicator. Data are also available for wetland birds (DOE & NISRA 2010).

Indicators need to cover as wide a range of taxa as is feasible. Birds are relatively large and easier to identify, and so have practical benefits as indicators. However, there is no evidence that they are a reliable

indicator of fungal and invertebrate biodiversity. Since fungi and invertebrates are the most species-rich groups they should be considered in monitoring programmes. Veteran trees can feature in most terrestrial habitats, such as farmland, urban and woodland. They support their own distinctive assemblages of epiphytes, fungi and invertebrates but also provide structural diversity which enhances the habitats of many other species, including people.

Monitoring of the Irish hare, the only mammal endemic to Ireland, has shown that there has been a large decline in the 50 years up to the 1960s, although there has been a slight increase in recent years (Reid *et al*. 2007; Reid *et al*. 2008; Reid et al. 2009). Caution is necessary when looking at trends on a yearly basis, as the Irish hare has exhibited cyclic population changes in the past. A main cause of decline has been changing habitat management, i.e. earlier cutting of silage. A delayed cutting option was introduced into the Northern Ireland Countryside Management Scheme (NICMS; see also 18.8.5) to help tackle this.

Grey squirrels were introduced into County Longford in Ireland in 1911 and have subsequently colonised most of Northern Ireland. A study by Queen's University Belfast in 2003 found that grey squirrels were absent in parts of north-east Antrim and that although red squirrels are still found throughout Fermanagh, Tyrone and Londonderry, the last remaining stronghold is within north-east Antrim (O'Neill & Montgomery 2003). However, grey squirrels are now colonising this area (Andrew Upton, UWT, pers. comm.)

18.3.3 Invasive Alien Species

Non-native invasive species have been receiving increasing attention as a driver of biodiversity loss and the evidence base on their distribution is increasing (Stokes et al. 2006; Early *et al.* 2009). The cost of control can be high; the CABI (2010) report estimated the direct market costs of non-native invasive species to the British economy at £1.7 billion per year (Williams *et al.* 2010). By far the greatest impact is on the agriculture and horticulture sector, and invasive plants overall have the highest costs (£483million), with plant pathogens (£403million) and mammals (£402million) also costing large sums (Williams *et al.* 2010). This study did not include Northern Ireland, where the major invasive species work has been done on a cross-border basis with the Republic of Ireland through the Invasive Species Ireland project (Maguire & Sykes 2004; Stokes et al. 2006; Habitas 2008; ISI 2010).

Non-native species must be addressed on a biogeographical basis, and this has been the approach in Northern Ireland. Data collection, analysis and risk assessment have mainly been carried out on an all-island basis so it is not possible to provide an analysis for Northern Ireland alone, nor is it meaningful to do so. Negative impacts on biodiversity can occur through a range of mechanisms such as competition, herbivory, predation, alteration of habitats and food webs, introduction of parasites and pathogens and through the dilution of native gene pools. Specific habitat types currently under specific threat include freshwater rivers and lakes; coastal floodplains, saltmarsh and sand dunes; maritime cliff and slopes; woodland; lowland heath and semi-natural grassland. A variety of native species including the Irish hare, red squirrel, white-clawed crayfish, freshwater pearl mussel, red deer (*Cervus elaphus*) and earthworms are threatened by non-native species (Stokes et al. 2006; ISI 2010).

Estimates of the number of non-native species in Ireland do not always distinguish between non-native species and invasive species; not all non-native species are invasive or have an impact on biodiversity. The total number of alien species has been estimated at 596 (DAISIE 2009); estimates for particular biodiversity groups include 99 non-native animal species (Stokes et al. 2006); 716 non-native terrestrial plants (Reynolds 2002); 112 aquatic and 63 cryptogenic aquatic invasive alien species (Minchin 2007). A pan-European analysis of the presence of the 163 'worst' terrestrial and freshwater invasive alien species threatening biodiversity in Europe showed that, in 2006, Ireland had 34 of these species (EEA 2010b) and since then a further seven have been recorded (ISI unpublished data). The introduction of non-indigenous individuals to replenish depleted local populations should be undertaken with extreme care as there may be damage to locally distinct gene pools; there is increasing evidence of such genetic distinctiveness across several taxa in Northern Ireland (Ian Montgomery, QUB, pers. comm.).

Invasive alien species impacts often occur in the context of other drivers of ecological change such as land use, climate change and pollution and it can be difficult to determine the specific degree of the impacts on biodiversity and therefore ecosystem services. There are limited studies of impact for each factor and variation in assessing the impacts amongst those studies. Data on invasive alien species status, trends and impacts are not currently linked to ecosystem service and therefore any assessment would be qualitative. However, there is increasing interest in this area as invasive species, and freshwater plant species in particular, are a growing problem and their establishment in lakes has directly impacted on cultural services such as recreation, tourism and amenity value (Cathy Maguire, ISI, pers. comm.).

Intercontinental ocean-based transport routes (via ballast water) and aquaculture (via the escape of farmed species) mean that Northern Ireland has a number of marine invasive species. Of these, perhaps the most significant to date has been the Japanese wireweed (*Sargassum muticum*). This brown alga was initially reported from Strangford Lough in 1995, but has spread rapidly from there. Although its main impacts seem to be related to fouling of man-made structures, it can also have ecological consequences for the benthos (Roberts *et al*. 2004; Strong et al. 2006). A recent addition to the list of confirmed invasive species is the slipper limpet (*Crepidula fornicata*), which has established populations in Belfast Lough (McNeill et al. 2010). The Asian tunicate (*Styela clava*), has also established in Northern Ireland's waters (Nunn & Minchin 2009). Although the Northern Ireland Environment Agency Invasive Alien Species website (Habitas 2008) lists several other species that are likely to invade Northern Ireland's Marine ecosystems, none are currently known to have established viable populations in the wild. An increasing reliance on aquaculture to produce seafood, together with climate change, means that the threat posed by marine invasive species is likely to increase.

There has been widespread control of invasive species across Northern Ireland as a result of training provided by the Northern Ireland Environment Agency (NIEA) and through the Invasive Species in Ireland Project. There are numerous examples including Roads Service Northern Ireland widely spraying Japanese knotweed (*Fallopia japonica*), Ballinderry river giant hogweed (*Heracleum mantegazzianum*) control, Belfast Hills Partnership project and work by a number of councils. In Northern Ireland the Rivers Agency spent £200,000 on a 12-mile stretch of the River Roe clearing Japanese knotweed, the Killyhelvin waste water treatment works required a £120,000 refit due to zebra mussels, and a number of projects to address floating pennywort (*Hydrocotyle ranunculoides*) have together cost £85,000, mostly in staff time. The Northern Ireland Environment Agency has spent an estimated £415,000 on clearing invasives from its country parks and over £32,000 at its nature reserves since 2005 (NIEA unpublished data).

18.3.4 Climate Change

The climate of Northern Ireland is already changing in line with predictions (UKCP09 2009). Air temperature is rising and the number of hot days is increasing; the proportion of rainfall falling in summer is decreasing, while winters are slightly wetter, and in 2009 and 2010 record low winter temperatures were recorded. Record breaking cold winter temperatures sustained for relatively long periods may become more frequent, with possibly severe impacts on native biodiversity; while some of these impacts may be positive (e.g. killing of pest species such as aphids) there are likely to be negative impacts as well as native species encounter more severe conditions. In Europe, annual air temperature has increased between 0.3^{o}C and 0.6^{o}C since 1900. Temperature change at local level may be more variable (Albanito *et al*. 2008; Sweeney *et al.* 2008). These changes are expected to accelerate over the coming century. Average temperature may rise by 3^{o}C or more; summer rainfall may fall by up to 50% while winters may be 25% wetter (SNIFFER 2008). Furthermore, relative sea level may begin to rise. Although there are ongoing efforts to mitigate climate change, principally by reducing emissions, some climate change is now inevitable. Adaptation to climate change – reducing risks and realising opportunities – is therefore required (Arkell et al. 2007; Coll et al. 2008).

Threats from climate change to the conservation, biodiversity and habitats of Northern Ireland include (SNIFFER 2002; Arkell et al. 2007; NIEL 2009a; IACCF 2010):

- distribution and species composition of habitats changing in response to warmer winters;

- increases in the range of invasive non-native species, which may threaten ecosystems in response to warmer temperatures;
- intertidal habitats, salt marshes and mudflats threatened through flooding and erosion;
- loss of coastal grazing marsh;
- estuarine and river ecology threatened by tidal flooding; and
- warmer sea temperatures affecting phytoplankton communities – the resulting decline in sand eel populations would adversely affect a wide range of seabirds (e.g. breeding seabird productivity at Isle of Muck has declined significantly in the past decade; Andrew Upton, UWT, pers. comm.).

The opportunities that a changing climate could bring to the conservation, biodiversity and habitats of Northern Ireland include expansion of some species (for example the spread of little egrets; Andrew Upton, UWT, pers. comm.) but this tends to be accompanied by equivalent threats (loss of other species and drier summers). Phenological changes for individual species have already been noted (Woodland Trust 2010c) with resultant ecological impacts including mismatching of species' life cycle events and food sources, decoupled predator-prey relationships, new invasions and the likely spread of already established invasive alien species (EEA 2010a). Distribution and range changes due to direct impacts or habitat loss are also possible, especially for species at the extremes of their ranges.

18.4 Northern Ireland's Habitats

18.4.1 Data available for Northern Ireland's Habitats

The assessment of ecosystem services requires reliable data on the types, structure, species composition and extent of habitats, as well as information on how the habitats are used and how they change with time. Terrestrial, freshwater and marine habitat classifications give useful categories within which ecosystems and their services can be assessed (Smart *et al*. 2010).

The habitats section summarises some of what is known about the habitats of Northern Ireland, how they are being managed and how they have changed over recent decades. A wide variety of data have been used to carry out the assessment, and in some instances comparisons between different data can be difficult. However, using all relevant data is still possible as long as it is made clear on what basis data were collected and care is taken in comparing across different methods.

Statistics are based on inventory data and sample-based surveys. In most cases data have not been collected using the habitat categories used in the Northern Ireland Synthesis exercise. For example, the Department of Agriculture and Rural Development definition of 'farmland' is a land-use term that includes parts or all of at least five of the habitat categories used in the Northern Ireland Synthesis. In addition, percentage area calculations vary slightly, depending on whether the land area used as the base for Northern Ireland includes or excludes lakes and/or islands.

For data compiled over many years, for example by the Department of Agriculture and Rural Development, the mechanisms and categories have often changed through time. Data presented in tables show values which have been corrected by the originating organisation to the extent possible.

18.4.1.1 Northern Ireland Countryside Survey

The Northern Ireland Countryside Survey (NICS) is one of the main data sources for the Northern Ireland Synthesis. It is a field-based research programme structured on statistical sampling principles and standard survey protocols with the aim of understanding how land use and environmental change influence Primary Habitat diversity. It provides information on how the habitats have changed in a time-series; 1986/1991 (baseline), 1998 and 2007 (Cooper & Murray 1987; Murray et al. 1992; Cooper et al. 2002; Cooper et al. 2009). It gives estimates of primary habitats with descriptive statistics from the sample. Field survey and analytical protocols are given by McCann et al. (2009).

The NICS uses a system of primary habitat mapping, derived from the UK Joint Nature Conservation Committee (JNCC) standard classification Phase I (McCann et al. 2009; JNCC 2010). Agreed combinations of primary habitats have been used to obtain broad habitat estimates. The broad habitat classification was constructed to communicate policy on habitats at a UK level (UK Biodiversity Steering Group1995a,b; Jackson 2000; Cooper et al. 2009; McCann et al. 2009).

18.4.1.2 Habitat classifications and National Ecosystem Assessment Habitat categories
For the purposes of the Northern Ireland Synthesis, NICS primary habitat and broad habitat data have been combined to provide area and percentage cover estimates for each of the UK NEA categories (Cooper & McCann 2010; **Table 18.4**; **Figure 18.5**; **Figure 18.6**). As NICS is a survey of terrestrial habitats, spatial analysis (NIEA 2010h) was used to calculate a figure for the Marine category (**Table 18.4**; **Figure 18.5; Figure 18.6**).

Insert Figure 18.5 and 18.6 here

Insert Table 18.4 here

18.4.1.3 UK NEA Habitat categories
Mountains, Moorlands and Heaths cover 13.1% of Northern Ireland (Cooper et al. 2009). Blanket bog is extensive, with smaller areas of heath in the uplands and rush-dominated poor fen in the marginal uplands, with some dense bracken and inland rock. Much of the bog has been cut-over for peat fuel in the past, but the rate of habitat decrease between 1998 and 2007 slowed to 3.4% (Cooper et al. 2002; Cooper et al. 2009).

Semi-natural Grasslands consist largely of Neutral Grassland, with smaller areas of species-rich wet grassland, acidic hill grassland, Calcareous Grassland and fen meadow. Collectively, Semi-natural Grasslands cover 18.5% of Northern Ireland and a large proportion has field boundaries (Cooper *et al.* 2009). Since the development of agricultural technology in the 1950s (Hunter 1987), there has been a large decrease in the area of Semi-natural Grasslands. The rate of decrease, mainly by conversion to more productive agricultural grassland, has slowed to 12.4% in the past decade (Cooper *et al.*2002; Cooper, McCann & Rogers 2009).

Enclosed Farmland includes lowland and marginal upland habitats, largely used for grass production, and a smaller area of cereal crops and other arable production. Small family farms predominate (Hunter 1987). Enclosed Farmland covers 44% of Northern Ireland (Cooper *et al.*2009). Their area increased by 1.5% between 1998 and 2007, mainly as a result of agricultural conversion from Semi-natural Grasslands. There is an extensive system of hedge and earthbank field boundaries. Since the 1950s many field boundaries have been removed, largely as a result of increased farm field sizes, but recent data (1992–1998) show a lower rate of decrease (Cooper *et al.*2002; Cooper *et al.* 2009).

Woodlands are distributed across the uplands, marginal uplands and lowlands, covering 10.0% of Northern Ireland (Cooper *et al.*2009). Just over half of this is broadleaved woodland (including scrub) and the rest is conifer plantation (largely Sitka spruce). The area of conifer plantation has changed little in the last 10 years. However, since 1986 there has been an increase in broadleaved woodland and scrub cover, mainly due to planting and ecological succession in other habitats (Cooper *et al.* 2002; Cooper *et al.* 2009). The figure quoted by the Forest Service for the total area of woodland cover in Northern Ireland is 87,903 ha (Forestry Commission 2009a), representing 6.2% of Northern Ireland. The reasons for the difference between the two figures are further explored in the woodland section and are largely due to differing definitions of woodland.

Open waters, Wetlands and Floodplains, mostly rivers, loughs (Lough Neagh and Lough Erne being the largest) and Bog, but also streams, Fen, Swamp, reedbeds and water-inundated vegetation, collectively cover 6.8% of Northern Ireland (Cooper *et al.* 2009). The small area of Fen, Marsh and Swamp vegetation occurs largely in drumlin hollows and around lough margins. Land drainage and flood defence engineering schemes after the 1950s resulted in large decreases in the area of wetland vegetation, but there has been

little change from 1998 to 2007 (Cooper *et al.* 2002; Cooper *et al. 2009*). Lowland raised bogs are included in this UK NEA habitat category.

Urban settlements (including rural buildings and roads) cover 7.4% of Northern Ireland (Cooper *et al.* 2009). A large increase in area, particularly between 1998 and 2007 (21.7%), occurred mainly over Enclosed Farmland and Semi-natural Grasslands (Cooper *et al.*2002; Cooper *et al.*2009).

Coastal Margins in Northern Ireland consist of Sea Cliffs, Sand Dunes, Saltmarsh, Shingle and Coastal Lagoons. They covered 3,576 ha of Northern Ireland (0.3%) in 2007 and there has been no change in the overall area since 1998 (Cooper *et al.*2002; Cooper *et al.*2009).

Marine habitats, as defined by the UK NEA, are either permanently immersed in saline water or are inundated by seawater over part of the tidal cycle. The area includes both the intertidal zone (HWMMT High Water Mark of Medium Tides to LWMMT (Low Water Mark of Medium Tides) covering an estimated 10,730 ha (Cooper *et al.*2009), and the subtidal zone (LWMMT to 12 nautical mile (NM)) covering an estimated 450,000 ha (NIEA 2010h). The 12NM territorial waters area is an estimate calculated using GIS (ArcGIS) by drawing a mid-line through trans-boundary waters out to the 12NM limit (or midway between Northern Ireland and Scotland).

18.4.1.4 Changes in Broad Habitat area

Key changes in Broad Habitats identified between 1986/1991 and 1998 (**Figure 18.7**) were an increase in the area of Improved Grassland (BH05); a decrease in the area of arable crops (BH04) and Neutral Grassland (BH06) due to conversion to Improved Grassland (BH05); a decrease in the area of Fen, Marsh and Swamp (BH11), which includes fens, reedbeds, swamps and water inundation vegetation (Section 18.5.6.4), species-rich wet grassland and fen meadow (Section 18.5.3.3) and poor fen (Section 18.5.2.3); damage to Bog (BH12), which includes lowland raised bog (Section 18.5.6.3) and blanket bog (Section 18.5.2.2) by peat cutting; and reduced ecological condition of Bog (BH12) and Dwarf Shrub Heath (BH10) due to grazing pressure. Also identified as important processes were ecological succession to broadleaf woodland (BH01) on a wide range of habitats including Bog (BH12), Fen, Marsh and Swamp (BH11) and Neutral Grassland (BH06), and an increased area of building (BH17) on Improved Grassland (BH05) and Neutral Grassland (BH06; Cooper *et al.*2002).

Insert Figure 18.7 here

Between 1998 and 2007 (**Figure 18.7**) there were smaller decreases in the areas of arable crops (BH04), Neutral Grassland (BH06) and Fen, Marsh and Swamp (BH11). Damage to Bog (BH12) from peat cutting was minimal and there was evidence of Dwarf Shrub Heath (BH10) restoration. Conversion of Acid Grassland (BH08) to more productive agricultural grassland, a process recorded between 1987–1992 and 1998, increased in the marginal uplands between 1998 and 2007. Ecological succession to broadleaved woodland (BH01) over species-rich habitats was greater between 1998 and 2007 and there was increased broadleaved tree planting on Improved Grassland (BH05) and Neutral Grassland (BH06). The large increase in area of building (BH17) over a wide range of habitats found from 1998 to 2007 was almost twice that reported from 1987–1992 to 1998 (**Figure 18.8**).

Insert Figure 18.8 here

18.4.2 Mountains, Moorlands and Heaths

Northern Ireland, on the extreme north west of Europe, has a marked oceanic climate that is much warmer than expected for its latitude (Kirkpatrick & Rushton 1990). This is due to the proximity of the North Atlantic Drift and because it receives predominantly moist, westerly air masses from the Atlantic. By forcing westerly air to rise, the uplands receive more precipitation, mostly in the form of rain, than the lowlands.

The extreme oceanicity of Northern Ireland makes its peatland habitats important in a UK, Ireland and European context (Kirkpatrick & Rushton 1990). They provide significant carbon storage, biodiversity, landscape and recreation ecosystem services and constitute a major opportunity for integrated management to deliver multiple benefits. A high proportion of the total area is designated for biodiversity, landscape or agricultural purposes and a significant area carries multiple designations (**Figure 18.60; Figure 18.62; Figure 18.64**; Sections18.9.2, 18.9.3 & 18.9.7).

With acidic parent rocks and glacial till, soils are generally acidic. The wet conditions promoted blanket peat development when the woodland cover was removed, particularly between 2000–1700BC and around 700BC. Peat became the major source of fuel in Ireland during the 17th and 18th Centuries (Aalen 1997). Cultivation expanded in the late 18th and early 19th Centuries. However, the limits of cultivation contracted after the Great Famine of the 1840s (Proudfoot 1990).

Mountains, Moorlands and Heaths in Northern Ireland can be generalised as a sequence from rare montane heath on a few summits to eroded peat on high mountain ridges and their steep slopes; extensive deep peat; extensive cutover peat; and smaller areas of poor fen (rush-dominated) and acid grassland (Section 18.5.3) on marginal agricultural land on lower slopes (with bent-fescue grasses on mineral soils and mat-grass on better-drained peaty soils; Cooper *et al.* 2002; EHS 2003d; Omagh District Council & UWT 2008; Newry & Mourne DC & UWT 2009; Cooper *et al.* 2009).

Mountains, Moorlands and Heaths contain the largest tracts of semi-natural habitats and cover roughly 13.1% of Northern Ireland (Cooper *et al. 2002*; Cooper *et al.* 2009; **Figure 18.36**) compared with 43% in Scotland, 12% in Wales, 5% in England and a UK average of approximately 18%. The overall area of Mountains, Moorlands and Heaths has been relatively stable over the past 20 years, although changes have occurred between some of the constituent habitats (Cooper *et al.* 2002; Cooper *et al.* 2009). Over a longer period use has shifted between low-level grazing and subsistence agriculture. Potential major future impacts could occur as a result of climate change, agricultural land use change and locally significant damage due to recreational use.

Bog, characterised by bog-moss (*Sphagnum*), covers much of the Mountains, Moorlands and Heaths area. The lower margin of blanket peat is generally correlated with the 1,250mm mean annual rainfall isohyet (Hamilton 1982). It consists of a wide range of peatland types (usually deeper than about 50cm), ranging from high quality wet bog to cutover and degraded bog. There was a small decrease in area between 1998 and 2007. However, much of this was bog in lowland landscapes (Cooper *et al.* 2009; Section 18.5.6). This follows an 8% decrease in Bog recorded between 1986 and 1998 (Cooper *et al.* 2002). The main change was succession to scrub at the edge of lowland bog complexes (Cooper *et al.* 2009). Mountains, Moorlands and Heaths also include small areas of other habitats, mainly poor fen and dwarf shrub heath (Cooper *et al.* 2002; Cooper *et al.* 2009).

18.4.2.1 Bog

The bogs in Ireland have been classified as either upland blanket (Section 18.5.2.2) or lowland raised (Cruickshank & Tomlinson 1988, 1990; **Figure 18.36**; Section 18.5.6.3). Blanket bog has built up over soil and rock, but lowland bogs are often filled-in basins and have a 'dome' structure. All bog types in Northern Ireland have been harvested for fuel peat (Section 18.6.2.7) and some lowland and a few upland bogs have been harvested for 'milled' peat most commonly used for horticulture (Section 18.6.2.14). The Northern Ireland Peatland Survey (Cruickshank & Tomlinson 1988) looked at a total peatland resource (excluding fen) of 167,580ha, of which 15% was lowland and 85% upland. It found that only 8% of lowland and 15% of upland bog was intact. The NICS (Cooper *et al.* 2002) recorded a loss of 8% of vegetation in lowland raised bogs (EHS 2003e), 25% in upland bog (EHS 2003b,c) and 18% in fens between 1992 and 1998 (EHS 2005g) with damage due to drainage, overgrazing and peat cutting (EHS 2003c). Much of the 25% decrease in upland bog was bare peat created by machine peat cutting. Although most of this now has vegetation cover, the full biodiversity of pristine peat will take much longer to re-establish. More recent NICS data (Cooper *et al.* 2009) show that between 1998 and 2007 the area of lowland bog decreased by a further 10%

and that upland bog decreased by just under 1% (1,018ha). There are distinct HAPs for Upland and Lowland Bogs (EHS 2003e,g).

Although there was a significant amount of machine peat cutting (Cooper & McCann 1995) between 1986 and 1998 which caused bog degradation, the area that was cut-over is recovering (Tomlinson 2010). Damage was also caused by drainage for forestry and agriculture and by heavy grazing. A recent reduction in peat cutting (1998 to 2007; Cooper *et al.* 2009) is linked to habitat conservation measures and to the largely favourable economics of oil fuel prices compared with peat cutting costs between 1998 and 2007. However, there is anecdotal evidence that hand cutting of peat has started in parts of Counties Tyrone and Fermanagh in the past few years (Andrew Upton, UWT, pers. comm.). There is an obvious need to consider the implications of significant oil price increases, but to 2010 price rises did not appear to lead to renewed activity on a large scale (Roy Tomlinson, QUB, unpublished data).

Peatlands are home to many iconic and unique species such as the carnivorous plants sundew (*Drosera* species.) and butterwort (*Pinguicula* species). The Antrim Hills are designated as a Special Protection Area (SPA) for the hen harrier (*Circus cyaneus*) and merlin (*Falco columbarius*) while the Garron Plateau, the largest area of intact blanket bog in Northern Ireland and one of the best examples in the UK, is designated as a Ramsar site. Hen harrier populations have increased in recent years, probably due to the expansion of young forest plantations, from 38 pairs in 1998 to 50–60 pairs in 2004 (Habitas 2010). Unusually, in Northern Ireland the hen harrier also nests in mature forest plantation (Scott 2000; EHS 2005h). Peatlands are also a habitat for migratory and wetland birds, including the curlew (*Numenius arquata*), dunlin (*Calidris alpina*) and golden plover (*Pluvialis apricaria*), and are increasingly important since alternative habitats such as damp lowlands have been drained. They are also a habitat for the Irish hare (*Lepus timidus hibernicus*), another priority species.

18.4.2.2 Blanket peat

Approximately 85% of Bog in Northern Ireland is blanket peat, which occurs predominantly in the uplands. Most blanket peat (73%) is in the west (Cruickshank & Tomlinson 1990) where uplands are more extensive, rainfall is higher, cloud cover is greater and temperatures are more equable. These conditions enable blanket peat to extend to low altitudes. For example, Bog on the Pettigoe Plateau is unique in Northern Ireland, as it has lowland Atlantic blanket peat vegetation similar to that found in western coastal regions of Ireland (Cruickshank & Tomlinson 1990). Within the upland Bog habitats there are areas with deep basin and raised bogs, complete with well-developed pool and hummock complexes.

Cruickshank & Tomlinson (1988) estimated that Northern Ireland has approximately 140,000 ha of blanket bog vegetation. About 15% of this area (22,000 ha) remains intact, with 10% (14,000 ha) having been drained and 46% (64,400 ha) hand-cut for fuel. The remaining 29% (40,600 ha) of blanket bog vegetation is a mix of vegetation types including large areas of eroded peatland (Roy Tomlinson, QUB, pers. comm.).In addition, significant proportions of peat soil, probably in excess of 10%, no longer support semi-natural vegetation. These soils have not been included in the blanket bog inventory. Loss of blanket bog has also been attributed to afforestation which occupies approximately 20% of peat soils (Cruickshank 1997), accounting for up to 40% (around 30,000ha) of the Forest Service estate (EHS 2003c).

The most extensive tracts of blanket bog tend to occur at altitudes above 200 m and are concentrated on the Antrim Plateau, the Sperrin Mountains and in County Fermanagh. In the north and west, where annual rainfall is much higher than in central and eastern regions of Northern Ireland, a number of blanket bogs occur in the altitude range 150–200m. In the extreme west, blanket bogs have developed as low as 90m. Peat depth is also variable, with 0.5 to 3m being fairly typical. However, where peat has accumulated in depressions, depths in excess of 5m are not unusual (EHS 2003c).

Although much of the blanket bog in Northern Ireland has been physically modified over centuries, most is still 'active', i.e. capable of forming peat. This active bog generally has a high proportion of peat-forming species such as bog-mosses, hare's-tail cottongrass (*Eriophorum vaginatum*) and deer sedge (*Scirpus caespitosus*). The NICS estimate of upland blanket bog from the 2007 survey is 139,796ha, of which just

over one-quarter has a *Sphagnum* cover of less than 10%. Between 1998 and 2007, the proportion of wet bog and wet heath (the main habitats of blanket bog) with a *Sphagnum* cover of more than 25% decreased by almost 10% (Cooper & McCann 2010). This high proportion of active bog contrasts with Great Britain, where significant areas have been subject to more intensive grazing and more frequent burning in recent decades. However, the decrease in the past 10 years of high *Sphagnum* cover areas indicates continued degradation.

Peat erosion is widespread on the higher hills, with networks of erosion channels on flatter parts and erosion gullies on higher slopes. Approximately 46% of the blanket peat has been cut-over at some time in the past (Cruickshank & Tomlinson 1990). In some areas this has left thin peat with poor fen heath or acidic grassland, whilst in others the intricate patchwork of cutting and remnant deeper peat provides a diversity of habitats that characterise the upland landscapes of Northern Ireland.

In the Sperrins almost all the lower levels are affected by past cutting; this forms a belt around the High Sperrins and completely covers peripheral lower ridges. The highest areas of the Sperrins have intensive peat erosion and the steepest slopes have thin or no peat. Blanket peat is widespread on the more modest uplands of mid-Tyrone, where a high proportion of the 15% of intact blanket peatland is found (Cruickshank & Tomlinson 1990). Cuilcagh Mountain and Slieve Beagh also have extensive intact blanket peat. However, in the 1980s and 1990s small-scale machine extraction was common in these three areas and some of this extended on to intact bog. Cooper *et al.* (2001) showed good plant community regeneration on blanket bog after mechanised cutting.

In the east there is little intact blanket peat, with large areas affected by past cutting and erosion. Of high conservation interest, however, are the Garron Plateau (Co. Antrim) for its extensive, diverse blanket bog and the Mourne Mountains (Co. Down) for their heathlands.

18.4.2.3 Poor fens

Poor fens (1.5% of Northern Ireland) arise where water originates over base-poor rock such as sandstones and granites and occur mainly in the upland margins. Some are associated with lowland heaths or raised bogs. Poor fens are likely to have a moss layer including, or dominated by, bog-mosses, purple moor-grass (*Molinia caerulea*), bottle sedge (*Carex rostrata*) and the smaller sedges, such as star sedge (*C. echinata*). Common sedge (*C. nigra*), may dominate amongst the vascular plants.

18.4.2.4 Heathland

Heath (1.2% of Northern Ireland) occurs on some upland slopes where past cutting of peat has left shallow peat (<0.5m), or on turf banks (>0.5m) on which common heather (*Calluna vulgaris*) is dominant. Wet heath also occurs as a mosaic of habitats with remnants of deeper bog. In other parts, cutover areas are dominated by acid grassland and purple moor-grass and rush pasture. Such habitat mosaics give a diverse flora and fauna and are characteristic of the upland landscapes of Northern Ireland. The Mournes and Slieve Gullion regions have the largest area of dry heath in Northern Ireland (Cooper *et al.* 2002), characterised by bell heather (*Erica cinerea*) and western gorse (*Ulex gallii*) in areas where mountain slopes are too steep for the formation of deep peat. This vegetation reflects the milder oceanic climate and shows affinities with the heaths of south-west Britain and the Wicklow Mountains in the Republic of Ireland. There is considerable diversity of heath habitats in the Mournes, depending on physical conditions, grazing intensity and land use history. Juniper, a Northern Ireland priority species, is subject to a restoration project in the Mournes (Mourne Heritage Trust 2010). Rhododendron (*Rhododendron ponticum*) has invaded localised parts of heaths, for example in the Mournes, and also bog elsewhere across Northern Ireland.

18.4.3 Semi-natural Grasslands

Like many other habitats in Northern Ireland, Semi-natural Grasslands are unique because Northern Ireland's biogeography, climate and cultural use have resulted in variations from the equivalent vegetation communities found elsewhere in the UK (Rodwell 1992; Jeffrey *et al.*1995). While this can mean a smaller flora, there is one notable exception, the fen meadow habitat. This sedge-rich community may contain

more than 40 plant species, including blue-eyed grass (*Sisyrinchium bermudiana*) and Irish lady's tresses orchid (*Spiranthes romanzoffiana*), found virtually nowhere else in the UK. Its associated fauna includes significant populations of the marsh fritillary butterfly (*Euphydryas aurinia*), increasingly rare elsewhere in the UK. The existence and survival of *fen meadows* depend on continued extensive cattle grazing (Upton & Bain 2006).

Semi-natural Grasslands cover about 18.5% of Northern Ireland and support a range of grassland fungi, notably waxcap (genus *Hygrocybe*), which are restricted in range throughout Europe. Found predominantly on drier grassland types, e.g. Acid Grassland and Calcareous Grassland, these species can also be found in high numbers and diversity on relatively small areas such as old churchyards or lawns (Neutral Grassland). Often botanically species-poor sites can be of high mycological interest and have been ignored by traditional nature conservation activities (McHugh *et al*. 2001; Genney *et al*. 2009).

Changes in agricultural practices in Northern Ireland since the 1950s have led to the replacement of much of its Semi-natural Grasslands with intensively managed grasslands dominated by ryegrass and clover (*Lolium-Trifolium* mix), a trend similar to that exhibited in the rest of the UK (Cooper & McCann 1994; Jeffrey *et al.*1995). This trend has continued over the past 20 years with significant losses of species-rich grasslands. A high proportion of the Neutral Grassland is agriculturally productive and not species rich. Remaining species-rich Semi-natural Grasslands occur as small areas in the marginal uplands and farms. Much of this habitat has been, and continues to be, converted to other types of agricultural grassland, while areas which are not accessible to farm machinery, or where there are other physical constraints on management, tend to be invaded by scrub (Murray *et al.*1992; Cooper *et al.*2002; Cooper *et al.*2009).

Neutral grassland covers an estimated 230,000 ha (in 2007), about 16% of Northern Ireland, which is by far the largest Broad Habitat in *the* Semi-natural Grasslands category. It has decreased by 30,000 ha over the last 10 years. The total area of the other habitat categories *of* Semi-natural Grasslands amounted to around 30,000 ha in 2007 (Cooper *et al.*2009). There has also been a loss in Acid Grassland of nearly 3,000 ha and over 1,000 ha of fen meadows over that period, while areas of Calcareous Grassland and species-rich wet grassland have been relatively stable. Semi-natural Grasslands often occur in a mosaic with other habitats and need specific management (EHS 2005b,i). The losses in the last 20 years, coupled with changing agricultural practices and subsidies, could lead to a further decline in these habitats.

Agricultural use of Semi-natural Grasslands is largely for livestock grazing or winter feed, overwhelmingly by sheep at relatively low stocking densities in the uplands and cattle in species-rich wet grassland and fen meadows. Recent agri-environment policies (e.g. NICMS) have encouraged low stocking densities through requiring NICMS participants to remove livestock for specified periods during the year with the aim of increasing biodiversity. This approach will require monitoring as understocking could lead to degradation of some areas, including scrub encroachment and loss of habitat condition. The proportion of purple moor grass and rush pasture priority habitat with shrub cover is 44% (Cooper & McCann 2010), highlighting the potential threat to these habitats from succession to scrub (Upton & Bain 2006). The influence of evolving agricultural policies and their delivery is likely to have significant impacts on these grasslands, for example Single Farm Payment eligibility (NIEA unpublished data).

The plant community composition and structure of habitats in Semi-natural Grasslands and Enclosed Farmland can change with management (in particular, grazing pressure). This is typified by shifts from one primary habitat type to another, or even from Semi-natural Grasslands to Enclosed Farmland habitat (Brennan 2005). Large decreases in species richness resulting from changed management are generally not reversible, but smaller decreases can be addressed (Brennan 2005). A Northern Ireland Environment Agency survey of Farmland priority habitats found that lowland meadow, purple moor grass and rush pasture, and fen meadow have declined in area over the past 10–20 years, but that upland calcareous grassland was stable, possibly because much of it is designated as ASSIs, following a steep decline in the 1990s. Lowland Acid Grassland showed no clear trend (NIEA 2008a).

Protection of Semi-natural Grasslands in Northern Ireland is mainly through designation as ASSIs, although the condition, even within ASSIs, is variable. For example, of 12 lowland meadow ASSIs, three are in favourable condition and nine are in unfavourable condition; of 23 purple moor grass and rush pasture ASSIs, eight are favourable and 14 unfavourable; and of five calcareous grassland ASSIs, three are favourable and two are unfavourable (NIBG 2009; Section 18.8).

18.4.3.1 Neutral Grassland

Neutral grassland (16% of Northern Ireland) consists largely of agricultural grasslands managed less intensively than ryegrass and with a more diverse floristic composition. The net change between neutral grassland and improved grassland conceals a much larger shift between these two habitats; while there was a loss of 90,268 ha of neutral grassland to improved grassland, 70,649 ha of improved grassland became neutral grassland between 1998 and 2007, indicating a high degree of change in management between these two habitats (Cooper *et al.*2009). These changes are likely to have been caused by different agricultural policies, new technology, fiscal drivers including fuel costs, and lack of active management. Scrub invasion and succession onto species-rich grassland is an important issue (Cooper *et al.*2009).

18.4.3.2 Calcareous Grassland and Acid Grassland

Calcareous grassland is a scarce habitat covering only 0.1% of Northern Ireland and occurring largely in the Fermanagh uplands. There was no change in the 1,802 ha of calcareous grassland in the past 20 years. Acid grassland is also uncommon, covering only 0.7% of Northern Ireland. There was a significant loss in this habitat (3,000ha), largely to dwarf shrub heath in the Mourne Mountains (Murray *et al.*1992; Cooper, McCann & Meharg 2002; Cooper *et al.*2009).

18.4.3.3 Species-rich wet grassland and fen meadows

Species-rich wet grassland and fen meadows are rare, covering 0.9% and 0.4% of Northern Ireland respectively. Transitions between other agricultural grassland and species-rich wet grassland have mainly been at the borders between the two habitats (Brennan 2005). The loss of the latter to species-rich wet grassland has been significant (due to natural species compositional changes), but there has been a gain to the habitat by succession from other agricultural grassland over the past 10 years. Losses are mainly are due to agricultural conversion and some conifer afforestation. Gains are of poor quality species-rich wet grassland from Enclosed Farmland habitats (Cooper *et al.*2009).

18.4.4 Enclosed Farmland

Enclosed Farmland covers 44% of Northern Ireland (Cooper *et al.*2009). Overall, about three-quarters of Northern Ireland is used for agricultural purposes (76% in 2005; EHS 2008a), including areas of peatland (Mountains, Moorlands and Heaths), Semi-natural Grasslands, Woodlands and Freshwater (Open waters, Wetlands and Floodplains).This compares to 61% in the Republic of Ireland, 77% in the UK and 47% in the EU15 (DARD 2010o).

Agricultural systems have changed markedly over the past century, and with intensification (particularly since the 1950s) there has been a marked loss of habitat and species diversity. Historically, a higher proportion of Northern Ireland was cultivated for arable crop production (Cruickshank 1997; **Figure 18.23**; Section 18.5.2). In the mid-19th Century, over 400,000 ha of land were in cropland (the area in 2010 is less than 50,000ha); of that area some 150,000 ha were in potatoes and flax, while figures for potatoes now are around 5,000 ha and almost no flax is grown. There has always been a high proportion of land used for hay or silage and pasture to produce animals, with that proportion increasing since 1859 (**Figure 18.24**; Section 18.5.2).

There is variation in the agricultural potential of land (**Figure 18.9**), with most arable farming in the south east and parts of the north west. Seventy per cent of all farms in Northern Ireland are designated as Less Favoured Area (LFA), with beef production the main farming activity in most of these areas (DARD 2009f, 2010o).

Insert Figure 18.9 here

There has been a slight net increase in Enclosed Farmland in recent years to just over 620,000 ha in 2007 (Section 18.4.1, **Table 18.4**), with a net decrease of 8,000 ha (15%) in arable and horticulture to 49,000ha, on top of a 25% decrease between 1989 and 1998, largely from conversion to improved grassland (Cooper *et al.*2009). This includes around 3,000 ha of horticulture in 2009 (DARD 2010c). Improved grassland increased by 33% between 1989 and 1998 with a further increase from 1998 to 2007 of some 18,000 ha (3%), largely by conversion from Neutral Grassland (Section 18.4.3). In Northern Ireland the overwhelming majority of improved grassland is ryegrass, used for grazing of animals, production of silage and for hay (**Figures 18.10**; **Figure 18.12**). There was a small recorded loss (379km; 0.2%) in field boundaries recorded between 1998 and 2007 (Cooper *et al.*2009).

Figure 18.10 presents a breakdown of how the land has been used since 1981. Much of this change has been in response to support structures and policies which encouraged different stocking densities, and price structures which have encouraged changes in crops, in particular through the CAP, which has been the main force determining production since the UK joined the European Union in 1973. Stocking densities have varied over time in response to market forces, subsidies and cross-compliance conditions (Section 18.5.2).

Insert Figure 18.10 here

Enclosed Farmland, in particular mixed farmland, is very important for biodiversity, especially in relation to farmland birds such as the yellowhammer (*Emberiza citrinella*), which is now largely restricted to east Down (EHS 2005m), and the corncrake (*Crex crex;* EHS & NPWS 2005). Arable farmland is particularly important for overwintering birds (RSPB & DARD 2004a–l).There are targets for halting declines of individual farmland bird species within Northern Ireland Species Action Plans (RSPB & DARD 2004a–l). Data collected in the previous decades suggest that populations of many specialist farmland birds have been declining rapidly (RSPB 2009).

18.4.4.1 Improved grassland

There has been an increase in permanent grassland over 5 years old during the past 28 years, with a decline in the amount of improved grassland under 5 years old of approximately 32% between 1997 and 2007 (**Figure 18.10**). Estimated yields of grass silage have remained relatively constant between 1981 (31.4 t/ha) and 2008 (30.76 t/ha), despite a decline in nitrogen fertiliser usage over the period, from 125 kg nitrogen/ha to 90 kg nitrogen/ha. This maintenance of yield despite a decrease in fertiliser usage (**Figure 18.11**) is probably a consequence of grass breeding for improved yield and improvements in crop technology (Section 18.5.3) and there may also have been an increase in the efficiency of use of manures and slurries over this period (DOE 2009). However, there has also been an increase in the amount of imported feed used, which provides indirect nutrient input, so much more information would be required to draw meaningful conclusions. The amount of grassland being reseeded (based on grass seed sales), has shown a steady decline (Gilliland *et al.*2007), some of which may be due to a reduction in reclamation. In terms of utilising grassland as a resource in production, the Ulster Grassland Society (UGS 2010) has calculated that although the average dry matter (DM) production for grassland is about 7t DM/ha, utilised DM in grazed grassland is about 5 t DM/ha, well short of the potential average production of about 12 t DM/ha.

Insert Figure 18.11 here

Here is a trend towards a reduction in numbers of sheep and cattle in Northern Ireland, probably due to a lack of profitability in these sectors and a move away from headage-based subsidies to area-based payments (Aileen Lawson, UFU, pers. comm.; Section 18.5.2). However, the situation may be more complex than this implies, as the Single Farm Payment (SFP) has led to a reduction in livestock numbers on many farms but others have intensified to remain competitive. Munton (2009) suggests this as a common trend

across the UK, although there do not appear to be any empirical data specific to Northern Ireland on this matter.

There are now issues with undergrazing in many areas, particularly in the hills, due to the decrease in sheep numbers (DARD 2010m; Section 18.5.2). This has resulted in scrub encroachment which has implications for biodiversity. Factors involved in the degradation of grassland ASSIs in Northern Ireland between 2002 and 2008 include intensification (16 sites), undergrazing/scrub encroachment (11 sites) and overgrazing (three sites; NIEA unpublished data). A development plan has been prepared for grazing management that promotes biodiversity (Upton & Bain 2006).

Management of grassland for silage production rather than for hay (**Figure 18.12**) has had impacts on the land and biodiversity. Northern Ireland has seen a dramatic switch from hay to silage production since 1950, with most of the decline in the last two decades. Most hay production has been replaced with 'big bale' silage, which can maintain species-rich grassland, but only when there are no other management changes which lead to increased intensification (McGurn 2008). Instead of the traditional single annual cut of grass for hay, usually at least two cuts are taken for silage. The gap between successive cuts is often too short to allow full development of the grasses and they go to seed for only a short period of time, if at all (EHS 2006b).Birds and all other animals have had to adapt to this change, with significant impacts on some species; the shift to silage production is responsible for the decline of the corncrake (EHS & NPWS 2005; Hynes & Hanley 2008). Other animals including the Irish hare and skylark (*Alauda arvensis*) use silage fields, but cutting of silage can cause problems for young birds and leverets which cannot escape the machines (BBC News 2010a).The longer growing seasons resulting from climate change are also impacting on silage cutting times and hence on these species.

Insert Figure 18.12 here

18.4.4.2 Field boundaries

Since the 1950s many field boundaries have been removed, largely to increase field sizes, but recent data (1992–1998) show a slowing of this trend (Cooper *et al.*2002; Cooper *et al.*2009). The length of field boundaries, a characteristic feature of small, family farms in Northern Ireland, was almost a quarter of a million kilometres in 1998. Hedges are a major source of biodiversity on Enclosed Farmland and in 1997 the length of hedges in Northern Ireland was 118,619 km. The width, height, management and species composition of hedgerows are also highly variable and impact on their value to biodiversity. Most hedges in Northern Ireland are composed of hawthorn, ash and gorse, although Fermanagh has some hedges dominated by willow species (Robinson 1977). Hedgebanks (of different ages and forms) are common and have been a feature of the landscape since the early 19th Century (Aalen & Whelan 1997). Most of Northern Ireland's hedges, unlike those in Great Britain, date from the last 200 years (Robinson 1977). Information on trees and hedgerows is provided in Woodlands (Section 18.4.5). There were also 41,284km of earth banks, 8,830km of dry stone walls and 55,130km of wire fences (Cooper *et al.*2002). Although there was little overall change in boundaries (-1.5%), dry stone walls decreased by an estimated 13%, while fences increased by an estimated 12% (McCann *et al.*2010).

The main threats to hedges and earthbanks are removal and lack of management. Between the mid-1970s and 1987 in the Glens of Antrim ESA, 6% of field boundaries were removed (Cooper & Murray 1987) and in the Mourne ESA, removal over a similar timescale was much higher (Cooper *et al.*1993). In Northern Ireland as a whole there was a continued decrease in the length of hedges, earthbanks and dry stone walls and a corresponding increase in wire fences between 1989 and 1998 (Cooper *et al.*2002). Maintaining a functional network of hedges, earthbanks and dry stone walls with their associated open wet drains (often modified streams) is a key biodiversity issue, as these features offer habitat for a wide range of wildlife, including plants, invertebrates, mammals and birds.

Within Northern Ireland, species-rich hedgerows are important for a number of UK priority species, identified as part of the UK BAP programme, including red squirrel, common pipistrelle (*Pipistrellus pipistrellus*), soprano pipistrelle (*P. pygmaeus*), linnet (*Carduelis cannabina*), reed bunting (*Emberiza*

schoeniclus), spotted flycatcher (*Muscicapa striata*), tree sparrow (*Passer montanus*), bullfinch (*Pyrrhula pyrrhula*), song thrush (*Turdus philomelos*) and purple ramping fumitory (*Fumaria purpurea*). In addition a number of Northern Ireland priority species utilise hedgerows, such as whitethroat (*Sylvia communis*) and barn owl (*Tyto alba*; DARD 2006)**.**Seed-eating birds that live in farmland habitats include yellowhammers, while wetland birds such as lapwings (*Vanellus vanellus*) are also important (Bradbury *et al*. 2000; EHS 2005m). Under the Rural Development Programme there are two schemes operating, the NICMS and the Organic Farming Scheme (OFS; Section 18.8). The Management of Special Sites (MOSS) scheme is also in place to address particular issues which fall outside the remit of the NICMS (Section 18.8).

18.4.4.3 Arable crops

The proportion of Northern Ireland's agricultural land devoted to arable crops is lower than in the past, and over time there have been considerable changes in which crops have been grown (**Figure 18.10;** Section 18.5.2).Agri-environment schemes promote retention of natural vegetation in field boundaries and winter stubble, valuable habitat for overwintering birds (Section 18.8).

Cereal yields per hectare have increased in line with trends in the UK as a whole. For example, in Northern Ireland mean barley yield increased from 3.34 t/ha in 1981 to 5.22 t/ha in 2009 and wheat yield increased from 5.00 t/ha to 7.23 t/ha over the same period (DARD 2010i). Fertiliser usage over that period was fairly constant but has fallen substantially since the introduction of the Nitrates Action Programme in 2008 (DOE 2009; **Figure 18.11**). The total weight of pesticides applied has decreased since 1998 (Withers *et al*. 2008). For example, in 2006, 203 tonnes of pesticides were applied to arable crops in Northern Ireland and this amount had decreased to 169 tonnes (down 20%) by 2008. The increase in yield of arable crops may be attributable mainly to crop breeding and improved husbandry, but to some extent, reductions in the amounts of pesticides applied may be due to improvements in pesticides themselves (newer, narrow spectrum active ingredients) and in the training of farmers in pesticide application techniques. Overall, although there have been significant changes in the areas of crops grown, the biodiversity value of arable areas and quality of water runoff from cereals has probably increased because of reduced fertiliser and agrochemical application (Jim McAdam, AFBI, pers. comm.).

Almost all grain grown in Northern Ireland is used for animal feeds, with some oats for human use and a very small amount of wheat used for milling (NIGTA unpublished data).While oil seed rape has experienced an increase in the 2000s, it still falls short of the levels seen in the early 1990s. Other forage crops (including forage maize, cabbage, turnips, swedes, root crops, kale, fodder beet and other forage and stock feed crops) have seen a major increase (although the overall area is still small), as has wheat production, especially since the mid-1990s. Significant decreases have been seen in potatoes and fruit, which appear to be on a steady downward trend (**Figures 18.13**; **Figure 18.25**).

Insert Figure 18.13 here

18.4.4.4 Horticulture and orchards

Cooper, McCann & Rogers (2009) estimated the area of orchards in 2007 at 1,165 ha (0.08% of Northern Ireland), a decrease of 28% on the total in 1998 of 1,623 ha (Cooper *et al.*2009). The Agri-food and Biosciences Institute states that 99% of orchards are Bramley apples with dessert apples and plums making up the remainder (**Withers***et al*. 2008). Mushroom production involves little land but is financially significant (Section 18.5.2.1). It is also a significant user of peat (Tomlinson 2010).

18.4.4.5 Short rotation coppice

Research into the possible production of willow to use as biomass fuel has been supported by the Department of Agriculture and Rural Development and Agri-food and Biosciences Institute for many years. Forest Service (2010a) reports that 64 ha of short rotation coppice were planted in 2008/9 and 36 ha in 2009/10 (Forest Service 2009a, 2010a), adding to more than 500 ha of planting between 2004 and 2006. In the past, short rotation coppice was occasionally planted on land containing semi-natural habitat of importance for biodiversity, e.g. planting of willow on wet grassland leads to a loss of breeding waders. However, development of improved guidance on implementation of the EIA (Forestry) Regulations has

prevented a reoccurrence. Dawson (2007) provides a detailed evaluation of short rotation coppice, including a summary of its environmental impacts, which include providing nesting habitat for farmland birds, overwintering birds and numerous invertebrates. The history of short rotation coppice willow in Northern Ireland from 1973 to the late 1990s has been analysed by McCracken & Dawson (1998). The Northern Ireland Executive has introduced the Short Rotation Coppice Scheme (DARD 2007b) to help with the economics of the practice (Dawson 2007; Section 18.6.2.11).

18.4.5 Woodlands

Beginning in Neolithic times, the woodland that covered Ireland was cleared, primarily for agriculture but with added economic (timber, charcoal, tanning), political and military benefits (Hall 1992). By 1600 Ireland was only one-third as wooded as England, with a woodland cover of 2–3%. Further woodland clearance resulted from the Plantation of Ulster in the 17th Century for iron-making and coopering (McCracken 1971). In the early 18th Century woodland in the Glens of Antrim was used for burning chalk to make fertiliser (McCracken 1971). As landowners developed their demesne estates, woodland and parkland designed landscapes were established, some of which are still significant features of the landscape. From the middle of the 19th Century, in the wake of the famine and mass emigration, semi-natural woodland developed on abandoned land. The 20th Century saw a large area of commercial afforestation, the majority of it coniferous woodland. In 1968 almost 37,000 ha had been acquired for forestry in Northern Ireland and conifers formed 94% of all plantings (McCracken 1971).

Northern Ireland has less woodland cover than other European countries (6.2%; Forestry Commission 2009a). The Forest Service estimates the total woodland cover in Northern Ireland as of March 2010 to be 87,903ha, which includes 61,200 ha of woodland managed by Forest Service (mainly coniferous woodland; **Table 18.5**; **Figure 18.14**) and 26,703 ha of non-Forest Service woodland (based on a 1970s inventory of private woodland (Graham 1981), plus subsequent planting supported by the Woodland Grant Schemes; John Griffin, Forest Service, pers. comm.; NIEA 2011).This represents an increase from an estimated 13,000 ha in 1924 (Forestry Commission 2009b) and is lower than the woodland estimate of 10.0% provided by the NICS (Cooper *et al.*2009; **Table 18.4**). This is due in part to limitations in the current woodland inventory, but is mostly because of variations in woodland definition. For example, the Forest Service estimate excludes scrub areas dominated by non-tree species such as European gorse and areas of grassland recently colonised by semi-natural broadleaves where a change of land use by the landowner has not been declared.

Insert Figure 18.14 here

Insert Table 18.5 here

The NICS 2007 revealed changes in the area of Woodland over the preceding 20 years. There was a 9% increase in the area of broadleaved woodland between 1989 and 1998 and an additional 29% (18,193ha) increase between 1998 and 2007.There was an increase of 2% in coniferous woodland from 1989 to 1998 and no significant change in area from 1998 to 2007 (Cooper *et al.*2009). The main increases from 1998 to 2007 were in broadleaved transitional woodland (<5m high), Broadleaf woodland (>5m) and scrub, with the increases mainly through successional processes on a wide range of unmanaged habitats, including birch woods developing on cutover bogland and scrub on abandoned farmland. The characteristic biodiversity of these open habitats (for example, species-rich grasslands, fen and fragmented heath/bog edge vegetation) is at risk from this change, and this is a key biodiversity issue; however much of the new woodland is also valuable for biodiversity (Cooper *et al.*2009).

A new Forestry Act was passed in July 2010, replacing the 1953 Forestry Act. The new Act specifically states that the Department of Agriculture and Rural Development has the general duty of promoting afforestation and sustainable forestry (Forestry Act, enacted 25 May 2010). The Act also includes a new requirement for felling licences, which will come into effect following the completion of subordinate legislation.

Tree Preservation Orders (TPOs) are designed primarily to protect individual trees which add to the character and appearance of an area, to keep and protect the structure and variety of woodland, especially where they offer protection to natural wildlife habitats, and to ensure that new developments take into account the landscape setting. Healthy trees of significance may be designated by the Department of the Environment's Planning Service and can only be cut down with permission; ignoring this is an offence which can elicit a fine of up to £30,000 (NIPS 2005).

Woodlands provide many ecosystem services, often simultaneously, including timber production, carbon sequestration, increased biodiversity and recreational opportunities. From 1955 to 1983 the Forest Service designated a number of areas of forest in key locations as Forest Parks, which are managed primarily for recreational use. Currently, the public have permissive access to 68,137 ha of woodland and associated open land owned by the Department of Agriculture and Rural Development and managed by the Forest Service (Forest Service unpublished data). In Forest Parks and Forest Recreation Areas specific provision is made for public access; however, all forest land is available for public access subject to environmental regulation, forest bylaws and Forest Service operations or permitted activities (Forest Service 2004).

A public opinion survey of forestry, conducted on behalf of the Forest Service in 2010, found that almost nine out of 10 people felt that 'a lot more trees should be planted' to help reduce the impacts of climate change. The majority of respondents would also welcome additional woodland in their own localities, especially near towns or villages, and there was almost universal support for the use of public money for forestry, particularly in relation to the provision of wildlife habitats and outdoor recreation (Forestry Commission 2010b; Forest Service 2010a).

18.4.5.1 Broadleaved woodland

Broadleaved woodland is widely dispersed throughout Northern Ireland. It is highly variable in character depending on soils and topography. Mixed ashwood is the main priority habitat found on base-rich soils, particularly the Tertiary basalts of County Antrim and the Carboniferous limestones of County Fermanagh. Oakwood priority habitat occurs on less base-rich soils, and is particularly common in the Sperrins and Co. Fermanagh. Although most of the oak woodlands are small, they are important in a national and European context as examples of Atlantic oakwoods; the mild, humid conditions encourage the growth of epiphytic mosses, lichens and ferns. In the larger woodlands, variation in ground conditions, including acidity and nutrient richness of the soils, leads to diverse ground flora. Wet woodland occurs on floodplains, in river valleys and as a successional habitat associated with fens, mires and bogs. Parkland priority habitat is characterised by veteran scattered trees or small groups of trees over grassland, mainly associated with demesne estates, for example Crom in Fermanagh and Glenarm in Antrim (Corbett 2007).

Ancient woods are generally recognised as being of very high ecological value by virtue of their long continuity, and therefore act as reservoirs of biodiversity. However, in Northern Ireland most ancient woodlands are very small and the total resource is highly fragmented, as shown by the ancient woodland inventory (AWI; Woodland Trust 2010a). Only 0.75% of the land area is covered with woodland that dates back to at least 1830. Around 0.04% (10,000 ha) of Northern Ireland is woodland that can be classified as ancient (continuously present since at least 1600) compared with 2% in Britain (Woodland Trust 2010a). Typically, the woodland recorded on the inventory consists of isolated fragments, with the majority less than 2 ha in area. About one-tenth of the area is parkland priority habitat.

Nearly two-thirds of woodland on the ancient woodland inventory is plantation, with ownership evenly divided between public bodies (mainly Forest Service) and private landowners (almost half of which is managed under agri-environment schemes administered directly by the Department of Agriculture and Rural Development). Restoration of some Forest Service planted ancient woodland sites to native woodland is underway. The current emphasis is to protect remnant ancient woodland features on all ancient woodland inventory sites (Richard Schaible, Forest Service, pers. comm.).

The value of forestry for nature is explicitly acknowledged in the concept of High Nature Value Forestry which is being considered by Europe for potential inclusion in the next CAP round (Caroline Barry, NIEA,

pers. comm.; IEEP 2007). There are 73 ASSIs in Northern Ireland, including 26 SACs, covering nearly 3,000 ha (**Table 18.6**) designated for their woodland features. In addition, two large areas including Forest Service upland coniferous woodland plantations are designated as SPA for 'hen harrier' and 'hen harrier and merlin' respectively. Overall more than 18,000 ha (24%) of the land managed by the Forest Service is protected by conservation designations. In 2010 roughly 74% of the area of woodland managed for timber in Northern Ireland, including all Forest Service land, is certified as managed sustainably in accordance with the requirements of the UK Woodland Assurance Standard (UKWAS; Forest Service unpublished data).

Insert Table 18.6 here

18.4.5.2 Coniferous woodland

Coniferous woodland currently covers 4.3% of Northern Ireland. The Forest Service has not planted significant areas of conifer woodland since 2004 (**Figure 18.15**). The loss of habitat diversity through conifer afforestation in the habitat-rich marginal uplands has been a biodiversity issue for many years. The Forest Service publication Afforestation – The DANI Statement on Environmental Policy (1993) marked a change in direction which stated a presumption against planting on species-rich marginal grassland sites which were later to become priority habitats under the Northern Ireland Biodiversity Strategy**.**

Insert Figure 18.15 here

The year 2010 marked the centenary of state forestry in Ireland. State planting and grant aid in Northern Ireland have contributed to an increase in overall woodland cover (both broadleaved and coniferous) from an estimated 1.1% in 1905 to 6.5% in 2009 (Forestry Commission 2009b). The Department of Agriculture and Rural Development Forest Service owns and manages over 70% of the woodlands with the remainder in private ownership (DOE & NISRA 2010). When the Ministry of Agriculture assumed responsibility for forestry in 1923 there were fewer than 2,000 ha of all forestry (Tomlinson 1997a). In 1985 the total area of planted forest belonging to the Department of Agriculture was 55,767 ha (Kula & McKillop 1988) and 61,147 ha were managed by the Forest Service in 2010 (Forest Service 2010a). The rate of state forest expansion increased markedly from the 1950s, largely due to the introduction of mechanisation, and reached a peak in the 1970s with the relatively large-scale conifer afforestation of upland blanket bog. As a result, most of the forest land managed by the Forest Service is in upland areas in the north and west of Northern Ireland.

Upland coniferous woodland consists predominantly of Sitka spruce plantations (**Table 18.5**) ranging in area from around 1,000 ha to 10,000ha, in areas of open bog and heathland (Richard Schaible, Forest Service, pers. comm.). In contrast, forests in lowland areas are less extensive and often include the surviving remnants of former estates. Lowland forests generally include Sitka spruce and other conifers such as European and Japanese larch, Norway spruce and Scots pine, with some broadleaved species, particularly oak and ash (both native to Northern Ireland) and beech (non-native; **Table 18.5**). They are less extensive compared with forests in the uplands and are often associated with former demesne woodland and historic estates (John Griffin, Forest Service, pers. comm.).

18.4.5.3 New woodland planting

The area of new planting of coniferous woodland has decreased over the past decade, with a dramatic drop after 2003/4 (**Figure 18.16**). Most of Northern Ireland's coniferous woodlands are located in the uplands on blanket peat where land was easier to acquire than in the lowlands with their better soils. However, since 1993 the Forest Service has not planted new areas of oligotrophic or dystrophic peat because of their high biodiversity value and the economic and environmental implications of dependency on repeated fertiliser applications required for timber production (Forest Service 1993).

Insert Figure 18.16 here

An estimated 2,324 ha of broadleaved woodland were planted by private landowners, largely over *Enclosed Farmland* and *Semi-natural Grassland*, between 1998 and 2007 (Cooper *et al.*2009), probably related to policy and financial initiatives promoting farm woodland. Long-term increases in characteristic broadleaved woodland ground flora species in planted woodland is possible if management includes biodiversity objectives, but unlikely if management is for agro-forestry (i.e. integrated sheep and timber production; Cooper *et al.*2009) or willow biomass production (recorded in the sample for the first time in 2007).

In 2008/9, 225 ha and in 2009/10, 177 ha were planted with grant aid from the Forest Service (DOE & NISRA 2010), short of its target of 550 ha per annum (Forest Service 2009a, 2010a; this does not include planting of short rotation coppice). Of this, 82% in 2008/9 and 98% in 2009/10 was classified as broadleaved woodland, approximately one-quarter of which in 2009/10 was classified as new native woodland (Forest Service 2009a, 2010a). During 2009/10 the Forest Service instituted a number of initiatives to encourage woodland creation by landowners, including increasing grant rates under both Woodland Grant Scheme and Farm Woodland Premium Scheme. In its Strategy the Forest Service places a strong emphasis on sustainability issues, focusing on forest creation and the sustainable management of existing forests. The Strategy also commits government to maintain the supply of timber from forests as well as providing environmental benefits and public access and contributing to the reduction of greenhouse gas emissions (Forest Service 2006, 2009b). These commitments were carried forward into primary legislation in 2010 (Forestry Act 2010). There are now targets to double the area of woodland in Northern Ireland by 2050, largely by encouraging the use of agricultural land for forestry. The Forest Service notes that the current rate of afforestation (500 ha per annum) will not be sufficient to meet this target (Forest Service 2006). There is also a short-term target to plant 1,650 ha of woodland between 2008 and 2011 (NI Executive 2008).

18.4.5.4 Hedgerows and hedgerow trees

Although Northern Ireland has a low level of woodland compared to the other parts of the UK, the Republic of Ireland and the EU, it has the highest density of field boundaries in the UK at 226,021km and an average of 16.7km (compared to 118,619km and an average of 8.8km in the UK; Section 18.4.4.2). The NICS 2000 estimated that 4% of hedgerows had been lost between 1986 and 1998 (Cooper *et al.*2002) and decreased by a further 4% between 1998 and 2007. Work carried out by the Woodland Trust in England has found that the total area covered by hedgerow trees, in-field trees, small copses and shelter belts can be as great as, or even greater than, the area covered by woodland, and that their contribution to biodiversity, and to other ecosystem services, can be high, especially in areas of low woodland cover. Most of the species in hedges are woodland edge species (Woodland Trust 2010b).

18.4.5.5 Woodland condition

Woodland surveys in the late 1980s (Tomlinson 1986a,b, 1988a,b, 1989) showed that most woodlands were in a poor condition. Many were open to grazing by farm livestock and few saplings were found; where saplings occurred they were often of ash, the seeds coming from adjacent hedgerow trees, and rarely of oak. There is little evidence of past organised coppice systems (i.e. wood management with panels and rides) as is found in lowland England and its introduction as a management tool was not recommended as many of the rich epiphytic communities could be lost. However, the surveys revealed that piecemeal coppice was common, with cutting of poles and branches to meet an immediate need for fence mending and filling gaps in field boundaries. Estate and demesne woodlands, in general, were also found to be in poor condition, with few showing replacement planting. In contrast, some estates included excellent examples of woodland, e.g. the beech woodlands in Mourne Park, Kilkeel, the ancient trees of Crom, Co. Fermanagh, and the woodlands of Finnebrogue/Quoile Pondage, Co. Down (Section 18.8.1).

Ramorum disease of Japanese larch (*Phytophthora ramorum*) has been confirmed in seven woodlands on the southern half of the Antrim plateau and one in mid Co. Down (December 2010). The best method to prevent the spread of the disease is to fell infected larch and apply the necessary bio-security measures. Around 268 ha of public forest estate and a further 6 hectares of private woodland will need to be felled by spring 2011. A system is in operation to permit logs to be taken from affected forests, under licence, to

authorised wood processing facilities. Both movement and processing of logs are subject to bio-security precautions to prevent accidental spread of the disease. The disease has also been confirmed in Japanese larch woodland in the south of Ireland, England and Wales (Forest Service 2010d).

18.4.5.6 Woodland biodiversity
State forestry has established monocultures of exotic tree species, often on areas of upland peat that have been drained. This has resulted in lower biodiversity, often poor tree growth on unsuitable sites, and soil erosion, especially of peaty soils. There is some interest in restoring unsuitable low-yielding areas after timber harvesting by not replanting and by impeding drainage to restore the local hydrology so that peat formation can resume. Clearfelling and restocking provide opportunities to enhance the biodiversity and landscape value of upland forests by diversifying their structure and composition.

Broadleaf and coniferous woodland provide refuges for the red squirrel, which is in decline due principally to the expanding distribution of the grey squirrel. Other protected native mammal species found in woodlands include the pine marten (*Martes martes*) and eight bat species. Red deer (*Cervus elaphus*), Sika deer (*Cervus nippon*) and fallow deer (*Dama dama*) are widespread in Northern Ireland and there are indications that the muntjac deer (*Muntiacus reevesi*) has naturalised, with confirmation of a roadkill in Co. Down during 2009. Deer may pose a major threat to woodland biodiversity.

Broadleaf woodland in Northern Ireland is particularly important for lower plants, including mosses, liverworts and lichens. Oceanic species are dependent on mild winters, cool summers, plentiful rain and high humidity, particularly in counties Fermanagh, Londonderry and Antrim. At Correl Glen, Fermanagh, for example, 131 species of lichen have been recorded (NIEA 2010c). The ground flora of woodland is of biodiversity importance and takes many years to develop in new planting.

18.4.5.7 Scrub
The main species in scrub habitats are blackthorn (*Prunus spinosa*), European gorse (*Ulex europaeus*), hawthorn (*Crataegus monogyna*), and willow (*Salix* species) and there are often small, regenerating ash (*Fraxinus excelsior*), birch (*Betula* species) or rowan (*Sorbus aucuparia*). Bramble (*Rubus fruticosus*) is often dominant. The 2007 scrub area was estimated at 12,408 ha, representing an increase of 33% since 1998. Transition to scrub was primarily from a wide range of semi-natural habitats and secondarily from agricultural grassland.

18.4.6 Open waters, wetlands and floodplains

Open waters and wetlands provide an environment for specialised organisms that are not found in any other habitat. They also provide services such as resting and feeding points for birds; regulating and providing water for domestic, agricultural and industrial use; a variety of sporting, recreational and tourism uses; and are important sources of fish and valuable materials such as sand and peat. Of the 55 plants protected under the Wildlife (NI) Order 1985, 29 are found in wetlands (NIEA 2009e).Northern Ireland has 21 Ramsar sites, encompassing 88,170 ha (NIEA unpublished data)including the two eutrophic standing water sites of Lough Neagh/Lough Beg and Upper Lough Erne (**Table 18.20**; EHS 2005f). Wetlands are prime examples of ecosystems capable of multiple uses and the delivery of numerous ecosystem services. However, as with all systems, they are highly vulnerable to disruption, especially from pollution. The increasing use of the river basin catchment as a unit of management has been recognised in development of River Basin Management Plans (Section 18.8.4).

Northern Ireland is notable within the UK for the large area of freshwater habitats, their flow dynamics, nutrient characteristics and their resident species. Of the four river basin districts in Northern Ireland, only one, the North Eastern (NIEA 2009g), is situated entirely within Northern Ireland. The others cross the international border with the Republic of Ireland: Neagh Bann (NIEA 2009f); North Western (NIEA 2009h); and Shannon (DEHLG 2010; **Figure 18.17**). There is therefore a strong need for cross-border cooperation in water management as both the Water Framework Directive (introduced in 2000) and the Floods Directive (2007) require catchment level approaches. This approach was adopted in work done on the Foyle and Erne

catchment strategies of the early 1990s The primary government bodies involved in managing catchments include the Department of Agriculture and Rural Development (especially Rivers Agency), Department of the Environment (DOE) (especially Water Management Unit), Department of Culture, Arts and Leisure (DCAL) (Inland Waterways and Fisheries), Waterways Ireland and the Environmental Protection Agency in the Republic of Ireland. Also of significance are the Loughs Agency which is a cross border body, the Office of Public Works (OPW) which carries out river maintenance in the Republic of Ireland and Inland Fisheries Ireland (formerly the Irish Central and Regional Fisheries Boards) whose remit includes guidance to OPW on environmental river management. In Northern Ireland there is a range of legislation for controlling or regulating activities which can cause morphological changes to waters. There is no streamlined comprehensive system to control physical modifications at present. Following an initial review of the legislation, Environmental Policy Division (DOE) did not identify any gaps in existing legislation (EPD unpublished data). However, further work is anticipated to examine cross-departmental guidance and to further review existing legislation to establish if it needs to be consolidated.

Insert Figure 18.17 here

Rivers, lakes and wetlands cover nearly 75,000 ha of Northern Ireland. Standing open water comprises the bulk of this, occupying 4% of Northern Ireland. Fen, swamp, reedbeds and water inundation vegetation occupy 0.55% of Northern Ireland and can be found on the fringes of freshwater bodies such as loughs. These habitats are a major source of biodiversity. There was a decrease in fen, reedbeds and water inundation vegetation but an increase in swamp between 1998 and 2007.

Around 15% of Northern Ireland's bogs were classified as raised bog in 1988 (Cruickshank & Tomlinson 1988) with a total area of 25,196ha, and they are a priority habitat, with 8% uncut or not drained in 2003 (EHS 2003e). Tomlinson found that peat extraction had expanded from 576 ha in 1990/1 to 689 ha in 2007/8 (Tomlinson 2010).

Changes to precipitation patterns resulting from climate change, particularly decreased flow, will compound the problems of planning for and managing changing patterns of supply and demand (Paddy Brow, NI Water, pers. comm.). Northern Ireland has particular problems and pressures with regard to fresh water, primarily arising from historic modifications to drainage patterns (NIEA 2009f), diffuse and point source pollution. All of these have led to habitat damage at various scales in water bodies of all types. A Regulatory Impact Assessment, commissioned by the Northern Ireland Environment Agency, stated that 71% of all water bodies in Northern Ireland were failing to reach the water quality standards set by the European Commission Water Framework Directive (NIEA 2009l; Section 18.5.3).

18.4.6.1 Standing open water

Standing open waters comprise one of Northern Ireland's most extensive natural habitats. There are more than 1,600 lakes, ranging in size from small ponds up to Lough Neagh (NIEA 2010f). There are two major lakeland areas: Lough Neagh and Fermanagh (containing Upper and Lower Lough Erne), which together make up 90% of the total hectarage of lakes >50 ha in Northern Ireland (DOE & NISRA 2010). All of the main monitored lakes are classed as eutrophic (including Lough Neagh and Upper and Lower Loughs Erne), with total phosphorus over double OECD levels and increasing between 2003 and 2005 (EHS 2008a). From 2004 to 2007 the numbers of eutrophic and hypertrophic lakes increased from 11 to 15 (DOE & NISRA 2009; Section 18.5.3). The situation with regard to dissolved oxygen and chlorophyll is better, with more than half of the monitored lakes showing high or good quality by those criteria (DOE & NISRA 2010).

Lough Neagh is the largest lake in the British Isles at 38,300ha, but is shallow with a mean depth of around9 m and a maximum depth of 30m.The total Lough Neagh and Lower Bann catchment is 574,000ha, of which 536,000 ha is in Northern Ireland, representing about 40% of Northern Ireland's land area (LNAC 2002; NIEA 2009f). Six major rivers flow into Lough Neagh (Blackwater, Ballinderry, Moyola, Six Mile Water, Main and Upper Bann) and it discharges to the sea via the Lower Bann River. Lough Neagh is a major source of drinking water. The Lough Neagh system is of international importance to conservation, particularly for its populations of wetland and migrant birds, and is designated as a Ramsar site, an SPA and an ASSI (EHS

2005m). There is a very important eel fishery based in the Lough, but output of grown eels has halved and natural recruitment of juvenile eels has fallen by over 90% since 1990 (Robert Rosell, AFBI, unpublished data; Section 18.5.2).

The Fermanagh lakelands (Upper and Lower Lough Erne) in the south west have a catchment of 435,000 ha (Rivers Agency 2010). They are important for wetland birds and the wet grassland habitats that surround them, and are a major focus for tourism, with international links through to the Shannon river system encouraging boating holidays and angling (EHS 2005f).

Water levels in Lough Neagh are controlled under legislation (Lough Neagh Levels Scheme 1955; as amended). Water levels in Lough Erne are controlled under the Erne Drainage and Development Act (NI) 1950 and are undertaken in conjunction with the Electricity Supply Board in the Republic of Ireland under the terms of an agreement made in 1950 when the River Erne was harnessed for hydroelectric power generation (DARD 2010l).Both Lough Erne and Lough Neagh have had their levels lowered during the 20th Century reducing the areas of land flooded occasionally, including those areas most useful for wetland birds (LNLBAC 2006).

The Silent and Annalong Valley reservoirs in the Mourne Mountains provide roughly 400,000 people with up to 130 million litres of water per day. The Mourne Conduit carries the water to Belfast (56km). Other important reservoirs include Dungonnell and Altnahinch on the edge of the Antrim plateau, and Altnaheglish and Banagher Glen in the Sperrins. These reservoirs have their feeder streams in blanket peat and peaty slopes (NI Water 2007).

There are seven canals in Northern Ireland: Broharris (Co. Londonderry), Coalisland (Co. Tyrone), Dukart's (Co. Tyrone), Newry (Co. Down), Shannon-Erne Waterway (Co. Fermanagh), Strabane (Co. Tyrone) and Ulster (Co. Armagh, Tyrone, Fermanagh). Coalisland and Newry still function for land drainage, the Ulster has been partly lost and subsumed into farming land, and Dukart's is largely lost, with only the dry inclines over which barges were hauled up remaining. The Lagan is present except for the section between Lisburn and Moira where it has been buried under the M1 motorway. There is public access for walking and cycling along most of the Lagan towpath and all of the Newry and Coalisland canals (Judith Bankhead, Rivers Agency, pers. comm.). The Shannon-Erne is open for navigation and there are plans to reopen portions of the Newry canal for canoe trails. However, reopening canals linking catchments can permit the spread of invasive species and impacts must therefore be properly assessed in advance.

18.4.6.2 Rivers and streams

There are 15,445km of rivers (defined in the NICS as >2.5 m in width) in Northern Ireland which support habitats and species of national and international importance, including otter (*Lutra lutra*), salmon (*Salmo salar*) and freshwater pearl mussel (EHS 2008a).Threats to rivers include nutrient enrichment, habitat destruction, littering, illegal dumping, runoff, siltation, flood damage, bank erosion, eutrophication, invasive species, poor planning decisions, *ad hoc* bank protection works, obstacles to fish passage and damage to spawning beds.

Approximately one-third of rivers are monitored annually against national water quality standards for the Water Framework Directive. It is important that both biological and chemical classifications are monitored, as the chemical quality can recover after damage more quickly than the biological status. Both chemical and biological river quality standards (DOE & NISRA 2010) specify that all water bodies should be 'at least good – A or B with no downward movement between classes'. Until 2007, monitoring was done by river length, and in 2005/7, 58% were of at least a good chemical standard and 41% were of at least a good biological standard (Class B or above; **Figure 18.18; Figure 18.19**). Trends for the preceding 10 years were generally improving for chemical but more static for biological quality. Since 2007 monitoring is by water body, with broader environmental objectives, so figures are not directly comparable. In 2008 only 57.9% of rivers were classified aschemically 'high' or 'good', and only 41% of river water bodies classed as biologically 'high' or 'good'(DOE & NISRA 2010). When plants were monitored, only 5.6% of Northern Ireland's rivers did not show signs of nutrient enrichment (EHS 2008a).About 28% (4,280km) of Northern

Ireland's rivers were designated in 2004 under the Freshwater Fish Directive as either salmonid (4,154km) or cyprinid (126km). In 2008 6% of the salmonid length and 22% of the cyprinid designated length failed to reach Directive standards (DOE & NISRA 2010).

Insert Figure 18.19 and 18.20 here

The Rivers Agency manages a network of 130 hydrometric stations across Northern Ireland, of which 102 monitor and record level and flow and 28 monitor and record level only. Changes in water quantity can also be affected by development, particularly as Sustainable Urban Drainage has not yet been taken up as standard practice for new development. Channel works may be carried out on urban watercourses in order to facilitate increased urban runoff from development sites. Currently there is no single overarching legislation to licence river works. Consequently, a number of government bodies need to be contacted for permissions, but small-scale or piecemeal works which do not affect hydraulic capacity or fishery habitat are not controlled. In Scotland, physical modifications are controlled under the CAR Regulations to ensure achievement of the Water Framework Directive objectives (Judith Bankhead, Rivers Agency, pers. comm.).

Shallow, fast-flowing reaches of rivers and streams are the spawning and nursery beds for salmonids and can be adversely affected by forestry and drainage (DCAL 2009b; Sections 18.4.2 &18.4.5).Application of fertilisers, runoff of pesticides, harvesting, drainage and planting activities can be harmful to upland streams, although much has been done to develop management policies to prevent harm. Yearly Catchment Status Reports for the Foyle and Carlingford areas provide information on river habitat monitoring, conservation limits, water quality and examples of habitat improvement works (Loughs Agency 2009).

Most water abstracted for human use comes from surface waters in Northern Ireland, so the quality of the rivers and lakes has a direct relationship to the cost of water treatment (Section 18.5.2.4). While it is often thought that flooding is the major problem with water-flow for abstraction, there is a considerable threat from low water volumes in rivers, perhaps exacerbated by the predicted effects of climate change. Low flows concentrate pollutants, increase costs of purification and have direct impacts on the plants and animals living in and adjacent to flowing water (Paddy Brow, Northern Ireland Water, pers. comm.).

A comprehensive programme of arterial drainage works in Northern Ireland commenced following WWII. The need for the work was identified due to food shortages suffered during the war years, and flooding in areas which had potential for agricultural productivity. The government undertook a Northern Ireland-wide programme of straightening, deepening and widening of rivers, focused on the main rivers of each catchment. Riparian woodlands and other vegetation were lost during the canalisation work. This can be restored to some extent and would considerably improve water quality, fisheries and riparian biodiversity. This has resulted in Northern Ireland having the highest percentage of severely modified rivers in the UK (5% compared to 3.5% UK average) and the lowest percentage of pristine rivers in the UK (10.1% compared to 15.1% UK average; Raven *et al*. 1998). A total of 6,800 km of watercourses including rivers, streams and canals have been designated under the terms of the Drainage Order (Northern Ireland) 1973. Designation means that the maintenance of the land drainage and flood defence function of these key watercourses is deemed to be beyond the scope of riparian landowners. Significant drainage programmes continued up until the 1990s, with drainage activities along the River Blackwater being one of the final schemes completed. These schemes and their subsequent maintenance have had significant impacts on the salmonid fishery resource (Evans *et al.*2006).There is a current focus, resources permitting, on restoring habitats for salmonids within formerly drained river channels. Physical restoration usually involves the replacement of the physical structure of habitat diversity, such as channel sinuosity, pool-riffle sequences, spawning gravel replacement and juvenile salmonid nursery areas. Restoration works to date have been contained within the formerly drained and straightened channels (DCAL 2009b).The Lagan Valley Regional Park shows what can be done to improve its value to recreation and potentially to health. A hydromorphology group has been set up in the Northern Ireland Environment Agency and will report on the quality of Water Framework Directive monitored river habitats in line with Water Framework Directive guidance, using methods currently under development (Robert Rossell, AFBI, pers. comm.).

18.4.6.3 Lowland raised bogs

Raised bogs are found in lowland areas, generally below 150m, in river valleys, lake-basins and between drumlins, having developed when peat accumulating in fens became isolated from groundwater. The surface of a raised bog is a mixture of pools, raised mossy hummocks and flatter lawns, and is colonised by plants and animals adapted to the acidic conditions and low levels of nutrients found there. This favours the growth of plants such as heather, cottongrasses and *Sphagnum* mosses. These plants die to form peat that is markedly different from fen peat, and often up to 12m deep. The largest areas of raised bog are in the eastern lowland corridor extending north along the Bann Valley from the Lough Neagh basin. There are also small raised bogs in counties Down, Armagh and Fermanagh (EHS 2004a). Cruickshank and Tomlinson (1988) estimated that the Northern Ireland lowland raised bog resource was 25,196 ha of which 2,270ha, about 9%, was still intact in 1988; in 2003 this figure was estimated at 8% (EHS 2003e). The NICS estimate for lowland bog in 2007 was 21,106 ha (Cooper *et al.*2009), which includes regenerating cutover bog. The difference in the estimated area is derived from different methodologies rather than by a major loss of peatland between the two survey dates. Bogs were drained for agriculture and peat, with some major excavations of lowland bogs to provide horticultural peat still taking place in 2010 (Section 18.5.2).

Northern Ireland has a large proportion of the UK raised bog resource and Ireland as a whole is internationally important for peatlands. Lowland raised bog habitats, including both intact surfaces and regenerating cutover bog, are important for a number of UK priority species identified as part of the UK BAP programme. These include skylark which breeds on lowland raised bog (EHS 2003e).

Cutover edges of some bogs and the whole of some former raised bogs have developed into fens. Where peat cutting lowered the land surface such that mineral water gained access to the former bog site, plants colonised which are more nutrient-demanding than those associated with bogs. This has happened extensively in the drumlin country of Counties Down and Armagh; fen now occupies many inter-drumlin sites where bog has been removed completely or where only small patches remain. Many cutover edges of raised bogs have been colonised by woodland of birch or, if ground conditions are wet, of alder and willow. Brackagh Moss, near Portadown, is a good example; it has remnant bog, species-rich fen, poor fen and dense alder and willow carr. These woodlands are a valued habitat in Northern Ireland; not only is woodland generally scarce, but along with other oceanic woodland types, they provide habitats for mosses and lichens that depend on the mild, humid conditions (Tomlinson 2010).

Although most of Northern Ireland's raised bogs have been affected by past peat cutting, some are large and still have their unique central dome of peat and intact edges. Many smaller remnant bogs have an intact central dome, often including unique pool and hummock complexes, but the laggs (areas between the raised bog and upland terrain) and rands have been removed by cutting for fuel. Wishart (1978) examined three bogs in north Antrim looking at the then current (1970s) levels of use and spatial changes over the last two centuries and found decreases of between 43 and 62%. Lowland bog reclamation in the mid- to late 20th Century was often grant aided under the Farm Capital Grant Scheme. The bog was levelled by a bulldozer and lime rotavated onto the peat, followed by reseeding and later use of plastic pipe drainage where necessary. This reclaimed land could be used for light cattle and sheep but not heavy cattle (Wishart 1978). Of the lowland raised bogs that remained in the 1980s, some are the uniquely northern representatives of the Irish Midland type, whereas others have a more oceanic flora and fauna and yet others are transitional to blanket bog (Leach & Corbett 1987; Cruickshank & Tomlinson 1990).

18.4.6.4 Fen, grazing marsh and swamp

Freshwater wetlands are areas of land, usually fringing standing open water, that are inundated by surface or groundwater and support vegetation typically adapted for life in saturated soils. Most of Northern Ireland's lakes are fringed by fen, marsh and swamp where this has not been drained for agricultural use. Upper Lough Erne is especially important for these types of habitats with the shoreline at Crom supporting particularly rich and diverse examples (Phil Davidson, National Trust, pers. comm.). However, these types of wetlands can also occur in low-lying wet ground or poorly drained marginal grassland (Section 18.4.3).

These wetlands help prevent flooding by slowing down flows and absorbing water, which they gradually release to rivers and streams to maintain the flow throughout the summer, and to recharge groundwater aquifers (NIEA 2010f).

18.4.6.5 Reedbeds

Reedbeds in Northern Ireland are especially associated with lowland wetlands around the large lakes and inter-drumlin wetlands. Inter-drumlin fens have declined substantially as open water has been filled in by marginal plants which have grown prolifically due to increased eutrophic conditions. These marshy areas are then invaded by willow scrub, resulting in the loss of a unique asset to our biodiversity. Several large stands (> 10ha) occur around Lough Neagh (e.g. at Portmore Lough and Blackers Rock) and in the Lough Erne catchment. There are also a significant number of stands greater than 2ha, including an estimated 40 sites in Counties Down and Armagh (Shaw *et al.* 1996). This is similar to the situation elsewhere in the UK where, out of 900 or so reedbed sites, only about 50 are larger than 20ha, and these make a large contribution to the total area. Historically there has been significant loss of reedbeds in the UK which may be as high as 40% between 1945 and 1990 (Hawke & José 1996). It is likely that similar losses also occurred in Northern Ireland during this period. NICS 2000 indicates that there was little overall change in the area of swamp and reedbeds in Northern Ireland between 1988 and 1998 (Cooper *et al.*2002). Between 1998 and 2007 there was an increase in swamp but a decrease in reedbeds of nearly 400 ha (Cooper *et al.*2009).

Reedbeds in Northern Ireland are generally unmanaged. Their extent is governed by water levels, nutrient enrichment, ecological succession and grazing. Historically, relatively few reedbeds were harvested for thatching material (e.g. around the shores of Lough Neagh) and there is virtually no reed harvesting occurring at present. This contrasts with Great Britain, where many of the most important reedbeds have been traditionally managed as natural resources, usually by cutting for thatch, which maintained them as reed-dominated sites, effectively limiting the process of succession. In the Republic of Ireland small scale reed harvesting occurs, notably along the Shannon estuary (EHS 2005j).

Reedbeds in Northern Ireland are an important habitat for several UK priority species identified in the UK BAP programme, particularly reed bunting, the reed beetle (*Donacia aquatic*) and greater water parsnip (EHS 2005j).

There is limited use of artificial reedbeds in sewage treatment (e.g. Castle Espie Wildfowl and Wetlands Centre). Planning Service can require reedbed installation after septic tank treatment for new housing in areas of permeable soils. However, so far this is on a very limited scale and overall, there remains a problem of pollution from poorly functioning septic tanks for rural dwellings.

18.4.6.6 Groundwater

Groundwater in Northern Ireland may typically be only tens of years old. There is some older slow-moving water, for example at depth beneath the basalts of County Antrim, so that a pollution event occurring at the surface today may not manifest itself in the groundwater body for several years or even decades. A diffuse or dispersed pollutant accumulating over a long period of time would be difficult and costly to deal with, even after the source of the pollution is removed. Therefore, surface-water catchments upstream of 'losing' sections of rivers should be considered as part of the groundwater system. The protection of groundwater can be critical to both the quantity and quality of baseflow to surface waters and hence drinking water resources (EHS 2001, 2008a).

Northern Ireland Water abstracts 98% of its water from surface sources (49% from impounding reservoirs, 49% from rivers and loughs) with groundwater sources (boreholes) making up the other 2%. This is in contrast to Great Britain, where most water is abstracted from groundwater (NIEA 2009b). Private supplies in Northern Ireland are used by less than 1% of the population. About 8% of the all of the water used in Northern Ireland is drawn directly from private boreholes and springs for industrial, agricultural or domestic use. Groundwater storage contributes baseflow to surface waters such as streams and rivers that in turn provide water for public supply (EHS 2001). Overall, abstraction from groundwater bodies is

generally only a very small proportion of recharge; therefore confidence can be high in assigning good status under this overall water balance test (NIEA 2009j).

Wetlands can also be fed from groundwater, with the ecology particularly sensitive to changes in the level of the water table. Groundwater therefore is an important and valuable resource which requires protection in both quality and quantity and requires land management for its maintenance. Northern Ireland's groundwater in 2008 was of high quality, with less than 2% of monitoring sites having an annual mean concentration of >40mg nitrate/l (DOE & NISRA 2010).

There are two major risks to groundwater. Firstly, over-abstraction from an aquifer may reduce the level of the water table, causing depletion of baseflow to surface waterways or a decrease in yields for some groundwater users and an adverse effect on groundwater quality by encouraging deeper saline water to come into circulation. Secondly, human activities such as waste disposal, industry and agriculture can pollute groundwater.

18.4.6.7 Floodplains

Floodplains are defined as flat areas adjacent to watercourses (including standing open water) or the sea where water flows in time of flood or would flow but for the presence of flood defences (DOE 2010d). In addition, there is a considerable area of floodplain adjacent to lakes. For planning purposes, and taking into account present scientific evidence, the limits of floodplains are defined as:

- Rivers – the extent of a flood event with a 1% annual probability of exceeding the peak floodwater level.
- The coast – the extent of a flood event with a 0.5% annual probability of exceeding the peak floodwater level.

There is no assessment of the area of floodplain in the NICS as all land is categorised under its more common purpose, usually *enclosed farmland*, *semi-natural grassland* or *urban settlements*. However, the floodplains are shown on the Strategic Flood Map (Rivers Agency 2010), which identifies areas at risk from flooding from rivers and the sea, including the predicted potential impacts of climate change up to 2030. The number of properties within the indicative floodplain in Northern Ireland is estimated at 46,000 with about 15,500 of those benefiting from flood defences or the culvert network (Rivers Agency 2008a).

The Department of Agriculture and Rural Development, through the Rivers Agency, is the competent authority for the Floods Directive (Directive 2007/60/EC). The Directive requires the production of a Preliminary Flood Risk Assessment (PFRA) for all river basin districts and coastal areas which considers the impact on human health, the environment, cultural heritage and economic activity. Areas deemed to have a significant potential flood risk are then required to have flood risk and hazard maps produced, along with flood risk management plans. The PFRA is to be completed by the end of December 2011, with flood risk management plans to be completed by December 2015.

The importance of floodplains has become much more apparent in recent years. The production of Planning Policy Statement 15 (PPS15 Planning and Flood Risk) in June 2006 recognised the impact of development in floodplains, and the consequent effect on flooding: "within floodplains the Department will not permit development unless it falls within one of the following exceptions or it is demonstrated that the proposal is of overriding regional importance" (DOE 2006b). Floodplain usage for flood alleviation is seen as part of sustainable flood management; other aspects include land usage, floodplain forestry and peat bog management. There is a role for all such techniques, but none provide complete flood alleviation, rather a mosaic of different techniques needs to be considered together. Land use management has a role to play in flood alleviation, but is not the only solution. Studies (Parrott *et al*. 2009; Hess *et al*. 2010) suggest that the impact is greatest in high frequency events, i.e. smaller floods, but that a range of factors including slope and soil type, have a role to play.

18.4.7 Urban

The UK NEA includes all built-up areas within this section, including buildings and hard standing in rural and peri-urban areas as well as towns and cities. The NICS 2007 found a 30% increase in built-up area between 1998 and 2007 (including both urban expansion and development in rural areas), almost twice that reported between 1989 and 1998. There has been a subsequent loss of habitats, largely Enclosed Farmland, Semi-natural Grassland and Woodlands (Cooper *et al.*2002; Cooper *et al.*2009). This has had profound implications on the countryside, particularly given the additional infrastructure required to support such developments, including transport access, septic tanks and connection to the electricity grid. The Regional Development Strategy for Northern Ireland 2025 has stated the need for future development to be concentrated in urban centres to reduce such impacts and build a more economical 'critical mass' to provide services and infrastructure (DRD 2008a).

Historically, Northern Ireland has had a dispersed population, with most of the countryside settled and farmed for centuries (Whelan 1997a,b; EHS 2008a). In contrast to Great Britain, Northern Ireland's urban areas have not had extensive links to heavy industry such as coal mining (West Midlands, Scottish west central lowlands), potteries (Stoke-on-Trent) or steel works (Teesside/Sheffield). Towns and cities tend to be small, with many situated in coastal or riverside locations. Priority habitats, designated sites and small areas of other broad habitats (e.g. woodland, lowland meadows) often occur within urban areas, parks and gardens and are a substantial form of land use in most larger towns and cities.

Given the size and distribution of the population, most of Northern Ireland can actually be considered as 'peri-urban' with only a small minority of people living more than 10km from a sizeable town. Similarly, even most Belfast residents live less than 5 km from the open countryside. Residential trends of the past 50 years have led to significant development in the countryside in the greater Belfast area, with the population of Belfast city declining steadily since 1981. There has, however, been no decline in the Belfast conurbation or the 'Belfast travel to work area,' which is now considered to include over half of Northern Ireland's population and a high proportion of the area east of Lough Neagh (Belfast City Council 2005a).

The population density of Northern Ireland has increased from 105 people/km^2 in 1960 to 133/km^2 in 2010; this is projected to continue with a density of 153/km^2 predicted for 2050. Current density is much higher than Scotland (67/km^2), about the same as Wales (145/km^2) and considerably lower than England (401/km^2), but all countries are expected to increase significantly over the next 40 years (ONS 2010a).

18.4.7.1 Demography and population distribution

Northern Ireland was home to 1.79 million people in 2009, a figure which has been slowly increasing for about 35 years and is expected to reach 1.92 million by 2020 (NISRA 2005a). There are two major cities and 41 large towns which are home to about 65% of the population (half of these in the Belfast metropolitan area; NISRA 2003, 2005b; **Figure 18.20**). The remaining people live in smaller settlements, many of fewer than 4,500 people, or in the open countryside (NISRA 2005b; **Table 18.7**). While the population of Northern Ireland as a whole has increased by some 19% since 1960, the population of Belfast has increased by 40% (NISRA 2002, 2009).

Insert Figure 18.20 here

Insert Table 18.7 here

18.4.7.2 Urban land use

Prior to 2007, applications for residential development in Northern Ireland reached historical highs (**Figure 18.21**), driven by, among other things, increasing ease of credit, high levels of growth in the Republic of Ireland ('the Celtic Tiger') and a general knowledge that tougher planning legislation was being considered for rural areas in particular as a result of the Regional Development Strategy for Northern Ireland 2025. Planning approval, even without subsequent development, automatically helped to increase land and property value in a booming marketplace. Since 2002 the number of applications has fallen by around 19%

(**Figure 18.21**). There were 19,557 planning applications across Northern Ireland from 2009 to 2010, a 4.5% fall from the previous year (NIPS 2010a). Belfast showed the greatest decrease in applications over that period, a fall of 20.6% from 2008. Overall, 92.2% of applications were approved. In relation to residential development, 91.4% and 96.6% of applications were approved for rural areas and urban areas respectively. There has been a much lower level of development in all areas in 2009 and 2010 (**Table 18.8**) in response to economic pressures, but there is still substantial pressure for housing in rural areas, including many extant planning permissions.

Insert Figure 18.21 here
Insert Table 18.8 here

The increase in urban development includes both green- and brownfield sites. The Northern Ireland Planning Service (NIPS) defines brownfield as any land in the urban area, including gardens, playing fields and parks, with greenfield sites being those outside the 'urban footprint' (DRD 2008a,b); this differs from the definition commonly used in Great Britain. The target in the Regional Development Strategy is for 60% of new development to be provided within urban footprints over the period of the strategy up to its review in 2010 (DRD 2008a). On average,6,200 residential units have been built per annum on urban sites and 5,000 per annum on greenfield or other sites (NISRA 2010a) with the proportion within the urban footprint varying between 65% and 85% from 2001 to 2007 (DRD 2009b). Mean household size was 2.48 in 2008/9, with the mean number of persons per room amounting to 0.45 (DSD 2009).Northern Ireland Housing Executive has not built new housing since 2002, but there has been development in the social rented sector through housing associations amounting to 4,976 residential units between 2004 and 2010 (DSD 2006, 2007, 2008, 2009, 2010). The majority of these were in urban areas, notably Belfast, Craigavon, Fermanagh and Lisburn.

In recent years there has been some movement back to the city and central Belfast is now home to people who largely live in new developments centred around the River Lagan. There are, however, still relatively fewer high rise flats than in other major UK cities and the majority of new build homes are suburban, either as grouped developments of houses or single homes in the countryside. Planning policy has been reformed in 2010 to encourage grouping of houses around existing infrastructure and to discourage single dwellings (DOE 2010e), but there are still many extant planning permissions in the open countryside and in 2005 there were more applications approved for single dwellings in the countryside in Northern Ireland than in England, Wales and Scotland combined. While this has obvious implications for the appearance and attractiveness of the countryside, the most significant environmental issues are associated with the infrastructure required to support scattered single dwellings, including water provision, septic tanks, electricity and phone lines and the amount of transport required by the residents. Although housing developments over the past 20 years have tended to lack greenspace, Planning Policy Statement 8 (Open Space, Sport & Outdoor Recreation; DOE 2004) only permits proposals for new residential of 25 units or more where public open space is provided as an integral part of the development.

Redevelopment of existing mature sites within urban areas has often resulted in one large dwelling with a sizeable garden being replaced by an apartment block or several houses or flats, with hard surfaced car parking replacing the original garden. There is also a trend of replacing hedges with wooden fencing and paving front gardens. This has negative impacts on biodiversity and aesthetics, but perhaps more importantly has led to rapid water runoff which has contributed to flooding in the Belfast urban area during heavy rainstorms. The Rivers Agency publishes an interactive strategic flood map which identifies all areas subject to flooding across Northern Ireland (Rivers Agency 2010) and Belfast City Council commissioned a report in 2009 outlining flooding hotspots in its area (BRC 2010) which states that 10,000 properties in the Belfast area are at risk from coastal or river flooding.

Planning policies and development control decisions have a major impact on both urban and rural ecosystems. There has been recent loss of urban wildlife habitats due to planning decisions, but Planning Policy Statement 7 (Quality Residential Environments; PPS7 (DOE 2001) and PPS7 Addendum (Residential Extensions & Alterations; PPSA7 DOE 2008) both seek as a policy objective to promote biodiversity.

McKenzie *et al.* (2011) found significant impact of development in rural areas and stressed the importance of a consistent rural development strategy across government in protecting habitats and ensuring effective delivery of ecosystem services. Planning in Northern Ireland is centralised but in 2010 a major review was undertaken (part of the ongoing Review of Public Administration and Planning Reform processes) which may lead to transfer of some planning powers to local authorities in 2011, prior to a further transfer, perhaps in 2015.

Recent development and promotion of health and exercise trails encourage recognition of the benefits of the natural environment on health. Visits to parks continue to be popular and are promoted through numerous events and activities based in parks. Belfast City Council offers grants for park-based community events (Belfast City Council 2010). The Health Protection Agency has published a Children's Environment and Health Strategy for the UK (2009) which makes explicit the link between the health of the natural environment and the health of children (HPA 2009). They also published a document in 2008 regarding the health impacts of climate change (HPA 2008)**.**

18.4.7.3 Urban greenspace

There are some important nationally designated sites in urban areas, including Lough Foyle in Derry/Londonderry (an ASSI, SPA and Ramsar site) and the Belfast Lough Shore (Ramsar, SPA and ASSI sites).There is a new UK priority habitat, 'open mosaic habitats on previously developed land', the criteria and survey methodology for which have yet to be finalised, but it seems likely that areas within Belfast Harbour Estate, for example, will be included.

Nevertheless, the majority of urban greenspace is of more local significance. Both Belfast and Derry/Londonderry have major policies and action programmes promoting sites and action in their areas (Belfast City Council 2007; Derry City Council 2008), and many local councils have equally important plans in place (e.g. Banbridge District Council 2007; Coleraine District Council 2008; Larne Borough Council 2008; Omagh District Council 2008). A variety of types of extensive parkland designations are in force in and near major urban centres; Regional Parks, Country Parks and non-governmental organisation (NGO)-managed properties (e.g. National Trust) provide significant areas of urban and near-urban recreational, educational and high biodiversity land. These areas have great potential for management for a wide variety of uses. At least 10 Local Nature Reserves (LNRs) have been established or are proposed in urban areas, including in Belfast, Bangor, Derry/Londonderry and Craigavon. These areas are a considerable resource for their local areas in financial (**Table 18.9**) as well as recreational, cultural and aesthetic terms.

Insert Table 18.9 here

As of May 2010, Belfast City Council maintained a total of 114 open spaces for various uses including parks, playing fields, allotments, playgrounds, graveyards and memorial sites (**Table 18.9**). This amounts to a total area of over 1,000ha. In Derry/Londonderry a figure of 305 ha was reported for various classifications of open spaces including watercourses, shrub and flower beds, playing fields, graveyards and amenity grass. Lisburn City Council also maintains 26 open spaces covering almost 160 ha (NIPS 2007).

Some councils are managing open space for biodiversity, in particular with woodland planting and wildflower meadow creation in parkland formerly managed as mown grass (e.g. Barnett's Park in Belfast). However, there is a demand on public parks for a variety of uses, including golf courses, sports facilities, allotments and burial grounds (Robert Scott, Belfast City Council, pers. comm.).

To the end of 2010, 12 of the 26 councils have Local BAPs which attempt to address priority habitats and species while involving local people in promoting biodiversity in their area. A duty to promote biodiversity on government and public authorities is part of the Wildlife and Environment Bill 2010.

Street trees have many benefits – biodiversity, shade, pollution abatement, aesthetics, and greenhouse gas abatement – and they contribute significantly to property values (Morales 1980; Anderson & Cordell 1988;

CABE Space 2005; Landry & Chakraborty 2009). Belfast City Council cites the number of street trees in its area as 11,000(Belfast City Council 2005b).

Tree Preservation Orders (TPOs) can be applied to protect trees under threat of destruction, and the Planning Service declared 531 TPOs between 2003 and 2008 (NISRA 2010a).In addition, all trees within the boundaries of a Conservation Area (designated by the Planning Service under the Planning (NI) Order 1991) are protected as if a TPO were in place.

Many councils are developing new allotment sites and community gardens, and allotments are being provided by the private sector. An Allotments Forum has been active since 2008, involving council officers and others in promoting the uptake and development of sites. Schools have also become involved and there are excellent examples of school grounds being used for growing vegetables as part of their curriculum to promote healthy eating (O'Hagan 2010).

School grounds are also increasingly used to promote environmental lessons and many grounds have wildlife areas. Eco-Schools is an international programme run locally by TIDY Northern Ireland, which encourages students to address numerous topics to improve the sustainability of their schools and over half of all schools in Northern Ireland participate (TIDY NI 2008). Organisations including Northern Ireland Water, the RSPB, the Ulster Wildlife Trust, the Woodland Trust and the Wildfowl and Wetlands Trust participate with schools in a certified scheme called Facilitating Primary Schools in Key Stage 1 & 2 Education Programmes 'The World Around Us', which incorporates sustainability and biodiversity (NI Curriculum 2010). Some funding is provided for education work through the Natural Heritage Grants Programme of the Northern Ireland Environment Agency.

18.4.7.4 Urban-rural interactions

The complex Urban ecosystem can have a significant impact on other habitats; not only are most of the materials required by cities sourced from rural areas, but urban areas rely on many services provided by rural ecosystems for disposal and detoxification of wastes. Many of Northern Ireland's large urban areas border coasts or estuaries and therefore urban pollution, reclamation, disturbance and waste disposal impact on coastal and marine environments.

Compared to the rest of the UK, limited information exists on how residents of Northern Ireland visit and use the countryside (CAAN 2008). However, it is clear that many people regularly visit rural areas for some form of recreation (Forestry Commission 2005, 2010b; Section 18.5.4).

Some progress seems to have been made with regard to raising public awareness of and interest in environmental issues. According to the Northern Ireland Statistics and Research Agency's (NISRA) Continuous Household Survey, people who were very or fairly concerned about the environment rose from 76% in 2004 to 82% in 2009 (NISRA 2010a). Most types of environmental concern have increased during this period, with climate change, household waste disposal, traffic fumes and urban smog, and traffic congestion being areas of highest concern in 2007/8. Climate change concern has risen from 13% in 2003/4 to 39%, the highest level of concern of any of the issues tested, in 2007/08 (NISRA 2009) but decreased slightly to 37% in 2010(DOE & NISRA 2010).

The Regional Development Strategy (DRD 2008b) and a revised draft currently in development aim to facilitate movement of goods and people around Northern Ireland and improve links with both Great Britain and the Republic of Ireland (DRD 2011).One of the biggest impacts on ecosystems is transport, at all levels, from carbon emissions to pollution to habitat destruction for road construction. Within Belfast there is increasing emphasis on providing public and active transport (DRD 2002a). However, investment remains heavily concentrated on roads, and the relatively large travel to work area of Belfast's population means that some public transport options are not currently financially viable (e.g. trams), so there is a continued emphasis on roads-based transport. Some initiatives ('cycle city', electric vehicles, park and ride) seek to address the issue, but for the foreseeable future Northern Ireland will continue to rely on an extensive road network with significant implications for the natural environment.

18.4.8 Coastal Margins

Northern Ireland has over 650km of coastline (DOE & NISRA 2010), with a wide range of topography and habitat types from sandy beaches to massive igneous cliffs. Sea loughs are a key feature and have particularly high biodiversity value (Section 18.4.9). The social and cultural identity of Northern Ireland is positively associated with its coast. Dramatic cliff lines on the north coast and sweeping landscapes from mountain to coastal zone (especially along the east coast) are iconic images of Northern Ireland and significant attractions to tourists. Consequently, coastal ecosystems are particularly valuable for their cultural and recreational aspects. The coastal zone is narrow, but of high scenic, ecosystem and resource value, and is under pressure for many different uses and types of development. Even relatively minor perturbations due to development, weather and erosion can have major impacts.

The UK NEA defines habitats of the Coastal Margins as Sea Cliffs, Shingle, Sand Dunes, Saltmarsh, Coastal Lagoons and Machair (absent in Northern Ireland). These habitats are discussed within this section with all other coastal and marine habitats discussed in Marine Habitats (Section 18.4.9). The NICS divides the coast between supralittoral rock and supralittoral sediment. There was no overall change in the area of coast between 1998 and 2007, at just over 3,500 ha, or 0.25% of Northern Ireland (Cooper *et al.*2009).

Coastal Margins habitats support a wide range of unique and rare species. Much of this diversity is dependent on natural dynamics creating early successional habitats. This is reflected in the number of sites designated for their biological importance, with sites such as Strangford Lough holding many designations (Section 18.8). However, there are also problems with invasive species impacting on high value sites. About 75% of the coast is protected, much of it by multiple designations (NIEA 2010g). It includes 52 SACs, 10 SPAs, 17 Ramsar sites and Northern Ireland's only World Heritage Site, the Giant's Causeway and Causeway Coast. Around one-quarter of Northern Ireland's 47 NNRs are on the coast and Strangford Lough was designated as Northern Ireland's first MNR in the mid-1990s. Recently there has been work promoting an integrated approach to coastal zone management (DOE 2006; McCusker 2009).

The sea level around Northern Ireland's coast is determined by two opposing forces, increasing sea depth due to climate change and land lift which has been proceeding since the end of the last ice age (Kelly *et al*. 2006; Orford *et al.*2006; Orford *et al*. 2007a). Tidal range varies from 5m (south east) to 1–2m (north). The entire coastline is characterised as storm dominated, with both the north and east coasts subjected to extreme storm severity (Orford *et al*. 2007b). Coastal habitats occupy a relatively narrow zone characterised by complex environmental gradients and spatial mosaics which support large numbers of plant and animal species.

The National Trust owns and cares for 123km of the Northern Ireland coastline (National Trust Regional Office). Indeed, nearly 90% of the National Trust's total UK coastline is in Northern Ireland. The remainder of Northern Ireland's coastline is mainly in private ownership, although district councils have significant land holdings, especially popular beaches. The Crown Estate owns and manages most of the foreshore. With the exception of industrial uses around Belfast Lough, military ranges at Magilligan and Ballykinlar, and coastal recreation and tourism developments (e.g. links golf courses, marinas, hotels), most coastal lands are either nature reserves or in agricultural use. Coastal defences are managed by three authorities; DRD Roads Service are responsible for defences which protect roads, the Harbour Commissioners manage most (but not all) harbour installations, and the Rivers Agency manages just over 26km of designated sea defence, mainly at Lough Foyle and Strangford Lough (UKMMAS 2010).

18.4.8.1 Sea Cliffs

About half of Northern Ireland's coast is defined as Sea Cliffs (JNCC 1997). The dramatic cliffs along the north and north-east coasts rise, often quite precipitously, from the sea to 100m or more, creating some of the iconic landscapes of the Giant's Causeway and Glens of Antrim. Coastal villages lie between cliffs and shore, with building development both within villages and in the countryside often encroaching on narrow beaches. Rathlin Island, the largest island off the Northern Ireland coast, has precipitous basalt and some

limestone cliffs which are very important for nesting seabirds and continue into the sea to provide diverse underwater habitats of high biodiversity.

18.4.8.2 Seabird nesting islands

Rathlin Island has by far the largest cliff-nesting colonies of seabirds in Northern Ireland, followed by Gobbins and the Isle of Muck near Larne Lough. Rathlin has 6% and 10% of the British and Irish populations of guillemots (*Uria aalge*) and razorbills (*Alca torda*), respectively. Rathlin also has 5% and 22% of the Irish populations of nesting fulmars (*Fulmaris glacialis*) and kittiwakes (*Rissatridactyla*), respectively (Mitchell *et al*. 2004). However, there has been an estimated 50% decline in puffin (*Fratercula arctica*), razorbill and fulmar populations on Rathlin Island between 1999 and 2007, possibly as a result of reduced food availability (AFBI & NIEA 2011). Islands in Larne Lough (including Swan Island, an SPA and NNR for tern populations), Strangford Lough and Carlingford Lough are also important for bird populations, particularly for breeding gulls and terns (BTO 2010).

The Copeland Islands have 1.4% of the British and Irish populations of Manx shearwater (*Puffinus puffinus*). Northern Ireland has 5.7% of the British and Irish breeding populations of cormorants (*Phalacrocorax carbo*; Swan Island SPA), 5% of breeding black-headed gulls, 14% of sandwich terns (*Sterna sandvicensis*) and 12% of common terns (*Sterna hirundo*). Recent seabird colonists in Northern Ireland include breeding great skua (*Stercorarius skua*, at Rathlin) and Mediterranean gull (*Larus melanocephalus*). There has been a dramatic decline of about 97% in nesting herring gulls (*Larus argentatus*) since the mid-1980s in Northern Ireland, largely attributable to birds feeding on rubbish dumps and becoming infected with botulism (Ian Humphreys, Copeland Bird Observatory, pers. comm.). However, improved management of landfill sites may be addressing this problem. The rare roseate tern (*Sterna dougallii*) continues to nest (Mitchell *et al*. 2004), but only one pair nested in 2010 (D. Allen & K. Leonard, pers. comm.; BTO 2010).

18.4.8.3 Shingle

Shingle coasts form in wave-dominated locations where suitably sized material is available (2–200mm). An estimated 50 ha of vegetated Shingle occurs in Northern Ireland (Paul Corbett, NIEA, pers. comm.). Of this, approximately 30 ha are considered stable. The most extensive areas have been surveyed for their biodiversity, for example Ballyquintin Point National Nature Reserve (NNR) and Gransha Point on Strangford Lough. These areas support a range of plant communities, including scrub and grassland, often rich in lichens. It is these areas of stable Shingle that are the main focus of the Coastal Vegetated Shingle Habitat Action Plan (EHS 2005e).

18.4.8.4 Sand Dunes

Most of the Sand Dunes in Northern Ireland have formed due to the falling sea level over the last 5,000 years. While there are estimated to be approximately 3,000 ha of dunes in Northern Ireland, Sand Dune vegetation is estimated to be between 1,300 and 1,500 ha (EHS 2005d).

Marram grass (*Ammophila arenaria*) plays an essential role in the formation of dunes by acting as a stabilising agent as sand accumulates (NIEA 2009d). The largest dune systems are at Magilligan (around 900ha) and Portstewart Strand on the north coast and at Murlough on the County Down coast. Some of the dunes at the Bann Estuary (Grangemore) are considerably older than others in Northern Ireland and have particular floristic significance. Murlough also contains examples of communities which generally occur further south in the British Isles, and all of the systems contain a range of plant species that are scarce in Northern Ireland (EHS 2005d). The Umbra at Magilligan has priority species including small eggar (*Eriogaster lanestris*) and scarce crimson and gold (*Pyrausta sanguinalis*) moths, and northern mining bee (*Colletes floralis*; EHS 2005a). Well-managed grazing (including by rare breeds such as Dexter cattle) is essential to maintain high levels of biodiversity and to fend off scrub growth which would otherwise colonise areas of bare ground necessary for dune mobility (EHS 2005d).

Murlough is managed by the National Trust and the dunes are estimated to be 6,000 years old, providing a habitat for 22 species of butterfly and up to 5,000 wildfowl and waders. The dunes also support 55 species of bee, ant and wasp (which equates to 33% of the Irish total), 213 species of moth (48% of moths in

Northern Ireland) and 21 species of butterfly (roughly 71% of butterflies in Northern Ireland; EHS 2005d). Murlough SAC, Magilligan SAC, Bann Estuary SAC and White Park Bay (North Antrim SAC) are all designated for their sand dune qualities featuring rare species. The main threats to dunes are a lack of management leading to scrub encroachment and invasive non-native species such as sea–buckthorn (*Elaeagnus rhamnoides*) and other nitrogen fixers (EHS 2005d).

Dune systems have been converted to agricultural use for centuries and a number of areas have been turned into golf courses, including Royal Portrush (1888) and Royal County Down (1889), which is set amid the Murlough dune complex (STRI 2010).While these have financial and tourism benefits, the dune systems were essentially destroyed in the process with concomitant loss of natural habitats and species. Also, dunes tend to be important as low grade coastal defences and their loss can impact on natural dune–beach sediment interactions, especially where artificial features are erected. At Portballintrae most of the sand from the Bay has disappeared over the last century, probably due to a jetty set up at the entrance of the bay (Carter 1991). Similarly, the harbour at Magilligan Point has affected coastal dynamics and therefore dunes.

Local landowners have traditional rights to remove sand and cobbles from beaches for use in agriculture as animal bedding and gateway maintenance, primarily on the north-east coast, and this has become a significant problem in some areas (Carter 1991).

18.4.8.5 Saltmarsh

Saltmarshes develop where fine sediments accumulate in relatively low-energy environments and salt-tolerant vegetation establishes where there is an accumulation of mud in estuaries. The composition of Saltmarsh flora and fauna is determined by complex interactions between flooding frequency, salinity, sediment water content, particle size, slope, and herbivory. While saltmarshes in England are dominated by lateral spreads of vegetation dependent on tidal inundation, the narrow and restricted spatial zones of marsh in Northern Ireland are often flooded by fresh water, preventing this lateral spread.

There are roughly 250 ha of Saltmarsh in Northern Ireland (Boorman in press) representing about 0.5% of the total UK Saltmarsh resource. The extent of loss of Saltmarsh in Northern Ireland is unknown (EHS 2005c). However, saltmarshes are under pressure from coastal development and are prone to damage from agricultural or golf course management.

There are two main types of Saltmarsh in Northern Ireland. The first, and more extensive, is the estuarine type with conspicuous natural transitions from low to upper marsh communities. Saltmarsh plays a major role in estuarine processes, both through the cycling of nutrients within the estuary and through its ability to dissipate wave energy and thus act as a natural coastal defence. The largest of the estuarine saltmarshes are found in the Roe Estuary in Lough Foyle, around Strangford Lough (where it is important for winter grazing by light-bellied brent geese*, Branta bernicla hrota*), at Ballycarry in Larne Lough, in the Bann Estuary and at Mill Bay in Carlingford Lough. These five sites account for 90% of the Saltmarsh area of Northern Ireland. The second main type is the smaller beach-head type, which tends to occur as small pockets on rocky shores (Barne *et al*. 1997). Other saltmarshes occur as a narrow coastal marginal fringe or as very small parcels (Baxter & Boaden 1990).

Saltmarshes are important habitats for a range of organisms, in particular specialist plant communities and associated animals, especially breeding and wintering birds which both feed and roost there, and often have a high conservation interest (EHS 2005c).

18.4.8.6 Coastal/Saline Lagoons

The key characteristics of saline lagoons are that they are shallow, quiet water bodies, adjacent to the sea, but sheltered from its direct effects and with a restricted connection to it. This leads to salinity from brackish to hypersaline, which can be highly variable spatially or temporally, depending on the hydrodynamics (EHS 2003f).

In Northern Ireland saline lagoons are not common. Of the 19 saline lagoons investigated by Carroll (1994), Donnan (1994) and Gorman (1994), only three were considered to be natural; a brackish wetland at Rathgorman (County Down), a series of pools on Grannagh Island and a series of salt pans and creeks at The Dorn (both in Strangford Lough). The remainder were considered to be artificial (EHS 2003f), but some of these are of high ecological value. A total of 16 saline lagoons occur in designated sites including ASSIs, SPAs and Ramsar sites. Lough Foyle ASSI and SPA include some saline lagoon habitat. Strand Lough is an SPA and is included in Killough Bay and Strand Lough ASSI (EHS 2005l).

18.4.9 Marine Habitats

Northern Ireland's territorial waters are defined as extending from the high water mark of medium tides (HWMMT) out to 12NM. The waters of Loughs Foyle and Carlingford are shared with the Republic of Ireland. The total surface area of the intertidal zone (HWMMT to LWMMT) is estimated to be 10,730 ha (Cooper *et al.*2009) of which 1,212 ha is composed of rock and 9,518 ha is sediment. The total surface area of the subtidal zone under Northern Ireland jurisdiction (LWMMT to 12NM) is estimated to be 450,000 ha (NIEA 2010h; calculated using a geographic information system (ArcGIS) by drawing a mid-line through trans-boundary waters out to the 12NM limit (or midway between Northern Ireland and Scotland)).

Most of Northern Ireland's territorial waters are over the continental shelf. The deepest waters (approximately 270m) are north of Rathlin Island, but most are shallower than 100 m (Barne *et al*. 1997). At these depths water movements are dominated by tides and wind-driven surface currents, the latter following the predominant westerly airflow and occasionally reversing the direction of flow through the North Channel (Davies *et al*. 2002; Lynch*et al.*2004). Tide ranges vary from microtidal (<2m) on the Londonderry and Antrim coasts, to mesotidal (2–4m) from Larne to just south of Dundrum Bay and macrotidal (>4m range) south of this. Wave exposure mirrors this pattern, decreasing from the west to the south east of Northern Ireland (Jackson & Cooper 2010). The combination of wind- and tide-driven processes means that the waters of the north coast of Northern Ireland (Lough Foyle to Larne) are well mixed (Lynch*et al.*2004). Sea surface temperatures range from roughly 6^{o}C in winter to 17^{o}C in summer, with means of 7^{o}C and 13.5^{o}C, respectively (Barne *et al*. 1997). Recent data demonstrate an increase in ocean temperature of between 0.5 to 0.75^{o}C in Northern Ireland watersover the past 20 years (Lyname*t al.*2010). Offshore salinity is fairly stable in space and time at about 34 practical salinity units (PSU) (Barne *et al*. 1997).

Habitats on the seafloor (sublittoral benthic habitats) are diverse. Some of these habitats are defined primarily on the basis of the physical substratum (e.g. circalittoral muds and sublittoral chalk), while in other instances the biota themselves generate the three-dimensional structures that define the habitat (e.g. seagrass beds and biogenic reefs). While there are no classically-defined habitats that are unique to Northern Ireland waters, there are several priority habitats that are significant not only to the UK, but also more broadly to the EU (**Table 18.10**).

Insert Table 18.10 here

Northern Ireland's marine biodiversity is typical of that of the broader UK. However, given its small size, its contributions to overall biodiversity inventories are relatively large, for example 30% of cetaceans resident in the UK are regularly seen in Northern Ireland waters. Of particular importance are biodiversity hotspots. Chief amongst these is Rathlin Island, with its rich assemblages of rare sponges (Picton & Goodwin 2007) as well as large nesting seabird colonies. In fact, 50–60% of all of Northern Ireland's sublittoral benthic species are found off Rathlin Island (Barne *et al*. 1997; Goodwin *et al*. 2008). By adding the species present in the next most important biodiversity hotspot, Strangford Lough, roughly 90% of Northern Ireland's known sublittoral benthos is represented (Erwin *et al.* 1990). However, care must be taken to ensure that observed 'hotspots' of diversity are not an artefact of increased study effort, and more information is still required to determine if this is the case for Northern Ireland, as it appears to vary with the group studied (Blight *et al*. 2009). Positioned at the interface between Boreal (cold, northern) and Lusitanian (warmer,

southern) marine biogeographical provinces (Dinter 2001; Hiscock *et al*. 2004), Northern Ireland's marine waters provide important opportunities to study the ecological consequences of climate change.

18.4.9.1 Intertidal zone

The low eastern coasts provide mixed sand and gravel beaches, sometimes partitioned to show an upper gravel beach and a lower sand terrace; most beaches show sand and gravel systems graded by varying proportions of the two substrates. Apart from the major sediment sink of Dundrum Bay (Orford, Murdy & Wintle 2003), most of these beaches are backed by small, depleted dune stores.

Intertidal invertebrate communities are a major ecological community, helping to purify water, stabilise sediments and providing important feeding areas for water birds and waders. Harvesting of lugworms, winkles, cockles and other shellfish has proceeded on a small scale for decades. However, harvesting on a larger scale is having an impact on wildlife around Strangford Lough, not only having potential impacts on the food chain but also causing disturbance to seal haul-outs and roosting and breeding birds (Kelso & Service 2000; Johnson *et al.* 2008). On the North Foreshore of Belfast Lough a large area of mudflat was used as the major waste landfill site for greater Belfast from 1958 until 2007. For the past 20 years or so this area has been lined and 'capped' and much of the site is now being managed as a nature reserve (Belfast City Council 2008).

18.4.9.2 Sea loughs

Northern Ireland has five major sea loughs (Belfast, Carlingford, Foyle, Larne, and Strangford), all of which are high in biodiversity and of great scenic and recreational value. Both Belfast and Derry/Londonderry are sited on major loughs. Strangford Lough is Northern Ireland's only Marine Nature Reserve, as well as being a European Natura 2000 site; the other loughs have SAC or SPA status. Strangford Lough is of particularly high value biologically and recreationally, with major populations of overwintering birds, extensive sand/mudflats and numerous small islands, which make it extremely scenic as well as of high value for nesting birds, breeding seals and shellfish cultivation. The eel grass (*Zostera marina*) community in Strangford Lough provides overwintering grounds for up to 75% of the world population of light-bellied brent geese as well as shelter for young fish and invertebrates (National Trust 2010). Many large rivers drain into the sea loughs (e.g. the Roe into Lough Foyle and the Lagan into Belfast Lough), which themselves are estuarine in nature, or smaller bays (e.g. Killough Harbour and Dundrum Inner Bay). Numerous smaller estuaries are also scattered along the coast.

Northern Ireland's sea loughs regularly host more than 120,000 birds each winter, including internationally important populations of mute swan (*Cygnus olor*), whooper swan (*Cygnus cygnus*), light-bellied brent geese, shelduck (*Tadorna tadorna*), knot (*Calidris calidris*), bar-tailed godwit (*Limosa lapponica*) and redshank (*Tringa totanus*; AFBI & NIEA 2011). Between 2004 and 2009 Strangford Lough was the twelfth most important site for wintering wetland birds in the UK. An average of 80,931 wetland birds used the site during the winters. Lough Foyle, Belfast Lough, Outer Ards shoreline, Carlingford Lough, and Larne Lough are also important sites for wading birds and waterfowl (Calbrade *et al*. 2010). Shorelines of all loughs are highly desirable for development, either for individual houses or expansion of development near existing settlements. Agriculture goes close to or even onto the shore in some areas, particularly on islands.

Alien species are becoming established in some of Northern Ireland's coastal waters and loughs, including *Spartina* in Strangford Lough. *Spartina anglica* was deliberately established in Ardmillan Bay during the 1940s in an attempt to stabilise a causeway which was silting up and for erosion protection of the National Trust property at Mount Stewart (Roberts *et al.* 2004). A major effort was launched in 1978 to eradicate *Spartina* from the Lough and the plant was virtually cleared by application of a selective herbicide. However, fears that this operation might be having an adverse effect on farmed shellfish and the introduction of tighter environmental controls on the use of chemicals in the marine environment led to the suspension of the spraying operation. As a result, the grass has recolonised much of the former range and has spread to many new locations. In 1997, *Spartina* covered over 30 ha in Strangford Lough. After much research on the impact of different herbicides in the marine environment, spraying was re-initiated in

1997–1998 with Dalapon. However, these control measures have been unsuccessful and *Spartina* continues to spread within the Lough (Hammond *et al.* 2002; Roberts *et al.* 2004).

18.4.9.3 Open ocean

The Marine environment of Northern Ireland includes portions of two distinct bodies of water, the north-east Atlantic and the north-western Irish Sea, which are linked through the North Channel. The predominant oceanic process is the north-eastward flow of the North Atlantic Current, which brings cool-temperate water to the shelf-break (Davies *et al*. 2002; Lynch *et al.*2004). Northern Ireland's location, at a transition between cold northern and warm southern waters, gives an extremely rich marine biodiversity (**Table 18.10**; AFBI & NIEA 2011).

There is a strong relationship between habitat complexity and the diversity of resident biotic communities (e.g. Kiessling *et al.*2010). Habitat complexity can be the result of the resident organisms, which amplify biodiversity by creating niches within which other organisms can thrive. Examples of such biogenic habitats in Northern Ireland's territorial waters include extensive kelp beds in the shallow waters off rocky shorelines, seagrass beds in the shallow waters of some loughs, as well as maerl, horse mussel and honeycomb worm reefs. Among the residents of such habitats are juveniles of many commercially important and rare species. Biogenic reefs are vulnerable to the effects of climate change and are particularly heavily impacted by mobile fishing gear, which is a particular problem because the gear destroys the habitat upon which the commercial species, and many others, depend. Besides supporting general marine biodiversity, Northern Ireland's territorial waters also house several charismatic species that capture the public attention (often referred to as flagship or indicator species; Heink & Kowarik 2010), thereby providing an impetus for conservation initiatives. In the local context these include basking sharks (Berrow & Heardman 1994; Southall *et al*. 2006), puffins, marine mammals (Berrow 2001) and sea turtles, which frequently travel along the coast of Northern Ireland (King & Berrow 2009). The utility of these species in representing the general health of the coastal waters of Northern Ireland has not been examined but the concept of focal species in marine conservation has a long and reasonably successful history (Zacharias & Roff 2001), although its utility has been disputed (e.g. Andelman & Fagan 2000).The emergent communities of The Dorn in Strangford Lough are of particular value (NIEA 2010i).

18.4.9.4 Water quality

Coastal water quality is monitored and new legislation and policies have been introduced over the years to address nutrient enrichment of coastal and marine waters (including the Water Framework Directive, Bathing Waters Directive, Urban Waste Water Treatment Directive, Nitrates Directive and the Ship-Source Pollution Directive). The Northern Ireland Environment Agency has called eutrophication "the most widespread threat to water quality in Northern Ireland" (EHS 2008a; **Figure 18.22**). Their data show that between 1994 and 2002 agriculture contributed over 70% of nitrogen loading to water in sea loughs, but that urban sources were the main contributors to ammonia and dissolved reactive phosphorus. Coastal waters were assessed as to the percentage which were 'at risk' under the Water Framework Directive in 2004. The factors driving classification in coastal waters tend to be nutrient concentrations and plant life. Nutrients and dissolved oxygen concentrations are the most important elements in determining status in transitional waters. Alien species, diffuse and point source pollution and morphological alterations were identified as the major threats (EHS 2008a). It was found that 66% of transitional and coastal water bodies in Northern Ireland are at moderate status, with approximately 27.5% at good status and 6.5% at high status by area/km^2 (DOE & NISRA 2010).

Insert Figure 18.22 here

18.5 Northern Ireland's Ecosystem Services

18.5.1 Introduction to Ecosystem Services

An ecosystem is an interdependent system of living things (animals, including humans, plants and microorganisms) and their physical environment. A change in any one of these components can impact on

the entire ecosystem. Ecosystems can be terrestrial or marine, inland or coastal, rural or urban and can vary in size and over time. In many cases, ecosystems overlap and interact. A healthy ecosystem is one that is resilient; able to adapt to changes in the external environment such as fires, flooding, insect population explosions, human activities and the introduction of exotic plant or animal species (Defra2007c).

Ecosystem services are defined by the Millennium Ecosystem Assessment (MA) as the benefits provided by ecosystems that contribute to making human life both possible and worth living (MA 2005b). For the UK NEA (and the MA) Ecosystem Services are grouped into four categories:

- Provisioning ecosystem services: the products obtained from ecosystems such as food, fibre and fresh water;
- Regulating ecosystem services: the benefits obtained from the regulation of ecosystem processes such as regulation of pollination, the climate, noise and water;
- Cultural ecosystem services: the non-material benefits obtained from ecosystems, for example through spiritual or religious enrichment, cultural heritage, recreation and tourism or aesthetic experience; and,
- Supporting ecosystem services: ecosystem functions that are necessary for the production of all other ecosystem services, such as soil formation and the cycling of nutrients and water.

These ecosystem services can potentially be provided by all ecosystems, including both those relatively undisturbed and those heavily modified, such as agricultural land and urban settlements. However, it is important to recognise that some of these services are mutually exclusive, i.e. the provision of one particular service may occur at the expense of another. This is particularly the case when people have modified an ecosystem to concentrate on the production of a single service. For example, when a wetland is drained to increase agricultural output or for residential/industrial development, it can no longer provide effective flood protection, improve water quality, maintain biodiversity or sequester carbon.

The resilience of many ecosystems around the world has been weakened by their past and current use by societies. Loss of resilience means than an ecosystem is unable to adapt to an external change and retain its structure and functions. This can have negative impacts on the ecosystem services it provides. When ecosystem resilience is damaged beyond a certain level the consequences of a small, additional change can be extreme or catastrophic (Goldschmidt 1997; Diamond 2005). However, a high level of uncertainty surrounds the scientific understanding of how these complex systems work and what these threshold limits or tipping points are (Rockström 2009b). There are also uncertainties around many elements of the structure and function of ecosystems, including the many types of bacteria, fungi and other small organisms, many of which are not yet identified, and whose roles are still poorly understood.

Degradation of ecosystem services has occurred at local, regional and global scales. The Millennium Ecosystem Assessment (MA 2005a,b) reported that approximately 60% of global ecosystem services are degraded or overexploited, often resulting in significant harm to human well-being. Species extinction, habitat loss, and decreased soil fertility and water holding capacity are examples which continue to have major impacts on human populations. All of these impacts have been noted in Northern Ireland to a greater or lesser extent.

Environmental management has shifted towards adopting the ecosystem approach (Defra2007b,c), defined by the Convention on Biological Diversity (CBD) as 'a strategy for the integrated management of land, water and living resources that promotes conservation and sustainable use in an equitable way'. It involves management at the ecosystem scale as opposed to management at the administrative level (land ownership, political boundaries). A good example of such management is the River Basin Management Plans (RBMP) proposed under the Water Framework Directive (WFD) which include actions for both Northern Ireland and the Republic of Ireland (NIEA 2009f,g,h).

The Department for Environment, Food and Rural Affairs action plan for ecosystem management (Defra2007c) is based on a number of core principles:

- taking a more holistic approach to policy-making and delivery, with the focus on maintaining healthy ecosystems and ecosystem services;
- ensuring that the value of ecosystem services is fully reflected in decision-making;
- ensuring that environmental limits are respected in the context of sustainable development, taking into account ecosystem functioning;
- taking decisions at the appropriate spatial scale while recognising the cumulative impacts of decisions; and
- promoting adaptive management of the natural environment to respond to changing pressures, including climate change.

The benefits of this approach include:

- more effective delivery of environmental outcomes;
- better-informed decisions that take full account of environmental impacts, helping us to achieve sustainable development;
- better prioritisation and more efficient use of our resources; and
- more effective communication and greater awareness of the value of the natural environment and ecosystem services.

Ecosystem assessment recognises the complex interactive nature of organisms and their physical environment and the provision by ecosystems of benefits to people. The interactions amongst animals and plants mean that disturbance of one component can have major impacts on the others. One example of this is reduced crop yields caused by poor pollination due to reduced bee population numbers. Ecosystem scale management provides a mechanism for identifying interrelationships within and between complex ecosystems, explicitly recognising the multiple benefits they provide. Understanding the trade-offs and synergies between different ecosystem services is crucial for informed, effective decision making which optimises all benefits to society in the short and longer terms.

18.5.2 Provisioning Services

Provisioning services are those goods provided by ecosystems for direct use by people including food, fibre, fuel, fresh water and minerals. In comparison to Regulatory and Cultural Services, they are more easily quantified and it is easier to assign a financial value to them; however, the different ways in which products are valued makes comparison and the determination of total contributions difficult. Land is consciously and actively managed by people for products; it is used to produce crops or animals which are then used directly by people or cycled back through systems to produce other outputs (for example, cereal may be eaten directly or fed to animals which produce milk or meat). Provisioning services are widely recognised as being essential for human well-being. However, the degree to which provisioning services are dependent on other ecosystems and ecosystem services is less clearly understood. Resources from the marine environment are generally not owned or managed to the same degree as those on land, with resulting issues of overexploitation.

18.5.2.1 Food from agriculture and horticulture

Northern Ireland's climate and soils are highly suitable for growing grass. Currently most of Northern Ireland's land is used for producing meat and dairy products, including the production of silage and cereals to feed the animals. The production-based subsidies of the CAP have also contributed to the major expansion of the dairy, beef and sheep sectors (Cruickshank 1997). However, this policy driver has reduced since the introduction of the Single Farm Payment in 2005, with clear results.

Some land, mostly in the east, is used for arable production of cereals, potatoes and, increasingly, additional crops such as oil seed rape and fodder maize (DARD 2010i). Around three-quarters of the 1,351,000 ha land area of Northern Ireland is agricultural. This is primarily rough and improved grazing for cattle and sheep with some arable farming, predominantly in the east; 93% grass and rough grazing; 5% agricultural crops; 0.3% horticultural crops; 1% woods and plantations (state forestry is in addition to this);

and 0.7% other (DARD 2010o). Farms are traditionally small and managed by the farmers and their families, with occasional additional help. In recent years some larger farms, especially in the east, have increased in size and become more intensive livestock or dairy enterprises, while smaller farms have become less viable. Farmland is sometimes sold as building plots to provide (often essential) farm income. The impacts of the current recession on farmland sales for building are not yet known, but planning applications have decreased in recent years (**Table 18.8**). This may in part be due to changing policies, which themselves may have an impact on the selling of building plots as the new PPS21 requires new dwellings to be integrated with existing farm buildings. The increasing capital value of land far outstrips any other investment which can lead to 'land rich, cash poor' farmers and unviable farms not being abandoned or sold. There is a widespread system of conacre, a system of letting land for the short term in which it is the use of the land for a specific purpose, rather than the land itself, which is rented (Alexander 1963).

There have been significant changes over the past 150 years in terms of the production of crops and animals (**Figure 18.23**; **Figure 18.24**; **Figure 18.25**). Trends over the past 50 years have continued those begun 150 years ago except for pig production, which dropped in recent years following a major rise in the first half of the 20th Century. Over this period there has been a significant shift in production from cereals and potatoes (and flax up until 50 years ago) to hay/silage and pastureland. The overall amount of land in production decreased from 1850 to 1950, but has remained relatively constant since then. However, this does not take into account the intensity of land use (e.g. low level grazing on uplands is not differentiated from intense livestock farming).

Insert Figure 18.23 and 18.24 here

Most of Northern Ireland's arable farmland is currently used for producing grain for animals rather than crops for direct human consumption (NIGTA unpublished data). The types of crops raised have varied over the years, and there have been changes in land use between arable crops and grassland as well (DARD 2010c). Such changes have been driven by markets, policies, subsidies and farmer preferences and indicate a fair degree of flexibility of the land to provide different outputs. The ability to respond to economic drivers is constrained by the soil and climate, and thus the impact of climate change must be considered highly significant for future agricultural production and land use patterns. **Figure 18.13** (area) and **Figure 18.25** (tonnage) present data on what crops have been grown over the past 28 years. Crop yield per hectare has shown an increasing trend over the period, except for grass silage for which it has remained relatively constant (DARD 2010i). The vast majority of arable land is used to produce cereals, mostly spring barley, and potatoes. There has been a significant increase in the area under wheat in recent years and a drop in potato and spring barley production.

Insert Figure 18.25 here

Although the area of land used to produce fruit has decreased substantially since 1981, the tonnage of fruit produced has risen during that period (**Figure 18.26** & **Figure 18.27**). Most fruit production is apples, 1,165 ha in 2007 (Cooper *et al.* 2009), and 99% of orchards grow Bramley apples with the remaining produce consisting of plums and dessert apples (**Withers** *et al*. 2008). Productivity is relatively volatile, but the area of land under orchards has shown a steady decrease since 1981. There has been a slight increase in land devoted to vegetable growing.

Insert Figure 18.26 and 18.27 here

Mushroom production increased in value from £5.1 million in 1981 to £19.9million in 2009. However, there has been a decline in output and value from its peak value of £32million in 1996 (DARD 2010j; Section 18.5.2).

Most of Northern Ireland's land is used to rear livestock (DARD 2010o; **Figure 18.28**). There was a considerable drop in the number of pigs in the mid-1990s, following an increase in the cost at abattoirs

(Defra2004) and market forces against which the pig market is less protected via subsidy than cattle and sheep (Thankappan & Flynn 2006).Sheep numbers show fluctuation but have decreased from very high levels in the late 1980s to the early 2000s, the rise being related to CAP payment calculated on headage. This trend was also seen in beef cattle but not to the same degree. Dairy cows have remained relatively constant over this period, following a drop in numbers in 1998. Adverse effects of the preceding BSE crisis and the outbreak of foot-and-mouth disease in 2001, in addition to the relative strength of the pound making exports less competitive, have been important drivers in this regard (Mead 2003).

Insert Figure 18.28 here

Given global instability in the food supply chain and price, increasing human population, costs of transport, drives for greater food security (at UK and Northern Ireland levels) and the impacts of climate change, it is likely that food supply will rise up the political agenda in Northern Ireland in parallel with the emphasis in the UK as a whole. However, there are many interacting factors with implications for land use, including the value of unploughed pastureland as a carbon store, future CAP reform, increasing emphasis on food security, rising global food prices, animal welfare, reducing food miles, drives for renewable energy production, increasing costs of fuel and chemicals, consumer preferences, food traceability and an increasing demand for meat globally. All these factors make predicting future trends difficult. There is a strong attachment to the small family farm in Northern Ireland due to the history of land ownership. This often goes against rational options for farm management and is a factor limiting structural reform (Moss & Chilton 1997a,b).

In 2009 there were 48,031 farm workers (full-time, part-time, casual and spouses) equating to 28,000 Annual Work Units (approximately equivalent to Full Time Equivalent), a 26% decline since 1988 (when the figure was 66,312) and a 30% decline since 1981 (DARD 2010f; **Figure 18.29**). Most of these are farm owners. This is around 4% of total civil employment in Northern Ireland compared to 1.6% in the UK, 5% in the Republic of Ireland and 3.7% in the EU15 (DARD 2010o). Off-farm sources of income are vitally important for many farmers.

Insert Figure 18.29 here

There has been a shift from full-time towards part-time and casual working patterns. Fewer farms in Northern Ireland are now economically sustainable, and over half of all farmers were over 55 years of age in 2005 (DARD 2007a; Spedding 2009). Diversification is an important source of farm income for some farmers, with 13% of farms involved in diversification activities such as organic beef production or providing bed and breakfast accommodation in 2001 (DARD 2002). In 2007 1,604 farms (6%) were involved in diversification projects, excluding contracting/haulage (2,339, or 9%, if this is included), with such projects encouraged and supported through EU structural funds (DARD 2008d).

Northern Ireland's average farm size of approximately 40 ha compares to the UK average of 54ha, the Republic of Ireland average of 32 ha and the EU15 average of 27 ha (DARD 2010o). Between 2004 and 2009 average farm size increased from 38.5 to 39.9ha, with a corresponding decrease in numbers of farms from 27,614 to 25,264, representing a drop of 9% (DARD 2010o).In 2009 almost a quarter of all farms had less than 10 ha of crops and grass while over 1,300 farms (5%) had 100 ha or more; these latter occupied 24% of the total area of crops and grass. Roughly half of all farmers had off-farm income, including both earned income and social security benefits (DARD 2010e). The downward trend in the number of farms is approximately 2% per year over the past 10 years (DARD 2010b; **Figure 18.30**). In 1963 there were 68,000 agricultural holdings but only 46,000 separate farm businesses, emphasising the importance of inheritance and conacre in farm viability. In Northern Ireland 48.9% of farms are entirely owner occupied, 28.5% are 50–100% owner occupied, 16.3% are 0–50% owner occupied, and 6.3% are not owner occupied [probably most of these involving conacre (DARD 2010o)] which, combined with inheritance tax, allows for some transfer of land management without impacting on land ownership. Turbary, water, mineral, shooting and other 'rights' are complex, rooted in history, and often do not follow land ownership (Cruickshank & Tomlinson 1995). About one-third of land farmed in Northern Ireland was let out through conacre in 2005

(DARD 2010o)**.** Conacre price varies by purpose, from £41/ha for rough grazing up to £686/ha for potatoes in 2008 (DARD 2010o).

Insert Figure 18.30 here

Land prices had remained relatively static at around £6,000/ha from 1981 to 1992 before rising to £10,000/ha in 2001. Following a steep rise since 2001 they are now some of highest in Europe at £19,837/ha in 2005(DARD 2009a, 2010o).

Northern Ireland is a net exporter of food, primarily animal products produced on large areas of rough and improved grazing land (Section 18.6). Livestock and livestock products accounted for an estimated £1.14 billion of agricultural output in 2008 compared to £66 million for crops and £59.6 million for horticultural products (DARD 2010o; **Table 18.11**). Milk (1.9 million litres; £514 million), beef (£280 million), pork (£77 million) and sheepmeat and wool (£51 million) are important products (output values), with exports to Great Britain contributing around half of that total. There is also a thriving chicken industry annually producing around 247,400 tonnes live weight of poultry meat (including broilers) and 738 million eggs (DARD 2010o,n; **Table 18.11**).Comparison of values is difficult due to different recording methodology, definitions and times.

Insert Table 18.11 here

There are 3,457 dairy farms in Northern Ireland, with a cumulative total of 290,000 dairy cows, producing 1.9 billion litres of milk. Businesses which pasteurise milk and those which manufacture milk products such as butter, cheese, ice cream and yoghurt employed 2,352 full-time workers in 2008 and represent around 12% of the agri-food industry in total. The largest single sector in terms of numbers employed is involved in beef- and sheep meat-related activities, i.e. all the businesses involved in the slaughtering of cattle and sheep and the processing of their meat. This employed 3,316 full-time workers in 2008, equal to 17% of the total (DARD 2010n).

The food and drink processing sector provided a gross turnover of £2,724 million in 2007, with a value added of £530 million (DARD 2009d). Beef and sheep meat were the primary sources of this revenue, making up 25% of gross turnover in the sector (DARD 2009d). The sector employed over 18,000 people in 2007 with export sales (outside the UK) of £645 million (DARD 2009d). **Figure 18.31** shows the destinations of Northern Ireland's produce, with sizeable exports of meat and milk products (Section 18.7 shows a comparison with imports). Not all of this value is directly related to the provisioning service (including human input and additional processing), but all relies on it for its existence.

Insert Figure 18.31 here

Northern Ireland is a net importer of animal feed (2,296,000 tonnes at a cost of £518.1million (gross) in 2009 (DARD 2010o), which accounts for 37% of the total expenses of Northern Ireland agriculture, compared to 19% in the UK (DARD 2010o).

Linking production outputs to UK NEA habitats is difficult, as categories do not coincide and data are not collected on a habitat basis, but the vast majority of arable land is categorised as Enclosed Farmland, which also includes most of the silage production and considerable grazing, particularly for milk production. Farm census criteria have been altered repeatedly, including when the UK became a member of the EU (McAdam 1988), so there are difficulties comparing livestock numbers from the post-war period to the present day.

Semi-natural Grasslands are largely used for low intensity grazing, and are particularly suited to native Irish cattle breeds which respond well to the wet conditions. The output from the smaller areas of specialised habitats is relatively small, but neutral grassland covers a significant proportion of the farmland of Northern Ireland. It is not possible to disaggregate the output from these habitat types from that of other agricultural production, but the Semi-natural Grassland habitat is largely in the Less Favoured Area (LFA) designated

parts of Northern Ireland and LFAs are used largely for beef cattle and sheep. Less Favoured Areas account for 70% of agricultural land involving 57% of all farms (DARD 2009d, 2010n).Agricultural use of uplands is largely for livestock grazing, overwhelmingly for sheep at relatively low stocking densities. In addition, animals may move between Enclosed Farmland and open moorland over the year. However, a number of sources point to increased pressure on moorland grazing in the 1970s and 1980s. McAdam (1988) found that the number of sheep on Northern Ireland hill farms increased from 150,000 in 1960 to 290,000 in 1975, Edwards (1987) reported an increase of nearly 70% in the Northern Ireland hill sheep flock from 1974 to 1985, and the Ballycastle District saw an increase of 30% in its sheep flock from 1983 to 1988 (Kirkpatrick *et al.*1999; **Figure 18.28**). A subsidy regime which rewarded those who increased their sheep numbers led to a peak of just under 4.5 million sheep in 1998, but by 2009 numbers were down to 2.7 million (DARD 2010d; **Figure 18.28**) as a result of agri-environment policies, for example through requiring Northern Ireland Countryside Management Scheme members to remove sheep for specified periods in the year and thereby encourage plant growth and biodiversity. However, under-grazing can also have negative biodiversity impacts (Upton & Bain 2006). There is still some limited grazing of cattle and sometimes sheep on coastal dunes, but this was higher in the past. Reclamation of tidal lands has occurred in most of Northern Ireland's sea loughs for agriculture (e.g. south side of the Foyle at Eglinton, Ballykelly).

18.5.2.2 Marine Fisheries

Northern Ireland's seas (shore to 12 NM) support a substantial amount of the UK's marine biodiversity with some 4,000 species (NIEA 2010g). The total value of fish landed by Northern Irish vessels was £23.2 million in 2008 (DOE 2010a; AFBI & NIEA 2011). There were around 625 fishermen, some of whom were part-time (DARD 2009d; DOE 2010a), and Northern Ireland accounted for approximately 4–5% of UK landings (Cracknall 2009; DOE 2010a; MFA 2009).In 2008 this amounted to 14,900 tonnes of shellfish, 12,100 tonnes of pelagic and 2,900 tonnes of demersal finfish for a total of 29,900 tonnes (Cracknall 2009; DOE 2010a; MFA 2009). There has been a significant shift from 1993 to 2007 from finfish to shellfish (DCAL 2008; **Figure 18.32**). An additional 615 full-time and nearly 200 part- time employees were involved in the industry in processing, marketing and other work (DARD 2009d).

Insert Figure 18.32 here

At the end of 2008 the Northern Ireland fishing fleet comprised some 147 fishing vessels over 10m in length and 204 vessels 10m and under in length. However, this does not include full data on the commercial operations of the 10m and under inshore fleet, for which data submission is voluntary for species other than crabs and lobsters (DOE 2010a).

In addition to the capture of wild fish stocks, Northern Ireland also produces a significant amount of seafood via aquaculture. In marine aquaculture Northern Ireland's production focuses on shellfish, primarily bottom-grown mussels, and here it outperforms other regions in relative terms, producing 25% of the UK's cultured shellfish harvest (UKMMAS 2010). Fisheries, aquaculture and marine tourism together generated £135 million and supported about 1,400 full-time jobs in 2008 (DOE 2010a).

In addition to the direct depletion of the target stock by capture fisheries there is unintended damage to the physical environment and other species through bycatch, disturbance and destruction of seabed communities. Although Northern Ireland specific data are not available, in general, fishing focuses first on predators (such as cod, which are near the top of the food web) and then moves down to lower trophic levels as predator populations decrease, with resulting significant impacts on the marine food web (Pauly *et al*. 1998), often resulting in population explosions of bottom-feeding invertebrates, such as shrimp (*Pandalus* species; Worm & Myers 2003; Frank *et al*. 2005).Impacts of fishing are more severe in sheltered habitats, such as sea loughs, that characterise the Irish Sea.

Overall, EU fisheries have declined by about 30% in 10–15 years (Lynam*et al.*2010). In 1994 roughly 45% of the Northern Ireland catch comprised bottom-dwelling species (Cracknell 2009), mainly cod, hake, whiting, monkfish, flatfish and dogfish, which were caught by trawl (Barne *et al*. 1997). The remaining catch was roughly evenly split between pelagic species, such as herring, and shellfish including *Nephrops* (caught by

otter trawl) and mussels. By 2008 bottom-dwelling fish made up only 10% of the catch, with shellfish increasing to 50% and pelagic species to 40% (Cracknell 2009).

This suggests that the threat of habitat destruction as a result of fishing is declining, although mobile bottom gear, including scallop dredges, is still in operation, some in sensitive areas such as the waters off Rathlin Island, and these activities are particularly significant (Foden *et al.*2010), with major damage to horse mussel beds in Strangford Lough (Roberts *et al.*2004). However, this also suggests that the marine food web in Northern Ireland has been fished to close to its base (Le Loc'h & Hily 2005). Further disruption of the marine food web could result in negative consequences, such as outbreaks of jellyfish, seaweeds or slimes (Pauly 2009; Richardson *et al*. 2009), which are among the few macroscopic organisms with a lower trophic level than the shellfish. The overall impact of fishing is to deplete higher trophic levels, allowing opportunistic species characteristic of unstable, regularly disrupted communities, to establish. Many notable commercial species, such as scallops, depend on stable habitats and communities.

Although there is some evidence of recent stabilisation or recovery of fish stocks (UKMMAS 2010), stocks are lower than they were a decade ago (Thurstan *et al.*2010). Nevertheless, the importance of Northern Ireland fisheries from a socio-economic perspective suggests that fishing effort will decline only slowly, and that heavily exploited stocks and habitats will continue to be impacted into the future, albeit at slightly lower levels than have been experienced over the past three decades. The Common Fisheries Policy (CFP) Review, currently being undertaken by the EU Fisheries Council, is likely to have implications for Northern Ireland in its attempt to combat such trends while maintaining the economic viability of the industry (NI Executive 2010a).

18.5.2.3 Freshwater fisheries

There are two major freshwater fisheries in Northern Ireland: eels and salmon. The production of eels from Lough Neagh is around 400 t/yr. With a value at £5/kg this would be worth £2 million and the industry employs an estimated 300 people part-time (April–September; Rosell *et al.* 2005). At its peak, this industry had a value of £5 million. There is a demand for eels, but not in Northern Ireland; most of the catch from the Lough Neagh fisheries is exported, mainly to Holland (Hansard 2010).

The stock of European eels has been in rapid decline since around 1980, so that by 2005 numbers had declined by as much as 95–99% (ICES 2006). The European Commission adopted regulations (Eel Regulation (EC) 1100/2007) in 2007 to establish measures to help facilitate its recovery, which require the establishment of eel management plans for the three Northern Ireland river basins (DCAL 2007; 2009a). Lough Neagh is home to Europe's largest eel fishery, but numbers of eels have been declining since 1983. Lough Neagh fishermen now have to source elvers from catchments in Southern Europe in order to sustain numbers. Eel numbers in Lough Erne have fallen so low that commercial eel fishing has now been banned there (NI Assembly 2010).

The Neagh Bann River Basin in Northern Ireland is now the only region in the United Kingdom where eel fishing is permitted. The European Eel Regulations demand that it be demonstrated that at least 40% of the adult eels from each river basin are escaping to spawn, compared with the best estimate of the potential escapement in the absence of human activity. Lough Erne is transnational and therefore a cross-border management plan must be devised by the relevant Departments in Northern Ireland and the Republic of Ireland. A 'trap and truck' operation to capture eels and transport them to the other side of Ballyshannon hydroelectric dam is used to prevent death of eels in hydroelectric machinery. The objective of this is to transport 22.5 t of eels during 2009, and four fishermen have been employed to do this conservation work (Hansard 2009).

Northern Ireland has a total of 27 salmon rivers over the two fisheries jurisdictions (Loughs Agency and the Fisheries Conservancy Board; NASCO 2009). Salmon fishing has decreased in recent years to just over 5,000kg in 2007 (**Figure 18.33**) but has stabilised since then. In 2009 the Department of Agriculture and Rural Development issued 34 commercial fishing licences (20 drift net, 12 draft net, two bag net; John

McCartney, Loughs Agency, pers. comm.)and DCAL issued six licences (two drift net, two tidal draft net, two bag net; Fiona Lavery, DCAL Inland Fisheries, pers. comm.). The catch in 2009 of 16.7 tonnes represented a significant decline on the previous 5-year average of 22.5tonnes, with nearly two-thirds of the catch now caught by line rather than net (Kennedy *et al.*2010). The number and proportion of salmon caught at sea and in estuaries has decreased markedly since 2002 (**Figure 18.34**).

Insert Figure 18.33 and 18.34 here

18.5.2.4 Aquaculture

The global tendency for wild fisheries to be replaced by aquaculture production is apparent in the UK in general, and specifically in Northern Ireland (Lynam *et al.*2010). While most wild capture fisheries are in decline, aquaculture output is increasing. These trends represent opportunities both for new economic activity and for initiatives that seek more sustainable approaches to seafood production, and to environmental threats.

The aquaculture industry, particularly the shellfish sector, has developed significantly in recent years in Northern Ireland. There are currently 81 licensed fish farms (covering 100 sites) of which 48 are shellfish farms and 33 are finfish farms. The main species cultured are common/blue mussels (*Mytilus edulis*) and Pacific oysters (*Crassostrea gigas*; **Table 18.12**), although there are also small quantities of native oysters (*Ostrea edulis*), clams (*Venerupis semidecussata*), scallops (*Aequipecten opercularis*), rainbow trout (*Onchorhynchus mykiss*) and Atlantic salmon (*Salmo salar*; DARD 2010b). The estimated production of the aquaculture sector in 2009 was valued at £10.9 million, with over 8,000 tonnes of mussels (£6,743,700), 282 tonnes of oysters (£902,400), 1,102 tonnes of salmonids (£3,141,750) andmore than 35 million trout ova (£188,000). In total the aquaculture sector in Northern Ireland directly employs around 150 people within some 25 businesses (Lantra 2009).

Insert Table 18.12 here

The Pacific oyster is listed among the species with a potential to invade Northern Ireland's waters (Habitas 2008), and is reported to have established in Strangford Lough (Guy & Roberts 2009), but the remaining species are indigenous. Threats in addition to the escape of cultured species include eutrophication and pollution of enclosed or sheltered waters (where aquaculture installations tend to be located), the capture of wild-caught fish to feed finfish and possibly the increased abundance of parasites due to artificially high concentrations of cultured species.

18.5.2.5 Timber

Northern Ireland's sawn timber is used primarily for fencing (47%), pallets and packaging (25%) and construction(26%) and is traded into Northern Ireland, UK and European markets (Forestry Commission 2010a, 2010c). Timber production increased from just under 50,000 m^3 in 1974/5 to a peak of almost 440,000 m^3 in 2004/5 after which it fell to roughly 400,000 m^3 and has remained at that level since. For 2008 and 2009 the Forest Service has slightly exceeded its target to sell at least 400,000m^3 of timber (2008/9: 404,000; 2009/10: 402,000; Forest Service 2010b), bringing in receipts of over £7.5million and £7.2million of timber sales for the 2 years respectively. Of all woodland in Northern Ireland, 73% is certified to UK Woodland Assurance Standard (Forestry Commission 2010c) and 95% of this certified woodland is under the management of the Northern Ireland Forest Service. All Forest Service-managed woodland is certified (Forest Service 2010a). Sales of broadleaved timber are negligible (Forest Service 2010a).

Most of Northern Ireland's coniferous forests are in the uplands where land was easier to acquire than in the lowlands with their better soils. Much of the forest is on blanket peatland. However, since 1993 the Forest Service has not planted new areas on oligotrophic or dystrophic peat because of the realisation of the uniqueness of the habitat and the need to sustain species and habitat diversity (Forest Service 1993). As forests mature and are harvested, most will be replanted to trees (Forest Service 2007a).

18.5.2.6 Water

Northern Ireland Water is the only public water supplier in Northern Ireland and is government owned. It supplies over 600 million litres (l) of high quality drinking water each day to approximately 795,000 properties, both domestic and non-domestic. Households account for most of this, with agriculture, industry and commerce each using substantial amounts (**Figure 18.35**). Northern Ireland Water utilises approximately 34 water sources, which include upland impounding reservoirs (49%), rivers and loughs (49%) and boreholes (NI Water 2010b). This contrasts with England and Wales where overall 35% is extracted from groundwater, exceeding 70% in the south east (Shand *et al*. 2007).The majority of water is supplied for domestic use, with non-domestic users supplied with approximately 153,000m^3 per day. Over 99% of households in Northern Ireland are connected to the mains for their supply of clean water. The best estimate of per capita household consumption in Northern Ireland is 145 l/person/day. With a population of 1,742,000 in 2006/7, this suggests a total household consumption of 250 million l/day. Growth in households (due to a small rise in population coupled with a fall in average household size) is expected to increase domestic demand for water (Entec 2004; NIEA 2009k). Agricultural water consumption is approximately 39.2 million l/day (DRD 2002b). Furthermore, it was estimated that agriculture water use from boreholes could be as high as 11 million l/day (Robins 1996). Industrial water consumption is 31.79 million l/day (DRD 2002b). Industry is required to adhere to trade effluent discharge consents, although compliance varies for different activities. Severe disruption in water supplies in December 2010 to January 2011 following extreme cold has further exposed the problems of the infrastructure, but has raised water up the political agenda.

Insert Figure 18.35 here

Less than 1% of water comes from private water supplies (NIEA 2009b). The Northern Ireland Environment Agency monitors drinking water for compliance with international standards (NIEA 2010e). There are 1,276 private water supplies (approximately 3,000 people) currently registered with the Northern Ireland Environment Agency. It is estimated that there are a further 4,000 private supplies to individual private domestic dwellings which do not need to be registered under the 1994 Regulations. The majority (98%) of private supplies in Northern Ireland are from groundwater sources. 91% (1,162) of the private water supplies registered with the Northern Ireland Environment Agency are dairy farms; the remaining 9% (114) are commercial and domestic supplies. There are 114 private water supplies monitored: 82% are commercial/public supplies; and 18% are domestic premises (groupings of two or more houses; Caroline Barry, NIEA, pers. comm.).

Northern Ireland Water also treats around 127 million m^3 of wastewater daily from the 663,000 properties connected to the wastewater system. According to the Utility Regulator's 2007/8 Cost and Performance Report, wastewater treatment compliance in Northern Ireland remained the lowest in the UK (NIAUR 2008). Decreasing water quality not only has implications for the habitats and species it supports, it also results in the loss of valuable ecosystem services including food and recreation, natural means of flood prevention, drought mitigation, soil fertilisation and water purification. This has implications for government finances in addition to the cost of treating drinking water often extracted from the same water bodies that treated water is discharged into. Northern Ireland Water's annual operating costs were £186.1 million for 2007/08, an increase of 35.2% since 2004/05 and high compared with those of Great Britain's water companies (NIAUR 2008). There has been extensive recent investment in the provision of wastewater collection and treatment systems in Northern Ireland; over the five years up to 2008 £1.1 billion was spent on infrastructure and upgrading, protecting both public health and the environment. Operating costs for Northern Ireland Water in 2008/09 were £262.2 million (NI Water 2010a) and they estimate the cost of phosphate removal at wastewater treatment works (WWTWs) is now in the order of £600,000 annually (NIEA 2009l).

Upland habitats are important to the water supply. For example, much of the water supply for south Belfast and Co. Down is from the reservoirs in the Mournes (e.g. Silent Valley, Spelga). Other important reservoirs include Dungonnell and Altnahinch on the edge of the Antrim Plateau and Altnaheglish and Banagher Glen in the Sperrins. These reservoirs have their feeder streams in blanket peat and peaty slopes. Management of these lands to ensure high quality water has favourable outcomes for habitat conservation, such as

reduced sheep grazing in the Mournes and retention of high quality peat bog in the Garron Plateau (RSPB unpublished data). In the west and north of Northern Ireland a significant proportion of the water supply is abstracted from local rivers whose headwaters lie in the blanket peat upland slopes.

18.5.2.7 Fuel peat

Blanket peat has for generations provided fuel for rural homes. Coal has a calorific value of around 6,000 cal/g while hand-cut turf, with a water content of around 35%, produces around2,600 cal/g (Hamilton 1982). Ignition occurs between 150 and 210^{o}C, a temperature at which much of the carbon is lost (Hamilton 1982), making it a convenient but not a carbon-efficient fuel. Hand cutting of peat turves was once widespread (47% of remaining blanket peatland has been cut-over at some time in the past and a large area has been totally removed), but by the mid-20th Century it was much reduced; electricity had reached most rural homes, oil heating was available and many family members had moved to the towns and cities and were no longer available for the intense work required to dig, dry and harvest the turf. However, in the late 1970s and early 1980s high global oil prices and the introduction of a compact harvester, attached to a farm tractor, which could cut a plot of peat sufficient for a year's fuel in a few hours, resulted in widespread cutting across the blanket bog, predominantly near to roads and tracks and on blanket peat that had previously been hand cut. Although widespread, it occupied a total area of 3.6% of the blanket peat (**Figure 18.36**). Whilst this cutting was of value to rural households, reducing expenditure on fuel, it had adverse effects on the environment, including loss of plant species, disturbance of migratory and wetland birds, and damage to spawning and nursery beds of salmonids through settlement of peat particles. Since the early 1990s this peat cutting has declined to an estimated 330ha, less than 10% of the area cut in 1990/91 (Tomlinson 2010). The estimates of carbon loss from peat extraction in 2008 range from 42,751 to 47,452 tonnes of carbon per year (tC/yr), or approximately 30% and 40% respectively of estimated losses in 1990/91.Whereas in 1990/91, peat extraction for fuel (hand and mechanical) accounted for 76–81% of carbon loss from peat extraction, in 2008 it accounted for only 16–24%, with extraction for horticultural peat now dominant (Tomlinson 2010).

Unlike the Republic of Ireland, Northern Ireland does not use peat to fuel electricity power stations. Peat-burning power stations in the Republic of Ireland have been in operation since the 1940s.Peat has a high methane content which is released when burned, although the power stations at Lough Ree and Shannonbridge have to meet strict emissions regulations. Some have labelled peat 'new coal', due to its effect on the atmosphere. The Irish Government sees peat as a key feature of the country's energy mix. A report published in 2006 states that intended projects involving lignite and peat power stations in the Republic equate to 600,000kW (VGB Secretariat 2006).

Insert Figure 18.36 here

The reduction in peat harvesting has a number of explanations.In 2005 new criteria were introduced into the ESA scheme and CMS, limiting the area of peat cutting to 0.1 ha maximum for domestic use, and mechanised cutting was not permitted. However, even before this, peat extraction for fuel had declined due to falling demand for fuel peat, largely due to rising standards of living and reduced availability of labour. Other possible causes of the decline in cutting for fuel include windfarm construction, peatland conservation and forestry. The majority of windfarms built and proposed over recent years occur on upland blanket peat and several coincide with areas that were machine cut in 1990/1991, for example in the Slievemore-Cappagh hills, in the west Sperrins and on Long Mountain. Peat cutting has ceased or its extent has been reduced at existing windfarms. Designation of additional peat conservation areas since 1991 has also led to restrictions on cutting. In the early 1990s Forest Service extended planting onto some areas formerly subject to peat extraction, but after 1995 planting of new areas declined steeply to zero in 2007. New state forest areas have not had a significant role in the decline of peat cutting, and while private forests have extended, this has not been over areas of former peat extraction (Tomlinson 2010).

18.5.2.8 Terrestrial renewable energy

Invest Northern Ireland states that the existing generation capacity of Northern Ireland's onshore wind power resources is 164.6MWe (Mega Watts electrical). As the report was being published in 2008, another

392.7MWe of wind power had been approved or was already under construction (Invest NI 2008). About 94% of identified renewable energy production would come from onshore and offshore wind (Action Renewables 2004, Table 18.13). The equivalent for biomass-generated electricity and heat (which includes anaerobic digestion, gasification, cogeneration, and boilers using chips, pellets and logs) was 3.05MWe and 0.73MWe respectively. Landfill gas capture was included in the report as an emerging technology, and since then the technology has been employed at the North Foreshore landfill site in Belfast and at other locations in Northern Ireland, in compliance with European waste management directives. **Table 18.13** presents information on the anticipated scale of various renewable energy technologies as of 2004; these figures are considered still valid (Action Renewables pers. comm.).

Insert Table 18.13 here

Many windfarms are located on blanket peat uplands, with possible impacts on wild birds, bats and scenery. Although construction of wind turbines and related infrastructure can lead to significant peat loss and erosion, these impacts can be offset by accompanying cessation of peat cutting and reduced grazing impacts, which can have beneficial impacts on recovery of the vegetation. A recent Northern Ireland Environment Agency scoping report into wind energy demonstrated in detail the inevitable trade-off between the positive impact in terms of increased use of indigenous renewable energy resources and consequent greenhouse gas reduction and the negative environmental and scenic impacts of such energy developments (NIEA 2010k). A Planning Policy Statement on Renewable Energy (PPS18; DOE2009b) and guidance on siting of wind farms (EHS 2008b) have been produced to ensure proper consideration of all issues before developments proceed.

18.5.2.9 Marine renewable energy

There are significant opportunities for the generation of renewable energy through wind, wave and tidal generators in the marine environment (DETI 2010b). At the end of 2010 the only commercial tidal generator in the world operated within Strangford Lough (capacity of 1.2MW), but opportunities for marine windfarms are probably more significant in the short term. Although there are currently neither windfarms nor wave-driven generators deployed in Northern Ireland's coastal waters, the Department of Enterprise, Trade and Investment set a target for generating 40% of Northern Ireland's electricity and 10% of heat from renewable resources by 2020, a very challenging target, with nearshore (<20m depth) windfarms a prime technology option (DETI 2010d). The regional economic development body, Invest Northern Ireland, is promoting economic investment in the local renewable energy market by Northern Ireland (Invest NI 2008).

Northern Ireland does not currently have any offshore windfarms in operation; however, there are proposals for development of up to 60 turbines at the Tunes Plateau off the north coast (B9 Energy, Powergen & RES 2002). Other areas cited as possible areas for offshore windfarms and also tidal and wave installations include the Strangford Narrows, around the Copeland and Rathlin Islands and around the North Coast between Fair Head and Runaby Head (**Figure 18.37**). The Department of Enterprise, Trade and Investment has identified that potential levels of marine renewables could give rise to possible investment of £330 million to £880 million by 2020. The same study estimated the potential employment figure to be in the order of 4,500 by 2020, although it is acknowledged that the number of regional jobs could be fewer than this estimate given the current relative immaturity of the sector (DETI 2010c).

Insert Figure 18.37 here

This scale of renewable energy development could well have significant impacts on Northern Ireland's Marine ecosystems. For example, different types of migratory birds are differentially vulnerable to injury or death on encountering wind farms, but evidence of significant impacts is weak overall (Stewart *et al.* 2007). Similarly, while it has been reported that porpoises approaching the tidal generator in Strangford Lough stop vocalising (BBC News 2010b), there have been no other apparent impacts. Noise levels are of increasing concern in the marine environment (Dolman & Simmonds 2010; Thompson *et al*. 2010), so the construction and operation of future renewable energy installations will need to take this into account and

Strategic Environmental Assessments are being conducted to identify and mitigate environmental problems related to large-scale development of renewable energy projects (DETI 2009b).

18.5.2.10 Hydropower

Hydroelectric technology has a long history in Northern Ireland, with many old mill sites coming back into use. Local government schemes over the years, for example under the First and Second Order of the Non-Fossil Fuel Obligations (NI-NFFO) in the 1990s and the more recent £8 million Reconnect scheme undertaken by the Department of Enterprise, Trade and Investment, have helped promote new interest in the technology. It also continues to be a source of interest for local engineering firms looking to develop supply chain opportunities in the marketplace.

There is a potentially significant renewable energy resource from flowing or stored water, but to date installations have been generally small scale, from 250 to 500kW. A 1999 assessment of renewable energy potential in Northern Ireland indicated that the maximum estimated contributions from small-scale hydro by 2010 would be 25GWh/y (DETI 2001). There has been little development of small-scale hydropower since then; however, there are currently 80 such applications in the planning process and Invest Northern Ireland believes a reasonable-sized industry of around 1,100 new installations will emerge over the coming decade (Sam Knox, Invest NI, pers. comm.).

There is concern about the potential impacts of hydroelectric installations on fish and water quality, especially during periods of low water flow. The Northern Ireland Environment Agency is the environmental regulator of hydro schemes. It has recently proposed a restoration scheme on the River Roe at its Roe Valley Country Park site. The proposal, intended as an industry benchmark, recognises the primacy of environmental protection with specifications ensuring the project will not have a significant negative impact on fish or the river ecology (NIEA pers. comm.).

18.5.2.11 Biomass

Research on short rotation coppice willow as a biomass crop started in Northern Ireland in the early 1970s in response to increasing oil prices, with experimental stands in Loughgall in County Armagh and in County Fermanagh. Short rotation coppice willow also has significant potential for the bioremediation/biofiltration of effluents and sludges; it takes up large volumes of water and can utilise the nitrogen and to some extent the phosphorous in high nutrient wastes. Current Agri-food and Biosciences Institute research includes the use of short rotation coppice willow for the treatment of primary sewage effluent, and initial results indicate that irrigation of willow with sewage effluent is a sustainable approach to waste management. Future research will be conducted at sites at the Agri-food and Biosciences Institute Hillsborough (farm wastewater) and Greyabbey (sewage effluent). One commercial farmer has been growing willows for a combined heat and power plant and is interested in the use of sewage sludge and slurry as nutrient sources for the crop. Future potential will depend partly on government support for renewable energy. The biomass can be used by domestic consumers in the form of 'chips' for solid fuel heating systems or by industry for heat and electricity generation (Alistair McCracken, AFBI, pers. comm.). Between 2004 and 2006 around 500 ha of short rotation coppice willow was planted (Dawson 2007) and the best estimate of the total figure in 2009 is around 1,000 ha (Easson 2009).

Miscanthus×gigantea (elephant grass, sterile hybrid) is a biomass crop native to the Far East. The Agri-food and Biosciences Institute has been conducting research on the establishment and growth of the grass for about 6 years, with experimental stations at Loughgall and Hillsborough. *Miscanthus* is already grown extensively in some parts of England, where it has been the subject of research for a longer period. The major advantages of *Miscanthus* are its ability to produce large biomass yields for perhaps up to 15 years on some sites without any fertiliser input. The potential market in Northern Ireland is difficult to predict at present. The scale of operation currently envisioned would be groups of farmers supplying biomass to small companies for combined heat and power units (Lindsay Easson, AFBI, pers. comm.).

18.5.2.12 Geothermal energy

Geothermal energy is an important emerging field which needs to be supported by government to meet its future targets. A Renewable Heat Route Map has been promised as a strategy for delivering the 10% renewable heat by 2020 target in Northern Ireland (DETI 2010d).

18.5.2.13 Stone and aggregate

There is a significant quarry industry in Northern Ireland with a turnover of approximately £600 million in 2010, 3% of Northern Ireland's GDP, and 3,750 employees, which is a 25% reduction from 2008 (DETI unpublished data).In 2009 about 23 million tonnes of minerals at a value of £90 million were extracted, down from almost 30 million tonnes in 2007 (**Figure 18.38**). There are around 180 quarries and sand pits in Northern Ireland extracting material primarily for local markets, although some 25% is exported to Great Britain and the Republic of Ireland. The construction industry, which contributes around 10% of GDP, relies on quarrying and the annual demand for aggregates in Northern Ireland is approximately 25 million tonnes (14.7 t/head of population). Northern Ireland is an important source of high quality aggregate for use in road surfaces across the UK and Europe. The quarry products industry in Northern Ireland also produces a wide range of stone products such as kerbstones, concrete floors and beams, paving slabs and concrete pipes of a wide range of diameters used to upgrade the roads, water and sewage facilities and buildings. The Quarry Products Association Northern Ireland has a biodiversity action plan (Bell 2008).

Insert Figure 18.38 here

The presence of rich, land-based sources of aggregate means that there are currently no licences for marine aggregate extraction (EHS 2005k) and the current economic climate suggests that such activity is not likely to escalate in the near future. Nevertheless, because of its multiple impacts in other UK waters (Foden, Rogers & Jones 2010), any future escalation in marine aggregate extraction should be carefully monitored. While the health of the marine ecosystem will not impact on the delivery of this service, the extraction of marine aggregates can have significant impacts on the resident benthic and pelagic communities (Cooper *et al*. 2008; Foden*et al.*2010).

In recent years Northern Ireland has had an Aggregates Levy Credit Scheme whereby producers of aggregate received an 80% rebate of the Aggregates Levy in exchange for carrying out environmental improvements. This scheme was cancelled from 1st December 2010 following an EU ruling, but the Minister for the Environment has stated his support for reintroducing the scheme if possible (NI Executive 2010c; Parliament 2010).

18.5.2.14 Peat for horticulture

Extraction of peat for horticulture is largely from lowland raised bogs and, unlike fuel cutting, has not declined. Whereas extraction provides a fuel and horticultural resource, it affects regulating services such as carbon storage and emissions.

In a survey of sites used for extraction of peat for horticulture in 1990/91, most sites were small (<5ha) and had been in operation for many years. Vacuum harvesting accounted for 57% of the area of extraction and sod cutting accounted for 18%. An extensive site of extraction for horticulture in 1990/91 was at Altahullion, unusually for horticultural extraction this was a blanket peat site and extraction was not by vacuum but of blocks of peat similar to those extracted for fuel peat. The site accounted for 22% of the area of extraction for horticulture. The remaining sites of extraction for horticulture listed in planning applications and consents produced peat for the mushroom-growing industry (Cruickshank *et al*. 1996).

A resurvey of extraction sites for horticulture in 2007/08 showed that the total area had increased from 576 ha in 1990/91 to 689ha. Sod extraction sites had ceased production or had been converted to vacuum harvesting, and the Altahullion site had declined from 178 ha to 39 ha (much of the area is now a windfarm). Some vacuum harvesting sites had expanded and new sites had opened, and areas can vary from year to year, depending on weather and markets (Tomlinson 2010).

18.5.2.15 Lignite

Lignite is similar to peat and coal in terms of emissions. Northern Ireland has seen attempts in recent years to open up tracts of land around Belfast and near Ballymena for open cast lignite mining (Belfast Telegraph 2006). The plan was eventually rejected, but pressure to tap these resources remains (Belfast Telegraph 2008).

18.5.3 Regulating Services

Regulating services buffer the effects of climate change; detoxify wastes and pollutants in air, water and soil; support species diversity and the services they provide (pollination, pest control); and play a major role in addressing hazards of all types (droughts, floods, fires, earthquakes) by providing the basis for resilience and supporting the ability to deliver all other ecosystem goods and services. They include the services which ameliorate and repair the damage to natural systems caused by human use.

Climate change may place additional strain on many regulating services. Climate regulation is discussed in this section, but its impacts are apparent throughout all ecosystem services; direct and indirect, mitigation and adaptation. Soils, in particular, are large stores of carbon, and dealing with carbon loss from these stores needs at least as much attention as reducing current emissions (Section 18.5.3.1.). Pure water is vital to all life and globally, water shortage is a major problem. The marine environment is also a major store of carbon, as well as providing crucial functions in all nutrient and hydrological processes. Changes in global marine temperature and acidity would have major impacts on all ecosystems.

The quality of soil and air in Northern Ireland is relatively good, and there are encouraging signs in terms of some aspects of water quality (Section 18.4.6). However, most lakes are eutrophic (many increasingly so), pollution of rivers (point source and particularly diffuse) causes biological damage and is costly, while the provision of fresh drinking water and treatment of waste water are increasingly expensive, due to heavy reliance on electricity and consequently carbon. The first effects of climate change will most likely be felt in our aquatic systems – floods and droughts – and these impacts will exacerbate current problems, escalating variability and unpredictability of flows in rivers and increasing their vulnerability to pollutants (Section 18.4.6).

Ecosystems may detoxify pollutants, but only if regulating functions are intact and the amount of toxin relative to the water, soil or air into which it is being discharged is within the capacity of the receiving ecosystem. While it is hard to estimate the direct economic benefits of fully functioning regulating services, it is often possible to estimate the costs of undertaking remediation if those natural systems are not functioning (Section 18.5.6). However, comprehensive figures are not available for Northern Ireland and it is important that this is addressed at both UK and Northern Ireland levels.

18.5.3.1 Carbon storage in peatland

Northern Ireland is committed to playing its part in addressing climate change as part of UK, EU and global action. Although only responsible for 3.5% of UK emissions (Committee for the Environment 2009), it has potentially much greater relative significance as a carbon sink. Northern Ireland, along with Scotland and Wales, is a net sink of carbon, but England is a net source; this is due to Northern Ireland's peatlands, forests and long-term grasslands (Sections 18.4.2 &18.5.2). The proportion of greenhouse gas emissions from agriculture is very large in Northern Ireland; over 20% of total greenhouse gas compared to 7% in the UK as a whole (AEA 2010), and there are major possibilities for agriculture to contribute significantly to greenhouse gas reduction targets if this were to be assigned a high priority (Mayne 2010). Specific targets for reducing carbon emissions for Northern Ireland have not been established, nor will sectoral targets be set until baseline data are compiled (Committee for the Environment 2009). There are also possibilities in Northern Ireland for carbon capture and storage in underground strata (Lewis *et al*. 2009).

Cruickshank *et al*. (1998) estimated the stock of carbon held in the soils of Northern Ireland at 386 million tonnes. Although occupying 15% of the land area, peat soils contain 42% of the carbon stock and peaty soils account for a further 10% of the carbon stock, with the highest soil carbon densities (>5000 tC/ha) in deep peat. Peatland vegetation stores some 6% of the vegetation carbon, but soil carbon stock is around 80

times that of the vegetation carbon stock. The role of forests in sequestering and storing carbon is often emphasised, but conserving the biodiversity and uniqueness of Northern Ireland's peatlands has a vital role in conserving carbon. Eroding peat bogs lose carbon from the peat and stop sequestering carbon (Cruickshank *et al*. 1993; Cruickshank*et al.*2000). Organic carbon stored within peat has accumulated over thousands of years but can be lost in days (Flitcroft 2006).

Peat carbon stocks have been reduced by peat extraction. In 1990/91 the loss of carbon as a result of mechanical extraction for fuel (by compact harvester) was between 75,936 and 126,623 tC/yr.For 2008, the estimate was between 6,481 and 10, 807 tC/yr. At both dates the majority of extraction for fuel was from blanket peat (Section 18.4.2). Carbon lost through hand cutting for fuel has also declined (Tomlinson 2010). Carbon is also lost through extraction of peat for horticulture, almost entirely from lowland raised bogs. Carbon loss due to peat extraction increased from an estimated 30,000 tC/yr in 1990/91 to 36,000 tC/yr in 2007/08 (Tomlinson 2010).

18.5.3.2 Carbon storage in soil

Peaty soils hold 42% of the soil carbon stock on 15% of the land area. Stagnogleys and stagnohumic gleys, which occupy around 53% of the land area, have 36% of the soil carbon stock. Brown earths, brown sands, brown calcareous soils and brown alluvial soils, which account for around 15% of the land, hold around 12% of the soil carbon stock (Cruickshank *et al*. 1998). The carbon density of a soil is affected by the vegetation or cover type as well as its management regime (e.g. ploughing frequency, depth, timing; fertilising). For example, a soil under semi-natural vegetation has a higher carbon density than that soil under improved grass, which in turn has a higher carbon density than that soil under arable crops. In Northern Ireland in 1990, soils with an arable cover had 2% of the soil carbon stock, soils under improved grass held 43% of the soil carbon stock, soils under semi-natural cover (mainly peat and peaty soils and vegetation) held another 43% of the soil carbon stock, soils under coniferous woodland had 9% and soils under broadleaved woods, 2% of the soil carbon stock (Cruickshank *et al.* 1998).

The distribution of soil carbon (**Figure 18.39**) shows the highest carbon densities in the blanket peatlands and deep-peat lowland bogs. Thinner peats and peaty soils have intermediate levels of carbon stocks, forming a fringe to the uplands. Elsewhere, carbon densities for mineral soils are generally low on the Enclosed Farmland of the lowlands. This broad pattern mirrors that of the vegetation or biomass carbon stocks; the peatland vegetation is mostly in the uplands and the highest vegetation carbon densities are evident in the larger forests. The lowest vegetation carbon densities dominate over much of the lowlands and correspond with the 'improved land' of Enclosed Farmland (Cruickshank *et al.* 1998).

Insert Figure 18.39 here

The overall soil carbon stock in Northern Ireland was estimated by Bradley *et al*. (2005) to be 296 million tonnes in the top 100cm. Carbon stocks to 1m depth under semi-natural vegetation were estimated to be 86 million tonnes at a carbon density of 39kg/m^2.

Undisturbed habitats are significant contributors to carbon sequestration through vegetation, some of which is stored in the soils. The impacts of climate change on these habitats could be significant due to habitat dependence on water levels. The general lack of fertilisation on Semi-natural Grasslands means that emissions of nitrogen dioxide are low and lower stocking densities decrease methane emissions relative to improved grassland used for animal production (Cruickshank *et al.* 1998; Sections 18.4.3 and 18.4.5).

18.5.3.3 Carbon sequestration in vegetation

Cruickshank *et al*. (1998) estimated that 55% of the vegetation (biomass) carbon in Northern Ireland in 1990 was held by forests and woodland (compared with 80% in Great Britain), which accounted for only 5% of the land area. By contrast, improved grassland accounted for 17% of the biomass carbon stock but covered 56% of the land area. Nevertheless, in Northern Ireland the percentage of carbon stored in agricultural vegetation was more than three times the proportion in Great Britain (36% compared with

10%). Forests and woodlands are clearly important carbon stores and of continuing importance as they grow and increase in biomass (provided that felled forests are replaced).

18.5.3.4 Greenhouse gases in agriculture

Agriculture accounted for 23% of greenhouse gas emissions in Northern Ireland in 2007, up slightly from 22% in 1990 (DOE & NISRA 2010) and compared to 7% in the UK as a whole (AEA 2010). Some statistics are encouraging; for example the amount of methane produced per litre of milk from grass-based production has decreased from over 32l/kg in 1980 to just over 26 l/kg in 2008 (T. Yan unpublished data).Research at Agri-food and Biosciences Institute Hillsborough is showing significant decreases in greenhouse gas emissions from changing diets of cattle and improved slurry management (Yan 2009), as well as potential for capture of gasses to produce energy (Frost & Gilkinson 2010).

Land use change can be either a net contributor or sink for greenhouse gases. Over the period, 1939 to 2000 there was little change in the soil carbon stock, even though in 1939 there was more arable agriculture than at present. The Northern Ireland Environmental Statistics Report (DOE & NISRA 2010) estimates the total greenhouse gas absorption contribution from land use change of just over 1% of total emissions (DOE & NISRA 2010).

There are significant opportunities for reducing greenhouse gas emissions from agriculture and, given the significance of emissions of methane (at 23 times carbon dioxide value) and nitrous oxide (at 310 times carbon dioxide), this is an extremely important area. However, it is not an easy area to tackle, and the Republic of Ireland has cited its large agriculture base as a reason why it is having difficulty meeting its Kyoto commitments (Styles*et al.*2008).

18.5.3.5 Climate regulation by oceans

Several aspects of the ocean's biogeochemical cycles contribute to climate regulation, most importantly the absorption and sequestration of atmospheric carbon through the processes of dissolution and photosynthesis. Northern Ireland's territorial waters are relatively small and shallow, therefore direct contributions in this regard are limited. However, even on such small scales, marine systems can play an important role in cycling nitrogen- and sulphur-based greenhouse gases. For example, chemicals produced by marine algae can enhance cloud formation (Seymour *et al*. 2010). On a local scale, these clouds can produce precipitation, and on a global scale, they can contribute to increasing the Earth's albedo, reflecting more solar radiation back into space (Woodhouse *et al*. 2010).

By the end of this century, UK waters are predicted to be 1.5–4.0^{o}C warmer, 0.2 practical salinity units (PSU) fresher (although there is greater uncertainty about this), and 0.3 pH units more acidic (UKMMAS 2010). Northern Ireland has so far largely been spared the effects of sea-level rise because isostatic uplift (the slow bounce-back of the land since the weight of the last glaciation was removed) has slightly exceeded sea-level rise (Orford*et al.*2006). However, the escalating rate of sea-level rise globally (Rahmstorf *et al*. 2007; Nicholls & Cazenave 2010) means that this is likely to become an increasing threat in the near future, especially for shallow-water and light-limited marine habitats.

Northern Ireland's territorial waters have warmed by about 0.5–0.74^{o}C since the 1990s, with accompanying shifts in fish species (including both commercial and non-commercial species, so this is not due to overfishing; Beaugrand *et al.*2009; Lynam *et al.*2010). These changing biotic assemblages may include new species that could have unforeseen consequences for marine habitats, possibly altering marine food webs or allowing establishment of invasive species (Sorte *et al.*2010). This could cause challenges for management and the integrity of the marine ecosystem as a whole, including carbon sequestration, waste processing and nutrient cycling (Hoegh-Guldberg & Bruno 2010).

18.5.3.6 Waste production and disposal

Around 16 million tonnes of waste are generated each year in Northern Ireland. Of this about 10 million tonnes are agricultural wastes, 4 million tonnes are construction, demolition and excavation (CD&E) waste, 1 million tonnes are municipal waste and another 1 million tonnes are commercial and industrial (C&I)

waste. Municipal waste increased by an average of 1% per annum between 2002/3 and 2006/7 with decreases in 2007/8 and 2008/9, so that 6,000 tonnes less were produced in the latter year than in 2002/3. These changes are thought to relate closely to the economic climate (DOE unpublished data). Municipal recycling rates have increased by 68% in the 5 years from 2004 (DOE & NISRA 2010). The total amount of municipal waste arising in 2009/10 was 1,004,020 tonnes, a decrease of 1.3% on the amount in 2008/09. Of this waste, 33.1% was sent for recycling (including composting), an increase from 31.6% in 2008/09 and just 8.9% in 2002. Banbridge District Council had the highest municipal recycling rate of 51.6%, while Belfast City Council had the lowest rate, 22.3%. The majority of the remaining municipal waste was sent to landfill (66.1%), with a very small amount reused. The percentage of municipal waste landfilled has decreased over the years, falling from 91.1% in 2002 to 66.1% in 2009/10 (NISRA & NIEA 2010).

Efforts are underway to increase the percentages reused and recycled in all waste streams, but recent figures still indicate a substantial amount going to landfill (EHS2007; NIEA 2009i). Most of this waste is disposed of in managed sites, including landfill gas capture at some sites. However, there is a substantial problem with illegal waste disposal, some of it involving cross-border transfer following the implementation of waste charging in the Republic of Ireland. There are also older landfill sites which are not built to modern standards, with resultant potential pollution problems and release of landfill gas (NIEA 2009j).

In 2003 it was projected that there would be 53,000 tonnes of sewage sludge produced, some of which was to be spread on agricultural land and some incinerated (EHS 2003b). In the past much of this was disposed of to sea, but since this was banned in December 1998 in line with the EC Urban Wastewater Treatment Directive (91/271/EEC), most has been incinerated with energy recovery.

Agricultural wastes are considered in a draft Biodegradable Waste Strategy produced by the Environment and Heritage Service (EHS 2003b) and are the responsibility of the Department for Agriculture and Rural Development. In 2003 there were 15,438,000 tonnes of biodegradable agricultural waste produced per annum (the vast majority of which was slurries and manures, but also small amounts of straw, vegetable processing and packaging waste). The majority of this was disposed of 'on farm' at the point of origin. Much research has taken place since then on uses for biodegradable waste, including for energy production through anaerobic digestion. Because most of these wastes are managed primarily by land-spreading and are not deemed controlled waste (where spread on land in accordance with the Nitrates Directive) detailed information on amounts and disposition is not available. Excessive or uncontrolled application of these wastes can lead to pollution of air and water (EHS 2008a).

There is potential to use biodegradable waste to produce energy, especially from farm or food processing wastes. The Agri-Food and Biosciences Institute is currently conducting research on a variety of possible mechanisms for utilisation of animal and food wastes, both to provide energy and to reduce pollution problems, for example through anaerobic digestion, irrigation of short rotation coppice willow with organic wastes, and low-trajectory methods of landspreading of slurry (AFBI 2007).

18.5.3.7 Detoxification in the marine environment

In Northern Ireland nutrients entering the marine environment are predominantly from agricultural sources and human sewage, as there has been a reduction in industrial sources with a rapid late 20th Century decline in secondary industrial capacity. There is a persistent problem of bathing beaches and sewage, as shown by Good Beach Guide changes (2009–2010). These show two failed beaches, two beaches with downward trends, 12 beaches staying the same and six beaches with an upward trend (MCS 2010). Water quality at over 80% of coastal sites tested was deemed to be 'at risk' under the Water Framework Directive from morphological alterations, about 85% at risk from point source pollution and around 50% each at risk from diffuse pollution and alien species (EHS 2008a).

Northern Ireland's marine ecosystem receives most of the wastes passed into rivers and estuaries, much of the nutrient load of nitrogen- and phosphorus-enriched groundwater (originating from intensive agriculture on land), some of the sewage, significant amounts of litter and all of the wastes produced by marine

aquaculture. They also absorb a large amount of the carbon dioxide, which originates from the many activities that require the burning of fossil fuels. With the exception of recalcitrant flotsam, such as plastics, many of these organic waste products are processed and detoxified by healthy marine systems using natural pathways that convert much of the waste into useful production. However, all marine systems have their limits, and these limits are lowest for sheltered (or enclosed) waters, like those off Northern Ireland's Irish Sea coast, and particularly in the sea loughs. Unfortunately, this is where most of the waste loads enter coastal waters.

18.5.3.8 Soil quality

The main greenhouse gases from agricultural soils are nitrous oxide from nitrogen fertiliser applications, methane from waterlogged soils and carbon dioxide from soil respiration. Atmospheric deposition of ammonia and nitrogen oxides from intensive livestock systems occurs. Northern Ireland has high levels of soil phosphorus and nitrogen compared to other parts of the UK, due to the importance of livestock farming (Foy & Jordan 2011; **Figure 18.40**). Agriculture contributed 81% of nitrous oxide emissions in Northern Ireland in 2007 (Chapter 14).

Insert Figure 18.40 here

Soils capture and release carbon, nutrients and water and through these processes they detoxify pollutants, purify water, and provide the physical and chemical support systems for land plants and animals. The ability to deliver these outputs effectively is determined by the chemical, physical and biological properties of soils and their interactions (EHS 2008a). Soil quality is fundamental to the productivity and condition of habitats and hence the delivery of all ecosystem services.

Most of the soil carbon resides in the soil organic matter, and this is an aspect of soil quality that influences the degree of compaction, water storage, capacity for resisting erosion and other properties which, in combination with the plant nutrients in the soil, determine its productivity. The role of soils in sequestering carbon is discussed in Section 18.5.3.1. Undisturbed soils sequester large amounts of carbon, which is lost through oxidation when soils are cultivated. The value of soil as a carbon store will become increasingly important and could become a major determinant of land use in the future (Azeez 2009).

In the 1940s most soils (73%) were low or deficient in phosphorus and hence agriculture benefited from phosphorus fertiliser inputs. By the 1990s excess phosphorus levels occurred in 48% of soils in Northern Ireland and in 52% by 2005. Agricultural production on these soils will not benefit from the addition of more phosphorus (Foy & Jordan 2011; **Figure 18.41**; **Figure 18.42**; Section 18.4.6).Measures to decrease nutrient losses from agriculture are enforced through the Nitrates Directive. However, passive losses from soils can still occur, especially losses of phosphorus. Calculation of farm nutrient balances shows that Northern Ireland has high phosphorus surpluses, reflecting the large area of intensive grassland and correspondingly small arable sector. Northern Ireland also has high nitrogen balances compared with most parts of the UK (**Figure 18.40**).

Farm nutrient balances can be calculated by comparing inputs such as fertilisers and animal feeds with outputs such as milk, meat or other agricultural products exported from the system (Foy & Jordan 2011). Large imbalances with surpluses of major nutrients such as nitrogen and phosphorus lead to environmental degradation by eutrophication of rivers and lakes. It was established that an action programme would be applied to the total territory of Northern Ireland under the Protection of Water Against Agricultural Nitrate Pollution Regulations (Northern Ireland) 2004 (DOE 2009). The Nitrates Action Programme Regulations (Northern Ireland) 2006 set out an action programme applying to all farms across Northern Ireland from 1st January 2007. In addition, other controls such as the Phosphorus (Use In Agriculture) Regulations (Northern Ireland) 2006 were introduced across Northern Ireland and these measures collectively are designed to reduce nutrient inputs from agriculture that contribute to eutrophication. The controls on the storage and application of nitrate and phosphorus fertilisers, at farm level, are an important contribution to tackling Northern Ireland's eutrophication problem. Many soils have accumulated excessive phosphorus from fertiliser application since WWII and phosphorus in animal feedstuffs is also a major input (**Figure 18.41**). To

comply with the Water Framework Directive, controls have been introduced on application rates of phosphorus fertilisers and new phosphorus regulation links the use of phosphorus fertilisers to a definable need. In 2004/6 about half of all grassland had levels of phosphorus above the normal range, but for intensive grassland soils this was 75% (**Figure 18.42**). Since 2003 there has been a decrease of over 70% in phosphorus-based fertiliser sales. Regulatory controls of phosphorus fertiliser use and voluntary agreements to lower phosphorus in animal diets have reduced the phosphorus surplus from 16.8 kilograms of phosphorous per hectare (kg/P/ha) in 2003 to 8.6 kg P /ha in 2008. Phosphorus balance has been reduced to historically low levels, with beef and sheep farms now close to balance (or with a negative balance; Foy & Jordan 2011). However, 50% of dairy and almost all poultry and pig farms are above 10 kg P/ha. In theory, these farms are also stocked above the 170kg N/ha limit and so will be exporting surplus phosphorus and, after exporting, these farms should mostly be below 10kg P/ha. As a result, monitoring by the Northern Ireland Environment Agency of long-term trends in soluble reactive phosphorus in rivers has shown a decline which was significant between 1999 and 2007 at 74% (182) of sampling sites (DOE 2009).Further research is required into exerting further controls over nutrient cycling in agricultural systems (Foy & Jordan 2011).

Insert Figure 18.41 and 18.42 here

Sulphur deficiency in Northern Ireland was highlighted 24 years ago by Stevens & Watson (1986) and may be more widespread now. Crops use nitrogen less efficiently when sulphur is deficient. It is therefore necessary to encourage farmers to test their soils or forages for sulphur status in the future. They will need to apply sulphur fertilisers in order to correct any deficiency, which will allow the efficient use of all major nutrients to control diffuse pollution (Balsom 2010).

Soil microorganisms and fauna are as important to ecosystem functioning as the above-ground biota, but are more difficult to study and therefore less well understood. Soil microbes, nematodes and earthworms are important detritivores that are critical for delivering services such as the cycling of nutrients in soils and the detoxification of pollutants. Alien flatworms which prey on earthworms (Boag & Yeates 2001) are an issue in Northern Ireland. Although there are no particular differences from the rest of the UK, livestock density in agricultural land is greater and invasive flatworms are more prevalent than in most parts of Great Britain and Ireland (Murchie *et al.* 2003).

18.5.3.9 Water quality

There is a substantial history of both direct and diffuse pollution in Northern Ireland's water bodies, but major concern in recent years has been with diffuse pollution from agriculture (Foy & Girvan 2004). This has led to significant acidification and eutrophication of areas of sensitive habitats (roughly 70% and 80% respectively exceeded critical loads during the past 10 years; NIEA 2011) and large lakes (39% eutrophic, 32% mesotrophic, 25% hypertrophic and 4% oligotrophic; Lough Neagh is hypertrophic; Lough Erne is eutrophic; Foy & Jordan 2011).

In 2009 less than 30% (ranging from 15 to 30% for the different River Basin Districts, or RBDs) of Northern Ireland's surface waters met the EU water quality standard of 'good ecological status' which they are required to meet by 2015 under the Water Framework Directive (NIEA 2009f,g,h; **Table 18.14**; **Figure 18.43**). Many ecosystem services depend on water quality, and compliance with Water Framework Directive targets and delivery of River Basin Management Plans are prime drivers for environmental action (EHS 2008a).

Insert Figure 18.43 here
Insert Table 18.14 here

Agriculture contributes 70% to nitrogen loading, while urban sources are the largest contributors to both ammonium (67%) and phosphorus (54%), with only 5.6% of monitored rivers not showing nutrient enrichment (EHS 2008a). Agricultural wastes, including silage effluent, slurry and dirty yard water, have a very high pollution potential; silage effluent has approximately 200 times the pollution potential of raw

domestic sewage. Water quality is showing signs of general improvement, with recent legislation leading to decreases in inputs of artificial fertilisers and restrictions on timing and conditions of slurry spreading.

Nutrient cycling studies in which nitrate has been monitored at river sites has shown that nitrate levels tend to peak in winter, corresponding to high rates of nitrogen use in agriculture. Long-term trend analysis of nitrate in surface waters from 1994 to 2009 shows a significant decrease in nitrate at 35% of sites and increases at 5%. Northern Ireland remains a low nitrate area with 99% of surface water sites and 82% of groundwater sites having annual average concentrations of less than 25mg nitrate/l(DOE 2009; **Figure 18.44**; **Figure 18.45**).

Insert Figure 18.44 and 18.45 here

Northern Ireland has over 1,000 lakes and reversing eutrophication in these lakes is a key water quality objective. Agriculture is the largest source of nutrients to these lakes and they remain enriched despite phosphate stripping at all large waste water treatment works (Foy & Jordan 2011; **Figure 18.40**; **Figure 18.41**; **Figure 18.42**; Section 18.4.6).Phosphorus is an important plant nutrient, but at excessive levels in water is a major cause of eutrophication. In 2007, 16% of rivers in Northern Ireland exceeded the EU standard for soluble reactive phosphorus, but that is a major decrease since 2000, when 27% exceeded the threshold (DOE & NISRA 2009). This period coincides with a major decrease in the amount of fertiliser applied, with a decrease from 470 to 314 thousand tonnes purchased from 1999 to 2006 (EHS 2008a).

In 2008, 2,244 water pollution incidents were reported to the Northern Ireland Environment Agency, of which 1,237 were substantiated as having an impact on the water quality of the receiving water course. This is 21% fewer than the number substantiated in 2001, and in 2008 only 20% of pollution incidents were considered to be of high or medium severity (DOE & NISRA 2010). There are localised and cumulative environmental problems in rural areas caused by sewage from scattered houses and industry, which are typically treated by privately operated septic tanks or small treatment works. In 2009 more than 110,000 properties (approximately 20% of the total) in Northern Ireland were without public sewerage provision, representing around 0.3 million people (one-fifth of Northern Ireland's population), and generating around 65 million litres of wastewater a day(NIEA 2009g).

Water discharge is regulated through Water Order consents for private sewage and trade effluent. Both have registered a slight improvement in percentage compliance since 2000, with reported figures in 2008 of 86% and 87%, respectively (DOE & NISRA 2010).

Sustainable Urban Drainage Schemes (SuDS) are now incorporated into PPS15 and River Basin Management Plans, but have not been used as much to date in Northern Ireland as in Great Britain (NIEA 2009c). The lack of regulation on conversion of soil to hard surfacing in gardens or new development can contribute to flood danger and resulting damage. Culverting of watercourses is also an issue in terms of water quality and the difficulty of tracing pollution incidents as well as the loss of habitat value.

18.5.3.10 Air quality

Northern Ireland's air quality has improved in recent years, with most pollutants below target values (**Table 18.15**). This is primarily due to the use of catalytic converters in cars and a move away from domestic coal burning to gas central heating. Air quality for the majority of Northern Ireland's population is affected by urban ecosystems; street trees and urban green spaces can improve air and water quality, remove some pollution and help with noise reduction (Broadmeadow & Freer-Smith 1996; Stewart *et al*. 2003). Green roofs can also contribute to pollution abatement, temperature regulation and carbon balance (Rowe 2010).

Insert Table 18.15 here

Ecosystems influence concentrations and deposition of air pollutants in four major ways:

1. They remove pollutants from the atmosphere; e.g. trees, green spaces and vegetation in urban areas reducing local air pollution.
2. They contribute directly to the emissions to the atmosphere; e.g. ammonia from intensive agriculture.
3. They contribute indirectly to air pollution levels via chemical processing in the atmosphere, e.g. volatile organic compounds (VOCs) that contribute to ozone.
4. Measures to reduce emissions to, or deposition from, the atmosphere can increase the potential for air quality regulation by ecosystems, e.g. reducing high levels improves functioning.

Northern Ireland does not have a history of extensive concentrations of heavy industry as in northern England. However, levels of atmospheric nitrogen increase towards the east of Northern Ireland. High levels of ammonia have been recorded in the Mournes and the Antrim Plateau and may encourage grasses at the expense of heather (EHS 2004b). Studies in the UK have shown that drift of fertiliser during application to adjacent fields and enriched runoff can also affect lowland peat bogs (Tang *et al*. 2004). There has been no attempt to value air pollution effects on grassland/heathland ecosystems in Northern Ireland. As in the case of forestry, the absence of reliable scientific research to underpin valuation is a limiting factor. Although some effects of air pollution on these vegetation types are documented, the problem of identifying the role of air pollution from other influences such as grazing management and erosion remains (MacMillan *et al.*2001).

18.5.3.11 Pollination

The relationship between natural ecosystems and crops with regard to pollination and pest control is complex; the natural systems provide many services to the crops, but also benefit from the crops which provide food and shelter. Honeybees pollinate both crops and natural plants; natural habitats provide pollen and nectar for the bees when crops are not flowering. Most honey production is small scale, with around 1,000 beekeepers and 4,000 hives. Honey production is estimated at 30 tonnes worth some £220,000 per annum (DARD 2010p).

In Northern Ireland the main crops pollinated by insects are apples, with over £7 million as the estimated market value of insect pollination; an estimated 80% of this is by honeybees. Strawberries, beans, oilseed rape, raspberries, currents and other soft fruit are also partially dependent on insect pollination, with an additional £100,000 estimated value of insect pollination (Archie Murchie, AFBI, pers. comm.).

18.5.3.12 Pest control

Natural ecosystems can contribute significantly to the control of pests in crops, providing nesting sites and food for animals which prey on plant pests. However, they are also potential reservoirs of diseases and can provide habitats or hiding places for crop pests. The dangers of plant and animal pests and diseases have been dramatically demonstrated in recent years (BSE, Foot-and-Mouth, Dutch elm) and continue to cause serious concern and significant costs (e.g. New Zealand flatworm (Section 18.5.3.4), nematodes, bovine TB, *Phytophora ramorum*; Forest Service 2010c). Appropriate management of both natural and cropped land can address some of these issues and the benefits of using natural pest control have been established in a range of habitats (greater biodiversity seems to improve natural pest control and disease resistance, see Chapter 14).

The impacts of pest species are highly variable and dependent on many factors, principally weather, but also the fluctuating value of the crop and the cost of control measures. Crops can be impacted upon by both decreased yield and loss of quality. The latter is particularly important with crops that are marketed directly to consumers (e.g. eating apples), where cosmetic damage can be very important and may even lead to rejection of a consignment by traders or supermarkets.

Aphids are a major worldwide pest of most crops. Their impact is by two mechanisms: direct feeding on the host plant's phloem and the transmission of viral diseases. A general estimate of damage in cereals assumes a 10% loss of yield (Tatchell 1989). However, clearly this is dependent on the level of infestation and whether or not viral diseases are vectored. Nevertheless, taking this as a basis and given that the

average farm income from cereal crops in Northern Ireland is approximately £40,000 (DARD 2009d) then the economic impact of aphid pests could be around £3,000–£4,000 on average each year per cereal farm (Archie Murchie, AFBI, pers. comm.).

The major crop in Northern Ireland is grass, making up 80% of agricultural land and supporting the dairy and beef industries. The total value of the grass crop is difficult to ascertain because it is used on farm for grazing and silage. However, estimates would be between £300 and £700 million per annum. The New Zealand flatworm (*Arthurdendyus triangulatus*) has reduced earthworm biomass by 20% in experimental plots (Archie Murchie, AFBI, pers. comm.). If it is assumed that earthworms contribute to grass yield between 10 and 30% (Stockdill 1982), then the presence of *A. triangulatus* could be reducing grassland productivity by 2 to 6%. The flatworm is present in 70% of grassland in Northern Ireland (Murchie *et al*. 2003). Acknowledging that these are very rough estimates and that there are many caveats, the economic impact of *A. triangulatus* could then be calculated as between £4.2 and £29.4 million per annum (Archie Murchie, AFBI, pers. comm.).

The Agri-food and Biosciences Institute is also investigating midges (*Culicoides* species) as vectors of Bluetongue. The impact of an outbreak of that insect-vectored disease would be very costly. In Scotland there was an estimate of £100 million per annum (30% of direct losses and 70% of indirect costs). It is likely that the impact on Northern Ireland would be slightly less but in that region (Archie Murchie, AFBI, pers. comm.). Bovine tuberculosis is regarded as a major problem for Northern Ireland agriculture, with the cost of its control estimated at £200 million over the past 10 years (NI Assembly 2009).

18.5.3.13 Flood control

Flooding occurs sporadically within Northern Ireland, although most urban flooding occurs from pluvial flooding rather than from rivers. The Rivers Agency is the government agency with the flood defence and land drainage remits. After WWII there was an emphasis on land drainage, but in more recent years this has swung towards flood defence and, more latterly, flood risk management. This is shown through the Agency's role as the competent authority for the Floods Directive (a sister directive to the Water Framework Directive), the subsequent production of flooded area maps, and the production of PPS15 (with the Planning Service) dealing with floodplain development. Urban flood defence aims to protect housing and infrastructure to a 1:100 level, whilst agricultural land is protected to a 1.3/5 level on average. Studies on more catchment-based sustainable flood management are currently underway. Sustainable urban drainage systems (SuDS) have not yet been adopted as standard methodology for development sites (Judith Bankhead, Rivers Agency, pers. comm.).

The value of natural habitats (especially those adjoining rivers, streams and lakes) in providing floodplains which help to regulate flood risk has been increasingly recognised in recent years, with a shift away from drainage, culverting and canalisation of rivers to more natural treatments which work with natural habitats to help reduce flood damage locally or further downstream (Jackson *et al*. 2008). The value of wetlands in general, both natural and artificial, is increasingly recognised for both flood control and pollution abatement. Planning Policy Statement 15 assists in limiting development in floodplain areas, but catchment-wide management for flooding is also required in the long term (SNIFFER 2009). Flood maps which identify areas at risk from flooding, including future climate change scenarios have been prepared by the Rivers Agency (Rivers Agency 2008b). Further need for flood defence is likely under climate change conditions (Sayers & Calvert 2007), and the possibility of multiple use of natural habitats to include flood defence could be encouraged. In 2009 significant flooding occurred in both Belfast (BRC 2010) and County Fermanagh (OFMDFM 2010b), causing severe and widespread damage, not only in economic terms (both business and residents suffered significantly), but also to residents' well-being, causing a general feeling of being under threat from similar events in the future.

Much of the damage caused by storm surges is a result of wave action, and the nearshore marine ecosystem can play a large role in regulating these waves. For example, sand bars, rocky reefs and biogenic reefs can cause ocean swell to shoal and break, thereby dissipating energy that would otherwise be expended on the coast. The greater the amount of energy dissipation, the lower the degree of coastal

erosion (e.g. Uda 2009; Harris *et al.*). The degree to which any nearshore marine habitat can contribute to this service is dependent on the efficacy of the management of coastal sediment budgets, the amount of aggregate extraction and the degree and frequency of disturbance by mobile fishing gear deployed at the seabed.

Coastal defences have been developed as a result of government support for coastal agricultural activity (e.g. low cost revetments and clay-based flood embankments), urban protection (sea walls as flood defence) and infrastructure defence (roads, ports and airports). The total percentage of open coastline defended is limited (around <15%), though defence of lough shores is high (e.g. Belfast Lough at around 90%). Most defences are of mid-20th Century origin, though the recent trend of revitalising old defences on a hold-the-line basis without regard for modern approaches is disconcerting (Julian Orford, QUB, pers. comm.). The cost of defences is high, but there are some incidences of private landowners infilling with hardcore rubble on both loughside tidal marshes and open coast cliff foots. The natural shifting boundary of dune and beach is also being fixed by the introduction of static defences on coastal golf courses. In coastal areas managed retreat, as with inland floodplains, could be used to avoid damage which could increase with climate change, but knowledge is needed on how the sediments are moving to ensure that land is managed to avoid further damage. The first trial of managed retreat was begun in 2009 at Anne's Point, Strangford Lough, with the Rivers Agency and National Trust working together to lower sections of sea defence to allow controlled inundation and increase brackish habitat (Judith Bankhead, Rivers Agency, pers. comm.).

18.5.4 Cultural Services

Cultural Services are defined in the Millennium Ecosystem Assessment (MA) as "the non-material benefits people obtain from ecosystems through spiritual enrichment, cognitive development, reflection, recreation and aesthetic experiences" (MA 2005b). The MA highlighted that human use of ecosystems for non-material benefits had increased over the past 50 years and pointed out that "the impact of the loss of cultural services is particularly difficult to measure, but it is especially important for many people" (MA 2005b).

Cultural ecosystem services address the need to interact (socially and with our surrounding environment), in time and space ranging from homes, streets, neighbourhoods, towns/cities and landscapes and back gardens, public parks, and natural habitats. The UK NEA identifies s the spaces in which people interact with nature as environmental settings which is split into two overlapping categories: small-scale meaningful local places and large-scale socially valued landscapes, both of which have biotic (living) and abiotic (non-living) factors (Chapter 16).

It is becoming increasingly recognised that interactions, both socially and with the environment, lead to better physical and mental health, resulting in longer and healthier lives and more productive and secure societies (Chapter 16). This has obvious benefits directly in terms of reduced health care costs, increased tourism and recreation infrastructure and more generally in terms of providing cultural and emotional benefits for all citizens. People use the natural environment for a wide range of cultural benefits, directly for recreation, leisure or tourism or indirectly for providing them with a sense of their heritage and a source of inspiration. It is important to have a variety of habitats available for a wide range of purposes; some people wish to actively participate in countryside activities, others like to visit more passively, and still others may simply wish to know that the natural environment exists in a healthy and diverse state. Natural settings receive a large number of visitors because they provide a wide range of opportunities: activities, experiences, attachments, feelings, emotions and memories, engagement with history and culture, photography, relaxation, gardening, pleasant settings (Castree 2005; Natural England 2005).They hold different values for different people and usage and the value assigned to it varies markedly across demographic, socioeconomic and cultural groups and different environmental attitudes (Pretty 2007). While some people enjoy gardens as their prime contact with nature, others feel the need to escape to remote wilderness locations to feel a connection with nature (Natural England 2009).

Because of this range of meanings, values, attitudes and behaviours by people to nature, and the diversity of the natural environment itself, it is not possible to argue that some natural environment spaces, features or habitats will be somehow more 'useful' in cultural terms than others. Wild mountains may provide the spaces mountaineers or wilderness lovers need to pursue their cultural activities but local parks also play important roles in providing contact with nature and the living world for those who cannot or do not wish to travel to more remote locations(Harrison, Burgess & Limb 1987; Burgess, Harrison & Limb 1988; Crouch & Lubbren 2003).Investing in heritage both makes people feel better and makes sound economic sense through tourism and local jobs associated with the heritage (English Heritage 2010).

Many people in Northern Ireland enjoy membership of or volunteer for organisations that provide access to their properties (e.g. National Trust, Wildfowl and Wetlands Trust, Colin Glen Forest Park, Ulster Wildlife Trust) with a wide range of functions and outputs, and which provide a range of benefits to members. Total membership of environmental organisations is over 100,000, but some individuals may be members of more than one organisation (Envision Management Consultants 2010).

There is a strong appreciation of the social value of farming in relation to the agricultural landscape. Research indicated that 89% of Northern Ireland's people agreed that farmers 'keep the countryside alive' and 83% claimed that farming adds to the beauty of the landscape. There is a strong attachment 'to the land' in Northern Ireland, with many people only one or two generations removed from living in the countryside themselves, and many wishing to live outside of cities for the benefits of a rural lifestyle (Sluka 1999). There is a general pride in the natural beauty of Northern Ireland amongst its citizens, but the fragility of that environment is not always recognised as changes to it are slow relative to a human lifespan (Shortall 2006).

Northern Ireland has a rich cultural and archaeological heritage extending over 9,000 years (Gormley *et al*. 2009). Many sites are popular visitor attractions, and the 'existence value' of the cultural heritage is particularly strong; even if they do not wish to visit sites personally, people place a value on having them preserved (Claire Foley, NIEA, pers. comm.).

There is no public 'right to roam' in Northern Ireland and there are relatively few public rights of way or public pathways (EHS 2006a). Councils have a duty under the Access to the Countryside (NI) Order 1983 to assert and protect rights of way. However, public access is largely restricted to lands in public or charitable ownership such as the Forest Service, Northern Ireland Environment Agency Country Parks, local authorities, the National Trust or Northern Ireland Water (Annett *et al.*2006). Accordingly, access to open countryside is more restricted than in other parts of the UK. Northern Ireland does not have any National Parks, although there have been campaigns for and studies commissioned on the issue for many years (Annett *et al.*2006). While many benefits have been identified and there is a substantial argument in favour of establishing parks, there is local opposition from landowners, largely based around worry that control of their land would be taken from them. Background work on the legislation necessary to introduce parks has begun, but is not scheduled for the Assembly term leading up to elections in May 2011.

18.5.4.1 Health, leisure and recreation

The physical, mental and emotional benefits of access to natural environments are well established. Positive physical health outcomes using heart rate, blood pressure, body mass index (BMI), waist measurements and physical activity level have all been noted. Epidemiological studies show associations between home proximity to green space and health and associations between the presence of nature on urban estates and reduced recorded crime (Chapter 16). However, these are not always fully recognised or quantified when people start to put an economic value on the natural environment (NI Green NGOs & EHS2007; Section 18.5.6). Some of the economic value of leisure, recreation and tourism can be captured through expenditure to undertake these activities, and certainly these activities have a direct relationship with human health and well-being. Northern Ireland has a rich variety of outdoor recreation and leisure activities, with a strong recognition that the natural environment is one of its prime attractions to tourists (Forest Service 2009b; **Table 18.16**).

Insert Table 18.16 here

Green spaces have a crucial role to play in mental and physical health within towns and cities. There is evidence that contact with nature can aid recovery from physical and mental illness (Bell *et al*. 2008). A UK study of 336,000 patient records showed a trend of significantly less health inequality between the wealthy and the poor in areas with higher levels of green space than between similar groups in areas with less green space. In areas with high concentrations of green space there was a 25% lower all-cause mortality rate (FPH 2010).

Parks, play areas, allotments and community gardens can help maintain physical fitness, alleviate social isolation and encourage social interaction between all age groups. This supports the development of social networks, understanding and cross-community relationships which are essential to Northern Ireland's healing process. In Northern Ireland, 25% of the population is obese and half is overweight (Belfast Healthy Cities 2010). This trend is increasing and will inevitably impact on the health service and economy. Parks and walks such as Belfast's Lagan Walkways provide a safe and attractive route in and around the city and there has been an increase in 'green exercise' through voluntary work with organisations such as the Conservation Volunteers and Groundwork. Improved road safety on active travel routes will encourage walking and cycling, helping to reduce obesity and maintain fitness. In 2010 70% of all journeys in Northern Ireland were made by car and these account for 81% of the total distance travelled (NISRA 2010c).

Recreational use of farmland is limited as access is often restricted. There is no 'right to roam', and many farmers are highly resistant to extending access, and particularly to the designation of National Parks. A major reason for reluctance to provide access is the issue of a landowner's legal responsibility for users of his/her land (CAAN 2007). The relevant legislation, the Occupiers' Liability Act (NI) 1957 and the Occupiers' Liability (NI) Order 1987, place a duty of care on the occupier to take reasonable steps to ensure the safety of visitors. The duty of care also applies to trespassers (i.e. where no permission or consent has been granted). However, case law indicates that it would be extremely rare for landowners to be deemed liable in these circumstances (Maia Taylor, NIEA, pers. comm.).Landowners also express concern about the cost of repairing any damage to property, e.g. walls knocked down or gates left open.

It is generally agreed that sport can improve physical, social and psychological well-being. Most of Northern Ireland's population lives within easy access of the countryside, hence it is a valuable recreational asset for both land and water sports. A report by the Countryside Access and Activities Network (CAAN 2009) identified key trends in outdoor activities between 1995 and 2008. It noted an increase in participation in the activities under study and a growth in the number of private estates offering their land for recreational use. There is, however, a shortage of suitable facilities and qualified instructors and certain social groups (disadvantaged, ethnic and disabled) were reported to be under-represented in sporting activities. Barriers to their participation included low awareness, the lack of a suitable public transport system, physical inaccessibility, and patchy information and marketing (CAAN 2008).

18.5.4.2 Tourism

Tourism is a significant industry in Northern Ireland. In 2009 there were 3.3 million visitors, 1.9 million from out of state (26% for holiday, leisure and recreation); 1.4 million domestic, generating a total revenue of £529 million (£337 million out of state visitors, £192 million domestic). Tourism is responsible for 4.9% or £1.5 billion of the Northern Ireland economy and over 40,000 jobs (5.6% of the workforce), with one in 18 jobs directly supported by the visitor economy and an additional 25.5 jobs for every £1 million generated. This is low in comparison with the other countries on these islands (9.7% for the UK and 6.3% for the Republic of Ireland in 2010; WTTC 2010a,b,c). The history of violent conflict in Northern Ireland has often restricted the willingness of tourists to visit (Jafari 2003), however, sites associated with the 'Troubles' are now of particular interest to many international visitors (NITB 2010a). This is sometimes referred to as 'dark tourism' (The Guardian 2006).

The Giant's Causeway is a World Heritage Site and hosted some 714,612 visitors in 2009, a reduction of 5% from 2008 figures (NITB 2010d). Of the 1.9 million out of state tourists in 2009 (down from 2 million in 2008); 53% of them came from Great Britain, 25% from the Republic of Ireland, 11% from Europe, 7.5% from North America and 3.5% from rest of the world (NITB 2010b). While visitors from overseas were increasing to 2008, there has been an overall drop since then with a decrease of 14.2% between 2008 and 2009. From 1967 to 1997 tourism grew very slowly, with visits doubling from 1 million to 2 million over that 30-year period. The political situation restricted the potential of tourism when most western economies were seeing their tourism sector flourish. In contrast, the 10 years from 1997 to 2007 saw rapid growth, with the number of visits increasing by 65%. The global financial crisis (late 2007 onwards) has had an impact on all business activity and has led to a decline in tourism globally (DETI 2010a; **Figure 18.46**).

Insert Figure 18.46 here

A Northern Ireland Tourist Board survey in 2010 (NITB 2010c) found that the most highly rated and important motivating activities were sightseeing opportunities of the country and coast, with slightly lower ratings for:

- cities, towns and villages that give Northern Ireland a distinctive sense of place;
- unique things to do that reflect local culture;
- information at visitor attractions which tells the story of the place you are visiting; and
- information provided about places you can visit.

The vast majority of visitors surveyed stated that the "unique and distinctive landscapes and coastlines" and the "warm and welcoming people" appealed to them. Most visitors to Northern Ireland undertook a wide range of leisure activities. The most commonly undertaken pursuits were visiting a pub; visiting castles, historic houses or other historic monuments; hiking or walking; visiting a park or garden and going to a visitor or interpretation centre. Activities make a significant contribution to the overall quality of Northern Ireland visitor experiences, more so than any other part of the 'visitor journey' (NITB 2010c).

Northern Ireland Tourist Board Research (NITB 2010d) shows that the total number of trips and short breaks taken within Northern Ireland by local residents increased by over one-third between January and December 2009 compared with the same period in 2008. Approximately 9.9 million visits were made to participating visitor attractions during 2009. Most of the top visitor attractions in Northern Ireland have an important ecosystem component (**Figure 18.47**). By 2020 a focused effort could increase employment supported by tourism to 50,000 jobs, increase the number of visitors to 4.5 million, generate £1 billion total revenue and be a source of civic pride (DETI 2010a).

Insert Figure 18.47 here

The most visited site was Crawfordsburn Country Park with 950,000 visitors, closely followed by the Giant's Causeway Visitor Centre with over 714,000. Most of the latter are probably 'unique visitors', while it is likely that some people will visit country parks many times each year. An overwhelming majority of the top attractions rely to a large extent on the natural environment (NITB 2010d; Figure 47).

Events which decrease access to the natural environment have a dramatic impact on tourism. For example, the restrictions to movement following the Foot-and-Mouth Disease outbreak in 2001 resulted in losses to the tourism sector in the UK in the region of £3.2 billion (Curry 2009). A small drop was recorded in Northern Ireland during that year also (**Figure 18.46**).

18.5.4.3 Angling

It is estimated that in 2005 there were 24,890 resident and 4,463 tourist or visiting coarse and game anglers in Northern Ireland. This represents an increase, of 10% and 2% respectively, on the number of resident and visiting anglers in 2003. Taking into account the game, coarse and sea/shore angling areas, the aggregate gross expenditure contribution of domestic game anglers in Northern Ireland is estimated to be around £39.3 million while visitor/tourist anglers contribute around £3.5 million. Analysis of the number of

visiting anglers, the number of trips and days/nights per trip and average expenditure, shows that the gross expenditure contribution arising from visitor/tourist anglers totalled approximately £3.5 million during 2005. Compared to other studies, as noted above, the contribution of tourist anglers to the overall angler expenditure in Northern Ireland (8%) is significantly lower than the proportion of expenditure provided by foreign tourist anglers in Ireland (44%) and Scotland (52%).

By monitoring the waterways, contributing funding through the sale of licences and investing in nursery areas, anglers have made a positive impact on the environment in Northern Ireland. Anglers regularly highlight areas of pollution to watchdog organisations such as the Fisheries Conservancy Board, and private fisheries and angling clubs have also been proactively involved in developing nursery areas that nurture fish and other wildlife (DCAL *et al*. 2007).

18.5.4.4 Cultural heritage, landscape and sense of place

Northern Ireland is traditionally a rural society; many people see themselves as having 'rural roots' and therefore feel a strong sense of connection to the rural land and landscape. This is in part what has fuelled the 'suburbanisation' of the countryside, with few places now truly rural, to the detriment of landscape, scenery, and tourist potential. Recent changes to planning policy seek to address this, but it is yet to be seen whether this will be effective; the recession is also having a significant impact on the building sector in general (Section 18.4.7). A recent report, building on a Landscape Character Assessment carried out in 2000, looked at the roles of different government and non-government bodies in addressing landscape-scale issues and how the European Landscape Convention is being implemented in Northern Ireland (Coates & Hadden 2010).

There are also strong cultural links to the marine environment (McCaughan & Appleby 1989). By virtue of its central role in connections between Northern Ireland, Scotland and the Republic of Ireland, the sea has long underpinned the formation of the social and cultural identities of its surrounding communities. The sea facilitated a sense of interconnectedness and a broader concept of place and belonging. Stories, music and songs connected to the sea are recurrent features of folk traditions, while the aesthetic value of the marine landscape has inspired generations of artists and architects to capture its character and essence. Coastal communities have been involved in the systematic exploitation of its resources, with fishing concentrated on the eastern seaboard and the smaller northern settlements involved in kelp harvesting for agricultural and industrial purposes (Forsythe 2006).

While English is now spoken by almost all people in Northern Ireland, both Irish (Gaelige) and Ulster Scots play an important role in its culture and heritage in mythology, folklore, literature, place names, music and song. Many place names have their origins in Irish, Ulster Scots, Norse, Anglo-Norman or Latin and many are linked with plants, animals and physical habitat features, e.g. Derry from Gaelic *doire* meaning oak grove, Whappstown from Ulster Scots *whaup* meaning curlew, Strangford from Norse *Strangfjörthr* meaning sea inlet (Culture Northern Ireland 2010).

The uplands provide outstanding scenery and wilderness, with views from upland, especially peatlands, being spectacular and appreciated as 'typical' scenery of Northern Ireland and having strong cultural associations. Peat cutting is an ancient cultural tradition and ancient Irish laws contain references to turf cutting. In the Irish language there are 130 words specific to bogland (Aalen 1997).

18.5.4.5 Archaeology and built heritage

Northern Ireland is rich in archaeological remains and the landscape itself is dotted with raths, long-abandoned hill forts and monuments from the past 9,000 years (Hall 1994). There are over 16,000 monuments and archaeological sites located throughout the countryside in all habitats, many of which are in state care or open for visits (**Figure 18.48**). Northern Ireland has 1,864 scheduled monuments (NIEA 2010j); around8,500 listed buildings (NIEA 2010d); around 157 registered historic parks, gardens and demesnes. These cover an area 17,921ha, equivalent to around 1.3% of Northern Ireland (NIEA unpublished data).

Insert Figure 18.48 here

The 2009 Condition and Management Survey of the Archaeological Resource in Northern Ireland (CAMSAR) report assessed the survival and condition of sites and monuments in Northern Ireland, focusing on sites earlier than 1700AD (Gormley *et al*. 2009). The report found that only 4% of sampled sites were in good or excellent condition, and 44% had no upstanding visible remains. It found that the worst survival rates for archaeological sites and monuments were on areas of arable land, improved grassland and areas of built development. Of the sample sites that were protected under the Historic Monuments and Archaeological Objects (NI) Order 1995, 93% were found to be in fair, good or excellent condition. The CAMSAR report identified a close connection between the management of archaeological sites and monuments and agricultural practice. This is significant, given that around 75% of Northern Ireland's land is in agricultural use. European agricultural policies in the 1970s and 1980s led to changes in marginal land use, damaging or destroying many archaeological sites in the process, leading to the introduction of the ESA Scheme in 1986. The Countryside Management Scheme was introduced in 2000 and ensures that historic features are protected by improved agricultural management. Light grazing is usually the best management for archaeological sites as it keeps scrub growth at bay and enables all the features to be seen and appreciated. Maintaining a good grass sward also helps to protect buried remains (Gormley *et al*. 2009; **Figure 18.49**).

Insert Figure 18.49 here

Blanket and lowland raised bogs are of particular archaeological significance as their anaerobic conditions sustain evidence of past lifestyles and landscapes through the pollen record. In some areas blanket peat covers old soil systems that attest to past, possibly Neolithic, agriculture and settlements. There are 222 sites and monuments within the Northern Ireland Sites and Monuments Record (NISMR) on peatlands (NIEA unpublished data). Excavation of sites and increasing access to them can damage peatland and pose conflicts over different management regimes.

While many vernacular buildings have been lost to development, some remain and there are numerous stately homes, historic demesnes and parks and gardens interspersed in the farmed landscape, many owned by the National Trust and allowing public visits. Some of these properties are extensive, and the Trust manages its land following sustainability principles, providing working examples of management demonstrating new and traditional techniques.

There are a number of historical and archaeological sites, scheduled monuments and state care sites in forests. Forests and woodland also form a significant part of the historic environment in respect of historic parks, gardens and demesnes. Around one-tenth of the woodland recorded on the Ancient Woodland Inventory was parkland. Many of these sites contain some of Northern Ireland's oldest trees, many of which are of high ecological value, particularly for lichens and insects (Woodland Trust 2007).

18.5.4.6 Land ownership and use

The farmed landscape of Northern Ireland is relatively recent; the pattern of small, family-owned farms date from the late 19th Century when tenants were given the right and assistance to purchase land through the Purchase of Land (Ireland) Act introduced in 1885 (enclosed fields are an older feature; Steele 1968; Cameron 2005). However, enclosure of the land generally stopped at the foot of the mountain, with hill grazing apportioned by 'soums'. A soum is the amount of pasture needed to support a cow or equivalent (e.g. five sheep equated to one cow (Symons 1963). Each joint-owner of a stretch of upland was entitled to a number of soums. Although common grazing and joint ownership have declined through inheritance and purchase of shares, they are still extensive and influence the use of uplands (DARD 2010o).

Land ownership is a very important part of the culture of rural Northern Ireland; many farmers are reluctant to sell land that came into the family only a little over 100 years ago or to accept 'direction' from government as to how to use and manage the land. For example, acquisition of large areas for forest planting is more difficult with multiple landowners than where land is in single ownership, part of the explanation for the disjointed pattern of forests. Jointly owned land can be entered into the Northern

Ireland Countryside Management Scheme (NICMS; DARD 2008b), but all the common graziers must participate in NICMS, CMS or the ESA Scheme, and this requirement can limit uptake of the scheme and thereby the success of environmental policies. However, other factors (such as the funding available for the scheme) may be more important. The complex of small farms situated along the upland margins, where owners may have different attitudes to farming, has produced high biodiversity. The drivers creating this biodiversity need further research, especially in the light of government policies to expand forestry (Forest Service 2006).

18.5.4.7 Aesthetic, inspirational, spiritual and religious aspects

Northern Ireland has a long history of literature, poetry, music and the visual arts. Artists have been inspired by diverse landscapes such as the Antrim Coast, the Sperrin and Mourne Mountains, and the Fermanagh lakelands. These have provided the raw material for a rich tradition in the arts. Nobel Laureate Seamus Heaney was born on a farm near Bellaghy in County Londonderry and his work clearly demonstrates an important connection with the landscape and environment. C. S. Lewis reportedly received inspiration from the Mournes for the Chronicles of Narnia (Gormley 1998). A classical writer once described the Celts as being so wretched that "their drink is the drink of swine, and they burn their very earth for warmth" (i.e. they drank beer and burned turf; Feehan & O'Donovan 1996). Bogs have also been the inspiration of countless artists, including T. P. Flanagan and Basil Blackshaw. Nor has Northern Ireland's troubled past escaped attention. Contemporary painters continue to be inspired by its landscapes and many have integrated the rural idyll depicted by Sir John Lavery, William Conor, Paul Henry, and John Luke with darker elements of violence. The resulting combination of rural tranquillity with terror has produced a unique genre of Northern Irish art, most notably in the work of Dermot Seymour and Jack Pakenham.

Monastic sites and medieval castles, abbeys, celtic crosses, round towers, churches and holy wells are to be found in every county; for example St. Aidan's 13th Century church, in County Derry/Londonderry, has an ancient holy well said to have healing properties. St. Patrick is patron saint and spiritual symbol of Ireland and consequently Northern Ireland's links with him are very important, with Armagh City and Downpatrick having particularly strong associations. Slemish Mountain is an important place of pilgrimage on St. Patrick's Day. The mountain, where St. Patrick is reputed to have spent his early days as a slave, is significant both for its Christian connections and as evidence of a volcanic past.

18.5.4.8 Education and ecological knowledge

The use of outdoor settings for educational purposes is now a compulsory element of primary and secondary education. "When planned and implemented well, learning outside the classroom contributed significantly to raising standards and improving pupils' personal, social and emotional development" (Ofsted 2008). "…children engaged in Learning Outside the Classroom achieve higher scores in class tests, have greater levels of physical fitness and motor skills development, increased confidence and self-esteem, show leadership qualities and are socially competent and more environmentally responsible" (Malone 2008).

While Northern Ireland Environment Agency government sites have information signs, they have not been supported by full-time education officers since 2009 (NIEA pers. comm.). However, there are a number of outdoor education centres run by both Education and Library Boards and charities such as the Field Studies Council, and several NGOs run educational programmes either based at their own sites or in partnership (e.g. National Trust, Ulster Wildlife Trust, Wildfowl and Wetlands Trust, Colin Glen Trust, RSPB). In addition, the Eco-Schools programme is very popular in Northern Ireland and currently more than half of all schools in Northern Ireland are registered (Tidy NI unpublished data). Universities conduct research in the natural environment, with student projects having provided considerable data over the years; however, this is often not publicly available.

18.5.5 Supporting Services

Supporting ecosystem services are those that are fundamental to the delivery of all of the others, including soil formation, primary production and nutrient cycling. They are even more difficult to value and quantify

than the others, as they often operate on much longer time periods and at greater spatial scales than individual political jurisdictions.

Soil formation in temperate regions is so slow that soil erosion is more important in practical terms and soil must therefore be regarded operationally as a non-renewable resource. In general, soil quality is closely related to organic matter content (and therefore carbon content). Soil degradation tends to be lower in Northern Ireland than in most other parts of the UK (**Figure 18.50**) and this is aided by the relatively wet and cool climate which slows down the rate of decomposition and thus promotes the retention of carbon in the soil, including the formation and maintenance of peat.

Insert Figure 18.50 here

Primary production in pristine natural and semi-natural terrestrial ecosystems is limited by the supply of nitrogen and phosphorus and these limits help to maintain species diversity, which in turn maintains the character of these areas. Protecting natural habitats from excessive nutrients from intensive agricultural areas avoids eutrophication, which would tend to increase primary production, reduce biodiversity and change the character of natural areas, which in turn can reduce their value for recreation, well-being and supplying clean air and water (Sections 18.5.3.3 & 18.5.3.4). Atmospheric pollution by ammonia is higher in Northern Ireland than in other parts of the UK because of gaseous emissions from intensive animal agriculture, and research has shown that atmospheric nitrogen inputs are high enough to threaten the ecology of all natural habitats, including protected areas, especially peatland and grassland (Tang *et al*. 2004), although field data are not yet available on whether there have been floristic changes in Northern Ireland in response to these levels.

Primary production in intensive animal farming has provided food and economic benefits. However, in addition to gaseous losses of nitrogen, excessive inputs of nitrogen and phosphorus in fertilisers and animal feeds have led to serious eutrophication of groundwater, rivers and lakes. Phosphorus has accumulated in most soils in Northern Ireland and some is transferred to surface waters by drainage and surface runoff. Because of intensive livestock systems, agricultural nutrient budgets show greater surpluses of nitrogen and phosphorus than the nutrient balances for most other parts of the UK (Sections 18.5.3.3 & 18.5.3.4). Legal controls over the application of phosphorus fertilisers may have recently started to reverse the eutrophication of rivers and lakes by phosphorus from sheep and beef cattle, and these controls, together with new controls over the quantities of phosphorus incorporated into animal feeds plus mitigation of nitrogen and phosphorus from dairy farming, can continue that trend (Section 18.5.3.3).

Although poorly managed intensive agriculture has led to eutrophication of air and water, the predominance of perennial grassland ecosystems helps to maintain (and even slowly build up) soil organic matter and may help to optimise soil storage of carbon and maintain good soil structure (Simpson 1983).

18.5.5.1 Soils and nutrient cycling

Moderately high altitude, oceanic position, acidic parent geological materials, and post-Neolithic woodland clearance have led to the formation of peat and peaty soils in the uplands of Northern Ireland. Northern Ireland's peatlands have been used traditionally for fuel, but during the 20th Century large-scale drainage of peatland and harvesting to produce fuel and horticultural peat have led to a serious decline in this important resource. Protecting and restoring peatlands is an important way to keep carbon from the atmosphere to help mitigate climate change (Section 18.5.3). In Great Britain, peat erosion is of much concern and there is considerable emphasis on restoration; however, it can take a very long time to re-establish the full range of biodiversity. In Northern Ireland it appears that many eroded areas are recovering naturally (Tomlinson 2010) and some restoration work has been undertaken at Cuilcagh and the Peatlands Park, with growth of bog mosses in channels. Further research is needed to determine long-term results. Some marginal hill-lands were drained up to the 1970s to encourage vegetative growth for grazing, whereas other slopes were more completely reclaimed (drained, deep ploughed, limed, fertilised and reseeded). The present state of these areas, and the location, extent, factors encouraging and effects of current reclamation all need to be investigated. There is little current research on the primary production

of upland ecosystems and hence on the rate of peat accumulation. Indeed, little or no local evidence is available from the International Biological Programme studies started in the 1960s; carbon studies in Northern Ireland have relied on research from the Republic of Ireland and Great Britain (Cruickshank *et al*. 1998; Tomlinson & Milne 2006). Upland ecosystems have a supporting role in water cycling, in the interdependence of farming (use of upland, combined with marginal and lowland, grazing), and in supporting the urban population by providing landscapes for aesthetic and recreational fulfilment.

Soil formation is a slow process in Northern Ireland as in other parts of the UK, but the soils are distinct in that they tend to have relatively high organic matter content, especially in the west and in the uplands, due to the wet and cool climate. Northern Ireland has a wide range of soil types that have developed from the solid geography. They have been studied extensively, with a major soil map and supporting document produced in 1997 (Cruickshank 1997) and the ongoing TELLUS project which is carrying out geophysical and geochemical mapping of the entire country (Young 2007; Beamish & Young 2009; **Figure 18.51**; **Figure 18.52**). Every major rock type except one is represented. Northern Ireland has a preponderance of gleys (56%) with a consequent requirement for artificial drainage for productive agriculture (Cruickshank1997; Section 18.5.3).

Insert Figure 18.51 here

Insert Figure 18.52 here

Soil organic matter provides a service by sequestering carbon and keeping it out of the atmosphere. Although intensive agricultural practices will have lowered the organic matter content and biodiversity of some soils, in general soil quality is good, with little or no degradation (**Figure 18.50**; Section 18.5.3.3). Indeed, Northern Ireland is the only country in the UK in which there has been no moderate or severe human-induced soil degradation. Soils in the east of Northern Ireland are not degraded and some soils in the west are only lightly degraded. Drivers of change are climate and land use. There was a much larger agricultural land area devoted to arable crops 100 years ago (Section 18.5.2.1). Grassland agriculture now dominates and continuing grassland systems will help to maintain or enhance soil quality by maintaining soil organic carbon (Simpson 1983). As 76% of the agricultural area in Northern Ireland is grass (Tomlinson 1997b), carbon sequestration could have a significant impact on Northern Ireland's greenhouse gas inventory and also on the calculation of the carbon footprint of ruminant products. The trade-off is the problem of diffuse nitrogen and phosphorus pollution from intensive dairy farming systems.

Soils provide a service both as a substrate and through providing nutrients for plant growth, with high primary production achieved in intensive grassland agriculture. However, the trade-offs are reduced biodiversity and excessive nitrogen and phosphorus in soils, which act as a diffuse source of pollution of surface waters. Many of the soils in Northern Ireland are vulnerable to compaction by grazing animals and heavy agricultural machinery, especially in the wetter climate of the west. Compacted soils do not support good plant yields and are subject to severe nutrient runoff. They are thus a major source of the phosphorus eutrophication of waterways (Sharpley 1985).

18.5.5.2 Marine ecosystems and nutrient cycling

The sustainability of life is fundamentally dependent on the ability of biophysical systems to recycle limiting compounds in biogeochemical cycles (Falkowski *et al.*2008; Doney 2010). Since much of the earth is covered by ocean systems, many of the most important biogeochemical cycles are dependent on marine processes, and many of these, in turn, are dependent on marine biota. Some of these cycles are important in removing material from circulation, including the biological carbon pump, which is vital in removing carbon dioxide from the atmosphere (via photosynthesis) and transporting it to the deep ocean floor (via various links and processes in the marine food web), where it can be sequestered in the long term (Riebesel l*et al.*2009). This process has both laid down many of the marine fossil fuel reserves and has ensured that the earth has not yet entered a phase of runaway warming.

Other biogeochemical cycles are important in transforming compounds from harmful to beneficial forms and keeping them in circulation. Photosynthesis (which transforms carbon dioxide to oxygen) and nutrient cycles, including nitrogen (Gruber & Galloway 2008), are most important. Not only are products of these cycles important ecosystem services in their own right, but they also support the ongoing existence of biotic assemblages in the sea and on land. The sea is also fundamental in driving the water cycle, receiving waters from land and returning it to the air for ultimate recycling onto the land.

Coasts are active in sediment storage and exchange between habitats, providing physical substrates or protection which allows other habitats to develop and biochemical exchange between the water column and shoreline habitats.

18.5.5.3 The water cycle

The cool and moist climate of Northern Ireland ensures a good supply of fresh water, especially in the west. However, freshwater services have been affected by major drainage schemes and canalisation of major rivers from the 1950s to the 1980s (Section 18.4.6.2) which have speeded up the hydrological cycle, reduced biodiversity and increased the risk of flooding. The biological quality of surface waters can decline despite decreasing trends in river nitrate and phosphorus concentrations (EHS 2000). The Water Framework Directive requires water to be of good quality by 2015, and this includes biological quality (Sections 18.4.6 &18.5.3.4).

18.5.5.4 Primary production

Ecological interactions depend on biotic and abiotic factors and drivers of change include biodiversity, nutrient inputs and climate change. Historical change has mainly been a reduction in biodiversity and changes in species composition resulting from anthropogenic nutrient inputs and physical disruption. Primary production via photosynthesis drives all ecosystems on land and in coastal seas (Sections 18.3&18.8).

18.5.5.5 Decomposition

Decomposition is fundamental to cycling of all nutrients; without the biota which decompose all organic matter to release nutrients, no habitat could function effectively. Threats to decomposition include chemicals used to treat parasites in domestic animals, which then lead to degradation of the natural soil organisms (Strong 1993), compaction of soils, which inhibits drainage and alien flatworms, which prey on earthworms (Boag & Yeates 2001). While many of these issues are shared across other regions of the UK, local conditions can vary the specific impacts.

18.5.6 Valuation of Ecosystem Services

A key objective of the UK NEA is a systematic and comprehensive valuation of ecosystem services which links ecosystems to human welfare by assessing the benefits accruing to society and economic prosperity from the UK's natural environment. The Economics of Ecosystems and Biodiversity (TEEB) work supports this goal. Assigning economic values to particular areas, ecosystems or habitats is difficult. Much of the TEEB work, as well as the information specifically available for Northern Ireland, concentrates on products, the costs of providing services if nature did not do so (pollination, water purification), the costs of ameliorating environmental damage (flooding, pollution, invasive species) and the economic benefits provided through tourism or recreation expenditure and income (TEEB 2009, 2010a,b,c).

Ecosystem services can potentially provide a wide range of benefits to society, such as:

- Market values – employment and income from direct use of the ecosystem services e.g. food and timber production.
- Shadow values – employment and income from the indirect use of ecosystem services by businesses which are highly dependent on the services, e.g. tourism and recreation activities; and household location decisions (i.e. increase in house values in the vicinity of the ecosystem service).

- Non-market values – the benefits derived from ecosystem services for which no market exists (direct and indirect), e.g. biodiversity, landscape, water and air quality; informal recreational use (bird-watching, hiking, cycling, boating) and values attributed to the continued existence of these features based on non-use motivations, such as for the sake of future generations.
- Social values – ecosystem services that contribute to the social well-being of local communities by providing a sense of identity and belonging, social capital building and social entrepreneurship.

It is clear that the value of ecosystem services goes far beyond the value of the products derived and that in many cases the additional values can be much greater than those of the products.

A further differentiation is made to the MA classification of provisioning, regulating, cultural and supporting services to separate ecosystem services into 'intermediate processes and services' and 'final services' that directly deliver goods and benefits to people (MA 2005a,b). Additionally, the UK NEA recognises capital inputs (including manufacturing, transport, processing and engineering) into the production of the goods/benefits derived from ecosystems (**Figure 18.53**).

Insert figure 18.53 here

There has been much recent work on valuing ecosystems and biodiversity. The TEEB project, which received a very high profile at the Nagoya COP Biodiversity summit in November 2010, is a major study providing a large amount of international information and expertise (TEEB 2009, 2010a,b,c). Another major group working in this field is the Natural Capital Project, a joint venture between Stanford University's Woods Institute for the Environment, the University of Minnesota's Institute on the Environment, the Nature Conservancy, WWF and a number of other institutions in the public, private and non-profit sectors. The Natural Capital Project has the goal of engaging leaders in key institutions, linking world-class research and development with influential, practical conservation programs and developing tools that facilitate the incorporation of natural capital into decisions (Natural Capital Project 2006). These and other organisations are developing techniques, progressing the concept and providing tools to help make these calculations and help ensure that the full value of biodiversity and ecosystem services is available to influence decisions.

Some rough estimates arising from this type of analysis are becoming available. The TEEB project (TEEB 2009, 2010a,b,c) estimates that $2–$4.5 trillion is lost every year due to global deforestation and that the total economic value of insect pollination is €153 billion. Expansion by non-native species is currently one of the biggest threats to the ecology and economy of the planet, costing an estimated £914 billion annually worldwide and causing 50% of all known extinctions (TEEB 2009, 2010a,b,c).

The National Parks and Wildlife Service of the Republic of Ireland estimate that the current marginal value of biodiversity and certain ecosystems in the Republic of Ireland in terms of their contribution to productive output and human utility is over €2.6 billion per annum (DEHLG 2008). This is considered a conservative estimate because it does not include services such as food production and waste assimilation, so the true figure will be much higher (Comhar SDC 2010b).

When looking at the valuation of services it is important to recognise the concept of thresholds and tipping points, also called 'planetary boundaries'. These are boundaries that, if breached, could lead to major environmental consequences and therefore need to be identified and quantified (Rockström *et al.* 2009a). This approach aims to prevent human activities from producing unacceptable environmental change and defines preconditions for human development. The costs of breaching these boundaries are extremely high and the closer the boundaries are approached, the higher the marginal costs (if there are 500,000 ha of wilderness providing multiple services, the value of each hectare is much less than if there are only 10 ha remaining).This has profound implications for valuing ecosystem services in financial terms, both globally and locally. While this concept is generally applied on a global scale, it has local ramifications as local limits are approached.

Little valuation work has been undertaken on the economic values of the final goods provided by the ecosystem services in Northern Ireland, especially those which have no market price. The absence of data or values does not indicate that there is no impact on human welfare, rather that no quantification of the value for Northern Ireland has been undertaken. While attempts have been made to value some of the ecosystem services (i.e. Jacobs *et al.*2008), these have used economic values derived in non-Northern Ireland based studies. Therefore these findings have not been included within this review. Information about economic valuation is covered in detail in the UK NEA Conceptual Framework (Chapter 2).

The ecosystem services for which economic values exist tend to be the provisioning services for which there are markets (e.g. agriculture, fishing and timber). However, even these values may not reflect the full benefits (or costs) of these ecosystem services as only the direct, private good aspects have been captured. For example, the value of forestry recreation reported below reflects only a proportion of the recreational benefits as charges are made at only nine of the 124 publicly owned forests of Northern Ireland.

Furthermore, if the provision of a good which is valued in the market depends on a number of ecosystem services for which no markets exist, the market price may not reflect the full economic value. For example, agricultural production, in addition to producing food, affects the goods provided by other ecosystem services which are not captured by the market, including landscapes (cultural), climate and flood regulation (regulating), water availability (provisioning), soil formation and nutrient cycling (supporting). The calculation indicated that the net negative impact of agriculture on the environment of Northern Ireland was £34.2 million per annum (excluding air pollution which has a cost to society of £189.71 million (net present value)). However, there is a lack of data on the level of provision. The market price of agricultural output does not take these external benefits and costs into account (Jacobs *et al.* 2008).

Even the inclusion of those ecosystem services which have market values can be problematic because the scale at which they were derived does not correspond to UK NEA habitat classifications. For example, while the economic value of agriculture is widely reported (e.g. DARD 2009f, 2010a), these data are reported at either the Northern Ireland level or at scales appropriate to agricultural/rural policy (e.g. the Less Favoured Areas) which do not relate to the UK NEA Habitats. In this case, rather than splitting the figure between the relevant UK NEA Habitat categories, the Northern Ireland figure is reported under the Enclosed Farmland habitat. As a consequence, it would appear that a gap exists for the value of the provisioning ecosystem services of Mountains, Moorlands and Heats and Semi-natural Grasslands whereas, in fact, these ecosystems contribute a considerable (but unquantifiable at present) portion of the agricultural output. **Table 18.17** provides examples of the values of some ecosystem services in Northern Ireland.

Insert table 18.17 here

While it can be difficult to assign an economic value to benefits, costs may be more easily established. The cost of controlling invasive species has begun to be recorded and calculated (Section 18.3). For example, the Rivers Agency spent £200,000 on a 12-mile stretch of the River Roe clearing knotweed, the Killyhelvin waste water treatment works required a £120,000 refit due to zebra mussels, and a number of projects to address floating pennywort have together cost £85,000, mostly in staff time. The Northern Ireland Environment Agency has spent an estimated £415,000 on clearing invasives from its country parks and over £32,000 at nature reserves since 2005 (John Early, NIEA, pers. comm.).

A study of the ESA scheme conducted in 1997 assessed the socio-economic benefits of the scheme through a household survey and found that the 'non-market benefits' were estimated at £13.1 million per year for the preceding 5 years. This was a benefit-to-cost ratio of 32:1. A contingent valuation aspect found that people were willing to pay £15–£31 per person for landscape value in the Mourne ESA which, when summed across households, yielded a value of £19 million (Moss & Chilton 1997a,b). A study of the Rural Environment Protection (REP) Scheme's contribution to rural landscapes in the Republic of Ireland in 2006 estimated the value put on landscape benefits alone amount to almost the entire cost of the scheme (Campbell *et al*. 2006).

In 2006 it was estimated that the natural environment contributed 32,750 full-time jobs and over £573 million to the economy through protection and management of the environment, sustainable use of natural resources, environment-dependent tourism and recreation and environmental management in industry and government (NI Green NGOs & EHS 2007; **Table 18.18**). In 2010, a survey of environmental NGOs (eNGO) was conducted which found that 38 eNGOs surveyed had a turnover of nearly £32 million, over half of which came from non-governmental sources. In addition, the value of volunteer input for the 38 bodies was estimated at £3.7 million (Envision Management Consultants 2010), comparing well to the estimate of £3.4 million in 2006 (NI Green NGOs & EHS 2007). Overall, for every £1 invested by government annually in the eNGO sector an additional £3.37 was invested through volunteers or other funding (Envision Management Consultants 2010).

Insert Table 18.18 here

18.6 Northern Ireland's Dependence on External Ecosystem Services

Northern Ireland is at the end of the supply chain for many of the commodities used by its citizens, with a high dependence on external provisioning services. This, plus the restricted range of local produce, has a strong impact on prices and security of supply and therefore has implications for how land is used. This also illustrates why Northern Ireland's dependence on other parts of the UK, as well as other parts of the world, is high. The importation of biological products and financial dependence on overseas economies are two of the more apparent examples. Dependence on external cultural services is primarily through tourism, and there is also strong support for local cultural services from tourists coming to Northern Ireland. Northern Ireland also relies on other countries for some less quantifiable services such as climate regulation.

Northern Ireland imports almost all of the energy it uses (DETI 2010d), making it highly vulnerable to both supply and price fluctuations. Significant amounts of food and building materials are also imported. Northern Ireland's ecological, carbon and greenhouse gas footprints are slightly lower than the UK per capita average (Curry *et al.*2004; Maguire *et al.*2008; **Table 18.19**). The ecological footprint of Northern Ireland's food consumption in 2006 was 1.2 global hectares/capita, making up some 28% of its residents' total footprint, and was the largest contribution of any sector (**Figure 18.54**). Other categories closely related to ecosystem service delivery include housing and transport, animal and vegetable oils, mineral fuels and crude materials. It is clear from **Figure 18.54**, **Figure 18.55** and **Figure 18.56** and **Table 18.19** that Northern Ireland relies heavily on other regions for delivering the goods which its citizens require.

Insert table 18.19 here
Insert Figure 18.54 and 18.55 and 18.56 here

Food and live animals grown and raised in Northern Ireland provided around 14% of total exports in 2009 (**Figure 18.73**). The value of these food imports and exports are very similar (around £5 billion), but the make-up varies significantly. Exports consist largely of milk and meat products, while most fruit and vegetables and many processed food products are imported. Northern Ireland is a net exporter of meat and dairy products but overall exports of food and live animals only slightly exceed imports (**Figure 18.73**; **Figure 18.74**). Most exports are to other parts of the UK and the Republic of Ireland, with only milk/milk products and fish having significant markets further afield. A detailed breakdown of imported products is not possible within the scope of this exercise. However, it is clear that Northern Ireland does not produce the food and other products which its citizens require on a daily basis, with 65% of exports being meat or animal products and only 8% vegetables and fruit. A number of factors, from policy changes to oil price to consumer preferences to transport disruption, could increase the pressure to address this situation, with potentially large impacts on land use (Chapter 21).

While these figures include some of the value of provisioning ecosystem services, it is not possible to conclude that the entirety of the value is directly attributable to ecosystems, due to the input of capital and human labour during manufacturing and processing. It does, however, show which products were exported and their destinations. Obviously much more work is required on the material flow analysis of the UK

regions to establish the precise dependence of Northern Ireland's production and consumption patterns on domestic, UK and international ecosystems, although these figures give an indication of directions and relative magnitude of flows. They suggest the need not only to maintain the regional ecosystems on which Northern Ireland depends, but also to maintain the ecosystems further afield on which it relies.

Impacts of cereals, animal feeds and wood are noticeably high and obviously related to local needs. More surprising is the relatively high level of meat and dairy/eggs imports, given the high level of exports in both categories, but this may relate partially to UK-wide distribution of and demand for goods by large retailers. In general, the higher codes, particularly code 6 (see Figure 18.57), represent more highly processed commodities. It is important to recognise that customs data fail to identify those commodities which may have passed through more than one other UK country. Beyond very general conclusions, far more detailed analysis is required of what exactly is happening regarding import and export data. What is clear is that Northern Ireland relies significantly on imports for subsistence products and on external markets for its domestic produce.

The data indicate the larger size (relative to population) of the Northern Ireland agricultural sector compared to the rest of the UK and the large amount of imported feedstuff required to sustain it (**Figure 18.57**). These imports come primarily from the EU15 and Eastern Europe (**Figure 18.58**). In addition, the figures for cereals indicate small domestic production levels and the subsequent need to import large amounts of animal feedstuffs, mainly from Latin America. In general, Northern Ireland imports more biomass commodities per capita than other parts of the UK across the categories identified, almost double that in England and over six times more than in Wales. The dependance of Northern Ireland on overseas ecosystems, in particular those of the EU15 and Latin America, for sustaining its socioeconomic activity is apparent. With the predicted 7% rise in population in Northern Ireland by 2020 (NISRA 2005a) and the likely increase in general demand for bioenergy and food in coming years, dependence on flows from overseas ecosystems are set to increase, given Northern Ireland's relatively limited capacity to increase domestic production on the same scale (DETI 2008b). Subsequently, given the potential of consumption of biomass from international sources to drive ecosystem change, the need to monitor the scale, nature and impact of these flows more accurately should be a key objective of regional administrations in the UK, as stated in the recently published Sustainable Development Strategy for Northern Ireland (OFMDFM 2010a).

Insert Figure 18.57 and 18.58 here

18.7 Consequences of Change

This document shows that the natural ecosystems and their biodiversity, coupled with sensitive management, have provided and will continue to provide considerable value to the people of Northern Ireland through a wide range of ecosystem services. The specific products have changed over time, and changes will continue. Some outputs, such as carbon sequestration and hazard resilience, are not currently recognised as having financial value but may become highly important in the future.

Table 18.20 provides a very general assessment of two factors, namely the relative importance of a particular ecosystem for the delivery of specific ecosystem services and the direction of change over the past 20 years. Population of the table has been carried out by local experts working together. There are serious issues in combining a large range of habitats, sites, aspects of benefits (e.g. types of crops) and trends into a single 'directionality' arrow, and the confidence with which colours and arrows have been assigned varies with regard to the spatial variability of the habitats, their current and past management and the degree of knowledge of past trends. It is also difficult to determine directionality of change over time; in several areas the trend has been generally downward, but over the past 1 or 2 years improvements have occurred.

Insert Table 18.20 here

It is clear that the habitats in general contribute greatly to the various services, and which services are delivered by these various habitats. Perhaps the most useful aspect of the table is to highlight areas of synergy or of particular concern. Those habitats which are very important for a particular service and where the trend is downward indicate areas for possible future concern.

It is important to note that most of the available habitat data are quantitative only, with little information available on the habitat's quality or its ability to deliver various services. Quality and quantity may, or may not, move in similar directions. If they do not, there are difficulties in determining which aspect is of greater importance, a factor not addressed in this table.

18.8 Sustainable Management

Some land in Northern Ireland is owned by charities. The National Trust owns 11,090 ha (National Trust Regional Office), the RSPB manages 2,794 ha of land as nature reserves (537 ha owned, 2,257 ha leased; RSPB NI Office) and the Woodland Trust manages 321 ha (125 ha owned, 195 ha leased). The Crown Estate owns property in Northern Ireland worth £10.9 million, including a marine estate which comprises the foreshore and seabed out to 12NM (The Crown Estate 2010). The Government of Northern Ireland is a significant landowner. Much of its land is designated for environmental or heritage purposes, including 68,000 ha owned by Forest Service (Forest Service, pers. comm.), 10,795 ha owned by the Northern Ireland Environment Agency and 8,647 ha by Northern Ireland Water (NI Water unpublished data). Most of the land is owned by private citizens, primarily farmers (Section 18.6.2). In addition, much land is subject to a complex system of 'rights', including turbary, fishing, shooting, minerals and water (Cruickshank & Tomlinson 1995).

Sustainable management needs to deal with a variety of issues, including environmental (climate change, invasive alien species, pollution, habitat loss and fragmentation), social (farming practices, new land uses including renewable energy and flood control, public involvement) and economic (consumer preferences, viability of farms, subsidies). This requires a full suite of tools including legislation, planning policies, designations, restrictions on activities, fiscal drivers, education and awareness (NIBG 2009). Management of ecosystems has primarily been through designations, the planning system and financial incentives for agricultural management, primarily directed by the Department of Agriculture and Rural Development under various agri-environment schemes.

The ecosystem assessment process has identified a variety of issues and threats, and sustainable management of both special sites and the wider countryside is needed to protect and enhance ecosystem services, biodiversity and human well-being.

18.8.1 Designated Sites

One of the main mechanisms for protecting biodiversity and habitats is through designation, although designation alone does not automatically ensure protection. Northern Ireland has been delivering a programme of designating sites at the local level to underpin international designations and obligations since the 1965 Act (ASIs then), but the network of Areas of Special Scientific Interest (ASSIs, comparable to SSSIs in the rest of the UK) is still some years from completion. The Northern Ireland Environment Agency intends to have a total of 440 ASSIs declared by 2016, with an undetermined number to be declared after that date (NIEA 2009a). By the beginning of 2010 a total of 305 sites had been declared as ASSIs (NIEA 2010a). Around 7.1% of Northern Ireland is designated as ASSIs (NIEA pers. comm. May 2011). The ASSI network forms the basis of international designations including terrestrial Natura 2000 sites, Special Areas of Conservation (SACs) and Special Protection Areas (SPAs). Northern Ireland has one Marine Nature Reserve in Strangford Lough covering a total area of 150km^2 and 10 of the 15 SPA-designated sites have a marine component. There has been a gradual increase in the total area of designated sites between 1990 and 2009 (**Table 18.21**).

Insert table 18.21 here

In terms of the state of biodiversity and ecosystems within these sites the Northern Ireland Environment Agency started a programme of condition assessment in 2002 using Common Standards Monitoring guidelines developed by the JNCC. Under this protocol the habitat and species features of a site are assessed every 6 years (DOE 2010b). In March 2008 the Northern Ireland Environment Agency had assessed 916 features on 195 ASSIs, with the first report published in autumn 2008 (NIEA 2008b) and an update proposed for 2010 (NIEA 2011).The general results focus on Natura 2000 sites (**Table 18.22**; **Figure 18.59**). The majority of designated geological sites are in favourable condition, while the majority of some habitats are in unfavourable condition.

Insert Table 18.22 here

Insert Figure 18.59 here

Of course, much important biodiversity also lies outside the nationally designated sites. In order to try to protect this, Sites of Local Nature Conservation Importance (SLNCI) have been introduced in a number of statutory development plans. In 2000 there were 81 SLNCIs and in 2009 there were 889, but only 137 have been formally adopted within the local development plans to the end of 2010. It is to be hoped that the revised Planning Policy Statement 2 on Nature Conservation (due to be published in 2011) will review and safeguard SLNCIs, but this is not guaranteed as it will be subject to consultation. It should be noted that the National Trust and other charities also have a significant role in conserving sites, including Strangford Lough and the Murlough sand dunes.

The Management of Special Sites (MOSS) scheme helps deliver appropriate management of designated sites in Northern Ireland by providing landowners with a grant payment for undertaking general conservation activity in agreement with the Northern Ireland Environment Agency. The scheme was review in 2009 and now addresses the protection and management of habitats not covered by other schemes, primarily the NICMS, such as elements of biodiversity or habitats that require specific attention. It aims to have 95% of the relevant areas being in favourable or unfavourable recovering condition by 2016 (DARD 2009c).

18.8.2 Wider Countryside and Landscape-scale Conservation

There is recognition that 'wider countryside' and 'landscape-scale' conservation measures are required (NIBG 2009) but to date movement in this direction has been limited. The problems of changes in quality and extent of priority habitats and species within and outside of the designated sites related to climate change impacts, the need for buffer zones around designated sites and the importance of establishing wildlife corridors have been raised at conferences (e.g. Biodiversity and Climate Change in Ireland, NIBG and Comhar SDC conference, November 2008) and have recently received major attention throughout the UK following the publication of the Lawton Report (Lawton *et al.* 2010). Protection for some features lies within planning guidelines and this comes into effect when planning permission is sought for development. Although there was provision in the 1965 Amenity Lands Act, Northern Ireland does not have National Parks. There are no facilities for buffer zones or stricter management conditions near designated sites, so management outside of a designated site can have impacts within it (pollution, erosion, disturbance, drainage operations, intensive farming). Also many animals range far beyond a designated site during their lifespan. Identifying issues and developing ways to address them in a wider countryside context is particularly important as the impacts of climate change become more significant in determining where animals and plants are able to live (Defra2006).

Identifying areas of particular conservation value and then using this to target their protection and proactive management is a technique which has been pioneered internationally ('hotspots' of biodiversity; Conservation International 2007). One way to begin this process is to look at sites which are subject to multiple designations. There are numerous areas in Northern Ireland which fulfil this criterion, including Strangford Lough, Lough Neagh and parts of the Mourne Mountains (**Figure 18.60**).

Insert Figure 18.60 here

Work on biodiversity conservation in the wider countryside is encouraged primarily through agri-environment schemes (Section 18.8.5). These schemes are also dependent on individual farmers joining them, which can result in a patchwork effect, especially as the entire farm has to be in the CMS in Northern Ireland (unlike England and Wales). Consequently, if a farm has Semi-natural Grasslands, which are very important habitats for biodiversity and landscape, the fact that other areas within the farm are under intensive agriculture may prevent it from being part of the scheme.

As with other parts of the UK, Northern Ireland does have Areas of Outstanding Natural Beauty (AONBs). This is a designation managed by the Northern Ireland Environment Agency under the Nature Conservation & Amenity Lands (NI) Order 1985.There is a very low level of financial support available for management of these areas, which cover upwards of 20% of Northern Ireland's land area (EHS 2008a; **Figure 18.60**). The Mourne Mountain Landscape Partnership has been awarded a Development Grant by the Heritage Lottery to work towards a £2 million Landscape Partnership Scheme which will preserve and celebrate aspects of the rich natural and cultural heritage of the Mournes, including heather heathland, Mourne juniper; water supply; Mourne granite and traditional farming (MHT pers. comm.). There is a proposal to introduce legislation to allow the formation of National Parks to the Assembly, but this will differ from the legislation in Great Britain in that there are unlikely to be any planning responsibilities for a National Parks authority in Northern Ireland. The timing is still unclear and designation of specific areas may be some years after the legislative process, which itself will take at least 2 years.

Country parks were first established in Northern Ireland following the introduction of the Amenity Lands Act (Northern Ireland) 1965. This set up the Ulster Countryside Committee which advised government on the purchase and management of land for recreational use, primarily by urban dwellers. Seven country parks were established between then and 2004 (Castle Archdale, Crawfordsburn, Ness & Ervey Woods, Peatlands, Redburn, Roe Valley and Scrabo) and they are important for educational purposes and conservation of the natural heritage (EHS 2004c). Additional country parks are managed by local authorities, and include Creggan, Carnfunnock, Delamont, Cave Hill, Ballyarnett, Maghery and Loughgall. In addition, there is the large and well-used Lagan Valley Regional Park running from Belfast to Lisburn along the old Lagan Canal. These sites, plus Forest Parks and sites managed by charities such as the National Trust, are vital areas for public access to the countryside where there is a limited system of public rights of way and no 'right to roam'.

18.8.3 Land Use Planning

Planning in Northern Ireland is based on the Regional Development Strategy, supported by a suite of Planning Policy Statements (PPSs) and delivered locally through Area Plans. Planning policy and practice have been undergoing many changes since the resumption of Assembly in 2007. A new Regional Development Strategy is expected to be released for public consultation in early 2011 after several years of development, PPSs are being revised and republished, while Area Plans, which should form the main basis for determining planning, remain at various stages, and the planning system is being significantly reformed through the Planning Bill progressing through the Assembly in early 2011. There is still uncertainty around the timing and extent of the Review of Public Administration, which has been under development since 2000 and aims to reduce the number of Councils while increasing their remit (substantially so in the case of planning powers and corresponding developmental control). A review of development control and other practical aspects of planning came into effect in 2010, and coupled with the revised PPSs on Sustainable Development in the Countryside (DOE 2010e), the Planning Bill and the reform of local government, may have significant impacts on land use and management.

Environmental Impact Assessments and Strategic Environmental Assessments (SEA) are legal requirements for many major developments, plans and programmes. Major SEAs have recently been carried out in Northern Ireland for the Regional Development Strategy (DRD 2009a) and for marine renewable resources

(DETI 2009b). These assessments offer the opportunity for identification and mitigation of environmental issues before development proceeds. They rely on the quality and thoroughness of the assessment to identify potential issues and options.

Environmental Impact Assessment Regulations (e.g. Environmental Impact Assessment Regulations (Forestry) NI 2006) apply to specific projects above a minimum threshold (which can be nil as in the case of deforestation within a designated area). Assessments of plans or projects may also be required in respect of the Conservation (Natural Habitats, etc.) Regulations 1995 and 2004. A considerable body of work is undertaken by statutory bodies including the Forest Service and the Northern Ireland Environment Agency each year in respect of both sets of regulations.

18.8.4 River Basin Management

River catchments have been assigned to River Basin Districts, which serve as the administrative areas for coordinated water management. Of the four RBDs, one is entirely contained within Northern Ireland (North Eastern), while three cross the border into the Republic of Ireland (Neagh Bann, North Western and Shannon) and are therefore designated as International RBDs (**Table 18.23**). A small portion of County Fermanagh contributes to groundwater flow in the headwaters of the Shannon catchment, therefore the Shannon RBD is classified as an International RBD.

Insert Table 18.23 here

River basin plans take an integrated approach to the protection, improvement and sustainable use of the water environment. The objective is to improve the ecological health of waters, support more sustainable use of water, create better habitats for wildlife in and around water, reduce the pollution of groundwater, and contribute to mitigating the effects of floods and drought. The river basin management plans are renewed every 6 years. For example, chemical classification varies among the three RBDs, with the North Eastern RBD having the highest percentage of 'poor' and 'bad' quality in 2008/09 (**Figure 18.61**).

Insert Figure 18.61 here

18.8.5 Agri-Environment Schemes

Agri-environment Schemes include the Countryside Management Scheme, Environmentally Sensitive Areas scheme, Northern Ireland Countryside Management Scheme and Organic Farming Scheme. Theseschemes have been developed by the Department of Agriculture and Rural Development to encourage farmers and landowners to adopt environmentally friendly management practices. The schemes are co-funded by the European Union.

The ESA Scheme was introduced in 1988 and was the first 'on farm' programme designed to promote the integration of production of wholesome food with responsible management of the countryside. By 1994 some 20% of the land area had been designated as environmentally sensitive in five distinct areas (Mournes and Slieve Croob, Antrim Coast, Glens and Rathlin, West Fermanagh and Erne Lakeland, Sperrins and Slieve Gullion; **Figure 18.62**) and by 1995 the Organic Aid Scheme (OAS) had also been launched.

Insert Figure 18,62 here

In 1999 the new Countryside Management Scheme was introduced for those farms outside ESA scheme areas. Coupled with this was the Organic Farming Scheme, which came into operation in 1999. Agri-environment scheme participation, which is voluntary, expanded rapidly in 2005 with increased funding and the introduction of the Single Farm Payment which removed the link between production and subsidies (Cooper*et al.*2009). The most recent agri-environment scheme, the Northern Ireland Countryside Management Scheme, was launched in 2008 along with the New Organic Farming Scheme (NOFS). It is an integral part of the Northern Ireland Rural Development Programme 2007–2013.The likely future emphasis

on climate change and emissions reduction was highlighted in the mid-term evaluation of the Northern Ireland Rural Development Programme (NISRA 2010b).

The NICMS covers all of Northern Ireland. It is a single unified countryside management scheme to maintain and enhance biodiversity in line with the Northern Ireland Biodiversity Strategy and the Northern Ireland Programme for Government 2008–2011 through the positive management of wildlife habitats to enhance ASSI/Natura 2000 sites. It also aims to assist in the implementation of the Water Framework Directive. It is claimed through the IACS Single Application Form (SAF) and in exchange for an enhanced payment, farmers actively manage their farms to achieve a number of benefits (**Table 18.24**; **Table 18.25**). Any farmer or land manager with a Business Identification Number and with at least 3 ha of eligible land can apply on submission of appropriate documents (DARD 2008a).

Insert Table 18.24 and 18.25 here

The total area under agri-environment schemes in Northern Ireland is approximately 468,000ha, 42% of the agricultural land area under agreement (**Figure 18.63**). The priority target in the Northern Ireland (NI) Programme for Government 2008–2011 is to have 50% under environmental enhancement agreement by 2013 (DARD 2008b). In late 2010 there were about 13,000 agri-environment scheme agreement holders, with a further 4,500 applicants awaiting announcements on funding (Aileen Lawson, UFU, pers. comm.).

Insert Figure 18.63 here

The estimated percentage of HAP habitats within the schemes as of 31 December 2009 is presented in **Table 18.26**. While variable, it is clear that a significant proportion of all of these habitats lies within these schemes. Less clear is the extent to which the schemes have been successful in protecting the habitats from damage (habitat quality is not recorded, only area) and monitoring of results for both general and specific outcomes is needed to assess overall effectiveness. Many additional benefits have been identified (DARD 2008a), and as of 31 December 2010 (DARD pers. comm.):

- 14,156 ha of species rich grassland are under agreement by 3,764 participants;
- 496 ha of grass margins are managed by 1,199 participants;
- 627 ha of native trees have been planted by 2,431 participants;
- 1,857 ha of wild bird cover have been grown by 699 participants;
- 578 ha of ancient monuments are protected by 888 participants;
- Farmers have agreed to restore almost 600km of field boundaries; and
- 7,148 ha of farmland are managed for breeding lapwing, curlew, redshank and snipe by 1,339 participants.

Insert Table 18.26 here

18.8.6 Woodland Grants and Certifications

The Woodland Grant Scheme aims to expand the amount of tree cover in Northern Ireland by encouraging the creation of new woodland, subsequently increasing the production of wood, improving the landscape and woodland biodiversity, and encouraging the sustainable management of forests and woodlands. The amount of funding depends on the tree species being planted; conifers covering over 0.2 ha will earn £1,250/ha, broadleaves earn £1,850/ha. Grants are paid in two instalments; 70% after planting and the remaining 30% after 5 years. The scheme came into effect in 1988 and has been periodically updated since then, supporting the planting of almost 12,000 ha (Forest Service 2007b).

Under agri-environment the minimum width of the planted area must be 2m and each area planted must be 0.2 ha or less within a field. The minimum area is 0.01 ha in any one field and the maximum area that can be planted on each farm is 1ha. Five hundred and ninety-five hectares have been planted with native trees in margins/field corners and 31 ha in riparian zones (Forest Service unpublished data).

Agri-environment schemes give financial encouragement to farmers for adopting farming practices that maintain and enhance the conservation value of farm woodland habitat by encouraging natural regeneration of native species and increasing the diversity of woodland ground flora. Since 2005 farm woodlands have been classified into three types; mixed ash, oak and wet woodland. There are two grazing options for managing these three woodland types: no grazing and light grazing. There are 7,043 ha of farm woodland managed as ungrazed woodland and 359 ha managed as grazed woodland. Prior to 2005 all woodland entering into agri-environment schemes was classified as 'farm woodland' or 'carr'. These woodlands may include examples of oak, ash or wet woodland types. Parkland and lowland wood pasture are areas of open grassland with mature trees spaced at various densities within a historic designed landscape. Parkland and lowland wood pasture are often associated with other habitats such as woodlands, lakes, ponds, rivers and streams. The trees, which will have been planted to enhance the landscape, are present as specimens, clumps, avenues, lines and copses and the open parkland will have a history of being grazed (**Table 18.27**).

Insert Table 18.27 here

In Northern Ireland there are two protocols for Sustainable Forest Management, the UK Forestry Standard (2nd edition 2004, 3rd edition due to be published in 2011; Forest Service pers. comm.) and the UK Woodland Assurance Standard. The latter is a certification standard endorsed by the Forest Stewardship Council and provides consumers with assurance that the wood product is produced from a sustainable source. The Forest Service estimate that in 2010 there are 64,000 ha of certified woodland in Northern Ireland, most of which is managed by the Forest Service. Applications for Woodland Grant Schemes are assessed in relation to criteria in the UK Forestry Standard and in respect of the Environmental Impact Assessment Regulations (Forestry) NI 2006.

18.8.7 Less Favoured Areas

The UK designates Less Favoured Areas (LFAs) as land areas of limited agricultural potential; areas where the economic results of farming is below 75% of the national average, population is less that 36 inhabitants/km^2, more than 19% of the working population are engaged in farming, or mountain regions above 600m or with steep slopes greater than 20% incline. Poor farming conditions were defined as producing crop yields of less than 80% of the national average and below the community average, and with stocking densities of less than one Livestock Unit (LU) per hectare and by land values below the national average. Almost 70% of all farmland in Northern Ireland is located in LFA designated areas (DARD 2009b; **Figure 18.64**). This compares to 75% in the republic of Ireland, 47% in the UK and 61% in the EU15 (DARD 2010o). Payment rates for 2011 will be £23.81/ha for Disadvantaged Areas and £47.62/ha for Severely Disadvantaged Areas (NI Executive 2010b). The scheme is open to farmers whose land is used to breed cattle, sheep, deer and goats (DARD 2010j).

Insert Figure 18.64 here

18.9 Knowledge Gaps

A coherent baseline is required on the state of and impacts on Northern Ireland's ecosystems and services, including economic valuation, and how they relate to both the remainder of the UK and the Republic of Ireland. The Northern Ireland Synthesis is a valuable starting point, but much more work is required. This should not be seen as justifying any delay in progressing the issues identified, but rather as a statement that in the time available this is an incomplete picture. Further data exist and are anticipated to be made available in the coming months. An ongoing mechanism to add data to this work should be developed to ensure that it is progressed in a coherent fashion.

Research is needed on how to maintain and enhance ecosystems and identify threats, values and roles. In particular, there is a lack of knowledge in terms of the ecosystem services provided by the marine

environment and a need for better understanding of system boundaries and interactions. Lack of information on an ecosystem service or lack of economic value does not imply an absence of value, but this is sometimes not taken into account when decisions on resource use are made.

Data and research issues centre around whether data exist, their accessibility and their comparability and compatibility. There is an increasing problem of data being seen as 'intellectual property' and therefore not being publicly accessible. Also, many sources of data exist as unpublished reports or in formats that are not easily accessed. There are a number of positive developments, including Inspire and Freedom of Information. Government departments and agencies should be encouraged to continue to improve accessibility, particularly in these times of financial restraint.

Understanding of functioning of ecosystems as a whole is still incomplete. Some ecosystems and some aspects are well understood, but other areas and the complex interactions are under-studied or under-represented. In particular, lack of understanding of underlying biodiversity/physical interactions (especially of soil and marine) makes understanding of ecosystem function difficult. These are complicated areas to study but their importance is increasingly recognised.

Integration across scientific and social disciplines is needed to improve communication and promote understanding of ecosystems and ecosystem services. This requires a 'common language'. Work is also needed to determine how people engage with, are affected by, and use the environment and from that, to understand how to promote the need for environmental protection. This will lead to improved ability to value the environment and make decisions concerning its use.

An agreed set of standardised indicators and definitions is needed across the UK and Ireland. This will allow progress to be easily monitored and compared across regions. Examination of the available information for the Northern Ireland Synthesis has identified a lack of standardisation of methodology, terminology and scale of reporting which makes comparison difficult.

A strategic plan for environmental management and resource use which identifies key ecosystem services and the most appropriate sites for future development and other changes in usage is required. Many decisions impacting on the environment are taken within focused and isolated policy and practical perspectives. The value of ecosystem services transcends the interests or remits of any individual Department or Agency and can only be fully recognised and properly valued when viewed from a broader perspective which looks at all impacts in an integrated fashion. Integration across government is required for effective ecosystem service delivery.

18.10 Conclusions

Northern Ireland's habitats and biodiversity deliver a suite of ecosystem services and contribute significantly to the quality of life and well-being of the population. Maintenance of a cohesive network of protected sites of high biodiversity value, within an appropriately managed wider countryside and marine environment, is key to ensuring delivery of a wide range of ecosystem services. Recognising the potential for multiple ecosystem outputs and establishing the importance of a resilient natural system to mitigate against unexpected natural and man-made impacts can deliver a highly valuable service to all the people of Northern Ireland. Some systems and habitats are currently robust, but others are partially degraded and require positive management to maximise their potential. Delivery of the major 'public goods' for the benefit of the wider community will need to be through landowners and managers, but to do so they require knowledge, skills and financial support. There is a need for a framework within which landowners and managers can operate a vision for the wider environment and improved understanding of its potential for improving human well-being.

The complexities of ecosystem services and their interactions are becoming better understood by ecologists. However, this knowledge and understanding needs wider dissemination and promotion to facilitate its incorporation in government decision-making processes. Many scientific data are not

accessible in Northern Ireland as they have been gathered by government departments and agencies but have not been published. Much of the data which do exist are descriptive; valuation data based on ecosystem services are scarce and these are required to make the case for the integrated ecosystem approach to land and sea management. Recent work on River Basin Management Plans offers the potential to deliver more integrated valuation and quantification of benefits and threats.

Northern Ireland has a range of policies and legislation that impact directly and indirectly on ecosystems and their service delivery, including the responsibility to ensure local compliance with UK and EU legislation. The funding needed to deliver positively on these policies is limited and is not likely to increase during the coming years as fiscal strictures increase. This competition for scarce government funding means environmental protection, aimed at enabling long-term delivery of ecosystem services, may not receive the necessary financial support. The ability to place a value, both financial and social, on the maintenance and enhancement of natural systems will be crucial if the necessary funding is to be secured.

Direct ecosystem outputs include the provision of food, wood, fuel and water. The outputs have changed over time. There is now less peat harvesting, a shift from hay to silage production, a higher proportion of land used for grazing compared to arable crops and increasing reliance on *Nephrops* and aquaculture compared to wild-caught finfish. Northern Ireland is a net exporter of meat and dairy products, but relies on imports of energy, many foodstuffs and other commodities. Major export markets are the Republic of Ireland and Great Britain.

The true value of the countryside and marine ecosystems are not fully recognised due to the difficulty of externalising and quantifying the many values and services ecosystems provide. Landowners are managing their areas in response to a range of drivers, primarily for provisioning services for which they receive monetary benefits, but are also often required to deliver 'public goods' (such as scenery, biodiversity, flood regulation, avoidance of pollution) without being paid directly for such delivery (although subsidies can encourage such action). Farmers manage land primarily for provisioning services and to a lesser extent for cultural services (tourism, recreation). This impacts on other ecosystem services including regulating (purification and detoxification) and supporting services. Beneficiaries of these services include Northern Ireland residents, visiting tourists, people elsewhere consuming exported goods, and in the case of carbon sequestration/storage, the global population. Development in Northern Ireland has resulted in a 'peri-urban' countryside with a dispersed population of commuters, many of whom also have limited awareness of the value of rural ecosystems. As a result, many urban dwellers are not fully aware of the benefits they derive from rural areas and the associated ecosystem services and hence may not value rural areas highly. Equally, ecosystem services currently, and potentially, provided in urban areas are also not widely recognised.

In the future there may be opportunities for multiple use management of habitats and possible changes in what food is produced and how this is done. These changes will impact on individuals whose livelihoods directly depend on ecosystems and on all citizens through the use of the products and the wealth they create. Farming practices and products have changed over time in response to market forces, policy and fiscal drivers, for example the decline in arable farming since World War II and the increase in improved grassland. Dealing with competing land and sea use for food and renewable energy production, recreation and tourism, carbon sequestration and flood control is likely to become a more important issue.

Identification and delivery of multiple outputs from single ecosystems is still in its early stages in Northern Ireland. Traditionally land was viewed as having a single purpose: farmland to produce food, forests to produce timber, or peatland to provide fuel. In recent decades this view has been changing, in particular with the tourism, recreation and leisure aspects of ecosystems such as uplands, coasts and forests being identified and developed. Some multiple service delivery models are being developed, for example woodland to deliver biodiversity and recreation services in addition to timber provision, and the potential of short rotation willow coppice to produce fuel and detoxify sewage. Opportunities for multiple service delivery exist for almost all habitats and encouragement of decision-makers to think more broadly in terms of multiple delivery is beginning to be seen in government policy and funding packages. There is

considerable opportunity to increase this multiple delivery model by taking an ecosystem service perspective when looking at policies and fiscal incentives for land and sea management.

Valuation of ecosystem services is still at an early stage. Taking an ecosystem service view of land and sea offers the potential to identify and put a value on delivery of 'services' which are currently undervalued or even assigned no value at all in standard economic assessments. Valuation of ecosystem services could lead to a radically different approach to ecosystems and their use. The concept of 'public goods' and of supporting people to manage land to deliver these, in addition to or in some cases instead of traditional outputs of livestock, crops and fisheries, may become more acceptable. The value of ecosystem services must be included in the overall assessment of policies and practice.

18.11 Key recommendations

Resilient, biodiverse ecosystems underpin economic and social prosperity by providing a wide range of valuable services. Mechanisms that fully reflect this value in economic and policy decisions are required. An ecosystems approach can demonstrate the synergies between services and lead to integrated management, to the benefit of habitats and citizens. Future challenges (weather, pests and diseases, changing consumer demands, changing political priorities, economic impacts, etc.) could place unanticipated demands on both natural and man-modified ecosystems. Resilience is key to dealing with these challenges.

- An ecosystems approach will conserve the biodiversity and countryside for people to enjoy, but also assist water management, flood control and carbon sequestration and storage, and provide the economic goods derived from these provisioning, regulating and cultural services. In particular, Northern Ireland has abundant peatlands, some unique in their biodiversity, which are valuable as carbon stores in a UK and an EU context.
- Marine and coastal ecosystems are highly diverse and productive, with areas such as Strangford Lough of international importance for biodiversity and important for tourism and recreation. Indeed, Strangford Lough could exemplify the need for a holistic ecosystems approach so that its unique habitats and species can be protected whilst providing living space, employment, recreation opportunities and tourism.
- The abundant freshwater ecosystems, many internationally important for wildfowl, migrant wetland birds and fish, also provide most of Northern Ireland's drinking water and are of value for recreation and tourism. However, many large lakes are eutrophic or hypertrophic as a result of human activity, and this has environmental impacts and imposes a direct financial cost for water treatment.
- Farming in Northern Ireland currently is centred around improved grassland to produce meat and dairy products for both local use and export. With appropriate management, farmland also has potential for contributing to greenhouse gas reduction targets through sequestering carbon and storing carbon in the soil, enhancing biodiversity, ameliorating flooding and addressing waste management and pollution issues.

Ecosystems and their services are complex and interdependent and must be managed in ways that reflect this. The Northern Ireland NEA should inform policy and decision-making to ensure long-term sustainable management of ecosystems and delivery of their services. This requires legislation, guidelines, planning policies, designations, restrictions, fiscal drivers, education and awareness. A fully integrated cross-departmental and inter-sectoral approach to managing ecosystems is needed. Aspects of all Government Departments and numerous agencies impinge on the delivery of ecosystem services, and all sectors both benefit from and impact upon ecosystems and their ability to deliver services. Although there has been a lack of integration of policies and their delivery in Northern Ireland, it is increasingly recognised that the principles of sustainable development are key to ensuring that ecosystem services are maintained and optimised in the long term, both on land and at sea.

Greater understanding is required of the value and benefits that accrue from ecosystem services and the degree to which people rely on the natural environment. There are currently limited data demonstrating and valuing ecosystem services in the UK, especially in a Northern Ireland context. Much greater understanding is required at public and political levels of what ecosystem services are, what benefits society and individuals gain from them, why natural habitats are crucial for providing the resilience necessary for meeting global and local challenges including climate change and food security, and how to manage ecosystems to deliver multiple services. Particularly important to promote are the physical and mental health benefits provided by ecosystems and their role in supporting human infrastructure. Education programmes are beginning to address these issues, but a full programme to inform and involve people during the progression of this agenda is required.

The role of ecosystem services in mitigating the effects of all human impacts, including climate change and biodiversity loss, should be considered in all decisions about the use of land and sea. Conserving ecosystem functionality can avoid or minimise the high costs associated with environmental degradation. Increasing ecosystem resilience will reduce costs by retaining restoration ability in changing circumstances, including unanticipated events. While direct impacts of climate change may be lower in Northern Ireland than in many other parts of the world, impacts of unanticipated events (including severe weather) and changing weather patterns are already apparent. The multiple roles of habitats (for example, of wetlands and peatlands in water management, of Woodlands and peatlands in carbon storage, of coasts and Marine habitats in flood control, of Enclosed Farmland and Semi-natural Grasslands in providing food, and the potential for all habitats to provide renewable energy) need to be fully recognised as underpinning the ability of people to live safely and sustainably. The ability of ecosystems to buffer changes and biodiversity to deliver ecosystem services need to be given full value in policy decisions affecting the environment.

The unique and internationally important biodiversity of Northern Ireland requires specific management and protection measures in an overall context of land and sea management. United Kingdom policies need to be integrated and coherent, but cognisant of and flexible in their response to the unique conditions in Northern Ireland. A network of ecologically coherent sites should form a core for integrated management within the wider environment, delivering ecosystem services and minimising negative environmental impacts, including adapting to climate change. Designation of high conservation value, multiple use sites, including completion of the ASSI network on which EU designations are based, is an important first step. Sites also require effective management to retain or regain favourable condition. Landowners and managers need to be rewarded to deliver 'public goods'. Given the various challenges to special sites (including invasive aliens, climate change, pollution, development), a protection policy is required which ensures that sites are linked and that potentially damaging activities are avoided in their vicinity (buffer zones with some restrictions on permitted activities within them). Invasive species are a major threat and need to be prevented from establishing whenever possible and controlled if they do become established, in order to avoid ecological damage and higher financial costs.

There is an overall trend of a decline in semi-natural ecosystems of high biodiversity with an increase in less biodiverse areas more heavily influenced by human activities. The last 50 years have seen changes in agricultural practices such as a shift from hay to silage production and a decrease in mixed and arable farming; a loss of peatlands, Semi-natural Grasslands and on some wetland habitats due to a range of factors including conversion to intensive grassland; development; drainage; peat cutting; and planting of coniferous trees. Some of these trends have halted or even reversed in recent years in response to changing policies, funding and priorities (e.g. uplands previously often suffered from overgrazing, but undergrazing is now a threat to some semi-natural habitats). However, the continuation of these positive changes will require supportive policy and financial encouragement. Urbanisation of the countryside is continuing, both on natural/semi-natural habitat and on valuable agricultural land.

Carbon storage and sequestration are vital ecosystem services and are cost-effective ways to mitigate and adapt to climate change. Carbon management needs to be seen as an important part of management for multiple service delivery. Key aspects include soils, peatlands, permanent pasture and Woodlands. The full value of sequestration in existing habitats must be factored into carbon/greenhouse gas budgets and

targets and given weight when making decisions on changing management regimes. There is a significant opportunity due to the scale of the resource in Northern Ireland, including potential financial benefits through carbon credits and targeting new markets for low carbon livestock production.

Planning and management policies need to be aligned with natural processes which maintain the capacity to deliver multiple services. Decisions on land and sea management need to be at a strategic level and sustainable in the long term, regarding trade-offs between outputs, opportunities for multiple service delivery and addressing competing demands. Implementing these strategic decisions locally requires a mixture of incentives and regulations for landowners which put an economic value on the 'public goods' delivered by functioning ecosystems.

An Ecosystem Assessment which incorporates the wider British Isles, the Republic of Ireland and the surrounding marine areas would be worthwhile. The island of Ireland should be considered as a whole for ecosystem management. Northern Ireland is unique since its legislation is decided by the Northern Ireland Assembly or UK Government, but it shares a land and sea border with another EU member state, the Republic of Ireland. The international border raises issues of differential management, protection, legislation and funding within single ecosystems. Work on River Basin Management and invasive alien species is proceeding on a cross-border basis and these are positive examples of how management of natural ecosystems benefit from international cooperation. Fiscal drivers can be particularly important in determining how people move, shop and spend their leisure time with regard to the border and the ecosystems which traverse it.

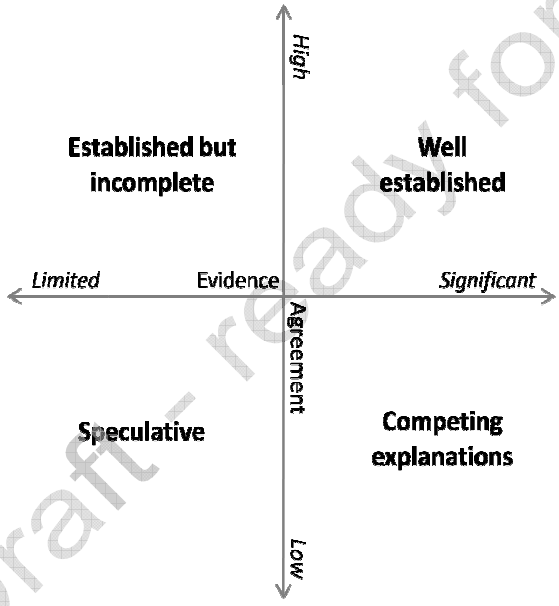
Issues of different data collection methods, metrics and scales make comparisons and long-term monitoring and reporting difficult. Limited data exist in Northern Ireland on local habitats and ecosystem services. Further research, especially around establishing financial values for service delivery, is required. However, there are also issues around what data exist, their accessibility and their comparability/compatibility with other data sets. There is a need for comparable and repeatable methods across the EU, establishing ecosystem indicators and minimum baseline standards to which Northern Ireland data contribute. A variety of methods increases the information available, but mechanisms to compare data sets are crucial.

Appendix 18.1 Approach Used To Assign Certainty Terms To Chapter Key Findings

This chapter began with a set of Key Findings. Adopting the approach and terminology used by the Intergovernmental Panel on Climate Change (IPCC) and the Millennium Assessment (MA), these Key Findings also include an indication of the level of scientific certainty. The 'uncertainty approach' of the UK NEA consists of a set of qualitative uncertainty terms derived from a 4-box model and complemented, where possible, with a likelihood scale (see below). Estimates of certainty are derived from the collective judgement of authors, observational evidence, modelling results and/or theory examined for this assessment.

Throughout the Key Findings presented at the start of this chapter, superscript numbers and letters indicate the estimated level of certainty for a particular key finding:

1. *Well established*: high agreement based on significant evidence
2. *Established but incomplete evidence*: high agreement based on limited evidence
3. *Competing explanations*: low agreement, albeit with significant evidence
4. *Speculative*: low agreement based on limited evidence



a. *Virtually certain*: >99% probability of occurrence
b. *Very likely*: >90% probability
c. *Likely*: >66% probability
d. *About as likely as not*: >33–66% probability
e. *Unlikely*: <33% probability
f. *Very unlikely*: <10% probability
g. *Exceptionally unlikely*: <1% probability

Certainty terms 1 to 4 constitute the 4 box model, while a to g constitute the likelihood scale.

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Graphics

FIGURES

Figure 18.1 Summary of the factors impacting on land use and ecosystem service delivery.

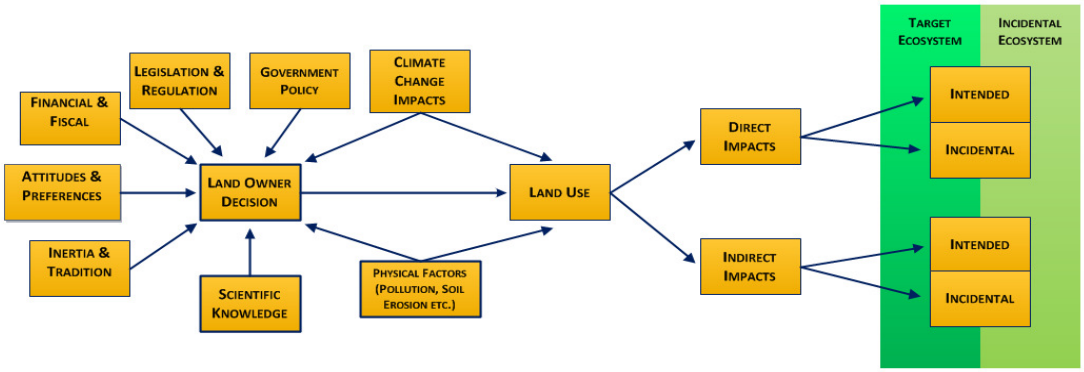


Figure 18.2 Status of Northern Ireland priority habitats in 2005 and 2008. Source: reproduced from NIEA (2011).

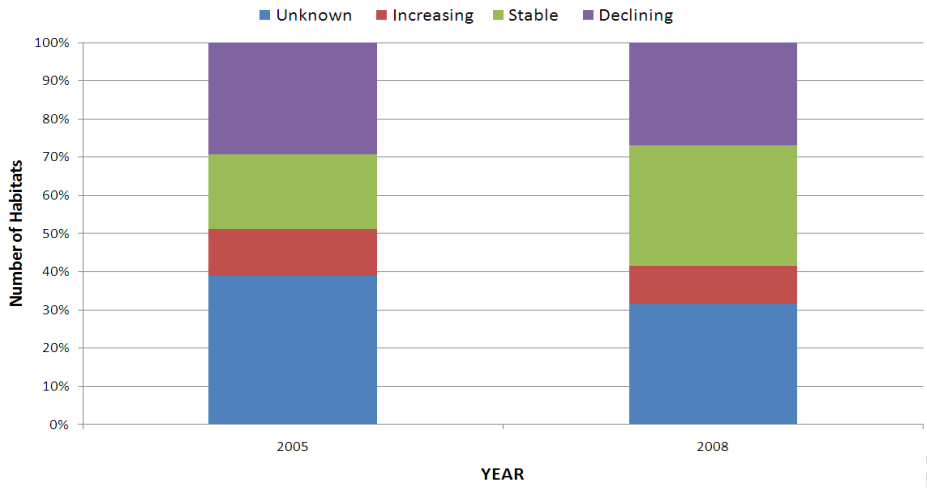


Figure 18.3 Status of Northern Ireland priority species in 2005 and 2008. Source: reproduced from DOE & NISRA (2010).

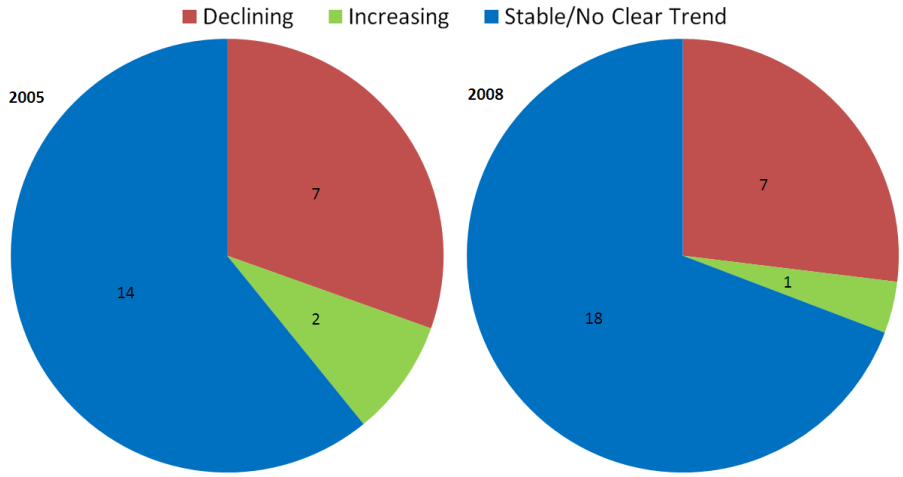


Figure 18.4 Status of Northern Ireland's biodiversity exemplar species. Source: reproduced from NIBG (2009).

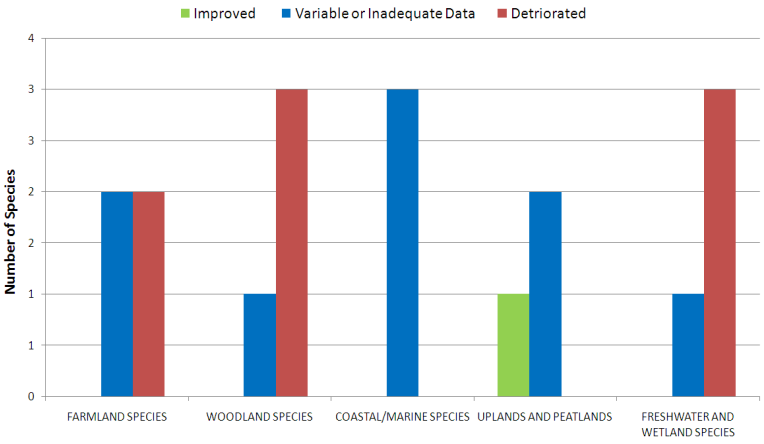


Figure 18.5 Northern Ireland land cover map. Source: NIEA (unpublished data).

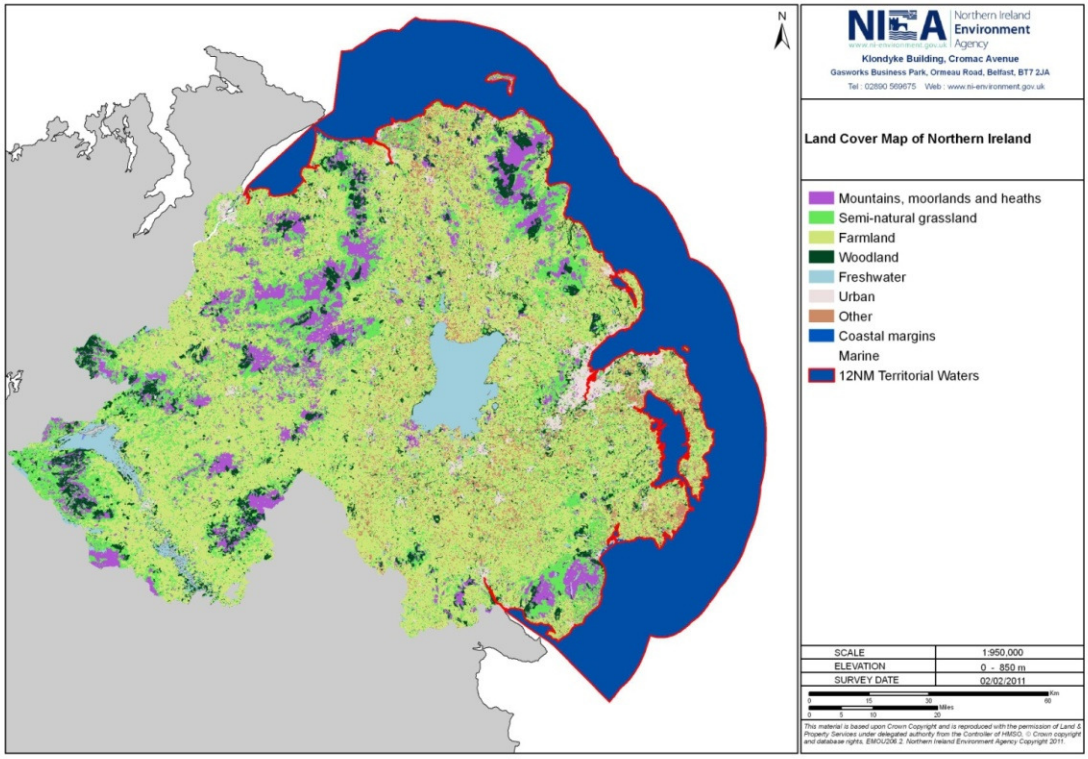


Figure 18.6 a)The percentage of Northern Ireland's land area (area to HWMMT, i.e. 1,416,047ha) covered by each UK NEA Broad Habitat in 2007;andb) the relative percentages of each UK NEA Broad Habitat category represented in Northern Ireland in 2007 including marine to 12 NM. Source: data from a) Cooper & McCann (2010) and b) Cooper & McCann 2010 (NIEA 2010h).

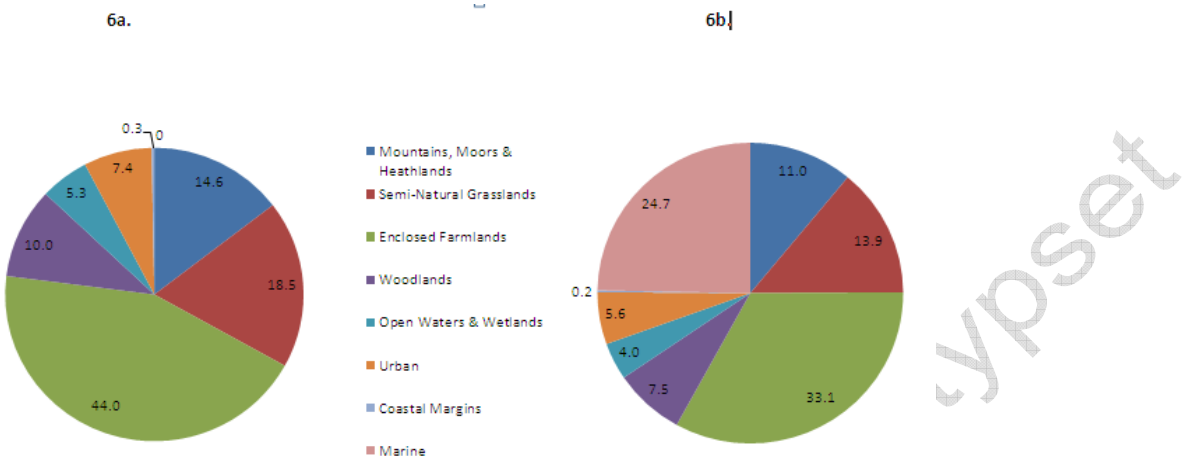


Figure 18.7 Change in the percentage cover of the main Northern Ireland Countryside Survey broad habitats between the baseline survey (1986–1991) and the resurveys in 1998 and 2007. Source: data from Cooper *et al.* 2002 and Cooper *et al.*2009.

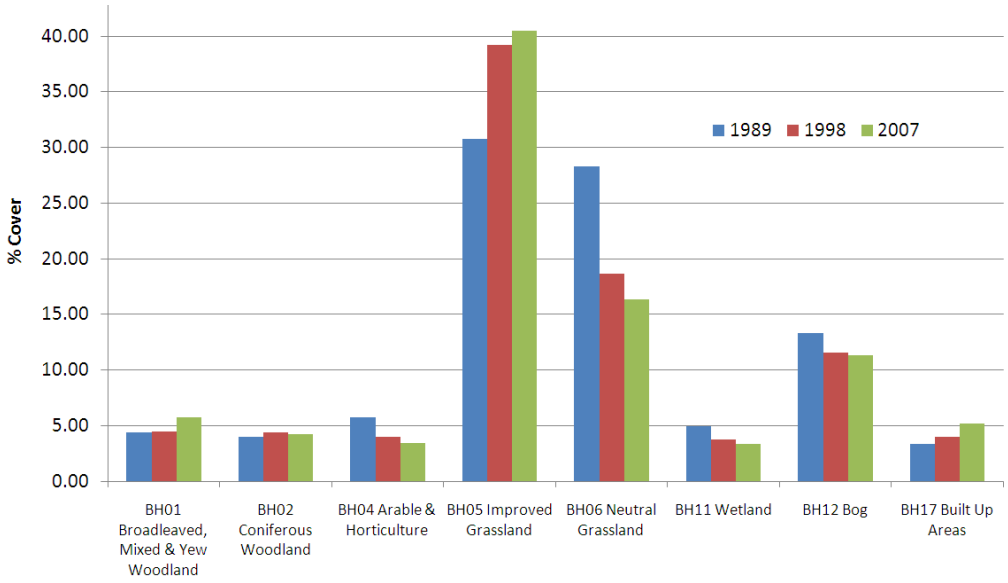


Figure 18.8 Net transitions (of >1,000 ha) between Countryside Survey broad habitats from 1998–2007. The area of each broad habitat is for 2007. Brown line = mainly agricultural conversion; green line = mainly ecological succession or conversion to woodland; grey line = building. Box colour denotes the predominant UK NEA Broad Habitats: red = Enclosed Farmland ; purple = Mountains, Moorlands and Heaths ; orange =Woodlands ; grey = Urban, green = Semi-natural Grasslands . Source: data from Cooper *et al.* 2009.

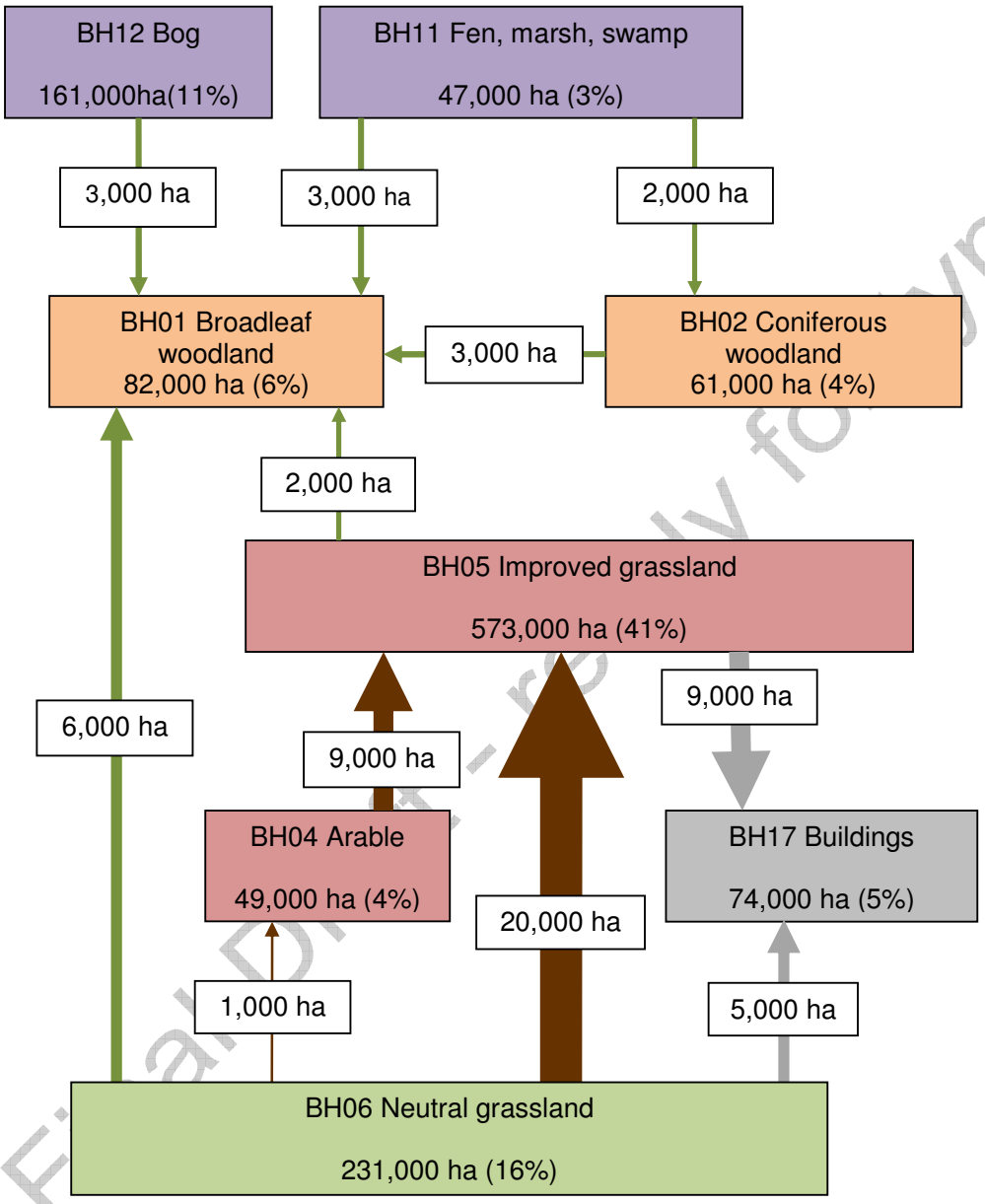


Figure 18.9 Agricultural land classification system. Land classes graded as: Class 1 = Excellent quality; Class 2 = Very good quality; Class 3a = Good quality; Class 3b = Moderate quality; Class 4 = Poor quality; Class 5 = Very poor quality. Source: reproduced from Cruickshank (1997).

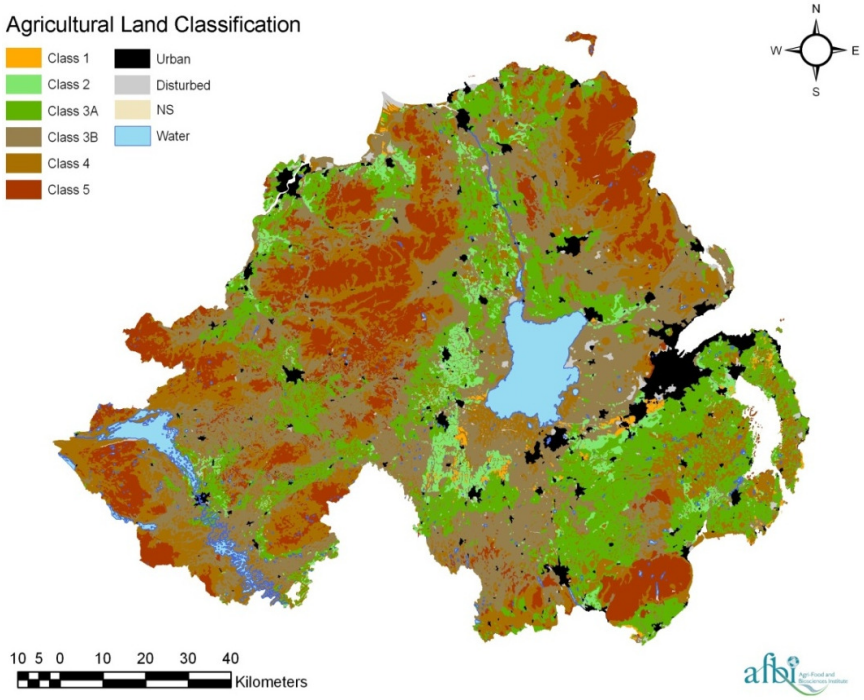


Figure 18.10 Agricultural land use from 1981 to 2009. Values based on numbers corrected for variations in data collection techniques of the June Farm Census. Solid lines reference axis on left, dotted lines axis on right; grass is by far the largest land use. *Arable = arable silage and arable forage crops as well as oats, wheat, barley, mixed corn, potatoes, oilseed rape and some other crops. Data for forage crops only included in total from 1997 onwards. **Excludes common rough grazing; ***Includes set aside. Source: data from DARD (2010c).

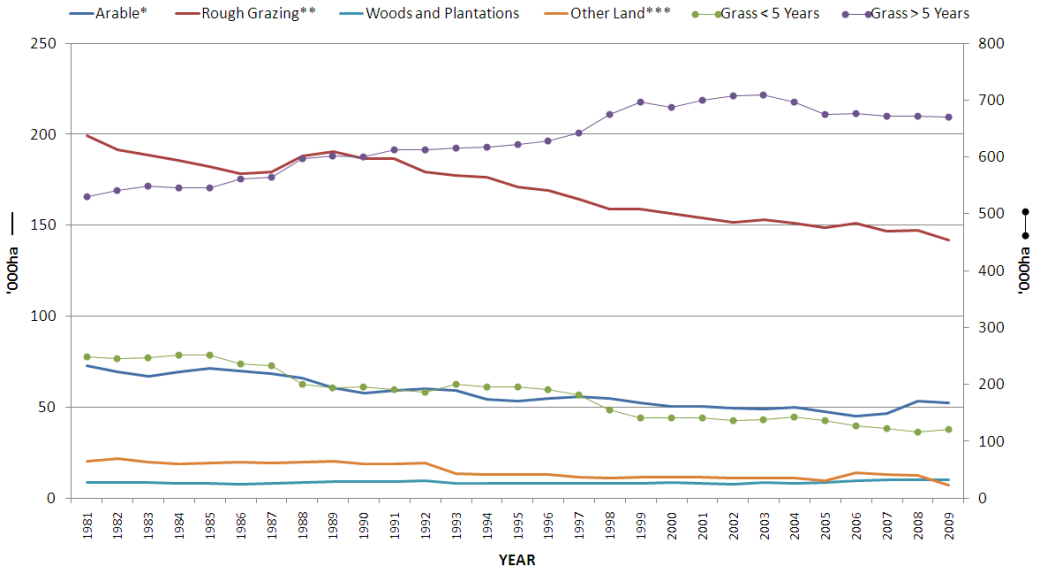


Figure 18.11 Fertiliser use in Northern Ireland between 1998 and 2010. Source: data from DARD (2010h).

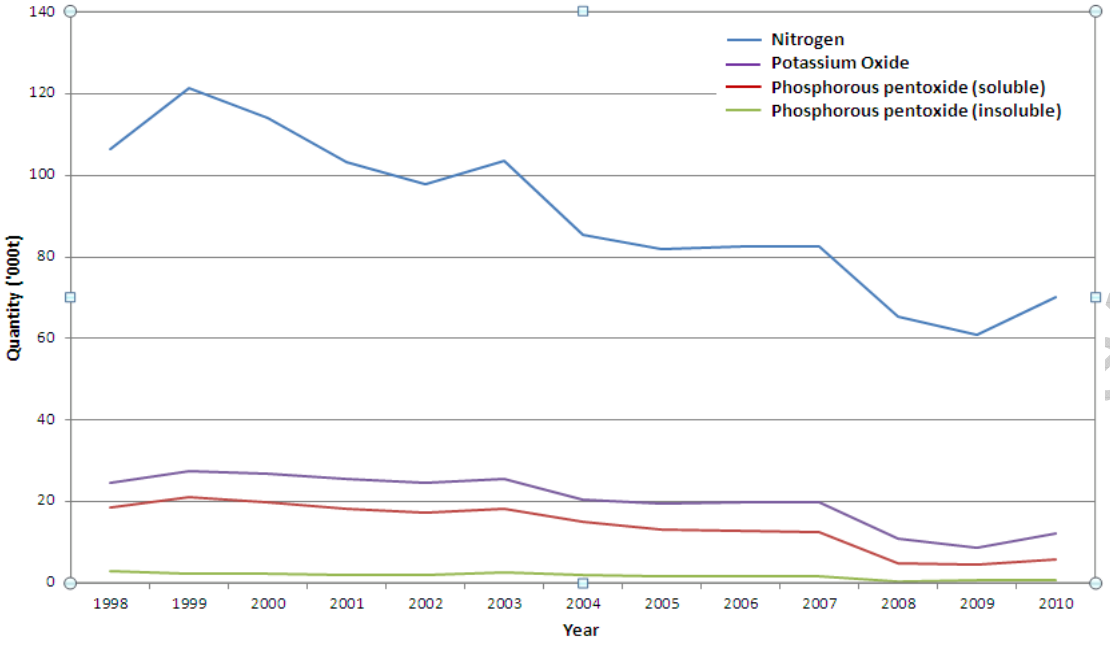


Figure 18.12 Hay and silage production from 1981 to 2009. Solid lines refer to left axis, Area Cut; dotted line to right axis, Production Source: data from DARD (2010i).

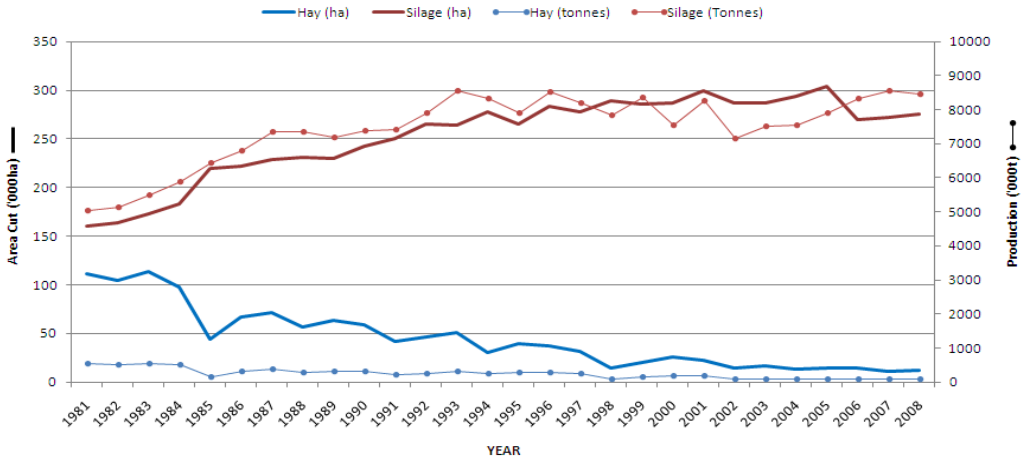


Figure 18.13 Areas under different arable and horticultural crops in Northern Ireland from 1981 to 2009.A) wheat, potatoes and barley; B Horticulture, Other Crops, Oilseed Rape, Arable Crop Silage and Oats) Source: data from DARD (2010c,j).

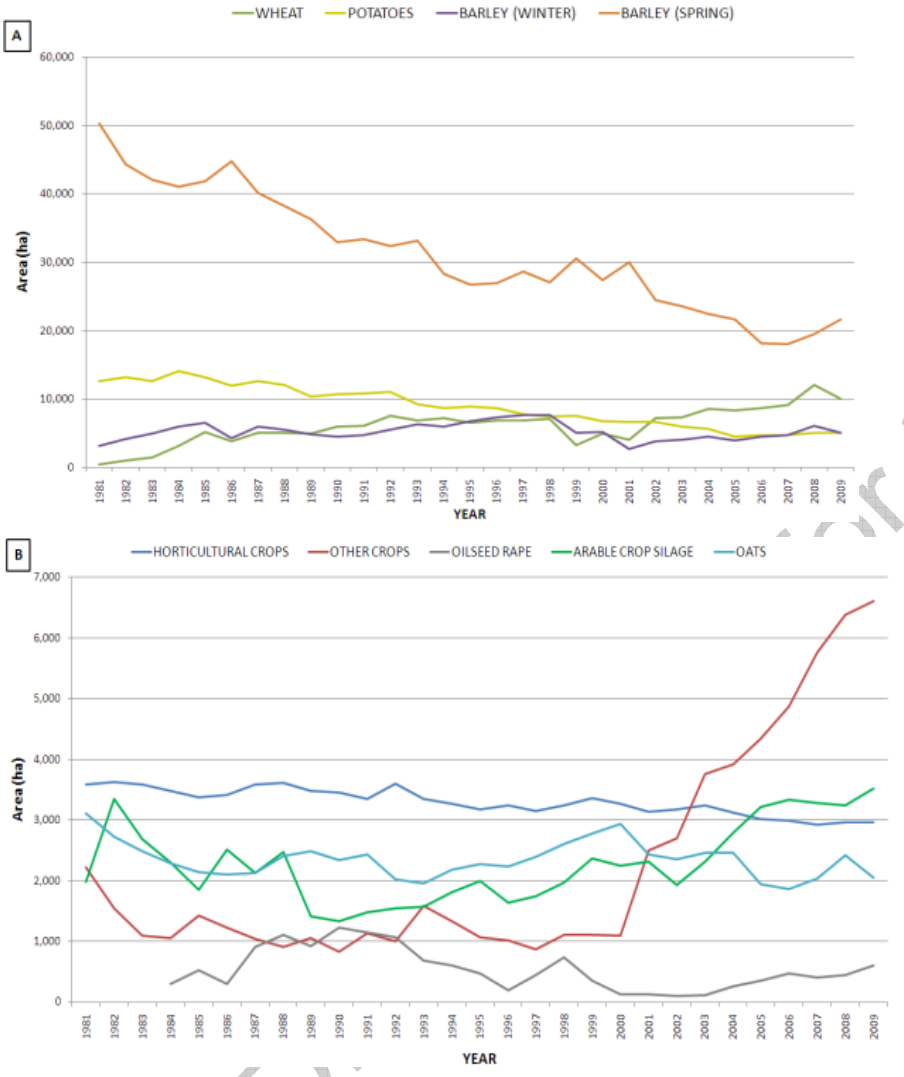


Figure 18.14 Distribution of forests managed by the Forest Service in Northern Ireland. Source: Forest Service (unpublished data).

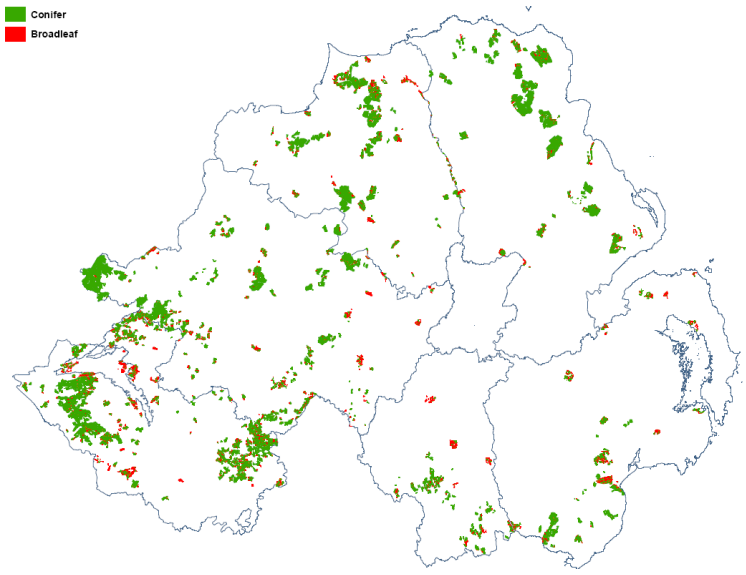


Figure 18.15 Age structure of woodland in Northern Ireland comparing broadleaved and coniferous planting. Source: Forest Service (unpublished data).

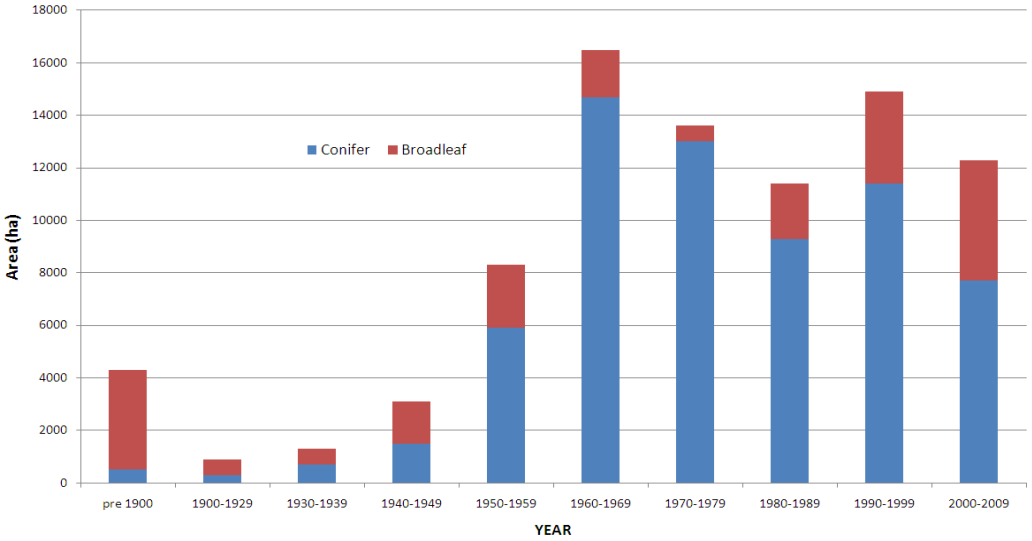


Figure 18.16 Areas of new planting by Forest Service and private planting. Source: reproduced from DOE & NISRA (2010).

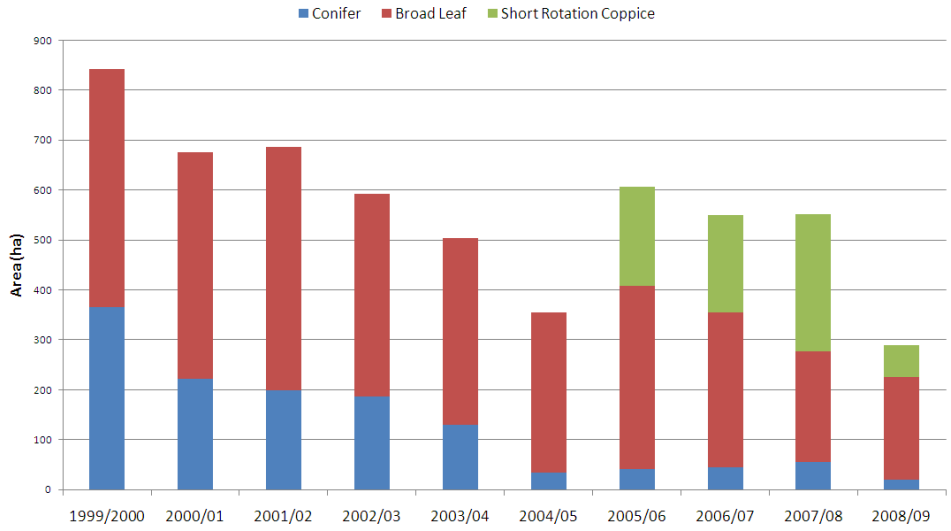


Figure 18.17 River Basin catchment areas in Northern Ireland including major lakes and rivers. Source: NIEA (unpublished). data).

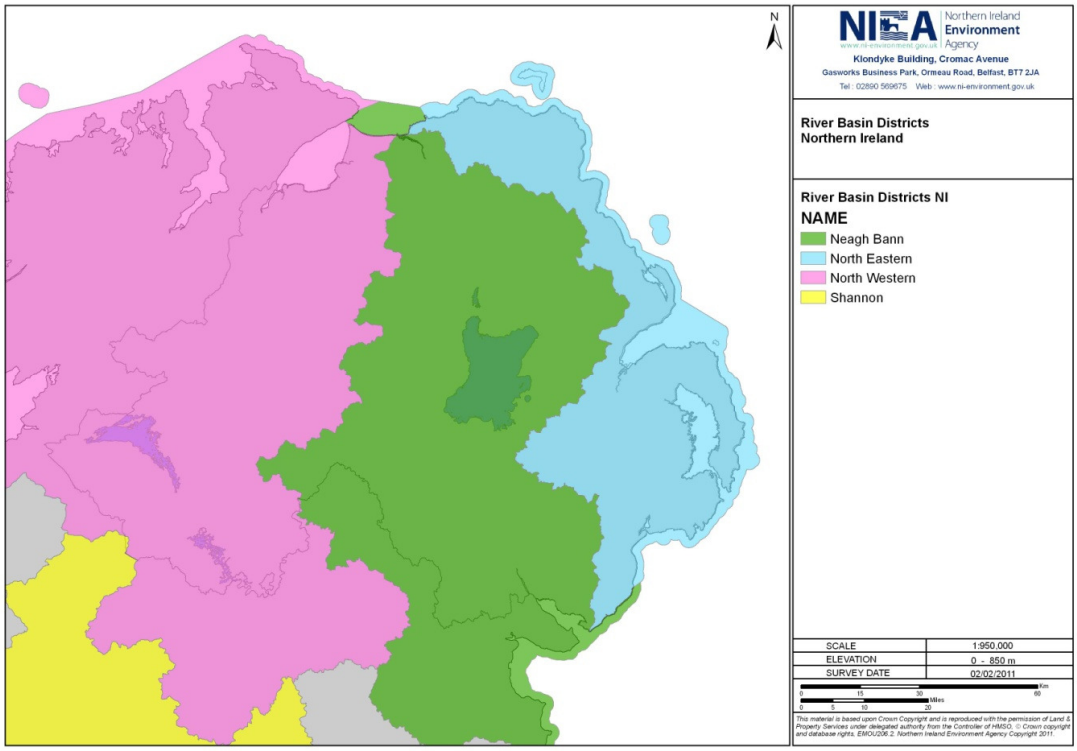


Figure 18.19 Chemical classification between 1996/98 and 2005/07. General Quality Assessment (GQA) chemical classification: Class A (Very good) to Class F (Bad), on a three year rolling sampling period. Methodology details changed between 2001 and 2002. Source: reproduced from DOE & NISRA (2009).

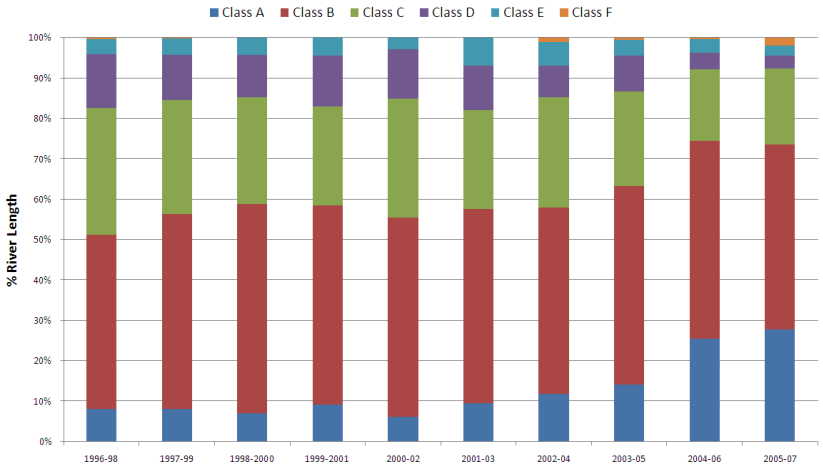


Figure 18.19 Biological classification between 1998 and 2007. GQA biological classification: Class A (Very good) to Class F (Bad). Methodology details changed between 1998 and 1999. Source: reproduced from DOE & NISRA (2009).

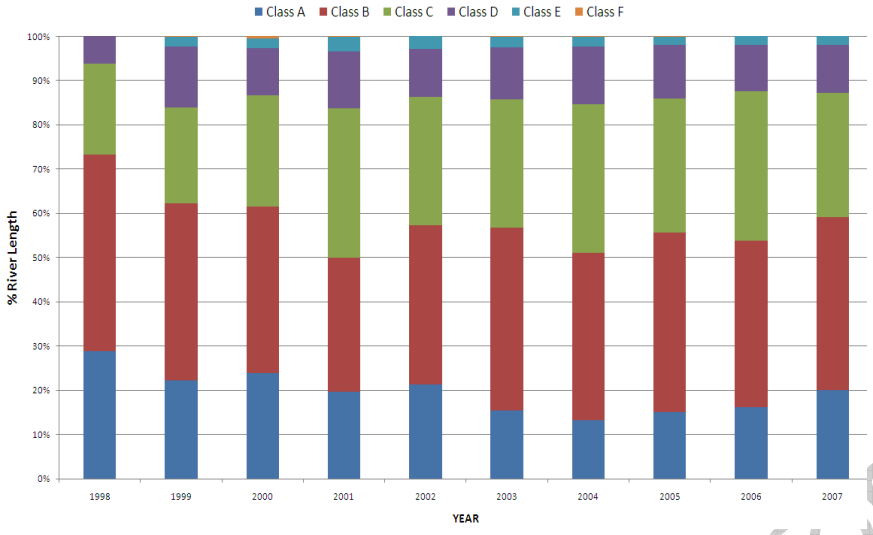


Figure 18.20 Size and location of urban areas of Northern Ireland. Source: reproduced from DOE & NISRA (2010).

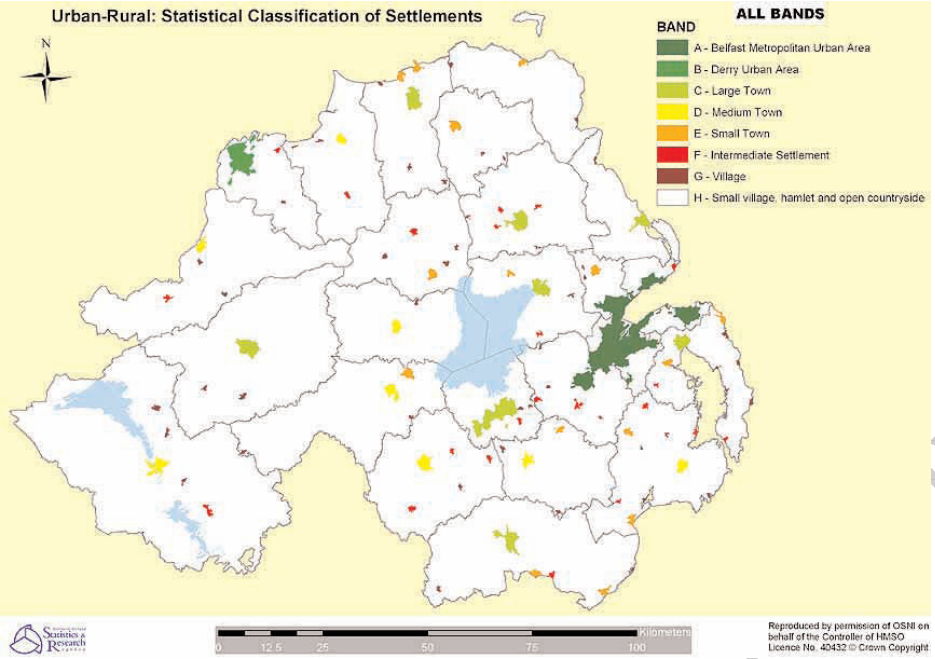


Figure 18.21 Applications for residential development from 2002 to 2009. Source: data from Northern Ireland Planning Service (NIPS 2003, 2004, 2006, 2008, 2010a).

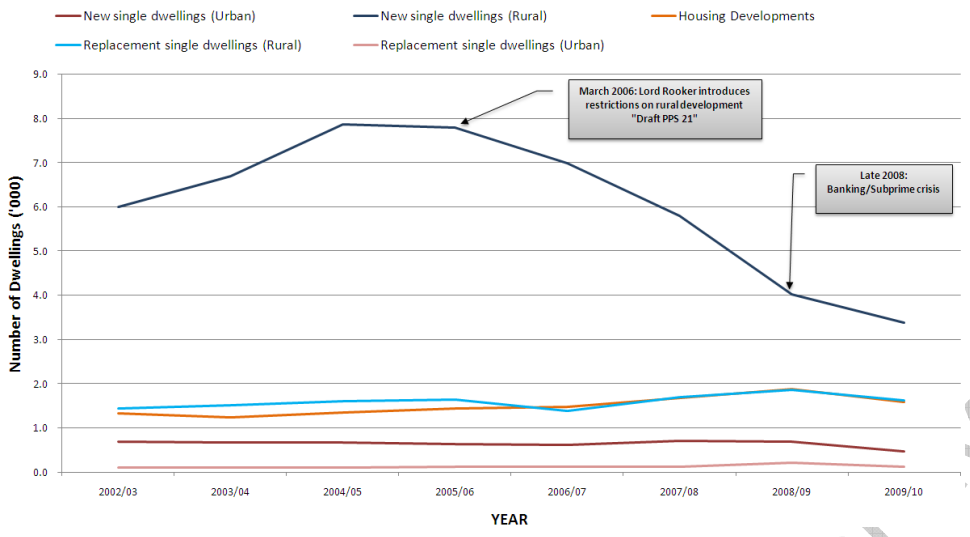


Figure 18.22 Winter dissolved inorganic nitrogen (DIN) for five sea loughs from 1992 to 2005. For all sea loughs (excluding Lough Foyle) the winter DIN values represented are averages from salinities of between 32–34.5 PSU. Lough Foyle is the only sea lough which exhibits the characteristic range of salinities and associated DINs typical of a transitional water and for this reason, the annual DIN value is not an average but is the DIN normalised to 32 PSU for that year. Source: reproduced from EHS (2008a).

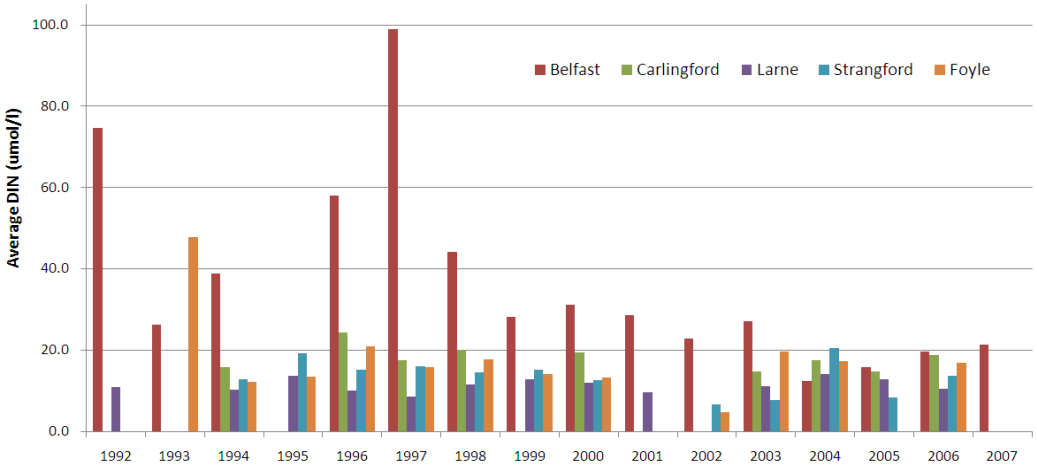


Figure 18.23 Area (in thousands of ha) of the main types of crop in Northern Ireland from 1859 to 2009. Source: reproduced from DARD (2009f).

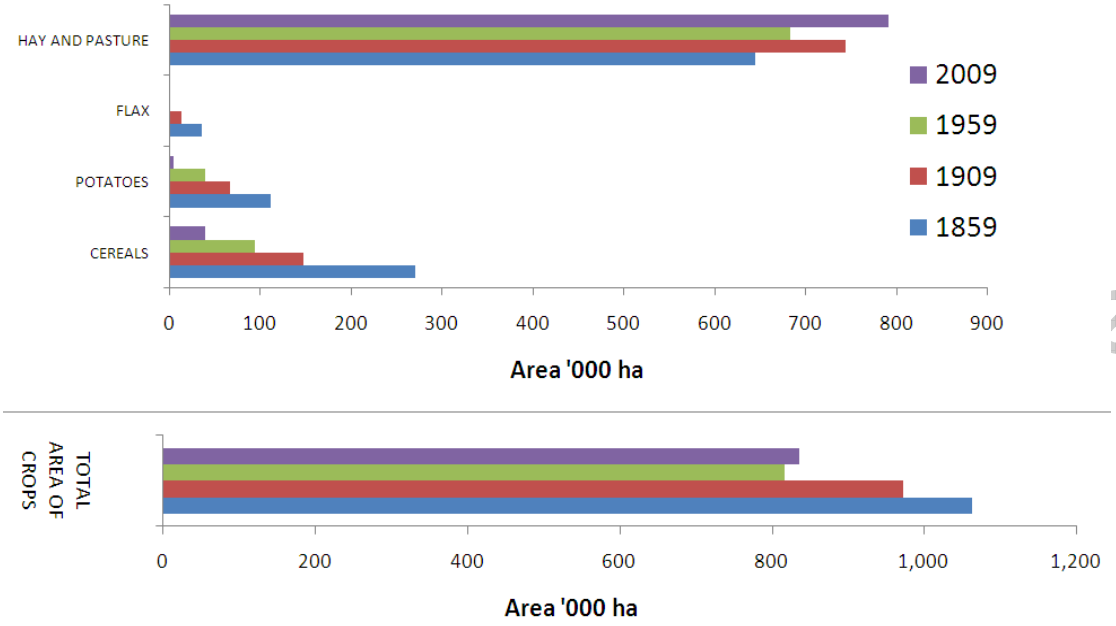


Figure 18.24 Livestock numbers (in thousands) in Northern Ireland from 1859 to 2009. Source: reproduced from DARD (2009f).

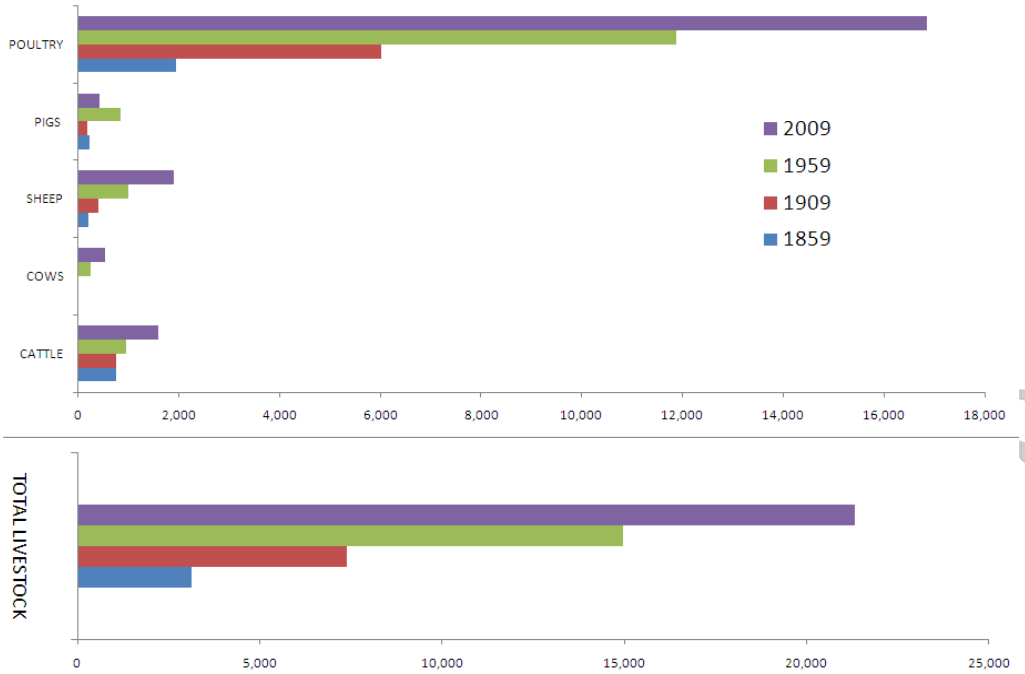


Figure 18.25 Production of arable and horticultural crops produced in Northern Ireland from 1981 to 2009. Source: data from DARD (2010i).

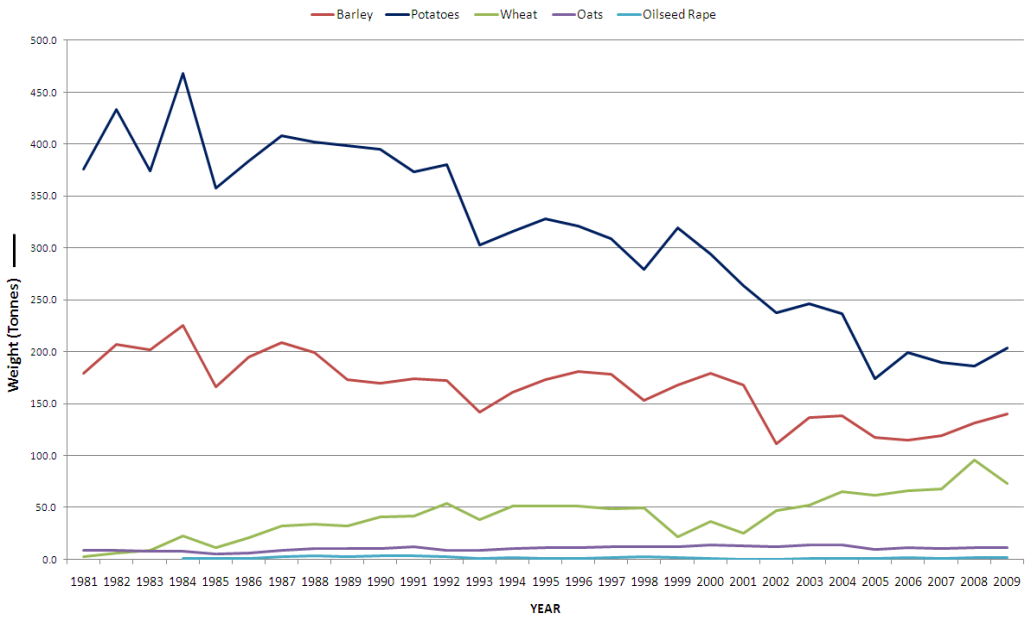


Figure 18.26 Area (—) and tonnage (•—•) of fruit (including apples) and vegetables raised in Northern Ireland between 1981 and 2009. Source: data from DARD (2010c,k).

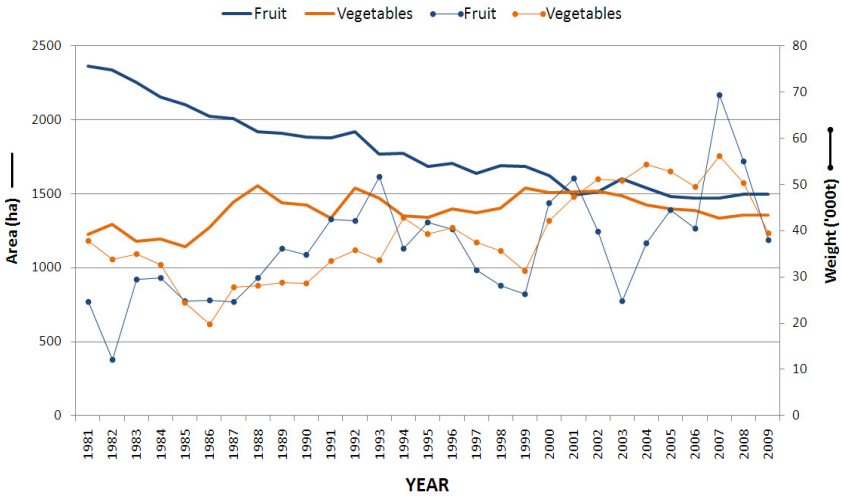


Figure 18.27 Tonnage (—) of mushrooms and apples produced and the average price/tonne (•—•) from 1981 to 2009. Source: data from DARD (2010j).

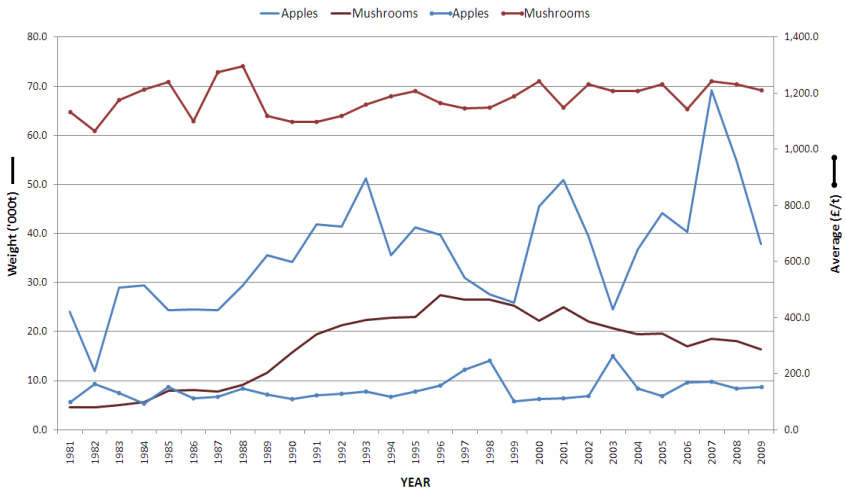


Figure 18.28 Numbers of cattle, sheep and pigs from 1981 to 2009. Source: data from DARD (2010d).

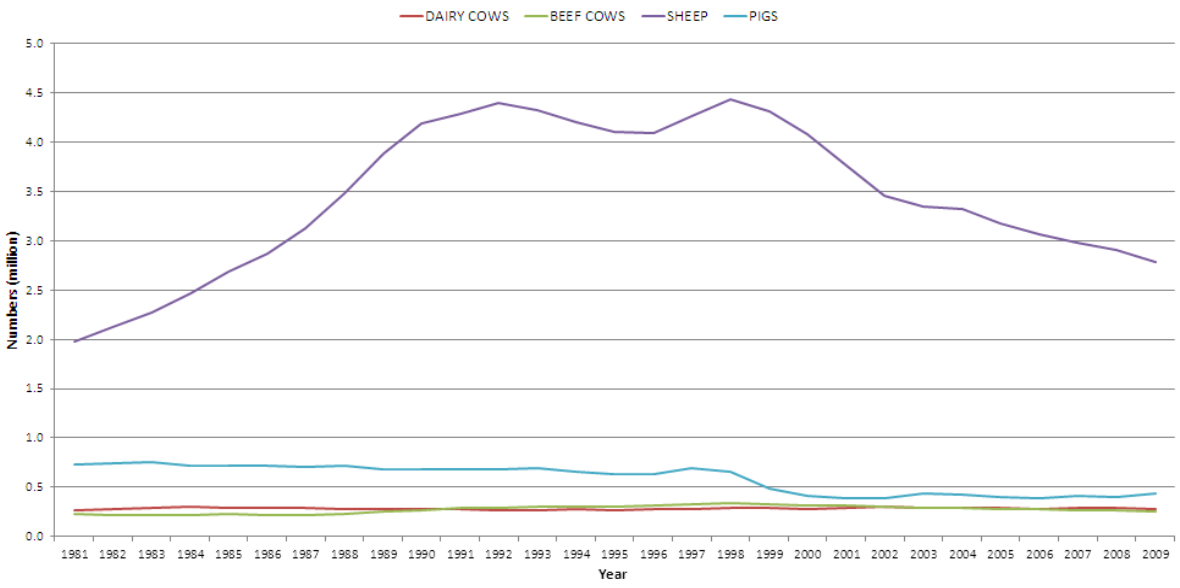


Figure 18.29 Agricultural employment from 1981 to 2009. Source: data from DARD (2010f).

Figure 18.30 Farm numbers (—) and relative income (•—•) from 1981 to 2009. The 2005 index value was set at 100. Source: data from DARD (2010g,q).

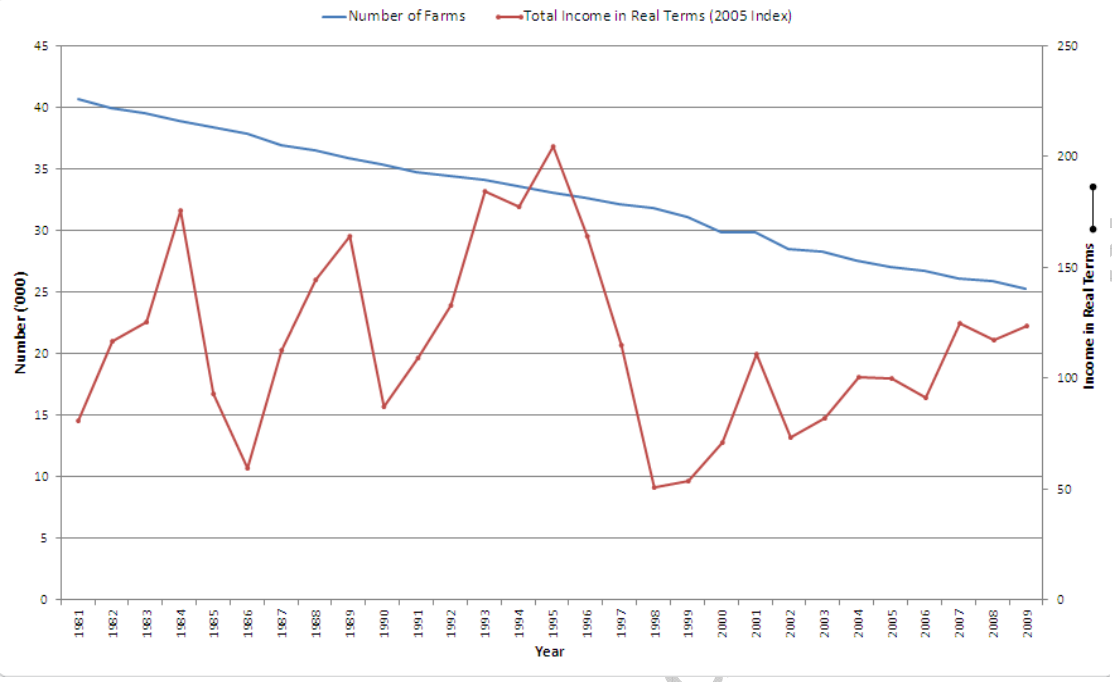


Figure 18.31 Sales for the Northern Ireland Agri-food sector in 2008. GB= Great Britain, ROI=Republic of Ireland, EU = European Union, ROW=Rest of World. Source: reproduced from DARD (2010n).

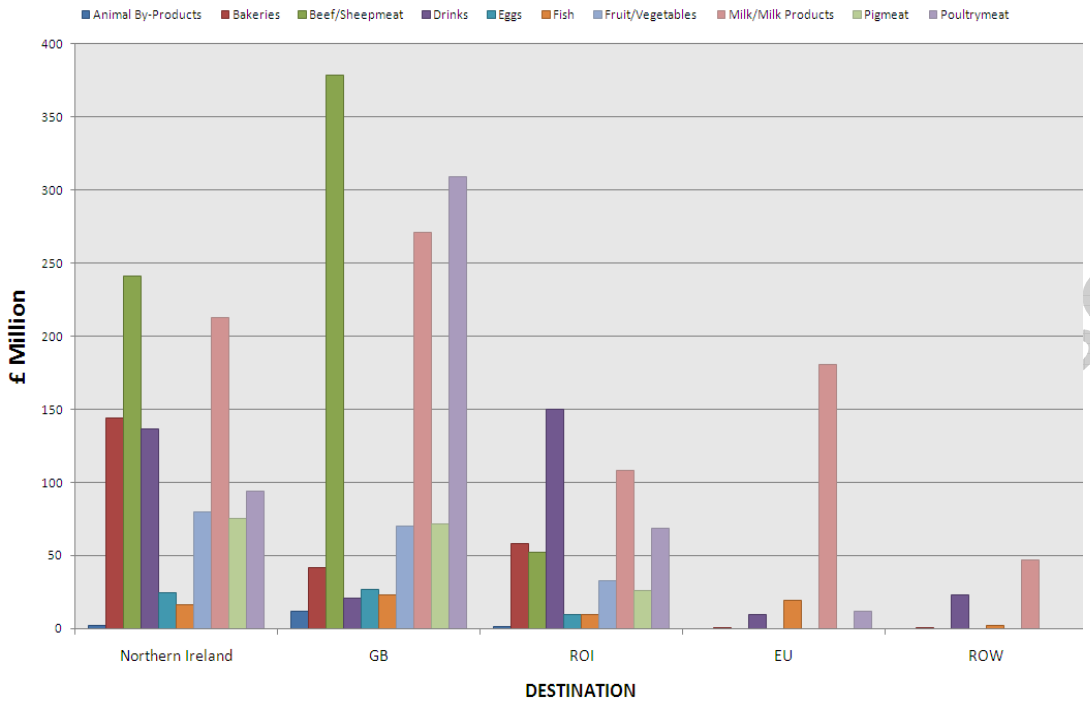


Figure 18.32 Tonnage (—) of fish caught and their value (•—•) from 1999 to 2008. Source: data from DARD (2005; 2009d).

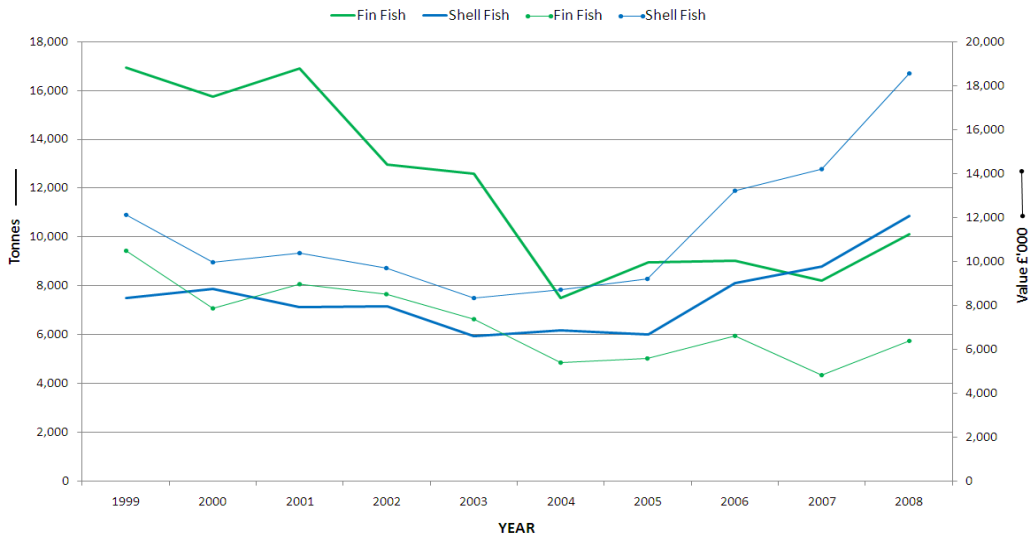


Figure 18.33 Commercial salmon catch in Northern Ireland by weight and value from 1994 to 2007. Figures do not include the Foyle Catchment, which lands fish primarily in the Republic of Ireland. Source: data from DCAL (2008).

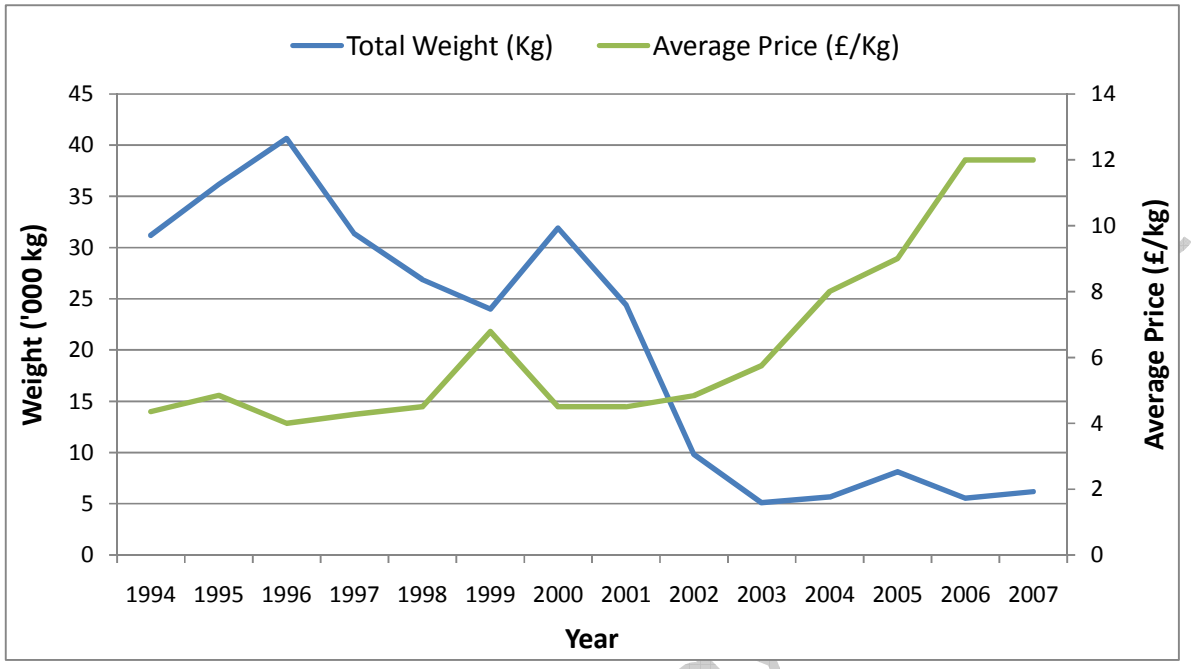


Figure 18.34 Northern Ireland salmon catch from 2002 to 2009 from freshwater, transitional and coastal waters. Source: reproduced from Kennedy *et al.*(2010).

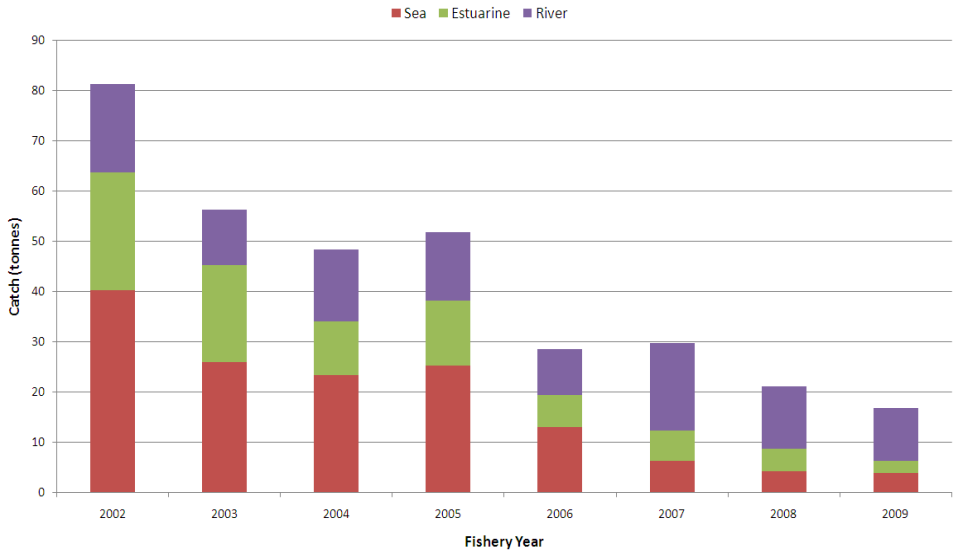


Figure 18.35 Uses of water supplied by Northern Ireland Water. Source: reproduced from Entec (2004).

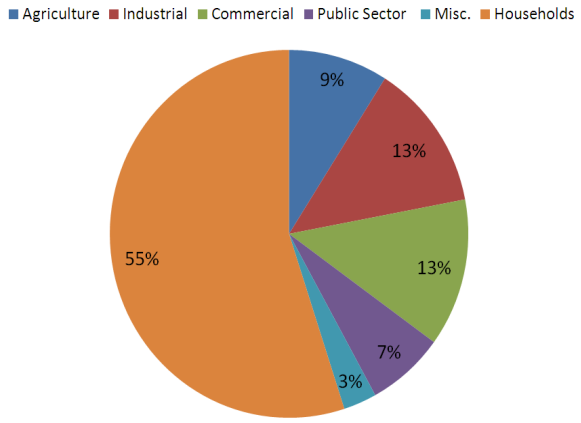


Figure 18.36 Distribution of lowland and blanket peat, mechanised peat cutting for fuel in 1990/91, Environmentally Sensitive Areas, areas of horticultural extraction and existing and proposed windfarms. Source: data from Tomlinson (2010).

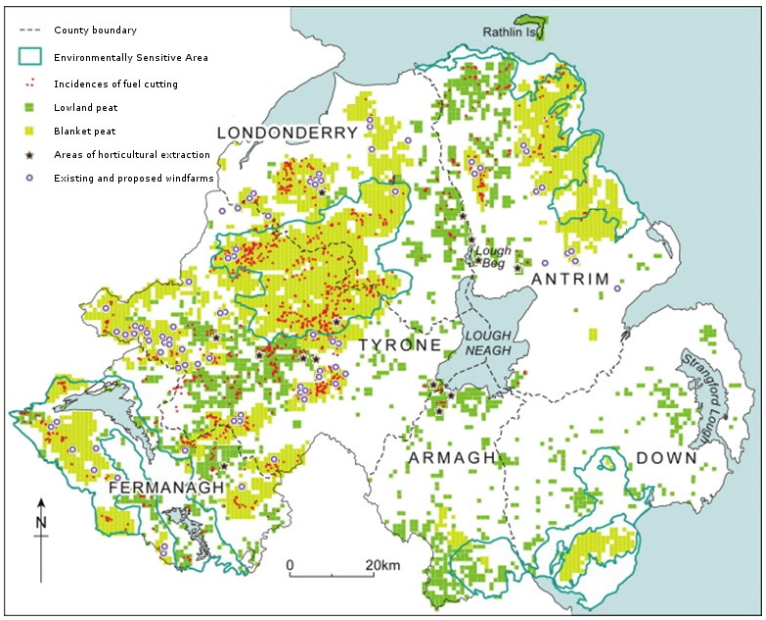


Figure 18.37 Possible sites identified for off-shore renewable energy installations. Source: reproduced from DETI (2009b).

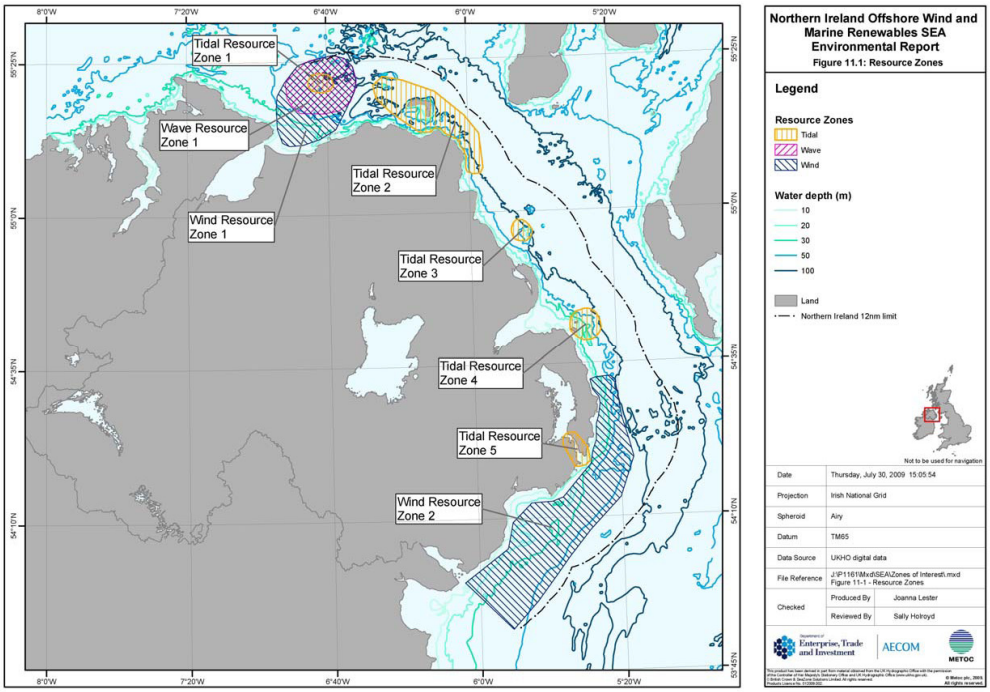


Figure 18.38 Mineral extraction in Northern Ireland from 2000 to 2009. Source: data from DETI (2002, 2003, 2004, 2005, 2006, 2007, 2008a, 2009a, 2010b).

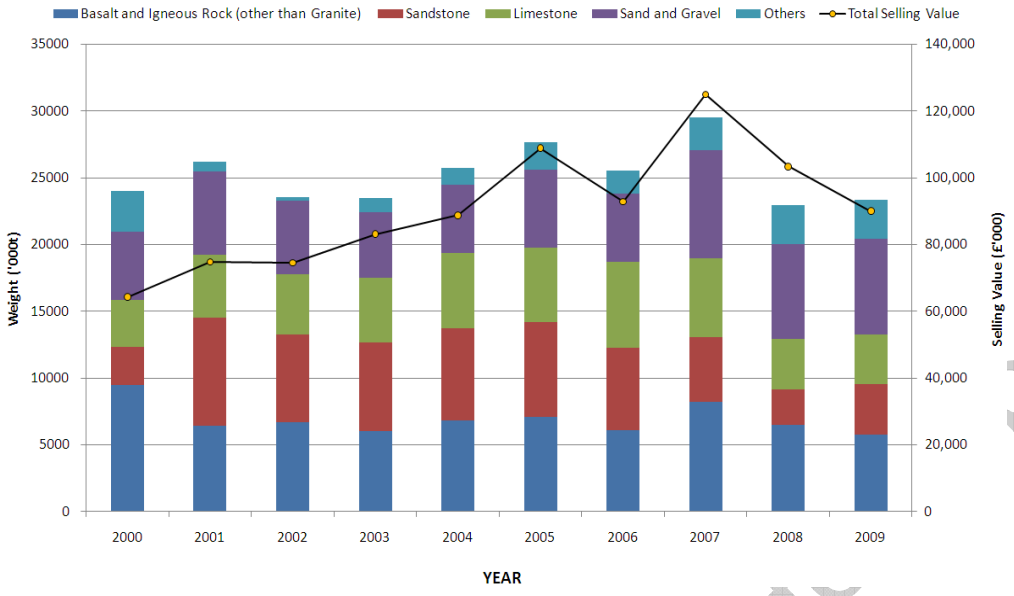


Figure 18.39 Carbon in vegetation and soils. Source: reproduced from Cruickshank *et al.* (1998).

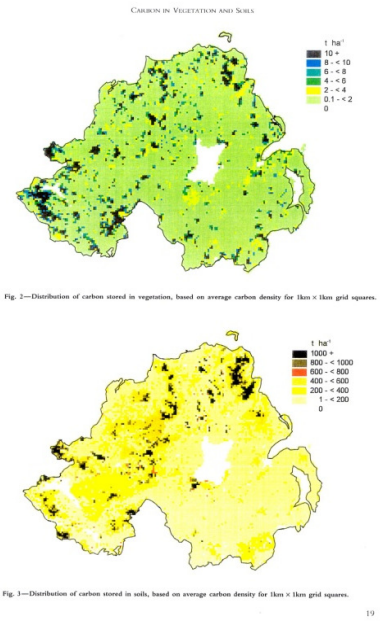


Figure 18.40 a)Phosphorus and b) nitrogen balance in the UK in 2004. Source: reproduced from Foy & Jordan (2011).

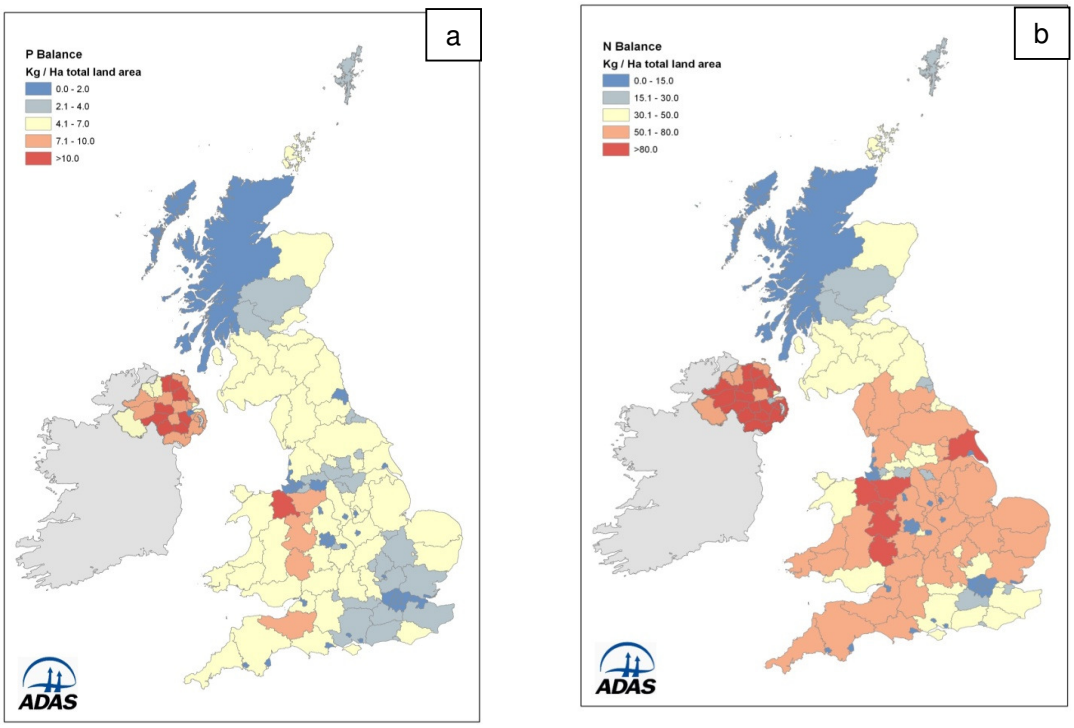


Figure 18.41 Soil phosphorus status for grass production in Northern Ireland in the 1940s, 1990s and 2004. In the 1940s most soils were deficient in phosphorus; by the 1990s 48% had excess phosphorus due to cumulative impacts of phosphorus fertiliser applications above plant requirements. Source: reproduced from Foy & Jordan (2011).

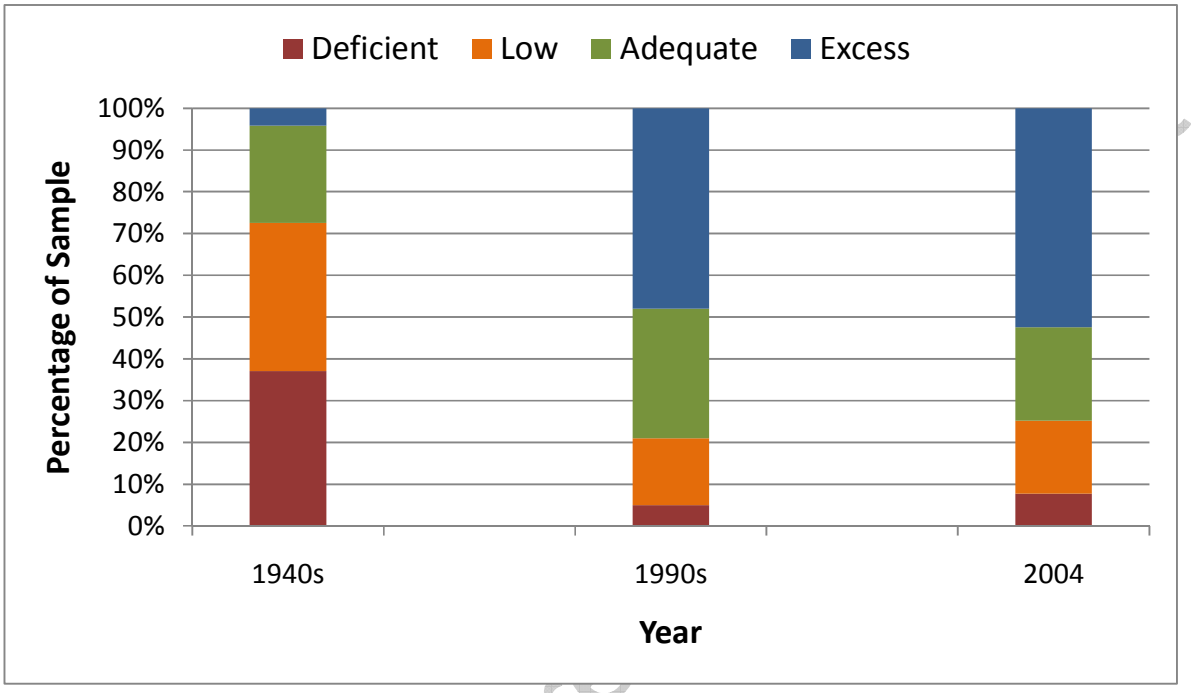


Figure 18.42 Soil phosphorus index of grassland soils (ADAS indices for extractable (Olsen) phosphorus 0=deficient, 2=normal (target), 6=excessive) in Northern Ireland in 2004/6. Agri-Environment Branch, Soil Survey based on 5 km grid sampling showing that 51% of all soils had phosphorus above the normal range, but for intensive grassland soils this figure was 75%. Intensive data based on random sampling of 100 fields on farms stocked at >170 kg organic N/ha. Source: reproduced from Foy & Jordan (2011).

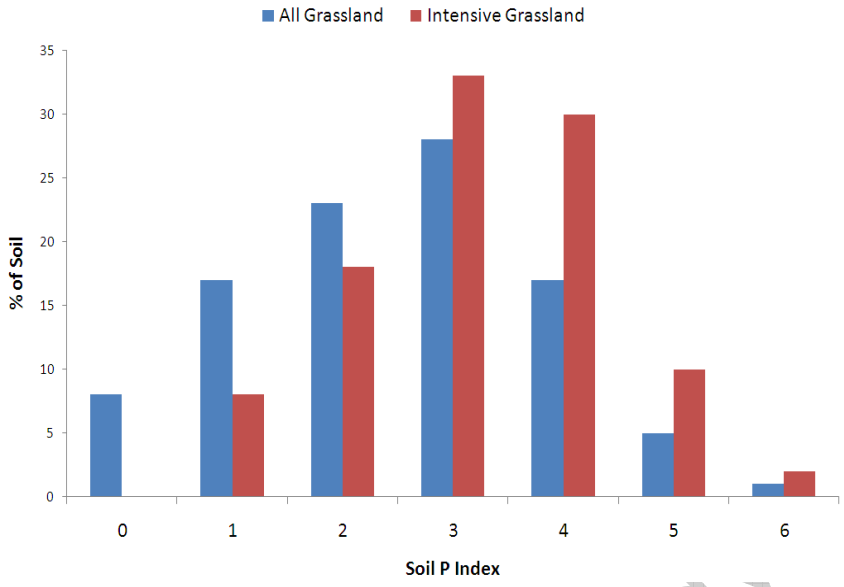


Figure 18.43 Percentage (%) of different types of waterbodies at risk of not meeting Good Ecological Status in 2015 without appropriate management action under the Water Framework Directive 2004. Source: reproduced from EHS (2008a).

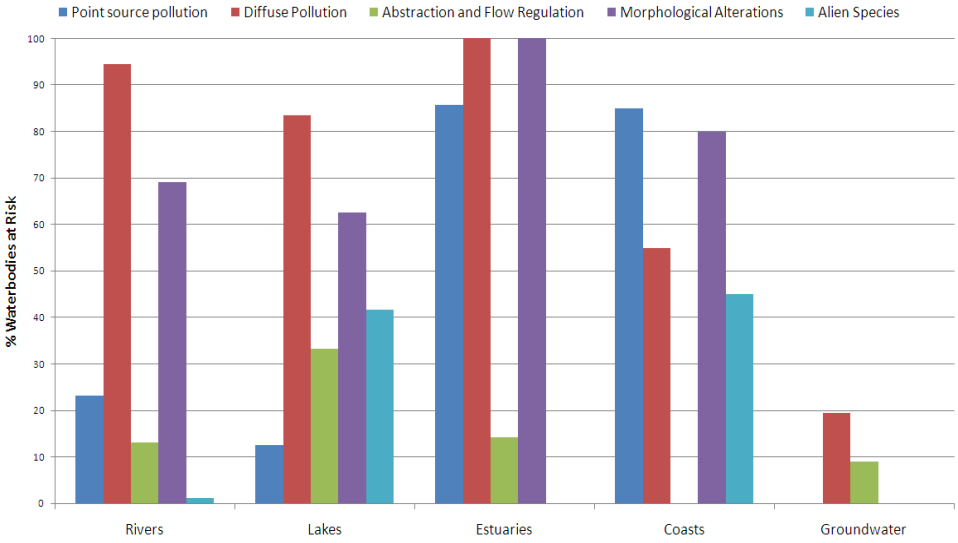
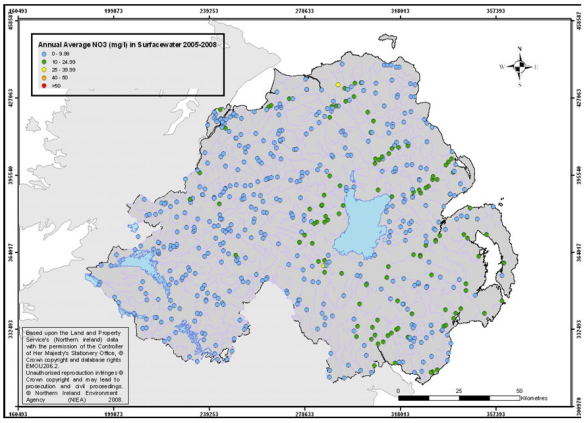


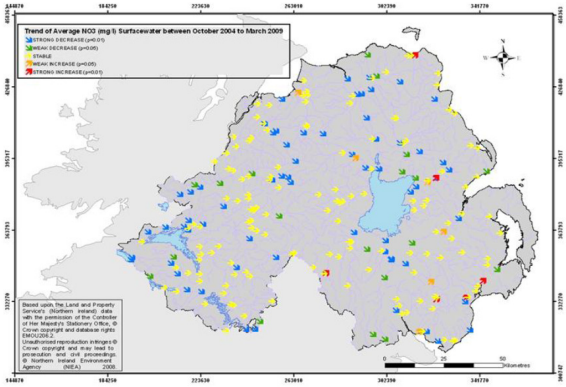
Figure 18.44 Average surface water concentrations of a) nitrate and b) trends, between October 2004 and March 2008. Source: reproduced from DOE (2009).

a)



Average Nitrate	2001-4	2005-8
(mg NO_3/L)	(% sites)	
0 – 9.9	87.9	78.8
10 – 24.9	11.9	20.8
25 – 39.9	0.2	0.4
40-49.9	0	0
>50	0	0

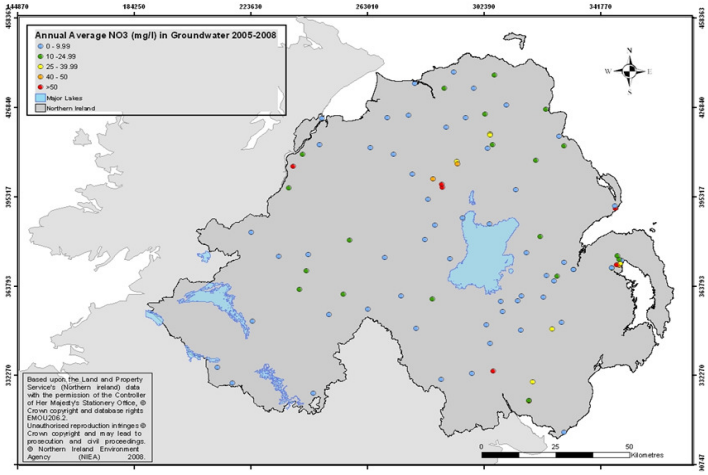
b)



Change probability *p* value		% of sites
Strong decrease	*p*<0.01	26.9
Weak decrease	*p*<-0.05	8.0
Stable	No trend	60.1
Weak increase	*p*<0.05	2.5
Strong increase	*p*<0.01	2.5

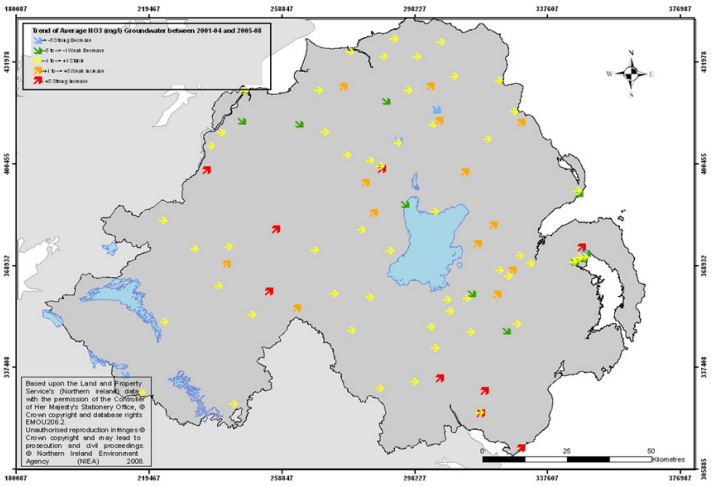
Figure 18.45 Average groundwater concentrations of a) nitrate and b) trends in concentrations, during that period between 2005 and 2008. Source: reproduced from DOE (2009).

a)



Change in average nitrate (mg NO_3/L)		% of sites
Strong decrease	< -5	6.9
Weak decrease	-5 to -1	15.1
Stable	-1 to +1	47.9
Weak increase	1 to 5	17.8
Strong increase	> 5	12.3

b)



Average nitrate (mg NO_3/L)	2001-4 (% sites)	2005-8 (% sites)
0 – 9.9	65.5	56
10 – 24.9	17.3	22.6
25 – 39.9	6.2	8.3
40-49.9	7.4	6.0
>50	3.6	7.1

Figure 18.46 Tourism in Northern Ireland from 1959 to 2009. Note: A change in methodology occurred in 2005 when NITB adopted figures produced by the Central Statistics Office (CSO) for Republic of Ireland residents visiting.1959 to 2004 domestic visits and revenue relate to holiday visits only. 2005 to2009 figures relate to total domestic trips (i.e. holiday, visiting friends/relatives, business and other) and therefore 2005 to 2009 data are not directly comparable with data pre-2005. Source: data from NITB (2010e).

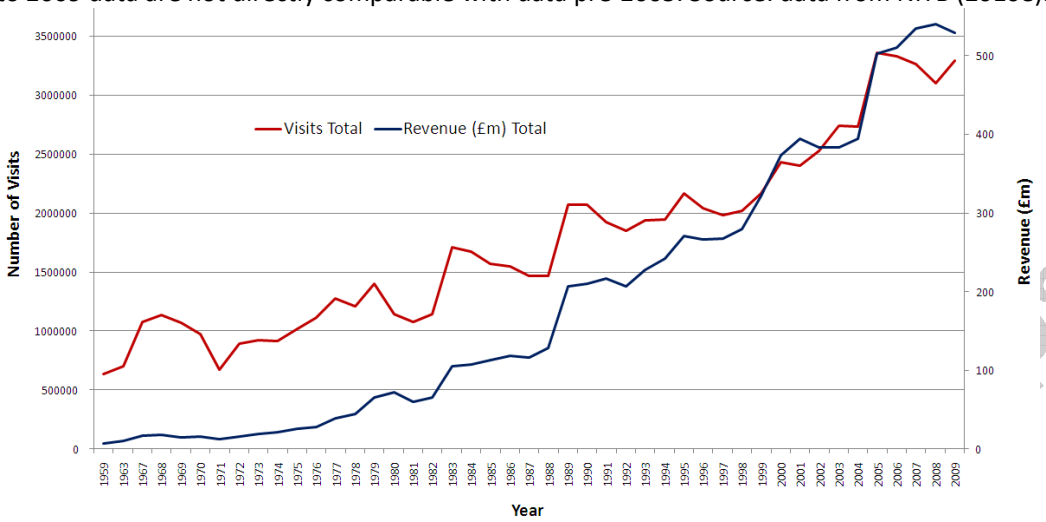


Figure 18.47 Market share of visitors to various attractions in Northern Ireland. Source: data from NITB (2010d).

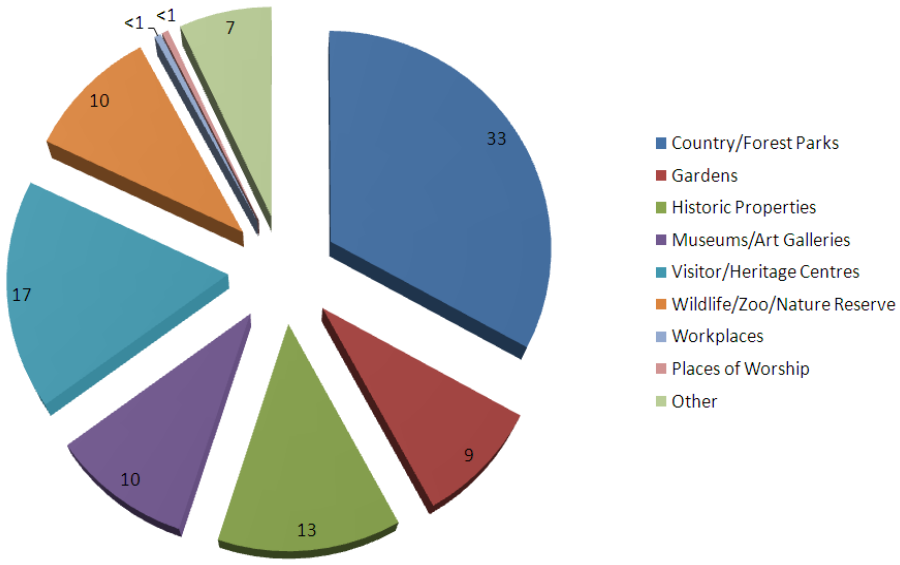


Figure 18.48 Archaeological sites in the Northern Ireland Sites and Monuments Record demonstrating their distribution and number across all habitats. Source: reproduced from NIEA (2010j).

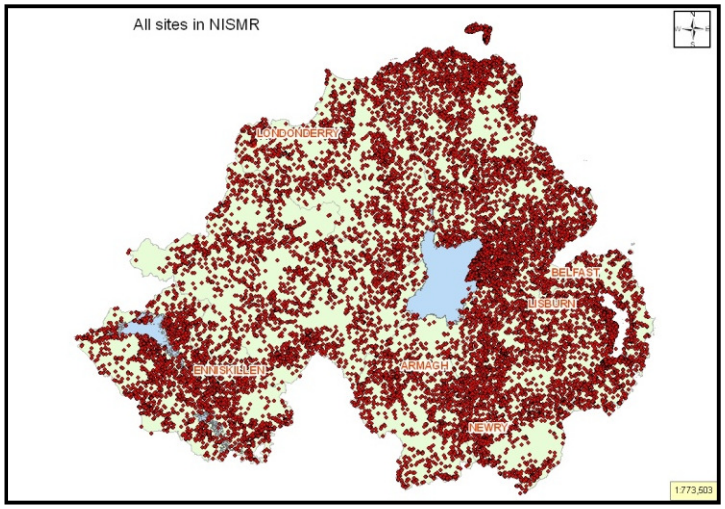


Figure 18.49 A comparison of the condition of monuments in the CAMSAR sample between protected and unprotected sites. Source: date from Gormley *et al*. (2009).

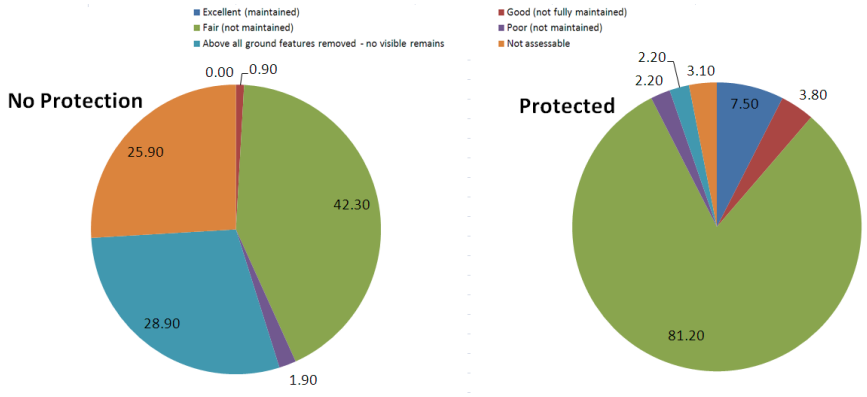


Figure 18.50 Severity of human induced soil degradation in the UK. Source: reproduced from FAO (2005).

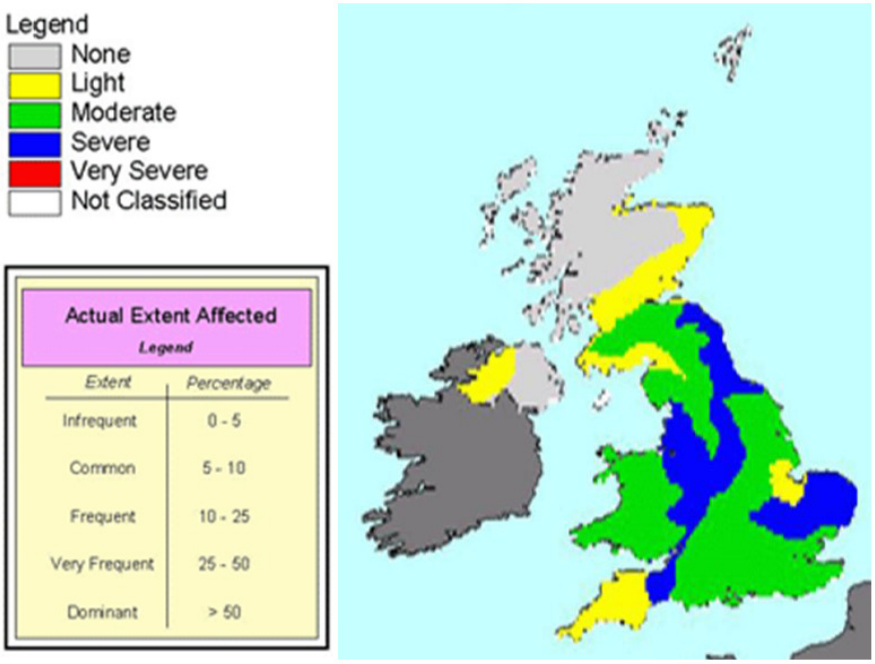


Figure 18.51 Solid geography of Northern Ireland. Source: reproduced from the Geological Survey Northern Ireland (2010).

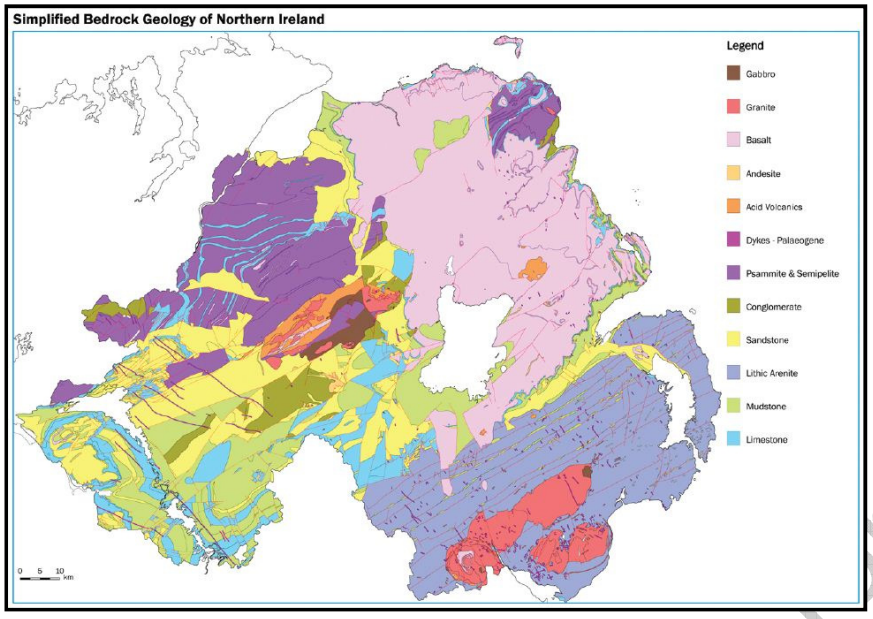


Figure 18.52 Soils of Northern Ireland. Source: reproduced from the Geological Survey Northern Ireland (2010).

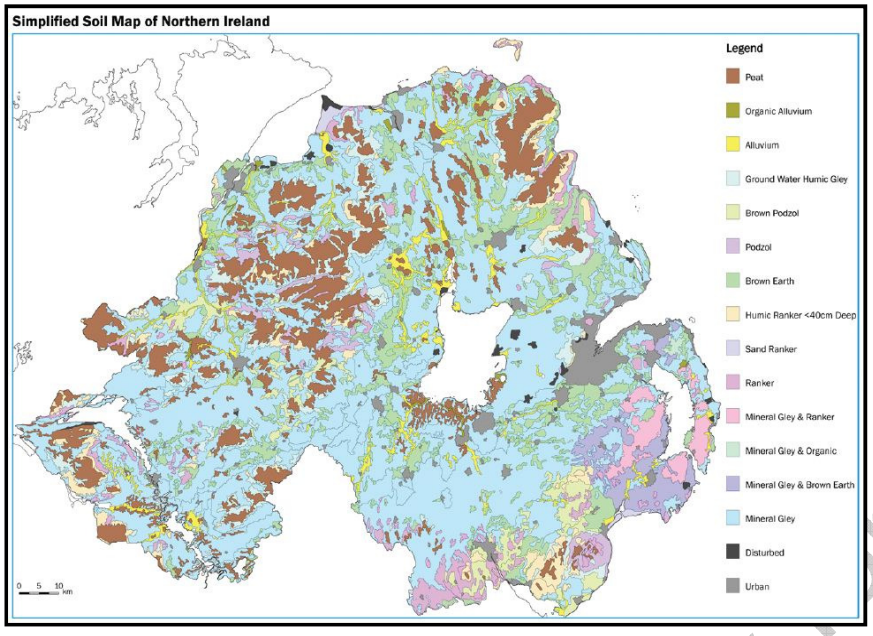


Figure 18.53 Total Economic Value Framework. Source: data from Defra(2007a).

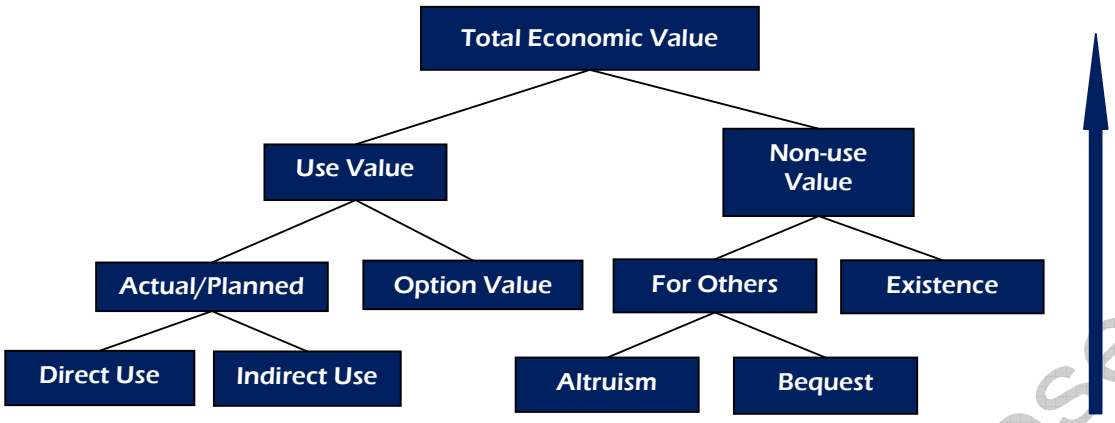


Figure 18.54 Northern Ireland's ecological footprint by sector in 2006. Source: reproduced from Stockholm Environment Institute (2009).

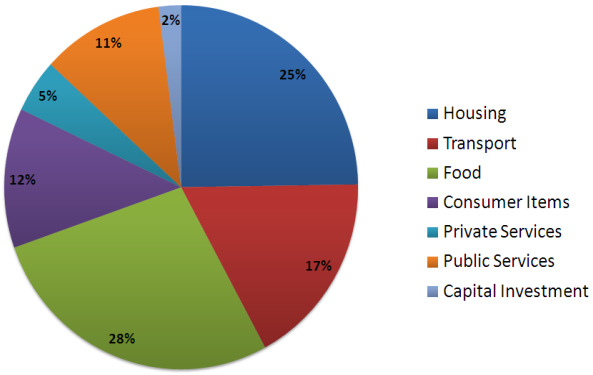


Figure 18.55 Northern Ireland import and export values in 2009. Source: reproduced from HM Revenue & Customs (2010).

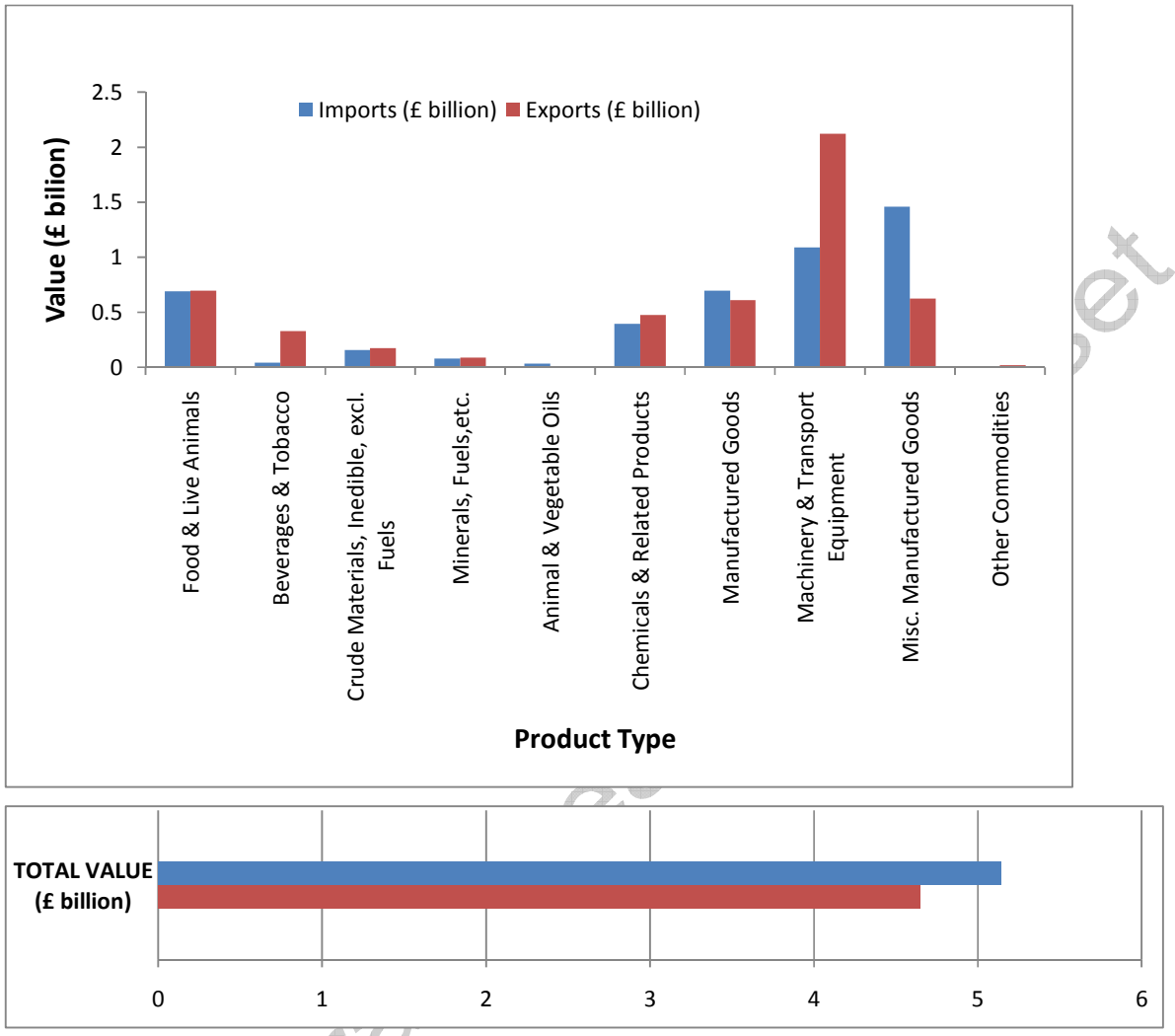


Figure 18.56 Northern Ireland import and export of food and live animals in 2009. Source: reproduced from HM Revenue & Customs (2010).

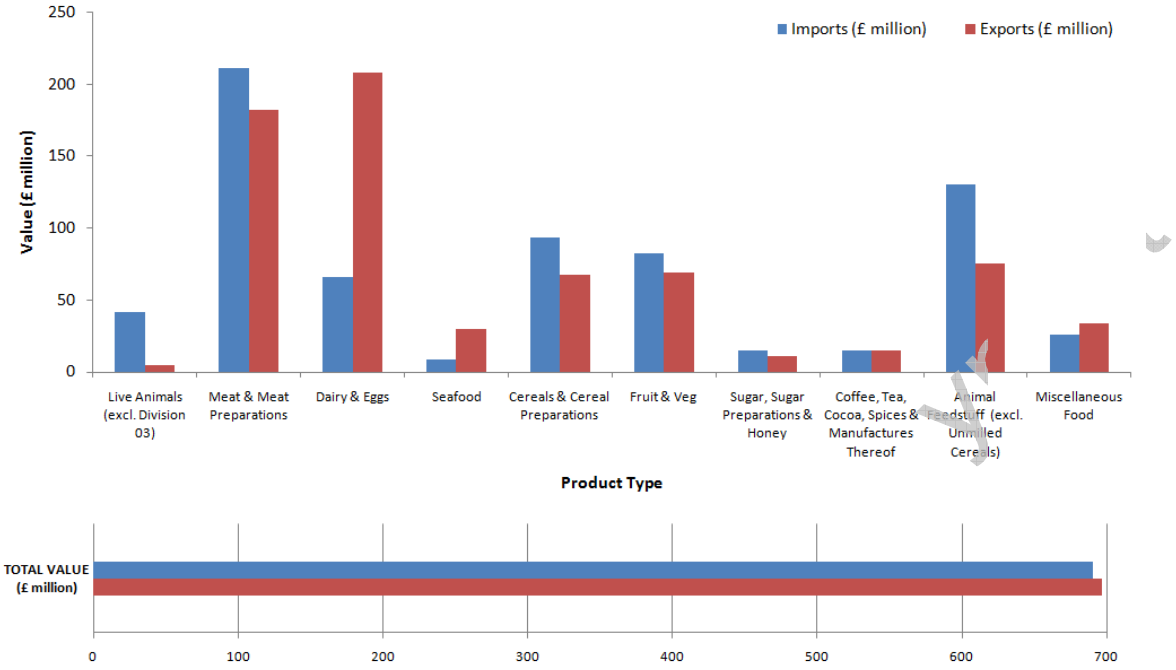


Figure 18.57 Profile of UK regional biomass imports, per capita, in 2009. Sources: data from HM Revenue & Customs (2010) and? ONS (2010a or b).

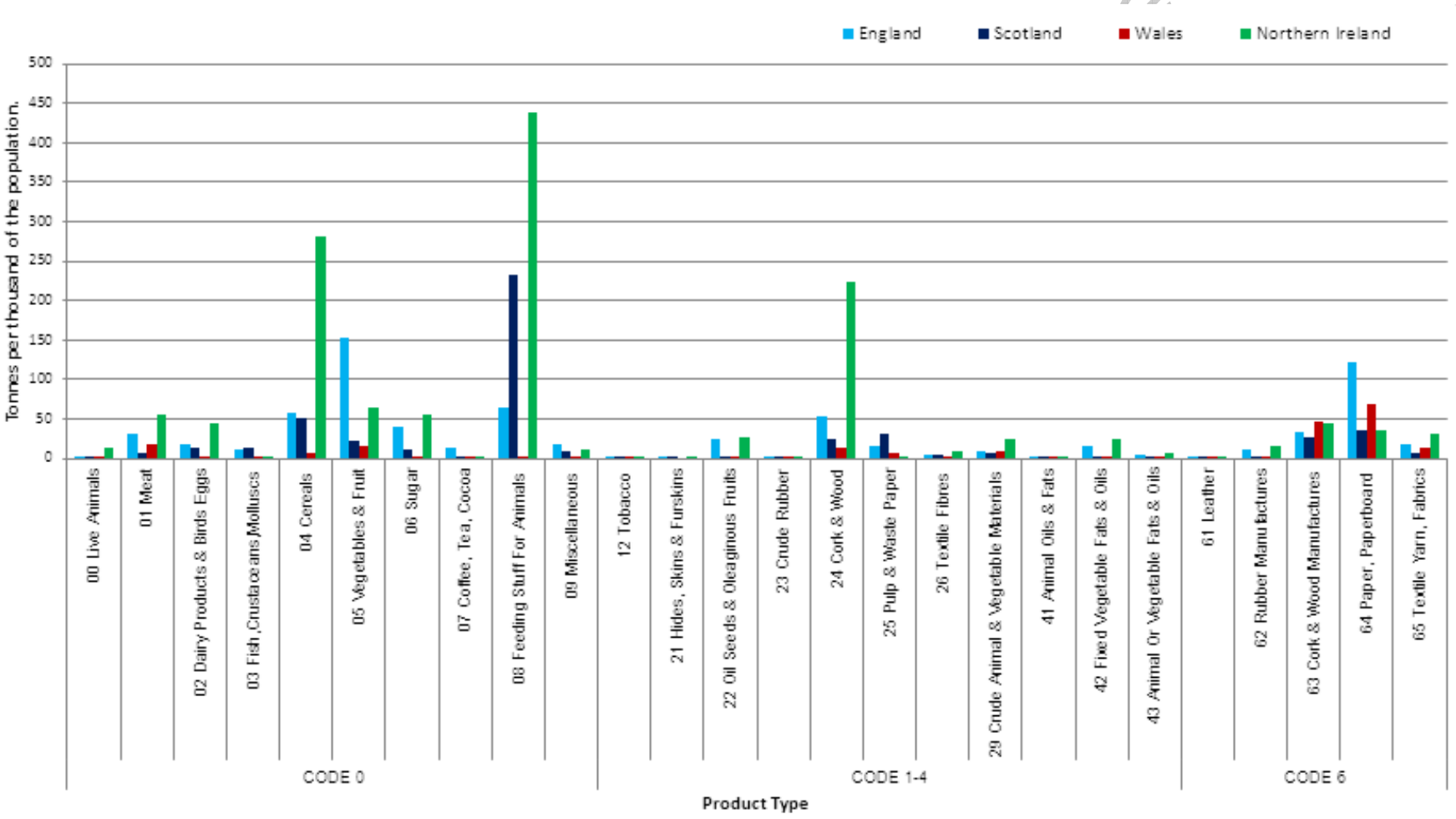


Figure 18.58 Origin of Northern Ireland's regional biomass imports in 2009. Source:data from HM Revenue & Customs (2010).

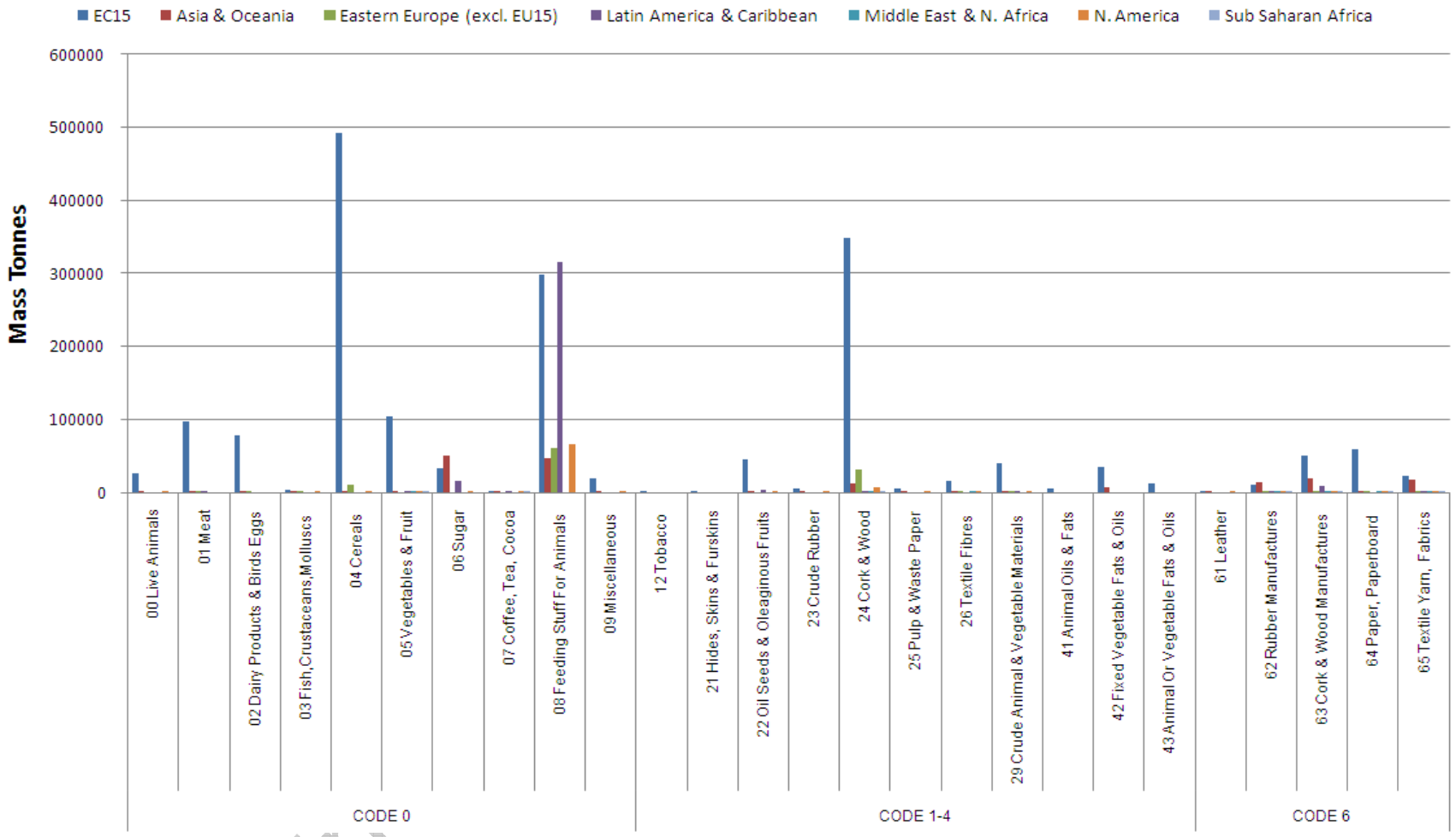
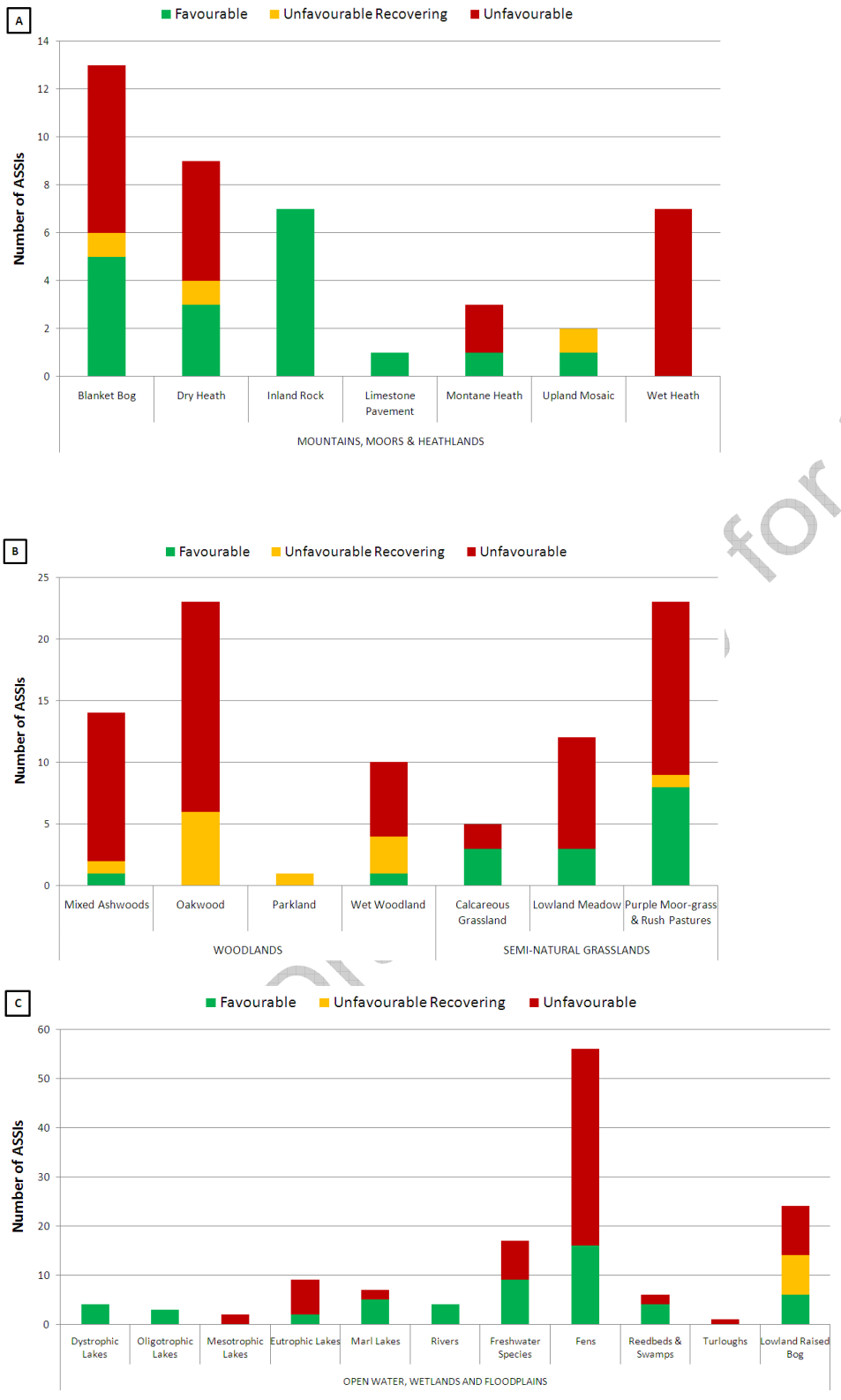


Figure 18.59 Condition of features within Areas of Special Scientific Interest for the six-year rolling period ending March 2008. Source: reproduced from NIEA (2008c).



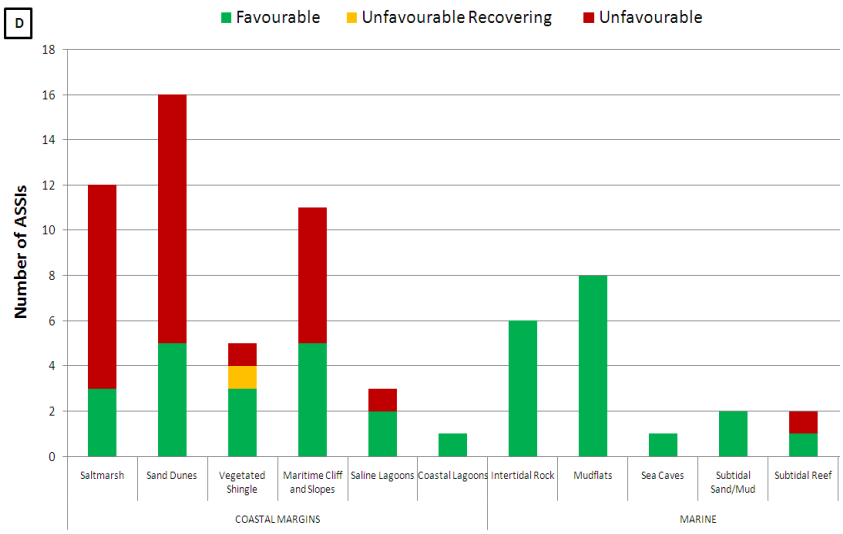


Figure 18.60 Areas designated for conservation purposes in Northern Ireland. Source: NIEA (unpublished data).

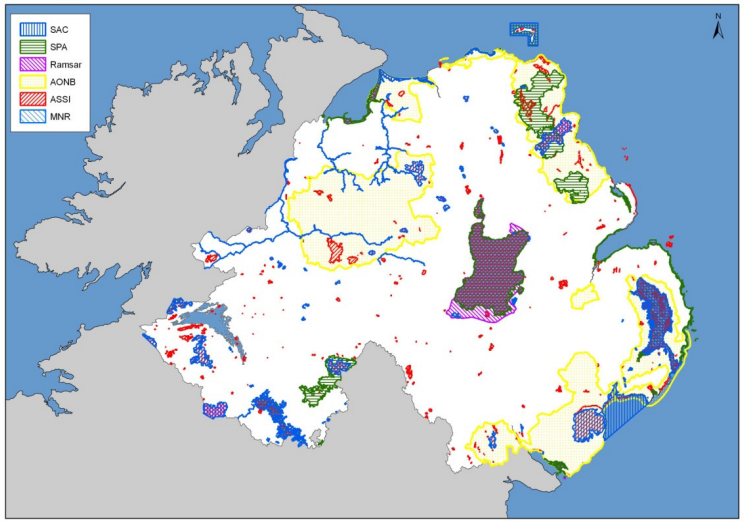


Figure 18.61 Water Framework Directive chemical classification for 2008 and 2009. Source: reproduced from DOE & NISRA (2010).

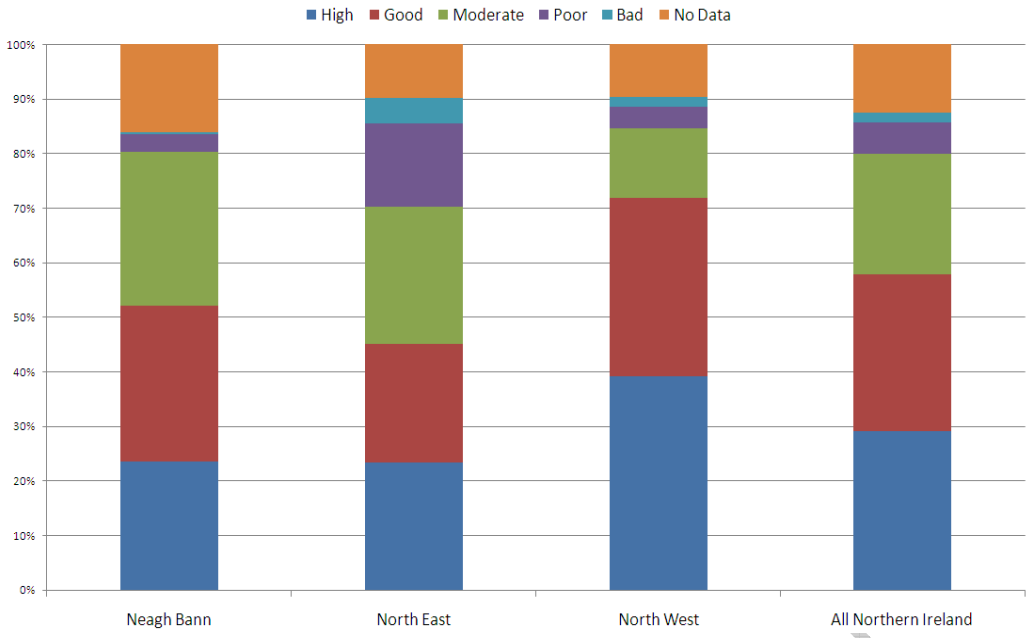


Figure 18.62 Environmentally Sensitive Areas in Northern Ireland at 2010. Source: DARD (unpublished data).

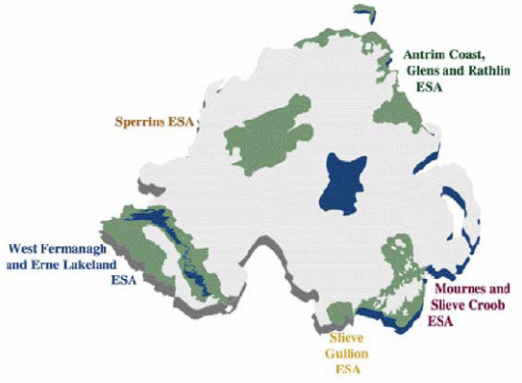


Figure 18.63 Areas under agri-environment scheme agreements from 2000 to 2008. Source: reproduced from DOE & NISRA (2010).

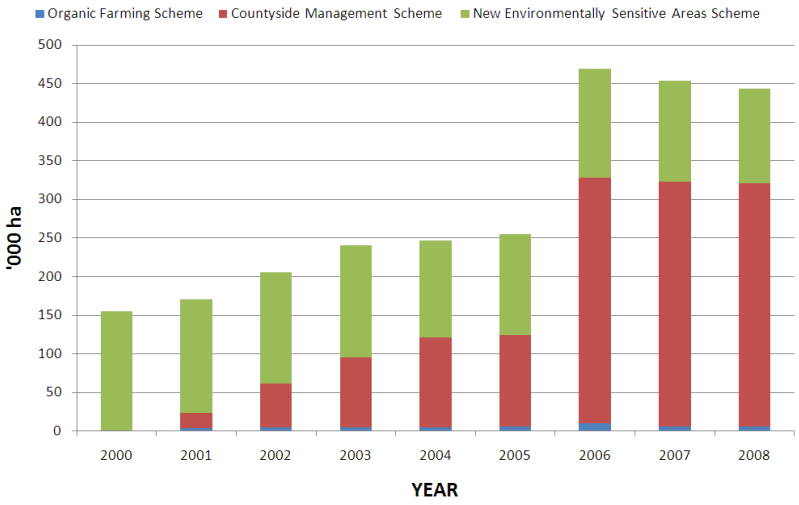
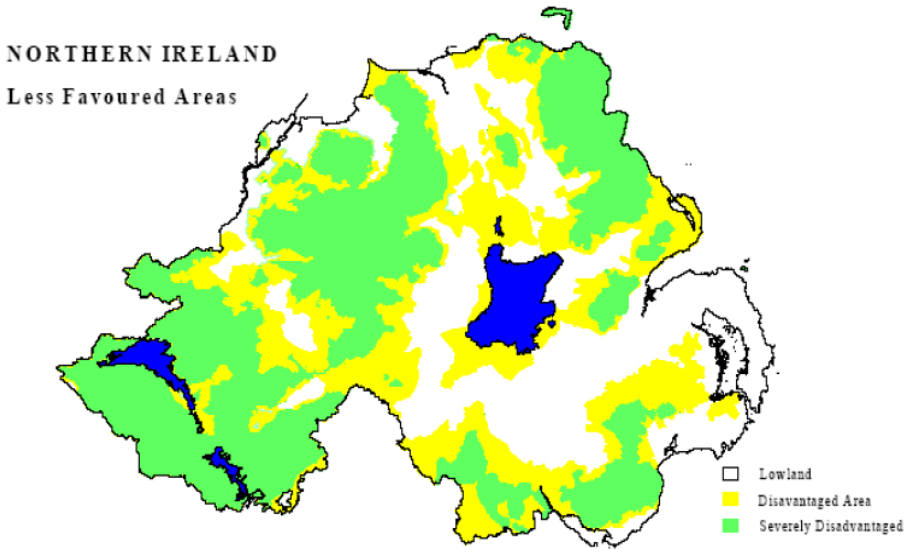


Figure 18.64 Extent of Less Favoured Areas designated in Northern Ireland, showing Disadvantaged Areas and Severely Disadvantaged Areas. Source: reproduced from DARD (2009e).



TABLES

Table 18.1 Examples of major drivers of change and their impacts on human well-being, habitats and services in Northern Ireland. Trends observed over of the past 20 years are also shown.

Drivers of change	Examples of changes with possible impacts on habitats and services		Observed changes since 1990
Demographic			
Demographic change	Increasing/ageing population; Changing motivation and behaviours of farmers and consumers;		Gradually increasing population (births and immigration with some emigration, especially by young people); Decreasing numbers of farmers; Increasing average age of farmers.
Migration	Vulnerability of farming and rural communities through emigration of young people; Immigration/increased multiculturalism; Second homes		Development in both urban and rural areas; Increasing housing development and supporting infrastructure, especially single homes in the countryside; Rapid rise followed by an even more rapid decrease in house prices; Continued increase in land prices; Loss of young rural population; Changing use of marginal land.
Land Manager characteristics	Lack of new entrants to rural economies; Increase in non-traditional land owners; Increasing/decreasing environmental awareness among land managers.		Decreasing numbers of farms Increasing price for land, especially with planning permission Viability of many farms dependent upon diversification or off-farm income for the farm family; Increasing rural to urban commuter-based lifestyle; Loss of skilled land management, funding and succession planning especially in marginal areas and on small farms;
Land use changes	Urbanisation/ suburbanisation/peri-urban; Changes in crops; energy/climate change land uses; Farm diversification; Farm amalgamation; Policy changes(national and European); Competing pressures for the allocation of scarce land resource;		Decreasing numbers of livestock; Decreasing amount of arable crops; Increasing silage production rather than hay Increasing broadleaved woodland; Development of renewable energy projects; Decline in peat harvesting for fuel; Decreasing farm viability; Changing use of marginal agricultural land
Policy and Institutional			
Governance	Devolved/undevolved matters; Review of Public Administration (RPA) Lack of independent Environmental Protection Agency; Low political priority for environmental matters		Variation between devolved and undevolved government until Northern Ireland Assembly in 2007 established local rule. Local governance responding to economic and other pressures; RPA and uncertainty around it potentially leading to fragmentation of policy and practice.
Legislation	Multi-layered legislation (regional, UK, EU, international).		Major environmental legislation driven by EU policy and requirements through UK commitments EIAs and SEAs increasing in quality and

			quantity Increasing emphasis on climate change mitigation and adaptation and biodiversity in line with EU and UK policies Local legislative programme delivering significant local legislation
Policy and Strategy frameworks	Multiple Departments and Strategies with impacts on land management; Lack of full integration amongst policies, strategies and funding.		Improved understanding of interactions and impacts; management changes recognising different priorities and social goods; Regional Development Strategy 2001, revision 2011; Waste Management Strategy 2005; Sustainable Development Strategy 2010; Implementation Plans 2011; Rural White Paper 2011; Sustainable Duty 2007; Biodiversity Duty 2011
Guidance and subordinate regulations	Agri-environment schemes, Planning Policy Statements; pollution control regulations; Possible changes in delivery of public goods and services to promote multi-functionality and incentivising private land owners to deliver public benefits		Planning Policy Statements; River Basin Management Plans 2010; Countryside Management Schemes; Environmentally Sensitive Areas(ESAs)
Designations	Local, national or international conservation designations		Programme for designation of Areas of Special Scientific Interest (ASSIs), Special Areas of Conservation (SACs), Special Protection Area (SPAs) and Areas of Outstanding Natural Beauty (AONBs); expected completion of ASSI network in 2016; National Parks (NPs) legislation planned for 2011; Multiple designations of single sites; lack of monitoring and enforcement; lack of funds for management of designated sites.
Collaboration and delivery arrangements	Greater integration of management and objectives		Northern Ireland Biodiversity Group; Coastal Zone Forum; NGO/government collaborative projects; Catchment Management Groups; local Partnerships; NGO/government partnership mechanisms; local government partnerships
Economics			
International impacts	Globalisation, trade, global market, consumption patterns; Exchange rates; Possible drive for more local self-sufficiency regarding food and energy		Increased globalization for provision of all commodities; Increasing awareness of 'local food' and problem of external sources of energy supply.
Grants and payments	Altered economic incentives leading to possible land use changes and degrees of environmental protection – impacts could be positive or negative.		Reliance on CAP and CFP requirements shaping how land is used and fishing arrangements; Common Fisheries Policy (CFP); Common Agricultural Policy (CAP) (Less Favoured Area (LFA), Single Farm Payment (SFP), , Countryside Management Scheme (CMS), Environmentally Sensitive Area (ESA);

			Management of Special Sites (MOSS); Northern Ireland Rural Development Programme (NIRDP)
Prices and exchange rates	Market prices; proximity to the Republic of Ireland; Possible price and support differentials across border		Role of supermarkets in driving supply; International border driving behavior for shopping, fuel, farming
Infrastructure provision (housing and transport)	Demands for rural infrastructure; land price changes; urbanisation of the countryside; septic tanks and pollution		Increase in rural housing due to demographic changes; PPS21 (DOE 2010e); rural transport (spatially diverse population); depopulation due to farm viability
Resource consumption	Demand for water coupled with reduced availability; Energy cost and security		Increasing costs/decreasing availability of resources; energy, chemicals, water; evolving consumption patterns Recent increase in awareness
Social and Cultural			
Public attitudes and behaviours	Reconciling conflicting public attitudes; influencing land use through incentives, market, regulation, decision-making; traditional/historical attitudes; changing consumer preferences		Shift in priorities for land use; greater responsiveness to market and policy drivers; Greater environmental and sustainable development awareness; Changes in action slowly increasing Environment increasingly on people's agendas
Motivation of decision makers	Fiscal and policy drivers to address multiple issues through integrated incentive programs		Profile of environmental issues in Assembly; Concentration on RPA priority away from environmental issues towards economic drivers; Green New Deal, fuel poverty, climate impacts on infrastructure, energy security, Carbon Reduction Commitments may drive greater Funding for Green New Deal in 2011–2014 budget
Heritage marketing and promotion	Scheduled monuments; Listed Buildings; Registered historic parks, gardens and demesnes.		Promotion of tourism and cultural heritage as factors strongly influencing land use; 'Sustainable tourism' accepted as policy goal Planning legislation and regulation protects heritage sites
Cultural and religious	Recognition of cultural value and 'sense of place'; spiritual value of nature; ecological learning.		Northern Ireland still 'in transition' to peaceful society 'Troubles' decreasing in public priority/profile; Shifting political priorities; changes/increase in designated areas.
Technological			
New Products	New developments in crops and manufacturing techniques leading to economies of scale; new roles for land (energy); landscape impacts		Government support for research and development (R&D) and employment of low carbon technology and renewable energy; Development of renewable energy products and businesses; Trial of Marine Current Turbine
Improved Husbandry	New management techniques or breeding improvements		Improved efficiency; decreased greenhouse gas production Recent research at the Agri-food and Biosciences Institute (AFBI) into husbandry mechanisms to reduce greenhouse gas
Renewable	Wind; marine; biomass; anaerobic digestion;		Continuing conflicts between renewable

energy	waste management		exploitation and landscape conservation interests Research and development of short rotation coppice and anaerobic digestion; Landscape impacts; Integrated waste and renewable; Farm wastes; Seascape
Environmental			
Climate Change	Mitigation; adaptation; move to low carbon economy; weather impacts; unpredictability; droughts and floods; changes in crops; energy crops; waste management; changes in habitats/species; need for 'wildlife corridors' and designated sites; water availability/conflicting demands on river flows; sea level rise		Targets for renewable energy; Use of land for sequestration; promotion of land uses with lower carbon outputs; Slow political acceptance of climate change action relevance to Northern Ireland; No local Act- Targets as 'part of' UK targets
Habitat Loss (change)	Degradation of habitats or loss of area; loss of species; degradation of ecosystem service delivery		Land abandonment, changes in management regime (overgrazing and burning); Nitrogen deposition (in the uplands), runoff, estuaries , chemical use (pesticides, herbicides, molluscicides, fungicides, fertilisers); Undergrazing in some areas (often following decades of overgrazing); Agri-environment schemes popular, 20% of land in ESA; Designation of ASSIs but target for completion repeatedly changed; General land management and pollution levels improving (Water and Waste Framework Directives)
Species introduction or removal	Invasive species; Extinctions of native species; changes in pollinators; changing geographical distributions of pests and diseases; Cost of prevention, eradication or control measures; major habitat loss or degradation		Awareness of invasive species recognised by Invasive Species Ireland project; Not high on public agenda; Problems increasing as new species become established
Eutrophicatio n	Algal mats; anoxic zones; species diversity variation		Decreasing water quality; increase in the cost of water treatment; habitat degradation; Species loss; Following major efforts at addressing point source pollution inputs in the 1980s levels improved, but still high primarily from diffuse agricultural pollutants; Major reduction in phosphate inputs through fertiliser use reduction; Major fish kills still annual occurrences
Wild harvesting	Marine fish stocks and economics of coastal and fishing communities; river fishing; game hunting		Sustainable management; loss of stocks; decreasing profitability of industry Most fish species over-exploited, catches decreasing; Eels in crisis; Dredging of Strangford Lough for scallops has damaged horse mussel beds severely.
Soil degradation	Land degradation; erosion; poaching		Decreasing productivity; pollution of waterways;

			Soil quality generally reasonable; Problems of compaction and loss of earthworms
Carbon sequestration /loss	Carbon storage in soils and vegetation		Opportunities for sequestration especially in uplands; Value beginning to be realised; Major peat extraction has decreased but could increase depending on oil prices
Air quality	Primarily an urban issue; Disease, decrease in human well-being		Major improvements due to fuel switch from coal to oil/gas Traffic main contributor
External inputs	Fertilisers, pesticides; Water; Habitat degradation		Decreasing use of fertilisers Still very little irrigation needed Better treatment of waste materials

Table 18.2 Examples of major legislative, policy, strategy and funding measures affecting the environment of Northern Ireland.

Key areas	Responsibility	Examples of key legislation	Examples of key plans and strategies
Overarching	Inter/multi-departmental	Northern Ireland Act 1998; Northern Ireland Act 2009	Sustainable Development Strategy for Northern Ireland; Programme for Government (PfG); Northern Ireland Budget
Planning	DOE (Planning Service, NIEA etc.); DRD (Roads Service)	The Planning (NI) Order 1991; The Planning Reform (NI) Order 2006; EIA Regulations (NI) 1999; The Planning Fees Regulations (NI) 2005 Planning Bill 2011; Local Government Reform (2011)	Regional Development Strategy for Northern Ireland 2025; Northern Ireland Rural Development Programme 2007–2013; Review of Public Administration (RPA); Regional Transport Strategy for Northern Ireland 2002–2012; Planning Policy Statements; Planning Strategy for Rural Northern Ireland
Land use/Agriculture	DARD; AFBI; DETI; DOE	Groundwater Regulations (NI) 2009; Environmental Liability (Prevention and Remediation) Regulations (NI) 2009; Control of Pollution (Silage, Slurry and Agricultural Fuel Oil) Regulations (NI) 2003; Wildlife Order (NI) 1985; Wildlife and Environment Bill (2010)	Code of Good Agricultural Practice (COGAP); NI Countryside Management Scheme; Rural White Paper (2011); River Basin Management Plans
Food	DARD; AFBI; DETI (Invest NI, SIB)	Food and Environment Protection Act 1985	Investment Strategy for Northern Ireland 2005/15; Focus on Food' partnership Strategy for the NI Food Industry 2010
Environmental Protection	DOE	Wildlife Order (NI) 1985; Conservation Regulations (NI) 1995; Environment (NI) Order 2002; Nature Conservation and Amenity Lands (NI) Order 1985; EIA Regulations (NI) 1999; Wildlife and Natural Environment Bill 2009; Water (NI) Order 1999; Radioactive Substances Act 1993; Pollution Prevention and Control (NI) Order 2002; EU Marine Strategic Framework Directive.	Integrated Coastal Zone Management Strategy; Northern Ireland Biodiversity Strategy; Waste Management Strategy 2006–2020; River Basin Management Plans
Climate Change	DETI; DOE; Rivers Agency	UK Climate Change Act 2008; EU Emissions Trading Scheme; Floods Directive	Regional Development Strategy for Northern Ireland 2025, Flood Risk Maps and Management Plans; Planning Policy Statement 15 – Planning and Flood Risk (DOE 2006b)
Forestry	DARD; DOE (Planning	Forestry Act (NI) 2010	NI Forestry – A Strategy for Sustainability and Growth 2006

	Service)		
Waste	DOE	Landfill Directive (1999/31/EC), Waste Emissions Trading Act 2003; Waste and Contaminated Land (NI) Order 1997; EU Waste Framework Directive and Revised WFD 2011	NI Waste Management Strategy 2006, NI Landfill Allowance Scheme

Table 18.3 Numbers of species in selected taxonomic groups present in Northern Ireland compared to overall figures for the UK. Source: data from Northern Ireland Fungi Group (2007); Fungus Conservation Forum (2009); Northern Ireland Biodiversity Group (2009; CEDaR (2010b); AFBI & NIEA (2011) Roy Anderson, Neil McCullough, NIEA (pers. comm.).

Group	Number of Species	
	UK	Northern Ireland
Marine	e.g. 28 species of cetaceans, 2 seal species (Chapter 12)	2,400 including 2 seal (common (*Phoca vitulina*) and grey *Halichoerus grypus)*)and 13 cetacean species; some may be endemic e.g. 29 new species of marine sponge off Rathlin Island in 2005; several internationally important waders and wildfowl – Strangford Lough contains 72% of marine biodiversity in Northern Ireland waters. 'Over half' of all biodiversity in NI (AFBI & NIEA 2011)
Freshwater fauna	Circa 50 species (Britain; PAA 2003)	Includes native fish such as pollan (*Coregonus pollan*; not found anywhere else in Europe), dollaghan (*Salmo trutta*) and ferox trout; Ireland is the last European stronghold of the white-clawed crayfish (*Austropotamobius pallipes)*.
Mammals	62 including 17 bats	26 including 8 bats and the native Irish hare (*Lepus timidus*)
Birds	258 regular breeders or migrants	170 regular breeders and non-breeding seasonal migrants; not including rare or vagrant species.
Invertebrates	13,500 including approximately 2,500 British Lepidoptera and 347 British carabids	Includes approximately 1,015 Lepidoptera; 207 carabids; 21 Odonata; several species found in Ireland do not occur in Britain.
Reptiles	6	Common lizard (*Zootoca vivipara)*; leatherback turtle (*Dermochelys coriacea*) occasionally
Amphibians	7	2 – common frog (*Rana temporaria)*and smooth newt (*Lissotriton vulgaris)*
Plants	1,760 higher plants including 1,142 native land plants and 1,000 lower plants and liverworts	Estimated 850 vascular plants (Mark Wright, NIEA, pers. comm.); 665 mosses and liverworts
Fungi	12,000 – 15,000	2,347 described so far; plus 969 lichens

Table 18.4 UK NEA Broad Habitats and estimated net change between 1998 and 2007. Source: figures derived from NICS data, calculated to HWMMT (High Water Mark of Medium Tides), as a percentage of Northern Ireland (1,416,047ha; Cooper & McCann 2010).

UK NEA Broad Habitats	UK NEA component habitats	Estimate from Northern Ireland Countryside Survey	1998		2007		Net Change	
			ha	% NI	ha	% NI	ha	%
Mountains, Moorlands& Heaths	Bracken	BH09 Dense bracken	3,084	0.22	2,645	0.19	-439	-14.2
	Dwarf Shrub Heath	BH10 Dwarf shrub heath	13,909	0.98	16,751	1.18	2,842	20.4
	Upland Fen, Marsh & Swamp	S16 Poor fen	24,784	1.75	21,005	1.48	-3,779	-15.2
	Bog	BH12 Bog (Above 150m)*	140,814	9.94	139,796	9.87	-1,018	-0.7
	Montane	BH15 Montane vegetation	735	0.05	735	0.05	0	0.0
	Inland Rock	BH16 Inland rock	7,969	0.56	5,450	0.39	-2,519	-31.6
	Mountains, Moorlands &Heaths TOTAL		**191,295**	**13.45**	**186,382**	**13.11**	**-4,913**	**-2.6**
Semi-natural Grasslands	Acid Grassland	BH08 Acid grassland	13,324	0.94	10,369	0.73	-2,955	-22.2
	Neutral Grassland	BH06 Neutral grassland	263,902	18.64	231,116	16.32	-32,786	-12.4
	Calcareous Grassland	BH07 Calcareous grassland	1,765	0.13	1,802	0.13	37	2.1
	Purple moor grass & rush pastures	S02 Species-rich wet grassland	13,396	0.95	13,186	0.93	-210	-1.6
		S65 Fen meadow	6,533	0.46	5,290	0.37	-1,243	-19.0
	Semi-natural Grasslands TOTAL		**298,920**	**21.12**	**261,763**	**18.48**	**-37,157**	**-12.4**
Enclosed Farmland	Arable & horticulture (including orchards & short rotation coppice)	BH04 Arable and horticulture	57,213	4.04	48,917	3.46	-8,296	-14.5
		W12 Orchard	1,623	0.12	1,165	0.08	-458	-28.2
	Improved Grassland	BH05 Improved grassland	554,982	39.19	573,010	40.47	18,028	3.2
	Boundary and linear features†	*BH03a Field Boundaries (km)*	*226,296*	*n/a*	*225,917*	*n/a*	*-379*	*-0.2*
	Enclosed farmland TOTAL‡		**613,818**	**43.35**	**623,092**	**44.01**	**9,274**	**1.5**
Woodlands	Broadleaved, Mixed & Yew Woodland	BH01 Broadleaved, mixed and yew woodland (Not including W12 Orchard)‡	61,884	4.37	80,534	5.69	18,650	30.1
	Coniferous Woodland	BH02 Coniferous woodland	62,135	4.39	60,617	4.28	-1,518	-2.4
	Woodlands TOTAL		**124,019**	**8.76**	**141,151**	**9.97**	**17,132**	**13.8**
Open waters, Wetlands & Floodplains	Standing open water (lakes, ponds & canals)	BH13 Standing open water	61,785	4.36	61,332	4.33	-453	-0.7
	Rivers and streams	BH14 Rivers and streams	5,390	0.38	5,495	0.39	105	1.9

	Lowland raised bog*	BH12 Bog (Below 150m)	23,402	1.65	21,106	1.49	-2,296	-9.8
	Fens, grazing marsh & swamp	S17 Reedbeds	2,958	0.21	2,563	0.18	-395	-13.4
		S18 Fen	2,723	0.19	2,499	0.18	-224	-8.2
		S66 Swamp	2,280	0.16	2,524	0.18	244	10.7
		S68 Water inundation vegetation	260	0.02	187	0.01	-73	-28.1
	Freshwater TOTAL		**98,798**	**6.98**	**95,706**	**6.76**	**-3,092**	**-3.1**
Urban	Built-up Areas & Gardens	BH17 Built up areas	56,847	4.01	74,098	5.23	17,251	30.3
		BH03b Roads, tracks and hard verges	29,449	2.08	30,951	2.19	1,502	5.1
	Urban TOTAL		**86,296**	**6.09**	**105,049**	**7.42**	**18,753**	**21.7**
Coastal Margins	Sea Cliffs	BH18 Supralittoral rock	1,717	0.12	1,581	0.11	-136	-7.9
	Shingle							
	Coastal Lagoons							
	Saltmarsh	BH19 Supralittoral sediment	1,859	0.13	1,995	0.14	136	7.3
	Sand Dunes							
	Coastal margins TOTAL		**3,576**	**0.25**	**3,576**	**0.25**	**0**	**0.0**
Marine	Intertidal Rock	BH20 Littoral rock	Not recorded	n/a	1,212	n/a	**n/a**	**n/a**
	Intertidal Sediment	BH21 Littoral sediment	Not recorded	n/a	9,518	n/a	**n/a**	**n/a**
	Subtidal Rock	12NM Territorial Waters¶	~450,000	n/a	~450,000	n/a	0	0
	Subtidal Sediment - shallow & shelf							
	Deep-sea Habitat							

* Lowland raised bog is included in the NICS broad habitat BH12 Bog, but is a constituent of the UK NEA Broad Habitat Freshwater – Open waters, Wetlands and Floodplains.
† A large proportion of these features are associated with the UK NEA Broad Habitat Semi-Natural Grasslands.
‡ Short rotation coppice is included in the NICS broad habitat BH01 Broadleaved, mixed and yew woodland, but is a constituent of the UK NEA Broad Habitat Enclosed Farmland.
¶ The 12NM Territorial Waters area is an estimate calculated using GIS (ArcGIS; NIEA 2010h) by drawing a mid-line through trans-boundary waters out to the 12NM limit (or midway between Northern Ireland and Scotland).

Table 18.5 Area of woodland under Forest Service management by main tree species in 2010.
Source: Forest Service (unpublished data)**.**

Species	Area (ha)	%
Sitka spruce	39,769	68.4
Lodgepole pine	5,074	8.7
Larch (Japanese, European and hybrid)	3,136	5.4
Norway spruce	2,562	4.4
Oak	1,081	1.9
Scots pine	965	1.7
Douglas fir	500	0.9
Noble fir	426	0.7
Others	4,639	7.9
Total	**58,152**	**100**

Table 18.6 Designated woodland habitats. Source: NIEA (unpublished data).

Priority habitats	Number of ASSIs	Extent of feature (ha)	Number of SACs	Total extent of priority habitat (ha)
Mixed ashwoods	19	517	2	3,430
Wet woodlands	13	687	9	2,600
Designated for both Wet and Ash Woodlands features	2	123	-	
Oakwoods	37	1,146	15	2,350
Parkland	2	353	-	1,100
TOTAL	**73**	**2,826**	**26**	**9,480**

Table 18.7 Distribution of Northern Ireland's population based on settlement size according to the 2001 census. Source: data from NISRA (2005b).

	Classification (Population Range)								
	Belfast Urban Area	**Derry Urban Area**	**Large Towns (18,000 – 75,000)**	**Medium Towns (10,000 – 18,000)**	**Small Towns (4,500 – 10,000)**	**Intermediate Settlement (2,250 – 4,500)**	**Village (1,000 – 2,250)**	**Small village, hamlet and open countryside (<1,000)**	**Northern Ireland**
Total (number) in 2001	579,276	90,663	223,524	100,149	101,535	64,722	67,647	461,784	**1,689,300**

Table 18.8 Planning application approval from 2003 to 2009. *Environmental installations include wind turbines, solar water heating panels, wood pelletising plants and solar panels. Source: data from NIPS (2003, 2004, 2006, 2008, 2010a).

Application Category	2003/4		2004/5		2005/6		2006/7		2007/8		2008/9		2009/10	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Agricultural	83	-	106	91.0	219	92.0	209	86.4	178	86.8	335	94.1	213	91.0
Commercial	1,382	96	1,329	95.0	1,359	92.0	1,252	89.9	1,273	89.8	1,184	92.1	1,221	92.9
Government and Civic	1,761	98	1,923	98.0	1,836	97.0	1,880	97.0	1,774	97.5	1,889	97.1	1,629	96.0
Industrial	366	96	357	94.0	371	95.0	335	88.6	341	88.6	388	93.0	306	89.2
Mixed Use	193	93	179	96.0	189	94.0	182	94.8	244	90.4	334	90.5	209	89.3
Residential	17,652	92	19,985	89.0	20,001	81.0	19,020	80.5	19,273	91.5	17,783	94.6	14,246	94.6
Others	951	94	930	92.0	1,120	91.0	1,131	86.3	1,270	89.4	1,298	87.9	1,192	88.9
Environmental Installations*	-	-	32	97	31	97	35	100	88	99	87	94	210	96
All Applications	22,388	94.8	24,841	94.0	25,126	92.4	24,044	90.4	24,441	91.6	23,298	92.9	19,226	92.2

Table 18.9 Estimated resource value of the open space areas of Belfast City Council. Source: Belfast City Council (2005b and unpublished data).

Type of Site	Number	Estimated Resource Value	Area (ha)
City Parks	2	£4,480,000	15.1
District Parks	9	£8,265,000	153.9
Local Parks	36	£14,109,000	168.6
Country Parks	5	£1,884,000	444.3
Playing Field Sites	8	£2,942,000	87.1
Cemeteries	9	£3,512,000	118.0
Playgrounds	41	£3,210,000	Unavailable
Allotments	4	£40,000	Unavailable
Other	-	£240,000	Unavailable
TOTAL	**114**	**£38,682,000**	

Table 18.10 Priority habitats in Northern Ireland's marine environment. Source: Dave Schoeman, University of Ulster (unpublished data).

Type	Habitat	Brief description	Location	Frequency of occurrence	Management value	Threats/Vulnerabilities	Listed in EC Habitats Directive?	Level of protection
PHYSICALLY DEFINED	Tidal rapids (EHS 2003 i)	Strong, turbulent tidal streams often in natural constrictions and generally shallower than 5m	Shallow subtidal	Frequent	Diverse algal and epifaunal communities	Possibly sea-level rise and renewable energy installations (tidal power)	Not listed, but could be a component of Annex 1 listed habitat (Reefs)	Some protection in Strangford Lough MNR and SAC
	Sheltered muddy gravels (EHS 2003 h)	Shallow, poorly sorted soft sediment with gravel fraction	Sheltered areas, particularly loughs and estuaries, lower intertidal to shallow subtidal	Rare in Northern Ireland and the rest of the UK	Characteristic specialist biodiversity; occasional high abundance of resident species; generally poorly studied due to nature of substrate	Vulnerable to changes in hydrodynamics; sensitive to physical disturbance, including by fishing gear	Not listed	Some protection in Strangford Lough MNR and SAC
	Circalittoral muds (EHS 2005 j)	Mud banks (fine soft sediments) often in sheltered areas	Generally at 20–30m depth	Common, especially in the Irish Sea	Large communities of burrowing megafauna; important for shellfisheries, especially *Nephrops*	Vulnerable to disturbance from fishing, particularly beam trawls; prone to accumulating pollutants, transported and aggregated by the same oceanographic processes that transport muds	Not listed, but could be a component of some Annex 1 listed habitats	Well represented in SACs
	Sublittoral sands and gravels	Banks of soft sediments that are coarser than mud; come in a range of types, from coarse, stable gravels	From the shallow subtidal to deeper than 50m	Most common habitat around UK, including Northern Ireland	Wide range of biotic communities and biodiversity; very rich communities when found in sheltered habitats; can support fisheries	Vulnerable to fisheries	Not listed, but could be a component of Annex 1 listed habitat (Sandbanks which are slightly	Some of the most diverse examples in Northern Ireland are represented in SACs

	(EHS 2005 n)	to mobile sand banks			for bivalves; likely important nursery areas for juvenile fish		covered by sea water all of the time)	
	Littoral and sublittoral chalk (EHS 2005 e)	Soft sedimentary rock (calcium carbonate)	From the intertidal to depths of 50m	Rare in Europe, including most of UK. Possibly more common in waters around Northern Ireland than elsewhere, but poorly mapped	Prone to formation of caves, which support specialised, rich biotic communities, including rare species of algae and sponges; rich in fossils	Flat chalk reefs can be vulnerable to fishing gear and ocean acidification	Not listed, but could be a component of Annex 1 listed habitat (Submerged or partially submerged sea caves)	Reasonable protection within ASSIs and SACs
	Saline lagoons (EHS 2003 f)	Marine waters with restricted access to the sea; frequently brackish due to freshwater input	Coastal, blocked from the open sea by some form of barrier	Rare. Out of approximately 30 in Northern Ireland, only 3 are thought to be natural. However, the distinction is often difficult because of historical modifications of existing seascape features	Specialised brackish-water biota; can be important to wildfowl and migrating birds	Prone to eutrophication; vulnerable to coastal squeeze caused by the combination of sea level rise and infrastructural development	Listed under Annex 1	Well represented in ASSIs, SPAs and Ramsar sites
BIOLOGICALLY DEFINED	Seagrass beds (EHS 2003 g)	Beds of sea grasses (the only marine flowering plants); three species of *Zostera* and two of *Ruppia*	Sheltered, shallow water, mainly in loughs	Frequent in Lough Foyle and Strangford Lough, but poorly mapped elsewhere	Highly productive; support a wide range of biota; act as important nursery habitats for fish; provide food for overwintering wildfowl	Sensitive to physical disturbance and turbidity; prone to invasion by *Sargassum muticum*; particularly vulnerable to climate change, especially sea-level rise	Not listed, but could be a component of some Annex 1 listed habitats	Well represented in ASSIs, SACs, SPAs and NNRs

	Maerl beds (EHS 2003e)	Beds of living or dead calcified (coraline) marine algae; complex biogenic reef	Mainly shallow, sheltered water to about 40m depth	Unknown, not well mapped	High biodiversity	Sensitive to disturbance, e.g. scallop dredging and boat anchoring; vulnerable to sea-level rise	Not listed, but could be a component of some Annex 1 listed habitats; listed under Appendix Vb	Some representation in Strangford Lough MNR and SAC
	Modiolus modiolus beds (EHS 2005i)	Beds of horse mussels, which are long-lived, slow-growing bivalve molluscs; form complex low-profile biogenic reefs	5m to more than 50m depth	Species is common in the northern hemisphere, but biogenic reefs are rare, only 4 are known in Northern Ireland	High biodiversity	Extremely vulnerable to benthic fishing gear and slow to recover; may also be sensitive to other forms of physical disturbance	Not listed, but could be a component of Annex 1 listed habitat (Reefs)	Large patch of reef protected in SACs and Strangford Lough MNR
	Sabellaria alveolata reefs (EHS 2005l)	Honeycomb worms form reefs of closely-packed sandy tubes	Areas with a degree of wave action and necessary sediment available	Unknown, not well mapped	Tend to be low biodiversity habitats; at the northern edge of their distribution in Northern Ireland	Vulnerable to changing sediment loads and hydrodynamic conditions	Not listed, but could be a component of Annex 1 listed habitat (Reefs)	May be protected in some ASSIs
	Sabellaria spinulosa reefs (EHS 2005m)	Generally solitary, these polychaete tubeworms can in places form reefs of densely-packed sandy tubes; complex biogenic reef	Areas with a degree of wave action and necessary sediment available; depth up to 40m	Unknown, probably rare, not well mapped (only 3 or 4 known reefs)	High biodiversity	Sensitive to physical disturbance, e.g. by fishing gear; vulnerable to changing sediment load and hydrodynamic conditions	Not listed, but could be a component of Annex 1 listed habitat (Reefs)	Not known to be protected

Table 18.11 Agricultural products for Northern Ireland in 2009. # signifies data not available. Source: data from DARD (2010o).

Sector		Numbers or Area (ha)	Quantities of the main product	Output (£million)	Input (£million)	Gross Margin (£million)
Livestock and livestock products	Dairy cows & followers	1.62 million (including 290,000 dairy cattle & 266,000 beef cattle)	Milk: 1,906 million litres	514.5	164.6	349.9
	Beef cattle, rearing & fattening		Cattle & calves: 140,749 t dressed carcase weight (dcw)	279.7	198.8	80.9
	Sheep and wool	1.97 million (including 935,000 breeding ewes)	Sheep &lambs: 18,818 t dcw	50.6	31.5	19.1
	Pigs	402,000 (including 37,000 breeding pigs)	Pigs: 70,155 t dcw	76.9	57.4	19.5
	Poultry	17.13 million (11.54 million broilers & 2.40 million laying birds)	Poultry: 247,400 t lwt (liveweight); Eggs: 61.5 million dozen	217.6	188.3	29.3
	TOTAL	**Grass: 789,600 ha; Rough Grazing: 147,100 ha**	**n/a**	**1,139.3**	**640.6**	**498.7**
Agricultural crops	Cereals	40,600 ha	239,400 t	45.5	13.2	32.3
	Potatoes	5,100 ha	160,700 t	20.5	6.1	14.4
	Other	9,800 ha				
	TOTAL	**55,500 ha**	**400,100 t**	**66.0**	**19.3**	**46.7**
Horticulture	Fruit	1,500 ha	54,800 t	8.9	#	#
	Vegetables	1,400 ha	50,300 t	#	#	#
	Mushrooms	100 ha	18,200 t	22.4	#	#
	Ornamentals			11.7		
	TOTAL	**3,000 ha**	**123,300 t**	**59.6**	**17.4**	**42.2**
Other	**TOTAL**	**22,300 ha**		**37.1**	**9.2**	**27.8**
AGRICULTURE TOTAL		**1,017,500 ha**	**n/a**	**1,302.0**	**686.5**	**615.5**

Table 18.12 Active aquaculture areas in five Northern Ireland Sea Loughs. Source: data from Ferreira *et al.* (2007).

Lough	Lough Area (ha)	Common/Blue Mussel		Pacific Oyster	
		Area (ha)	Type	Area (ha)	Type
Carlingford (NI area)	4,900	168	Bottom Culture & Rafts	83	Trestles
Strangford	14,900	6	Rafts	24	Trestles
Belfast	13,000	953	Bottom Culture	0	n/a
Larne	800	10	Bottom Culture	60	Trestles
Foyle	18,600	1603	Bottom culture	0.1	Trestles

Table 18.13 Potential renewable resources in Northern Ireland (Megawatts electrical). Source: data from Action Renewables (2004).

	Onshore wind	Offshore wind	Hydro	Short Rotation Coppice (SRC) willow	Poultry waste	Sawmill residue	Municipal solid waste	Landfill gas	Agricultural wastes	TOTAL
Co. Antrim	94.0	100.0	4.7	1.5	2.2	0.1	13	10.2	1.0	**226.7**
Co. Armagh	12.5	-	3.0	0.8	0.5	-	-	3.0	0.6	**20.4**
Co. Down	92.5	200.0	0.4	1.3	0.7	-	-	5.1	0.9	**300.9**
Co. Fermanagh	89.3	-	0.2	0.9	-	3.3	-	0.9	0.5	**95.1**
Co. Londonderry	70.5	200.0	1.7	1.0	0.3	1.8	-	2.9	0.7	**278.9**
Co. Tyrone	205.8	-	0.6	1.7	1.9	0.1	-	1.6	1.2	**212.9**
Northern Ireland	**564.6 (49.75%)**	**500.0 (44.06%)**	**10.6 (0.93%)**	**7.2 (0.63%)**	**5.6 (0.49%)**	**5.3 (0.47%)**	**13.0 (1.15%)**	**23.7 (2.09%)**	**4.9 (0.43%)**	**1,134.9 (100%)**

Table 18.14 The percentage (%) of each River Basin District at different levels of Ecological Status.
Source: data from NIEA (2009f,g,h).

River Basin District	Ecological Status of Waterbodies			
	Heavily Modified and Artificial Waterbodies		Natural or Moderately Modified Waterbodies	
	Moderate Ecological Potential or Worse (%)	Good Ecological Potential or Better (%)	Less Than Good Status (%)	Good or Better (%)
North Eastern	17.0	2.0	65.0	16.0
North Western	7.0	0.0	63.0	30.0
Neagh Bann	12.6	0.4	72.6	14.4

Table 18.15 Air pollutants, their impacts and their status in Northern Ireland. Sources: data from EHS (2008a); DOE & NISRA (2009, 2010); Chapter 10.

Air Pollutant	Major Effects	Ecosystem Regulation Impacts	Northern Ireland status
Particulate matter (PM)	Human health	Pollen, fire, deposition on plants	Urban areas are higher than rural areas but both are well below the UK Air Quality Objective (DOE & NISRA 2010).
Ozone (O_3)	Human health, reduced crop yield, changes in species composition	Deposition and absorption by plants; emissions of volatile organic compounds (VOCs) contribute.	Highly variable with target levels exceeded especially in Londonderry (DOE & NISRA 2010).
Nitrogen oxides (NO_x) Ammonia (NH_3) Nitrogen deposition	Human health, eutrophication, acidification	Deposition reduces impacts on health and ecosystem services. Heavy levels of deposition impact on habitats. Emissions from livestock and farming.	NO_x levels stable, higher at roadsides, within target limits. Ammonia has decreased slightly, with 94% from livestock and 6% from fertiliser applications (DOE & NISRA 2010).
Sulphur deposition	Acidification	Deposition impacts on health and other ecosystem services. Heavy levels of deposition can impact on habitats.	Significant decrease since 1992 (EHS 2008).

Table 18.16 Some examples of recreational, tourism and leisure uses of Northern Ireland's natural environment.

	Assets and uses	Some issues
Mountains	Recreational use of upland habitats is of increasing importance (CAAN 2007). Around 370 ha of upland heathland/moorland are managed for public access and conservation in the Belfast Hills; walking, camping and nature based tourism (bird watching, angling).	Erosion of footpaths, particularly of peaty soils and thin mineral soils on steeper slopes, especially where marked 'Ways' cross blanket peatland (CAAN 2007).
Forests	Two million visits annually to Forest Service properties involving 473,368 paying visitors (Forest Service 2010a). Partnerships with a wide range of environmental NGOs, local authorities and others to carry out a variety of projects and events (Forest Service 2010a). Forests are also an important part of upland recreation (Tomlinson & Fennessy 2009).	Only 7.2% of people have access to a wood of at least 2 ha within 500 m of their homes and only 40.2% have access to a wood of at least 20 ha within 4 km of their home. The UK average figures are 15.6% and 64.8% respectively (Woodland Trust 2010b).
Urban areas	Opportunities for healthy activity from cycle networks, city/village parks, rivers, lakes, canals, cemeteries, allotments and various Highway to Health routes.	Conflicts due to other pressures on land use.
Coast and sea	Eight Blue Flag Beaches, one Blue Flag Marina and eight beaches with the Seaside Award (Tidy NI unpublished data). Scuba diving, boat tours, Cruise ships: 39 ships brought more than 64,000 visitors to Belfast in 2008 (Belfast City Council 2008). Sailing; many marinas, yachting clubs - approx. 12,000 participants in 2008 (CAAN 2009).	Litter, lack of facilities, car access to dunes.
Hiking and walking	Lagan Towpath (most popular public pathway in Northern Ireland); Ulster Way.	No 'right to roam'; few Public Rights of Way; damage from overuse (e.g. Mournes).
Horse riding	Popular, some trekking, but few bridleways.	Not included in access legislation.
Fishing	Salmon and sea trout angling, especially Lough Erne; world class sea angling on the Antrim Causeway Coast; DCAL estimated 25,000 freshwater anglers in Northern Ireland and 4,500 visitors in 2007 (DCAL *et al*. 2007).	Upland rivers and streams can be adversely affected by forestry and farming (UK NEA Freshwaters – Open waters, Wetlands & Floodplains; UK NEA Woodlands).
Shooting	Organised game shooting in upland habitats of Northern Ireland is limited and restricted largely to pheasant and partridge.	The red grouse is a red list species of conservation concern, showing a 60% decline in the last 30 years (Gibbons *et al.*1993; Newton *et al.* 1999).
Archaeology and historic buildings	European Heritage Open Days which attracted a record 56,000 visitors (an increase of 8% from 2008 figures (NIEA 2010a). National Trust properties - the National Trust in Northern	Destruction or damage to monuments and buildings due to neglect and/or vandalism. There is a lack of adequate funding for

	Ireland estimates that over 1.5 million people visit its coast, countryside and gardens annually.	their upkeep.

Table 18.17 Examples of studies which have valued ecosystem services in Northern Ireland.

UK NEA Broad Habitats	Ecosystem Service	Final Good	Valuation
Mountains, Moorland and Heaths (MMH)	Cultural	Landscape	In 1996, annual benefits of £13.09 million derived from the ESA scheme to protect rough land, rebuilding and maintaining stone walls, replanting and maintaining hedges, repairing traditional farm build buildings and painting buildings in approved colours (Moss & Chilton 1997a,b).
		Recreation	A 2008 Travel Cost study found that visitors to the Mourne Mountain gained annual benefits of £25.06 per person. A choice experiment was also carried out examining a number of potential management options identified benefits of £3–£12 per trip per person (Rowan & Longo 2009).
Enclosed Farmland incl. ***MMH*** and ***Semi-natural Grassland***	Provisioning	Food and fibre	Gross output of Northern Ireland agriculture estimated at £1.3 billion for 2009 while GVA (taking into account capital & other inputs) was estimated as £304 million in 2009 (DARD 2010a).
Woodlands	Provisioning	Fibre	Timber: 403,000m^3 of timber produced in 2008/9, with a gross output value of £7.5 million (Forest Service 2009).
	Cultural	Recreation	Two million recreational visits in 2008/9, more than 500 permits for organised events within forests. £0.7million received through charges. However, only 9 of the 124 state owned forests charge (Forest Service 2009). A contingent valuation study in 1992, undertaken as part of a EU project funded under the CAMAR programme, valued the recreation benefits in Northern Ireland's forests at £2.6 million annually (Ni Dhubhain *et al*. 1994).
Open waters, Wetlands and Floodplains	Regulating	Pollution control	A contingent valuation study in 2003/4 valued water quality of all the rivers and lakes in Northern Ireland. Benefits of £8–£12 million/annum if current water quality is maintained and £13–£18million/annum if quality is improved (Hutchinson *et al.* 2005).
	Cultural	Existence of fish	A choice experiment to estimate benefits of conserving rare and endangered fish species in the Lough Melvin Catchment in Northern Ireland and the Republic of Ireland. Benefits (in Euros/year) ranged from €9.63 to €20.50 per person for the individual fish species and €25.57 per person to conserve all the species (Campbell 2008).
		Recreational fishing	A study using Travel Cost and Contingent Valuation methods valued gross domestic user benefits in 1988 at £8–£10 million. Visiting anglers generated expenditures of a further £1.5 million (Davis & O'Neill 1992). The average Northern Ireland resident angler (all types) spent £1,313 during the 2005 season on angling-related spend; each visiting angler typically spent £707. Aggregate gross expenditure for

			game and course fishing is approximately £31.9 million for Northern Ireland residents and £3.2 million for visiting anglers (DCAL *et al.* 2007).
Urban	Cultural	Good health	A choice experiment in 2001 aimed to elicit people's preferences for potential regeneration of St. Anne's Square in Belfast. Although it was unable to calculate figures for St. Anne's Square, it found that increasing open space within a hypothetical square by 50% would produce benefits of £3 per person and an increase in building height would induce a cost of £7.20 per person. The study did find that respondents preferred regeneration alternatives for St. Anne's Square that entailed more open space (Alberini *et al.*2003).
Coastal Margins and Marine	Provisioning	Food	In 2008, 20,300 tonnes of fish with a gross output value of £23.2 million were landed in Northern Ireland by UK registered vessels (shellfish – 10,900 tonnes worth £17.4 million, demersal – 1,900 tonnes worth £3.2 million, pelagic – 7,500 tonnes worth £2.5 m; MFA 2009). No data exist for the GVA of the fishing sector within Northern Ireland. At the UK level, GVA is approximately 50% of gross output of fishing (SeaFish 2007). From 2000 to 2009, an average £17.69 million of fish landed annually (Outcrop/rocky reef – £0.16 million, shelf trough –£0.33million, coarse sediment –£2.38 million, mixed sediment –£0.62million, sand –£3.23 million, mud – £9.55 million, sea loughs –£1.42 million; Strong 2010). In 2007, the aquaculture sector produced 8,400 tonnes of shellfish valued at £5.8 million and over 999 tonnes of finfish valued at £1.85 million. This sector directly employs 113 full time and 48 part time employees (DARD 2010b). Some of this value may be attributable to inland water, not the coast or Marine ecosystems.
	Cultural	Recreation and good health	Trips to the Causeway Coast and Glens were worth £134.2 million in 2007 (26% of all tourist spend; NITB 2007). The aggregate gross expenditure contribution by sea/shore anglers was approx £7.4 million for Northern Ireland residents and approx £0.3 million from visiting anglers (DCAL *et al*. 2007).

Table 18.18 Contribution of the environment to the Northern Ireland economy in 2006. Source: data from NI Green NGOs & EHS (2007).

	Full time equivalent jobs	**Gross Value Added (£million)**
Protection and management of the environment	9,413	226
Sustainable use of natural resources	17,071	211
Environment dependant tourism and recreation	6,125	130
Environment management in industry	140	6
TOTAL	**32,749**	**573**

Table 18.19 Comparison of Northern Ireland's ecological, carbon and green house gas footprints with those of the UK in 2004. Source: data from Stockholm Environment Institute (2009).

	Ecological footprint (global ha/capita)	Carbon footprint (tonnes of carbon dioxide/capita)	Greenhouse gas footprint (carbon dioxide equivalent/capita)
Northern Ireland	4.85	11.18	15.09
UK	5.30	12.08	16.34

Table 18.20 Trends in the habitats and ecosystem services in Northern Ireland since 1990.

Service Group	Final Ecosystem Service		Mountains, Moors & Heathlands	Semi-Natural Grassland	Enclosed Farmland	Woodland	Open Waters, Wetlands	Urban Settlements	Coastal Margins	Marine Habitats
Provisioning	Crops		↔	n/a	↑	n/a	n/a	n/a	↓	↔
	Livestock		↑	↘	↑	↔	n/a	n/a	↗	↗
	Fisheries		↑	n/a	n/a	↔	↗	n/a	n/a	↓
	Trees, standing vegetation and peat		↑	↓	↘	↗	↔	↗	↘	↔
	Water supply		↑	↓	↗	↔	↗	↔	n/a	n/a
	Wild Species Diversity		↔	↓	↓	↗	↘	↘	↘	↘
Cultural, Social & Health	Environmental Settings - Local Places		↑	↘	↘	↑	↔	↗	↗	↘
	Environmental Settings - Landscape/Seascapes		↑	↓	↘	↗	↔	↘	↔	↘
Regulating	Climate		↔	↘	↓	↑	↔	↘	↔	↘
	Hazard		↔	↘	↘	↗	↘	↗	↓	↘
	Diseases and pests		↔	↔	↘	↔	↗	↔	↘	↘
	Detoxification & purification	Water quality	↑	↘	↓	↗	↗	↘	↔	↔
		Soil quality	↑	↘	↘	↗	↘	↘	↔	n/a
		Air quality	↑	↘	↘	↗	↔	↔	↔	↔
		Noise	↔	n/a	↘	↔	↔	↔	↘	↘

KEY	
Importance for Ecosystem Service	
	High
	High-Medium
	Medium-Low
	Low
n/a	Not applicable
Direction of Change	
↑	Improving
↗	Some improvement
↔	Equivocal changes
↘	Some deterioration
↓	Deteriorating

Table 18.21 Designations in Northern Ireland. Percentages cannot be calculated for designations that include marine areas. The percentage of Northern Ireland cannot be summed as many sites hold multiple designations. Source: NIEA unpublished data (2011).

Designation	Description	Area (ha)		Increase in area 98/99 - 07/08 (%)	No. of Sites	Area (ha)	% Northern Ireland (1,415,000 ha)
		1999 (31/3/99)	2008 (31/3/08)		2010 (1/4/2010)		
Area of Special Scientific Interest (ASSI)	Land identified by scientific survey as being of the highest conservation value.	83,535	95,555	14	304	100,474	7.10
ASSI Features	Earth Science	27,801	33,452	20	107	36,846	2.60
	Habitats	80,775	92,412	14	219	98,037	6.93
	Species	79,623	89,738	13	138	91,236	6.45
Special Protection Area (SPA)	Safeguard the habitats of migratory birds and certain particularly threatened birds.	71,035	108,607	53	17	114,402	N/A
Special Area of Conservation (SAC)	Protect the 220 habitats and approximately 1,000 species of European interest.	44,950	66,321	48	55	67,579	N/A
Ramsar Site	Conservation and wise use of wetlands.	84,330	86,214	2	20	88,170	6.23
Marine Nature Reserve	Conserve marine flora and fauna and geological features of special interest.	16,500	16,500	0	1	16,500	N/A
Area of Outstanding Natural Beauty (AONB)	Protect and enhance the qualities of landscapes of distinctive character and special scenic value.	284,948	288,592	1	9	312,610	22.09
Site of Local Nature Conservation Interest (SLNCI)	Designated for their habitats, species and/or earth science, which make a contribution to the local natural heritage & contribute to National and European biodiversity.	N/A	N/A	N/A	911	36,092	2.55
Country Parks	Promote access to the countryside, encouraging a greater understanding and knowledge of the environment.	2,424	2,424	0	8	2,424	0.17
National Nature Reserves	Conserve terrestrial flora and fauna and geological features of special interest.	1,249	1,675	34	12	1,808	0.13
Local Nature Reserves	Areas set aside for biodiversity and where people can enjoy wildlife.	69	541	684	23	865	0.06

Table 18.22 Current status of designated sites. Source: data from NIBG (2009).

Status of features (basis of designation)	**Favourable condition (%)**	**Unfavourable –recovering (%)**	**Unfavourable (%)**
ASSI	62	3	35
SPA	83	-	17
SAC	39	10	51
Ramsar sites	84	-	16

Table 18.23 Summary information on the three main River Basin Management Districts of Northern Ireland. Source: data from NIEA (2009f,g,h).

	Neagh Bann	North Eastern	North Western
Area	574,000 ha including Lough Neagh at 39,200 ha	300,000 ha including 100,000 ha of marine waters	490,000 ha including Foyle and Erne basins
Sites of importance	10 loughs over 50 ha, 36 drinking water protected areas, wetlands around Lough Neagh. 16 Water dependent SACs, 4 water dependent SPAs.	0.7 million people live in the district including the population of Belfast and surrounding commuter areas. 18 rivers, 2 lakes, 2 coastal waters and 2 transitional waters. 16 Water Dependent SACs, 9 Water Dependent SPAs.	24 water dependent SACs, 4 water dependent SPAs, 3 Bathing Waters, 2 Shellfish Waters, 1681 km Freshwater Fish Directive rivers, 14,900 ha Freshwater Fish Directive lakes, 4 Urban Waste Water Directive sites.
Status			
Surface water bodies below good status	73%	65%	63%
Groundwater bodies below good status	7%	data not provided	data not provided
Benefits £3 million–£15 million investment (all figures relate to values discounted over 15 years)	Quantifiable benefit of £23 million–£25 million. Non-monetary benefits include improvements to tourism and recreation, enhanced soil quality and biodiversity, greater flood resilience, and moderate savings to water consumers.		
Targets by 2015			
Surface water bodies at good status or better	43% (117 of 270)	46% (61 of 133)	67%
Good ecological potential or better in heavily modified water bodies	3% (9)	3%	2%
Groundwater bodies maintained at good status	93%	88% (7 of 8)	100%

Table 18.24 The Northern Ireland Countryside Management Scheme aims, targets and potential outcomes. Source: data from DARD (2008a).

Aims	Maintain and enhance biodiversity in line with the Northern Ireland Biodiversity Strategy (NIBS) and the Programme for Government (PfG) 2008–2011 by maintaining species diversity through the positive management of wildlife habitats and to protect and enhance ASSI/ Natura 2000 sites.
	Assist implementation of the Water Framework Directive.
	Enhance landscape and heritage features by integrating their management into the everyday workings of the farm.
Target	• The target in the Programme for Government is to increase to 50% the area of agricultural land in Northern Ireland covered by environmental enhancement agreements by 2013, allowing 18,000 farmers to participate in agri-environment schemes. • Reversing the decline in farmland biodiversity. • Enhancing the landscape. • Managing natural resources to improve the quality of water, air and soil.
Payments and Options	• Payment rates are typically 25% higher than legacy schemes to reflect the increased costs associated with the new scheme. • Minimum Entry Environmental Benefit (MEEB), where landowners undertake habitat enhancement to manage specific habitats on their farms, resulting in greater environmental and financial benefit. • Special Environmental Project (SEP) option, enabling farmers to propose projects individually and jointly with other agreement holders which are capable of delivering environmental benefits.
Water protection	Water Environment (Water Framework Directive/WFD) Regulations (NI) 2003, aim to establish overall framework for protection of surface and ground waters. Compliance with Nitrates Directive and agri-environment schemes deliver water quality benefits that will help with WFD compliance. The new option – Farm Waterway and riparian zone management aims to enhance farm waterways and their associated riparian zones in terms of water quality improvement through practical management measures.
Biodiversity	NICMS aims to make a major contribution to the conservation action required for many priority Northern Ireland habitats and species. Specific habitat management requirements specify how participants can contribute to the conservation of these habitats and species. Several new options deliver on biodiversity – Pollen and Nectar Mixture (benefits insects) and Delayed cutting/grazing of grassland (positively managing land for Irish hare).
Natura 2000	Special Protection Areas (SPAs) and Special Areas of Conservation (SACs) along with Areas of Special Scientific Interest (ASSI) are a priority for the new Scheme.
Climate Change	Climate change objectives have been identifies in NICMS.

Table 18.25 Summary of agri-environment schemes. Source: data from DARD (2008c).

Environmentally Sensitive Areas Scheme	Designed to integrate the production of wholesome food with responsible management of the countryside.	Highly successful, covering 20% of Northern Ireland. It applied only to land inside one of the five designated ESA areas.
Countryside Management Scheme	First introduced in 1999, encouraging farmers to positively manage habitats, improve water quality and protect heritage.	The CMS applied to land outside the ESAs.
Northern Ireland Countryside Management Scheme (NICMS)	To enhance landscape and heritage features; to assist implementation of the WFD and to maintain and enhance biodiversity.	All of Northern Ireland but selection criteria may be applied to prioritise entry which achieves the greatest environmental benefit
Organic Farming Scheme	Provides payments to help farmers with the additional costs and loss of income that occurs during the conversion period to organic production.	Participants must adhere to the organic standards specified by their chosen certification body and maintained for the duration of a five year agreement. Eligible land in an ASSI or Natura 2000 site may be entered into the OFS.

Table 18.26 Priority Habitats and agri-environment schemes in 2010. Note: these data must be viewed with care as the definitions used by NIEA and DARD do not always correspond. * wet heath and dry heath; † due to differences in DARD and NIEA classification of parkland. Sources: data from NIBG (2009); updated by DARD (2010 unpublished data).

Priority Habitat	HAP estimated total area (ha)	Area under agri-environment scheme (AES) agreement (ha)	% HAP area in AES
Upland Heathland	10,972	33,743*	100
Blanket Bog	140,000	14,066	10
Lowland Raised Bog	21,106	5,140	24
Mixed Ashwoods	3,430	3,520	100
Oakwood	2,350	914	39
Wet Woodland	2,600	1,613	70
Parkland	1,100	2,772	100†
Calcareous Grassland	1,156	1,162	100

Table 18.27 Agri-environment scheme woodland plantings in 2010. Source: Forest Service (unpublished data).

Habitat type	Area (ha)
Ungrazed oak woodland	894
Grazed oak woodland	20
Ungrazed wet woodland	1,508
Grazed wet woodland	105
Wet carr (ungrazed)	200
Ungrazed Ash woodland	3,266
Grazed Ash woodland	234
Farm woodland (ungrazed)	1,175
Parkland and lowland wood pasture	2,772