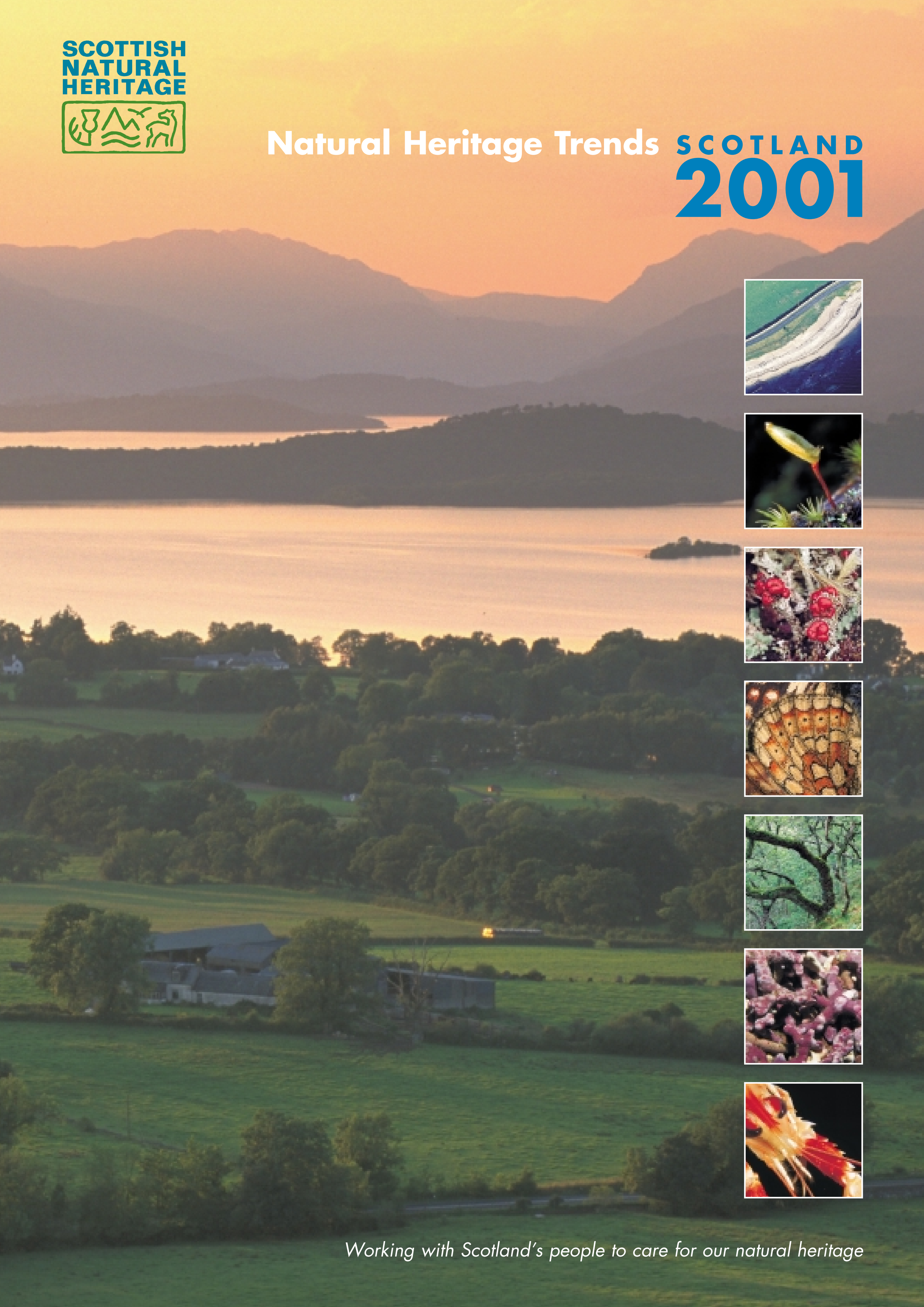
SCOTTISH NATURAL HERITAGE

Natural Heritage Trends SCOTLAND 2001



Working with Scotland's people to care for our natural heritage

SCOTTISH NATURAL HERITAGE

Natural Heritage Trends SCOTLAND 2001

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Scottish Natural Heritage

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2001

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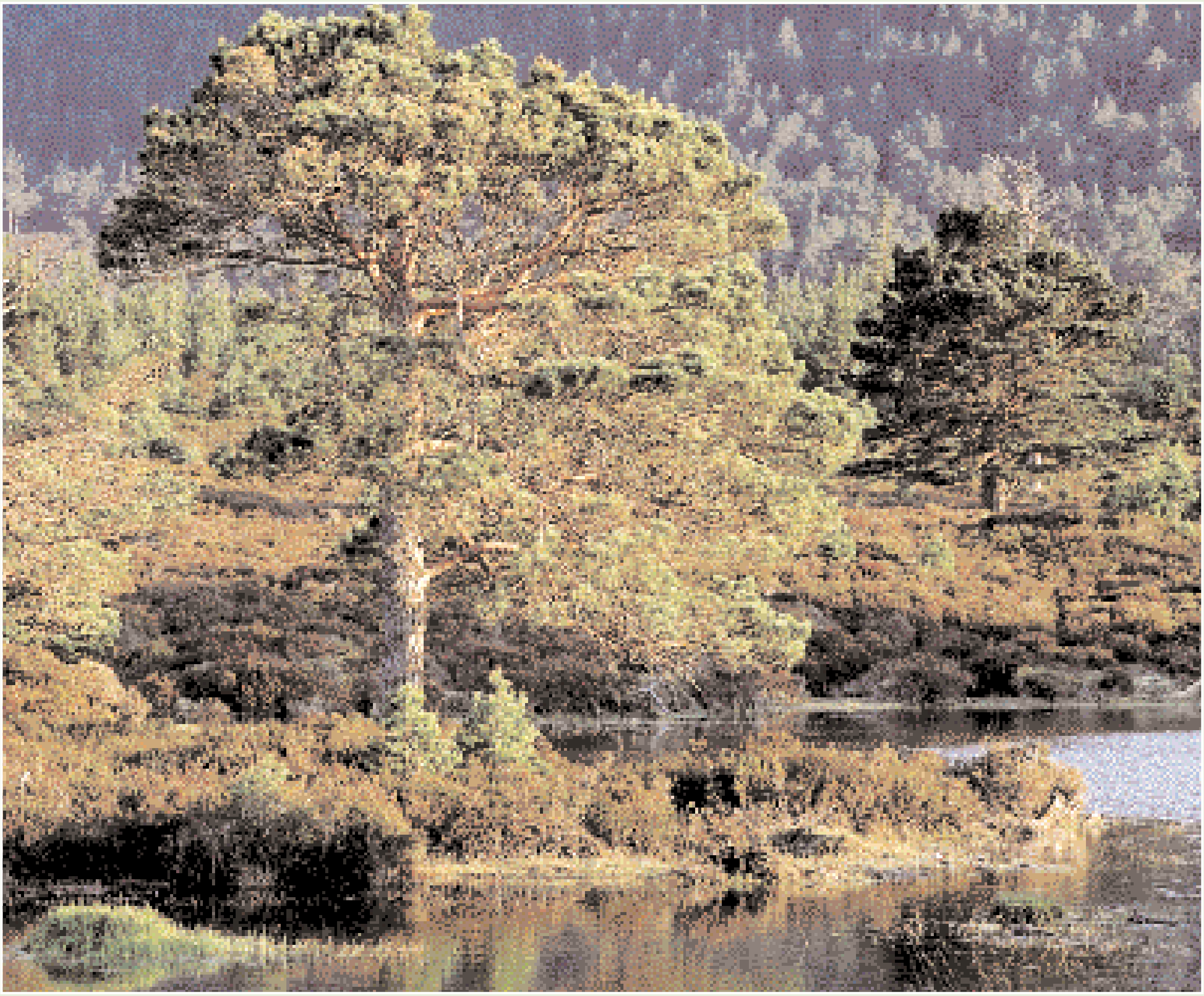
Contents

Front cover main photograph: Loch Lomond, looking northwards.
Scotland's first proposed National Park.



Foreword

In the latest Survey of Environmental Issues in Scotland (2000) on the web site of the Scottish Executive, three-quarters of respondents felt that damage to the countryside and loss of wildlife were 'fairly' or 'very' serious matters. People are justifiably concerned about the natural heritage, but what do we really know about how it is changing?

Newsworthy stories are capable of raising awareness and focusing on issues of concern. Through time they are influential in forming public perceptions. Yet, as isolated accounts they can only provide fragmentary, and not necessarily impartial, views. Tracking down published reports and scientific papers requires time and specialist knowledge. Clearly, the best available information needs to be brought together and presented in a more accessible way. For that reason Scottish Natural Heritage published a report, entitled *The Natural Heritage of Scotland: an Overview*, as a contribution to European Nature Conservation Year in 1995. It embraced the scope of the natural heritage defined in the Natural Heritage (Scotland) Act 1991, by including the plants and animals of Scotland, its earth science features, its natural beauty and amenity value.

That was six years ago. The world around us has changed and so too have information needs. What we need now is to know how the natural heritage is changing and why, and where we should be most concerned. This new report provides the most comprehensive account of natural heritage trends to date. We have set out to present information as clearly and as systematically as possible so that it can be used by the widest possible readership, in Scotland and beyond. We see it as becoming a key reference for policy makers and planners, for teachers and researchers, for practitioners and environmentalists, and indeed for the wider interested public.

We have tried to be balanced and comprehensive, but this is necessarily a summary view. We have focused for the most part on Scotland-wide trends, but feel that the approach could be adapted for use in more localised areas. We feel that this account, which we intend to sustain and expand upon through trend reporting on our web site (www.snh.org.uk), takes an important step forward in the dissemination of knowledge about the natural heritage of Scotland.

I hope that you too will find it readable and informative.

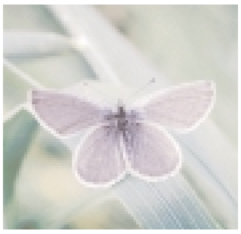
Roger Crofts
Chief Executive

1 Introduction and summary

The natural heritage of Scotland – its plants and animals, geology and landforms, natural beauty and amenity – is remarkably diverse. In the past few decades, many aspects of our natural heritage, including its diversity, condition and the way in which we exploit it, have changed substantially. In this report we try to summarise these changes, where possible identifying any emerging trends.

Chapter 2, as a prelude to accounts of more recent change, provides a glimpse of some of the dramatic events in the history of the Earth that formed and shaped Scotland. Change has been turbulent across geological time-scales, and has given rise to Scotland's distinctive landscapes, to its unique array of habitats and species, and to the wealth of recreational pursuits that take place on land, fresh water, the coast and at sea.

Against that backdrop, the time-frame for reporting on natural heritage trends is decades rather than millennia, the agent of change being related predominantly to human activity rather than natural processes. Where possible, the focus of interest is on changes that have taken place over the past decade. An ability to predict likely future changes would be even more useful, examples of which are the likely consequences of air pollution and climate projections.



Biodiversity

Chapter 3 provides an overview of species trends. Trends that are known on range and abundance (no reliable trend data exist for reptiles, amphibians, the majority of invertebrates or for lower plants) indicate declines as well as increases.

Some 60% of **rare and endemic vascular plant** species examined during 1990-96 were stable or increasing, but the remaining 40% appeared to have fewer populations than were known to exist prior to 1990. Over 40% of native **land mammals** are thought to be in decline. The geographic ranges of most **non-native plant species** changed little between the 1950s and 1987-88. Nevertheless, of 58 plant species that increased their range significantly, 31 are thought to have a medium or high adverse impact on native species.

Although the ranges of 80% of **butterfly** species remained stable or increased between surveys in 1970-82 and 1995-99, widespread species have tended to increase, while scarce species have declined. The geographic ranges of about half of Scotland's **terrestrial and freshwater bird** species showed little change between c.1970 and c.1990, but almost one third of species, including 60% of farmland birds, showed marked reductions in range size. A more recent breeding birds survey has shown that 16% of widespread species decreased significantly in abundance between 1994 and 1999. Nearly two-thirds of **species given legal protection** in Scotland were thought to be stable or increasing in 1997, with 36% in decline.

The majority of wintering **waders and wildfowl** increased markedly in abundance from the 1970s to the 1990s. Goose populations, in particular, have shown remarkable gains. Most **seabird** populations also increased between the 1970s and 1980s.

The relatively mild, wet climate of the western seaboard is particularly favourable to lower plants. Some 60% of Europe's liverwort and moss species occur there. Being sensitive to air and water pollutants, many have their European stronghold along the Atlantic coast and Western Isles. The richness of bryophyte and other flora of the western Atlantic oak woods has been likened to that of a temperate rain forest. Also noteworthy are Caledonian pinewood remnants of the drier interior, relict arctic-alpine communities of the high mountain tops, expansive blanket mires and heather moorlands that dominate large parts of the uplands, and the varied coastal margins of high sea cliff and shingle shore, sand dune and machair grassland.

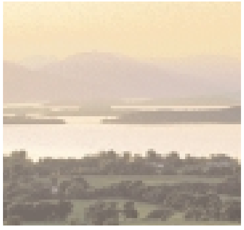
Chapter 4 summarises land cover trends from the late-1940s to the late-1980s, a period of rapid growth in farming and forestry, urban development and road building. Consequently, long-established and semi-natural habitats such as heather moorland, peatland, rough grassland and woodland, were reduced in extent. Between around 1947 and 1988 the area of **semi-natural habitat** in Scotland was reduced by an estimated 17%.

Chapter 5 reports on more recent trends on 'broad habitats'. Between 1990 and 1998 the extent of **fen, marsh and swamp** increased by about 19%, pointing to reduced intensity of grassland management and land drainage, with more rushiness appearing in wet grassland. A 9% expansion of **broadleaved and mixed woodland** was another notable departure from previous trends, reflecting new planting and forest restructuring in the 1990s. There were some signs of a continued **conversion of grassland to arable**, particularly in the marginal uplands. Previous declines in **peatland** and **acid grassland** appeared to have been arrested.

Past rates of decline of heather moorland, or **dwarf shrub heath**, appeared to have continued in the 1990s, with weak statistical evidence of a 5% reduction in extent between 1990 and 1998. There was also some evidence of declines in the much less extensive **neutral and calcareous grasslands**. Although there was no clear evidence of change in overall **hedgerow** length, significant increases in relict hedges with trees and scrub suggested reduced hedgerow management. The length of fencing increased by around 4%.

Small changes in the **botanical composition of habitats** pointed to nutrient enrichment, favouring competitive species at the expense of plants that are naturally adapted to acidic or nutrient-poor environments.

Chapter 6 describes the development of the **UK Biodiversity Action Plan (BAP)**, which quantifies the extent and nature of the problems facing each of a selection of habitats and species considered threatened in the UK. Action plans offer an approach to tackling these problems, and provide biological objectives and targets against which levels of success may be gauged. Some **41 BAP priority habitats** and **261 priority species** either occur in, or have recently been lost from Scotland. Among these, four habitats show signs of recovery, while five still appear to be declining. Of 186 BAP priority species recently assessed, 11 were showing signs of recovery, or were thought to have recovered. A further 47 species were thought to be declining. Sixteen species had been lost from Scotland, all prior to the BAP programme.
Trend data indicating progress towards achieving BAP targets are generally available only for priority bird species. Of 20 BAP **priority bird species** occurring in Scotland, at least 16 seem unlikely to achieve all of their UK plan targets.



The countryside

Chapter 7 considers the ever-changing appearance of Scotland's landscape, in which observations of the mid-1990s landscape confirm and supplement land cover trends. Explorations of **landscape** change include the appearance of features that were new to the 1990s landscape, such as **wind farms**. More qualitative aspects of landscape change, from a study of part of Scotland between the mid-1960s and the mid-1990s, is illustrated by the cumulative effects of development on **tranquillity**.

Chapter 8 gives an overview of trends in access and recreation The Scottish countryside has long been valued as a setting for **informal recreation**. The forests, mountains, rivers, lochs and coasts are the most varied and extensive in Britain. Between 1994 and 1998 the number of visits by Scottish adults to the coast or countryside increased from 105 million to 137 million. The proportion of adults taking part in outdoor activities increased from 41% to 46% between 1987-89 and 1996-98. Participation in hill-walking and mountaineering increased throughout the last century. Between 1986 and 1996, the number of Forest Enterprise walks and nature trails increased from 199 to 336 and visitor centres increased from six to twelve. Under the 'Paths For All' initiative, launched in 1996, the development of over 100 path networks was proposed or being implemented by May 2000.

Distinctive natural heritage settings

Chapter 9 considers trends in green space in and around settlements, places where most people live and interact frequently with the natural heritage.

Commonly accounting for as much as 20% of the urban area in Scotland, green space is integral to sustaining local biodiversity and to the quality of life in towns and cities. The extent of **built-up land and transport corridor** had expanded by over a third from the late-1940s to the late-1980s, but in the 1990s the rate of development appeared to have slowed. Although the number of households continued to increase during the 1990s, there was no clear evidence of that from the Countryside Survey. Between 1989 and 2000 the number of **Local Nature Reserves** increased from six to 34. During 1990/2000, seven out of 28 **bird species** in Scottish suburban gardens were reported more frequently, and ten species less frequently, than they had been in 1995/96. The extent of **vacant and derelict land**, around 50% of which had remained so for more than 14 years, decreased by 22% between 1993 and 1999. Over 450 **school grounds** natural heritage projects were supported between 1995/96 and 2000. Around 80 **community-based woodland** initiatives were in place by 2000. The Scottish Golf Course Wildlife Initiative had visited and provided environmental reports to around 200 (39%) **golf courses** between 1996 and 2000.

Chapter 10 summarises farmland trends, including increased participation in **agri-environment schemes** from 802 to 4491 (including the Organic Aid Scheme) between 1992/93 and 2000/01. Reductions in **arable weeds** between 1930-1960 and 1987-1988 indicate reduced biodiversity within arable fields. Declines between 1990 and 1998 were not statistically significant and so provide no clear evidence of change. The area of **farm woodland** doubled between 1991 and 2000, to represent 3.6% of the total agricultural area in 2000. Of 20 **farmland bird species**, 12 declined in range by more than 10% between 1968-72 and 1988-90 whilst only one increased by more than 10%. Of 13 species for which adequate abundance data are available, three showed a statistical significant decline between 1994 and 1999; the remainder showed no significant trend.

Chapter 11 considers forest and woodland trends. Following expansion of the conifer forest over recent decades, forest and woodland extended to around 17% of Scotland's land area by 2000. Historically, neglect, overgrazing and replacement planting with exotic conifers contributed to a decline in the area and quality of Scotland's semi-natural woodland. In a reversal of that trend, **native woodland** increased in area by 34% between 1984 and 1999. Natural regeneration of native woodland increased by 3,132 ha between 1995 and 2000. Changes in the range and abundance of widespread **woodland bird** species have generally been more favourable than for farmland birds. Between around 1970 and 1990, ten woodland species contracted in range by more than 10% and 11 expanded. In the more recent 1994-1999 survey, five out of 14 widespread woodland species showed a statistically significant increase in abundance, while one species declined.

Chapter 12 reports on trends in the uplands, where moorland, peatland and rough grassland form a mosaic of semi-natural habitats covering more than 50% of Scotland's land area. Between 1982 and 1998 **grazing pressure** appears to have increased by at least 10% within about a third of the marginal and true uplands, but it also decreased equally markedly within a similar area. Between the 1970s and 1990s, the geographic range of the **red grouse**, the number of keepered moors in Scotland and the number of red grouse shot all fell substantially. During that time-frame also, the breeding range of nine **upland bird species** expanded, seven declined, and 15 showed little or no change. The number of breeding pairs of dotterel declined by 23% between 1987-88 and 1999.

Chapter 13 summarises trends in Scotland's fresh waters of lochs and rivers. Beyond changes in fresh water extent arising from hydro-scheme development from the 1950s to the 1970s, the main changes have been in terms of water quality and in wildlife. Between 1996 and 1999, about 90% of Scotland's rivers were of excellent or good quality. This included a small decrease (3%) in the length of rivers classified as excellent, and a corresponding increase (2%) in the length of rivers classified as good quality. Benefiting from improved water quality in Central Scotland, between 1977/79 and 1991/94 **otters** recolonised much of their former range.

Trends in other wildlife associated with fresh water are less favourable. The non-native **American mink** also increased in range and population density, and is thought at least partly responsible for reduced numbers of **water vole**, which declined from around 2.5 million to just over 354,000 between 1989/90 and 1996/98. Between 1986/72 and 1988/91 there was a contraction of at least 10% in the breeding range of nine **bird species** dependant on fresh waters, little or no change in 15, and an increase in the range of five. By 2000, 12 of the 26 native **fish** of Scotland had declined, the vendace had become extinct (although recently re-introduced), nine species were considered stable and four had increased. By 1998, rod-caught salmon had decreased by 6.3% and net-caught salmon by 94% compared to the 1950s. Of the six amphibians native to Scotland, the **great crested newt** had declined throughout its range, according to a re-survey in 1995/96 of sites with historical records. Surveys of **freshwater pearl mussel sites** with historical records from the 1900s showed that by 1996/99, 65% had functionally extinct populations and only about 7% were considered to be near-natural.

The sea

The natural heritage of Scotland's coastal waters, to the 12-nautical-mile territorial limit and beyond that to the continental shelf, are equally distinctive. Lying in a transition zone between sub-tropical waters to the south and sub-polar waters to the north, many marine species occur at their northern or southern limits within Scottish waters. The prevailing northerly currents and relatively warm waters of the west coast allow species associated with more southerly latitudes to establish. In contrast, the colder North Sea favours species of temperate-arctic waters. Between the two, and biogeographically isolated by the fluctuation of temperature seasonally, are the northern seas around the Fair Isle and Shetland Islands. Consequently, Scotland's marine flora and fauna are rich and diverse, with major commercial fish and shellfish stocks, as well as internationally important populations of seabirds and grey and harbour seals.

Chapter 14 summarises trends in the marine environment. It is only comparatively recently, from the 1970s onwards, that **marine surveys** have started to reveal the habitats and wildlife in the seas around Scotland. Some 25 species of **whales, dolphins and porpoises** have been recorded in British and Irish waters within the last 100 years, and 23 within the last 20 years. Improved water quality in the Clyde and Forth estuaries in recent decades has allowed **invertebrates and fish to recolonise formerly polluted areas**. The clean and sheltered waters of the west coast have attracted fish farming, with rapid expansions in **salmon and shellfish production** from the 1980s onwards. **Sea levels** are rising relative to land in places, with increased storminess. Short-term increases in sea temperature provide no clear long-term trend. **Harbour seal** numbers remained largely stable over the last decade but **grey seal** numbers increased by around 6% per year. Eleven out of 18 **seabird** species showed a marked increase in their breeding population and four showed a marked decline, between around 1970 and 1987.

Chapter 15 provides an overview of Scottish marine fishery trends. In view of their ecological importance, commercially exploited **fish** species have been identified for biodiversity conservation action through Species Action Plans. Of the 1000-or-so species of fish that inhabit the seas around Scotland, some 2% account for 95% of total fish biomass. Scottish data are available for 12 **commercially exploited species**, nine of which are considered to be outside safe biological limits. At current levels of exploitation, the stock of some, such as cod, are at risk of collapse. The status of 12-or-so commercially exploited **deep water species** is mostly unknown or outside safe biological limits.

Global pressures affecting future change

Chapter 16 identifies trends and projections in air pollution impacts. As emissions of airborne pollutants have been reduced in recent years, and with further reductions planned, threats to the natural heritage have receded. The area of damage due to the acidification of soils is projected to decrease in Scotland by 12% between 1995/97 and 2010; the area of damage due to the acidification of **fresh waters** is projected to decrease by 67%; and the area of **peatlands** damaged through eutrophication from airborne nutrient nitrogen is projected to decrease by 37%. Ground-level ozone damage to **semi-natural vegetation** is also projected to decline, with a reduction in exceedance of about 20% over the coming decade.

Chapter 17 documents changes in the Scottish climate. During the 20th century, **precipitation** over land increased in the high latitudes of the northern hemisphere. Within Scotland, the wettest decade on record occurred during the 1990s, especially in the west. **Cloud cover** has increased. Days with bright sunshine have decreased in winter since the 1970s, particularly in the west. Although there has been little evidence of any increase in mean annual **wind speed** or maximum gust strength within Scotland, westerly air flows and the frequency of days with gales have both increased.

During the 20th century also, countries such as Scotland at latitudes north of 55˚ experienced temperature rises greater than the global average, with a **warming** of 0.8˚C in Europe. Changes in minimum temperatures have a greater ecological effect than any other temperature change. Within Scotland, an overall decrease in the diurnal (day-night) temperature range has been most pronounced in spring. Spring temperatures rose by 0.5˚C between 1960 and 2000. Coastal sea temperatures have increased by around 1˚C since the 1970s, with warming most apparent in winter. Off-shore sea temperatures increased by 1-1.5˚C. Minimum temperatures of oceanic waters during the 1990s were the highest recorded during the 20th century, matching near-surface air temperature trends for the northern hemisphere. Warming in Scotland is expected to continue to be greater in winter than in summer, with mean increases of between 1.5 and 5.8˚C projected for the next century.

Chapter 18 considers the consequences of climate change on habitats and species. By 1998, the **growing season** across the British Isles had become three weeks longer than it had been 1962, with **earlier arrivals** of migrant birds and earlier reproduction among some animals. The breeding **distributions of a number of British bird and butterfly species** extended northwards during the 20th century. Wetter winters and drier summers may have affected the structure of peatlands, with signs of more frequent and more extensive forms of **peatland erosion**. Heavier downpours of rain have caused **rapid stream discharges**, altering the physical structure of some riverbanks and floodplains, and in places washing out young fish and uprooting beds of freshwater pearl mussel.

Chapter 19 concludes with a synthesis of the state of the natural heritage in Scotland, with reference to Europe.

2 Prelude: a record in time

The natural heritage reflects an evolutionary history from earliest times. Within a relatively small area, Scotland exhibits a remarkable geological, palaeontological and geomorphological diversity – the heritage of some three billion years of Earth history at the crossroads of colliding and rifting continents, when component pieces of Scotland journeyed across the face of the Earth to the southern hemisphere and back. The jigsaw of Scotland came together as it is today only 400 million years ago.

The varied history and composition of different pieces of Scotland explain its rich geological diversity and varied landscape, evident, for example, in the abrupt boundary faults that separate the Highlands of the north and the Southern Uplands from the low-lying Midland Valley.

Rocks

The rocks of Scotland were formed in different locations on the Earth's surface, under tropical, desert and glacial conditions. Past volcanic activity and mountain formation reflect times when Scotland was positioned on the edges of the Earth's tectonic plates. There, magma activity, rock folding and mountain building were concentrated.

Today, Scotland's rocks are a resource of national and international importance for studies of these processes and they form the foundation of our most valued landscapes (Gordon & MacFadyen, 2001; Trewin, 2001).

Fossils

More than half of Scotland's land area is underlain by igneous and metamorphic rocks. Elsewhere, sedimentary rocks contain rich fossil assemblages of immense diversity, some of which are unique. This fossil heritage, which spans 800 million years of Earth history, has been crucial in unravelling the evolution of the plant and animal kingdoms.

Scotland has yielded the world's oldest known vertebrate (the jawless fish, *Jamoytius kerwoodi* of the Silurian sea, discovered near Lesmahagow), some of the earliest amphibian tracks and reptile remains (e.g. *Westlothiana lizziae*, a fossil reptile of the Carboniferous, found near Bathgate), some of the oldest known plants (that grew around hot volcanic springs in the vicinity of Rhynie, Aberdeenshire), the oldest known insect (*Rhyniella praecursor*), and some of the earliest mammal remains found within the dinosaur bearing strata of the Jurassic on Skye.

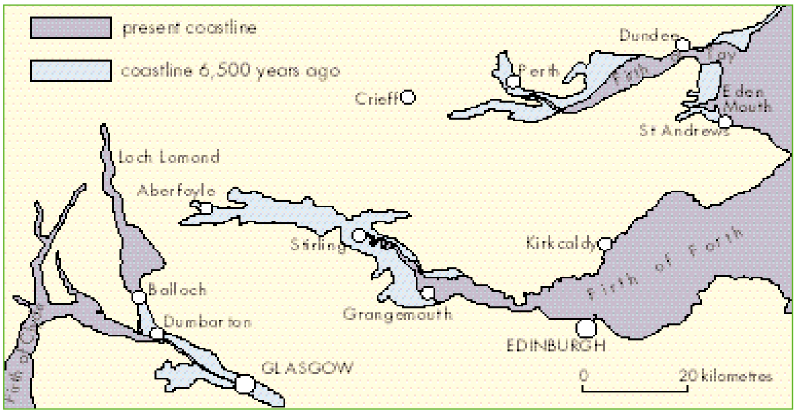
Above: Folded schist, Imacher Point, Arran.

Fossil of fern which grew in a tropical environment c. 300 m years ago.

Top: Open-cast coal mine, Blairbathie, Fife.

Bottom: A raised beach at Dougarie, Arran, dating back about 6,000 years, to a time when the sea was higher than it is at present.

Figure 2.1
The coastline as it would have appeared 6,500 years ago.



Minerals

Scotland's industrial history was founded on coal-bearing measures of the Midland Valley, laid down in equatorial swamp forests of the Carboniferous. The early petrochemical industry was founded on oil shales of the Lothians, derived from organic sediments laid down in lagoonal conditions, to be superseded by oil and gas of the North Sea and North Atlantic.

Aggregate for road construction is derived from igneous and metamorphic rock. Building, or dimensioned, stone traditionally reflects the local geology: e.g. the granite of Aberdeen and the Carboniferous sandstones of Glasgow and Edinburgh.

Other rocks and minerals of economic value include limestone from warm, shallow seas of the Cambrian, Ordovician and Carboniferous; talc from rocks that once floored the ancient Iapetus Ocean; potash fertiliser from Cambrian aged sediments; metalliferous minerals; and barytes from mineral veins.

Landforms

During the last two million years, ice sheets and glaciers carved and moulded the surface of the land, altered the courses of rivers, and deposited parent materials for soils and sand sources for beaches. The position of the coast varied according to the level of land relative to sea (Figure 2.1), giving rise to raised beaches and flooded former valleys. Relict landforms, such as drumlins and eskers, were formed under glacial conditions. The glaciers shaped the present day landscape and supplied the parent materials and support systems for soil, habitat and ecosystem development. Land, lake and sea sediments also reveal evidence of past environmental change. For example, the pollen record of peat bogs reflects vegetation responses to changing climate since the last glaciation, and can help to reconstruct the native vegetation structure.

Scotland's landforms are of great importance for understanding the evolution of the landscape and for the diversity of scenery and habitats they provide (Gordon & MacFadyen, 2001). Active elements, in the form of geomorphological and soil processes, continue to modify the landscape and interact with habitats and ecosystems. This is particularly evident in coastal, freshwater and upland environments (e.g. Hansom & Angus, 2001; Soulsby & Boon, 2001; Thompson *et al.*, 2001).

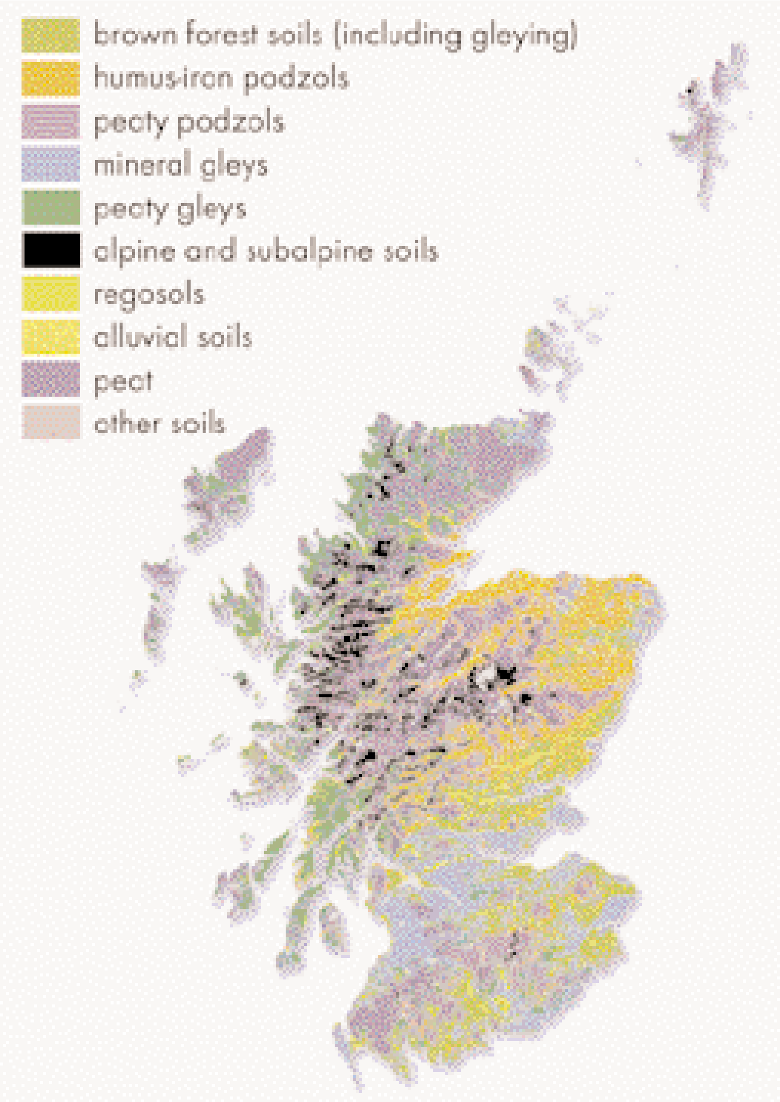
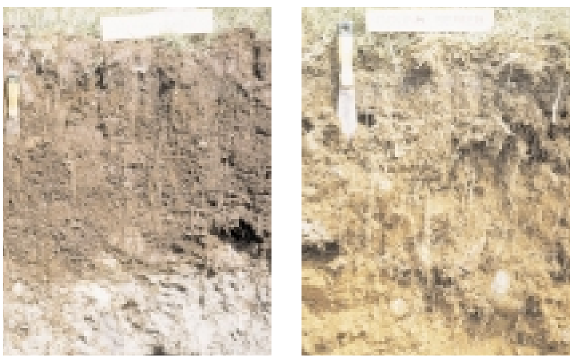


Figure 2.5
Simplified soils map.
Source: MLURI

Left: Peat

Right Podzol



Left: Peaty Gley

Right: Brown forest soil

Soils

Soil is the dynamic interface between physical, biological and hydrological systems. It is the medium upon which plant growth and terrestrial ecosystems depend, influencing habitat distribution and biological diversity. Parent material, climate, topography, drainage, vegetation and human influence give rise to many distinct soil types (Figure 2.2). With widely differing physical and biological properties, the soils of Scotland can be broadly divided into four main groups: peats, gleys, podzols and brown forest soils.

Scotland's soils are a fundamental part of the natural heritage, both in their own right and for the diversity of habitats and species which they support (see Taylor *et al.*, 1996). They are also an important reservoir of terrestrial carbon, containing approximately 70% of the soil carbon in Great Britain (Milne & Brown, 1997).

The Earth heritage continues to evolve over long time-spans, and is much more rapidly affected by a range of development and land-use activities (Box 2.1).

Plants and animals

For the most part, Scotland's native plants and animals colonised from the south and across the European land bridge as the polar ice sheet receded some 15,000-or-so years ago.

Scotland's distinctive biogeography, its climate, topography, geology and soils, and history of land use, are reflected in its land cover. The uplands are characterised by expansive tracts of blanket mire, where high rainfall and low temperatures have inhibited the decay of bog vegetation over millennia. Mosaics of acid grassland, which becomes increasingly dominant towards the wetter west, and heather moorland which is at its most luxuriant on freely drained soils to the east, have been sustained by grazing and burning since the natural forest was cleared from Neolithic times onwards. On the higher mountain tops, above the natural treeline, scrub remnants give way to arctic-alpine vegetation that echoes Scotland's post-glacial past. In the lowlands, agricultural land use reflects the west-east rainfall gradient, where pastoral livestock systems in the wetter west contrast with arable farming in the drier east. Settlement has located mainly in the lowlands, with the advantages of fertile soils, navigable river estuaries suited to maritime trade, minerals for industrial development, and a wealth of natural resources from the sea.

Box 2.1 Pressures on the Earth Heritage
(from Gordon & MacFadyen, 2001)

Pressure	Examples of on-site impacts	Examples of off-site impacts
1. Mineral extraction (includes pits, quarries, dunes and beaches)	• destruction of landforms and sediment records • destruction of soils, structure and soil biota • may have positive benefits in creating new sedimentary sections • soil contamination • loss of structure during storage	• contamination of watercourses • changes in sediment supply to active process systems, opencast, extraction from rivers, leading to deposition or channel scour • disruption of drainage network (impacts on runoff) • dust (may affect soil pH)
2. Restoration of pits and quarries	• loss of exposures • loss of natural landform • habitat creation	
3. Landfill	• loss of sedimentary exposures • loss of natural landform; soil disturbance • detrimental effects of gases and other decomposition products on soils and soil biotas	• contamination of water courses • contamination of groundwater • redistribution of waste on beach/dune systems • leakage of contaminants to water courses or ground water
4. Reclamation of contaminated land	• improvement of soil quality	
5. Commercial and industrial developments	• large scale damage and disruption/loss of surface and sub-surface features, including landforms and soils • soil contamination • damage to soil structure • changes to soil water regime • loss of soil biota	• changes to geomorphological processes downstream, arising from channelisation or water abstraction • leakage of contaminants to water courses or ground water
6. Coast protection	• loss of coastal exposures • destruction of active and relict landforms • disruption of natural processes	• changes to sediment circulation and processes downdrift
7. River management and engineering	• loss of exposures • destruction of active and relict landforms • disruption of natural processes	• changes to sediment movement and processes downstream • change in process regime
8. Afforestation	• loss of landform and outcrop visibility • physical damage to small scale landforms • soil erosion • changes to soil chemistry and soil water regime • changes to soil biodiversity	• increase in sediment yield and speed of runoff from catchments during planting and harvesting • changes to ground water and surface water chemistry

Box 2.1 **Pressures on the Earth Heritage**
(continued)

Pressure	Examples of on-site impacts	Examples of off-site impacts
9. Agriculture	• landform damage through ploughing, ground levelling and drainage • soil compaction, loss of organic matter, reduction in biodiversity • effects of excess fertiliser applications on soil chemistry and biodiversity; changes to nutrient status • effects of pesticides on soil biodiversity • soil erosion	• changes in runoff response times arising from drainage • episodic soil erosion leading to increased sedimentation and chemical contamination in lochs and river systems • pollution of groundwater
10. Other land management changes (e.g. drainage, dumping, construction of tracks)	• degradation of exposures and landforms • oxidation of soil organic material • changes to soil water regime • soil contamination	• changes in runoff and sediment supply • drying out of wetlands through local and distal drainage
11. Recreation (infrastructure, footpath development, use of all-terrain vehicles)	• physical damage to small-scale landforms and soils (compaction) • localised soil erosion • loss of soil organic matter	
12. Irresponsible fossil collecting	• loss of fossil record	
13. Soil pollution	• acidification of soils • accumulation of heavy metals • effects on soil biodiversity	• downstream impacts on watercourses • contamination of groundwater
14. Soil erosion	• deterioration of landforms • loss of organic matter	• enhanced sedimentation streams and lochs • changes in water chemistry
15. Climate change	• changes in active system processes • changes in system state (reactivation or fossilisation)	• changes in flood frequency • changes in sensitivity of land-forming environments e.g. rivers, coasts), leading to changes in types and rates of geomorphological processes (e.g. erosion, flooding)
16. Sea-level rise	• changes in coastal exposures and landforms • enhanced flooding	• changes in wider patterns of erosion and deposition

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3 Species

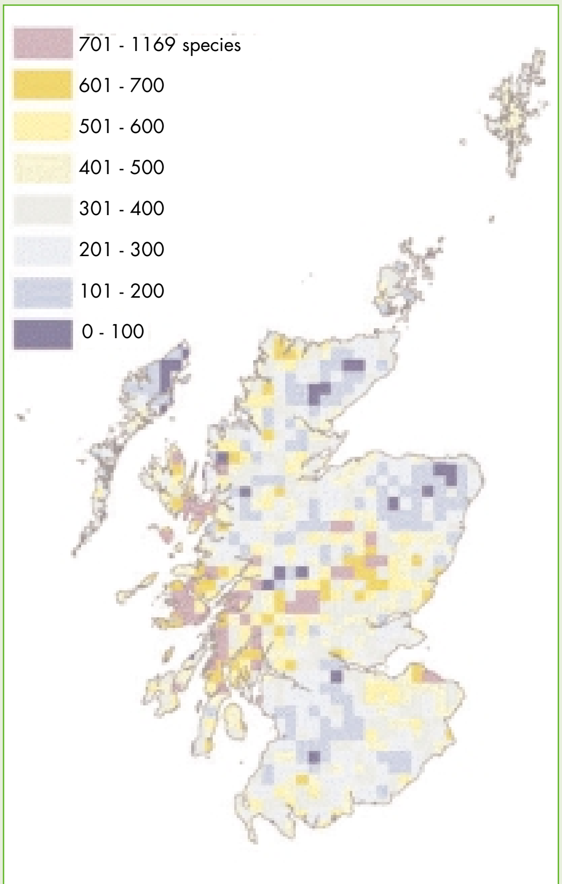
Scotland and its surrounding seas may support up to 90,000 native species (Usher, 1997); perhaps less than 1% of the world total (Hawksworth & Kalin-Arroyo, 1995). Scotland's species complement is, nonetheless, remarkable for its diverse mix of Atlantic, arctic, arctic-alpine and boreal elements, many of which are on the extreme edge of their global range. Some have highly disjunct ranges which otherwise include only a few widely dispersed localities in Asia, North or tropical America. Around thirty Scottish species occur nowhere else in the world.

A relatively mild, wet climate is particularly favourable to 'lower' plants. Consequently, more than half of the liverworts and mosses, and over a third of the lichens of Europe occur in Scotland. Being sensitive to air and water pollutants, many lower plants have their European stronghold along the Atlantic coast and Western Isles. Also of international importance are Scotland's breeding populations of seabirds and grey seals, and over-wintering geese.

Species richness varies markedly across Scotland (Box 3.1). Heathlands and broadleaved woodlands

Box 3.1 Variation in species richness

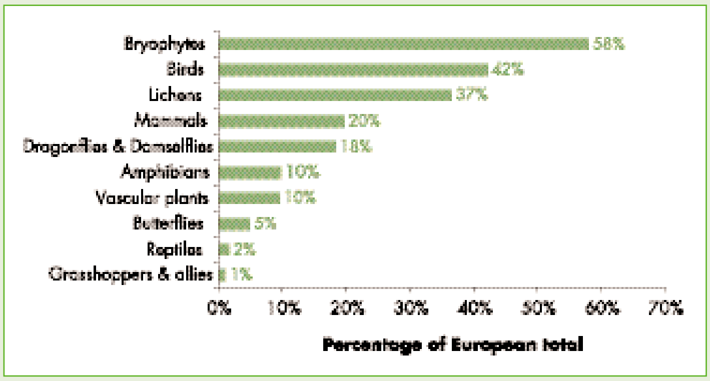
Figure 3.1 The number of species recorded from 14 taxonomic groups, at a scale of 10x10 km.



Species richness varies markedly across Scotland. Figure 3.1 shows the combined distributions of 3,685 species in 14 groups: lichens, seaweeds, bryophytes, stoneworts, rare and scarce vascular plants, molluscs, dragonflies & damselflies, grasshoppers & crickets, carabid beetles, butterflies, amphibians, reptiles, birds and mammals.

The largest of these groups are the bryophytes (mosses and liverworts) and lichens, which together account for 63% of the species mapped. In Europe, Scotland is particularly important for these lower plant groups (Figure 3.2); some 50% of Atlantic bryophytes endemic to Europe have at least half of their British and Irish range in Scotland (Hodgetts, 1997). The pattern of diversity shown in Figure 3.1 therefore tends to reflect the ecological needs of lower plants, with 'hotspots' arising in moist, oceanic and upland areas.

Figure 3.2 Scotland's species complement as a percentage of that recorded throughout Europe.



Sources: Biological Records Centre, British Lichen Society, British Trust for Ornithology, Merritt *et al.*, (1996), Fleming *et al.*, (1997), Haes & Harding (1997), Hill *et al.*, (1999), Asher *et al.*, (2001), Coppins (2001), Curtis & Long (2001).

for example, tend to be species-rich, particularly in areas favourable for lower plants.

Many species have become restricted to modified remnants of their original habitats. Between the 1940s and 1980s an estimated 17% of semi-natural habitat in Scotland was converted to more intensive use, such as for farming or forestry (Mackey *et al.*, 1998).

The way in which land and wildlife habitats are managed affects the abundance and diversity of species. For example, changes in farming practices have been linked to declines in terrestrial bird populations throughout the United Kingdom in recent decades.

Alpine gentian: only five out of 11 populations known to exist prior to 1990 were re-found during 1990-96.

In 1998 a national survey found signs of **water voles** at less than 10% of the sites occupied prior to 1989. The species' decline has been attributed to mink predation, habitat loss, fragmentation, disturbance and pollution.

Key sources: Butterfly Conservation, The Mammal Society, the Wildfowl and Wetlands Trust, Atkinson *et al.*, (2000), Fleming (1997), Lloyd *et al.*, (1991), Maitland (1997, 1999), Welch *et al.*, (2001). Spatial and other data were provided by the Biological Records Centre, the British Lichen Society and the British Trust for Ornithology.

Trends

Species groups for which adequate trend information is available are summarised in Table 3.1. This shows the following.

- Within a sample of rare and endemic vascular plant species examined during 1990-96, the majority appeared to have fewer populations than were known to exist prior to 1990.
- The distribution of many butterfly species has changed. Most of the species in decline are already scarce, whilst those that have increased are already widespread (Box 3.2).
- Almost half of Scotland's native freshwater fish species are thought to have declined recently, having been affected by a wide range of habitat pressures. One species, the vendace, became extinct, but has been re-introduced at two sites (Box 3.3).
- During the 1970s-90s, population sizes of the majority of wintering waders and wildfowl increased markedly[1] in abundance (Box 3.4). This was particularly true of the geese (Box 3.5).
- Most seabird species also showed marked increases during the 1970s-80s (Box 14.5).
- Although the geographic ranges recorded for about half of Scotland's terrestrial and freshwater bird species showed little change between c.1970 and c.1990, almost one third of species, including 60% of farmland birds, showed a marked reduction in range size (Box 10.3).
- In a survey of widespread, terrestrial and freshwater birds between 1994 and 1999, 12 out of 57 species showed a statistically significant increase in abundance, nine showed a significant decrease and 36 showed no significant change.
- Over one third of native mammals are thought to be in decline.
- Over one third of species given legal protection in Scotland, and for which trend information is available, were thought to be declining in 1997. Almost half were thought to have shown little recent change.
- The geographic ranges of most non-native plant species introduced into Scotland are thought to have changed little between the 1950s and 1987-88. However, of 58 non-native plant species that increased their range significantly, 31 are thought to have a medium or high adverse impact on native species.

No reliable trend data exist for reptiles, amphibians, the majority of invertebrates or for lower plants.

[1] Here, a 'marked' change is one of 10% or more.

Box 3.2 Butterflies

Of the 28 butterfly species currently resident in Scotland, three species - the chequered skipper, mountain ringlet and scotch argus - are almost entirely restricted to Scotland, while several others have important Scottish populations, having declined markedly in England and Wales. Four of Scotland's butterflies are UK Biodiversity Action Plan (BAP) Priority Species: the chequered skipper, northern brown argus, pearl-bordered fritillary and marsh fritillary.

The geographic ranges of most butterfly species resident in Scotland appear to have been relatively stable in recent years (Asher *et al.*, 2000). However, while five species categorised as 'specialists' have tended to decline, five categorised as 'generalists' (the large skipper, orange-tip, peacock, speckled wood and ringlet) have expanded their ranges in Scotland.

Declines shown by the specialists have been associated with the destruction and deterioration of their habitats, while increases shown by the generalists have largely been attributed to climate change. Generalists are better able to move through the modern landscape, finding places to breed, even in intensively managed agricultural and urban areas. They therefore have the potential to track shifts in climatic zones as these move north. Habitat specialists, on the other hand, are becoming increasingly isolated in small patches of semi-natural habitat, and may not be able to keep pace with climate change.

Trend data for two other specialists, the chequered skipper and mountain ringlet, are sparse. In Britain the chequered skipper is restricted to a small area of western Scotland, in which it is thought to have been generally stable over the last few decades. The mountain ringlet is the only British butterfly restricted to high altitudes, almost all of its UK distribution being in the Scottish Highlands.

Sources: Asher *et al.*, (2001), and information kindly provided by Butterfly Conservation

Declining specialists

Pearl-bordered fritillary: declining in Dumfries & Galloway, and probably in other parts of Scotland. Recent, newly discovered colonies reflect an improvement in our knowledge rather than an expansion. Threatened by a reduction in grazing of open woodland, woodland edge and bracken habitats, and by over-grazing in grassland habitats.

Marsh fritillary: threatened on a European scale. Now extinct in east and southern Scotland. Threatened by the loss of unimproved grassland habitat, the loss of extensive grazing regimes, and perhaps by the replacement of cattle by sheep.

Large heath: has declined in the south and east, but still widespread and locally common in the north and west. Scotland's population forms a large proportion of the remaining UK resource. Threatened by the loss of lowland raised bogs through drainage, peat extraction and forestry.

Dingy skipper: one of the rarest species in Scotland. Declines have been attributed to the conversion of semi-natural grasslands to 'improved' pasture or arable land. Most remaining colonies are reliant on processes that maintain short, sparse vegetation and bare ground.

Small blue: has suffered major recent declines, particularly in southern Scotland, but is easily overlooked. Declines have been attributed to the loss and inappropriate management of unimproved grasslands.

Box 3.3 Species re-introductions

Species such as the **vendace**, **red kite** and **European beaver** have become extinct in Scotland, and are now the subject of re-introduction programmes.

Re-introduction[2] has been defined as the re-establishment of a species in an area where it formerly occurred naturally, but is now extinct. The World Conservation Union (IUCN) has developed guidelines for re-introductions, proposing that: the species must have occurred in the area naturally in the past; suitable habitat must exist; the causes of extinction are known and should no longer exist; genetically, the stock selected should be as similar as possible to the original native stock; and the re-introduction should be carefully monitored (IUCN, 1987).

Examples of species re-introduced into Scotland are listed in Table 3.2. They include species re-introduced through the accidental or covert release of individuals (e.g. goshawk, polecat), as well as those re-introduced through programmes meeting the IUCN criteria (e.g. white-tailed eagle, red kite).

Under Article 22 of the EU Habitats Directive (92/43/EEC), Member States are urged to 'study the desirability of re-introducing species … that are native to their territory where this might contribute to their conservation'. In response, SNH has developed a reintroduction plan for the European beaver, considered 'in need of strict protection' within the European Community. Following an ecological appraisal and extensive public consultation, SNH is now considering seeking approval to proceed with a trial re-introduction of 3-4 European beaver families in Knapdale, Argyll, during 2003. The outcome of the trial will be assessed after five years, when a decision will be made on whether to proceed with full re-introduction.

Vendace have recently been re-introduced from England into two sites in Scotland.

The **red kite** has been successfully re-introduced into Britain from populations in Sweden, Germany and Spain.

The **European beaver** may become Scotland's next mammal re-introduction, having been re-introduced into at least 16 other European countries.

[2]Although in common use, 're-introduction' is more correctly termed 're-establishment' (Sutherland, 1998), defined as 'an attempt to establish a species in an area where it had been introduced but the introduction was unsuccessful'.

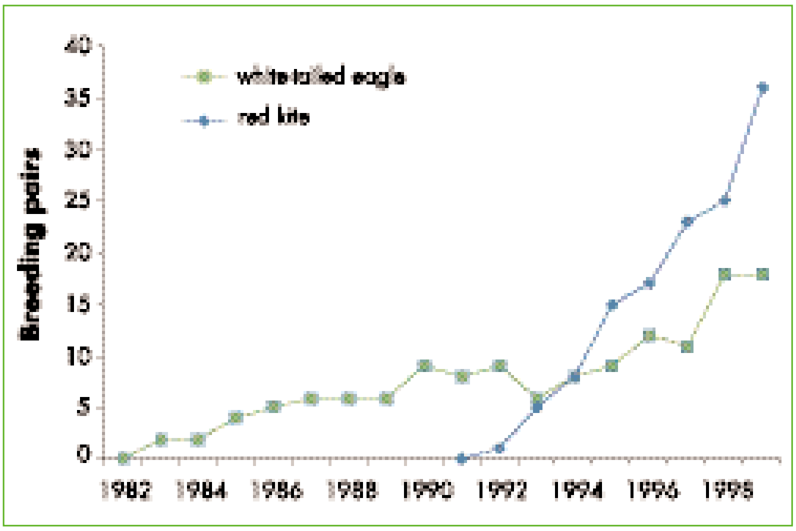
Table 3.2 Examples of species re-introduced into Scotland

Species	Date of extinction	Likely cause	Re-introduced:	Current status
Vendace	c. 1980	Eutrophication	1994-97	Released into Loch of Skene and Daer Reservoir.
Red kite	c. 1880	Persecution	1989 onwards	Increasing (Figure 3.3)
White-tailed eagle	1916	Persecution	1959-85	Increasing (Figure 3.3)
Goshawk	Late 19th C.	Persecution	Mainly 1960s onwards	Well-established. Widespread, especially in southern Scotland.
Capercaillie	18th C.	Hunting	Mainly 1837-38	Initially successful, but now rapidly declining; 550-2,040 birds in 1998-99.
Polecat	c.1912	Persecution	1980s-early 1990s	Present in Argyll. Evidence of hybridisation with ferrets.
Reindeer	c.8,200 bp	Climate change?	1952	Managed populations (c.80 animals in 1993) in the Cairngorms and Tomintoul.
Beaver	c.1550	Hunting	[Proposed]	Extinct.

Sources: Kitchener (1998), Thom (1986)

During 1999 18 pairs of **white-tailed eagle** laid 15-16 clutches, of which nine were known to have hatched. Six of these fledged a total of 11 young.(Source RBBP)

Figure 3.3 Trends in the number of breeding pairs of white-tailed eagles and red kites since their re-introduction into Scotland.



Source: Rare Breeding Birds Panel

Box 3.4 Wildfowl and waders

Scotland supports internationally important populations of wintering ducks, swans, geese and waders, many of which breed north of the Arctic Circle during the summer months and fly south in the autumn. Attracted by relatively mild winter weather and extensive wetlands and estuaries, over half a million wildfowl and waders were counted at Scottish sites in the winter of 1998/99.

Count data, derived mainly from the Wetland Bird Survey (WeBS), are thought to provide a reasonably accurate indication of trends in the populations of 18 native wildfowl species, and of 11 out of 18 wader species wintering in Scotland. Those showing substantial population changes are identified using a system of 'Alerts' developed by the British Trust for Ornithology (BTO). Changes exceeding 25% or 50% over a specified period trigger a 'Low Alert' or 'High Alert' respectively.

Wildfowl

- Between the 1960s and 1998, 12 wildfowl species[3] increased and four declined in abundance by at least 10%. Two species' populations changed by less than 10% (Figure 3.4a).
- 'Alerts' have been raised for three common wildfowl species[4] on the basis of a decline in their Scottish populations during 1966-98: the mallard (Low Alert), shoveler and pochard (both High Alert).
- High Alerts have also been raised for whooper swan and goosander, on the basis of population declines in Scotland during 1988-98.
- Eight wildfowl species have exceeded alert limits on the basis of population increases in Scotland during 1966-98.

Waders

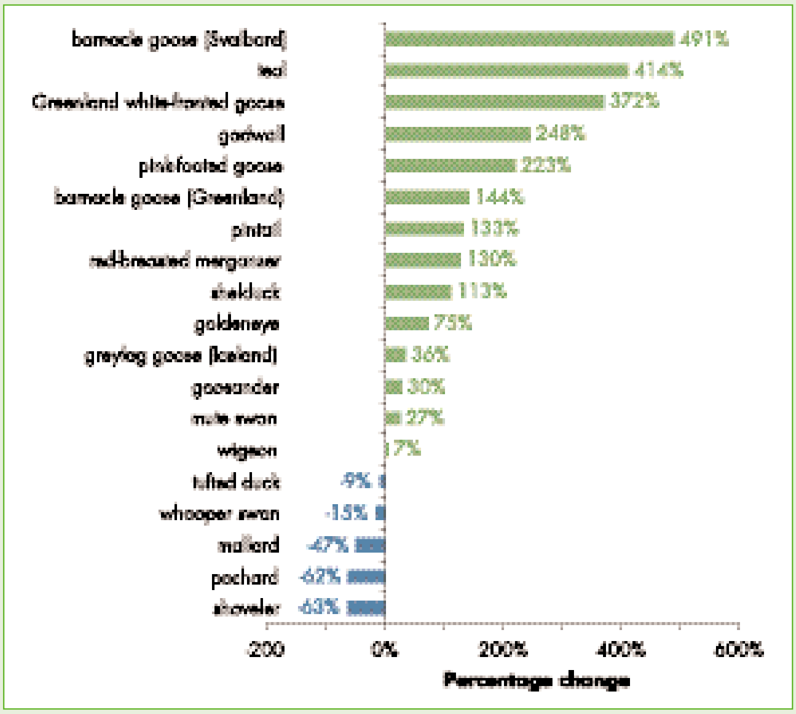
- Of 11 wader species wintering in Scotland, for which adequate WeBS data exist, 10 species increased by at least 10% during 1969-98 (Figure 3.4b). The only species showing a marked drop in numbers is the knot, whose decline has been linked to severe spring weather on its Arctic breeding grounds, triggering a 'Low Alert' for this species.
- Eight wader species exceeded alert limits as a result of population increases during 1969-98. One of these was the turnstone, which has more recently shown a marked decline: of 32% during 1988-98.

Most wildfowl and wader species are geographically widespread and highly mobile, capable of responding rapidly to adverse conditions and to new feeding or breeding opportunities. Therefore, rather than indicating changes in abundance, trends may sometimes reflect large-scale changes in distribution, as well as variation in survey effort.

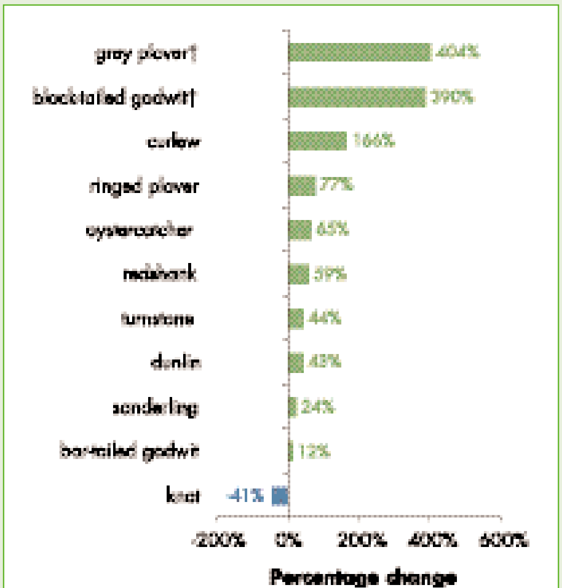
Figure 3.4 Changes in the number of wildfowl and waders counted in Scotland during the 1960s and 1990s.

Percentage change in goose populations was estimated by comparing the mean peak count in 1994-98, with that for the first five years for which data are available (mainly the mid-1960s). Changes for other species were estimated by Atkinson *et al.*, (2000), using General Additive Models.

a. Wildfowl



b. Waders



† Data for 1972/73 - 98/99.

Key sources: from data collected through the Wetland Bird Survey, a partnership scheme of the British Trust for Ornithology, the Wildfowl and Wetlands Trust (WWT), the Royal Society for the Protection of Birds and the Joint Nature Conservation Committee (Cranswick *et al.*, 1999, Atkinson *et al.*, 2000), and from WWT goose monitoring schemes. Counts of Islay goose populations were provided by M.A. Ogilvie, and extracted from SNH files.

[3] Includes both the Svalbard and Greenland populations of the barnacle goose, shown separately in Figure 3.4.

[4] A fourth species showing a substantial decline, Bewick's swan, occurs in Scotland in very small numbers, mainly on passage.

Box 3.5 Wintering goose populations

Barnacle goose populations from Svalbard and Greenland winter largely within Scotland and have increased in numbers substantially since the 1960s.

Scotland is particularly important as a wintering ground for goose populations (Figure 3.5). These include the Greenland and Svalbard populations of the barnacle goose, and the Iceland population of the greylag, almost all of which winter in, or pass through Scotland. Similarly, Scotland plays host to about two-thirds of all Greenland white-fronted geese, and three-quarters of the Iceland and Greenland populations of pink-footed goose.

The number of geese wintering in Scotland has increased substantially since counts began in the 1960s, and particularly since the early 1980s (Figure 3.6). Although most populations have increased by about 100-500%, the Iceland population of the greylag goose was only 36% higher in the late 1990s than in the late 1960s. The Scottish population of the greylag goose has also increased, numbers on the Uists having almost doubled between 1986 and 1997.

In most cases, increases have been attributed to the introduction of protective legislation in Britain and to improved feeding conditions, either in Scotland or on the breeding grounds. The recent decline shown by the Icelandic population of the greylag goose has been attributed to hunting in Iceland.

Greenland white-fronted goose 67%
Barnacle goose (Greenland & Svalbard population) c.100%
Greylag goose (Iceland population) c.99%
Pink-footed goose (Iceland & Greenland populations) 76%

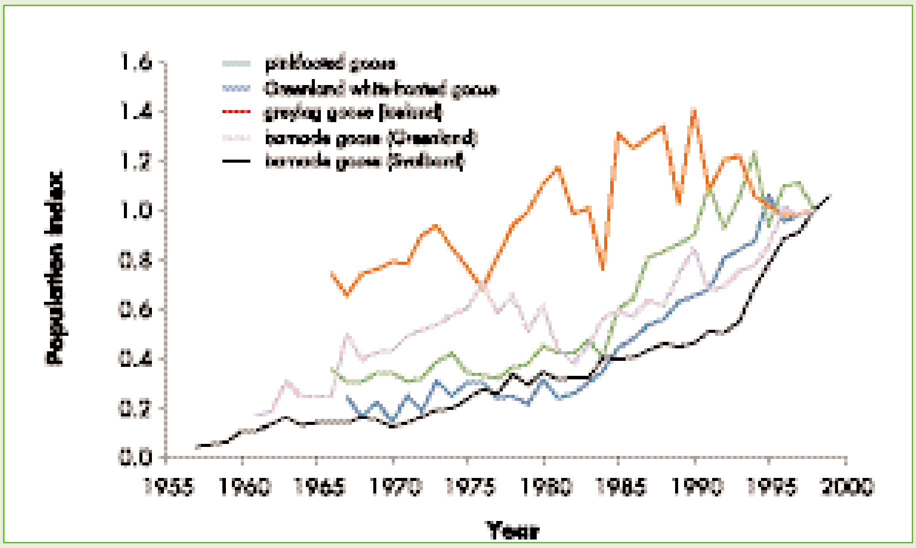
Figure 3.5 Breeding grounds and flyways of goose populations wintering mainly in Scotland.

The percentage of each population counted in Scotland during 1998/99 is shown below.

Source: Scott & Rose (1996)

Figure 3.6 Trends in the number of wintering geese counted in Scotland.

All count data have been converted to an index, in which the 1998/99 total = '1'.



Key sources: from data collected through the Wetland Bird Survey, a partnership scheme of the British Trust for Ornithology, the Wildfowl and Wetlands Trust (WWT), the Royal Society for the Protection of Birds and the Joint Nature Conservation Committee (Cranswick *et al.*, 1999, Atkinson *et al.*, 2000), and from WWT goose monitoring schemes. Counts of Islay populations were provided by M.A. Ogilvie, and extracted from SNH files. International population estimates were obtained from Madsen *et al.*, (1999) and Rose & Scott, (1994). Likely causes of goose population trends are based on Pettifor *et al.*, (1997), Fox *et al.*, (1989), Owen & Black, (1999), Pettifor et al., (1999a,b).

Table 3.1 Species trends

Group	Trends	Percentage of species:			Reliability of trend[5]
		decreasing	static	increasing	
Rare and endemic vascular plants	**1990-1996:** of 45 threatened and/or endemic vascular plant species surveyed in Scotland between 1990 and 1996, 18 had at least 10% fewer populations than had been found before 1990. Fourteen species had at least 10% more populations, while thirteen showed little change (SNH).	**40%** ⇩	29% ⇔	31% ⇧	**C**
Butterflies	Of 28 butterfly species resident in Scotland, five have shown a contraction in their recorded distributions in recent decades and five have expanded. Of the remainder, 16 appear to have relatively stable distributions, and two potentially vulnerable species are data deficient. The declining species are all scarce or have a restricted distribution, whereas all of the expanding species are common and widespread in Britain (Asher *et al.*, 2001).	19% ⇩	**62%** ⇔	19% ⇧	**C**
Freshwater fish	Of 26 freshwater fish species native to Scotland, 12 are thought to have declined, one (the vendace) recently became extinct, but has been re-introduced, nine are stable and four are thought to have increased (Maitland, 1997).	**50%** ⇩	35% ⇔	15% ⇧	c
Breeding seabirds	**1967-1987:** of 18 Scottish breeding seabird species for which trend data are available, 11 increased by more than 10% between 1969 and 1987, three varied by less than 10%, and four declined by more than 10% (from Lloyd *et al.*, 1991).	22% ⇩	17% ⇔	**61%** ⇧	**C**
Wintering wildfowl	**1966-1998:** of 18 native wildfowl species wintering in Scotland, for which reliable data are available, 12 increased by at least 10% between 1966 and 1998. Four species decreased in abundance by at least 10%, and two varied by less than 10% (from data provided by the Wildfowl and Wetlands Trust).	22% ⇩	11% ⇔	**67%** ⇧	**T**
Wintering waders	**1969-1998:** of 11 wader species for which Scottish winter count data are available between 1969/70 and 1998/99, 10 had increased by at least 10% and one had declined (Atkinson *et al.*, 2000).	9% ⇩	0% ⇔	**91%** ⇧	**T**
Breeding land birds	*Geographical range* **1968/72-1988/91:** of 124 widespread terrestrial and freshwater breeding bird species in Scotland, surveyed in 1968-72 and again in 1988-91, the range size of 38 appeared to have decreased by at least 10%, 24 expanded their range by at least 10%, and 62 changed by less than 10%. Farmland birds showed the greatest changes, 60% of species having reduced their range (from British Trust for Ornithology (BTO) data).	31% ⇩	**50%** ⇔	19% ⇧	**C**
	Abundance **1994-1999:** of 57 terrestrial breeding bird species surveyed between 1994 and 1999, 12 showed a statistically significant increase in abundance, nine showed a significant decrease and 36 showed no significant change (Noble *et al.*, 2000).	16% ⇩	**63%** ⇔	21% ⇧	**C**
Land mammals	Of 26 native mammal species for which estimates have been made, 11 are currently thought to be declining, eight to be stable, and seven to be increasing in population size (The Mammal Society, 1999).	**42%** ⇩	31% ⇔	27% ⇧	c
Species given legal protection	Of 111 species given legal protection in Scotland, and for which trend data were available, 18 were thought to be increasing in 1997, 40 to be declining, and 51 to have shown little recent change (SNH).	36% ⇩	**48%** ⇔	16% ⇧	c
Introduced plant species	Of 826 non-native plant species introduced into Scotland by the 1950s, 709 showed only minor changes in their geographic range by 1987-88, 104 species showed a small or significant increase, and 13 showed a small or significant decrease in range.	2% ⇩	**86%** ⇔	13% ⇧	c

[5] Reliability of changes or trends between the specified years: T = increasing (or decreasing) trends clearly established; C = changes clearly established between first and last year, but no clear evidence of a trend; c = changes probable but not clearly-established; c = changes suggested but not well-established. A blank indicates that assessment of change was not relevant. Statistical significance was tested where possible (at the 5% level).

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4

Land cover: 1947-1988

Considerable changes took place within Scotland's towns and countryside between the late 1940s and the late 1980s. Urban expansion, road development and afforestation were among the more striking. Changes in the structure of farmland, or in the extent and condition of moorland, may have been less obvious. Yet they have been no less relevant to the visual appearance of the countryside, to its wildlife, and to the quality of experience for outdoor recreation and enjoyment.

The land cover of Scotland has been mapped from 1988 aerial photography (Figure 4.1). Additionally, the Scotland-wide photo cover created a third time-point in the National Countryside Monitoring Scheme (NCMS), a land cover change study that had utilised photography from c.1947 and c.1973 (Mackey *et al*., 1998). The three dates correspond with important policy decisions. Firstly, legislation that shaped the course of farming, forestry, water supply, hydro-power and built development was set out in the late 1940s. Around 1973, the UK joined the European Economic Community and embraced the Common Agricultural Policy. Then, in the mid- to late-1980s, environmental considerations became embedded within reforms to agriculture and forestry policy. Thus, the period c.1947 to c.1988 was characterised by rapid and sustained technological advances and economic growth. The evidence of land cover change during this period can be read through the NCMS (Shewry *et al*., in prep.). It is fascinating and educational to view a sampled site, of which there are 467 covering around 7.5% of Scotland's land area, and to assemble the evidence of change (see Box 4.1).

Subsequently, the Countryside Survey (see Chapter 5) has provided updated estimates of land cover change.

Land uses in the unenclosed uplands and intensively farmed lowlands. Ochil Hills.

Trends

Long established and semi-natural features were reduced in extent by 17% from c.1947 to c.1988 (see Box 4.2). Other key changes were as follows.

Urban

- Built land increased by an estimated 46%, mainly on improved or 'smooth' grassland and arable farmland.
- Land managed for formal recreation (such as playing fields and golf courses) also increased, by around 138%, mainly on grassland and arable land.
- The area of transport corridor (roads and railways) increased by about 22%, mainly on mire, arable, smooth grassland and heather moorland.

Arable

- Arable land expanded by 11% and became more dominant in the east.
- The increase in arable was mainly at the expense of smooth grassland.
- Hedgerow length was reduced by half, from over 40,000 km in the 1940s to under 20,000 km in the 1980s (see Box 4.3).

Grassland

- Rough grassland decreased by 10%, mainly due to afforestation and pasture improvement.
- Intermediate grassland increased by 15%, mainly from rough grassland, heather moorland and drained mire.
- Smooth grassland decreased by 11%, mainly due to arable or urban development.

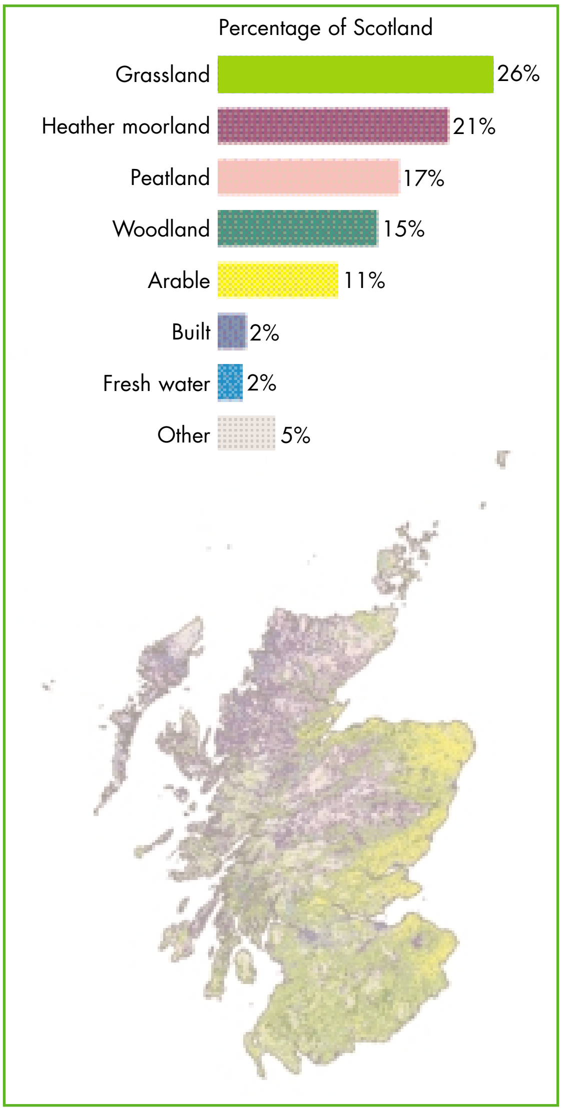
Forest and woodland

- Forest and woodland expanded by nearly 200%.
- Former woodland was replaced by new conifer plantation: broadleaved woodland decreased by 23%; mixed woodland by 37%; and coniferous woodland by 47%.
- Young conifer plantation increased nine-fold and mature plantation increased more than four-fold, mainly on heather moorland, rough grassland and blanket mire.
- The length of ditches, often associated with mire drainage for tree planting, doubled.

Upland

- Heather moorland was reduced by 23%, due to afforestation and through conversion to rough grassland.
- Blanket mire decreased by around 21%, and lowland mire by 44%, mainly due to afforestation and drainage.
- The length of unsurfaced tracks (mainly in the uplands) increased by around 29%.

Figure 4.1 The land cover of Scotland, 1988 (summarised into eight classes).



Source: adapted from MLURI (1993).

Key source: Air photography from c.1947, c.1973 and c.1988 was interpreted to quantify the magnitude, rate and geographical variation of land cover change (Mackey *et al.*, 1998). A stratified random sample, representing 7.5% of Scotland's land area, was designed to detect changes of 10%-or-more in extensive land cover features, with 95% confidence.

Box 4.1 Reading the landscape

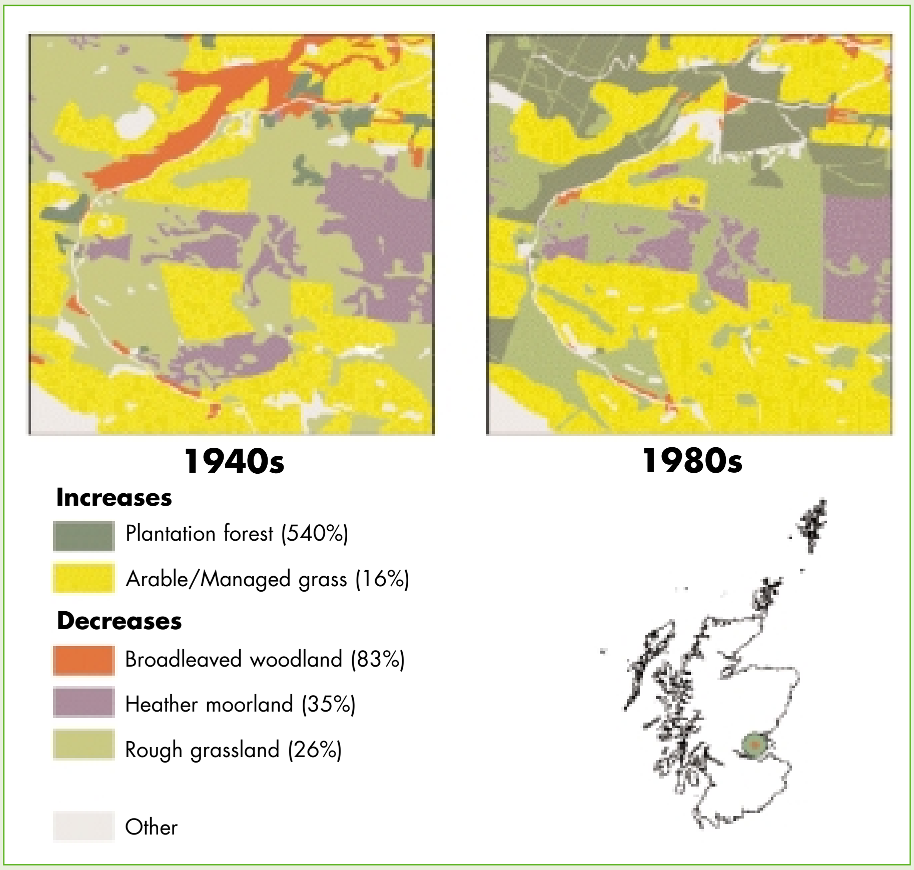
The Lomond Hills of Fife rise to an elevation of around 525m. Surrounded by arable farmland, they have the attractive appearance of an enduring landscape. Nevertheless, they encapsulate many changes that are more widely characteristic of the uplands and marginal uplands of Scotland. Within the Lomond Hills there is striking historical evidence of land use change (Figure 4.2), with settlement and abandonment dating back to the early nineteenth century.

Each of the 467 maps from the NCMS give insights into local, regional and national trends

Whereas enclosure on the high ground had fallen into dereliction, in the foothills it was clearly evident in the 1940s. There, land improvement for agriculture continued into the late-1980s, constraining the moorland and rough grassland of the open hill into a narrow strip on the higher ground. Grassiness within the moorland mosaic became more prominent at the expense of heather cover. Conifer planting took place on the northern part of the hill and surrounding land, and replaced broadleaved woodland in stream gullies. Consequently, heather moorland was reduced by 35%, and rough grassland by 26%.

Although the moorlands of Fife host a large diversity of invertebrates, few sizeable areas remain that can support viable populations of moorland birds. Red grouse are still to be found within the Hills, but the black grouse has disappeared within the past twenty years. Biodiversity action is therefore being directed at maintaining and enhancing existing areas of moorland and heathland, and where possible linking fragments into more viable blocks (Fife Local Biodiversity Action Plan Steering Group, 1997).

Figure 4.2 Land cover change in the Lomond Hills of Fife, c.1947- c.1988 (interpreted from aerial photography).



Source: SNH

Box 4.2 Semi-natural habitats

Distinctive semi-natural habitats include rough grassland, heather moorland, blanket mire, lowland mire, broadleaved woodland, mixed woodland, coniferous woodland, lochs, bracken and scrub. Few have been unaltered by human activities over the course of history and some, such as rough grassland and heather moorland, rely on active land management of grazing and moorland burning to suppress tree regeneration below the natural treeline. The term 'semi-natural' is therefore used to describe plant communities that, although modified by management, are composed of native species.

The general trend has been a contraction of semi-natural habitats, which covered an estimated 72% of Scotland in 1947 (56,060 km^2) and 60% of Scotland in 1988 (46,540 km^2). Notable were the effects of:

- urban development;
- agricultural intensification in arable and lowland grassland production systems; and
- the utilisation of the uplands for water catchment, farming and, notably, for forestry.

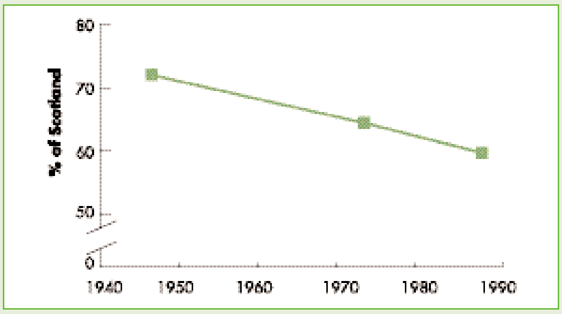
Trends

Over 41 years, between c.1947, c.1973 and c.1988, the area of semi-natural land cover in Scotland is estimated to have declined by 17%: the mean annual reduction was 230 km^2 (Figure 4.3).

Afforestation, grassland improvement and urban development took place throughout much of Scotland between the 1940s and the 1980s. The biggest reductions in semi-natural cover were in the south and parts of the west, where afforestation was especially prominent.

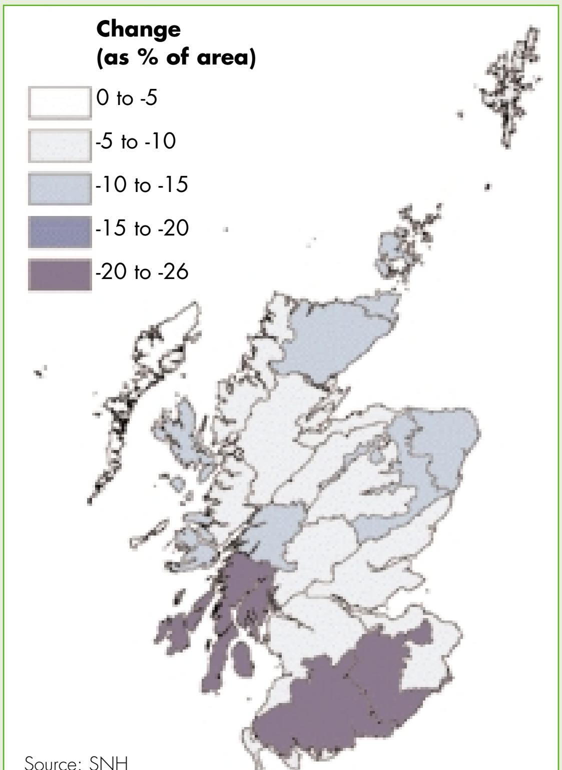
In contrast, in the Western Isles, where land capability for forestry and agriculture is highly restricted, relatively little change took place (Figure 4.4).

Figure 4.3 The extent of semi-natural habitats, c.1947, c.1973 and c.1988.



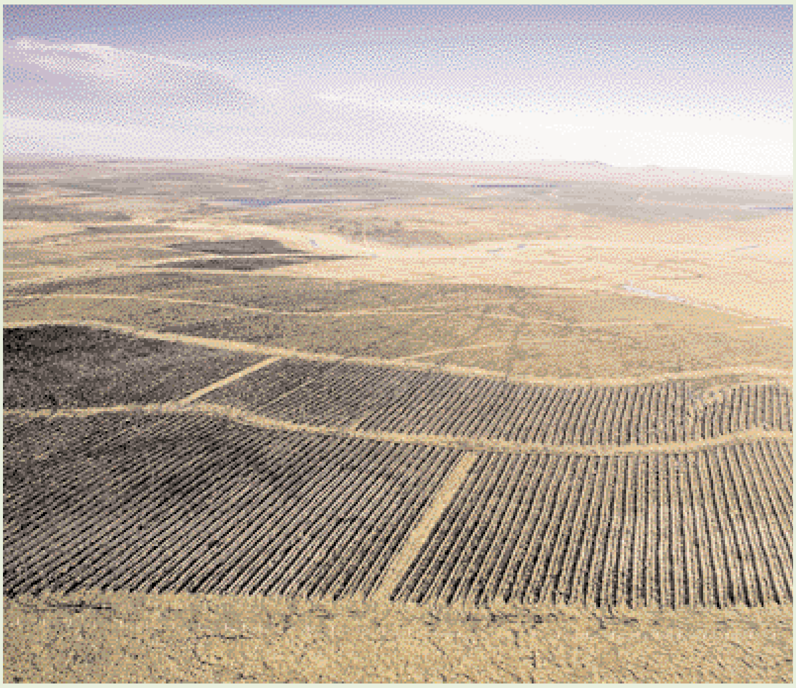
Source: SNH

Figure 4.4 Geographical pattern of change in semi-natural habitats, 1940s - 1980s.



Source: SNH

Until the 1980s, much of the Flow Country of Caithness and Sutherland was drained and planted with conifer forests.



Box 4.3 Hedgerows

Many of Scotland's agricultural hedgerows originate from enclosure in the latter half of the eighteenth century and the early years of the nineteenth. At that time, agricultural improvement required the amalgamation of fragmented and intermixed strips and blocks of land, and the segregation of crops and livestock. Hedgerows, as well as ditches and walls, defined small-scale field systems and estate boundaries. Incompatible with mechanisation, small fields and hedges subsequently became an obstacle to agricultural progress.

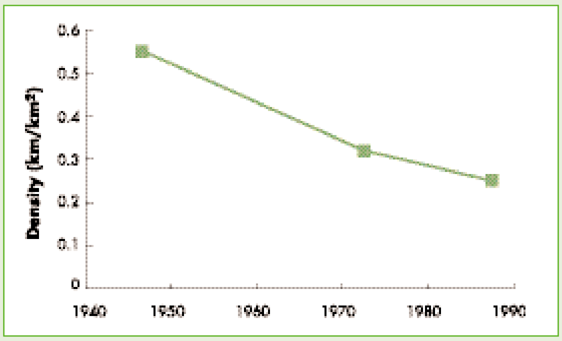
Hedgerow removal, especially evident from the late-1940s onwards, stimulated concern for the broader value of hedges in the landscape and for wildlife. According to their structure and diversity, hedges can be important for food and shelter to invertebrates, birds, mammals, amphibians and reptiles. Hedges can serve as woodland edges, and may contain an abundance of fruit-bearing woodland-edge shrubs. Common woodland birds can become dependent on hedges for song-posts, and as structures in which to feed, roost, hide and nest.

Trends

Over 41 years, between c.1947, c.1973 and c.1988, the total length of hedgerows in Scotland is estimated to have declined by 54%; a mean annual rate of 560 km (Figure 4.5).

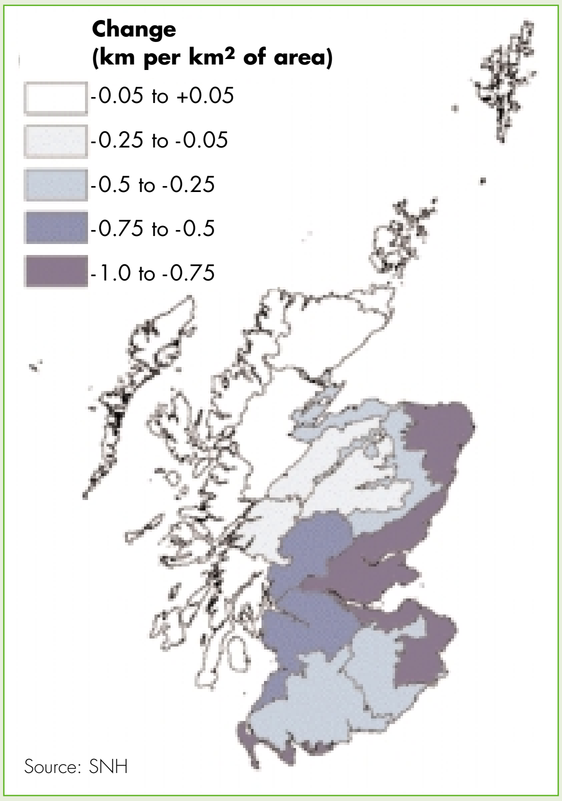
Reduction took place wherever hedgerows occurred. This was particularly so in the more intensively farmed lowlands where there was evidence of intensification, specialisation and a polarisation of arable and pastoral farming systems (Figure 4.6).

Figure 4.5 The extent of hedgerow, c.1947, c.1973 and c.1988.



Source: SNH

Figure 4.6 Geographical pattern of change in hedgerow, 1940s - 1980s.



Source: SNH

Typically, it was the inner field boundaries that were removed, resulting in a more open landscape in which the outer perimeter and property boundaries were left in-tact.

Table 4.1 Habitat trends (ordered by magnitude of change).

Feature	Trends	Decreasing	Static[1]	Increasing	Reliability of trend[2]
Forest	• Young plantation increased by 929% (430 km^2 – 4,430 km^2) • Mature coniferous plantation increased by 462% (840 km^2 – 4,700 km^2) • Felled woodland increased by 267% (30 km^2 - 110 km^2) • Overall, plantation increased by 613% (1,300 km^2 – 9,240 km^2)			613% ⇧	**C**
Arable	• Arable land increased by 11% (7,750 km^2 – 8,590 km^2), and became more dominant in the east.			11% ⇧	**C**
Urban	*Built land* • Built land (including land take for roads) increased by 36% (1,570km^2 – 2,130 km^2)			36% ⇧	**C**
	Recreation • Land managed for formal recreation (playing fields, golf courses, etc.) increased by 138% (70 km^2 - 170 km^2)			138% ⇧	**C**
Reservoirs	• Reservoirs expanded by 115% (150 km^2 - 320 km^2)			115% ⇧	**C**
Grassland	*Managed grassland* • Intermediate grassland increased by 15% (3,280 km^2 – 3,760 km^2) • Smooth grassland (permanent pasture in the lowlands) decreased by 11% (7,540 km^2 – 6,740 km^2) • There was no strong evidence for a change in managed pasture as a whole (10,820 km^2 – 10,490 km^2)		⇔		
	Rough grassland • Rough grassland decreased by 10% (12,330 km^2 – 11,130 km^2).	10% ⇩			**C**
Lowland Mire	• Lowland mire was reduced by 44% (230 km^2 - 130 km^2)	44% ⇩			**C**
Woodland	*Broadleaved woodland* • Broadleaved and mixed woodland decreased by 26% (2,080km^2 – 1,540 km^2)	26% ⇩			**C**
	Coniferous woodland • Coniferous woodland decreased by 47% (210 km^2 - 110 km^2)	47% ⇩			**c**
Heather Moorland	• Heather moorland was reduced by 23% (14,620 km^2 – 11,290 km^2)	23% ⇩			**C**
Blanket Mire	• Blanket mire decreased by 21% (22,720 km^2 – 17,930 km^2)	21% ⇩			**C**
Hedges	• Hedgerows declined in length by 54% (42,560 km – 19,460 km)	54% ⇩			**C**
Semi-natural[3]	• As a group, semi-natural and long-established features (rough grassland, blanket and lowland mire, heather moorland, broadleaved, mixed and coniferous woodland, lochs and a range of minor features) decreased by 17% (56,060 km^2 – 46,540 km^2)	17% ⇩			**C**

[1] Change too small to be established
[2] Reliability of change between the specified years, according to statistical significance: **C** = $P < 0.05$; **c** = $P < 0.1$
[3] NCMS results re-analysed for this purpose.

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5 Broad habitats: 1990-1998

Following signature of the Biodiversity Convention at the Earth Summit in Rio de Janeiro in 1992, the UK Biodiversity Action Plan (HMSO, 1994) set out a programme of action to conserve and enhance biological diversity throughout the UK. A classification of 'broad habitats' was defined for consistent reporting and as context for 'priority' habitats and species requiring conservation action (UK Steering Group, 1995). The UK and surrounding seas were classified into 37 broad habitats (Jackson, 2000) of which 20 occurred in Scotland, 18 being terrestrial. Of those, 16 were sufficiently widespread to be reported on in the latest Countryside Survey, CS2000 (Haines-Young *et al.*, 2000) and are described here.

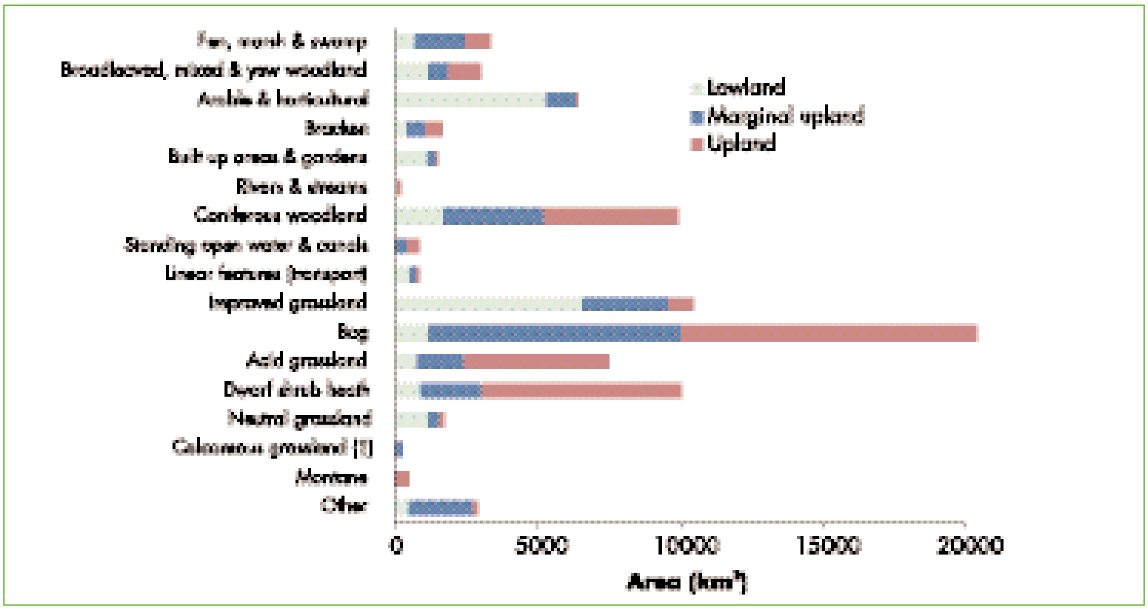
The CS2000 sample survey estimated the extent of terrestrial broad habitats in 1998 (Table 5.1, Figure 5.1), and change in extent since 1990.

Table 5.1 Estimated broad habitat extent in 1998, according to CS2000.

Broad Habitat	**Lowland**		**Marginal upland**		**Upland**		**Scotland**	
	Area (km^2)	%	Area (km^2)	%	Area (km^2)	%	Area (km^2)	%
Fen, marsh & swamp	710	3	1,770	7	890	3	3,370	4
Broadleaved, mixed & yew woodland	1,180	5	710	3	1,110	3	3,000	4
Arable & horticultural	5,360	24	1,000	4	40	< 0.5	6,390	8
Bracken	440	2	670	2	550	2	1,660	2
Built up areas & gardens[1]	1,130	5	300	1	80	< 0.5	1,510	2
Rivers & streams	70	< 0.5	80	< 0.5	70	< 0.5	210	<0.5
Coniferous woodland	1,710	8	3,510	13	4,720	15	9,930	12
Standing open water & canals	60	< 0.5	360	1	430	1	850	1
Linear features (transport)	530	2	230	1	110	< 0.5	870	1
Improved grassland	6,600	29	2,990	11	920	3	10,510	13
Bog	1,170	5	8,840	33	10,370	32	20,380	25
Acid grassland	840	4	1,590	6	5,060	16	7,480	9
Dwarf shrub heath	910	4	2,200	8	6,910	22	10,020	12
Neutral grassland	1,190	5	380	1	110	< 0.5	1,680	2
Calcareous grassland[2]	0	0	270	1			270	<0.5
Montane	0	0	< 5	< 0.5	480	1	480	1
Other	480	2	2,280	8	180	1	2,940	4
Total area	**22,380**		**27,160**		**32,030**		**81,570**	
% Scotland		27		33		39		100

[1]Excludes 370km^2 unsurveyed urban core
[2]Insufficient data to estimate extent in Upland

Note: estimates are rounded to the nearest 10km^2 and so may not sum exactly to the totals



† Insufficient data to estimate extent in the uplands.

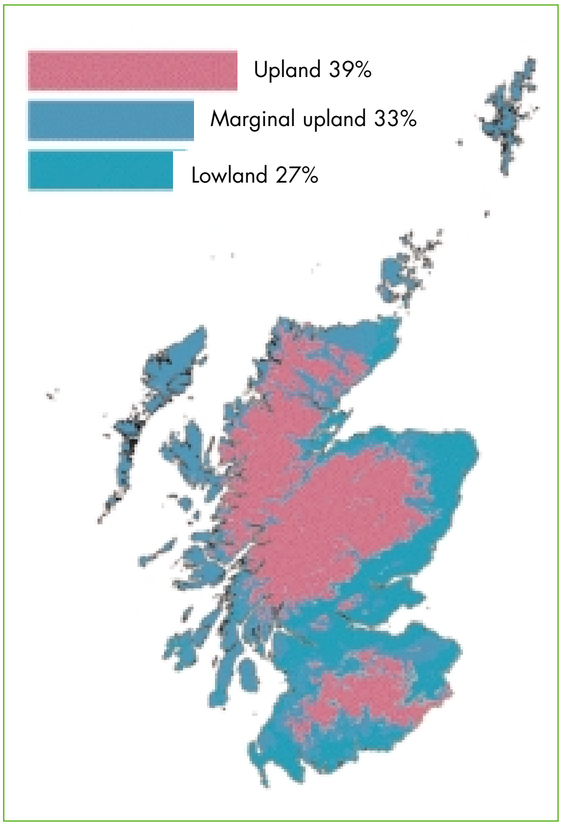


Figure 5.1
Scottish broad habitats 1998.

Fen, marsh & swamp increased by 19%.

Broadleaved, mixed & yew woodland increased by 9%.

Trends

With a sample size of 195 1km squares in 1990 and 203 in 1998, the CS2000 spatial coverage was around 0.25% of Scotland's land area. The increased sample size in 1998 was required for improved estimation of habitat extent, but change was based on 193 squares that were common to both surveys.

Results from CS2000 may be analysed further in order to examine findings more fully, noting that the 1990 survey season was particularly dry whilst that of 1998 was wet. Changes between 1990 and 1998, from greatest proportional increase to greatest proportional decrease, were as follows (Table 5.2, Figure 5.2).

Fen, marsh & swamp
The extent of fen, marsh & swamp increased significantly ($P<0.05$), by around 19% in Scotland. Gains were from improved, neutral and acid grasslands, and from bogs. Much of the expansion appeared to be associated with increased rushiness of wet grasslands, with slightly more overgrown and shaded conditions due to increased rankness of vegetation.

Broadleaved, mixed & yew woodland
The area of broadleaved, mixed & yew woodland increased overall, by around 9%. An expansion of 9.5% in the lowlands was also significant, consistent with widespread planting and woodland restructuring throughout the 1990s.

Arable & horticultural land
There was no clear evidence of change in the extent of arable and horticultural land in Scotland, although an increase of 33% in the marginal uplands was statistically significant. Considerable interchanges with improved grassland were consistent with crop rotation.

Bracken
There was no clear evidence of change in the extent of bracken. Interchange with acid grassland and dwarf shrub heath suggested both bracken infestation and its control.

Built up areas & gardens in rural areas
There was no clear evidence of change in the extent of developed land in rural areas.

Rivers & streams
There was no substantial change in the area of rivers and streams. Water quality remained high and improved in many places, but with signs of eutrophication in plant communities of streamsides.

Coniferous woodland
The extent of coniferous woodland did not change substantially. Nevertheless, a net expansion onto dwarf shrub, heath and bog suggested tree planting in the uplands and canopy closure. Interchange with acid grassland was in favour of grassland, as might occur after felling.

Standing water & canals
The area of standing water and canals increased by 20% in the lowlands, possibly due to wetter conditions in 1998. Elsewhere there was little evidence of change.

Linear features (transport)
There was no clear evidence of change in extent. Qualitative changes in the botanical composition of roadside verges pointed to eutrophication and reduced acidity, with a small but significant decline in ruderal species.

Improved grassland
The overall extent of improved grassland remained unaltered (large interchanges with arable & horticultural land are noted above). Gains from acid and neutral grasslands were offset by reductions to arable and fen, marsh & swamp, suggesting intensified management in some places and reduced management in others.

Bog
No significant change in the extent of bog was detected, but small qualitative changes pointed to eutrophication (in combination with management factors) taking place.

Acid grassland
There was no clear evidence of change in the extent of acid grassland, with numerous gains and losses with other habitats cancelling-out. A decline of 15% in the lowlands, perhaps associated with woodland planting, grassland improvement and arable expansion, was significant.

Dwarf shrub heath
Declines in heather moorland, by 5% across Scotland and by 8% in the marginal uplands & islands, were only weakly significant. Expansion

of coniferous woodland was partly responsible, together with net reductions to acid grassland, bracken and bog. A small but significant decline of stress tolerant plants, coupled with an increase in competitor plants, pointed to habitat deterioration.

Neutral grassland

There was no clear evidence of change in the extent of neutral grassland, although a decline of 39% in the marginal uplands and islands was statistically significant. Reductions appear to be associated in part with grassland improvement and fen, marsh & swamp expansion. Interchange between neutral and improved grassland implied reduced biodiversity. Significant increases in competitor species and plants which favour more fertile conditions pointed to eutrophication.

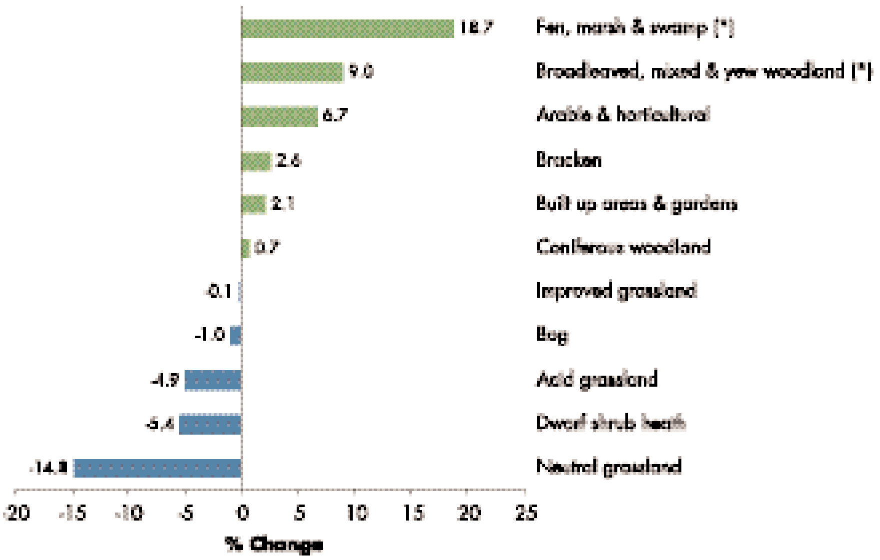
Calcareous grassland

Scarce in Scotland and almost entirely limited to the marginal uplands & islands, a 16% decline, mainly associated with grassland improvement, was only weakly significant.

Montane

The CS2000 estimate for montane, being land above the natural treeline, was 480 km^2. Change estimation was not possible due to insufficient data in the sample.

Figure 5.2 Net change in the major broad habitats (* = P < 0.05).



Key sources: based on McGowan *et al.* (2001).

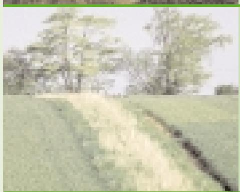
Box 5.1 Landscape features

Landscape features can be of functional, historical, ecological and landscape importance. Hedges, dry stone walls and pond estimates from the Countryside Survey have served as a landscape indicator for reporting on Sustainable Development in the UK (DETR, 1999). A Scottish commentary, from CS2000, is as follows.

Apart from in the lowlands, the length of fence increased significantly. The length of walls decreased significantly in the marginal uplands and islands. An apparent 9% increase in hedgerow length was not statistically significant (Table 5.3, Figure 5.3).

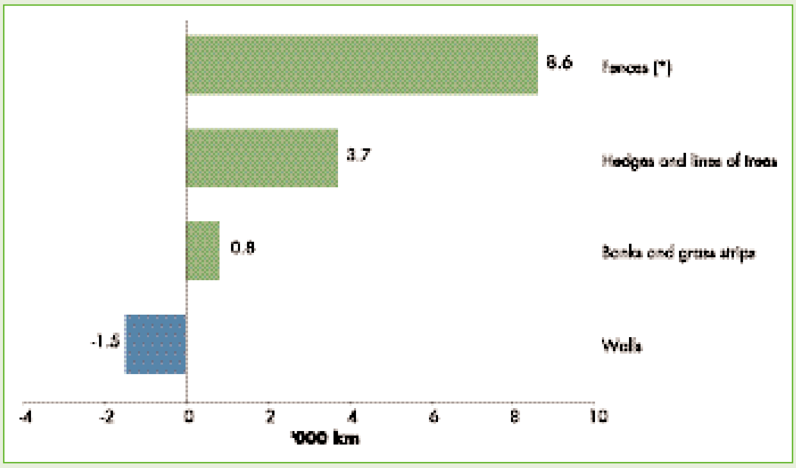
Table 5.3 Landscape Features.

Statistically significant changes are shown in **bold**, P<0.05.

Environmental Zone	1990 extent '000 km	1998 extent '000 km	Change 1990-1998 '000 km	Change 1990-1998 %
 **Fences**				
lowlands	113.2	117.2	2.4	2.1
marginal uplands & islands	**71.4**	**77.1**	**3.6**	**5.0**
uplands	**36.1**	**39.4**	**2.7**	**7.4**
Scotland	**220.7**	**233.7**	**8.6**	**3.9**
 **Hedgerows and lines of trees**				
lowlands	34.9	40.2	2.4	6.9
marginal uplands & islands	7.0	7.5	1.0	14.2
uplands	0.7	1.1	0.3	46.3
Scotland	42.7	48.7	3.7	8.8
 **Banks and grass strips**				
lowlands	7.8	8.1	0.8	10.4
marginal uplands & islands	4.0	3.2	0.0	-
uplands	1.1	1.1	0.0	-
Scotland	12.8	12.4	0.8	6.3
 **Walls**				
lowlands	46.8	50.7	-0.6	-1.4
marginal uplands & islands	**26.8**	**23.2**	**-0.6**	**-2.4**
uplands	13.5	13.6	-0.2	-1.5
Scotland	89.0	87.5	-1.5	-1.7

CS1990 stock, and estimates of change between 1990 and 1998, were calculated using the 193 1km squares common to both surveys. 1998 stock was based on the 203 squares surveyed for CS2000.

Figure 5.3 Change in landscape features (* = P<0.05).



There was no clear evidence of change in the number of inland water bodies as the following results were not statistically significant:

- an increase in the number of inland water bodies of about 1%;
- with 63% of water bodies in the smallest size group (less than 0.04ha) in 1998, the greatest change was an increase of 2% in that group;
- a slight net decrease in the 0.04-0.2ha size group.

Box 5.2 Hedgerows

A hedgerow is defined in the Countryside Survey as a more-or-less continuous line of woody vegetation that has been subject to a regime of cutting in order to maintain a linear shape. When hedge management is diminished or abandoned and the overall natural shape of the component tree species is regained, or when gaps interrupt the linear continuity, then the structural form may become that of a scattered line of shrubs or trees. A 'relict hedge' is defined as a line of shrubs showing where a hedge has once been.

Significant findings were as follows (Table 5.4):

- a 22% increase in the length of relict hedges and lines of trees and scrub without fences, with increases in all three environmental zones;
- a 14% increase in the length of relict hedges and lines of trees and scrub with a fence, with increases in the lowlands and marginal uplands & islands.

These may suggest abandonment of hedgerows in some places, tree planting, or individual trees growing into lines of trees.

Table 5.4 Hedgerows and lines of trees.

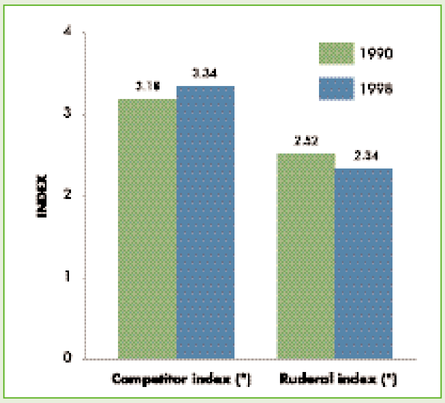
Statistically significant changes are shown in **bold**, P<0.05.

CS1990 stock, and estimates of change between 1990 and 1998, were calculated using the 193 1km squares common to both surveys. 1998 stock was based on the 203 squares surveyed for CS2000.

Environmental Zone	1990 length '000 km	1998 length '000 km	Change 1990-1998 '000 km	Change 1990-1998 %
Hedgerows				
lowlands	16.3	17.4	0.2	1.2
marginal uplands & islands	1.1	1.6	0.6	53.1
uplands	0.0	0.0	0.0	-
Scotland	17.4	19.0	0.8	4.6
Relict hedgerows				
lowlands	4.0	4.6	-0.8	-21.1
marginal uplands & islands	0.4	0.7	-0.1	-17.3
uplands	0.0	0.0	0.0	-
Scotland	4.4	5.3	-0.9	-20.7
Relict hedges & lines of trees and shrubs (no fence)				
lowlands	**7.7**	**10.0**	**1.9**	**23.9**
marginal uplands & islands	**2.4**	**2.3**	**0.3**	**11.7**
uplands	**0.7**	**1.0**	**0.3**	**42.9**
Scotland	**10.8**	**13.3**	**2.4**	**22.4**
Relict hedges & lines of trees and shrubs (with fence)				
lowlands	**6.9**	**8.1**	**1.2**	**17.5**
marginal uplands & islands	**3.1**	**2.9**	**0.2**	**6.2**
uplands	0.1	0.1	+	+
Scotland	**10.0**	**11.1**	**1.4**	**14.4**

Note: 'Competitors' are plants that survive by 'out-growing' other species, and usually require better climate or soil conditions to maintain their fast growth. 'Ruderal' plants have high demands for nutrients and/or are intolerant of competition. They are species that frequently colonise waste ground.

Figure 5.4 Changes in competitive and ruderal plant indices in hedgerows (* = P<0.05).



The proportion of competitive plant species in tall herb vegetation increased, while the proportion of smaller, weedy species better suited to open and disturbed conditions (ruderals) decreased (Figure 5.4).

Changes in condition may reflect reduced intensity of land management or grazing pressure, the demarcation of conservation 'headlands' around arable fields, or reduced management of the hedge.

Box 5.3 Plant Diversity

With a view to reversing declines in UK wildlife and habitats, plant diversity estimates from the Countryside Survey have been put forward as an indicator of sustainable development in the UK (DETR, 1999). A Scottish commentary, from CS2000, is as follows.

Although no significant overall change in plant diversity was detected, considerable changes in species richness occurred within some individual survey squares and in all environmental zones. Overall change was statistically significant in two broad habitats (Table 5.5, Figure 5.5).

- The species richness of acid grassland increased, due to plants of less-acid conditions.
- A significant decrease in species richness in dwarf shrub heaths was due to a decline in stress-tolerant species and a (smaller) increase in competitors.

Findings for acid grassland and heath point to slight declines in habitat quality. No significant changes were detected in other broad habitats.

Table 5.5 Species richness.

	Mean number of vascular plant species per 1km square		% change
Key trends 1990-1998	**1990**	**1998**	**1990-1998**
Mean number of vascular plant species			
● No significant overall change (species per 1km square)	70.5	70.1	-0.6
● **In acid grassland, significant increase in species richness due to an increase in plants characteristic of less acid conditions**	**15.4**	**16.5**	**6.9**
● **In dwarf shrub heath, a significant overall decline in species richness as a result of a decline of stress-tolerant plants, and increase in competitive species**	**14.4**	**13.4**	**-6.6**

Statistically significant changes are shown in **bold**, P<0.05.

Estimates of plant diversity were calculated using the 193 1km squares common to both surveys and only the vegetation plots on those squares that were considered to be valid replicates in 1990 and 1998.

Species richness declined on dwarf shrub heath and increased on acid grassland.

Box 5.3 Plant Diversity (continued)

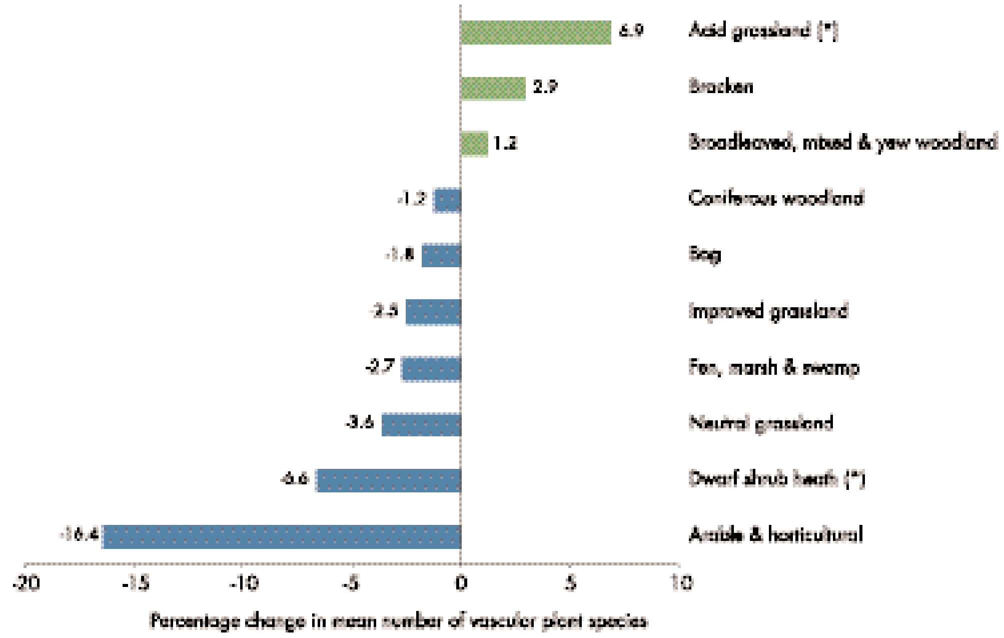


Figure 5.5 Species richness change in major broad habitats (* = $P < 0.05$).

The change in species richness within the arable and horticultural broad habitat, although apparently much larger than for dwarf shrub heath and acid grassland, was not statistically significant. A much larger standard error was due to its considerably smaller sample size and a high degree of variability in numbers of plant species arising from changes in management and/or crop between 1990 and 1998.

Changes in dwarf shrub heath and acid grassland may be associated with land management, and notably grazing pressure, reduced acid loading from atmospheric sulphur, and continued deposition of airborne nitrogen compounds.

A marked increase in tissue nitrogen, associated with increased air pollution during the twentieth century, has been shown to pose a threat to snowbed bryophyte communities (Woolgrove & Woodin, 1996a,b).

Nitrogen enrichment, together with grazing pressure, has been implicated in declines in the extent and quality of montane heaths dominated by the moss *Racomitrium lanuginosum* in Scotland and other parts of north-western Britain (Baddeley, *et al*, 1994). A close geographical association has been established between tissue nitrogen and atmospheric deposition patterns. The decline of *Racomitrium* heath south of the Scottish Highlands since the mid-1900s, characterised by a loss of cryptogam species and an increase in the abundance of grasses, coincided with a marked increase in atmospheric nitrogen deposition.

Heather moorland conversion to grass-dominated vegetation has been shown to be driven principally by grazing, resulting in less palatable grasses such as *Nardus stricta* becoming dominant. Preferential grazing of heather, and possibly greater susceptibility to attack by the heather beetle can result in invasion by grasses in nutrient rich environments. Suspension of grazing has been shown to allow *Calluna* cover to increase again within a period of three years, even on relatively base-rich soils with previously high levels of browsing (Hartley, 1997).

Table 5.2 Change in broad habitats in Scotland.

Broad Habitat	Trends (1990-1998)[1]	Decreasing	Static[2]	Increasing	Reliability of trend[3]
Fen, marsh & swamp	• 2,970 km² - 3,370 km² • Significant **overall increase in extent** • The main increases were from improved, neutral and acid grasslands, as well as bog. • Small but significant reduction in light penetration associated with **more overgrown conditions**.			**18.7%** ⇧	**C**
Broad-leaved, mixed & yew woodland	• 2,770 km² - 3,000 km² • Significant **increase in extent in the lowlands (9.5%), and for Scotland as a whole (9.0%)**. • Expansion took place mainly on grassland (improved, neutral and acid), and to a lesser extent on heath, swamp and bog habitats, arable land and road verges. A net gain from coniferous woodland would be consistent with the reinstatement of broadleaved woodland following conifer felling.			**9%** ⇧	**C**
Arable & horticultural	• 5,660 km² – 6,390 km² • Significant **increase (33%) in the marginal uplands**, but not for Scotland as a whole. • Interchange with improved grassland was consistent with crop rotational, but resulting in a net conversion of improved grassland to arable.		**6.7%** ⇔		
Bracken	• 1,460 km² - 1,660 km² • No significant change in extent. • Considerable interchange with acid grassland, heath and bog suggested infestation and control. • Planting of broadleaved and coniferous woodland reduced bracken extent.		**2.6%** ⇔		
Built up & gardens in rural areas	• 1,480 km² - 1,510 km² • Change in extent was not statistically significant, but apparently occurred mainly in the marginal uplands and on neutral and improved grassland.		**2.1%** ⇔		
Rivers & streams	• 210 km² - 210 km² • No significant change in extent. • Evidence of eutrophication in streamside vegetation, particularly in the lowlands, with a statistically significant **increase in competitive species**. • **Streamside infertile grasslands and moor-land/grass mosaics also became more fertile.**		**0.9%** ⇔		
Coniferous woodland	• 9,780 km² - 9,930 km² • A small increase was not statistically significant. • Expansion was mainly on dwarf shrub heath and bog. • A net decrease to acid grassland would be consistent with expanding rates of felling in the 1990s. • Evidence of eutrophication, with small but significant **increase in fertility in conifer woodlands**. • A small but significant **reduction in light penetration** was attributed to tree growth since 1990.		**0.7%** ⇔		
Standing open water & canals	• 860 km² - 850 km² • Significant **increase in the area of inland water bodies (by 20%) in the lowlands** but not for Scotland as a whole • no significant change in the number of inland water bodies.		**0.6%** ⇔		

[1]CS1990 extent, and estimates of change between 1990 and 1998, were calculated using the 193 1km squares common to both surveys. 1998 extent was based on the 203 squares surveyed for CS2000 (except for plant diversity). Estimates of plant diversity were calculated using the 193 1km squares common to both surveys and only the vegetation plots on those squares that were considered to be valid replicates in 1990 and 1998. Statistically significant changes are shown in **bold**, P<0.05.
[2]Change too small to be established
[3]Reliability of change between the specified years, according to statistical significance: **C** = P < 0.05; **c** = P < 0.1

Table 5.2 Change in broad habitats in Scotland. (continued)

Broad Habitat	Key trends (1990-1998)[1]	Decreasing	Static[2]	Increasing	Reliability of trend[3]
Linear features (transport)	• 890 km^2 - 870 km^2 • No significant change in the areal extent of transport features. • Statistically significant **increase in fertility of infertile grassland road verges, the pH of moorland / grass mosaics, and the light index of moorland / grass mosaics**. • In fertile grassland road verges there was a statistically significant **decline in ruderal species**.		**1.8%** ⇔		
Improved grassland	• 10,940 km^2 – 10,510 km^2 • No significant change in overall extent • Interchange with arable land consistent with rotational management, with a net conversion to arable. • Small decreases to fen, marsh and swamp were countered by small increases to neutral and acid grassland.		**-0.1%** ⇔		
Bog	• 20,270 km^2 – 20,380 km^2 • No significant overall change. • Interchange with acid grassland, heath and fen, and marsh & swamp may in-part reflect mapping difficulties in the unenclosed uplands. • Significant **increases in plants associated with more fertile conditions and higher pH**.		**-0.1%** ⇔		
Acid grassland	• 7,920 km^2 – 7,480 km^2 • Significant **decrease of 15% in the lowlands**, but not for Scotland as a whole. • Net reductions to improved grassland and broadleaved woodland. A net expansion within coniferous woodland would be consistent with felling. • Interchanges with bracken; heath; fen, marsh & swamp; and bog may be due to real changes and/or mapping difficulties. • Significant **slight increase in plants characteristic of less acid conditions**. • Significant **slight increase in light index**.		**-4.9%** ⇔		
Dwarf shrub heath	• 10,750 km^2 – 10,020 km^2 • Suggested decline of 5.4% across Scotland as a whole, and 8% in the in the marginal uplands & islands. • Net decrease to coniferous woodland. • Slight reductions from Interchange with acid grassland, bracken and bog. • Significant **decline of stress-tolerant plants, and increase in competitive species**.	**-5.4%** ⇩			c
Neutral grassland	• 2,000 km^2 – 1,680 km^2 • Significant **decline, by 39%, in the marginal uplands & islands**, but not for Scotland as a whole. • Net reductions to improved grassland and fen, marsh & swamp. • Significant **increase in more competitive plant species and species indicative of more fertile conditions**.		**-14.8%** ⇔		
Calcareous grassland	• 320 km^2 – 270 km^2 • Small in extent and detected only in the marginal uplands & islands, an apparent 16% decline was only weakly significant	**-16.2%** ⇩			c
Montane habitats	• Insufficient data available for estimating 1990 extent. 1998 extent estimated as 480 km^2.				

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6 The UK Biodiversity Action Plan

The term 'biodiversity' refers to the variety of life on earth, including variation between ecosystems, between the species of which they are formed, and genetic variation within species. The United Nations Convention on Biological Diversity, held in Rio de Janeiro in 1992, emphasised the importance of three aspects of biodiversity, namely:

- the conservation of biological diversity;
- the sustainable use of its components; and
- the fair and equitable sharing of benefits arising out of the utilisation of genetic material.

Over 150 countries, including the United Kingdom, signed the convention, which requires each contracting party to:

> *'develop national strategies, plans or programmes for the conservation and sustainable use of biological diversity, or adapt for this purpose existing strategies, plans or programmes which shall reflect, inter alia, the measures set out in this Convention relevant to the Contracting Party concerned'.*

In response, the UK Government published, in 1994, *Biodiversity: The UK Action Plan*, setting a challenging but attainable overall goal for biodiversity conservation:

> *'to conserve and enhance biological diversity within the UK and to contribute to the conservation of global biodiversity through all appropriate mechanisms.'*

It also convened a Biodiversity Steering Group to oversee the preparation of action plans for habitats and species considered threatened within the UK.

The criteria used to identify Biodiversity Action Plan (BAP) priority habitats are as follows.

- Habitats for which the UK has international obligations.
- Habitats at risk, such as those with a high rate of decline, especially over the last 20 years, or which are rare.
- Habitats which may be functionally critical (e.g. as reproductive or feeding areas for particular species).
- Habitats which are important for priority species.

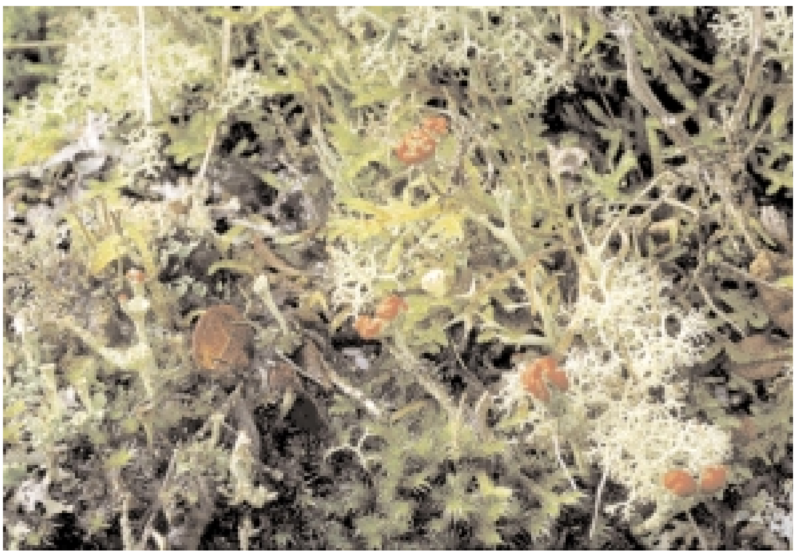
BAP priority species are selected on the basis that they are globally threatened or have declined by at least 50% in the UK over the past 25 years.

The development and implementation of each habitat and species action plan is coordinated by a separate steering group, and taken forward primarily by one or more Lead Partners. Some 41 statutory and non-statutory organisations serve as Lead Partners for BAP habitats and species occurring in Scotland. A Scottish Biodiversity Group (SBG), on which the Lead Partners and other interested parties are represented, also coordinates BAP development and implementation.

The involvement of local communities is crucial to the success of the BAP process. Partnerships have been established in all Scottish Local Authority areas to develop Local Biodiversity Action Plans (LBAPs), each of which provides a perspective on what is important locally, as well as nationally.

By 2001, action plans had been developed for 45 habitats and 391 species in the UK (UK Biodiversity Steering Group, 1995, UK Biodiversity Group, 1998-99). Of these, 41 BAP

Many peatland areas are particularly rich in lower plant species, and have persisted for thousands of years. As well as acting as a natural sink for methane (a 'greenhouse' gas), they provide other environmental services, including water storage and purification.



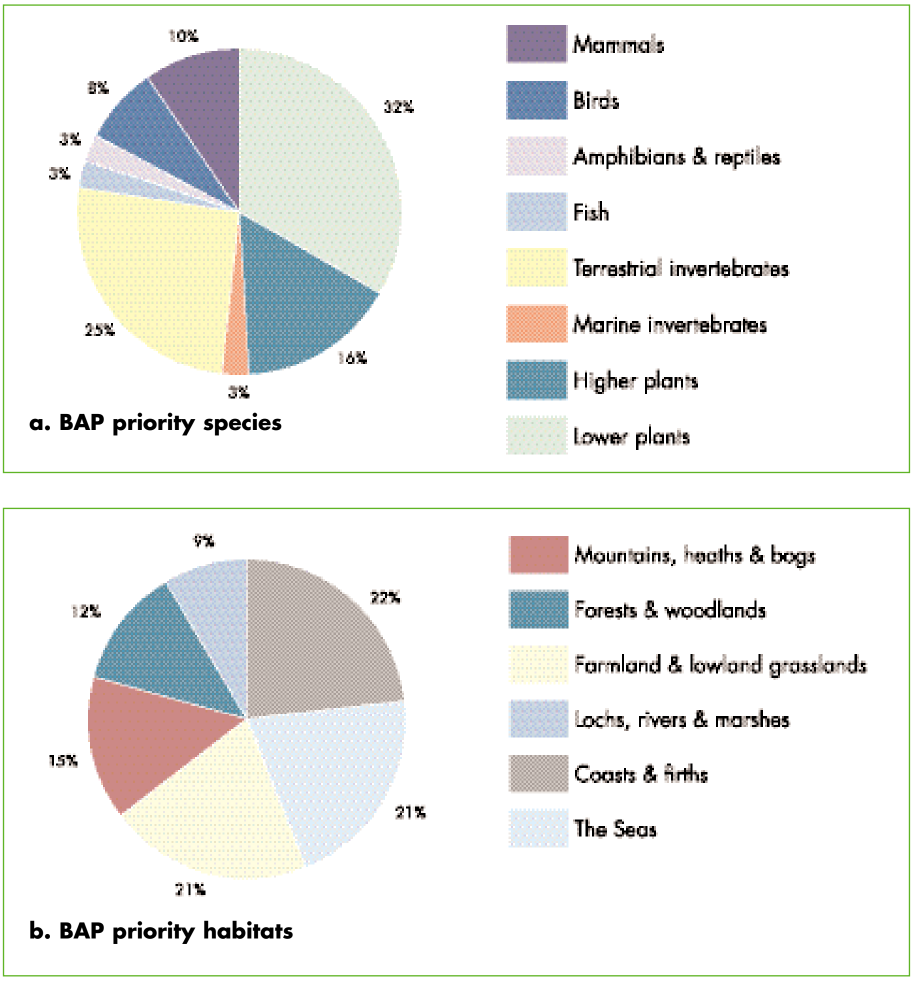
priority habitats and 261 species either occur in, or have recently been lost from Scotland (Appendices 1 & 2).

The majority of BAP priority species are either lower plants or invertebrates, reflecting the numerical predominance of these groups generally (Figure 6.1a). Although almost two-thirds of BAP habitats in Scotland occur within the agricultural, coastal or marine environment (Figure 6.1b), forests and woodlands support a much greater number of BAP priority species than any other habitat type (Figure 6.2).

Action plans quantify the extent and nature of the problems facing species or habitats and offer an approach to tackling these problems. They also provide biological objectives and targets against which levels of success may be gauged.

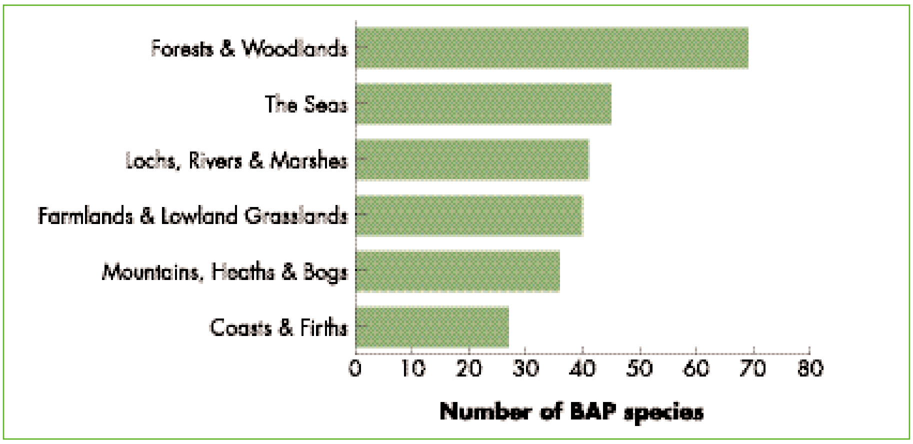
Many Biodiversity Action Plans set targets for population size, rate of change or geographic range, often specifying a target figure and date (Box 6.1). For poorly-known habitats and species, however, targets are usually less specific, reflecting the paucity of information on current status or trends. Since progress towards achieving BAP

Figure 6.1
The percentage of: a. BAP priority species within each taxonomic group; b. BAP priority habitats associated with each main habitat setting in Scotland.



Source: Usher *et al.*, 2000

Figure 6.2
The number of BAP priority species associated with each habitat setting in Scotland.



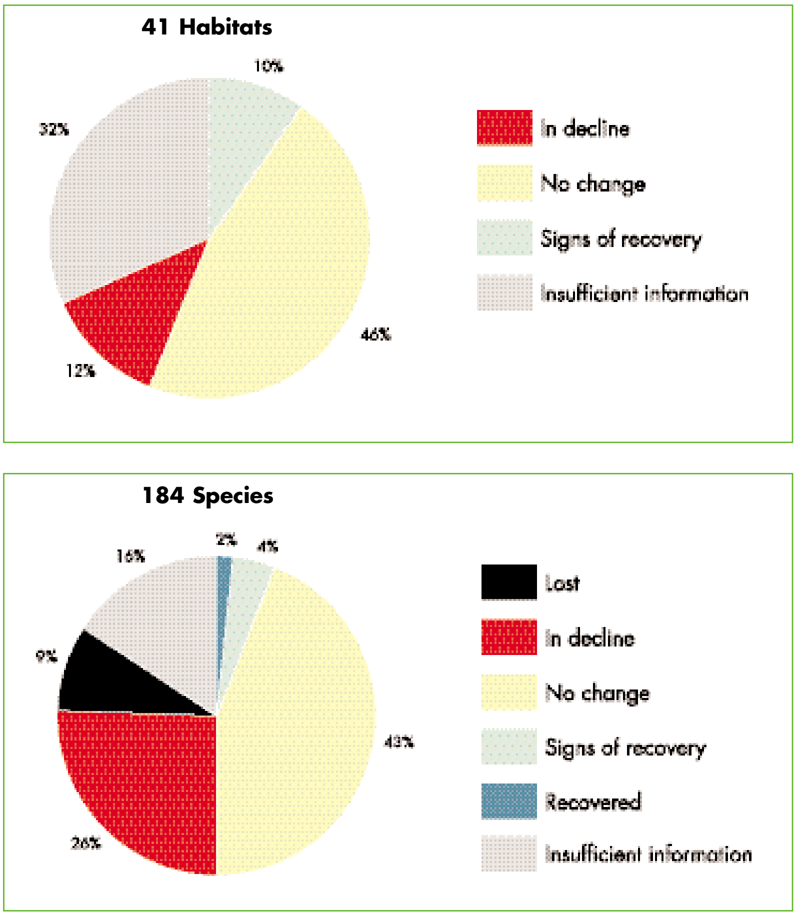
Source: Usher *et al.*, 2000

plan targets may therefore be difficult to gauge, alternative measures of progress have sometimes been used, including the proportion of specified actions currently underway (Avery *et al.*, 2001), the number of steering groups established, or the number of workplans prepared (Jones *et al.*, 2001).

A recent review by the Joint Nature Conservation Committee and the Scottish Biodiversity Group suggests that among the 41 BAP priority habitats occurring in Scotland, four show signs of recovery, while five still appear to be declining (Figure 6.3; Jones *et al.*, 2001). Of 186 BAP priority species assessed, three were thought to have recovered, while eight were showing signs of recovery. A further 47 species were thought to be declining, while 16 species had been lost from Scotland; all prior to establishment of the BAP programme.

Quantitative trend data, indicating progress towards achieving BAP targets, are generally available only for priority bird species, as described in Box 6.2.

Figure 6.3
The UK status of BAP priority habitats and species occurring in Scotland.



Source: Jones *et al.*, 2001

Box 6.1 Examples of Biodiversity Action Plan targets for priority habitats and species

Native pine woodlands

- *Maintain remnant native pinewood areas listed in the Caledonian Pinewood Inventory and restore their natural diversity of composition and structure.*
- *Regenerate and expand a total of 35% of the current wooded area … by 2005, predominantly by natural regeneration within the core and regeneration zones.*
- *Create the conditions by 2005 for a further 35% of the current area to be naturally regenerated over the following 20 years…*
- *Establish new native pinewood over a cumulative total area of 25,000 hectares by 2005…*

Green shield-moss

In the UK, since 1950, has been recorded from only two sites, both in Scotland, but has only been recorded from one site recently.

- *Survey to confirm status of this species in the UK.*
- *Maintain the population at the only remaining site, and any newly discovered sites, through the maintenance of suitable habitat conditions.*
- *If found to have been lost, re-introduce to former site in Scotland if conditions remain suitable.*
- *Promote further research into the ecological requirements of this species to underpin appropriate management advice.*

Eutrophic standing waters

- *Classify eutrophic water bodies into three tiers, on the grounds of naturalness, biodiversity and restoration potential.*
- *Ensure the protection and continuation of favourable condition of all 'Tier 1' eutrophic standing waters.*
- *By 2005 take action to restore to favourable condition … 'Tier 2' eutrophic standing waters that have been damaged by human activity.*
- *Ensure that no further deterioration occurs in the water quality and wildlife of the remaining 'Tier 3' eutrophic standing water resource.*

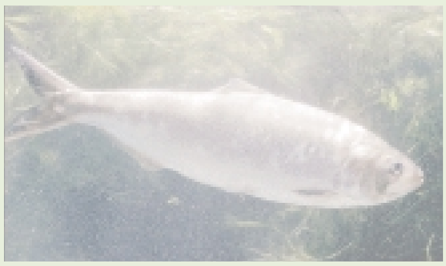
Netted mountain moth

- *Maintain populations at all known sites.*
- *Enhance the population size at known sites by 2010.*

Bottlenose dolphin

From Small Dolphins Grouped Species Action Plan:

- *In the short term, maintain the current range and abundance of small dolphins.*
- *In the longer term, seek to increase the ranges of small dolphin populations where appropriate.*



Allis shad

- *Confirm the status of the allis shad as a breeding fish in UK waters.*
- *Protect the allis shad in UK waters and ensure the continued survival of stocks.*

Sources: UK Biodiversity Group, 1998a,b, 1999a,b.

Box 6.2 Recent trends in BAP Priority bird species in Scotland

Of 26 Biodiversity Action Plan (BAP) priority bird species, 20 have bred in Scotland on more than a handful of occasions since 1950. They include one globally threatened species (the corncrake) and one classified as 'data deficient' (Scottish crossbill). Eighteen of the 20 species have shown a decline in geographic range or population size of at least 50% in the past 25 years, and seven now have UK populations of about 1,000 pairs or less.

For some bird species, status or trend data are sparse, and progress towards meeting their targets is difficult to gauge. This applies particularly to species that are widespread, but thinly distributed or highly localised, such as the tree sparrow, spotted flycatcher and corn bunting. In Scotland, such species are now too scarce to be adequately sampled through annual surveys, and require more targeted survey work. Adequate Scottish trend data therefore tend to exist either for the relatively abundant species (e.g. the linnet, reed bunting, song thrush), or for very rare species with restricted breeding ranges (e.g. the corncrake, roseate tern, red-necked phalarope).

Trends in BAP priority bird species have recently been reviewed in *The state of the UK's birds 2000* (Gregory *et al.*, 2001). This uses Common Birds Census (CBC) data to examine trends in the populations of widespread species during 1970-98 and 1993-98, much of it gathered in southern England. Since there are insufficient equivalent data for Scotland over the same time period, population changes described below are derived mainly from the more recent Breeding Bird Survey (BBS), spanning 1994-99. Trend data for rare species have been drawn from records held by the Rare Breeding Birds Panel (RBBP). Estimates of changes in range-size have also been used, based on two breeding bird atlas projects (1968-72 and 1988-91; Sharrock, 1976, Gibbons *et al.*, 1993) (Table 6.1). In many cases the figures presented here for Scottish populations are therefore not directly comparable with UK figures.

- During the 1990s, five BAP bird species declined in Scotland, five showed little apparent change, and two, the corncrake and nightjar, showed signs of recovery. One species, the turtle dove, was already extinct as a breeding species in Scotland. No adequate Scottish data were available for seven species.
- An analysis of trend data suggest that at least 16 of the 20 BAP priority bird species occurring in Scotland are unlikely to achieve their UK plan targets.
- Of the four remaining species, one, the corncrake, has already met its population target, whilst another, the nightjar, is considered likely to do so. Reliable status and trend data for a third species, the Scottish crossbill, are lacking. Survey results for the remaining species, common scoter, are inconclusive, although regional declines suggest that it may also fail to meet its national targets.
- Given that the majority of bird action plans have been developed only in the past 4-6 years, it is as yet too soon to gauge their likely influence on most of the relevant species' populations.

The UK breeding population of the **common scoter** is now largely confined to Northern Scotland

Table 6.1 Trends in BAP priority bird species in Scotland.
Range-size changes are shown for species present in at least 10 Scottish 10x10 km squares in 1968-72. Non-significant changes recorded by the Breeding Bird Survey are shown in parenthesis.

Species	Change in geographic range within Scotland: 1968/72 - 88/91	Recent trend in Scotland: Period	Change	Measure used	Source	Comments
Common scoter	+5%	1995-98	Decline?	Breeding pairs (confirmed or probable)	Targeted surveys/ RBBP[1]	An apparent 54% decline during 1995-98 (Gregory *et al.*, 2001) is likely to reflect variation in survey effort.
Black grouse	-21%	1991/92-1995/96	Decline	Displaying males	Targeted surveys	The UK population declined by 41-86% in 1991/92-95/96. Scotland was thought to support c. 70% of the UK population in 1995/96.
Capercaillie	-64%	1992/94-1998/99	-51%	Individuals	Targeted surveys	Declined from about 2,200 in 1992-94 to about 1,070 in 1998/99.
Grey partridge	-24%	1994-98	(+67%)	Individuals	BBS[2]	Change not statistically significant. Sample size less than 30 sites.
Corncrake	-65%	1995-2000	+10%	Calling males	Targeted surveys/ RSPB	The recent trend figure applies to 'Scottish Core Areas'.
Red-necked phalarope	-44%*	1995-99	-21%	Breeding males (confirmed or suspected)	RBBP	A recent decline of 16% has been reported by the RSPB, based on confirmed breeding attempts.
Roseate tern	-59%*	1995-99	-18%	Breeding pairs	RBBP	Declined from 11 pairs in 1995 to nine pairs in 1999.
Turtle dove	-76%*	-	Extinct	Breeding pairs	-	Extinct as a breeding species in Scotland.
Nightjar	-71%	1981-92	+24%	Churring males	-	The Scottish increase during 1981-92 was broadly consistent with a 74% increase in the UK population.
Wryneck	-71%*	1995-99	Virtually extinct	Breeding pairs + singing males	RBBP	2-5 pairs or males detected annually during 1995-99.
Skylark	-2%	1994-99	-13%	Individuals	BBS	A statistically significant decline.
Song thrush	-3%	1994-99	(+20%)	Individuals	BBS	Change not statistically significant.
Spotted flycatcher	-2%	-	-	No data	-	No reliable Scottish population data. 10% decline in the UK, 1993-98.
Red-backed shrike	-	1995-99	Virtually extinct	Breeding pairs + males present	RBBP	Range increased from one to seven squares, 1968/72 – 1988/91. Up to five pairs or males annually in 1995-99.
Tree sparrow	-29%	-	-	No data	-	No reliable Scottish population data. 11% decline in the UK, 1993-98.
Linnet	-13%	1994-99	(+1%)	Individuals	BBS	Change not statistically significant.
Scottish crossbill	No data	-	No data	-	-	No reliable trend data available.
Bullfinch	-11%	1994-99	(+73%)	Individuals	BBS	Change not statistically significant, and based on fewer than 30 sites.
Reed bunting	-19%	1994-99	(+40%)	Individuals	BBS	Change not statistically significant.
Corn bunting	-60%	-	-	No data	-	No reliable data: recorded in too few BBS squares.

* Range size changes should be treated with caution: species recorded in fewer than 30 Scottish squares in 1968-72.

[1] Rare Breeding Birds Panel
[2] Breeding Bird Survey

Common scoter

A small, declining UK population, largely restricted to Scotland.

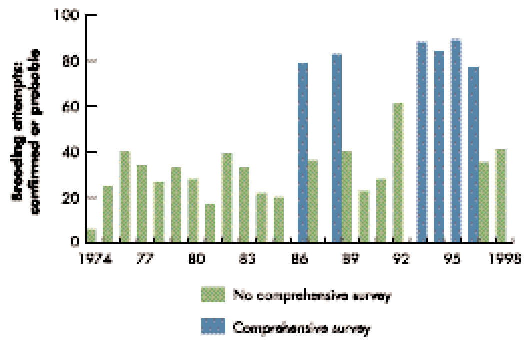
In Scotland, the geographic range of the common scoter appeared to increase by 5% between 1968-72 and 1988-91, but had contracted substantially by 1995 (Underhill *et al.*, 1998). During 1973-98 its breeding population fell by 69% (Gregory *et al.*, 2001), due largely to declines in the Northern Ireland population.

Since 1986, six comprehensive surveys have recorded a mean of 83 confirmed or suspected breeding attempts, compared with a mean of 38 breeding attempts reported annually during 'non-survey' years (Figure 6.4).

Although the common scoter is said to have declined by 54% between 1995 (a survey year) and 1998 (a non-survey year) (Gregory *et al.*, 2001), this change is likely to reflect differences in survey effort, and may therefore prove misleading. The species has, nonetheless, shown marked declines in some key areas, including a 42% decline in the Flow Country between 1988 and 1996 (Underhill & Hughes, 1996). It has also recently ceased to breed in Shetland and Dumfries & Galloway.

- Although regional population declines are evident, further national surveys are required to determine whether the common scoter is likely to meet its BAP targets, which include a Scottish breeding population of at least 100 pairs by 2008.

Figure 6.4
The number of confirmed or suspected breeding attempts by common scoter in Scotland during 1974-1998.



Sources: Rare Breeding Birds Panel, Wildfowl & Wetlands Trust.

Black grouse

A declining UK population, of which about 70% occurs in Scotland.

The geographic range of the black grouse in Scotland appeared to decline by 21% during 1968/72–1988/91. Surveys carried out in 1991/92 and 1995/96 indicate a 41-86% decline in the number of displaying males throughout the UK population (from Baines & Hudson, 1995, and Hancock *et al.*, 1999).

- The black grouse population in the UK is thought to have declined further since 1996, and has almost certainly failed to meet one of its plan targets: to 'maintain at 1996 level'.

Capercaillie

A small, declining UK population, restricted to Scotland.

The capercaillie has recently shown a steep decline in both population and range size, attributed, in part, to poor reproduction and increased mortality through deer-fence collisions.

Between 1968-72 and 1988-91 the capercaillie's range appeared to decline by about 64%. During the 1970s its population is thought to have been in the region of 20,000 birds, falling to about 1,500-3,200 birds by 1992-94, and to about 550-2,040 birds by 1998-99 (Catt *et al.*, 1998, Wilkinson *et al.*, in press). It has been estimated that the number of hen capercaillies in Scotland declined by about 18% (± 5%) per annum during the 1990s, but might otherwise have increased by about 6% (± 10%) per annum were it not for the additional mortality caused by deer fence collisions (Moss, 2001). In a model incorporating recent rates of decline the most probable projected hen population in 2014 was about 40. The model also indicated that there was a 59% chance of hen numbers dropping below the Minimum Viable Population (MVP) by 2014, and a 95% chance of doing so by 2024. In the absence of deer fences, however, the most probable projected hen population for 2014 was around 1,300, with only a 2% chance of dropping below the MVP (Moss, 2001).

- Although the existing Action Plan for the capercaillie includes a target of 20,000 birds by 2010, the species is considered likely to become extinct in Scotland in the near future if recent trends continue. Population modelling suggests that this could almost certainly be avoided, however, if deer fence mortality can be eliminated (Moss, 2001).

Hen **capercaillie** numbers are thought to have declined by about 18% per annum during the 1990s.

Grey partridge

Widespread but declining in lowland Scotland. The bulk of the population occurs in England.

Between 1968/72 and 1988/91 the geographic range of the grey partridge appeared to contract by about 24% in Scotland, and by 20% in the UK as a whole. CBC results (derived mainly from English survey sites) indicate a population decline of about 84% in the UK during 1970-98. There are no reliable, equivalent data for Scotland during this period.

The number of grey partridge recorded on Scottish BBS sample squares showed a non-significant increase between 1994 and 1998. Grey partridges were recorded on a mean of only 26 survey squares, however, dropping to fewer than 20 squares by 1999. These small sample sizes in themselves provide an indication of the species' scarcity.

- At the UK level, the grey partridge is considered unlikely to meet its BAP target of 150,000 breeding pairs by 2010 (Gregory *et al.*, 2001).

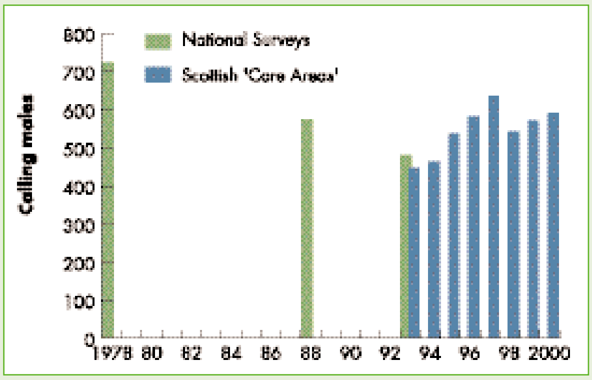
Corncrake

A small UK population, showing signs of recovery. About 98% of the UK population occurs in Scotland.

The corncrake's geographic range appeared to decline by about 65% during 1968/72 - 1988/91. Between 1978 and 1993 the number of calling males recorded in Britain and the Isle of Man dropped by 34% (from 723 to 480), but by 2000 had increased by 33% (from 446 to 591) in Scottish 'Core Areas' (Figure 6.5) (Data supplied by RSPB).

- Since 1992, when the Corncrake Initiative started, the species has met its BAP targets to: halt the decline in its population and range; maintain a UK population and range at or above the 1993 level; by 1998, increase the total numbers of singing males in Britain to 600, and its UK range to at least that of 1988.

Figure 6.5
The number of calling male corncrakes recorded in Britain since 1978.



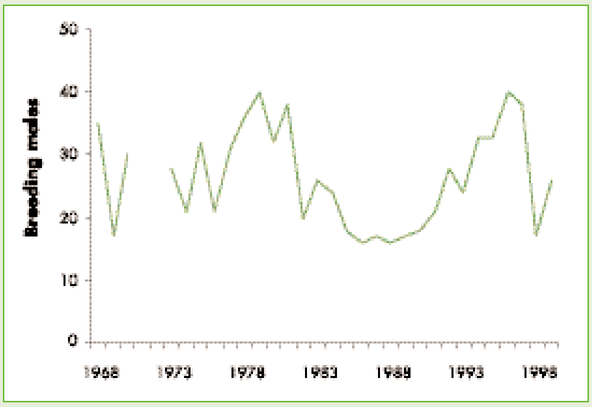
Source: RSPB

Red-necked phalarope

A small UK population, restricted to Scotland.

In the UK, the **red-necked phalarope** breeding population is largely confined to Shetland.

Figure 6.6
The number of male red-necked phalaropes proved or suspected of breeding



Sources: Rare Breeding Birds Panel.

The Red-necked phalarope's geographic range in Scotland declined by 44% during 1968/72-1988/91; from just 16 to nine 10x10 km squares. Data provided by the Rare Breeding Birds Panel suggest that the number of males present and either proved or suspected of breeding peaked at 40 in 1979, and again in 1996 (Figure 6.6). During 1999, 26 males were thought to have bred, raising 23-25 young.

In Gregory *et al.*, (2001) the number of displaying or breeding males is said to have declined by 25% during 1970-99, and by 16% during 1995-99. Equivalent RBBP figures suggest a drop of 13% and 21%, respectively. These disparities at least partly reflect differences in the criteria used to identify suspected breeders.

- The red-necked phalarope is unlikely to reach its BAP target of 55-60 breeding males on Shetland by 2003, and of 10 breeding males in the Hebrides by 2005.

Roseate tern

A small, declining UK population, of which about 16% breeds in Scotland.

During 1968/72 – 1988/91 the roseate tern's geographic range declined by 59% in Scotland, and by 23% in the UK as a whole. Changes in its breeding population have been even more marked: a decline of 93% in Scotland during 1970-99, and of 18% during 1995-99. Equivalent figures for the UK were -94% and -61%. These declines have been partly attributed to a shift in the breeding population, from the UK to Ireland.

- In view of its continuing decline, and a UK population estimate of 55 breeding pairs in 2000, the roseate tern is unlikely to meet its BAP target of 200 pairs by 2008.

Turtle Dove

A declining UK population. Extinct as a breeding species in Scotland.

In 1968/73 about 2% of the turtle dove's geographic range lay within Scotland. By 1988/91 its range had fallen by 24% in the UK, and by 76% in Scotland, to just six 10x10 km squares. The turtle dove was last confirmed breeding in Scotland in 1966, but may have done so in 1968-72. CBC data indicate a population decline of 70% in England and Wales during 1970-98, and of 24% during 1993-98.

- The turtle dove is therefore unlikely to meet its UK BAP target of a 50% increase in its 1996 population index by 2008.

Nightjar

Showing signs of recovery. The bulk of the population occurs in England and Wales.

During 1968/72 – 1988/91 the nightjar's geographic range appeared to decline by 71% in Scotland, and by 53% in the UK as a whole. Between 1981 and 1992 however, it showed strong signs of recovery, having increased by 24% (from 33 to 41 churring males) in Scotland, and from an estimated 2,100 to 3,400 churring males within the UK as a whole (Morris *et al.*, 1994).

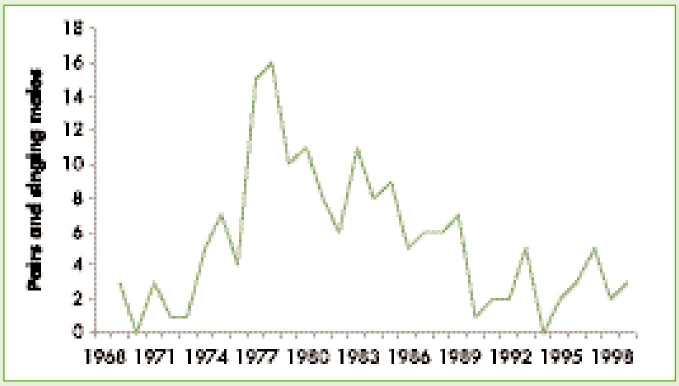
- The nightjar therefore seems likely to meet its UK BAP target of 4,000 churring males by 2003.

Wryneck

A small, declining UK population, restricted to Scotland.

Wrynecks are recorded at a handful of sites in the central highlands in most years.

Figure 6.7
The number of pairs of wrynecks and singing males recorded annually in Scotland.



Source: Rare Breeding Birds Panel

This species was first recorded breeding in Scotland in 1969. Its subsequent colonisation of the central highlands during the 1970s (perhaps by Scandinavian birds) coincided with a period of rapid decline in SE England. In 1968/72 wrynecks were recorded in 14 10x10 km squares in Scotland, but in only four squares by 1988/91. RBBP figures indicate that the number of breeding pairs and singing males peaked during the intervening years, reaching 16 in 1978, but dropping to a maximum of five during the 1990s (Figure 6.7). Breeding was confirmed in 1993 and 1997, and in 1999, when one pair is thought to have raised five young.

- The wryneck is an extremely rare, sporadic breeder in the UK, and thus fails to meet its BAP target of becoming a 'regular' breeding species.

Skylark

Widespread but declining in Scotland. The bulk of the population occurs in England.

The skylark's geographic range is thought to have declined by 2% in Scotland and in the UK during 1968/72-1988/91. CBC results, derived mainly from sites in England, indicate a much larger decline in its population; by 52% between 1970 and 1998. In Scotland, recent BBS data show a statistically significant decline of 13% between 1994 and 1999, compared with a 16% decline in the UK as a whole.

- The skylark has failed to meet its BAP targets, which include stabilising the population and reversing its decline.

Song thrush

Widespread but declining in Scotland. The bulk of the population occurs in England.

During 1968/72-1988/91 the song thrush's geographic range is thought to have declined by 3% in Scotland and by 2% in the UK as a whole. CBC data, derived mainly from English sites, indicate a population decline of 59% during 1970-98, and of 5% during 1993-98. More recent CBC and BBS results, however, indicate that the species' population may have begun to increase. BBS data indicate a 6% increase in the UK during 1994-99, and an apparent (non-significant) 20% increase within Scotland.

- The target to 'halt the decline in numbers of song thrush in the UK by the year 2000' may therefore have been met. There is, however, little doubt that its range and population levels have yet to be restored to their 1970 levels, and that it has therefore failed to meet at least one of its BAP targets.

Spotted flycatcher

Widespread but declining in Scotland. The bulk of the population occurs in England and Wales.

The spotted flycatcher's geographic range is thought to have declined by about 2% in Scotland and the UK during 1968/72-1988/91. CBC data, however, indicate a population decline of 78% during 1970-98, and of 10% during 1993-98. BBS data also show a (statistically significant) decline of 23% at the UK level during 1994-98, and a (non-significant) decline of 11% during 1994-99. In Scotland, the spotted flycatcher showed a non-significant decline of 4% in 1994-99, during which it was recorded on a mean of only 21 survey sites. This figure should therefore be treated with caution.

- The spotted flycatcher is unlikely to meet its BAP targets, which include a return to the 1996 level by 2003, and a 50% increase over the 1996 level by 2008.

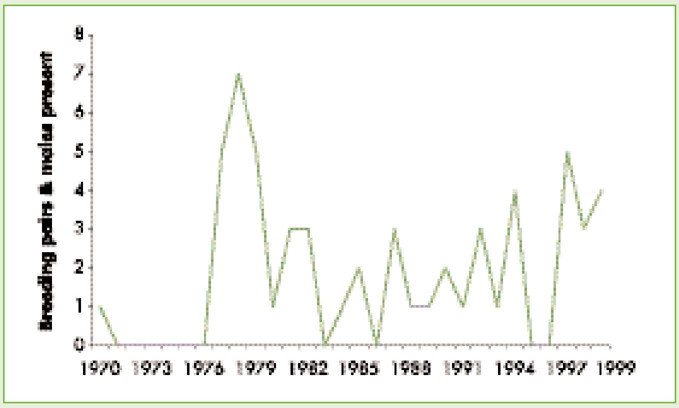
Red-backed shrike

A small, declining UK population, almost entirely restricted to Scotland.

The **red-backed shrike** breeds sporadically in Scotland, mainly in the central highlands.

Red-backed shrikes were first confirmed breeding in Scotland in 1977, since when pairs or single males have been recorded on up to seven sites annually (Figure 6.8). The species' arrival in Scotland coincided with a period of steep decline in SE England, where it was formerly well-established. Although still present in 111 UK squares in 1968/72, its range had declined to just 15 squares by 1988/91.

Figure 6.8 Number of pairs and summering male red-backed shrikes recorded in Scotland.



Source: Rare Breeding Birds Panel

During the 1990s, breeding was confirmed in 1994 and 1997, and in 1999, when one pair bred and two males were recorded at other sites.

- The BAP target for the red-backed shrike, to 'ensure the success of any pairs ... which attempt to breed', is thus only met in some years.

Tree sparrow

Formerly widespread in lowland Scotland, but declining. The bulk of the population occurs in England.

During 1968/72-1988/91 the tree sparrow's geographic range is thought to have declined by about 29% in Scotland and by 18% in the UK as a whole. CBC data, derived mainly from English sites, indicate a much greater decline in its population; of 95% during 1970-98, and of 11% during 1993-98. BBS data for the UK suggest (non-significant) changes of -8% during 1994-98, and of +11% during 1994-99. This species occurs on too few BBS sites to provide reliable trend data for Scotland.

- The tree sparrow is unlikely to meet its BAP targets, which include a return to the 1996 population level by 2003, and a 50% increase over the 1996 level by 2008.

Linnet

Widespread but declining in lowland Scotland. The bulk of the population occurs in England and Wales

During 1968/72-1988/91 the linnet's geographic range is thought to have declined by 13% in Scotland and by 5% in the UK as a whole. While CBC data indicate a population decline of 54% during 1970-98, and of 13% during 1993-98, recent BBS population data for Scotland suggest a non-significant change of +1% between 1994 and 1999, compared with a (significant) 14% decline in the UK as a whole.

- The linnet is therefore unlikely to meet its BAP targets, which include a return to the 1996 population level by 2003, and a 50% increase over the 1996 level by 2008.

Scottish crossbill

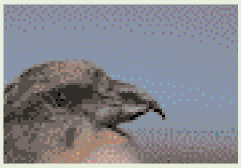
A small global population, endemic to Scotland.

There are no reliable status or trend data for Scottish crossbill, due to inherent difficulties in distinguishing this taxon from common and parrot crossbill. The three taxa differ in terms of body size, bill size and voice, but show no diagnostic plumage characters (Marquiss & Rae, in press; Summers *et al.*, in press).

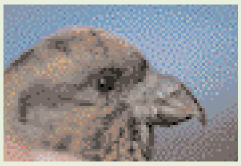
Bill size and shape influences not only the type of food taken, but also the pattern of movement shown by each species. A recent study has shown that on Deeside, common crossbills tended to be itinerant and migratory, switching seasonally between the (softer) cones of spruce and larch, and those of Scots pine. The larger-billed parrot crossbills were more sedentary, feeding throughout the year on pine seed, in semi-natural pine forest. Scottish crossbills, with their intermediate-sized bills, were also sedentary, but switched seasonally between conifer species (Marquiss & Rae, in press). There is, therefore, substantial overlap between the habitats used, such that one cannot use forest type as an aid to species identification (Summers *et al.* in press).

During 1996-99 Scottish crossbills, identified by call type, were recorded in 93 10x10 km squares, centred on the eastern Highlands, with outlying records in Flow Country plantations, Perthshire and Glen Garry (Summers *et al.*, in press). This finding represents an apparent increase over the 68 squares from which it was recorded during the winter bird atlas (Lack, 1986) and the 59 squares in which it was recorded during the 1988-91 breeding atlas (Gibbons et al., 1993). However, most of the increase reflects advances in field identification techniques, and perhaps an earlier reluctance by birdwatchers to identify the species outside of what was considered its core range (Summers *et al.*, in press).

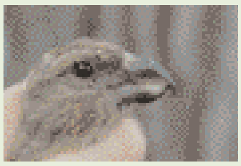
- Improved field methods and further survey effort are required to adequately determine the species' distribution, abundance and any subsequent changes in its status.



Common crossbill



Scottish crossbill



Parrot crossbill

The **Scottish crossbill** is mainly associated with ancient native pine forest, and is entirely restricted to Scotland. Its bill is intermediate in depth between that of **common crossbill** and **parrot crossbill**, with which it partly shares its habitat.

Bullfinch

Widespread but declining in Scotland. The bulk of the population occurs in England.

During 1968/72-1988/91 the bullfinch's geographic range is thought to have declined by 11% in Scotland and by 6% in the UK as a whole. While CBC data indicate a UK population decline of 52% during 1970-98, and of 10% during 1993-98, recent BBS population data for Scotland show a non-significant increase of 73% during 1994-99, though based on average sample sizes of fewer than 30 survey sites.

- BBS results for the UK during 1994-99 show a significant 28% decline, indicating that the bullfinch is unlikely to meet its BAP targets. These include a return to the 1996 population level by 2003, and a 50% increase over the 1996 level by 2008.

Reed Bunting

Widespread but declining in lowland Scotland. The bulk of the population occurs in England.

During 1968/72-1988/91 the reed bunting's geographic range is thought to have declined by 19% in Scotland and by 11% in the UK as a whole. CBC data for the UK indicate a much greater population decline; of 54% during 1970-98, and of 25% during 1993-98. This contrasts with recent BBS population data for Scotland, which suggest a (non-significant) population increase of 40% during 1994-99.

- BBS results for the UK show no significant change during 1994-99, indicating that the reed bunting is unlikely to meet its BAP targets. These include a return to the 1996 population level by 2003, and a 50% increase over the 1996 level by 2008.

Corn Bunting

Widespread but declining in Scotland. The bulk of the population occurs in England.

During 1968/72-1988/91 the corn bunting's geographic range is thought to have declined by 60% in Scotland and by 33% in the UK as a whole. CBC data, however, indicate a much greater decline in population size; of 85% during 1970-98, and of 30% during 1993-98. BBS data also show (statistically significant) declines at the UK level: of 42% during 1994-98, and of 26% during 1994-99.

Corn buntings have been recorded on a mean of only seven BBS squares in Scotland. Although the data are therefore too sparse to provide a reliable indication of Scottish trends, numbers recorded on these sites have shown a steep decline, even within this short period.

- The corn bunting is therefore unlikely to meet its BAP targets, which include a return to the 1996 level by 2003, and a 50% increase over the 1996 level by 2008.

The jangling song of the **corn bunting** has disappeared from much of the species' former range, apparently due to a reduction in seed availability in the winter, and in insect availability in the summer.

Key sources: changes in geographic range size were calculated from data provided by the British Trust for Ornithology (BTO), derived from Sharrock (1976) and Gibbons *et al.*, (1993). Abundance data for widespread species were kindly provided through the BTO/ Joint Nature Conservation Committee/ Royal Society for the Protection of Birds (RSPB) Breeding Birds Survey, 1994-99. Summary trend data for rare species were provided by M.A. Ogilvie, from records held by the Rare Breeding Birds Panel. Additional information was provided by the BTO, RSPB and The Wildfowl and Wetlands Trust.

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Landscape

The rich and varied landscape of Scotland is among the most evocative aspects of the natural heritage. It comprises physical, natural and cultural attributes which people see and experience. Aesthetic qualities which people enjoy are also influenced by people's values and preferences. With a view to providing the first comprehensive and consistent account, between 1994 and 1998 a systematic and relatively objective 'landscape character assessment' (LCA) was undertaken (Hughes & Buchan, 1999). This identified more than 3,900 different units of landscape character throughout Scotland which group into over 360 distinct landscape character types (Figure 7.1).

The LCA is an aid to, for example,

- cataloguing the diversity and geographical distribution of landscape character,
- helping to identify what is distinctive and worth protecting in Scotland's landscape,
- enabling an assessment of the capacity of different landscapes to accommodate change, and
- helping to guide development to appropriate landscape settings.

Trends

As the first study of its kind, the LCA serves as a baseline for Scotland's landscape in the mid-1990s. Landscape appearance is influenced by activities in agriculture and aquaculture, forestry, urban development and transport, energy generation and transmission, industry and mineral extraction, as well as leisure and recreation. Signs of landscape alteration were documented from a pre-coded list of 165 'forces for change' (Appendix 3). In this way, landscape change was recorded consistently by observers of the mid-1990s landscape, in each of the 29 regional LCA studies that made up the national assessment (Figure 7.2).

An attempt has been made here to relate forces for change to different settings. Appreciable differences might be expected between, for example, lowland farmland and mountain and moorland, or between woodland and urban settings. The categories are not geographically exact or mutually exclusive, but an overview of forces for change that were recorded as frequent/ widespread/ increasing is as follows.

The built environment

- Major urban expansion was confined to lowland farmland and the coast.
- Village expansion and incremental edge-of town development also occurred in woodland and fresh water settings.
- Industrial, business, retail and warehousing occurred in fresh water, coastal and woodland settings.
- Telecommunications masts were evident in farmland, mountain & moorland and coastal settings.
- Rural building redevelopment occurred in urban settings.
- Incremental road improvement was recorded in all settings, with new main road / bridge construction associated with fresh water and coastal settings.
- Increased urbanisation through roadside clutter was recorded in farmland, fresh water and urban settings.
- New single houses in the countryside appeared in all non-urban settings.
- An alteration of landscape character in farmland, fresh water, coastal and urban settings was due to inappropriate siting, design or building materials in new developments.
- The appearance of wind farms was recorded in all non-urban settings.
- Petro-chemical / gas installations were recorded in coastal and fresh water settings.
- Overhead lines occurred in all non-urban and non-woodland settings.
- Sand & gravel extraction were recorded in fresh water, coastal and woodland settings.
- Hard rock quarrying was associated with the coast.
- A decline and dereliction of mineral extraction, and new commercial peat extraction, were recorded in coastal settings.
- A loss or decline of historical / archaeological features was recorded in farmland, coastal and urban settings.

Farmland

- Semi-natural grasslands were reduced by farming and forestry.
- Grassland was converted to arable.
- Field boundaries were neglected or removed, and fields enlarged.
- Large new agricultural buildings appeared.
- Farm steadings fell into dereliction, but became converted to mainly residential new uses in lowland farmland.
- Crofting appeared to be in decline.
- Set-aside was recorded in arable farmland.

Woodland

- New large-scale coniferous afforestation was confined to mountain & moorland and coastal settings, with medium-scale afforestation also on lowland farmland and in fresh water settings.
- New large-, medium- and small-scale broadleaved / mixed woodland planting in mountain & moorland settings.
- Some woodlands obscured landforms, historical features and views.
- Maturity / neglect / decline of semi-natural and policy woodland was recorded in farmland and coastal settings.
- Changes were evident in the structure, edge and fragmentation of woodland.
- New forest tracks occurred in mountain & moorland settings.

Mountain & moorland

- Changes in grazing and muirburn practices were evident, with overgrazing by deer in woodlands and reduced heather cover on moorlands.
- Erosion of vegetation due to recreational pressure was reported in the uplands.

Fresh water

- Flood prevention works.
- Fish farming installations.
- Port/ harbour / pier construction / improvement.
- Water sports.
- New / extended waste management schemes.
- Erosion and engineering defence works.
- Canal related development.
- Reservoir and water supply infrastructure, and hydro-electric power schemes.
- River engineering for fishing.

Coast

- Fish farming installations.
- Port/ harbour / pier construction / improvement.
- Golf courses.
- New / extended waste management schemes.
- Erosion and engineering defence works.

Tourism & recreation

- Development pressure related to scenic value occurred in fresh water and mountain & moorland settings.
- Tourist attractions occurred there also, as well as in coastal settings.
- More general forms of tourism, leisure & recreation development occurred in the above settings, as well as in woodland.
- Caravan and camping sites were associated with fresh water and coastal settings.

New to the 1990s, in a number of locations in the uplands and on the coast, was the appearance of wind turbines for electricity generation (Box 7.1).

By virtue of its length and diversity, more forces for change were recorded in the coastal margin than elsewhere (Box 7.2). Many were common to farmland and woodland change, and urban development, but some were more closely identified with the coast than with other settings.

Mapping landscape change is not currently possible, and is unlikely to be easy. A simplified technique, based on tranquillity mapping, can provide insights into cumulative effects of physical and sensory disturbance in the countryside. A pilot study from the north-east of Scotland, incorporating elements of urban development, lowland farmland, marginal upland and coast, provides an illustration of this (Box 7.3).

Key sources: An explanation of landscape character assessment can be found in Hughes & Buchan (1999). The analysis of landscape change was based on David Tyldesley and Associates (1999).

Figure 7.1 The Landscape Character of Scotland
(over 360 distinct landscape character types are summarised here into 45 classes)

Excluded

Highlands and Islands

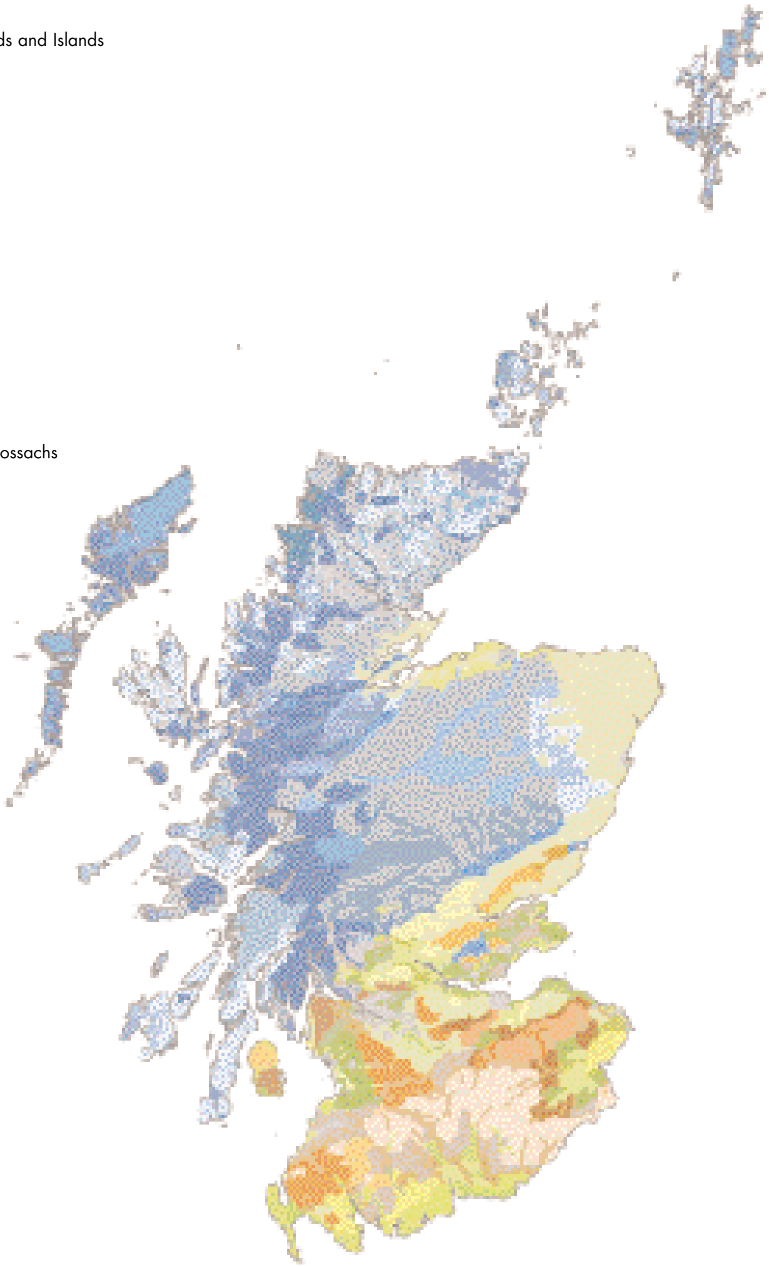
Farmlands and estates of the Highlands and Islands
Flat or rolling, smooth or sweeping, extensive, high moorlands of the Highlands and Islands
High massive mountain plateaux of the Cairngorms
High, massive, rolling, rounded mountains of the Highlands and Islands
High, massive, rugged, steep-sided mountains of the Highlands and Islands
Highland cnocan
Highland foothills
Highland straths
Highland and Island crofting landscapes
Highland and Island glens
Highland and Island rocky coastal landscapes
Highland and Island towns and settlements
Knock or rock and lochan of the islands
Low coastal hills of the Highlands and Islands
Low, flat, and/or sandy coastal landscapes of the Highlands and Islands
Moorland transitional landscapes of the Highlands and Islands
Peatland landscapes of the Highlands and Islands
Rocky moorlands of the Highlands and Islands
Rugged, craggy upland hills and moorlands of the Highlands, including the Trossachs
Sea lochs of the Highlands and Islands

Lowlands

Agricultural lowlands of the North East
Coastal hills, headlands, plateaux and moorlands
Coastal margins
Coastal raised beaches and terraces
Drumlin lowlands
Flatter wider valleys and floodplains of the lowlands
Low coastal farmlands
Lowland coastal flats, sands and dunes
Lowland coastal landscapes of the North East
Lowland hill margins and fringes
Lowland hills
Lowland loch basins
Lowland plateaux and plains
Lowland river valleys
Lowland rolling or undulating farmlands, hills and valleys
Lowland urbanised landscapes
Lowland valley fringes
Narrow valleys in the lowlands
Rocky coasts cliffs and braes of the lowlands
Rocky volcanic islands

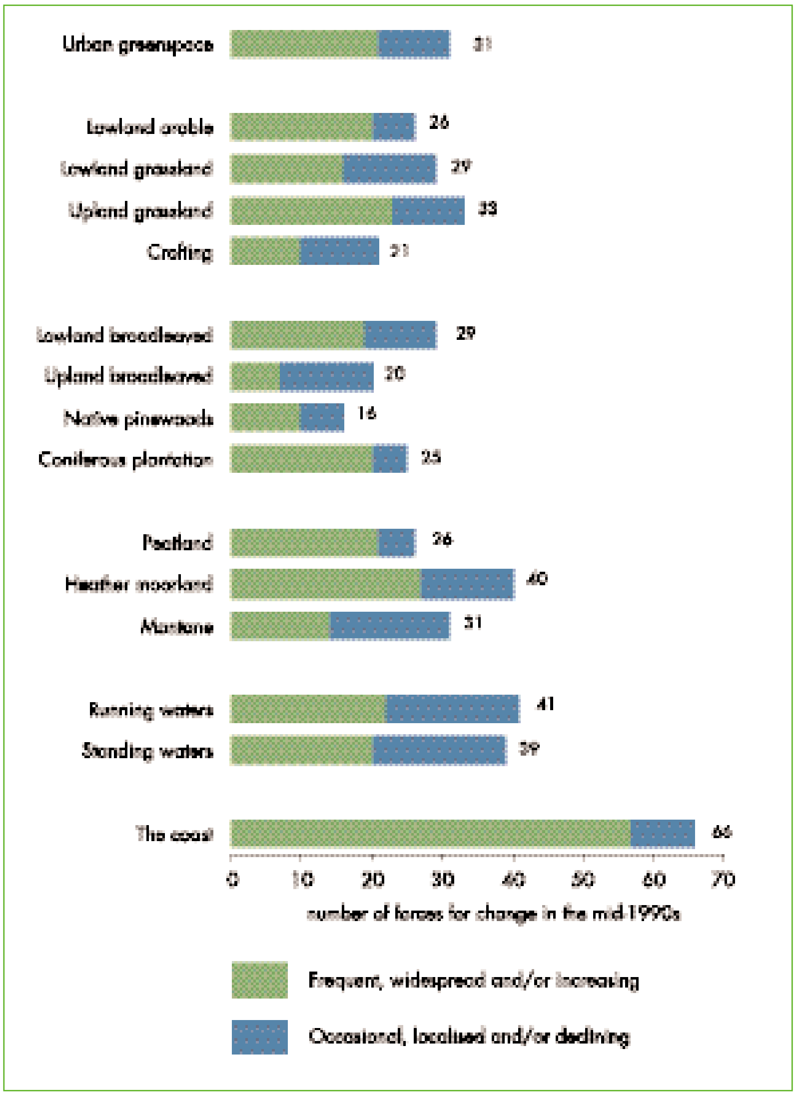
Uplands

Foothills and pronounced hills
High plateau moorlands
Rugged granite uplands
Rugged moorland hills
Smooth upland moorland hills
Upland basin
Upland fringe moorland
Upland fringe valleys and farmlands
Upland glens, valleys and dales
Upland hills, the Lammemuir, Pentland and Moorfoot Hills
Upland hills, the Southern Uplands and Cheviots
Upland igneous and volcanic hills, the Ochil, Sidlaw, Cleish and Lomond Hills

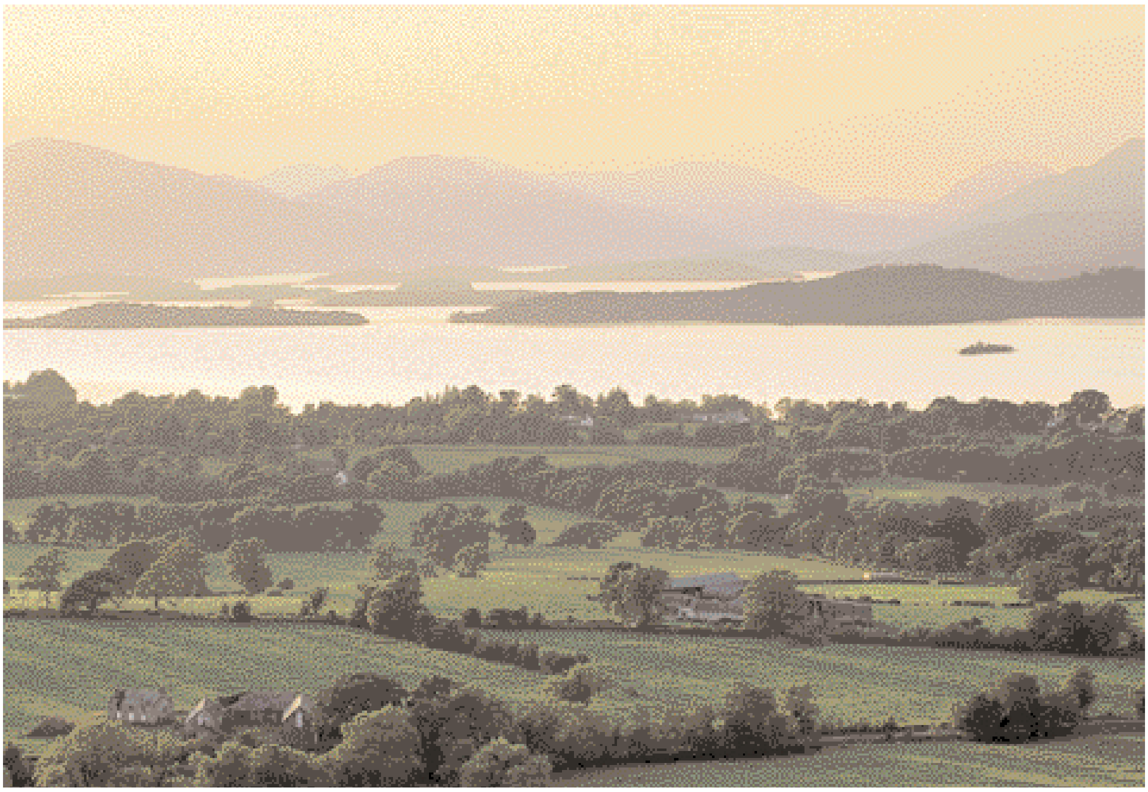


Source: SNH

Figure 7.2
Landscape change recorded in each setting



Source: based on David Tyldesley and Associates (1999)



The exceptional landscape character of Loch Lomond and The Trossachs was part of its attraction for Scotland's first National Park.

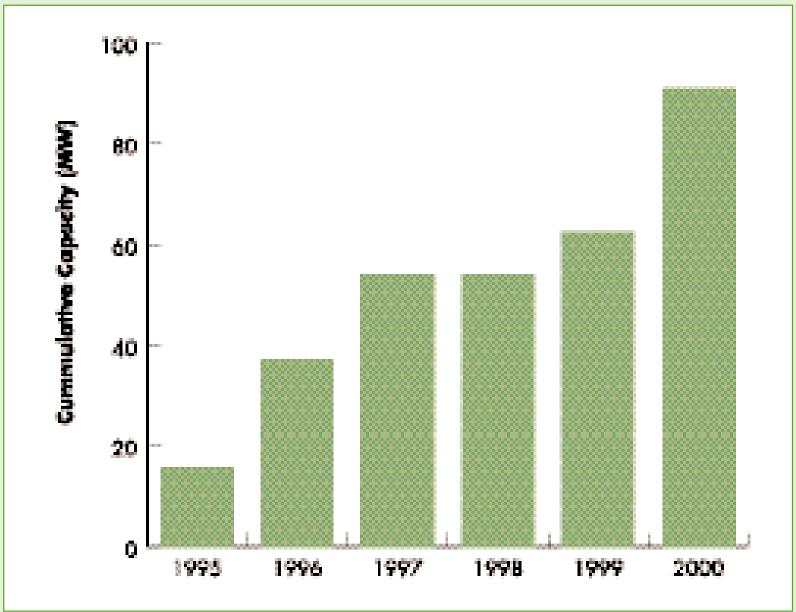
Box 7.1 Wind Power

Electricity generated from five main power stations in Scotland (Torness, Hunterstone B, Longannet, Cockenzie and Peterhead) is from nuclear (2), coal (2) and gas fuels (1) respectively. Over 50 hydro-power stations account for around 10% of total capacity. A grid of transmission lines carries electricity to distributed consumers. Scotland has a surplus in generation capacity, some of which is exported to England. When a new Northern Ireland interconnector becomes operational, together with upgrades to England, the total export capacity will rise to around 3 GW.

In addition to 21 smaller installations, including single domestic turbines, by 2001 there were six large windfarms in Scotland (Figure 7.3).

As a contribution to climate change obligations, the Scottish target is to generate 18% of electricity from renewables by 2010, including existing hydro schemes. This implies considerable expansion of wind energy generation. By May 2001, a further 51 schemes had been identified for possible development (Figure 7.4). Of these, 22 were large schemes, three of which had been approved.

Figure 7.3
Large Wind Farms



Scotland is considered to have the best wind resource (onshore and offshore) in Europe, with six large windfarms in operation.

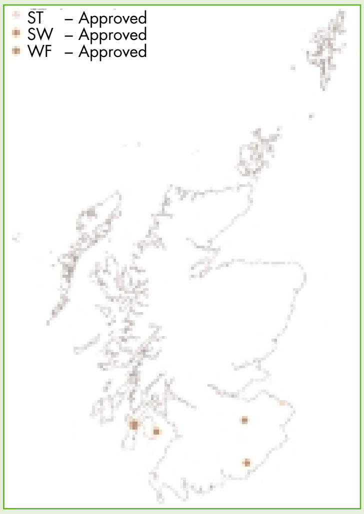
Name	Location	Number of turbines	Date	Capacity (MW)	Cumulative capacity
Hagshaw Hill	South Lanarkshire	24	1995	15.6	15.6
Windy Standard	Dumfries & Galloway	36	1996	21.6	37.2
Novar	Highland	34	1997	17.0	54.2
Beinn Ghlas	Argyll & Bute	16	1999	8.4	62.6
Dunlaw	Scottish Borders	26	2000	15.6	78.2
Hare Hill	South Ayrshire / Dumfries & Galloway	17	2000	13.0	91.2
Total		153		91.2	

Source: SNH

Box 7.1 **Wind Power** (continued)

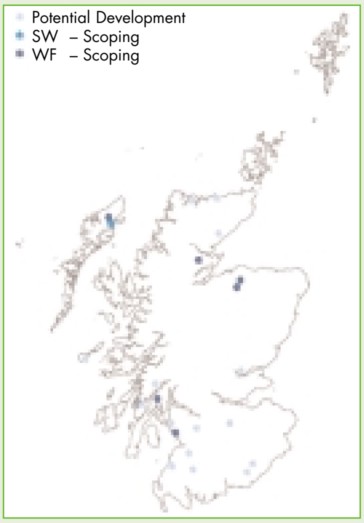
Figure 7.4
Projected wind energy development

Existing

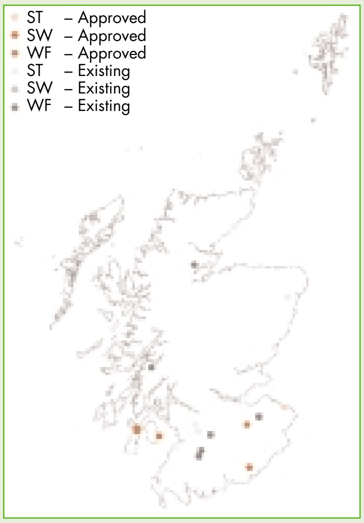


Approved

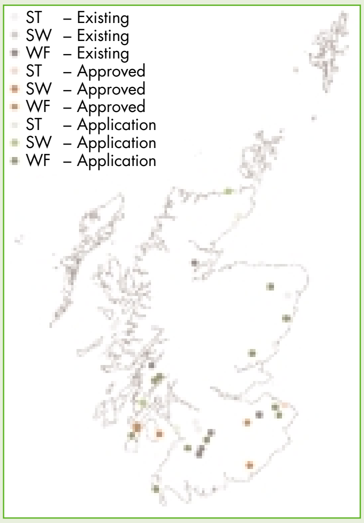
Applications



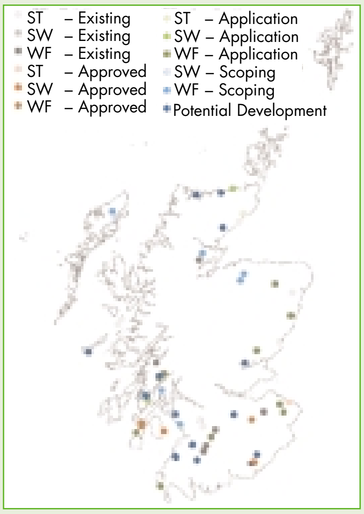
Scoping/potential development



Existing and approved



Existing, approved and applications



All

ST = Single Turbine
SW = Small Wind Farm (2-5 turbines)
WF = Wind Farm (> 5 turbines)

Status at May 2001	Number of schemes	Number of turbines	Cumulative turbines
Existing	27	176	176
Approved	8	69	245
Applied for	15	200	445
Scoping / Potential Development	28	210 (+18 unknown)	655 (+18 unknown)
Total	78	655 (+18 unknown)	

Note: the number of turbines is not known for 18 schemes for potential development.

Key source: SNH.

Due to their size and modern industrial appearance, the sensitive siting of windfarms and their service tracks needs to take account of the capacity of a landscape to accommodate change, ecological considerations (e.g. risks of collision on goose flight paths or raptor hunting grounds) and proximity to demand. Appropriate siting, design and layout should aim to create a positive visual image, whilst avoiding landscapes that are valued for qualities of wildness.

Box 7.2 Coast

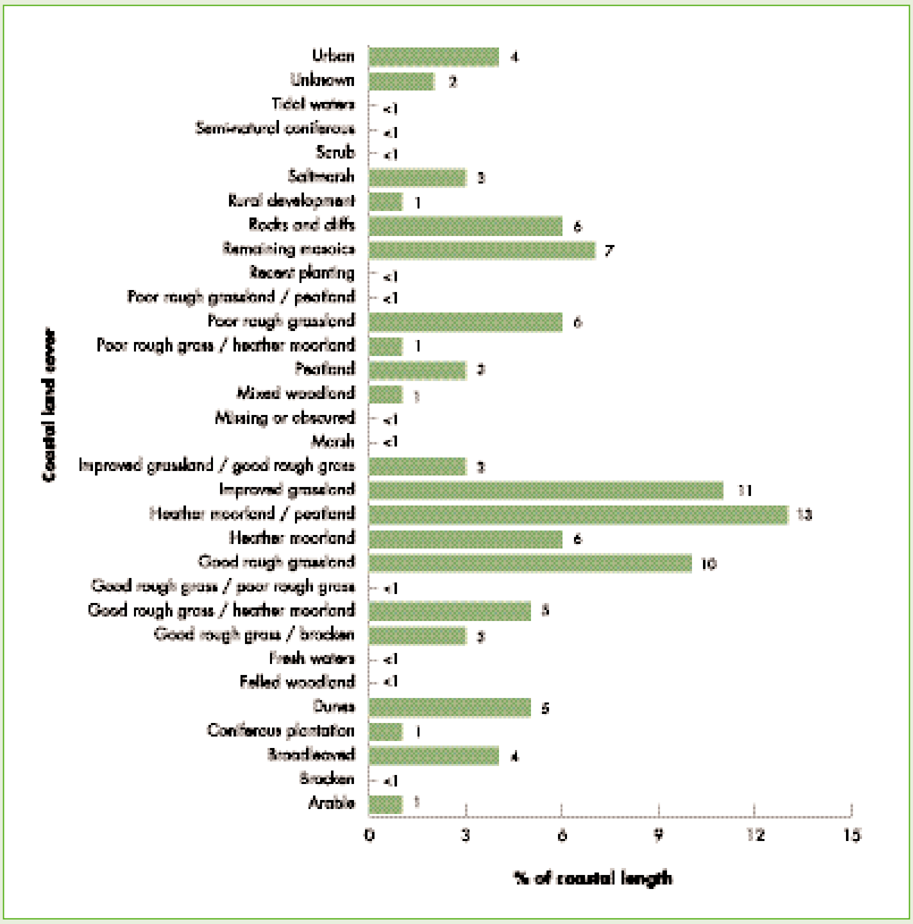
Much of the Scottish coast remains relatively unspoilt, hosting large numbers of species and distinctive habitats such as sand dune, machair, saltmarsh, shingle, sea cliff, hard shore, sandy shore and intertidal flats. It is a naturally dynamic environment of erosion and accretion in which continuous processes of habitat creation and ecological succession are vital to maintaining species-richness (Usher, 1999). On exposed coasts, the maritime influence of salt spray may extend several kilometres inland. Conversely, deciduous woodland can reach the shore of sheltered sea lochs and Firths. A striking effect of oceanicity is that plants and animals associated with high altitudes inland are to be found near sea level in some northern and western exposed coasts.

The coastal margin is long and varied, measuring around 16,500 km at a scale of 1:25,000. A highly indented, typically rugged west coast, with over 2000 rocks and islands (800-or-so of which are vegetated above the high water mark) is in contrast to the much smoother form of the east coast. Settlement patterns vary geographically, with long stretches of sparsely populated coast, particularly in the western Highlands and Islands, punctuated in places by harbour villages. Even along the most intensively farmed and settled low-lying coasts, the firths of Clyde, Forth and Tay, parts of the North Sea coast and the Moray and Cromarty Firths, are to be found relatively unaltered coastlines. By European standards the level and impact of human activity, for example from industry and tourism, is low (Doody, 1999). Nevertheless, a host of social, economic and environmental pressures come together at the coast. The needs of conflict resolution, for consensus building and more integrated management strategies led in 1997 to the establishment of a Scottish Coastal Forum (Sankey, 1999).

In the late 1980s, it was estimated that about 8% of Scotland's coast had been physically modified in some way, essentially since the late 18th century (Richie & McLean, 1988). By 1999, remarkably little had changed, with a growing importance of leisure and recreational uses. Almost 90% of the coastline in the late 1990s was not affected by intensive urban or industrial use (Richie, 1999). However, the visual impact and perception of development can be much greater. Landclaim has historically resulted in losses of intertidal mudflats, by as much as 50% of the inner Forth estuary (upstream of the Forth Road Bridge) for example.

With the bulk of population and infrastructure located close to the coast, and most land-based activities represented (Figure 7.5), a relatively large number of forces for change were evident along the coast (Figure 7.6).

Figure 7.5 Land cover along Scotland's coastline (%)

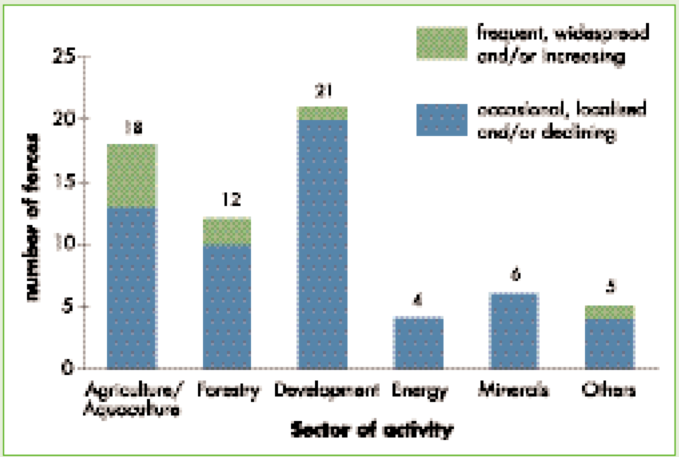


Source: an analysis of the Land Cover of Scotland 1988 (LCS88)

Box 7.2 Coast (continued)

Figure 7.6 'Forces for Change' in the mid-1990s - The Coastal Margin

Number of forces recorded in each sector



Source: based on David Tyldesley and Associates (1999)

Key sources: The analysis of landscape change was based on David Tyldesley and Associates (1999). An overview of coastal issues can be found in Baxter *et al.* (1999).

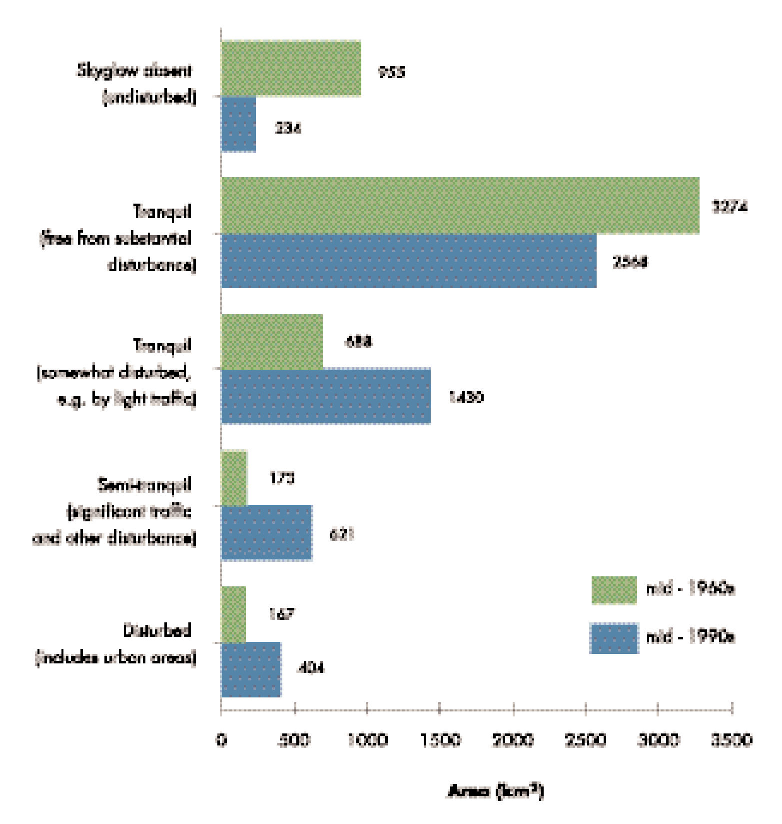
The main forces for change recorded

- changes in lowland farmland and woodland
- urban expansion, edge of town development, village expansion and single house building
- industrial, business, retail and warehousing
- port / pier development, road / bridge construction
- linear developments along roads
- tourism developments and tourist attractions
- leisure & recreation development
- caravan and camping sites
- golf courses
- new / extended waste management schemes
- telecommunications masts, wind farms
- fish farming installations on-shore
- coniferous afforestation, small - large in scale
- overhead lines, pipelines
- sand & gravel extraction, hard rock quarrying
- coastal engineering and reclamation

The shoreline can vary from being highly modified to relatively unaltered, such as on the Clyde Estuary.

Box 7.3 Tranquility: mid-1960s to mid-1990s

Figure 7.8 Changes in tranquillity



Source: based on Ash Consulting Group

Tranquillity in the countryside refers to qualities of quietness and visual calm. The mapping of tranquillity in Scotland has been piloted in a study around the A96 corridor between Aberdeen and Inverness. The study area extended along the northern margin of the Grampian and Cairngorm mountains, from Deeside to the Moray and Cromary Firth coasts. Visual and sensory disturbance included road traffic, settlements, electrical infrastructure, rail traffic, airport noise, windfarms, quarry working and telecommunications masts. Skyglow was taken to be the reflection of artificial (mainly street) lighting from the base of cloud cover in the night sky (Figure 7.7).

Although tranquillity can be enhanced locally, for example by tree screening, the direction of change in the pilot area was of increased disturbance (Figure 7.8).

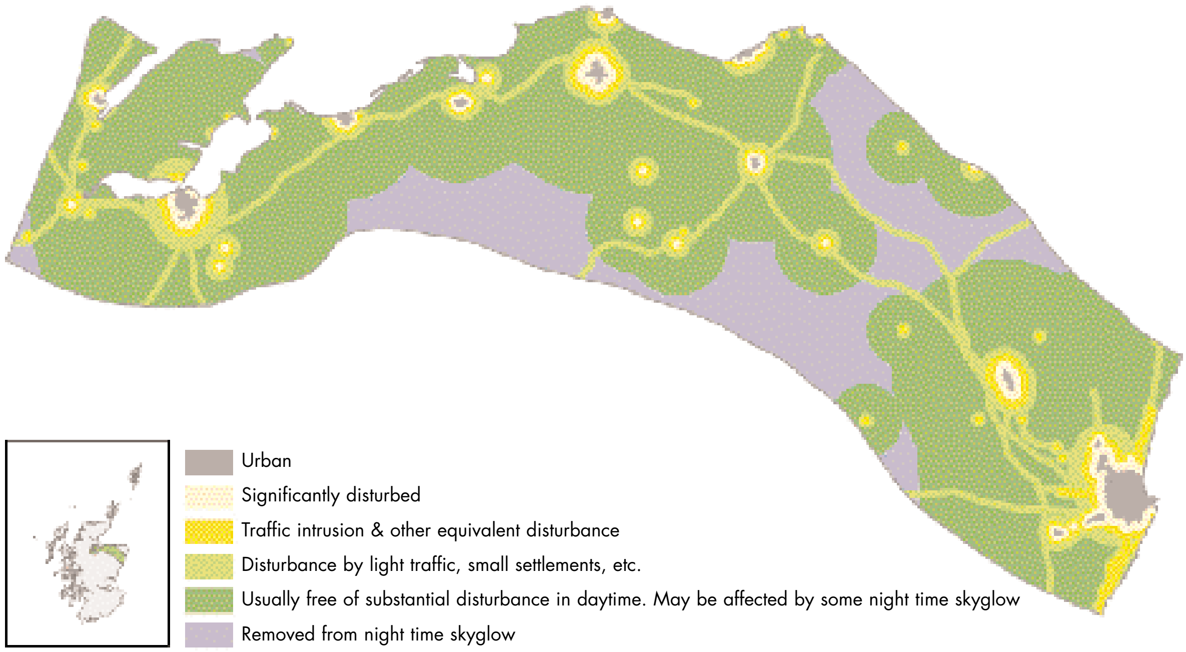
- Levels of disturbance from the 1960s remained unchanged within about half of the pilot area (55%).
- The most tranquil areas, where skyglow had been absent in the mid-1960s, were reduced by three-quarters.
- Tranquil areas that had been free from substantial disturbance were reduced by a fifth.
- The extent of slight disturbance from light traffic or small settlements doubled in extent.
- Semi-tranquil areas that were subject to significant traffic or other forms of disturbance increased by three-and-a-half times.
- Heavily disturbed or urbanised areas more than doubled in extent.

Key source: based on Ash Consulting Group (1998).

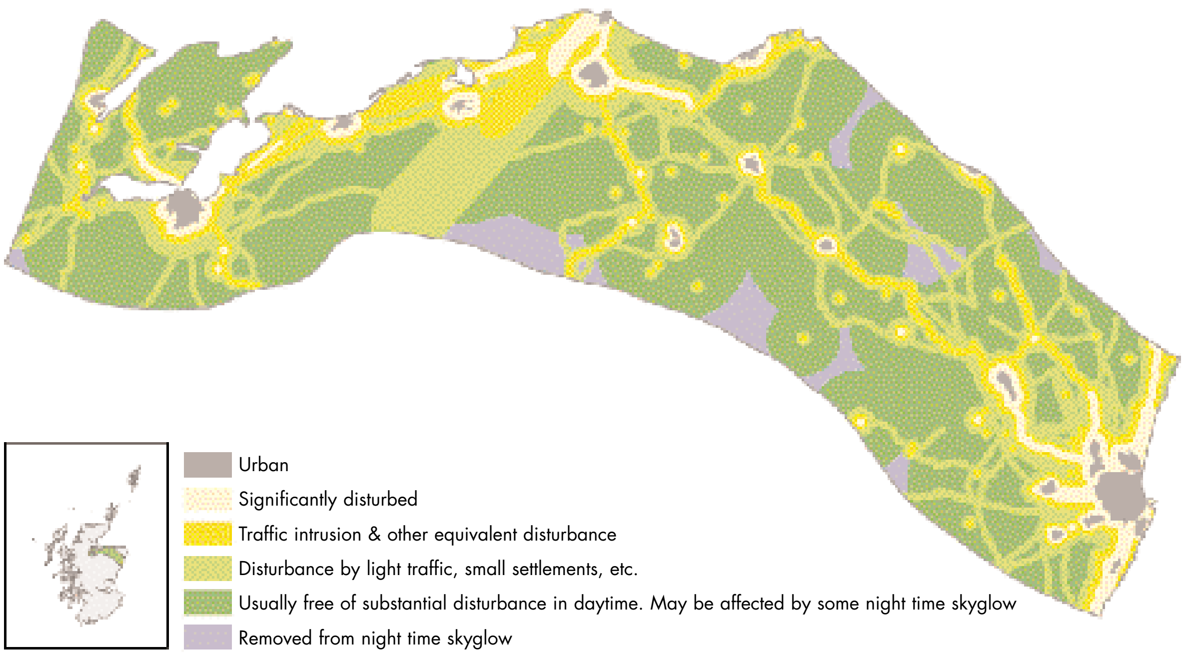
Box 7.3 Tranquility: mid-1960s to mid-1990s (continued)

Figure 7.7 Tranquillity maps

a) mid-1960s



b)1996



Source: based on Ash Consulting Group

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8 Access and recreation

The Scottish countryside has long been valued as a setting for informal recreation, by the Scottish people and visitors alike. The forests, mountains, rivers, lochs and coasts of Scotland are the most varied and extensive in Britain.

Forests can accommodate a wide range of pursuits, including cycling, cross country skiing, orienteering, picnicking, and walking. Large woods can absorb many people, and many different activities, while still offering a sense of solitude and seclusion.

Scotland's mountains are among the best areas of wild land in Britain. They offer unparalleled opportunities for hill-walking, climbing and skiing; and their outstanding landscapes also attract visitors who enjoy the hills without engaging in such active pursuits.

The scenic grandeur and wildlife value of the Scottish coastline are incomparable. As well as swimming and sun-bathing, coastal waters provide for excellent sailing, diving, sea-kayaking and wildlife tourism in wild and challenging settings.

Scotland's attractiveness for open air recreation underlies its status as a tourist destination. In 1998, it was estimated that expenditure on such activities amounted to about £730 million and supported about 29,000 full-time equivalent (FTE) jobs (SNH, 1998). Tourists participating in hiking and walking generated £257 million (15% of tourist expenditure), supporting about 9,400 FTE jobs.

Open air recreation is vital to health and well-being, to escape the pressures of day-to-day living and to enjoy the natural heritage.

Trends

Participation in, and provision for, many forms of recreation has increased in recent years. The principal trends for which information is available are summarised in Table 8.1.

- Between 1994 and 1998 the number of visits by Scottish adults to the coast or countryside increased from about 105 million to 137 million (Greene, 1998; SCPR, 1999).
- The proportion of adults taking part in outdoor activities increased from 41% to 46% between 1987-89 and 1996-98 (MacGregor & Martin, 1999).
- Detailed information on coastal recreation is available for only a few locations. Data from electronic counters at coastal sites in East Lothian have shown a steady increase in the number of visitors between 1992 and 1999.
- Participation in hill-walking and mountaineering has increased throughout the last century (see Box 8.1).
- Provision for recreation in Forest Enterprise woodland increased between 1986 and 1996. For example, the number of forest walks and nature trails increased from 199 to 336 and visitor centres increased from six to twelve (Scottish Office, 1998).
- The 'Paths For All' initiative was launched in 1996. By early 2001, over 100 path network projects had been implemented or proposed (see Box 8.2).

As participation in recreation increases, more investment in countryside management is needed to make better provision for visitors, and to ensure that where problems arise they can be resolved.

For example, path management is required to prevent unsightly erosion. Between 1964 and 1976, the length of mapped footpaths within a 100 square km area around the four highest Cairngorm peaks, increased by almost 120% (Aitken, 1985).

Scotland's coast: both invigorating and relaxing.

Well-managed footpaths protect the natural heritage against damage and unsightly erosion. Cairngorms.

Key sources: There is a lack of consistent long-term data to follow trends in recreation participation, largely because changes in survey methods make some comparisons impossible (Greene, 1996).

For hill-walking, the best comparison is between the Scottish Tourism and Recreation Study of 1973 and the National Walking Survey of 1995 (Davison, 1997).

sportscotland (formerly the Scottish Sports Council) have been gathering data on participation in sport since 1987 (sportscotland, 1998), and this is now the best long-term trend data available.

The UK Day Visits Survey, run in 1994, 1996 and 1998, collects information on participation in different kinds of day trip, and on the characteristics of respondents and their leisure visits (Greene, 1998; SCPR, 1998, 1999).

Automatic counters are increasingly used to maintain continuous records of visitors to key sites. A few sites have been monitored since 1992, and are now beginning to generate basic data about levels of use of these sites.

Box 8.1 Recreation in the uplands

At the turn of the 19th century, mountain activities were largely the preserve of the well off, who had transport, leisure time and money (Hankinson, 1972; Crocket, 1986). Later they became, for some, a temporary escape from the grind of the Clydesdale shipyards or the monotony of unemployment (Borthwick, 1939; Connor, 1999). At the beginning of the 21st century, they have become a more broad-based and popular pursuit. Significant factors in increasing their popularity include:

- improved access to the Highlands;
- increased personal car ownership;
- increased income and leisure time.

While there is a lack of long-term data, comparison between surveys from 1973 and 1995 indicates a growth from 0.8 million to 1.8 million trips over that period (Davison, 1997).

By the 1990s, about 4 – 5% of the Scottish population went climbing, hill-walking, or mountaineering in an average month of survey (MacGregor & Martin, 1999).

Long term growth in recreational activity can be indicated by increases in the number of hillwalkers completing all 284 Munros, the number of mountain rescues and growth in hill-walking/mountaineering clubs (Figure 8.1).

Although the number and geographical range of hill-users has expanded, areas with easy access from the Central Belt still attract the most visits. The 1995 walking survey found that the Perthshire hills and the Grampians/Cairngorms attracted 37% of those whose last walk was in a mountain/moorland setting (Davison, 1997).

Mountain-based recreation is economically important to many communities, particularly out of the main tourist season. Between January and March it may comprise more than 80% of tourism-related income. In 1996 mountaineers spent a total of £148.9 million in the Highlands and Islands Enterprise area, generating about 3,950 jobs (Highlands & Islands Enterprise, 1996).

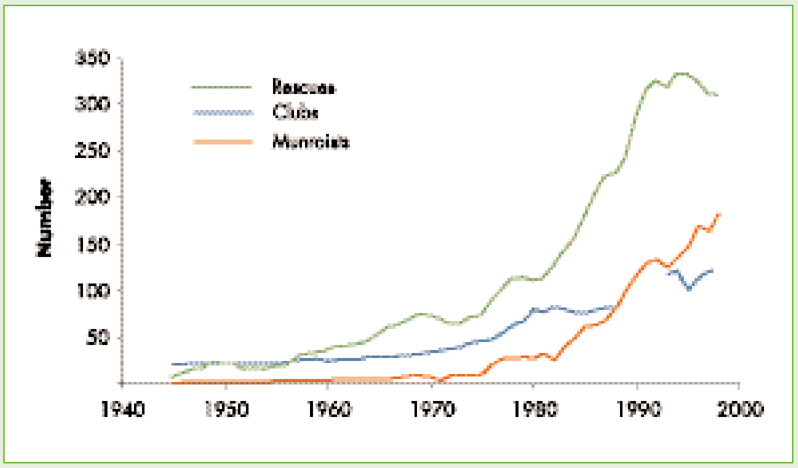

Figure 8.1 Three indices of growth in mountain recreation 1945 – 99

Source: Data supplied by R. Aitken, after Aitken (1977). Derived from annual listings of mountain rescues and Munro completions in the *Scottish Mountaineering Club Journal*, and from the records of the Mountaineering Council of Scotland.

Key sources: For hill-walking, the best comparison is between the Scottish Tourism and Recreation Study of 1973 and the National Walking Survey of 1995 (Davison, 1997). Further information is derived from sportscotland's data (formerly the Scottish Sports Council), summarised in MacGregor & Martin (1999) and from System Three Scotland's walking survey for Scottish Natural Heritage (System Three Scotland, 1996).

Data on Munroists, mountain rescues and hill-walking/ mountaineering clubs, were provided by R. Aitken.

Information on trends in climbing was provided by C. Wells.

Scotland's mountains offer many recreational opportunities. Northern Corries, Cairngorms.

Box 8.2 Path networks

Walking is Scotland's most popular outdoor activity, with about a quarter of adults taking a walk every month (MacGregor & Martin, 1999). Amongst those who walk for leisure in Scotland, the most frequent concern (52%) is knowing where they are permitted to go (System Three Scotland, 1996).

Local path networks

In much of Scotland, particularly the lowlands, there are few well-constructed, sign-posted paths which the public can confidently use. In response to this shortage of local access, the Paths for All initiative was launched in 1996.

The aim is that "within the next decade, communities throughout Scotland should have networks of local paths for the enjoyment of local people and visitors" (Currie, 2000). This will be achieved through partnerships between local authorities, landowners, communities, user groups and agencies.

By early 2001, 20 Local Authorities had appointed access officers, 22 access strategies had been completed or were underway, and 10 local access forums had been established.

By that time, over 100 path networks projects had been implemented or proposed.

Case Study: Mortonhall
Mortonhall is a small private estate on the south side of Edinburgh. Until recently, access was tolerated, but without defined paths many people were uncertain where they were allowed to walk.

The landowner and the local people worked with the Paths for All Partnership to develop a path network. The resulting 8.5 km of local paths are well-used. Counters reveal a nine-fold increase in the use of one path and, in summer 1999, another had over 5,000 visitors per month.

The landowner has found that the paths have improved the management of the estate. They know where to expect people and can plan accordingly. Self-closing gates have eliminated stock escapes; 1999 was the first year sheep were not let out.

The future
SNH's target is for 60 networks, comprising 3,092 km of path, to be completed by 2003.

Longer distance paths

There are three Long Distance Routes in Scotland (Figure 8.2):

- The West Highland Way opened in 1980
- The Speyside Way opened in 1981 and was extended in 2000
- The Southern Upland Way opened in 1984

In addition, the northernmost six miles of the Pennine Way lie within Scotland. The Great Glen Way is due to open in 2002.

Counter data from the West Highland Way show considerable variation in walker numbers between years. However, the seasonal distribution of long distance walkers on this route is fairly consistent. May is the most popular month, followed by August, July and June. Reasons for May's popularity include:

- The weather tends to be more settled and the midges are less likely to be active
- There are several public holidays in May
- Most guidebooks recommend walking in May

Parts of the Way are also popular with day walkers (Skipper, 2001).

Apart from these officially designated long-distance routes, there are several other routes providing opportunities for longer walks, such as the Clyde Walkway, Fife Coastal Path and St Cuthbert's Way. These regional routes are often well-used by both local people and visitors and help to stimulate the provision of better path networks, particularly in tourist areas where the benefits may be significant.

Figure 8.2 Long distance routes in Scotland

Key sources: Information on Paths for All's achievements was provided by SNH's Recreation and Access section and by the Paths for All Partnership.

Table 8.1 Access and Recreation Trends

Measure	Trends	Decreasing	Static	Increasing	Reliability of trend[1]
Tourism and visits to the countryside	**1994-1998:** the number of visits by Scottish adults to the coast or countryside increased from about 105 million to 137 million.			**30%** ⇧	**c**
	1970-1998: visits to Scotland by overseas tourists increased from 620,000 to 2,100,000.			**240%** ⇧	**C**
	1970-1998: visits to Scotland by tourists from elsewhere in the UK decreased from 12.3 million to 9.8 million trips.	**20%** ⇩			**C**
Outdoor activities	**1987/89 – 1996/98:** the proportion of adults taking part in outdoor activities is likely to have increased from about 41% to 46%.			**12%** ⇧	**c**
	1987/89 – 1996/98: the proportion of adults walking as a leisure activity remained relatively stable at 25%.		⇔		
	1987-89 – 1996-98: adult participation in cycling as a leisure activity appeared to increase from about 6% to 9%.			**50%** ⇧	**c**
	1987-1999: membership of the Scottish Canoe Association increased from 1300 to 2150.			**65%** ⇧	**T**
Recreation along the coast	**1994-1998:** day visits to the coast are likely to have increased by about 50%.			**50%** ⇧	**c**
	1988-1999: bathing water quality generally improved. The number of bathing waters passing the mandatory standards varied between 12 (out of 23) in 1998 and 21 in 1996.			⇧	**C**
	1993-1999: the volume of beach litter, which is a deterrent to tourism, has fluctuated, with no particular trend, since 1993.		⇔		
Recreation in the uplands	**1973-1995:** participation in walking and mountaineering increased from about 800,000 to 1.8 million people.			**125%** ⇧	**c**
	1978-1998: mountain rescues increased from 112 in 1978 to 309 in 1998.			**175%** ⇧	**T**
	1978-1998: the number of walking/ mountaineering clubs increased from 63 to 121.			**100%** ⇧	**T**
	1978-1998: the number of people completing the Munros increased from 28 to 183 per annum.			**550%** ⇧	**T**
Recreation in woodland	**1994-1998:** day visits to woodlands are likely to have increased by about 200%.			**200%** ⇧	**c**
	1991-2000: Community Woodland Supplement enabled the planting of 307 new woods (2813.4ha) for public access.			⇧	
	2000: by the end of March 2000, 771 private woodland owners were participating in the Walkers Welcome scheme.			⇧	
Path networks	**1996-2001:** access officers were employed by 20 Local Authorities and access strategies were initiated by 22.			⇧	
	Through the Paths For All initiative, development of more than 100 path networks is proposed or underway.			⇧	

[1]Reliability of change or trend between the specified years: **T** = an increasing (or decreasing) trend established; **C** = change clearly established between first and last year, but no clear evidence for a trend; **c** = change probable but not fully-established; c = change indicated but not well-established. A blank indicates that assessment of change was not appropriate. Statistical significance was tested where possible (at the 5% level).

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9 Green space in and around settlements

Green space networks are integral to sustaining local biodiversity, and to the quality of life in towns and cities.

Urban green space (Table 9.1) has been defined as "any open space which is, or has the potential to be, of value for wildlife and people, whether natural and semi-natural areas, parks, sports pitches, gardens or any other open space" (McCall & Doar, 1997). It fulfils a multitude of functions, the preservation and enhancement of which are vital to environmental quality, economic prosperity and social well-being (Table 9.2).

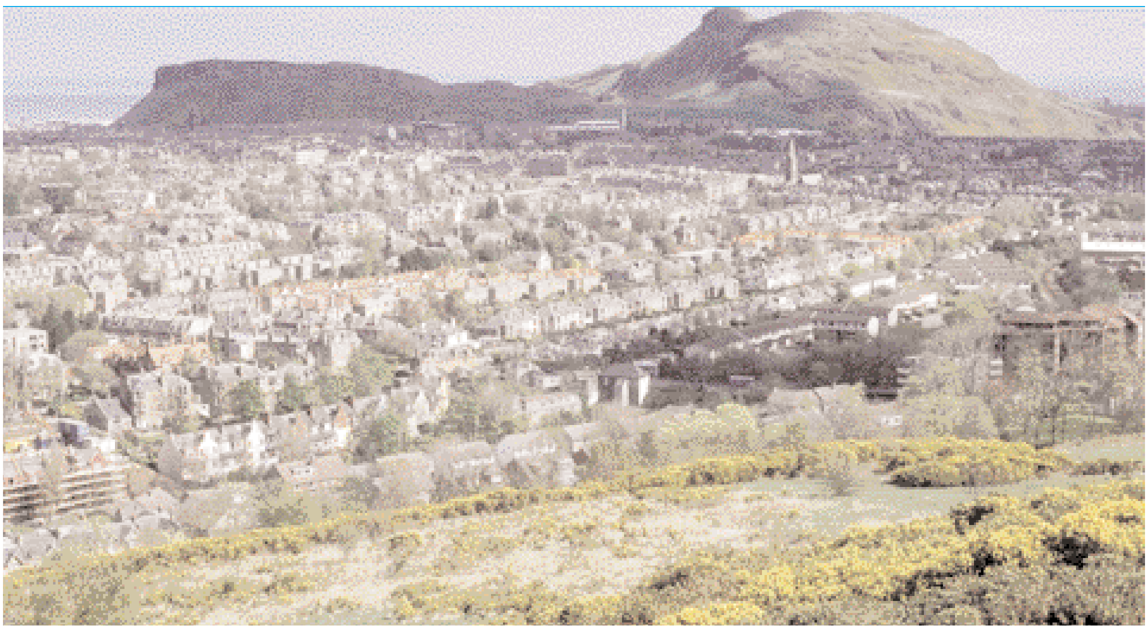
As expanding settlements envelop surrounding countryside, they reduce the extent and connectivity of local wildlife habitats. They also increase levels of disturbance. A network of open and green spaces, including undeveloped remnants such as woods, streams and local floodplains, can be linked through the preservation of linear routes (such as paths, cycle tracks, verges and river corridors). These can provide refuges that allow wildlife to flourish in and around settlements.

The composition, diversity and connectivity of green space are important aspects of local sustainability strategies. Good examples of

Table 9.1 Examples of green space

Semi-natural areas
Lochs, ponds and wetlands
Woodland
Hill, rough grass and moorland
Rivers and streams (in a semi-natural state)
Floodplains and swales for water management
Coastal waterfront, beaches and tidal flats
More modified open space
Surrounding and encapsulated farmland
Historical / cultural sites
Tranquil cemeteries
Private gardens, parkland and estate grounds
Derelict / vacant / reclaimed industrial land
Allotments
Formal recreation (e.g. golf courses)
Parks and formal gardens
Linear routes
Canals, their verges and towpaths
Undisturbed road and railway verges
Informal recreation routes (e.g. paths, cycle tracks)

Edinburgh's attractiveness owes much to the quality of its green spaces.



development planning promote integrated approaches to meeting development and transport needs, whilst having regard to the character of local landscapes, wildlife and opportunities for open-air recreation. They foster healthy lifestyles in pleasant surroundings, and an empathy with the natural world.

The balance and naturalness of green space in relation to built-over land can greatly influence the character of an urban setting. Accounting for nearly two-fifths of the city area, Edinburgh has the greatest proportion of green space for a Scottish city (Figure 9.1). Much of it is semi-natural in character, with encapsulated woodland, moorland and wetland, as well as path and river corridors.

Green corridors can be used to accommodate local path and cycle networks within and between settlements, and to enable access out into the countryside. Such access networks can benefit the 40% of Scottish households that do not own a car, and offer a more sustainable travel option to those that do. Since the 1970s, 'greenbelts' have fulfilled an important role in development control. They have contained urban sprawl, helping to preserve the character of towns by preventing merger, and making surrounding countryside more accessible. The six greenbelts in Scotland have a total area in excess of 1,500 km^2.

Figure 9.1 Green space within the major urban areas.

Source: McCall & Doar (1997)

Trends

Remarkably little is known about urban green space trends. New remote sensing technology, with improved imagery, may in future present opportunities for more systematic exploration of this important aspect of the natural heritage. In the meantime, an overview of what is known is presented in Table 9.3.

- The extent of built-up land and transport corridor expanded by over a third from the late-1940s to the late-1980s.
- The rate of development appears to have been greatly reduced in the 1990s, with much of the expansion occurring in the lowlands.
- Local Nature Reserves (LNRs) offer local recreational and environmental education

Table 9.2 Benefits of green space

Social	Environmental	Economic
Opportunities for sport, recreation and relaxation	Biodiversity protection/enhancement	Enhancing urban landscapes, creating a positive image
Promotes physical and mental health through healthy lifestyles	Reduces air, light and noise pollution	Provides attractive settings for life and work
Tackles social exclusion through access by all	Provides shading and regulates micro-climate	Enhances property values
Strengthens communities through provision of communal space, and promotes community involvement	Helps with flood mitigation and water quality management; provides permeable surfaces which absorb run-off	Encourages inward investment, providing a competitive advantage
Provides tranquil places in the city for mental health	Enhances landscapes, visual amenity, screening and softening of visual impact	Attracts tourism
Instils pride and stewardship in the environment	Provides opportunities for environmental and historical study	Assists with environmental improvement and the reclamation of degraded areas

opportunities. Between 1989 and 2000 the number of designated LNRs increased from six to 34 (Box 9.1).

- In 1999/2000 seven out of 28 bird species were reported more frequently in Scottish suburban gardens, and 10 species less frequently than they had been in 1995/96.
- The total extent of Scotland's vacant and derelict land decreased by 22% between 1993 and 1999. Around 50% had remained so for more than 14 years. Appropriate land management can enhance the benefits of such land within a matrix of green spaces in built-up or rural areas.
- There has been increasing activity in developing natural heritage education opportunities in school grounds. Over 450 projects were supported by the SNH School Grounds Grant Scheme between 1995/96 and 2000.
- Around 80 community-based woodland initiatives existed by 2000. Over 3,130 ha had been established or proposed through the Community Woodland Supplement of the Woodland Grant Scheme.
- The extent of land given over to formal recreation expanded by a factor of 2.38 between the 1940s and the late 1980s.
- The natural heritage of Scotland's golf courses is assessed and enhanced through The Scottish Golf Course Wildlife Initiative, which visited and provided environmental reports to around 200 (39%) clubs between 1996 and 2000.

Development can erode the extent and quality of green space and greenbelt areas. Local Biodiversity Action Plans are now providing much better documentation for maintaining and enhancing green space in and around settlements.

Key sources: The National Countryside Scheme (Mackey *et al.*, 1998), The Vacant and Derelict Land Survey (Scottish Executive, 2000), databases of Local Nature Reserves, SNH school grants and the Scottish Golf Course Wildlife Initiative.

Many types of green space contribute to the quality of life in urban areas. Law Hill, Dundee.

Box 9.1 Local Nature Reserves

Local Nature Reserves (LNRs) are sanctuaries for the protection of nature in and around towns (Figure 9.2). At the same time, they can often accommodate and contain high levels of visitor pressure, without undue disturbance to wildlife. They offer ease of access for relaxation and peaceful enjoyment of nature, where it can be observed at close quarters, in attractive, relatively natural and tranquil settings. Nature sites 'on the doorstep' can offer opportunities for community involvement in practical conservation, interpretation and education. Benefits for wildlife and recreation may be enhanced when these sites are connected within a network of green and open spaces that link town and countryside.

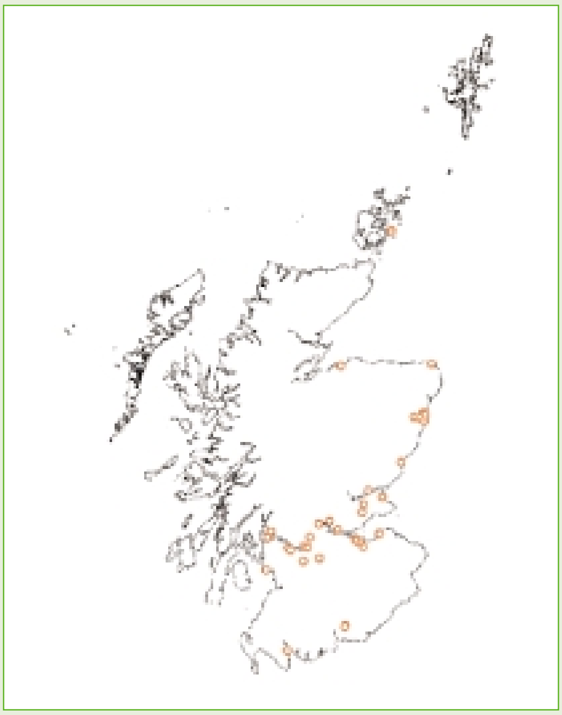
The first Scottish LNR was designated at Aberlady Bay, East Lothian, in 1952. Although by 1989 there were only six LNRs designated in the whole of Scotland, this figure rose to 34 by 2000, compared with about 600 LNRs in the rest of the UK (Figure 9.3).

The 34 Scottish LNRs extend to about 9,400 ha. Three quarters of this area is intertidal coast, reflecting large coastal LNRs at Aberlady Bay, the Inner Tay Estuary, Findhorn Bay and Montrose Basin. LNRs range in size from 0.3 ha (Waters of Philorth, Aberdeenshire) to 2,800 ha (Wigtown Bay, Dumfries and Galloway). Three quarters of LNRs are smaller than 70 ha in size.

The establishment of LNRs is a responsibility of local authorities, with advice and guidance from SNH (SNH, 2000). The National Planning Policy Guideline 14 on the Natural Heritage recognises the role of LNRs in protecting the natural heritage locally. Provision for Local Nature Reserves and green space are promoted under Objective 16 of the UK Biodiversity Action Plan, and taken forward through Local Biodiversity Action Plans (LBAPs). The Edinburgh LBAP, for example, has adopted the national target of one hectare of LNR per 1,000 head of population. The Dumfries and Galloway LBAP promotes action to consider the designation of urban wildlife reserves as LNRs.

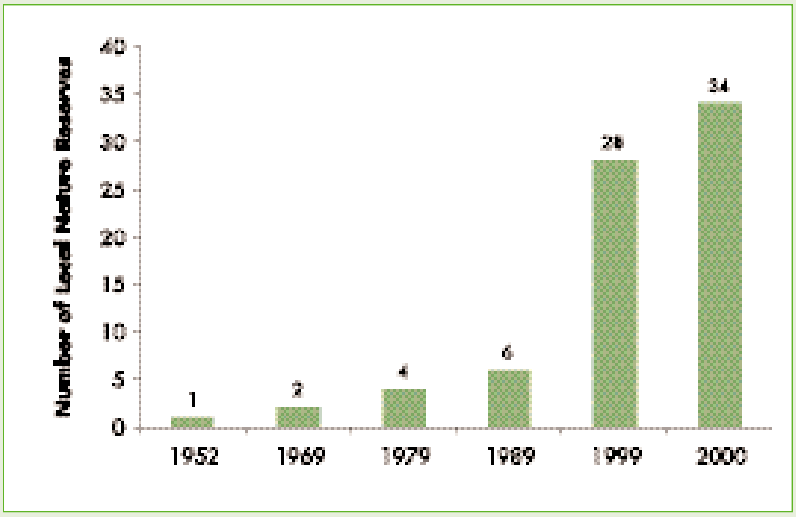
Key source: Scottish local authorities.

Figure 9.2 The distribution of Local Nature Reserves. Source: SNH



Local Nature Reserves provide opportunities to enjoy and learn about the environment.

Figure 9.3 Changes in the number of Local Nature Reserves in Scotland. Source: SNH

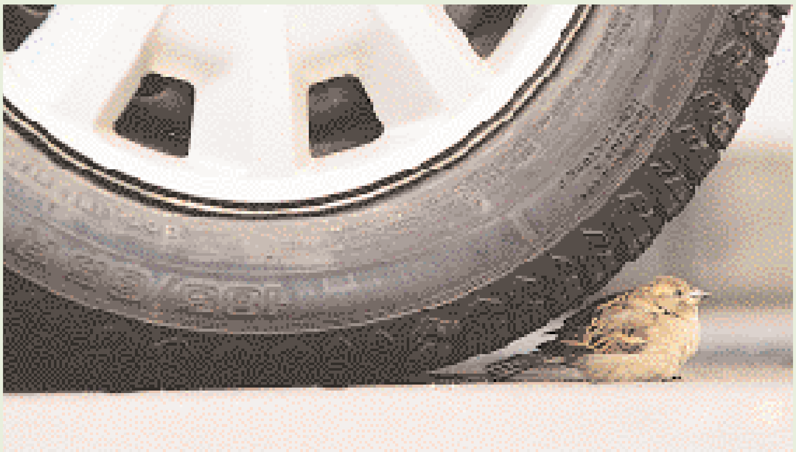


Box 9.2 Garden birds

In urban and suburban areas, parks and gardens form an important refuge for birds and other wildlife, providing a source of food, cover and breeding sites. Some bird species, such as the house sparrow, swift, house martin, feral pigeon and collared dove, are now more strongly associated with urban habitats than with any other.

During 1995-99 participants in the British Trust for Ornithology (BTO) Garden BirdWatch scheme recorded 28 bird species regularly in Scottish gardens. In the following analysis, urban and suburban gardens are treated as one category, referred to as 'suburban' gardens, as most of the records were obtained from the latter.

House sparrow numbers showed no significant change in Scotland during 1994-99, but declined by 7% in the UK as a whole.



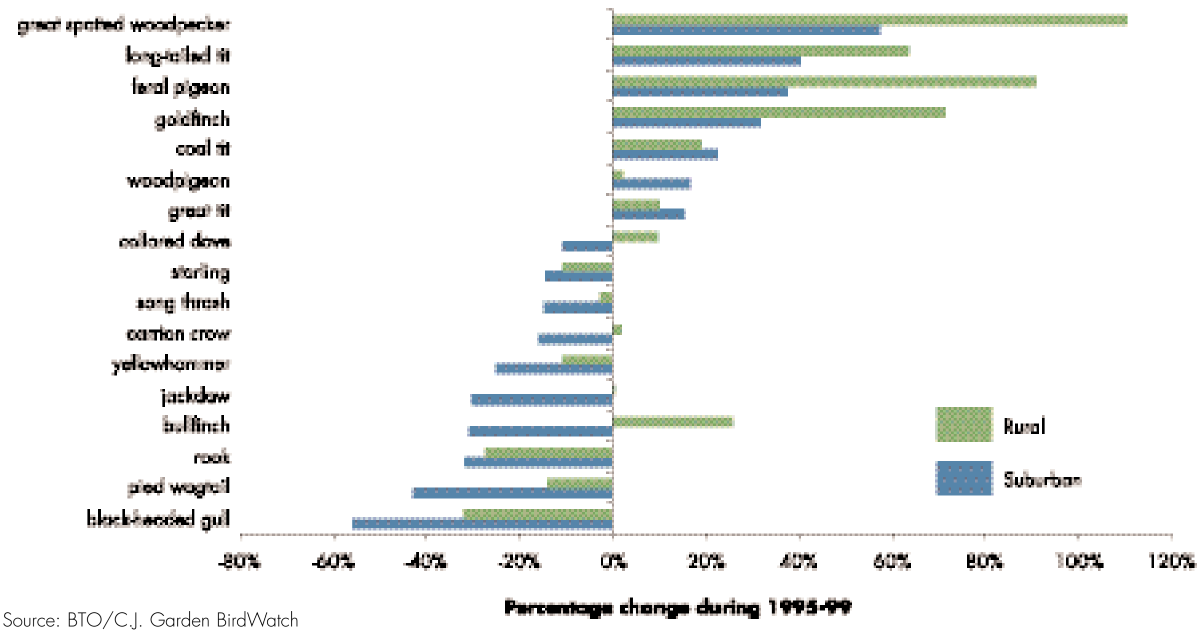
In 1999/00 seven bird species were reported at least 10% more frequently in Scottish suburban gardens than they had been during 1995/96 (Figure 9.4). These included woodland birds, such as the great spotted woodpecker (showing an increase of 57%), long-tailed tit (up by 40%) and coal tit (up by 22%).

Reporting rates for 10 bird species declined by at least 10% in suburban gardens. These included two Biodiversity Action Plan priority species: the song thrush, for which there were 15% fewer records in suburban gardens and 3% fewer in rural gardens; and the bullfinch, which showed a 31% decline in suburban gardens, but a 26% increase in rural gardens. In general, birds in suburban gardens showed proportionally greater decreases and smaller increases than in rural gardens.

During 1994-99, populations of five urban bird species were assessed on 30-or-more Breeding Bird Survey (BBS) sites in Scotland. Two of these showed a statistically significant increase in abundance; the house martin, by 375%, and the feral pigeon, by 44%. Three species (house sparrow, collared dove and swift) showed no significant change.

Key sources: Garden trend data were provided by the BTO, extracted from the BTO/CJ Garden BirdWatch, funded by participants' contributions and supported by CJ Wildbird Foods Ltd. Abundance data were drawn from the BTO/ Joint Nature Conservation Committee/ Royal Society for the Protection of Birds Breeding Birds Survey (BBS: Noble *et al.*, 2000).

Figure 9.4 Species showing at least a 10% change in reporting rates within suburban gardens in Scotland during 1995/96 - 1999/00.



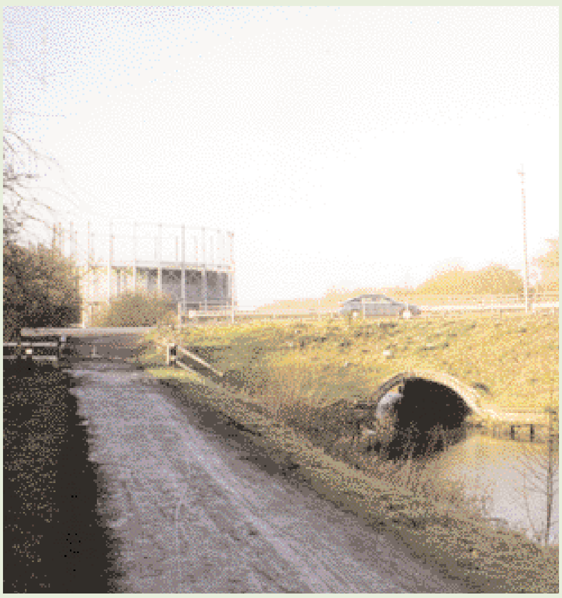
Source: BTO/C.J. Garden BirdWatch

Box 9.3 Urban renewal: the canals of central Scotland

The canals of central Scotland are of cultural, environmental and natural heritage importance. They thrust forward the development of central Scotland during the time of the industrial revolution by connecting the major estuaries of the Clyde in the west and the Forth in the east. Yet canal transport was quickly superseded by rail. Modern road links and development pressures caused them to be severed, in-filled, disused and neglected. All rights to navigation ceased on the Forth & Clyde canal in 1963.

Between March 1999 and December 2001, the internationally acclaimed 'Millennium Link' is re-instating the 200-year-old canals as navigable waterways through Scotland's most densely populated Central Belt. As a partnership which is led and coordinated by British Waterways, it combines state-of-the art civil engineering with innovative community involvement throughout the conservation and restoration works.

Figure 9.5 The Millennium Link: A green corridor through Scotland's Central Belt.



Cleveden Road, Glasgow. Restoration of canal navigation and continuity of the towpath.

Box 9.3 Urban renewal: the canals of central Scotland (continued)

The 56 km long Forth & Clyde Canal, opened in 1790, is Scotland's oldest canal and the world's first sea-to-sea ship canal. Re-connecting it to the Union Canal at Falkirk, a 51 km barge canal opened in 1822, will reinstate waterways that formerly linked the cities of Edinburgh and Glasgow. A section of the Union Canal, severed by the M8 motorway in the 1970s, was reconnected in 1999. Many other road culverts have been replaced by new bridges. The Wester Hailes housing estate, which built upon and around the line of the Union Canal on the southern outskirts of Edinburgh in the 1960s, required a 1.7 km stretch of buried canal to be excavated or constructed anew. A 9 km stretch of the Union Canal at Falkirk, which over a century of operation had received mercury in effluent from a former detonator factory, has been decontaminated.

The world's first rotating boat lift will replace a flight of 11 locks at Falkirk to overcome a 33 m height difference and re-connect the waterways of the Union Canal (a 'contour canal') and the Forth & Clyde Canal. Incorporating some of Scotland's most spectacular engineering accomplishments of the eighteenth and nineteenth centuries, the canals are Scheduled Ancient Monuments. Wildlife protection, nature conservation and habitat enhancement have been at the forefront of their restoration. A canal network Biodiversity Action Plan is being prepared to guide the future management of these assets. New recreational opportunities have been created along the canals and their towpaths, for uninterrupted walking, cycling and boating across central Scotland.

Over 20,000 people lined the banks of the Forth & Clyde canal during its re-opening weekend in May 2001, to cheer on a flotilla of vessels that made the first voyage through central Scotland for over 40 years, from the North Sea towards the Atlantic Ocean.

A 9 km stretch of the Union Canal was found to be contaminated by mercury.

Decontamination, by dredging the contaminated silt, also restored the canal to navigation.

The Forth and Clyde canal runs adjacent to Dullatur Marsh, a remnant of the once extensive Kelvin Valley marshes. The marsh is important for wetland birds, with botanical transitions from open water within the canal to fen and marshy grassland. The species rich flora of the canal includes the nationally scarce **tufted loosestrife**, the **flat-stalked pondweed** and the rare hybrid **yellow water-lilly**.

The rotating boat lift at Falkirk will reconnect the Union and the Forth & Clyde canals.

Key source: Millennium Link web site: www.millenniumlink.org.uk

Table 9.3 Green space trends in and around settlements

Feature	Trends	Decreasing	Static	Increasing	Reliability of trend[1]
Built land	**c.1947 - c.1988**: change over 41 years (NCMS). The following change estimates were statistically significant: • Built land increased by 46%; • Land-take for transport corridor increased by 22%; • Together, they expanded from 1,570 km^2 to 2,130 km^2, or 36%, equivalent to a mean annual rate of 14 km^2			**36%** ⇧	**C**
	c.1990 - c.1998: change over 8 years (CS2000). The following change estimates were not statistically significant: • Built and gardens in rural areas increased by 2.1%; • Transport corridor increased by 1.8%; • Total developed land in 1998 covered 3.1% of Scotland.		⇔		
Local Nature Reserves	**1952-2000**: following designation of the first LNR in 1952, only 6 sites had been designated by 1989. This was followed by a rapid upturn, to a total of 34 LNRs by 2000; an increase of around 470% between 1989 and 2000.			**470%** ⇧	**T**
Garden birds	**1995/96 - 1999/2000**: out of 28 bird species regularly recorded in suburban gardens (under a British Trust for Ornithology scheme), seven species were reported at least 10% more frequently in 1999/2000, ten species were recorded at least 10% less frequently, and eleven species showed little change in reporting rates.	36% ⇩	**39%** ⇔	25% ⇧	**c**
Vacant and derelict land	**1993-1999**: vacant and derelict land decreased by around 22%; from 15,400 ha to 11,982 ha. By 1999, 51% of the land classified as vacant or derelict had remained so for more than 14 years. When left undisturbed, such land can provide natural heritage opportunities and contribute to open and green space within or around settlements.	**22%** ⇩			**T**
Environ-mental projects in school grounds	**1995/96 - 2000**: over 450 environmental projects benefited from the SNH School Grounds Grants Scheme.			⇧	
Community woodlands in or near settlements	**By 2000**: there were around 80 local community woodland initiatives in Scotland, seeking a wide range of benefits for local communities.			⇧	
	1991-2000: the Community Woodland Supplement of the Woodland Grant Scheme, aimed at informal recreation, has supported community woodlands within 5 miles of settlements, and up to a level of 1 ha per 500 of population. By 2000, around 2,800 ha of woodland was established in 307 schemes. A further 40 proposals covered 330 ha.			⇧	
	By 2000: the Central Scotland Forest Strategy aimed to regenerate areas degraded by urbanisation, mining and other industrial activities. About 300 ha (600,000 – 900,000 trees) were planted per annum.			⇧	
Urban: recreational land	**c.1947 - c.1988**: change over 41 years (NCMS). Recreational land around towns increased from about 70 km^2 to 170 km^2, an expansion of 138%.			**138%** ⇧	**C**
Wildlife on golf courses	**By 2000**: there were 514 golf courses in Scotland, with new courses proposed. The Scottish Golf Course Wildlife Initiative was involved in around 200 courses (39%).			⇧	
	1996-2000: over 40 courses had an Environmental Management Plan in place, with over 30 more in progress. Around 70 courses were involved in the Environmental Award Scheme.			⇧	
	1996-2000: in total, around 50 ponds, 4,300 m of hedgerow and 30 ha of tree planting had been established or planned on golf courses.			⇧	

[1] Reliability of change or trend between the specified years: **T** = an increasing (or decreasing) trend established; **C** = change clearly established between first and last year, but no clear evidence for a trend; **c** = change probable but not fully-established; c = change indicated but not well-established. A blank indicates that assessment of change was not appropriate. Statistical significance was tested where possible (at the 5% level).

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Farmland

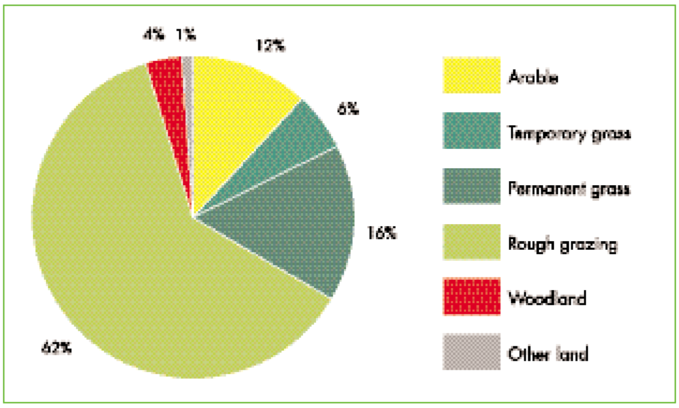
In 2000, agricultural land[1] covered around 71% of Scotland. Some 62% of this was rough grazing, 12% was in crop production, 22% was improved grassland and the rest was mainly woodland (Figure 10.1). Agricultural employment has been in decline since the 1940s. By 2000, it accounted for 70,000 jobs (3% of the Scottish workforce) across 50,000 holdings. The geographical pattern of farming activity is illustrated in Figure 10.2. In broad terms, cropping and mixed farming occur largely in the lowland east, dairy farming to the south-west and more extensive livestock rearing in the uplands and islands.

Such is the extent and nature of farming activity that changes in agricultural practices can have major effects on the natural heritage, for example in terms of landscape, biodiversity, soil and water quality and opportunities for recreation. Farmland settings can be rich in biodiversity, and even cereal fields can be important for some species. Habitats that are particularly important for wildlife include woodland, wetlands, unimproved grassland, hedges, streams, ponds, track corridors and verges. A mosaic of small fields and other features generally supports a greater range of wildlife than large-scale, simplified agricultural landscapes. The nature and timing of farming activities are also important, where, for example, winter stubble or late grass mowing can be important to birds and other species.

Farmland may be divided into four main settings, as follows.

Lowland Arable
Barley and wheat are the main crops, with smaller areas of oats, oilseed rape, pulses and potatoes.

Figure 10.1 Composition of farmland in Scotland in 2000.



Source: SEERAD

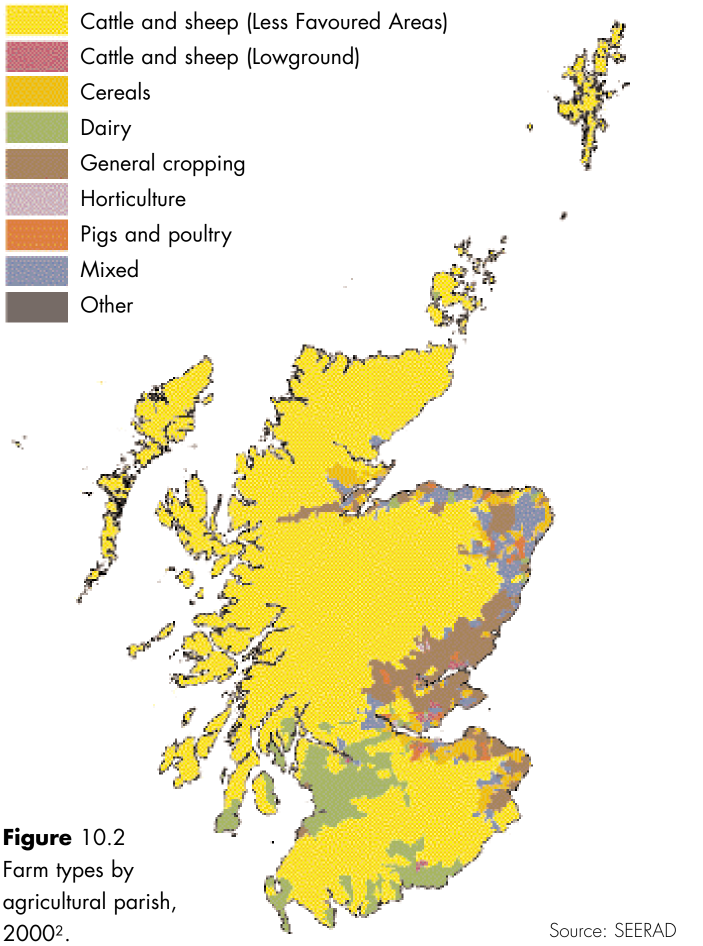


Figure 10.2 Farm types by agricultural parish, 2000[2].

Source: SEERAD

[1]The area within agricultural holdings. Excludes common grazings.

[2]Only the largest farm type, by area, is shown for each parish. Each parish is likely to contain several farm types.

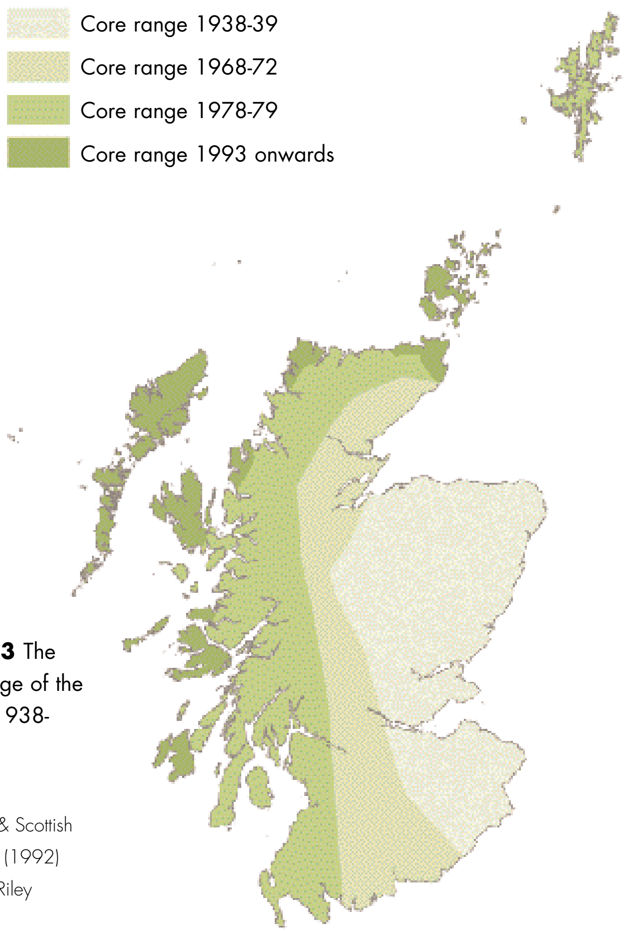


Figure 10.3 The reduced range of the corncrake, 1938-1990s.

Source: RSPB & Scottish Crofters Union (1992) and Green & Riley (1999)

Production is mainly mechanised and high output levels are usually maintained by the application of chemical fertilisers, herbicides and pesticides.

In recent decades specialisation in farming has meant that the west has become more pastoral and the east more arable. A decline in mixed farming (crops and livestock on the same farm) may have had a detrimental effect on species such as the lapwing, which benefits from a variety of habitats in close proximity for nesting and feeding.

Although spring barley was still the largest arable crop in 2000 (about 42% of the cropped area), a substantial increase in winter wheat during the 1980s led to a reduction in the availability of winter stubble for wintering birds. Spring barley is most common in the north and west, whereas winter crops predominate in the arable east.

Increased use of inorganic fertilisers and crop protection chemicals since the 1940s has led to concerns over soil and water quality. Herbicide and pesticide use have been linked to declines in arable weeds and insects, important for farmland birds such as the grey partridge.

Reform of the Common Agricultural Policy (CAP) in 1992 allowed for a shift to more environmental objectives. Expansion of the agri-environment programme encouraged conservation and enhancement of valued habitats and landscapes. Since 1992 it has been a requirement for larger arable farms to set-aside a percentage of land from production. As this percentage has varied (from 5-15%, currently 10%) the area under crops has fluctuated. Depending on its management, set-aside land can provide a refuge and habitat for wild flowers, insects and birds.

Improved Grassland

Mostly grazed and cut as silage for dairy and beef cattle, and for sheep fattening, improved grassland occurs mainly in the western lowlands. These grasslands are often intensively managed with high inputs of fertilisers and slurry. Herbicides are used to ensure that swards consist mainly of rye grass and clover. Only small areas of unimproved lowland grassland remain in Scotland (roughly 200km^2) as pastures have been improved and hay meadows replaced by rye grass for grazing and silage production. A switch to silage often implies greater fertiliser use to enable two cuts per year. Inappropriate cutting practices and other factors can impact on ground nesting birds like the corncrake, which has retreated in range to the north-western coastal fringe and islands (Figure 10.3).

Rough Grassland

Rough grassland occurs mainly in the uplands and is associated with sheep and, to a lesser extent cattle, rearing on largely unenclosed land. Mainly uncultivated and often in a mosaic of semi-natural vegetation with heather moorland, stocking densities are necessarily lower than on improved grassland. Nonetheless, grazing pressure can affect sward and habitat quality (Chapter 12) and soil erosion (Box 10.1).

Crofting

A small scale, low-intensity farming system, crofting is a distinctive component of the agricultural landscape in the north and north-west of Scotland. Crofting land management, as a mosaic of land uses, can be of benefit to a diversity of plants, invertebrates and birds. Machair, an internationally important coastal grassland, is maintained by crofting management. The area within which crofting takes place has remained relatively stable since first demarcated in 1886. A reduction of 4% between 1963 and 1990 was due to land coming out of crofting for non-agricultural purposes such as forestry (The Crofters Commission, 1991).

The number of crofters fell by 23% between 1960 and 1985. Other changes include a 70% decrease in the area of tilled land between 1965 and 1976, a

Arable farming is dominant in the eastern lowlands.

Extensive sheep grazing, and to a lesser extent cattle, can be found throughout most of the uplands.

Livestock rearing, mainly on intensively managed grassland in the wetter western lowlands.

Crofting is a distinctive component of the landscape in the far north and north-west.

6% reduction in the number of beef cattle between 1970 and 1990, and a 14% increase in the number of breeding ewes over the same period (RSPB & Scottish Crofters Union, 1992). The move towards more uniform grazing by sheep is likely to have been detrimental to the conservation of habitat mosaics, and the wildlife they support.

Trends

Aspects of farmland and agriculture for which current trend information is available are summarised in Table 10.1. Focusing on recent trends, the main changes have been:

Land use

- The area of cereals (excluding set-aside) was 4% lower in 2000 compared with 1991, with fluctuations in area partly accounted for by changes in the area required for set-aside and by changes in the profitability of oil-seed rape. The relative amounts of each of the main crops showed little overall change.
- The area of temporary grassland fell by 22% between 1991 and 2000, partly as a result of the declining number of dairy cows. Permanent grassland increased by 20%, possibly linked to declining farm incomes and the cost of reseeding. Rough grazing decreased by 8%, partly as a result of grassland improvement and afforestation.
- The area of farm woodland doubled between 1991 and 2000, promoted by Farm Woodland Premium Scheme grants. Expenditure on the scheme rose steadily from inception in 1992 to £3.4m in 1999/2000. Farm woodland represented 3.6% of the total agricultural area in 2000.
- Livestock numbers have fluctuated according to changes in the balance of sale price, costs and subsidies. The number of breeding ewes declined by 7% between 1991 and 2000 although this followed a period of increased numbers in the 1980s. Dairy cattle[3] numbers declined by 14%, whereas the number of breeding beef cattle[3] increased by 6%.
- The average size of holdings declined from about 117 ha to 111 ha between 1987 and 1999 as the number of very small holdings (less than 20 ha) increased from around 26,600 to 28,300. The number of holdings over 100 ha also increased, from around 9,300 to 9,400.
- The number of mixed farms declined from 4,500 to 2,600 between 1987 and 1999, with the greatest decrease in the west. Over the same period, the number of farms whose main source of income was non-agricultural increased from 12,500 to 19,000.

[3]Excludes heifers for breeding and heifers in calf for the first time.

Inputs and pollution

- By weight of active ingredient, pesticide use on arable crops declined between 1982 and 1998 from about 1,720 tonnes to 1,460 tonnes (excluding potatoes). Counting multiple-spraying, the sprayed area increased from an estimated 2.7 m ha to 5.9 m ha, implying more frequent spraying at lower dose rates (Pesticides in the Environment Working Group, 2000).
- Application rates of fertilisers fluctuated but remained little changed overall between 1983 and 1998. In 1998, an average of about 131 kg/ha of nitrogen was applied on tilled crops and 119 kg/ha on grassland. For phosphorus, the rates were 66 kg/ha and 27 kg/ha respectively. Application rates of potash increased slightly on tilled crops in the 1980s but remained fairly stable since 1990. In 1998, the average application rate was about 73 kg/ha for tilled crops and 36 kg/ha on grass. Sulphur deficiency can affect susceptible crops in areas of reduced atmospheric deposition, and so application rates may be expected to rise.
- Nitrate levels in rivers are highest in the east of Scotland. Between 1980 and 2000, average concentrations increased by 17% in SEPA East Region and by 28% in SEPA North Region. There was no overall change in SEPA West Region. The main source of nitrates was run-off from agricultural land.
- After sewage effluent, agriculture is the main cause of river pollution in Scotland. Mostly it is responsible for the classification of fair water quality, rather than poor or seriously polluted (Table 10.2). Out of 50,000 km of river, the length affected by agricultural point- and diffuse-sources was 1,404 km in 1996 (SEPA, 1999). These figures are currently being updated.

Table 10.2 Length of river affected by agricultural pollution.

	Water quality			
	fair	poor	seriously polluted	Total polluted water
Length (km)	1,076	320	8	1,404
% of total	77	23	1	

Source: SEPA (1999)

Agri-environment schemes

- The uptake of agri-environment schemes increased between 1992 and 2000 (Box 10.2). Participants in the Environmentally Sensitive Area and the Countryside Premium Scheme (both to be superseded by the Rural Stewardship Scheme) increased from 802 to 4,063 between 1992/93 and 2000/01. Participation in the Organic Aid Scheme rose from 16 in 1994/95 to 428 by the end of 1999.

Biodiversity

- Arable weeds are the most threatened group of plants in the British flora. A reduced abundance of arable weeds was one of the main changes in plant distribution between 1930-1960 and 1987-1988 (Rich & Woodruff, 1996). However, there was no clear evidence of change between 1990 and 1998 in the average number of species in Countryside Survey arable vegetation plots (a decline 7.1 to 6.0 was not statistically significant) (McGowan *et al.*, 2001). Of 142 species of arable weed, 45% are thought to be increasing, 30% decreasing and 24% stable in 2001 (K. Davies, pers. comm.).
- Since 1970, substantial changes in the range and abundance of farmland birds have been observed (Box 10.3) . Of 20 farmland bird species, 12 declined in range by more than 10% between 1968-72 and 1988-90 whilst only one increased by more than 10%. Of 13 species for which adequate abundance data are available, three showed a statistically significant decline between 1994 and 1999. The remainder showed no significant trend.

Agriculture as an industry has come under immense pressure from domestic and world markets. In addition, reduced prices that are only partly compensated for by subsidies, changing consumer requirements and concerns over the environment all point to further changes in the years to come.

Key sources: the main source of information on agricultural land use change were the June and December Agricultural Census', with data supplied by SEERAD. Some figures for 2000 are provisional. Pesticide and fertiliser usage data are derived from sample surveys (Snowden & Thomas, 1999 and Burnhill *et al.*, 1999). Data on nitrate concentrations is collected by SEPA through the Harmonised Monitoring Scheme.

Box 10.1 Soil erosion

Scotland is dominated by organic or peaty soils (53% of the national resource) which, along with mineral soils (43% of the national resource), can be susceptible to erosion. Natural rates of soil development in the UK are estimated to be around 0.03-0.1 mm per annum but this can be increased substantially by cultivation and manuring. Governed by natural processes, soil particles move downslope through surface runoff or soil creep. Where normal rates of erosion are exceeded, and become higher than rates of soil development, then soils can become shallow and impoverished, with a loss of organic matter from surface horizons.

Accelerated erosion arising from human activities can have adverse impacts on a soil's physical and chemical status, organic matter content and biodiversity, with physical damage evident from soil truncation and gullying. Further impacts can arise from increased sediment loads in streams, which may bury fish-spawning gravels. Increased nitrate and phosphate loads lead to eutrophication and depressed dissolved oxygen levels in surface waters. Sedimentation reduces the operating life and capacity of reservoirs.

Lowland soils

In the lowlands, rills, gullies and depositional fans at the base of fields are generally erased by cultivation in the spring. Although such erosion might be little more than a minor agricultural nuisance, soil erosion at rates above soil development is not sustainable. Less obvious, subsurface erosion can take place through subsurface channels or artificial drains. Downslope soil movement induced by ploughing can be at least as great as fluvial erosion. On fine sandy and silty soils, wind erosion may also occur in dry weather or in the winter when soils are left bare.

In areas that are susceptible to erosion, appropriate management measures should be taken, such as the maintenance of plant cover over winter months and the avoidance of downslope cultivation. In many parts of Scotland soil conservation measures can also help to preserve archaeological features and crop marks.

Downslope soil movement induced by ploughing can be at least as great as fluvial erosion.

Key source: based on Davidson & Greive (2001)

Quantifying erosion in the field is not easy, but Caesium Cs^{137} has recently been used as an indicator to investigate rates of erosion over the past 40-or-so years (Davidson *et al.*, 1998). In a study of fluvioglacial sands and gravels near Blairgowrie (Figure 10.4), the upper convex slope was determined to be subject to an annual erosion rate of 2.0 mm yr^{-1}, corresponding to around 30 t ha^{-1} yr^{-1}. This falls within the bounds of sediment yield studies from other parts of Scotland, which have estimated that erosion can range from 1 - 80 t ha^{-1} following heavy rainfall events.

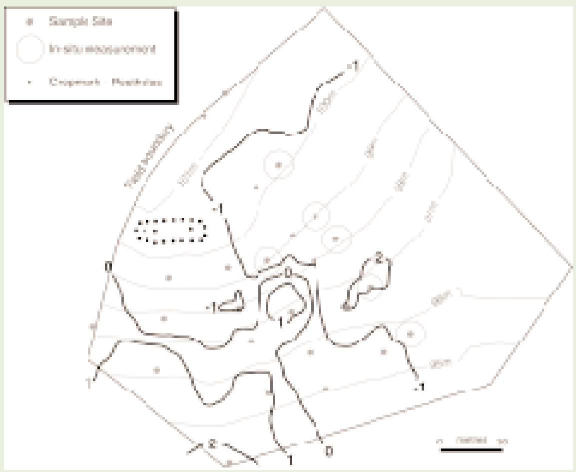
Upland soils

A large proportion of upland soils have a high inherent erosion risk (Lilly *et al.*, 1999), due to steep slopes and greater extremes of climate. An air photo interpretation of 20% of the upland area determined that 12% was visibly affected by soil erosion (Grieve *et al.*, 1995). This was associated mainly with peat erosion and gullying on steeply sloping mineral soils, as well as debris flows and landslides, damage to footpaths in popular mountain areas and damage to tracks. Most instances of severe erosion have been linked to human activities, such as increased visitor pressure on footpaths, forest planting and harvesting, moorland burning and drainage.

Upland soil erosion trends can be appraised from the land management factors that influence erosion rates, such as grazing pressure by sheep and deer, visitor numbers on footpaths, as well as predicted changes in rainfall patterns.

Reducing erosion impacts is now assisted by Forest and Water Guidelines (Carling *et al.*, 2001) and the code of good practice for the Prevention of Environmental Pollution from Agricultural Activity (SOAEFD, 1997).

Figure 10.4 Erosion and deposition rates (mm yr^{-1}) determined from Cs^{137} in a field with Neolithic post holes.



Source: Davidson *et al.*, 1998

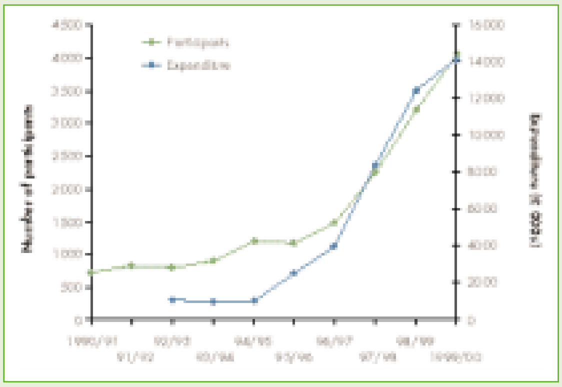
Box 10.2 Agri-environmental schemes

The agri-environment programme is one of the largest sources of funding for conservation management in the countryside. A range of schemes have made payments available to farmers to create and manage habitats, maintain landscape, improve access and convert to organic production. The Rural Stewardship Scheme (RSS) will supersede the Environmentally Sensitive Area (ESA) and Countryside Premium Scheme (CPS). In keeping with the earlier schemes, participants in the RSS will be encouraged to adopt environmentally friendly practices and to maintain and enhance valued habitat and landscape features. Additional to the RSS, the Organic Aid Scheme has provided assistance for conversion to organic production since 1994, and the Farm Woodland Premium Scheme has supplemented Woodland Grant Scheme support for the planting of farm woodland since 1992.

Creation and management of species rich grasslands is one prescription of the Rural Stewardship Scheme.

Uptake of agri-environment schemes has risen markedly in recent years. By 2000, over 4,000 farmers were participating in the schemes which will be superseded by the RSS. Expenditure in 2000/01 is expected to have increased to £20m from £1.1m in 1992/93 (Figure 10.5). This compares with a total of £489m spent on agricultural grants and subsidies in 2000.

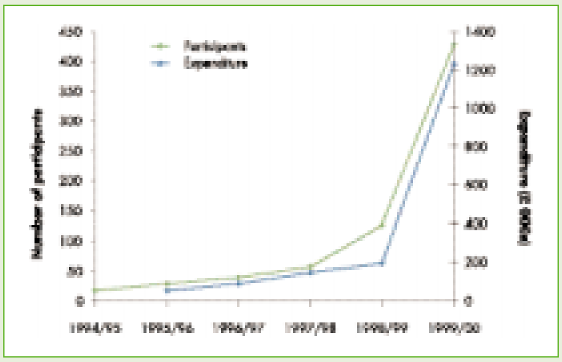
Figure 10.5 Uptake of schemes to be superseded by the Rural Stewardship Scheme.



Source: SEERAD

The Organic Aid Scheme has helped to offset loss of income during a two year conversion period. At the end of 1999 there were 428 participants in the scheme, compared with 126 earlier in the year (Figure 10.6). At the end of 2000, about 134,000 ha of farmland in Scotland was registered as organic, with a further 188,000 ha under conversion.

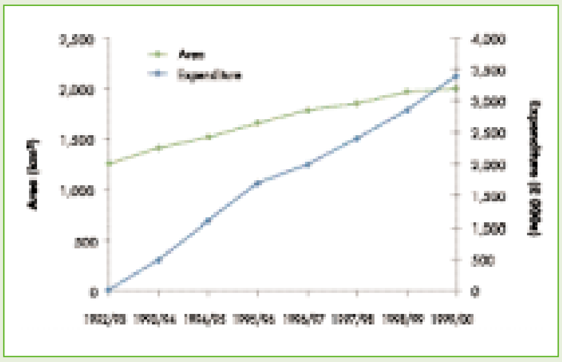
Figure 10.6 Organic Aid Scheme uptake.



Source: SEERAD

The Farm Woodland Premium Scheme (FWPS) aims to improve the landscape, create new habitats and increase biodiversity through payments additional to the Woodland Grants Scheme (WGS). Expenditure has risen steadily since its inception in 1992, to £3.4m in 1999/2000 (Figure 10.7). A total of 2,625 applications had been received for an area of 44,000 ha by April 2000. The WGS and FWGS are currently under review.

Figure 10.7 Uptake of the Farm Woodland Premium Scheme and the area of farm woodland.



Source: SEERAD

Key sources: the data were supplied by SEERAD and the UK Register of Organic Food Standards. For 1999/00 expenditure figures are provisional and the number of participants is for 31/12/99. Otherwise, the number of participants is for 31st March and expenditure figures are for financial years. The area of farm woodlands is taken from the June Agricultural Census.

Box 10.3 Farmland birds

Range size

Between 1968-72 and 1988-91, 12 out of 20 farmland bird species showed marked range size reductions (i.e. of at least 10%) in Scotland. Seven species showed small reductions, and one species expanded its range (Figure 10.8). In ten cases the scale of the decline appeared to be proportionately greater in Scotland than in the rest of the UK.

The greatest decline recorded was that of the corncrake which, in the late 1960s, was still widespread in central and south-west Scotland. The corn bunting has contracted by a similar degree, disappearing from 60% of its former range. Species showing marked range contractions (including the barn owl, grey partridge and tree sparrow) vary substantially in their ecological requirements, pointing to a range of causal factors. Declines were most commonly attributed to the loss of nest sites (affecting six of the twelve species), and a switch from spring to autumn sowing, reducing winter seed availability. Other important causes were: loss of hedgerow; a shift from hay to silage production; conversion of rough grazing to improved grassland; and the effects of pesticides and herbicides on food availability.

The tree sparrow's range in Scotland declined as agricultural practices became more intensive.

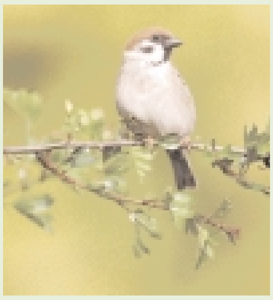
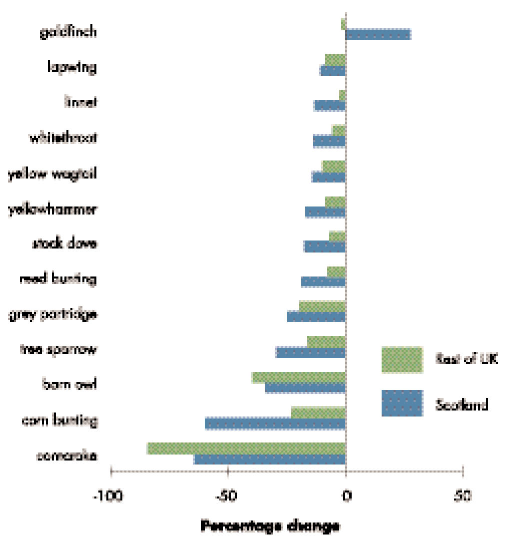


Figure 10.8
Farmland species showing apparent range-size changes of greater than 10% between c.1970 and c.1990.



Source: BTO

Abundance

During 1994-99, populations of 13 farmland bird species were assessed on 30 or more Breeding Bird Survey (BBS) sites in Scotland. Three species showed a statistically significant decline. The remainder showed no significant trends in Scotland.

Skylark numbers declined by 13% in Scotland and by 16% in the UK as a whole. While breeding performance has improved recently, there has been a decline in adult survival and the number of breeding attempts made each year (Crick *et al.*, 1998).

Lapwing numbers declined by 34% in Scotland and by 20% throughout the UK. This followed a 46% decline during 1972-96 on Common Birds Census plots in the UK. Changes in agricultural practices are implicated, and may account for a drop in chick survival rates.

Kestrel numbers in Scotland fell by 61%, and by 30% in the UK as a whole. During 1972-96 a decline of 24% was recorded in the UK, possibly due to the impact of agricultural intensification on small mammal prey populations.

No significant population changes were recorded for the starling, jackdaw, yellowhammer, greenfinch, linnet, wood pigeon, rook, goldfinch, whitethroat, or reed bunting.

Several species showing the greatest declines in recent decades now occur on too few Scottish BBS sites to provide meaningful results. They include Biodiversity Action Plan priority species, such as the grey partridge, tree sparrow and corn bunting. At the UK level, the grey partridge showed a significant decline of 43% during 1994-99, while the corn bunting also declined significantly, by 26%. Note however, that changes over such a limited time-span may reflect short-term fluctuations in environmental conditions rather than long-term trends in species' populations.

Key sources: range data were provided by the British Trust for Ornithology (BTO), drawn from Sharrock (1976) and Gibbons *et al.* (1993). Abundance data were drawn from the BTO/ Joint Nature Conservation Committee/ Royal Society for the Protection of Birds Breeding Birds Survey (BBS: Noble *et al.*, 2000). BBS data are presented only for species recorded on at least 30 Scottish sites.

Table 10.1 Farmland trends

Topic	Trends	Decreasing	Static	Increasing	Reliability of trend[4]
Land use	*Total extent* **1991-2000**: the total area of land used for agriculture in Scotland declined from 5.60m ha to 5.49m ha (1.5%).	**1.5%** ⇩			**C**
	Cereals **1991-2000**: the area used for cereals declined from 469,000 ha to 448,000 ha (4.1%).	**4.1%** ⇩			**C**
	1991-2000: spring sown barley as a percentage of all cereals was little changed at 57%.		⇔		
	Grassland **1991-2000**: the total area of grassland (excluding rough grazing) increased from 1.13m ha to 1.19m ha (4.7%).			**4.7%** ⇧	**C**
	1991-2000: the percentage of grassland under five years old decreased from 36% to 27% (25% decline).	**25%** ⇩			**T**
	1991-2000: Despite annual fluctuation hay production declined and was reduced from 537,000 to 355,000 tonnes (34%). Conversely grass silage production increased from 6.1m to 6.6m tonnes (8%).	**34%** ⇩ **hay**		**8%** ⇧ **silage**	**T**
	Woodland **1991-2000**: the area of farm woodland increased from 101,000 ha to 200,000 ha (98%).			**98%** ⇧	**T**
	Livestock **1991-2000**: the number breeding ewes of decreased from about 4.0m to 3.7m (7.1%) and dairy cattle have declined from 242,000 to 207,000 (14.2%). Conversely, the number of beef cattle increased from 489,000 to 518,000 (5.9%)..	⇩ **ewes, dairy cattle**		⇧ **beef cattle**	**T**
	Farm characteristics **1987-1999**: the total area of mixed (crops and livestock) farms declined by 23%.	**23%** ⇩			**C**
	1991-2000: the proportion of agricultural land in holdings less than 100 ha in size was little changed (14.2% to 14.1%).		⇔		
Inputs and pollution	*Pesticides* **1982-1998**: the weight of herbicide and pesticide active ingredients applied on arable crops (excluding potatoes[5]) declined from about 1,720 tonnes to 1,460 tonnes (15%). The area sprayed increased from about 2.68m ha to 5.86m ha (120%).	**15%** ⇩ **weight**		**120%** ⇧ **area**	**T**
	Fertilisers **1983-1998**: application rates of nitrogen and phosphorus remained fairly stable since the early 1980s.		⇔		
	Nitrate levels **1980-2000**: Despite fluctuations, average nitrate concentrations in rivers in SEPA East and North Regions increased by 17% and 28% respectively. There was no overall change in West Region.		⇔ **west**	⇧ **east and north**	**C**

Table 10.1 Farmland trends (continued)

Topic	Trends	Decreasing	Static	Increasing	Reliability of trend[4]
Agri-environment	*Agri-environment schemes* **1992/93-1999/00**: the number of participants in the Environmentally Sensitive Areas and Countryside Premium Schemes (now superseded by the Rural Stewardship Scheme) rose over 400%, from 802 to 4,063.			⇧	**T**
	Organic farming **1994/95-1999/00**: the number of participants in the Organic Aid Scheme rose from 16 in the scheme's first year to 428 by the end of 1999.			⇧	**T**
Bio-diversity	*Arable weeds* **1930/60 - 1987/88**: a reduced abundance of arable weeds was one of the main changes in plant distribution.	⇩			**C**
	1990-1998: no clear evidence of change from the Countryside Survey (the average number of species recorded in arable plots fell from 7.1 to 6.0 (i.e. by 16%), but the change was not statistically significant).		⇔		
	Farmland birds **c.1970 - c.1990**: 12 farmland species contracted in **range** by more than 10%, one expanded, and seven showed little change.	**60%** ⇩	35% ⇔	5% ⇧	**C**
	1994-1999: three out of 13 widespread farmland species showed a statistically significant decrease in **abundance**. The remainder showed no significant change.	23% ⇩	**77%** ⇔	0% ⇩	**C**

[4] Reliability of changes or trends between the specified years: **T** = increasing (or decreasing) trends clearly established; **C** = changes clearly established between first and last year, but no clear evidence of a trend; **c** = changes probable but not clearly-established; c = changes suggested but not well established. A blank indicates that assessment of change was not appropriate. Statistical significance was tested where possible (at the 5% level).

[5] By weight, usage of pesticides is dominated by the large amount of sulphuric acid applied as a desiccant on potatoes.

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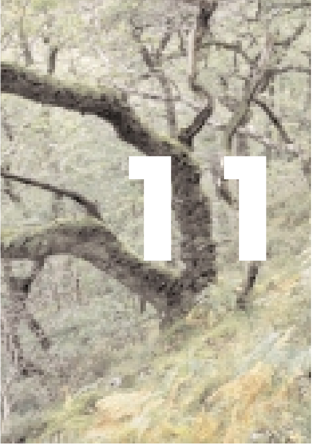


Forest and woodland

Scotland's tree cover, which extended to around 17% of Scotland's land area in 2000, includes conifer plantations (covering about 15% of Scotland) as well as semi-natural woods of broadleaved species and Scots pine (covering about 2% of Scotland).

Most plantations are stands of exotic species, planted during the 20th century. They are often dense, even-aged monocultures, but opportunities are being taken to restructure and diversify them, particularly as they reach harvesting age. A high proportion of recent plantations of native species are classed as 'new native woodlands' and will be managed according to the guidelines for semi-natural woodlands.

Semi-natural woods have originated mainly through natural regeneration. They may be coniferous, broadleaved or mixed in composition, and are composed predominantly of native species. They tend to have a more 'natural' appearance than plantations, with greater variation in tree age and greater diversity of structure and species composition.

The character and ecology of rural and urban landscapes, and opportunities for recreation, are greatly influenced by woodland. Semi-natural woodland is an especially important habitat for native plants and animals. It provides game habitat on sporting estates, enhances the biodiversity of farmland, and creates an attractive image for tourism. Native and semi-natural woods play an important role in watercourse management: they protect against heavy run-off, acidification and erosion, and help to maintain habitat quality for fish and other freshwater life. Where plantations exist, good design and management practices are vital to achieving the same benefits.

Plantation forestry is important, both socially and economically, in many areas of rural Scotland. In 1993-94, commercial forestry and primary wood processing accounted for over 10,000 jobs in Scotland (SNH, 1998). By 2000, about 90km^2 (0.8% of the total area of plantation) was felled annually and the value of Scottish timber production (at the forest gate) was around £100 million per year. As nearly half of Scotland's plantations are less than 30 years old, production is projected to double by 2015 (Figure 11.1) (Forestry Commission, 1999). Ease of extraction and transport, timber quality and the buoyancy of world prices will, however, influence harvesting patterns.

Native woodland has suffered from over-grazing and coniferisation in the past, but is now increasing again through planting and natural regeneration

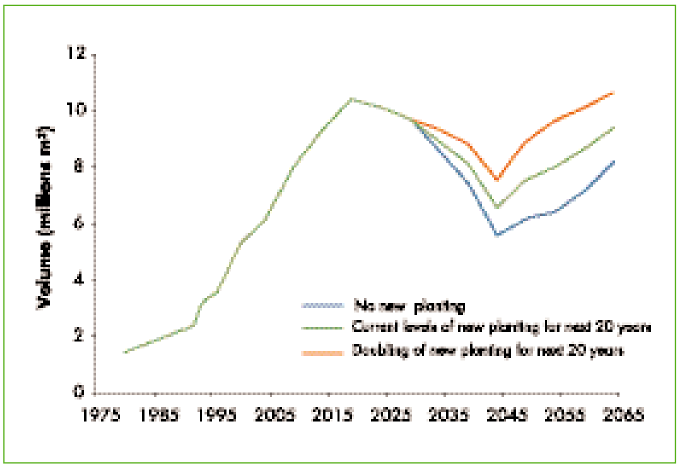


Figure 11.1 Volume of softwood timber, felled and forecast

Source: Forestry Commission

Flowers typical of ancient woodland, such as **twinflower,** often survive in plantations on ancient sites.

	Woodland area (km²)[1]			
	Semi-natural	Plantation	Total	% semi-natural
Ancient (ASNO)	891	591[2]	1,482	60
Long Established (LEPO)	249	1,628	1,877	13
Other historic woods	51	119	170	30
Total	1,191	2,338	3,529	34

Table 11.1 Origin and composition of historic woodland (1999)

Source: SNH

The ecological value of semi-natural woodland, in terms of the diversity of plant communities and species present, is often closely related to woodland age and origin. Three categories of historic woods are recognised.

1) Ancient woods of semi-natural origin (ASNO) appear as semi-natural woods on maps from 1750 or the mid-1800s, and have been continuously wooded to the present day. These woods represent the most valuable asset to conservation, where complex communities of native flora and fauna have developed over centuries.

The oakwoods of western Scotland are rich in ferns, mosses, liverworts and lichens. They are internationally important because of their extent, and their distinctive plant and animal communities.

[1] Figures for ancient and long-established woodland are derived from Ancient Woodland Inventory GIS analysis, compiled from mid-1970s data.
[2] Plantations on Ancient Woodland Sites

Where such woods have subsequently been planted up they are known as Plantations on Ancient Woodland Sites (PAWS). In such cases, surviving ground flora and native trees can provide a basis for restructuring and restoration.

2) Long-established woods of plantation origin (LEPO) appear as plantations on maps from 1750 or the mid-1800s. Native species of local provenance were generally used. These sites have been continuously wooded to the present day, and many have developed semi-natural characteristics.

3) Other historic woods appeared on the 1750 maps, were absent from those of the mid-1800s, but are present today. These sites may not have been continuously wooded but are, nonetheless, of historic interest.

Ancient woodland is a highly fragmented (most of the 14,500 ASNO sites are smaller than 10 ha), but vital part of Scotland's natural and cultural heritage (Table 11.1).

Neglect, overgrazing by sheep and deer, and replacement planting with exotic conifers have contributed to a decline in the area and quality of Scotland's semi-natural woodland. An appreciation of their broader environmental, economic and social benefits is now contributing to their revival.

Trends

Aspects of the woodland heritage for which adequate information is available are summarised in Table 11.2. This shows the following.

- The extent and composition of tree cover changed appreciably during the 20th century (Box 11.1).
- The area of native woodland increased by 34% between 1984 and 1999.
- Natural regeneration of native woodland has increased since 1995, with 3,132 ha being established in this way by 2000.
- Significant changes have been observed in the range and abundance of widespread woodland bird species since 1970 (Box 11.2).

Key sources: The main sources of information on the extent and changes in woodland in Scotland are the Forestry Commission (National Inventory of Woodland and Trees and the previous censuses, Woodland Grant Scheme database and publications) and SNH (Ancient Woodland Inventory).

Box 11.1 Woodland cover

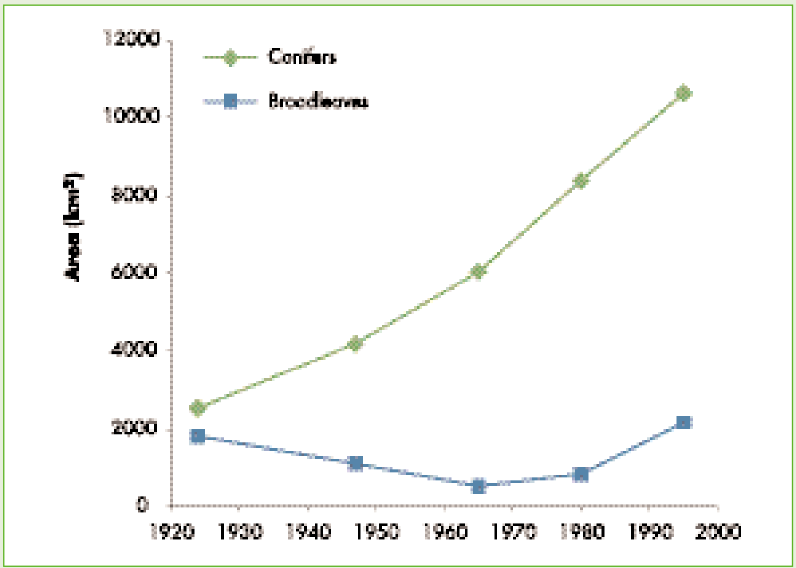
In an unaltered state, woodland would cover most of Scotland, except where the land is too wet, or too exposed. Native pinewoods alone, which are restricted to the Highlands, may have extended over 15,000 km^2 (UK Steering Group, 1995).

Over several millennia, tree cover has been reduced by deliberate clearance and the suppression of regeneration by heavy grazing. More recently, concerted planting programmes have reversed the decline.

Exotic species were being planted prior to the 20th century. They included beech (native to southern England) and sycamore (native to mainland Europe), both widely planted in lowland estates in the 18th and 19th centuries.

Beech has been planted in Scotland for centuries and old specimens make a valuable contribution to the landscape. Edzell, Angus.

Figure 11.2 Changes in tree cover (1924-1994).



Source: Forestry Commission

In 1913, just prior to the outbreak of the First World War, woodland covered only 4.4% of Scotland. The lack of timber threatened the war effort and so, in 1919, the Forestry Commission was formed to create a strategic reserve of timber. By 1924, 5.6% of Scotland was covered by trees. Broadleaves covered 2.3% of the country (1,830 km^2), and conifers covered 3.2% (2,527 km^2) (Figure 11.2).

Despite heavy felling during the Second World War, woodland cover had increased to 6.8% by 1947.

By this time, two-thirds of woodland in the Highlands and less than two-fifths of that in the Lowlands was composed of native species (MacKenzie & Callander, 1995, 1996). In the following decades, many native woods were cleared or under-planted with fast-growing exotic conifers, and plantations expanded rapidly on rough grassland, moorland and peatland.

By 1980, 11.8% of Scotland (9,210 km^2) was covered with trees. Conifers had expanded to 8,381 km^2, but broadleaves had declined to 829 km^2.

By the late 1980s, the natural heritage value of woodland had become more widely recognised. The Forestry Commission's Broadleaves Policy of 1985 recognised that broadleaved woodland should be maintained and enhanced. Tax benefits, which had driven the growth of private sector conifer plantation, were discontinued in 1988 and new grant schemes awarded higher rates of grant for planting native species.

In response to these changes, the establishment of broadleaves increased gradually, and exceeded that of conifers for the first time in 1994. By 1997 the rate of broadleaved planting was almost double that of exotic conifers.

By 1995 woodland covered 16.4% of Scotland (12,820 km^2), 2,180km^2 of broadleaves and 10,641 km^2 of conifers. It is estimated that by 2000 this had increased further to 17.2% of the country (13,415 km^2).

Key sources: Except where stated, all data were provided by the Forestry Commission. Tree cover was drawn from the National Inventory of Woodland and Trees and previous woodland censuses. Planting data were drawn from the Woodland Grant Scheme database.

Box 11.2 Woodland birds

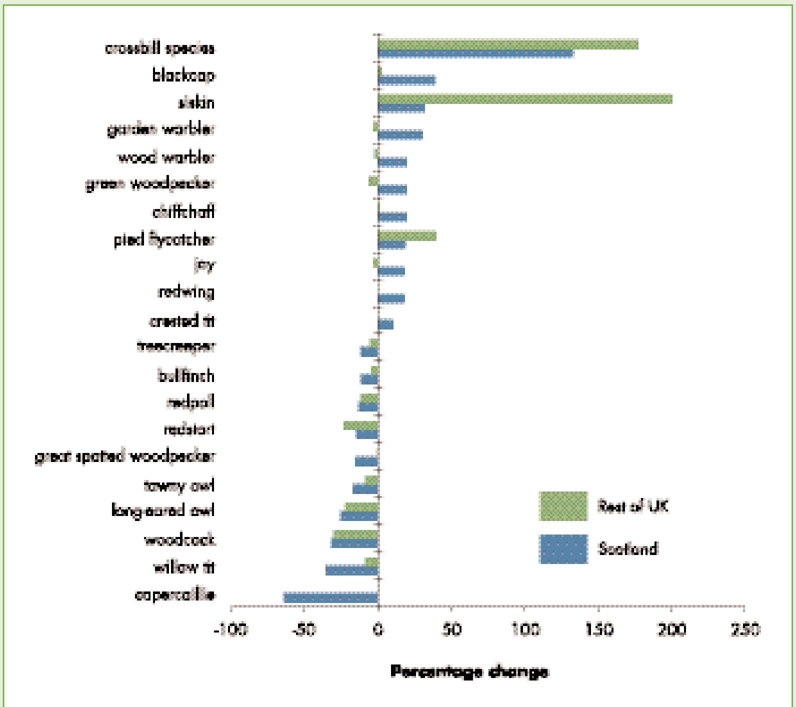
Range size

Between 1968-72 and 1988-91, 11 woodland bird species in Scotland showed marked increases in their range size (i.e. of at least 10%) while 10 showed marked declines (Figure 11.3).

The **siskin's** range in Scotland has increased with the expansion of conifer plantations.

Figure 11.3.
Woodland species showing geographic range-size changes of greater than 10% between c. 1970 and c.1990.

Source: BTO



The greatest range contraction was that of the capercaillie, which was recorded in 64% fewer grid squares in c.1990 than in c.1970. Its recent, rapid decline has been attributed to poor reproductive success and increased adult mortality, partly through collisions with deer fences (Moss *et al.* 2000).

Between the 1950s-70s and the late 1980s the area of coniferous forests over 25 years old doubled, enabling several species to extend their range. The greatest apparent gains were made by the crossbills, whose combined ranges increased by 133%[3]. The siskin has also benefited from afforestation, its range having increased by 32%.

Abundance

During 1994-99, six out of 14 woodland bird species assessed on at least 30 Breeding Bird Survey (BBS) sites in Scotland showed a significant change in abundance. Five of these increased, while one species declined.

The five species showing a significant increase were primarily insectivorous. They included the goldcrest (+87%), wren (+60%), great tit (+31%) and robin (+17%), all of which are resident, and likely to have benefited from recent mild winters. Four other resident woodland birds (blackbird, song thrush, blue tit and dunnock) showed non-significant increases in Scotland, but significant increases within the UK as a whole.

The fifth species showing a significant increase in Scotland was the willow warbler, a summer visitor whose numbers rose by 43%. Tree pipits also showed a significant increase (of 86%), but were recorded on fewer than 30 sites.

The only woodland species showing a significant decline in Scotland was the pheasant, a non-native species whose population is influenced by the number of birds bred and released for shooting.

[3] Survey data for common and Scottish crossbill were combined, due to difficulties in separating these species in the field.

Key sources: Range data were provided by the British Trust for Ornithology (BTO), drawn from Sharrock, (1976) and Gibbons *et al.*, (1993). Abundance data were drawn from the BTO/ Joint Nature Conservation Committee/ Royal Society for the Protection of Birds Breeding Birds Survey (BBS: Noble *et al.*, 2000). BBS data are presented only for species recorded on at least 30 Scottish sites.

Table 11.2 Forest and woodland trends in Scotland

Feature	Trends	Decreasing	Static	Increasing	Reliability of trend[4]
Extent of woodland cover	**1924-2000**: the area of woodland cover increased from 5.6% to 17.2% of Scotland, mostly due to the planting of conifers.			**207%** ⇧	T
Broad-leaves and conifers	**1924-1980**: the area of broadleaved woodland declined by 55%.	**55%** ⇩			C
	1924-1980: the area of conifer plantation increased by 330%.			**330%** ⇧	T
	1988-1999: 569 km² of broadleaves were planted, under the Woodland Grant Scheme and on Forest Enterprise land.			**569 km²** ⇧	
	1988-1999: 1,430 km² of conifers were planted under the Woodland Grant Scheme and on Forest Enterprise land.			**1,430 km²** ⇧	
Native woodland	**1984-1999**: the extent of native woodland increased by 34%.			**34%** ⇧	C
	1994-2005: the area of native pinewood is set to increase from 1994 levels by 305 km².			⇧	
	1999-2015: the cover of priority broadleaved woodland types will be increased from 1999 levels by 72 km².			⇧	
Native pine woods	**1988-1998**: 275 km² were established through Woodland Grant Scheme funding.			⇧	
Natural re-generation	**1995-2000**: native woodland was established over 31.3 km² by natural regeneration (26.8 km² broadleaves and 4.6 km² Scots pine).			⇧	T
Woodland birds	**c.1970 - c.1990**: 10 woodland species contracted in range, and 11 expanded, by more than 10%.	48% ⇩	0% ⇔	**52%** ⇧	
	1994-1999: five out of 14 widespread woodland species showed a statistically significant increase in abundance, while one species declined. The remaining eight showed no significant change.	7% ⇩	**57%** ⇔	36% ⇧	C

[4] Reliability of change or trend between the specified years: **T** = an increasing (or decreasing) trend established; **C** = change clearly established between first and last year, but no clear evidence for a trend; **c** = change probable but not fully-established; **c** = change indicated but not well-established. A blank indicates that assessment of change was not appropriate. Statistical significance was tested where possible (at the 5% level).

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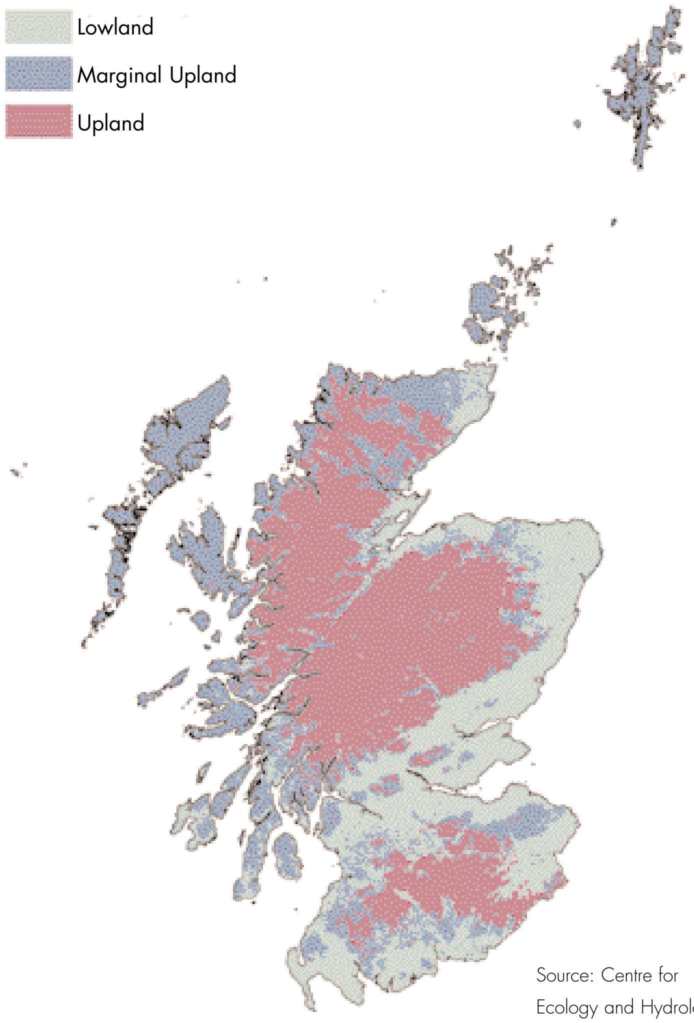
12 The uplands

Moorlands, peatland and rough grassland form a mosaic of semi-natural habitats covering more than 50% of Scotland's land area. Some of the species and plant communities they support are comparatively rare by national or international standards, or are considered threatened on a European scale. These habitats are distributed throughout Scotland, but are mainly found in the uplands and marginal uplands (Figure 12.1). Little of this area can be considered truly natural, however, having been substantially altered through woodland clearance, grazing, fire and forestry (Milne *et al.*, 1998). In particular, sheep, deer and grouse management have transformed much of Scotland's uplands, inhibiting the regeneration of a more diverse, and more wooded environment.

In combination with farming, tourism and recreation are major sources of employment in the uplands, and strongly influence the structure and diversity of upland habitats. Some 36% of plant communities associated with the uplands depend on low-intensity land-use, including muirburn and grazing (Thompson & Horsfield, 1997). Striking a balance between economic, social and environmental needs is therefore key to maintaining the integrity of heather moorland, peatland and montane habitats.

Natural woodland regeneration following deer management at Creag Meagaidh National Nature Reserve.

Figure 12.1 The distribution of uplands, marginal uplands & islands, and lowlands, as defined by the Countryside Survey 2000 (Haines-Young *et al.*, 2000).



Source: Centre for Ecology and Hydrology

About 10% of rough grassland, most of which occurs in the uplands, was converted to other forms of land cover between the 1940s and 1980s.

Key sources: the Countryside Survey 2000 (Haines-Young *et al.*, 2000); the National Countryside Monitoring Scheme (Mackey *et al.*, 1998); Thompson *et al.*, (1995a); breeding bird atlas projects of 1968-72 (Sharrock, 1976) and 1988-91 (Gibbons *et al.*, 1993); the British Trust for Ornithology Breeding Bird Survey (Noble *et al.*, 2000).

Trends

Table 12.1 summarises trends in upland habitats, management practices and wildlife, and shows the following.

- Between the 1940s and 1980s, heather moorland decreased by about 23% (Box 12.1), peatland by about 21% and rough grassland by about 10%.
- An apparent 5% decline in heather moorland cover between 1990 and 1998 was only weakly significant ($P < 0.10$).
- Afforestation increased seven-fold between the 1940s and 1980s, mainly through conifer planting on moorland and peatland, but showed no statistically significant change in land cover terms during 1990-98.
- The length of ditches, mainly associated with peatland drainage, doubled between the 1940s and 1980s.
- The area covered by bracken showed no significant change between 1990 and 1998, following an apparent expansion between the 1940s and the 1980s.
- Sheep numbers in Less Favoured Areas (LFAs) rose by 18% between 1982 and 1998, from 7.25m to 8.55m (Box 12.2).
- Over the same period, cattle numbers fell by 11%, from 1.70m to 1.52m.
- Grazing pressure from red deer, roe deer and rabbits is thought to have increased since the 1950s.
- Between the 1970s and 1990s, the geographic range of red grouse, the number of keepered moors in Scotland and the number of red grouse shot all fell substantially.
- The mean annual temperature in Scotland is expected to rise by about 1.7% by the 2050s, and is likely to cause a reduction and fragmentation of montane habitats.
- Between c.1970 and c.1990, the breeding range of nine upland bird species expanded, seven declined, and 15 showed little or no change.
- During 1995-98 545 alleged offences involving raptor persecution were reported to the RSPB in Scotland. Eighteen cases involving Scottish red kites were reported during 1989-January 2001, compared with seven in February-July 2001 alone (Box 12.3). This increase coincided with a period of reduced public access to shooting estates as a result of the Foot & Mouth epidemic.
- The number of breeding pairs of dotterel declined by 23% between 1987-88 and 1999 (Box 12.4).

Box 12.1 Heather moorland

Areas of prostrate heather with dwarf shrub heaths have been an intermittent feature of north-west European landscapes for thousands of years, but are now extensive only in the British Isles (Thompson & Brown, 1992), covering an estimated 12% of Scotland in 1998 (Haines-Young *et al.*, 2000). About 69% of this lay in the uplands, with a further 22% occurring in the marginal uplands and islands.

Through management dependant on grazing and burning, heather moorland persists in a dynamic state of apparent equilibrium between woodland and acid grassland. The communities of plants that occur in well-managed heather moorland show marked regional variation. Alpine bearberry and dwarf juniper, for example, are commoner in the north-west, which is also noted for its rich and distinctive assemblages of oceanic liverworts (Wrightham & Armstrong, 1999). At higher altitudes, with a slight shift towards increased snow-lie, heather moorland becomes dominated by blaeberry and crowberry, and by an increasing abundance of *Racomitrium* mosses and *Cladonia* lichens.

Small patches of scrub dominated by birch or Scots pine are an integral feature of some moorland areas, a few of which harbour the last surviving examples of climatically limited tree-line scrub in Scotland.

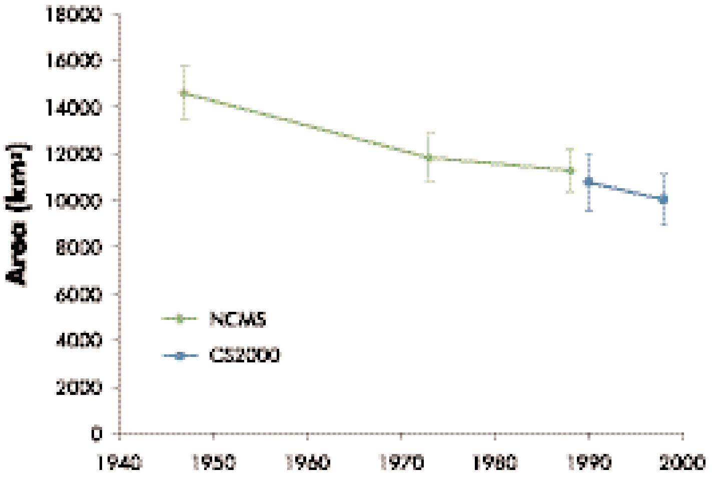
Regional and local variation associated with the underlying geology, aspect, topography and drainage, sustain a wide range of moorland micro-habitats, some of which support diverse assemblages of beetle and spider species. About 40 bird species are associated with heather moorland, of which 21 rely on it as their sole or main breeding habitat (SNH, 1995). These include a distinctive, endemic subspecies of the red grouse and internationally important populations of golden eagle, peregrine and twite.

Recent trends in heather cover have been assessed by the National Countryside Monitoring Scheme (NCMS) and the Countryside Survey 2000 (CS2000). The former has shown that between the late 1940s and 1980s the area of heather in Scotland declined by about 23% (Mackey *et al.* 1998). Much of this was due to afforestation and conversion to grassland.

Although based on a very different type of survey, and not as statistically significant, the decline appeared to continue at a similar rate between 1990 and 1998 (Figure 12.2).

Large areas of heather moorland have been lost through the planting of dense stands of exotic conifers.

Figure 12.2 Heather cover in Scotland, c.1947- c. 1998.



Error bars indicate ±1 standard error.
Note: the NCMS air photo survey and the CS2000 field survey are entirely different in design.

Key sources: The National Countryside Monitoring Scheme (Mackey *et al.*, 1998) and the Countryside Survey 2000 (Haines-Young *et al.*, 2000). The NCMS was an air photo survey of 467 sample squares covering around 7.5% of Scotland. The Countryside Survey was based on field observation, from a different sample of 203 squares covering around 0.25% of Scotland.

Box 12.2 Grazing pressure

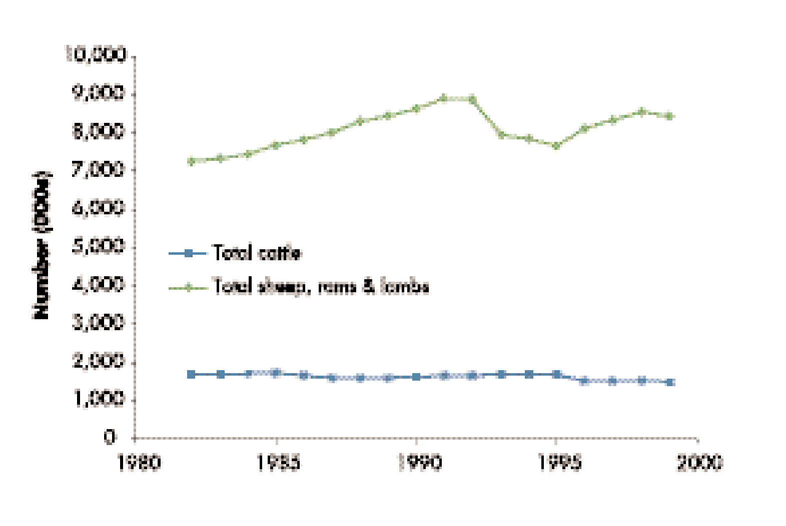
Livestock grazing, mainly by sheep, has suppressed natural succession to scrub and woodland throughout much of upland Scotland, largely accounting for the treeless character of many hill areas. At appropriate levels of intensity, grazing can be beneficial to biodiversity, but overgrazing severely limits habitat diversity and species richness.

Moderate to low grazing levels tend to maximise plant and animal diversity. Invertebrate species diversity, for example, may increase in the short-term following a reduction in grazing, but is likely to benefit from moderate grazing pressure in the long-term (Milne *et al.*, 1998). Heavy grazing inhibits the regeneration of woody cover, leading to a transition from woodland, through heathland to grassland. It may also exacerbate rates of natural soil erosion. In some areas, browsing by deer has prevented woodland regeneration for several hundred years (Staines *et al.*, 1995).

Fragile upland communities are very susceptible to trampling, which displaces plants, increases erosion and may cause a decline in the invertebrates (especially lepidoptera larvae) on which grouse chicks depend. Grazing herbivores may also attract scavenging birds and foxes into some areas (Gordon *et al.*, 1998), raising levels of nest predation.

- Between 1875 and 1966, sheep numbers are thought to have increased by about 50% in Grampian, north of the Great Glen and in Western and Northern Isles (Harding *et al.*, 1994).
- The number of sheep in Southern and East Scotland, the Highlands & Islands and Northern Isles increased by 32% between 1950 and 1990 (Fuller & Gough, 1999).
- Sheep numbers in Less Favoured Areas (LFAs) rose by 18% between 1982 and 1998, from 7.25m to 8.55m (Figure12.3). This increase is thought to have had a particularly adverse effect on areas of better quality grazing.
- Hill cattle numbers increased between 1945 and 1970 (Hill Farming Research Organisation, 1970), but fell by 11%, from 1.70m to 1.52m, between 1982 and 1998.
- Red deer numbers are thought to have almost doubled between 1959 and 1989, to about 300,000 (Staines *et al.*, 1995).
- Anecdotal evidence suggests recent increases in roe deer numbers in upland Scotland (Milne *et al.*, 1998).
- Rabbit numbers have increased since the myxomatosis outbreak in 1954, although trends are difficult to quantify and vary locally.
- Mountain hare numbers fluctuate locally, making national trends difficult to assess.
- Populations of red grouse, black grouse, hen harrier and ring ouzel declined during the 1970s-90s, and this has been attributed, at least in-part, to heavy grazing (Thompson *et al.*, 1995b).

Figure 12.3 Sheep and Cattle Numbers in Less Favoured Areas, 1982 - 1999



Source: June Agricultural Census

Land cover surveys have provided estimates of the amount of plant production available to sheep, cattle and deer. This has been compared with estimated average levels of offtake through grazing in each parish. In much of the Southern Uplands, Stirling, Perthshire and the Northern Isles, average offtake is thought to have exceeded levels likely to maintain vegetation in its current state (Figure 12.4). Results elsewhere do not imply a sustainable state as grazing pressure may vary substantially within each parish, and the current state of upland vegetation in many areas is already poor.

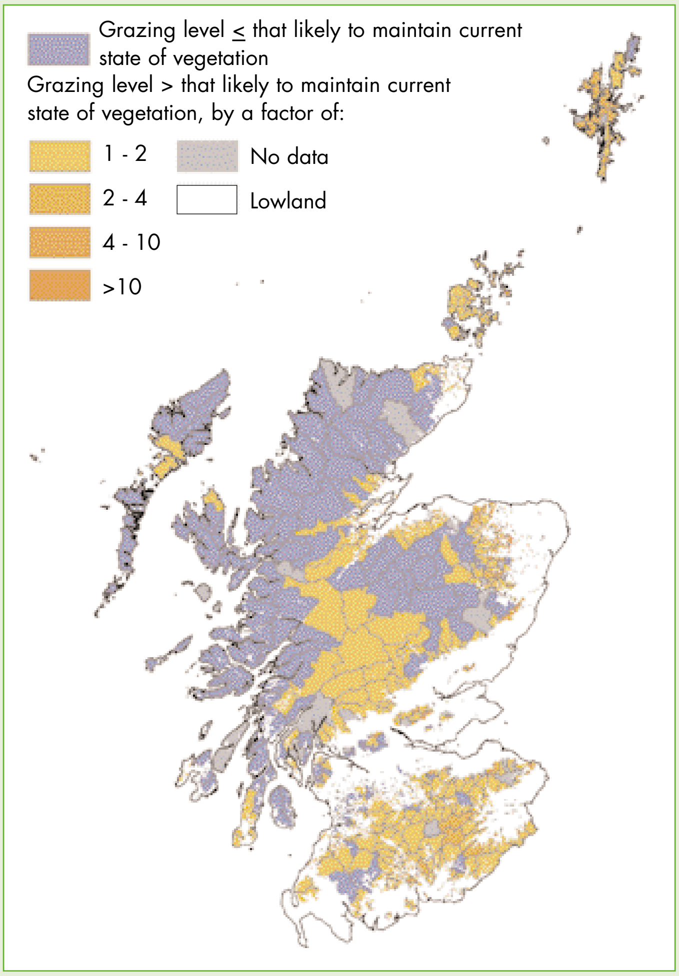
Trends in grazing pressure show marked regional differences. Between 1982 and 1998 grazing pressure appears to have increased markedly (i.e. by at least 10%) throughout 31% of the marginal and true uplands, but decreased equally markedly throughout 26% of the area (Figure 12.5).

Key sources: The National Countryside Monitoring Scheme (Mackey *et al.*, 1998), Thompson *et al.*, (1995a). Estimates of the ratio of offtake to plant production were provided by H.M. Armstrong, based on a hill vegetation grazing model described in Armstrong *et al.*, (1997a,b).

Red deer numbers are thought to have almost doubled between 1959 and 1989, inhibiting natural regeneration in the uplands.

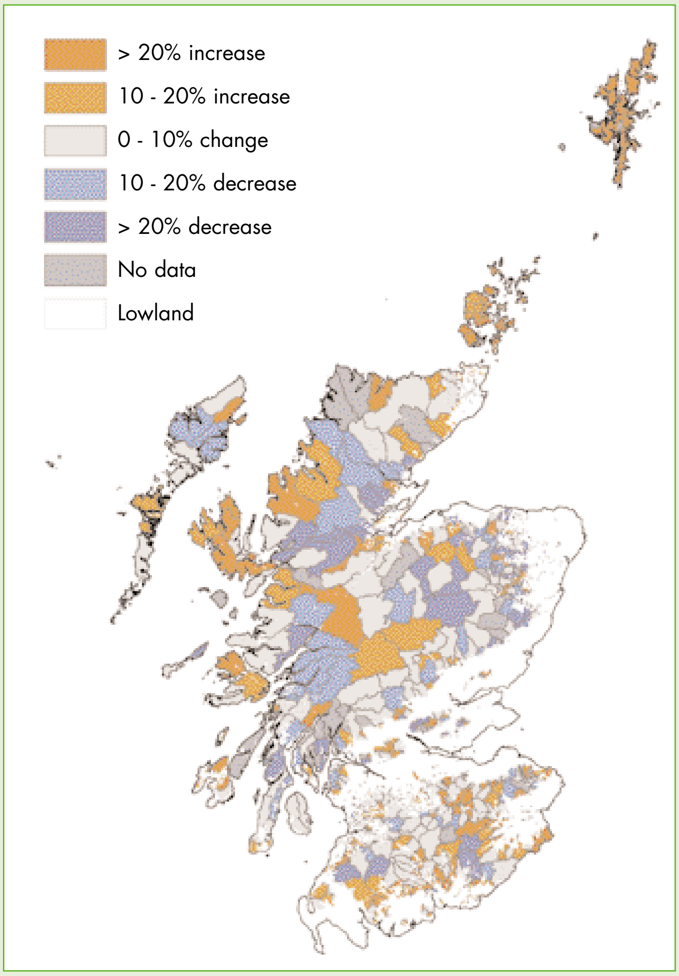
Grazing, particularly by sheep, has suppressed heather cover throughout much of the uplands.

Figure 12.4 The ratio of estimated offtake likely to maintain vegetation in its current state to plant production, within upland and marginal areas in 1998.



Source: SNH, H.M. Armstrong, Forest Research

Figure 12.5 Percentage change in grazing pressure in each parish during 1982-98.



Source: SNH, H.M. Armstrong, Forest Research

Figures in the key indicate the extent to which grazing exceeded the level likely to maintain vegetation in its current state, e.g. parishes with twice this level are given a value of '2'. Grazing pressure has been estimated from the number of domestic livestock (converted to livestock units) in 1998, and from red deer census figures. Vegetation cover was measured in 1988.

Box 12.3 Raptor persecution

Grouse moor management is sometimes accompanied by the illegal persecution of raptors, and may be sufficiently widespread to cause marked declines in the abundance of some predatory species (Thompson *et al.*, 1997). Breeding buzzards and ravens, for example, tend to be absent from upland areas where there are grouse moors (Gibbons *et al.*, 1995), although factors other than persecution may also be limiting their distribution. Nonetheless, incidents of alleged raptor persecution are associated geographically with parts of the country where game shooting is practised, and are disproportionately common in Scotland (RSPB, 1995-98).

During 1987-2000 the RSPB recorded 293 poisoning incidents in which raptors were thought to have been the intended victims. Most of these occurred in upland areas, particularly the eastern highlands, where grouse shooting is prevalent (Figure 12.6).

Cases involving the illegal poisoning or shooting of birds of prey, such as this red kite, are disproportionately common in Scotland.

Other illegal methods used include spring traps, cage traps, shooting and nest destruction. Upland species targeted during 1995-98 included hen harrier, golden eagle, buzzard, short-eared owl, peregrine, merlin and red kite (RSPB, 1995-98).

The incomplete nature of raptor persecution data precludes detailed analyses of trends. However, the number of alleged offences involving raptors reported to the RSPB during 1995-98 (545) indicates that persecution has a marked impact on some raptor populations in Scotland. Of 263 alleged offences against wild birds reported to the RSPB in 1998, 86 involved the persecution of birds of prey, and a further 52 involved the alleged illegal use of poisons, where raptors were likely to have been the main targets. Twelve incidents in 1998 involved a minimum of 42 hen harrier adults, eggs or chicks (RSPB, 1995-98).

Between 1989 and January 2001, the RSPB recorded 18 cases in which red kites were poisoned in Scotland. During February-July 2001 alone, a further seven Scottish red kites were poisoned or, in one case, shot. These cases coincided with a period of reduced public access to shooting estates, as a result of the Foot & Mouth epidemic.

Key sources: The RSPB, from information provided by members of the public, Scottish Raptor Study Groups, the Scottish Agricultural Science Agency and the Scottish Police Force.

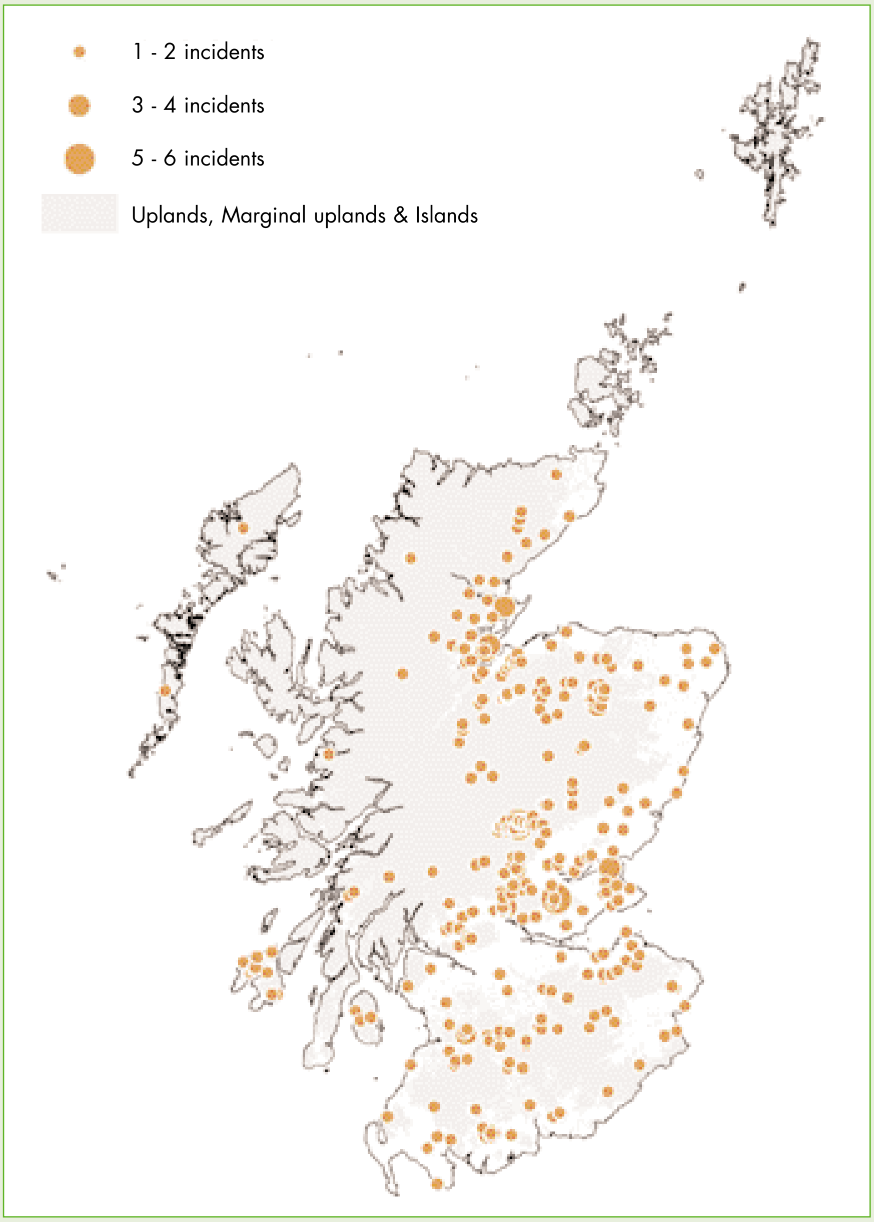


Figure 12.6 The distribution of poisoning incidents in which raptors are thought to have been the intended victim, 1987-2000.

Source: RSPB

Box 12.4 Dotterel numbers

In Britain, breeding dotterels are virtually restricted to the high tops.

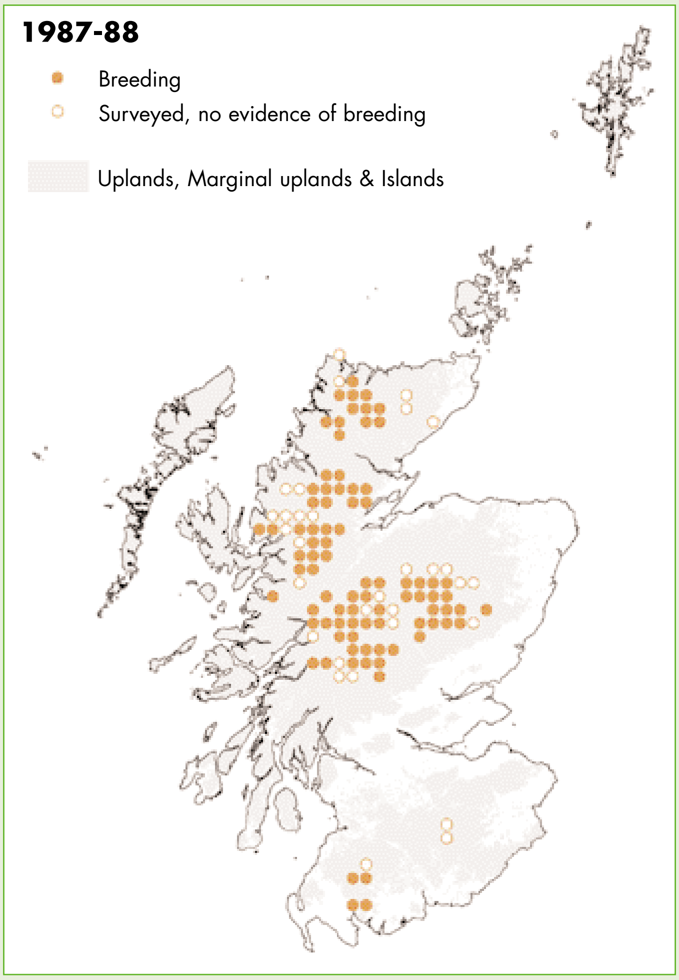
The dotterel breeds predominantly in the tundra and fellfields of Asia and Scandinavia, but has a small outlying population of about 750 pairs in Britain. All but one or two pairs breed in the highlands north of the Central Belt (Whitfield, in press).

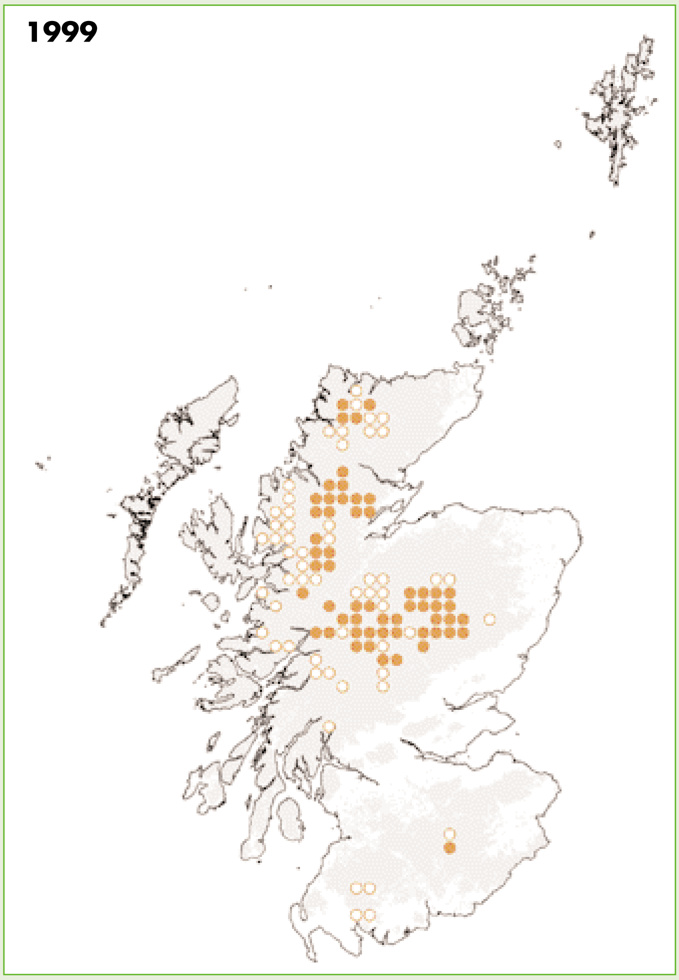
Between c.1970 and c.1990 the species' geographic range size appeared to increase by about 113%. More recent survey work, however, has suggested a subsequent population decline of about 23%; from 870-1,100 pairs in 1987-88, to 590-970 pairs in 1999. Declines were recorded in six out of eight regions surveyed in 1999, and were particularly marked in the north and west, where range contractions were also evident (Figure 12.7).

Since there has been no obvious deterioration in the dotterel's Scottish breeding areas the reasons for its decline are thought to lie elsewhere. Possible causes include a deterioration in its wintering grounds (in Morocco), and a redistribution of birds between Scotland and Scandinavia.

Key sources: Distribution data for 1968-72 and 1988-91 were derived from Sharrock (1976) and Gibbons *et al.*, (1993), respectively. Recent distribution and population trend data were extracted from Whitfield (in press).

Figure 12.7 Changes in the breeding distribution of dotterel, 1987-88 to 1999.





Source: SNH

Table 12.1 Trends in upland habitats and species in Scotland

Topic	Trends	Decreasing	Static	Increasing	Reliability of trend[1]
Habitats	*Heather moorland* **1990-98**: heather moorland cover appeared to decrease by 5.4% throughout Scotland as a whole (P <0.10) (Haines-Young *et al.*, 2000).	**5%** ⇩			c
	1940s-80s: heather moorland cover decreased by about 23% (Mackey *et al.*, 1998).	**23%** ⇩			C
	Peatland **1990-98**: peatland showed no significant change (Haines-Young *et al.*, 2000).		⇔		
	1940s-80s: peatland cover decreased by about 21% (Mackey *et al.*, 1998).	**21%** ⇩			C
	Acid and calcareous grassland **1990-98**: the combined area of these two grassland types showed no significant change (Haines-Young *et al.*, 2000).		⇔		
	1940s-80s: the area of 'rough grassland', which includes acid and calcareous grassland, declined by about 10% (Mackey *et al.*, 1998).	**10%** ⇩			C
Land management	*Afforestation* **1990-98**: the total stock of coniferous forest in Scotland showed no significant change (Haines-Young *et al.*, 2000).		⇔		
	1940s-80s: the area of (mainly coniferous) plantation in Scotland increased seven-fold, mainly at the expense of heather moorland, which contracted by c. 15% through afforestation, and blanket bog, which contracted by c. 11%.			**700%** ⇧	C
	Drainage **1940s-80s**: the length of ditches, largely associated with drainage of peatlands, doubled in Scotland. Over 40% of the estimated reduction in peatland for that period was associated with drainage, which precedes conversion to grassland or heather moorland.			**101%** ⇧	C
	Peat cutting **1969/70 - 1987/88**: the extent of visible peat cutting on Mainland Orkney declined from 24 km² to 18 km².	⇩			C
	1940s-80s: 75 km² of blanket bog was converted to bare ground, associated with peat stripping.				
	Grazing **1982-1998**: sheep numbers (sheep, rams, lambs) in LFAs increased from 7.25m - 8.55m, an increase of 18%.			**18%** ⇧	T
	1950-90: the sheep population throughout much of the uplands and marginal uplands increased by 32%.			**32%** ⇧	T
	1982-1998: cattle numbers in LFAs decreased from 1.70m - 1.52m, a decline of 11%.	**11%** ⇩			T
	1945-70: The hill cattle population increased.			⇧	T
	Late 1900s – present: grazing pressure from wildlife increased. The red deer population is thought to have almost doubled between 1959 and 1989, while roe deer numbers are also thought to have increased. Mountain hare and rabbit numbers are thought to have increased, although trends in both species are often localised, and therefore difficult to assess nationally.			⇧	c

Table 12.1 Trends in upland habitats and species in Scotland (continued)

Topic	Trends	Decreasing	Static	Increasing	Reliability of trend[1]
Land manage-ment (continued)	**1982-1998**: Provisional estimates indicate that grazing pressure increased markedly (i.e. by at least 10%) within 31% of the uplands and upland margin, and declined markedly within 26% of this area. Grazing pressure within the remainder changed by less than 10%.	**26%** ⇩	**43%** ⇔	**31%** ⇧	**C**
	Grouse management **1950s and 1990s**: the number of red grouse shot on Scottish moors declined, particularly from the early 1970s onwards.	⇩			**T**
	c.1970-c.1990. the geographic range of red grouse contracted by 10%.	**10%** ⇩			**C**
	1940s-80s: 10% of heather moorland was converted to grassland.	**10%** ⇩			**C**
	1970-99: the number of keepered grouse moors fell from about 450 to 170 (Connell, 1999).	**62%** ⇩			**C**
	1940s to 1960s and 1988: a study in Borders and Grampian suggested that there had been little change in the area of moorland burned annually.		⇔		
Climatic and atmospheric changes	*Climate change* The mean annual temperature in Scotland is predicted to rise by about 1.7°C by the 2050s. Conditions for some upland species, particularly those restricted to montane areas, are expected to deteriorate, leading to a contraction and fragmentation of their habitats.			**1.7°C** ⇧	
	Airborne pollution **1990s**: four forms of air pollution (sulphur dioxide, aerosols, heavy metals and Persistent Organic Pollutants) declined, and four others (nitrogen oxides, ammonia, ground level ozone and Volatile Organic Compounds) showed little change.	⇩	⇔		
Wildlife	*Invasive species* **1990-98**: the area of bracken in Scotland showed no significant change (Haines-Young *et al.*, 2000).		⇔		
	1940s-80s: the area of bracken appeared to expand by about 79%, although this increase is thought to have been over-estimated (Mackey *et al.*, 1998).			**79%** ⇧	**C**
	1972-85: the sika population is thought to have expanded locally, particularly around Peebles, Argyll, the Great Glen and Glenmazeran.			⇧	c
	Birds **1968-72 - 1988-91**: the range sizes of 15 out of 31 upland breeding bird species in Scotland appeared to change by less than 10%, seven decreased by at least 10% and nine expanded their range by at least 10%.		**48%** ⇔		**C**
	1987-88 - 1999: the number of pairs of dotterel breeding in Britain declined by an estimated 23%. In Britain, the species is almost entirely restricted to montane habitats north of Scotland's central belt.	**23%** ⇩			**c**

[1]Reliability of change or trend between the specified years: **T** = an increasing (or decreasing) trend established; **C** = change clearly established between first and last year, but no clear evidence for a trend; **c** = change probable but not fully established; c = changed indicated but not well established. A blank indicates that assessment of change was not appropriate. Statistical significance was tested where possible (at the 5% level).

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13 Fresh waters

Scotland's fresh waters, 30,000-or-more lochs and lochans and over 10,000 burns and rivers, are strong visual components in the landscape. Covering about 2% of Scotland's land area, they represent some 70% of the total surface area of fresh water (90% of the volume) in the United Kingdom.

The shape and form of Scotland's rivers and lochs (Figure 13.1) have been considerably influenced by climate and geology, and by Scotland's glacial history. Scottish rivers tend to be large for the size of their catchments and have dense channel networks. The greatest abundance of standing waters occurs in the Western Isles. The west and north-east Highlands contain nine of Scotland's 13 largest lochs and the highest numbers of running waters, often small, steep watercourses that respond rapidly to precipitation and snow melt.

The larger rivers, the largest of all being the Tay, tend to flow to the east coast, with lower gradients and more delayed response to precipitation.

The interplay of rainfall, altitude, geology, soil type, landform and land use has resulted in a diversity of fresh waters and associated assemblages of habitats and species (Table 13.1).

Figure 13.1 Scotland's rivers and lochs.

Source: SNH

Table 13.1 Distinctive features of Scotland's rivers and lochs.

Nationally

- Richer diversity of freshwater geomorphological processes, patterns and forms than in any other comparable part of the UK.
- Large number of lochs and rivers in a relatively undisturbed and unpolluted state.
- Extensive development of intricate systems of blanket bog pools.
- Wide range of aquatic plant communities with unique biogeographical elements.
- Abundance of certain plant species which are rare in the UK.
- Nationally rare invertebrate species.
- Large populations of several fish species which are rare in Europe.
- Breeding sites, overwintering grounds and feeding areas for nationally important numbers of wildfowl, waders and osprey.

Internationally

- Large concentration of deep, unpolluted lochs formed as a result of glacial activity, often with communities characteristic of nutrient-poor waters.
- Extensive systems of blanket bog pools, which are globally rare, reflecting distinctive climatic, topographic and hydrological conditions.
- Unusual assemblages of freshwater plants at the interface of North American and European species distributions.
- Several internationally rare invertebrate species, including glacial relicts with boreo-alpine distributions.
- Existence, within the northern temperate zone, of relatively unmodified and unpolluted river systems exhibiting natural physical, chemical and biological changes along their length due to altitudinal and geological transitions.

Source: SNH

The fresh waters of Scotland are renowned internationally for their purity and attractiveness and their sport, recreation, tourism and nature conservation value

Scotland's fresh waters include running waters (rivers, streams), standing waters (lochs and lochans, reservoirs, ponds, gravel pits, canals), groundwaters and tidal fresh waters (where there is incomplete mixing of fresh and sea water in the upper reaches of estuaries).

It has been estimated that there are 56,200 km of running waters in Scotland. Some 950 river systems enter the sea, with 3,957 streams within their networks (Smith & Lyle, 1994). The diversity of plants and animals in natural rivers tends to be high, increasing with river size and variations in conditions within catchments. Diversity is also a function of geology so geographical location within Scotland is important.

Standing waters range from small peat pools and mountain corrie lochs, to more expansive waters in shallow basins and long deep-valley lochs. An estimated 3,788 lochs in Scotland are larger than four ha in area, and a further 27,672 are smaller than four ha. The largest water bodies in Great Britain are found in Scotland: Loch Lomond being the largest in area (71 km^2); Loch Morar the deepest (310 m); Loch Awe the longest (41 km); and Loch Ness the greatest in volume (7,452 m^3) (Lyle & Smith, 1994).

Trends

A number of reservoirs were constructed or enlarged from natural lochs at the end of the 19th and up to the middle of the 20th centuries. Apart from these developments, where change has occurred, it has not been in terms of the extent of freshwater lochs and rivers, but in associated water quality and wildlife (Table 13.2).

- Between 1996 and 1999, about 90% of Scotland's rivers were of excellent or good quality, with a small decrease of 3% in the length of rivers classified as excellent and a 2% increase in the length of those classed as good quality.
- Between 1968/72 and 1988/91 there was a marked contraction (by more than 10%) in the breeding range of nine birds associated with fresh waters, an increase in the range of five species and little or no change in a further 15 species.
- Three mammals are strongly associated with fresh waters. Between 1977/79 and 1991/94, otters expanded in range to recolonise most of Scotland (Box 13.1). The non-native American mink increased in range and population density, with an estimated population in the wild of 52,000 by 1994 (Box 13.2). Between 1989/90 and 1996/98, the estimated populations of water voles in Scotland declined from around 2.5 million to just over 354,000.
- Between the 1950s and 1980s ponds declined by an estimated 7% in Scotland. Recent surveys in 1990 and 1998 suggested that there were no significant changes over this period (Box 13.3).
- Of the six amphibians native to Scotland, the great crested newt declined throughout its range, as determined by a resurvey in 1995/96 of sites with historical records.
- By 2000, 12 of the 26 native fish of Scotland had declined, the vendace had become extinct around 1980 (although it has been recently re-introduced), nine fish were considered stable and four species had increased.
- By 1998, rod-caught salmon had decreased by 6.3% and net-caught salmon by 94% compared with the 1950s (Box 13.4).
- In 1996/99, surveys of freshwater pearl mussel sites with historical records from the 1900s showed that 65% had populations not currently viable (Box 13.5). Only about 7% were considered to be near-natural.

Key sources: include SEPA river water quality surveys, the British Trust for Ornithology for bird data, the Fish Conservation Centre, salmon data from the Fisheries Research Services, national surveys of otter and water vole (and which also provided data for American mink), Swan & Oldham (1993) for information on ponds, and Cosgrove et al., (2000) and SNH for information on freshwater pearl mussel.

Box 13.1 Otter

The otter declined over much of its European range in the latter half of the twentieth century, particularly in the industrialised west. European populations have started to recover over most of their former range, (Green & Green, 1997). Scotland did not experience such a severe decline as many parts of Europe. Otters now receive national and international protection and are a UK Biodiversity Action Plan Priority species.

The status of the otter is relatively well known, having been the subject of three systematic national surveys between 1977 and 1994, (Reuther *et al.*, 2000).

- While otters were widespread in the late 1970s (Figure 13.2), the mainland population was fragmented, being split into a large, healthy northern population and a smaller southern one. There was a zone of habitat unoccupied by otters in the central lowlands, with otters absent from 10% of Scotland's land area (Green & Green, 1980).
- By 1984/85 the number of survey sites with positive evidence of otters increased from 57% to 65%, thus reducing the area without otters to 7% of Scotland, (Green & Green, 1987).
- Otters had recolonised almost all of the country by 1994 (Figure 13.3). Only about 2% of Scotland, situated around the Firth of Forth, was still without otters (Green & Green, 1997).
- The Scottish otter population has grown during the 1970s to the 1990s, through geographical expansion and increased population density.
- In 1995, the Scottish population was estimated to be 3,600 on the mainland and 3,000 in the islands (Harris *et al.*,1995).

Otters will exploit any suitable aquatic or semi-aquatic habitat from coasts to headstreams, but prefer lowland rivers and lochs with a coarse fish fauna or sheltered sea lochs.

Levels of the contaminants, implicated in the otter's former decline, have gradually been reduced in Scottish waters. Water quality in central Scotland has improved in recent decades with the decline of heavy industry and improved sewage treatment. Fish stocks have been restored to many water courses.

Figure 13.2 Otter site occupancy 1977/79.

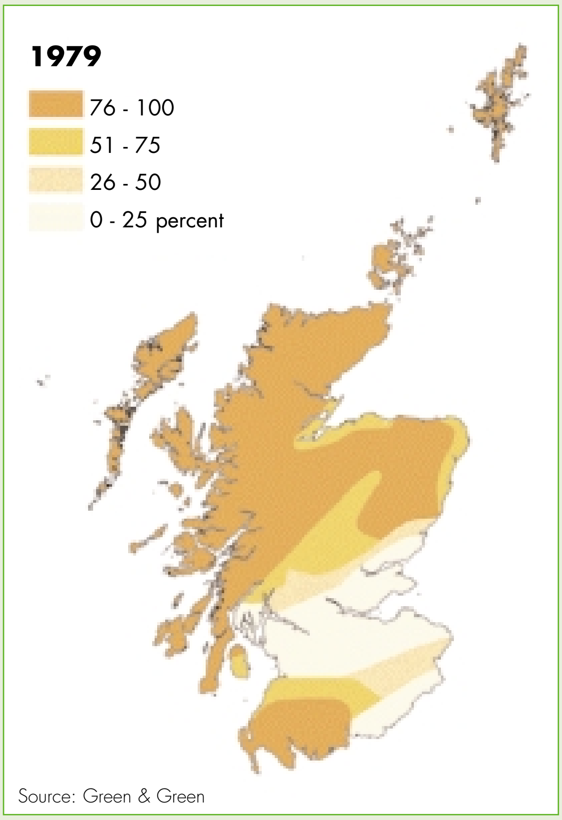
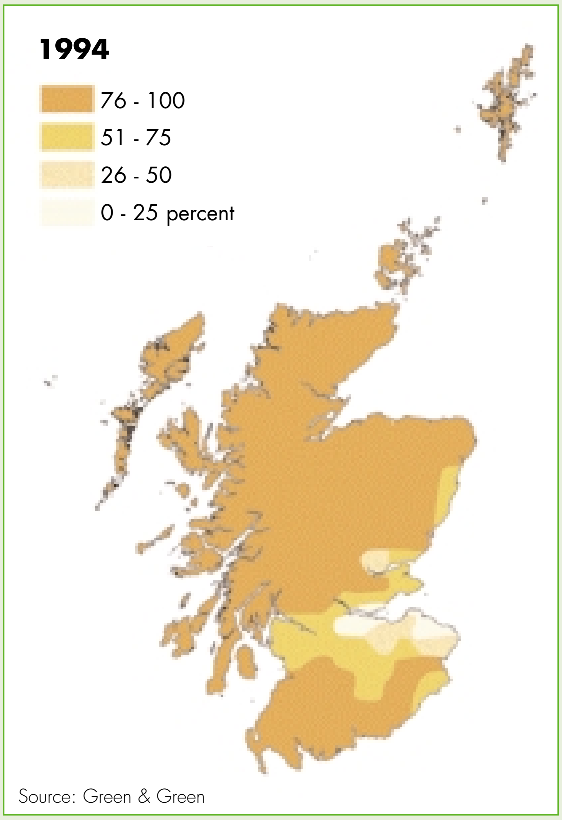


Figure 13.3 Otter site occupancy 1991/94.



Key sources: data on trends was provided by the three national otter surveys and reports by Green & Green (1980, 1987, 1997).

Box 13.2 American mink

The first Scottish fur farm opened in 1938. The first mink escaped the same year. Over the next two decades fur farming expanded to a peak of around one hundred units, then dwindled, from the 1960s to none by the late 1980s (Cuthbert, 1973).

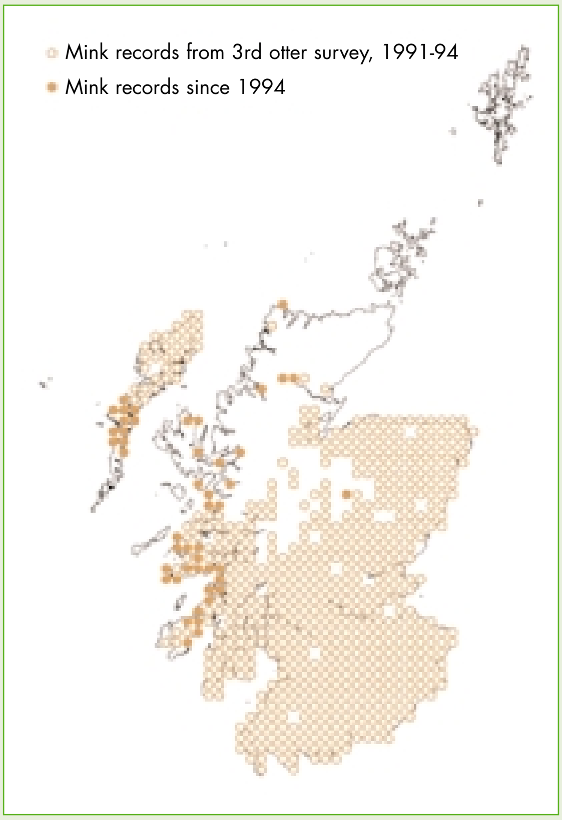
Mink farming was first regulated in 1962. In 1981, it became illegal to release or allow the escape of mink to the wild. The impact of mink on ground nesting birds, especially seabird colonies, waterfowl and water voles led to the prohibition of mink farming on any island where they were not already present, and in Caithness and Sutherland under The Mink (Keeping) Order, 1987. Mink were breeding in Aberdeenshire, Kirkcudbrightshire, Lewis and the Borders by 1962-64. As there has been no systematic survey of mink in Scotland, data are derived from three Scottish surveys of otters, which identified the presence of mink (Figure 13.4).

In 1995, the UK population of mink was estimated to be 110,000 of which at least 52,250 were Scottish (Harris *et al.*, 1995). Colonisation by mink in Scotland has taken longer and has occurred in the context of an increasing otter population. The three otter surveys (Green & Green, 1980, 1987, 1997) and subsequent records indicate an overall increase in mink, although anecdotal evidence suggests that mink may be declining in some parts of Scotland.

Key sources: mink records from 1979 and 1994 were from Green & Green (1980 and 1997 respectively). Recent records were from Clive Craik, Roger Cottis, Xavier Lambin, the Highlands Biological Records Centre at Inverness Museum, the Game Conservancy Trust and SNH. Unpublished local surveys were also used.

Since its first appearance in the wild in Scotland in 1938, the **American mink** has become widespread.

Figure 13.4 Mink distribution in Scotland 1979-2000.



Source: Green & Green

Box 13.3 Ponds

Ponds are a natural waterbody type which have also been extensively recreated by man.

In Scotland, naturally formed ponds still occur in many areas, particularly where water tables are seasonally high (e.g. meander cut-offs, glacial depressions, bog-pools, tree-fall pools and dune slack pools). In more intensively managed areas, however, processes such as drainage and river channelisation have considerably reduced opportunities for natural ponds to form. In these areas, man-made ponds, dug either deliberately (e.g. field ponds, forestry fire ponds) or created as a by-product of human activities (e.g. quarry pools), can provide valuable semi-natural pond habitats.

The most recent data (Haines-Young *et al.*, 2000) suggest that there are approximately 140,000 ponds in Scotland. However, this figure is thought to underestimate the number of seasonal ponds, urban ponds, bog pools and ponds in woodlands. The true number may be 30-50% higher. Pond density from the Countryside Survey in Scotland is estimated to be 1.6 ponds per km^2, slightly greater than in England and Wales. (Barr *et al.*, 1993, 1994 and Haines-Young *et al.*, 2000).

Ponds can be exceptionally species-rich and are particularly important for aquatic invertebrates, plants and amphibians. In Great Britain as a whole, for example, ponds are believed to support about 10% more invertebrate species, and twice as many Red Data Book invertebrate species, as rivers (Williams *et al.*, 1998). Ponds can also be an important component of the habitat of aquatic birds, as well as mammals such as water vole, bats and otter.

- Pond numbers in Scotland declined during the second half of the 20th century but by now may have stabilised (Swan & Oldham, 1993; Swan *et al.*, 1994). In Scotland, there was an estimated 7% loss of ponds between the 1950s and 1980s which was lower than Britain as a whole (17% loss in the same period).

- Between 1950 and 1970 there were estimated pond losses of 57% in Fife and 42% in Lothian Region, with agricultural practices, mismanagement or infilling thought to be the main causes of change. In contrast, the number of ponds increased by 19% in Strathclyde Region (approximately 1,500 km^2 of this region was surveyed with about 1,000 ponds).

- More recently, Countryside Survey data for 1990-1998 suggested that there were no significant changes over this period (Haines-Young *et al.*, (2000).

The DETR Lowland Pond Survey 1996 (Williams *et al.*, 1998) showed that, in general, Britain's lowland ponds are badly degraded, supporting less than half the expected number of wetland plant species when compared with 'minimally impaired' ponds (i.e. those in areas not exposed to damaging impacts such as agricultural runoff or intensive land management). At present, little is known about the ecological status of Scotland's upland ponds and pools.

It is likely that in many areas of Scotland the quality of ponds declined during the 20th century, with urban and rural land use intensification and acid deposition. The commonest threats to ponds in Scotland are likely to be water pollution (e.g. agricultural and urban runoff, acidification) and direct infilling. Artificial stocking with fish may cause increased water column turbidity, loss of aquatic plants and predation on invertebrates. The introduction of alien plants may also become a serious problem in Scotland. New Zealand pigmyweed, which poses a considerable threat to floristic diversity in ponds in England and Wales, is now beginning to spread to Scotland. Pond biota may also be threatened by mismanagement and damage to habitat (e.g. removal of plants, dredging of silt).

Key sources: general information on the historical trends, ecology and management of ponds is summarised in Williams *et al.* (1999). Information on pond numbers is derived from the Countryside Survey 2000 (Haines-Young *et al.*, 2000), Swan & Oldham (1993) and Barr *et al.* (1994). Information on the biological quality of ponds is mainly derived from the Lowland Pond Survey (Williams *et al.*, 1998) and from the databases of the National Pond Survey, maintained by Pond Action.

Box 13.4 Salmon

Salmon catches have declined since the 1970s.

Many Scottish rivers are managed for salmon, and may contain several genetically distinct populations. Salmon fishing is economically important nationally and locally. Anglers' total annual expenditure increased from £50.4 million in 1988 to £70 million in 1997 (SOAFD, 1997). In 1988, gross revenue from netting was £2.7 million a year (Scottish Tourist Board, 1989).

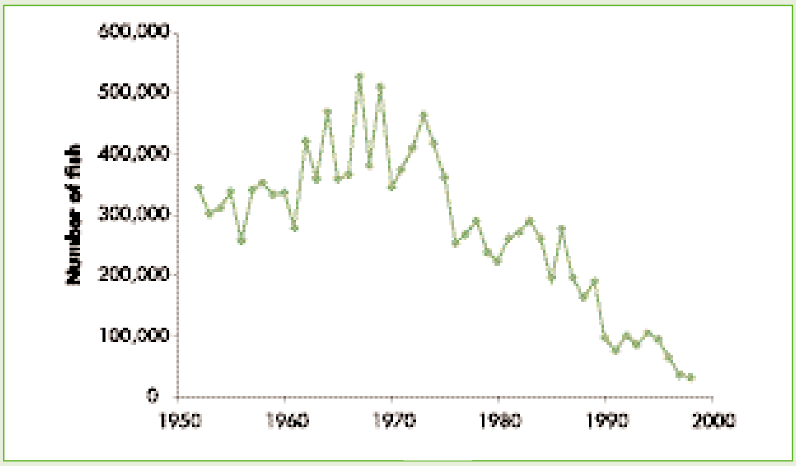
As the origins of fish caught at sea are unknown, sea-fishing affects population monitoring and management. In 1962, Scotland became the first major salmon fishing country to ban drift netting on conservation and management grounds.

Most trends are derived from catch statistics. These are affected by variations in fishing effort and in the time of year fish enter rivers. Fishing effort is affected by weather and water conditions, the market and the efficiency of catching methods.

Total catch

- Salmon catches increased from 1952 until the late 1960s (Figure 13.5). They remained high, although fluctuating, until the mid-1970s.
- Catches declined from the mid-1970s and in 1997 the catch was 18.5% of the 1960s average.

Figure 13.5 Total catch, by number, of Atlantic salmon in Scotland.



Source: Scottish Executive

Overall, the most severe declines have been on the west coast. The spring salmon catch has decreased nation-wide, especially on east coast rivers and in net fisheries. There has been an increase in marine mortality, although there have been enough spawning fish to maintain smolt production, (SOAFD, 1997). Improved water quality has led to population increases in some rivers, and recolonisation of tributaries of the Forth and Clyde where the salmon had become locally extinct.

Net fishing

- Between 1952 and 1998, the number of fish caught by nets decreased by 94%. This was probably due initially to decreased fish numbers and then to reduced netting.

As salmon farming increased, the price of salmon dropped. Catch by net fishing decreased as netting became uneconomic in many areas. Fishing rights tended to be bought up by angling or salmon conservation interests (SOAFD, 1997).

Angling

Rising costs of maintaining fisheries has led to an increase in the number of rods permitted to fish (SOAFD, 1997).

- Angling catch increased by 6.3% from 179,042 kg in 1952 to 190,359 kg in 1998.
- Between the 1950s and late 1970s, anglers took about 15% (by weight) of the total catch. By 1998 rod catch increased to 70% of the total catch.

Salmon populations are thought to have been affected by factors such as changing rainfall and flooding patterns, altered flow regimes due to hydro-dams, acidification, eutrophication and fish farming. Trends differ between rivers, and between different salmon populations in the same river.

Climate change is implicated in changes in ocean currents. As warm currents have moved further north, the area suitable for salmon has been reduced. Industrial fishing has increased in the North Sea in recent years. Salmon may be taken by fisheries directed at other fish. The loss of other species may reduce the food-supply for salmon. Predation of the early life-stages may have relatively little effect on the population unless the number of spawning adults, and hence young fish, is low. High levels of predation of parr or smolts can then lead to decreases in the number of returning adults.

Key sources: Scottish Tourist Board (1989), Scottish Office Agriculture and Fisheries Department (1997) and Scottish Executive (1999).

Box 13.5 Freshwater pearl mussel

The freshwater pearl mussel is threatened throughout its range, and is protected under British and European law. Europe has about 50 functional populations outside the UK, in Ireland, Russia, north-east Scandinavia and central Europe (Cosgrove *et al.*, 2000). Comparisons between countries are difficult, but in terms of international ecological status, only Canada and Russia compare with Scotland.

Mussels are long-lived, often surviving to 100 years or more. Many Scottish populations have few juveniles, threatening their long-term viability. Juveniles are small and inconspicuous, so the cessation of reproduction may not be noticed for many years. Low levels of organic pollution, harmless to adult mussels, are thought to prevent the survival of juveniles (Hastie *et al.*, 2000).

Between 1996 and 2000, surveys were carried out of rivers for which there were historical records of mussels. Populations were:

- 'Functional' (i.e. juveniles present) in 57 rivers of which only 17 had juveniles under five years in age). In 11 of these mussels were common or abundant.
- Of 155 populations known to have existed in 1900, 101 were not currently viable (contained either dead shells or live adults with no juveniles) in 2000. It is thought that one third (35) become non-viable before 1970, and two-thirds (66) since.

The main causes of decline are thought to be pearl fishing (illegal since 1998), pollution (including industrial pollution and eutrophication), river engineering and a link to a decline in salmon (especially in west-coast rivers).

The increase in severe flood events, predicted as a result of climate change, may also be a threat. These can affect mussels directly, by washing them away, or indirectly by degrading the riverine substrate as a habitat.

About half of the world's functional populations of **freshwater pearl mussel** are in Scotland, chiefly on the north-west mainland and some of the islands.

In 1998 the existing protection under the Wildlife and Countryside Act was extended so that the mussel is now fully protected. It is illegal to kill mussels, or to fish for, or sell pearls (Cosgrove *et al.*, 2000).

In 1997 a pilot exercise, 'Operation Necklace', was undertaken to publicise illegal pearl fishing. The scheme was re-launched in 2000.

Key sources: Cosgrove *et al.*, (2000), Hastie *et al.*, (2000) and research by SNH.

Table 13.2 Scotland's freshwater environments

Topic	Trends	Decreasing	Static	Increasing	Reliability of trend[2]
Rivers and streams	**1990-1998**: there was no statistically significant change in the extent of rivers and streams. There were no significant changes in the overall condition of the vegetation found on the banks of rivers and streams. Changes in botanical composition in the lowlands suggested eutrophication and vegetation succession (CS2000).		⇔		
Standing water	**1990-1998**: the stock of standing water and canals increased in the lowlands, but not in Scotland as a whole. The increase may be partly accounted for by wetter conditions in 1998 (CS2000).			⇧	c
	1990-1998: there was a statistically significant increase in fen, marsh and swamp in Scotland (BAP broad habitat), possibly due to a decline in land management in some areas (e.g. lack of maintenance of drains) (CS2000).			**19%** ⇧	**C**
Ponds	**1983-1998**: ponds are an important habitat for wildlife, especially aquatic plants, invertebrates, and amphibians. The National Amphibian Survey (1983-1992) indicated a median percentage loss per survey of 7% since the 1950s in Scotland. Largest decreases were in Fife (57%) and Lothian Region (42%). Major causes were agricultural practices, mismanagement and infilling. Estimates from the Countryside Surveys of 1984 and 1990 indicated that 4 - 9% of the water bodies in the UK had been lost. The 1998 survey reported no significant change in Scotland for the period 1990-1998.	**7%** ⇩			**C**
Birds associated with fresh waters	**1968-72 - 1988-91**: the Scottish breeding ranges of nine freshwater bird species contracted markedly (i.e. by at least 10%). Five species showed a marked expansion in their geographic range, while 15 species showed little or no change in their range.	31% ⇩	**52%** ⇔	17% ⇧	**C**
Native fish	**By 2000**: of 26 freshwater fish species native to Scotland 12 are thought to have declined, one became extinct about 1975 (but has recently been reintroduced), nine are stable, and only four are thought to have increased. Of 11 native species considered threatened, one is extinct, six are decreasing and four are thought to be stable.	**50%** ⇩	35% ⇔	15% ⇧	c
Salmon	**1960s-1997**: total catches have declined from the mid 1970s and in 1997, the catch was 18.5% of the 1960s average.	**81.5%** ⇩			**T**
	1952-1998: the number of fish caught by net fishing decreased by 94%.	**94%** ⇩			**T**
	1952-1998: rod catch increased slightly by about 6.3% . Although the proportion of the total salmon catch (including net), caught by rod increased from 15% between the 1950s and 1970s, to 70% in 1998, this is set against the overall decline in the total catch.			**6%** ⇧	**T**
Non-native fish	**By 2000**: of the 16 non-native fish species in Scotland, none are declining, 12 were increasing and four were considered stable.	0% ⇩	25% ⇔	**75%** ⇧	c
	By 2000: ten of the non-native fish were alien to Scotland, but native to other parts of GB. Many appeared before 1880. All were increasing.			**100%** ⇧	c
Native mammals – otter	**Late 1977/79 - 1991/94**: while otters were widespread in the late 1970s, the mainland population was fragmented. Otters at that time were absent from around 10% of Scotland. By 1984/85 the area without otters had decreased to 7% of Scotland. By 1991/94, about 2% was without otters, which had recolonised almost all of the country.			⇧	**C**

Table 13.2 Scotland's freshwater environments (continued)

Topic	Trends	Decreasing	Static	Increasing	Reliability of trend[2]
Native mammals – water vole	**1989/90 - 1996/98**: water voles were thought to have been ubiquitous around 1900, but to have declined since then. The decline in the 1980s was attributed to predation by American mink. The first national survey in 1989/90 indicated an estimated Scottish population of 2,374,000. Preliminary results from a repeat survey in 1996/98 showed water vole numbers in decline throughout the UK. This was less severe in Scotland, with an estimated summer population of 354,000 voles.	**85%** ⇩			**C**
Non-native mammals – American mink	**1938-1997**: in 1938, the first American mink in Scotland escaped from a mink farm. Mink have become widespread, with increasing site occupancy rates in Scotland south of the Highlands and Arran between 1977 and 1994. By 1997, the Scottish population was estimated at over 52,000 mink in the wild.			⇧	**c**
Amphibians	**1876 - 1995/96**: resurveys in 1995/96 of 97 great crested newt sites recorded since 1876 found 54 extant sites, with losses most marked in south east Scotland.	⇩			**C**
Freshwater pearl mussel	**1900s - 1996/99**: this protected species is threatened throughout its range, with about half of the world's functional populations found in Scotland. Of 155 rivers surveyed between 1996/99, which had historical records from 100 years ago, about 65% had populations that were currently not viable (no juveniles). Only about 7% of populations were classified as near natural. Pearl fishing was evident at 99% of the sites surveyed.	**65%** ⇩			**C**
Water quality – rivers and streams	**1996-1999**: most of Scotland's rivers are of excellent or good quality (90%). Over the four years that water quality was assessed by SEPA, there was a small decrease (3%) in the length of rivers with excellent quality and, as a result, a small increase (2%) in those of good quality. There was no significant change in the extent of rivers classified as fair, poor or seriously polluted (SEPA).		⇔		**C**
Acidification of fresh waters	**1995/97 - 2010**: deposition of acidifying pollutants to fresh waters in 1995/97 resulted in exceedance of the critical load for acidity of fresh waters in 12% of the ecosystem area examined. By 2010, and under current emission reduction commitments, this area will be reduced to 4%, representing an overall decrease of 67% compared to the 1995-97 figure.	**67%** ⇩			
Dippers & acidification of fresh waters	**1968/72 - 1988/90**: there is a close link between dipper densities and stream acidity (pH). Dipper populations may be at risk from acidification due to air pollution. Between 1968/72 and 1988/90 the range of dippers decreased in Scotland by 6.6% and 11.3% in the rest of the UK.	**6.6%** ⇩			**c**
Restoration of rivers	**1998-2000**: there is evidence that river restoration is increasing. Concerns have been raised about increased flooding and climate change. In 2001, the River Restoration Centre, established in 1998, had 38 Scottish projects in its database; ten of these had catchment wide objectives, the rest were more site specific. Habitat management (44%) and fisheries (29%) were the main reasons behind many the projects.			⇧	**C**

[1]Reliability of change or trend between the specified years: **T** = an increasing (or decreasing) trend established; **C** = change clearly established between first and last year, but no clear evidence for a trend; **c** = change probable but not fully-established; c = changed indicated but not well-established. A blank indicates that assessment of change was not appropriate. Statistical significance was tested where possible (at the 5% level).

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14 The marine environment

Scotland's marine natural heritage is as visually spectacular and varied as the Scottish terrestrial environment, but remains largely hidden from sight and comparatively little studied. Because of the cost and technical difficulties of working in the marine environment our knowledge of many of the species, habitats and communities, particularly those found below the low tide line, can still be considered to be at an early stage of development. Aspects of the marine environment for which trend data are available are summarised in Table 14.6.

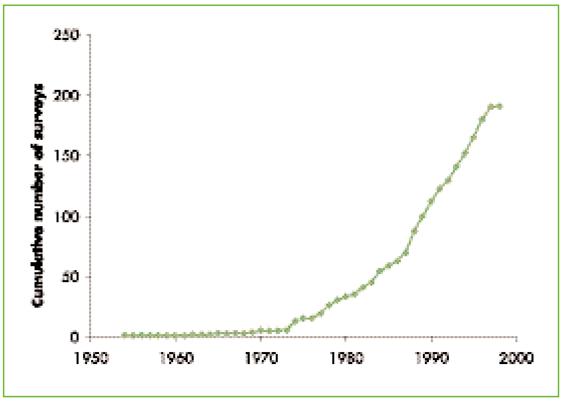
An estimate of the number of Scottish marine species was made by Davison (1996) and Davison & Baxter (1997), arriving at a total figure of over 40,000 if protozoa, bacteria and viruses were included, but of the order of 8,000 species of plant, invertebrate and fish (Box 14.1).

Marine survey around Scotland, as with the rest of the UK, has not been uniformly distributed, often being concentrated around favoured sites, or close to research or educational establishments. A major expansion of survey activity occurred in the late 1970s and early 1980s (Figures 14.1 & 14.2) and was further accelerated by the establishment of the Marine Nature Conservation Review (MNCR) in 1987. The increasing survey effort was sustained into the 1990s partly due to the additional information required for supporting initiatives under the EU Habitats Directive. Additionally, the late 1970s were also a time of increased oil and gas industry activity, with environmental monitoring and sampling, largely from sedimentary environments, accompanying all major exploratory and development projects (Figure 14.3)

The diversity of Scotland's coasts and seas is still less well recorded and understood than that of the terrestrial environment. Tolsa, Isle of Lewis.

Figure 14.1 Cumulative Scottish survey effort represented by entries into the MNCR Database

a) Surveys



b) Individual survey stations

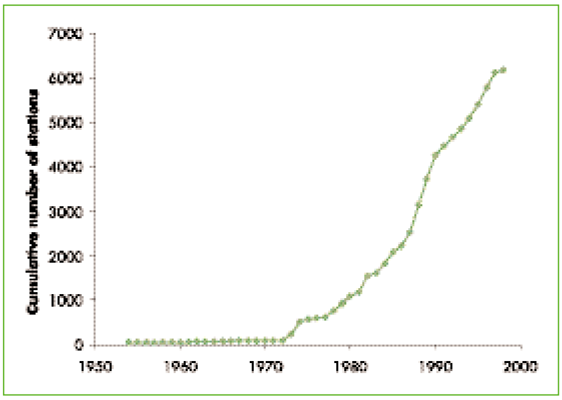
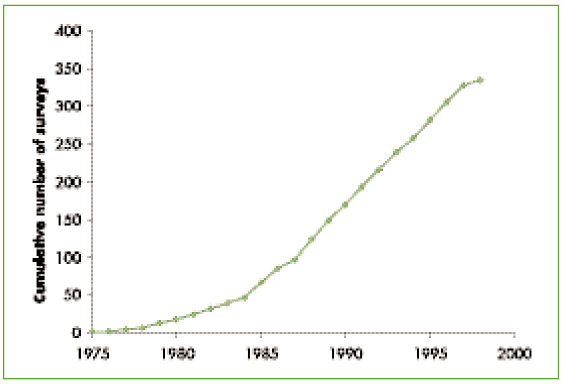


Figure 14.2 Location of Scottish survey stations held in the MNCR Database (1954-1998)

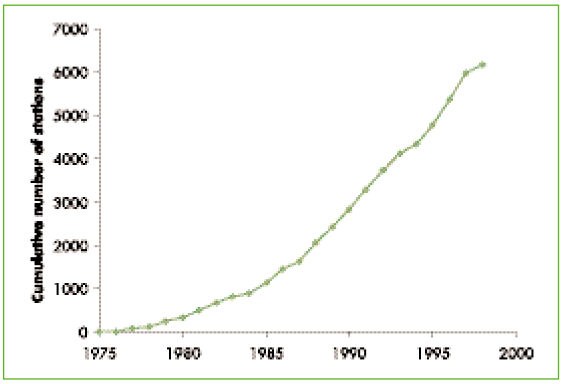
Source: MNCR Database

Figure 14.3 Oil and gas industry survey effort

a) Surveys



b) Individual survey stations



Source: UKbenthos Database

It is largely from these sources that the character, distribution and extent of many of the species and habitats identified as UK conservation priorities have been determined. Some of these habitats, although not unique to Scotland are particularly well-developed around the Scottish coast, such as the beds of maerl and horse mussel (Figure 14.4)

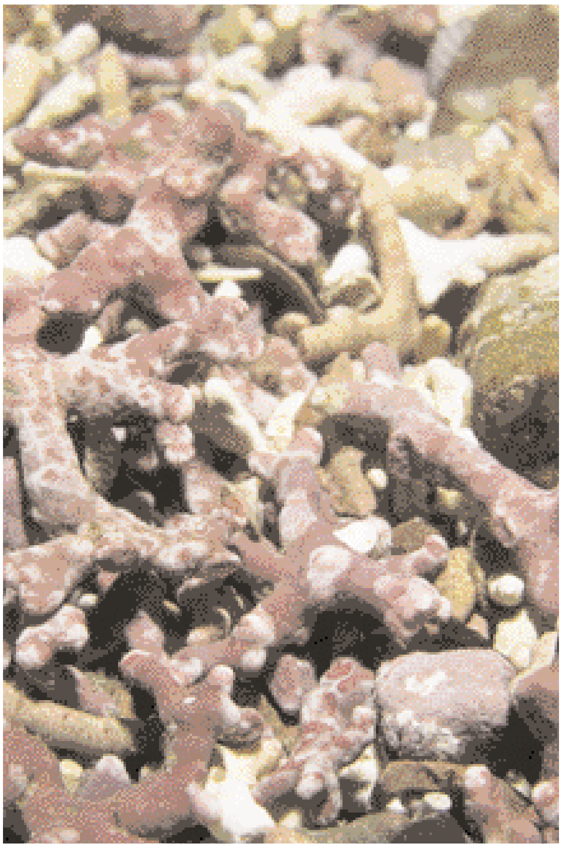
Scotland is also host to a range of larger marine animals such as the basking shark (Box 14.2), seals (Box 14.4) and cetaceans.

Figure 14.4 Distribution of Scottish maerl beds and horse mussel beds at a resolution of 10x10 km

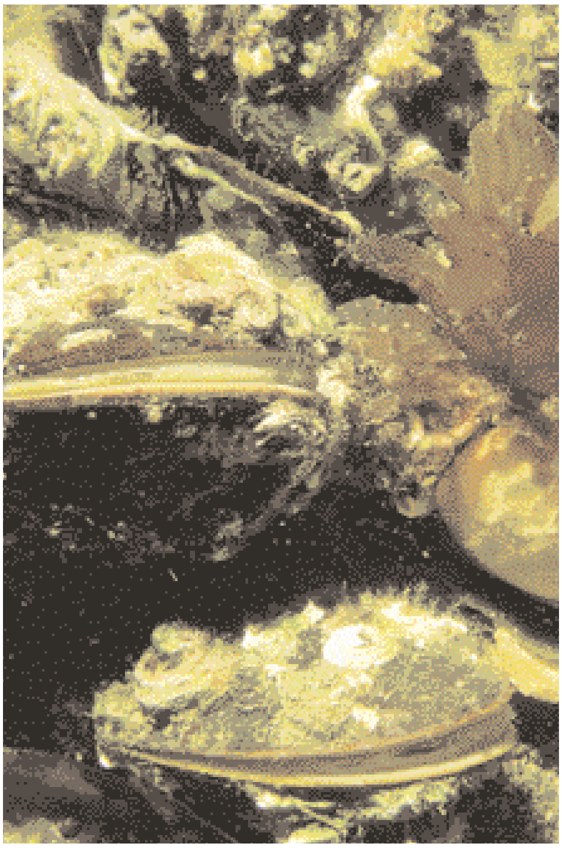
a) Maerl beds

b) Horse mussel beds

Source: MNCR Database



Maerl is a collective term for several species of calcareous red seaweed of which at least two species, *Lithothamnion glaciale* and *Phymatolithon calcareum*, are known to form extensive beds in Scottish waters. Maerl beds may cover substantial areas of the seabed and constitute an important habitat for a wide variety of marine animals and plants. Scallop dredging constitutes the greatest threat to maerl beds in the Clyde.



The **horse mussel** can form beds on a variety of seabed types, but the denser aggregations are usually to be found on muddy sediments. The live mussels, together with shells, sediment and other debris, are bound together by secreted byssus threads, providing an important stabilising effect on the seabed. Horse mussel beds support an extremely rich associated fauna. The use of trawls and dredges causes widespread and long-lasting damage to these beds.

Cetaceans

Twenty-five species of cetacean have been recorded in British and Irish waters within the last 100 years and 23 within the last 20 years (Evans, 1992). Of these, 21 species have been sighted alive and reported more than once around Scotland. Accurate assessments of the distribution and population status of almost all cetacean species occurring in European waters are not currently available. However, an overview of all of the Scottish resident or migrant species, combining information from several sources, is given in Table 14.1.

The **harbour porpoise** is Britain's most abundant and widely distributed cetacean. It is particularly common around the Shetland Islands and the northern coast of Scotland. Marked declines in porpoise numbers were recorded in these areas during the 1980s.

A Scottish-based, Norwegian-owned commercial whaling operation was established in Loch Tarbert, Harris around 1903 and operated from 1904 to 1928, and briefly reopened between 1950 and 1951. Catch records and reported impacts of the wider industry are given in Table 14.2. A moratorium on commercial whaling was imposed in 1986, but Norway lodged a formal objection and resumed exploitation of North Atlantic minke whale in 1993, taking 153 whales in the first year, increasing to 580 in 1997. A Norwegian national quota of 549 has been set for 2001.

Apart from direct exploitation, cetaceans are under threat from the following sources:

- **Fisheries** – The scale and nature of commercial fishing operations is such that entanglement in fishing gear and subsequent damage or drowning is a significant threat to cetaceans. Studies of incidental catches are few, but indicate that porpoises and dolphins are at greatest risk. Estimates for a range of north-eastern Atlantic pelagic trawl fisheries arrived at a catch rate of one dolphin for every 98 hours of towing (Morizur *et al.*, 1999). The total annual bycatch for the North Sea Danish gill net fishery in 1993 was estimated at approximately 7,000 harbour porpoises (Lowry & Teilmann, 1994; Vinther, 1995) out of a total population of around 300,000 (Hammond *et al.*, 1995)

- **Pollution** – Anthropogenic inputs to the marine environment have greatly increased in the last 100 years. Organochlorines such as DDT, PCBs (and their metabolites and impurities) and other man-made chemicals are more soluble in fat than in water and so will accumulate to high levels in animals that rely on blubber as an energy store. At critical concentrations an interaction with an animals hormonal system may occur resulting in reduced reproductive performance and disease resistance. The manufacture of many of these chemicals has been strictly controlled in Europe for over twenty years, but careless disposal, leakage from storage sites and a persistence in marine sediments has resulted in a continued accumulation in marine mammals. Comparatively higher levels are found in coastal species that are at, or close to, the top of the food chain. Levels found in cetaceans from the west of Scotland are lower than those found in the North Sea (Shrimpton & Parsons, 1999). Trace metal levels in resident Scottish cetacea have been determined to be well within the range observed for marine mammals world-wide.

- **Acoustic disturbance** – Noise from marine traffic, military activity, coastal industry and oil exploration and production is thought to cause varying levels of disruption to normal cetacean activity. Shock waves and explosions may cause direct tissue damage and permanent auditory organ damage. An increase in background noise can interfere with acoustic communication, reducing the distance over which such communication can take place. Around Scotland, overall seismic activity associated with oil exploration has increased since 1994. A code of practice, designed to reduce the impacts of such activity, was recently introduced by the UK Government.

- **Overfishing of prey** –The depletion of herring stocks may have resulted in the decline of UK harbour porpoise populations during the last 50 years (Evans, 1990; Hammond *et al.*, 1995). The recovery of herring stocks following a fishing ban in 1977 was followed by a slight increase in sightings of harbour porpoises. In the 1980s there was a decline in both seabird and harbour porpoise numbers in Shetland coastal waters coinciding with successive years of poor recruitment of sandeels into the adult population (Evans, 1997).

Cetaceans have also been affected by ingestion of, or entanglement in marine debris and collision with marine vessels.

Species	Occurrence	Abundance estimate	Evidence for population increase/decline
Harbour porpoise	Common	Approx. 300,000 in North Sea (1994)	Decline (North Sea)
Bottlenose dolphin	Common	130 in the Moray Firth	Decline
Risso's dolphin	Uncommon	142 individuals identified in the Minch	Unknown
White-beaked dolphin	Common	Approx. 8,000 in North Sea & English Channel (1994)	Unknown
False killer whale	Rare	None	Unknown
Atlantic white-sided dolphin	Uncommon	None	Unknown
Common dolphin	Common	None	Unknown
Striped dolphin	Uncommon	None	Unknown
Northern bottlenose whale	Uncommon	None	Unknown
Cuvier's beaked whale	Uncommon	None	Unknown
Sowerby's beaked whale	Rare	None	Unknown
True's beaked whale	Rare	None	Unknown
Killer whale	Common	3,500-12,000 in eastern North Atlantic	Unknown
Long-finned pilot whale	Common	Estimated at over 700,000 in North Atlantic (late 1980s)	Unknown
Sperm whale	Uncommon	None	Unknown
Blue whale	Rare	None	Recovery (central-north Atlantic)
Fin whale	Uncommon	Over 14,000 (North Atlantic)	Unknown
Sei whale	Rare	None	Unknown
Minke whale	Common	Approx. 8,400 in North Sea (1994) 110,000 in eastern North Atlantic (1995)	Unknown
Humpback whale	Uncommon	10,000-15,000 in North Atlantic in 1992/93	Recovery
Northern right whale	Very rare	300 - extremely rare or possibly extinct in eastern North Atlantic	Decline

Sources: Evans *et al.*, (1986), Evans (1992), Hammond *et al.*, (1995), Shrimpton & Parsons (1999)

Table 14.1 (above) Status of cetacean species occurring in Scottish waters

Table 14.2 Scottish whaling catch records 1903-1951

Sources: Brown (1976), Evans (1992), Thompson (1928)

	Scottish catch records			
Species	Shetland (1903-1928)	Outer Hebrides (1903-1928)	Outer Hebrides (1950-51)	Population reduction by whaling
Northern bottlenose whale	25	1	0	Uncertain
Sperm whale	19	76	1	Reduced
Blue whale	85	310	6	Greatly reduced
Fin whale	4,536	1,492	46	Greatly reduced
Sei whale	1,839	375	3	Reduced
Minke whale[1]	-	-	-	Uncertain
Humpback whale	51	19	0	Greatly reduced
Northern right whale	6	94	0	Greatly reduced

[1]Not targeted by Scottish fishery but taken by Norwegian vessels around the Northern Isles

Marine Environment Quality

Some 6,900 km of coastline and 810 km^2 of estuarine catchment is examined annually for environmental quality by the Scottish Environment Protection Agency (SEPA). Assessment of each is by separate classification schemes applied to discrete stretches of coast or estuary and incorporates data on water quality, seabed invertebrate quality, status of fish populations and observations of aesthetic modifications. The current classification scheme is a revision of an earlier, less sensitive scheme and has been in use since 1995/96. Grading is on the basis of four classes; excellent, good, unsatisfactory and seriously polluted.

The overall quality of coastal waters was predominantly excellent or good between 1996 and 1999, with little more than 260 km, about 3%, of the coastline classified as unsatisfactory or seriously polluted at any time (Figure 14.5). In general, the areas rated as polluted were localised contaminated sites, either around long sea outfalls, inappropriately sited fish farms or sludge and spoil dumping sites. Some areas of the Solway coastline, notably Loch Ryan, had elevated levels of tributyltin, a chemical antifoulant monitored through its masculinisation effect on female dogwhelks. It is possible that this contamination originated from a breakers yard dismantling large naval vessels.

The majority of Scottish estuarine areas also maintained a favourable overall rating between 1996 and 1999. About 35 km^2 was classed as unsatisfactory or seriously polluted, but this declined to 32.5 km^2 in 1999 (Figure 14.6). The small, mostly localised areas classified as seriously polluted in1996 were further reduced by 40% in the same period.

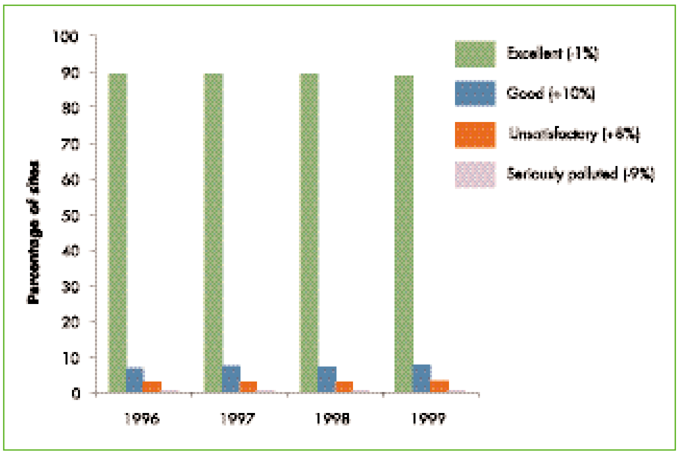


Figure 14.5 Coastal classification as a percentage of sites surveyed in 1996-99 (percentage change between 1996 and 1999 shown in brackets)

Source: SEPA

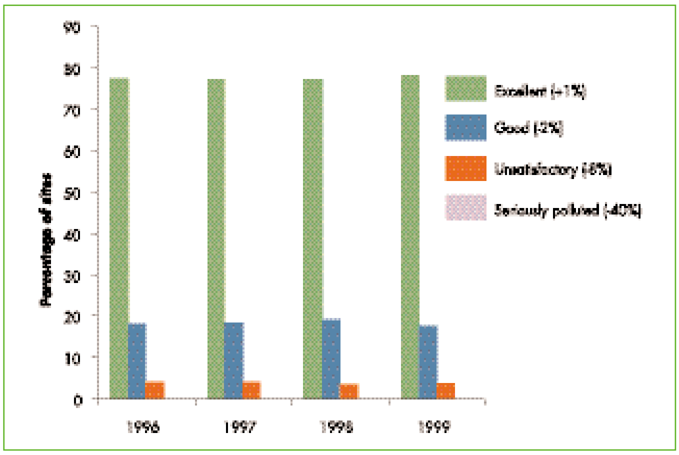
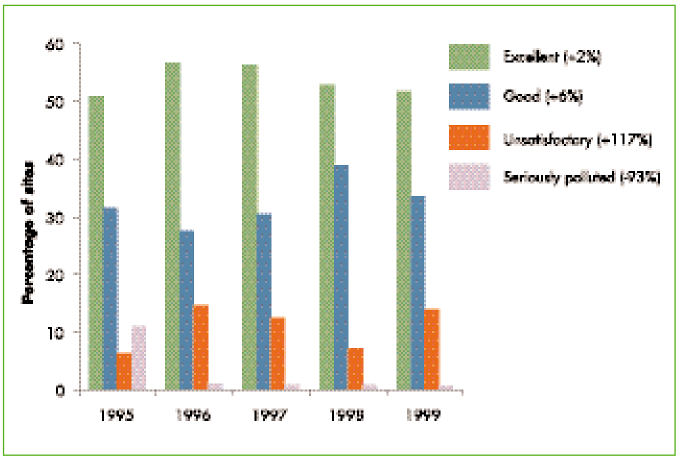


Figure 14.6 Estuarine classification as a percentage of sites surveyed in 1996-99 (percentage change between 1996 and 1999 shown in brackets)

Source: SEPA

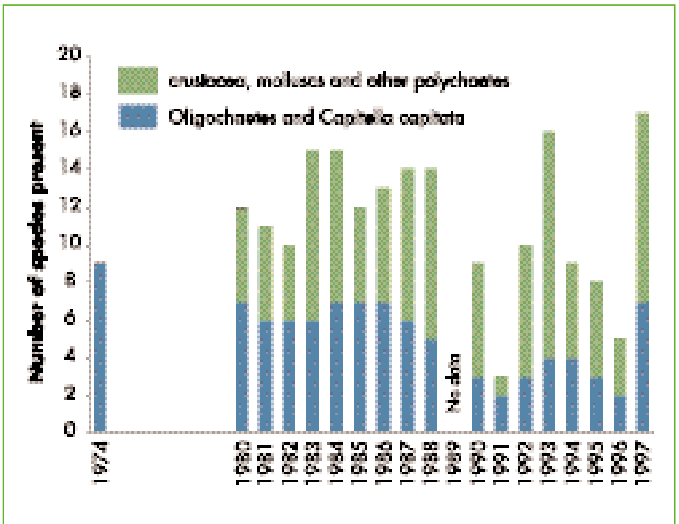
The Clyde Estuary receives domestic and industrial waste generated by half of Scotland's population. Since the 1970s discharge reductions and greater care in the treatment of waste has seen major improvements in the environmental quality of this and other estuaries.

Figure 14.7 Clyde estuarine classification as a percentage of sites surveyed in 1995-99 (percentage change between 1995 and 1999 shown in brackets)



Source: SEPA

Figure 14.8 The composition of benthic fauna at the Clyde/Cart confluence



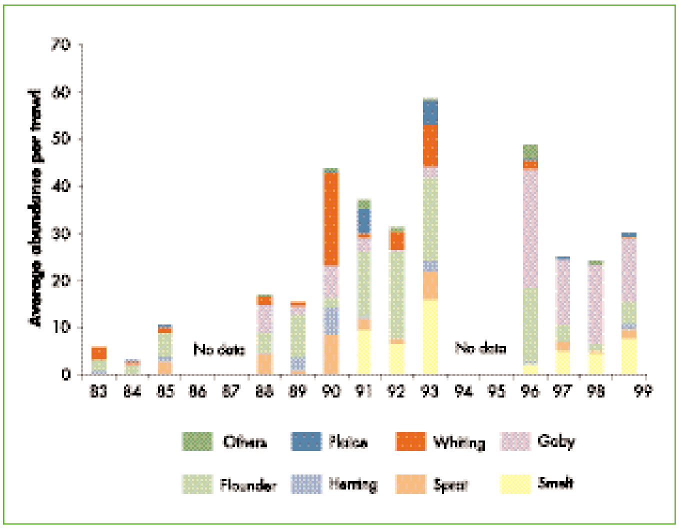
Source: SEPA

As the historical foci of Scotland's population and industry, the larger estuaries, such as the Forth and the Clyde have a long history of contamination. However, statutory controls on discharges have resulted in a steady improvement in water quality. In the Clyde, a major reduction in seriously polluted areas was achieved between 1995 and 1999 (Figure 14.7). In the 1970s the upper Clyde estuary sediments were dominated by a few pollution-tolerant species. In the 1980s, with improving water quality the faunal composition began to change in favour of a more diverse invertebrate community (Figure 14.8) and rising numbers of fish species (Figure 14.9). The establishment of resident populations of flounder was a further indication of improving water quality. Similarly, in the Forth, increasing dissolved oxygen and declining organic and metallic waste levels have been linked to returning fish populations, notably the smelt, a species known to be particularly sensitive to low oxygen levels (Figure 14.10).

Figure 14.9 Number of fish species recorded in the Clyde Estuary 1978-99

Source: SEPA

Figure 14.10 Fish species recorded in the Forth Estuary 1983-1999



Source: SEPA

Mariculture

The relatively clean waters and the widespread availability of wave-sheltered locations around the Scottish coast (notably the sea lochs of the west coast of Scotland, the Western Isles, and the Orkney and Shetland Isles) have proved highly suitable for mariculture.

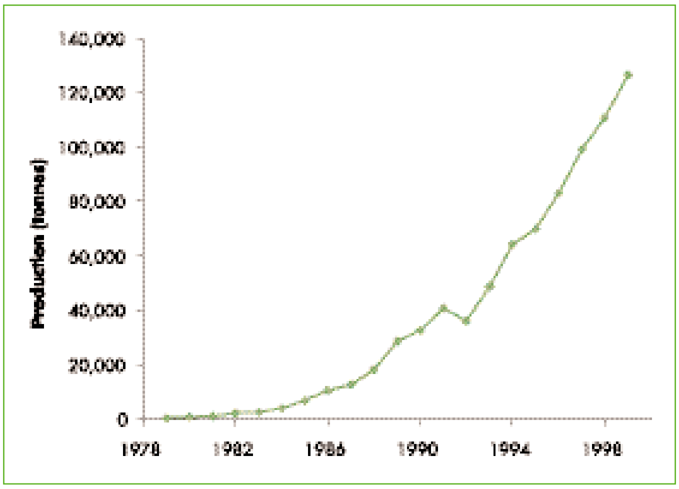
Mariculture, notably salmon farming, is a particularly important industry for Scottish coastal communities.

Commercial salmon farming began in Scotland in 1969 with the establishment of the first farms near Aberdeen and at Loch Ailort, Inverness-shire. At that time the availability of fresh salmon was limited and it was considered a high value species. In 1979 perhaps just over a thousand tonnes of wild salmon was available for market, but only 510 tonnes of farmed fish were produced (Anon., 2000a). Growth in production was slow until the mid-1980s, when financial incentives stimulated a major expansion of the industry (Figures 14.11a & b). In 1999 over 126,000 tonnes of farmed salmon was produced from 351 marine farm sites around Scotland.

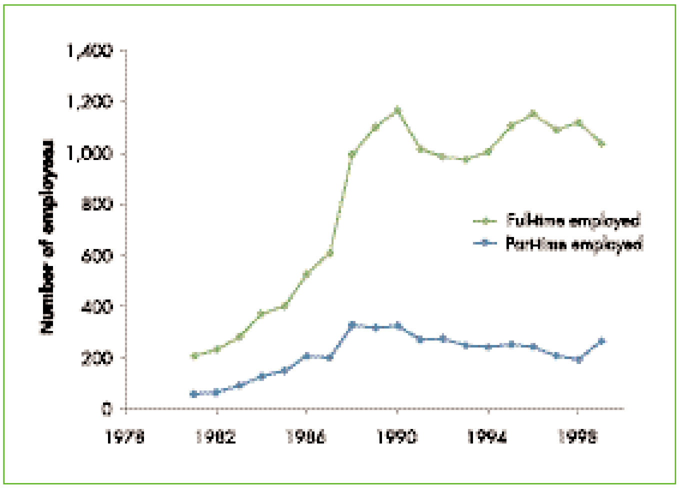
The number of salmon farm-related businesses peaked in 1989, but employment and the number of production sites have remained largely stable since then (Figure 14.11c). Advances in production methods and the use of modern technology in the design and manufacture of holding cages has led to greater yields and higher productivity (Figure 14.11d).

Figure 14.11 Trends in Scottish Fish Farming

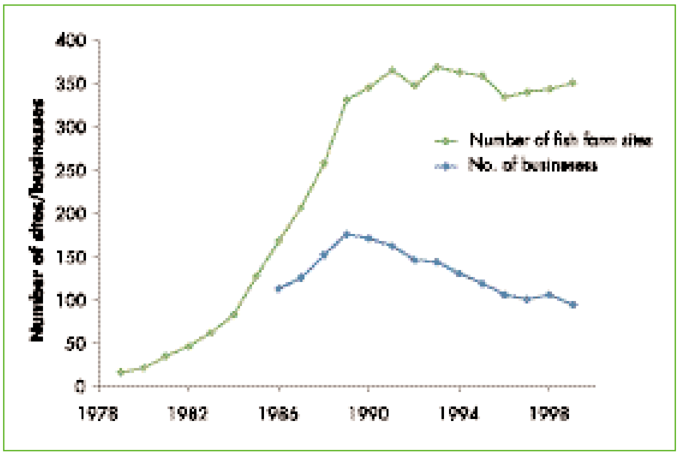
a) Total annual Scottish production of farmed salmon



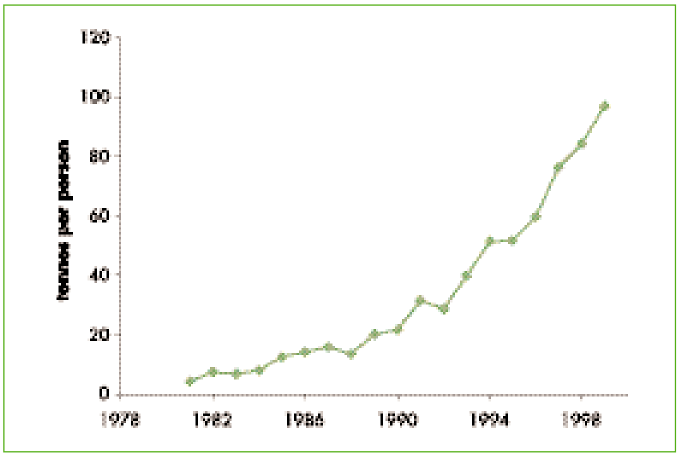
b) Number of people employed in the salmon farm industry



c) Number of fish farm production sites and businesses



d) Productivity



Source: Fisheries Research Services, Aberdeen

High stocking densities have increased susceptibility to disease outbreaks. Heavy losses of salmon occurred in 1990-91 due to sea lice and the bacterial disease furunculosis. A programme of slaughter and site fallowing was initiated following a 1998 outbreak of Infectious Salmon Anaemia (ISA) along the west coast of Scotland.

Experimental farming of other fish species, such as cod, turbot, sea trout and Arctic char is currently underway.

Shellfish farming has also undergone a rapid expansion since the 1980s. Five species; the scallop, the queen scallop, the mussel, the native oyster and the Pacific oyster were farmed at some 237 Scottish sites in 1999 (Figures 14.12a & b).

The transfer of disease and interactions with escaped fish are potential threats to wild salmon.

The seabed directly beneath salmon cages receives high levels of organic input from uneaten food and faecal material, often supplemented with pharmaceuticals and pesticides. In addition, copper, used as an antifoulant may also be introduced to nearby sediments. Evidence suggests that these areas of contamination and organic enrichment are localised and can be minimised if careful consideration is given to local factors such as the water depth below cages and current flow.

Shellfish farming is considered to be less environmentally damaging, but both activities may present an unfavourable visual impact. Careful siting to reduce effects on landscape attractiveness is considered an important factor in the planning of mariculture installations.

Climate and Sea Level Changes

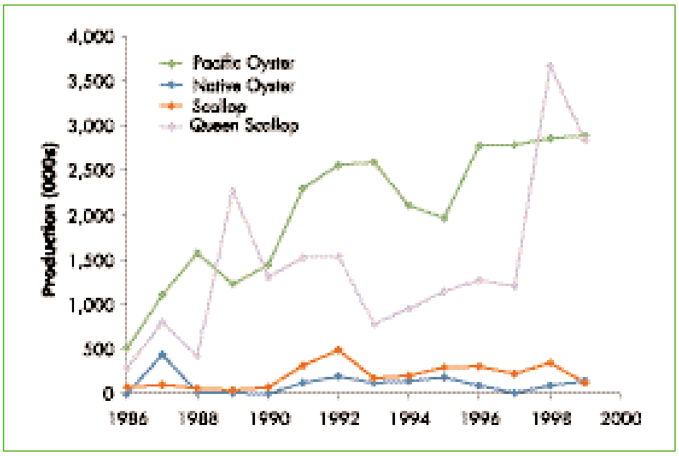
The issues of global warming and sea level rise continue to be the focus of much international debate. The interactions between weather, ocean currents and sea temperature are complex on both global and local scales. Although some Scottish records for wind speed, tidal height, sea and air temperature extend back over a hundred years, they commonly exhibit a high degree of short- and long-term variability, making the evaluation of overall trends difficult and subject to regular revisions. The conclusions presented here are taken from Dawson *et al.*, (2001) and Fisheries Research Services (2000b).

Sea level change – All Scottish mainland tide gauges have recorded a sea level rise over the long term. The longest time-series from a gauge installed at Aberdeen indicates a rise 0.6 mm per year since 1862. In contrast, a tide gauge in Lerwick, Shetland has recorded a fall in sea level since 1957. This aside, the overall consensus is that relative sea levels are rising in all of the other areas where recording instruments are installed.

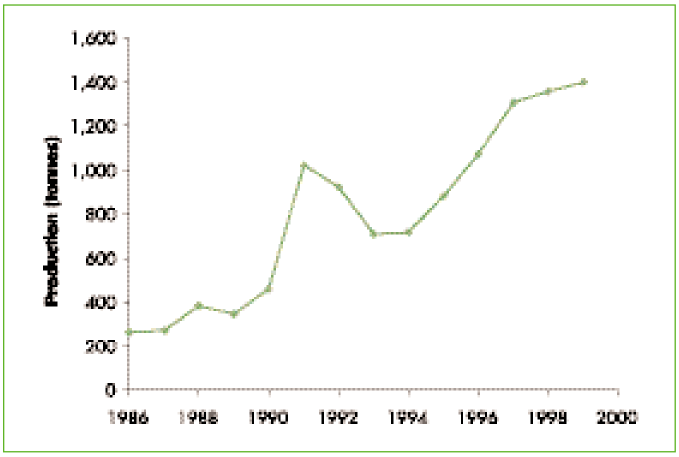
However, estimates of sea level change are modified by the simultaneous rise in the Scottish land mass which is still undergoing a rebounding process following the melting of the overlaying ice sheet some 10,000 years ago at the end of the last ice age. The rate of rebound is greatest in mainland areas where the ice layer was thickest, while offshore areas, such as the Northern Isles and the Outer Hebrides were under thinner ice and so the extent of rise is correspondingly smaller and may even amount to a relative sinking. Estimates of current and future sea level change for Scotland, adjusted to take account of uplift movements, are shown in Figures 14.13 and 14.14.

Figure 14.12 Trends in Scottish shellfish production

a) Pacific oyster, native oyster, scallop, and queen scallop



b) Mussel



Source: Fisheries Research Services (2000a)

Increased storminess, higher sea temperatures and rises in relative sea level are predicted for Scottish coastal areas. Some marine species at their southern distribution limit may disappear, but an influx of southern species could increase overall diversity.

Storminess – There has been an increase in storminess in the NE Atlantic over the last 30 years, with an associated increase in wave height of 2.5-7.0 mm per year.

Sea temperature change – Fisheries Research Services (2000b) report that Scottish coastal waters warmed between 1980 and 1998, with summer temperatures increasing at about 0.5˚C every 10 years and winter temperatures by 1˚C. Correspondingly, the average range of temperatures from summer to winter narrowed by about 0.5˚C. In 1999, however, overall water temperatures were cooler than the previous year. Dawson *et al.*, (2001) observed that between 1977 and 1997 there was a pattern of short-term temperature rise with a range between 0.05 and 0.12˚C, but argued that when placed in context with records from the past hundred years there is no clear trend.

An examination of the possible effects of currently predicted rises in sea and air temperature on the distribution of marine species and communities was undertaken by Hiscock *et al.*, (2001). They concluded that species losses would be restricted to a small number of northern species currently at their southern limit and that warming may increase diversity of Scottish seabed communities. A summary of proposed modified species distributions is shown in Table 14.3. Some communities that are particularly well-developed in Scotland could be affected over the longer term, such as those associated with maerl and horse mussel beds. Enclosed areas of seabed, such as sea lochs may experience greater seasonal impacts from deoxygenisation caused by increased thermal stratification.

Figure 14.13 Present rates of relative sea level change in Scotland

Source: Dawson *et al* (2001)

Figure 14.14 Best estimate of sea level rise for 2050 AD

Table 14.3 Species with currently restricted distributions in or near Scotland and predicted effects of sea temperature rise

Southern species not currently recorded in Scotland but which may spread to Scotland	Southern species currently recorded in Scotland whose extent of distribution or abundance might increase		Northern species which may either decrease in abundance and extent or disappear from Scotland
Ciocalypta penicillus	*Axinella dissimilis*	*Crassostrea virginica*	*Thuiaria thuja*
Haliclona angulata	*Hemimycale columella*	*Cerastoderma glaucum*	*Swiftia pallida*
Gymnangium montagui	*Phorbas fictitius*	*Gari depressa*	*Bolocera tuediae*
Eunicella verrucosa	*Haliclona cinerea*	*Pentapora fascialis*	*Phellia gausapata*
Aiptasia mutabilis	*Haliclona fistulosa*	*Asterina gibbosa*	*Lithodes maia*
Balanus perforatus	*Haliclona simulans*	*Paracentrotus lividus*	*Tonicella marmorea*
Maja squinado	*Alcyonium glomeratum*	*Holothuria forskali*	*Margarites helicinus*
Osilinus lineatus	*Anemonia viridis*	*Centrolabrus exoletus*	*Tectura testudinalis*
Patella depressa	*Aulactinia verrucosa*	*Crenilabrus melops*	*Onoba aculeus*
Crepidula fornicata	*Corynactis viridis*	*Ctenolabrus rupestris*	*Colus islandicus*
Tritonia nilsodheri	*Sabellaria alveolata*	*Labrus mixtus*	*Akera bullata*
Solen marginatus	*Chthamalus montagui*	*Thorogobius ephippiatus*	*Limaria hians*
Phallusia mammillata	*Chthamalus stellatus*	*Scinaia trigona*	*Anomia ephippium*
Scinaia furcellata	*Hippolyte huntii*	*Asparagopsis armata*	*Thyasira gouldii*
Chondracanthus acicularis	*Palinurus elephas*	*Bonnemaisonia hamifera*	*Leptometra celtica*
Stenogramme interrupta	*Polybius henslowi*	*Naccaria wiggii*	*Leptasterias muelleri*
Laminaria ochroleuca	*Ebalia tumefacta*	*Jania rubens*	*Semibalanus balanoides*
Bifurcaria bifurcata	*Corystes cassivelaunus*	*Lithothamnion corallioides*	*Lithodes maia*
Cystoseira baccata	*Liocarcinus arcuatus*	*Mesophyllum lichenoides*	*Strongylocentortus droebachiensis*
Cystoseira foeniculaceus	*Liocarcinus corrugatus*	*Calliblepharis ciliata*	*Cucumaria frondosa*
	Goneplax rhomboides	*Kallymenia reniformis*	*Styela gelatinosa*
	Pilumnus hirtellus	*Rhodymenia delicatula*	*Lumpenus lumpretaeformis*
	Xantho incisus	*Rhodymenia holmesii*	*Zoarces viviparus*
	Xantho pilipes	*Rhodymenia pseudopalmata*	*Lithothamnion glaciale*
	Tricolia pullus	*Halurus equisetifolius*	*Phymatolithon calcareum*
	Gibbula umbilicalis	*Sphondylothamnion multifidum*	*Callophyllis cristata*
	Patella ulyssiponensis	*Drachiella heterocarpa*	*Odonthalia dentata*
	Bittium reticulatum	*Drachiella spectabilis*	*Sphacelaria arctica*
	Cerithiopsis tubercularis	*Stilophora tenella*	*Sphacelaria mirabilis*
	Melaraphe neritoides	*Halopteris filicina*	*Sphacelaria plumosa*
	Calyptraea chinensis	*Dictyopteris membranacea*	*Chorda tomentosa*
	Clathrus clathrus	*Taonia atomaria*	*Ascophyllum nodosum mackaii*
	Ocenebra erinacea	*Carpomitra costata*	*Fucus distichus distichus*
	Acteon tornatilis	*Cystoseira tamariscifolia*	*Fucus evanescens*
	Pleurobranchus membranaceus	*Codium adhaerens*	
	Atrina fragilis	*Codium tomentosum*	

Source: Hiscock *et al* (2001)

Box 14.1 The number of marine species occurring in Scottish waters

Phyla	Common Name	Great Britain & Ireland	Scotland
Protista	Protozoa	25,000 – 30,000	25,000 – 30,000
Mesozoa	(Micoscopic parasites)	2 (10)	Unknown
Porifera	Sponges	353 (360)	250 – 300
Cnidaria	Jellyfish, hydroids, anemones, corals	375 (390)	250 – 350
Ctenophores	Comb jellies	3	3
Platyhelminthes	Flatworms and meiofaunal worms	355 – 375 (377)	300 – 350
Nemertea	Ribbon worm	67 (85)	60 – 70
Rotifera	"Wheel animalcules"	10 – 15	10 – 15
Gastrotricha	Meiofaunal roundworms	85 (140)	80 – 90
Kinorhyncha	Microscopic worms	15 (16)	6 – 10
Nematoda	Round worms	408 (410)	350 – 400
Acanthocephala	Spiny-headed worms	10 – 20	10 – 20
Priapulida	(Worm-like animals)	1	1
Entoprocta	(Similar to sea mats)	35 (45)	35 – 40
Chaetognatha	Arrow worms	22	20
Pogonophora	"Beard" worms	2 (10)	2 – 10
Sipuncula	(Worm-like animals)	12 (21)	12 – 15
Echiura	"Spoon" worms	7	3
Annelida	Bristle worms, sludge worms and leaches	940 (995)	800 – 900
Chelicerata	Sea spiders and marine mites	91	60 – 70
Crustacea	Branchiopods, barnacles, copepods, ostracods, stomatopods, shrimps, crabs, lobsters etc.	2,465 (2,665)	2,000 – 2,460
Uniramia	(Marine arthropods)	3 – 4	3 – 4
Tradigradia	"Water bears"	16	16
Mollusca	Chitons, limpets, sea snails, sea slugs, tusk shells, bivalves octopus etc.	1,395 (1,465)	650 – 700
Brachiopoda	Lamp shells	18	11
Bryozoa	Sea mats	270 (290)	120 – 150
Phoronida	Tube worms	3 (5)	2
Echinodermata	Feather stars, sea stars, brittlestars, sea urchins, sea cucumbers etc.	145	100 – 130
Hemichordata	Acorn worms and planktonic larvae	>12	>11
Tunicata*	Sea squirts and salps	120 (125)	100
Pisces	Fish	300 (332)	250
Reptilia	Sea turtles	5	4
Mammalia	Sea mammals	28 (35)	28 – 35
Archaebacteria and other Eubacteria	Bacteria	1,500 – 2,000	1,500 – 2,000
Cyanobacteria = Cyanophyta	Blue-green algae	41 (120)	41 (70)
Rhodophyta	Red algae	350 (450)	250
Heterokontophyta	Golden etc. algae, diatoms, phytoflagellates	>1,241 (1,341)	>1,201 – 1,321
Haptophyta = Prymnesiophyta	Phytoflagellates	117	115
Cryptophyta	Phytoflagellates	78	78
Dinophyta	Dinoflagellates	440 (460)	250 – 450
Euglenophyta	Euglenoids	5 – 10	5 – 10
Chlophyta	Green algae	160 (220)	100 – 150
Non-lichenous fungi	Non-lichenous fungi	120 (150)	120 – 150
Viruses	Viruses	2,000 – 2,500	2,000 – 2,500
GRAND TOTAL	**Excluding Protista**	**13,625 – 14,666 (15,573)**	**11,207 – 13,605 (13,634)**
	Including Protista	**38,625 – 44,666 (45,573)**	**36,207 – 43,605 (43,634)**

*Subphylum

Numbers in brackets indicate a "potential maximum" i.e. numbers of those that could potentially occur plus those that have been recorded from British waters.

Sources: Davison (1996); Davison & Baxter (1997)

Box 14.2 Basking shark

Basking sharks occur in the temperate waters of most seas and are present in both the northern and southern hemispheres. They are widely distributed but are infrequently recorded, except around a few apparently favoured coasts where they are sometimes seen in relatively large numbers.

In Scottish coastal waters, basking sharks are seasonal visitors, and are observed mainly on the west coast in the summer months. Sightings peak around August with movements thought to be migratory and largely dictated by zooplankton abundance. However, long-distance tracking of individuals has never been carried out and it is not currently known if there is a migration from deep to shallow water or from lower to higher latitudes, or both. The presence of moderately high levels of squaline in basking shark livers, a chemical characteristic of deep-water species, suggests that a part of their life history is spent in deep water.

Accurate and reliable quantitative data on basking shark populations in Scottish waters are not available. However, the Marine Conservation Society initiated a reporting scheme for public participation in 1987. These data (Figure 14.15) indicate a substantial UK and Scottish peak in sightings for 1989 and 1990 respectively, with a subsequent large decline in sightings during the following 2-3 years. A second peak for Scottish sightings in 1996 was not reflected by overall UK observations. It is likely, though, that these data have been influenced by the timing and level of active promotion of the reporting scheme (Nicholson *et al.*, 2000). Increased media promotion occurred in 1988, 1989, 1990, 1991, 1995 and 1996.

Exploitation of the basking shark has occurred over several centuries, initially for the high oil content of the liver, which was used in the steel, medical, cosmetic and tanning industries as well as a fuel for lighting. In recent times there has been limited growth in its use in cosmetic and health supplement products, but it has been the demand and associated high prices paid for shark fin in Asian markets that has been the major driving force behind recent basking shark catches.

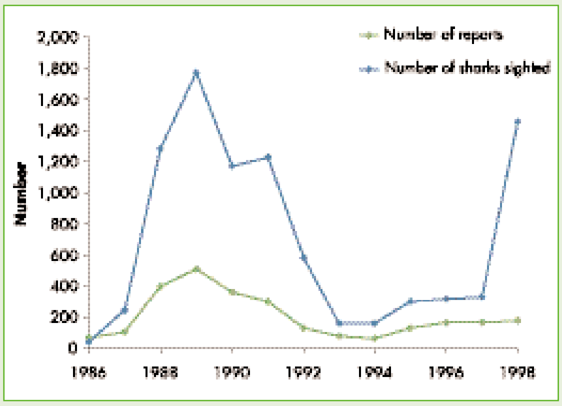
Throughout the North-east Atlantic, large numbers were caught between the mid-1940s and early 1980s (Figure 14.16), particularly by the Norwegian fleet. In the 1980s and 1990s catch levels were much reduced despite the high demand for shark fin. Several recent attempts to establish a Scottish fishery based in the Minch and Clyde areas failed due to marketing difficulties and widely fluctuating shark numbers (Kunzlik, 1988; Nicholson *et al.*, 2000) (Figure 14.16).

Although the influence of natural cyclical factors make assessments of population trends difficult, it is thought that their biology and location-faithfulness make basking sharks particularly vulnerable to overexploitation. Some directed fisheries have seen catch declines ranging between 50 to over 80%, often over periods of ten years or less (Table 14.4). There has been no subsequent population recovery, indicating that there is little or no migration of individuals from other areas.

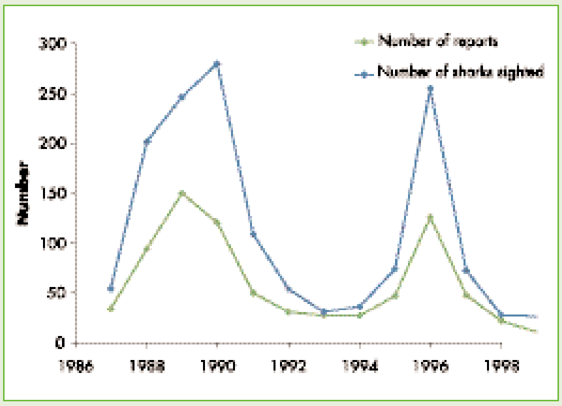
The **basking shark** is the largest fish in UK waters. Its appearance in Scottish waters is seasonal and the numbers may be associated with zooplankton abundance. Basking shark fisheries have been characterised by large abundance fluctuations, often with stock reductions of at least 50% over very short time periods.

Figure 14.15
Basking shark sightings reported to the Marine Conservation Society

a) Total UK sightings



b) Scottish sightings



Source: Marine Conservation Society

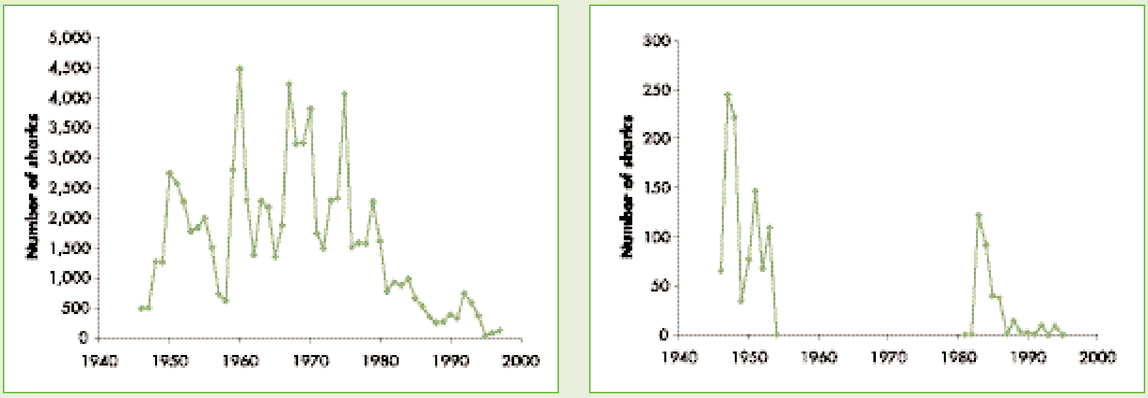
Globally, the status of the basking shark is assessed as vulnerable, but the Northeast Atlantic sub-population is currently considered to be endangered (2000 IUCN Red List of Threatened Species). Basking sharks have been protected within British territorial waters under the Wildlife and Countryside Act (1981) since 1998, and identified for conservation action through a Species Biodiversity Action Plan.

Key sources: Anon. (2000b); Fairfax (1998); ICES (1995).

Figure 14.16 Targeted basking shark landings

a) Northeast Atlantic

b) Scotland only



Source: ICES (1995), Anon (2000b)

Table 14.4 Trends in basking shark fisheries

Geographical area and description of records	Time scale	Average catches or sightings per year	Overall (decline) or increase in catches
Achill Island, Ireland (a targeted coastal basking shark fishery)	1947-1975	1947-1950: 360 1951-1955: 1,475 1956-1960: 489 1961-1965: 107 1966-1970: 64 1971-1975: 50 1990s: rarely seen	>95% decline in 25 years
West coast of Scotland	1946-1953	121 throughout fishery 1946-1949: 142 1950-1953: 100	~30% in 7 years, but trend unclear
Firth of Clyde, Scotland	1982-1994	58.6 in first 5 years 4.8 in last 5 years.	>90% in 12 years
Norwegian catches	1946-1996	1946-1950: 837 1951-1955: 554 1956-1960: 1,541 1961-1965: 1,792 1966-1970: 3,213 1971-1975: 2,236 1976-1980: 1,706 1981-1985: 797 1986-1990: 343 1991-1995: 403	87% decline from peak landings in late 1960s to levels in the early 1990s
Northeast Atlantic (all catches combined)	1946-1996	1946-1950: 1,254 1951-1955: 2,094 1956-1960: 2,030 1961-1965: 1,899 1966-1970: 3,277 1971-1975: 2,385 1976-1980: 1,706 1981-1985: 848 1986-1990: 355 1991-1995: 407	90% decline from the main period of peak landings in the late 1960s to landings in the late 1980s. This followed 20 years of fluctuating but rising catches.

Source: Anon. (2000b)

Box 14.3 Cetacean strandings

Live strandings of cetaceans are thought to occur for a range of reasons, such as old age, poor health, injury, toxic chemical build-up and disorientation (Figure 14.17).

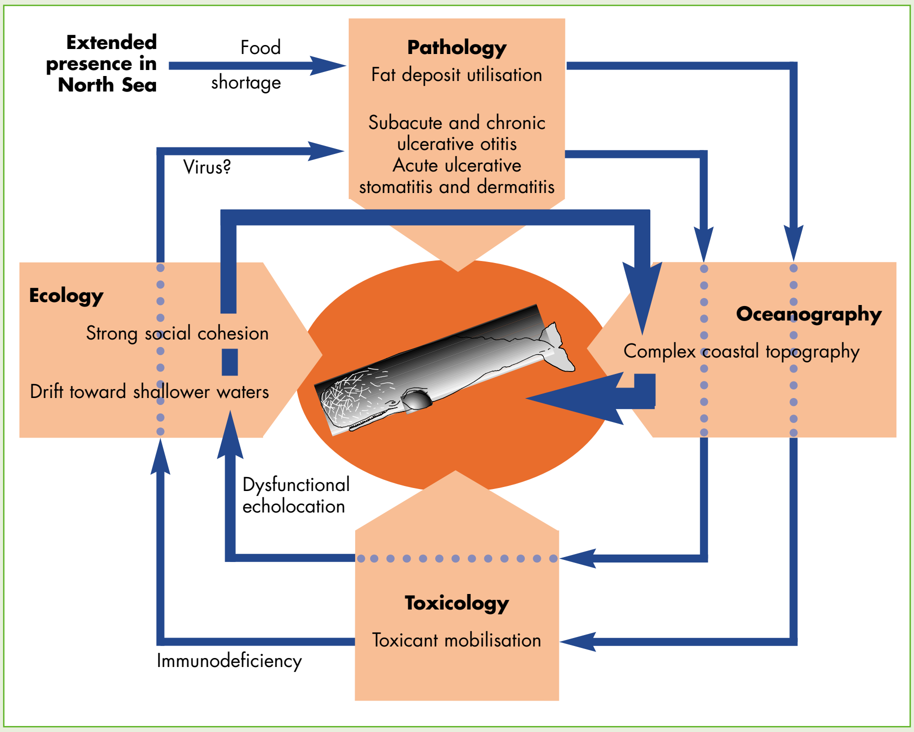
Between 1992 and 1995 Scottish strandings accounted for about 60% of the UK total. Of these, some 55% were associated with mass stranding events (Mayer, 1996). Records of strandings increased steadily around the UK and Ireland between the 1960s and 1980s and have continued to do so along continental North Sea coasts throughout the 1990s (OSPAR Commission, 2000).

Systematic records for Scottish standings have been compiled by the Scottish Agricultural College Veterinary Investigations Centre since 1992. Between 1992 and 2000 there was an average of 143 standings per year with relatively minor annual fluctuation (Figure 14.18). Harbour porpoise accounted for the greatest number of strandings each year and the annual proportion of the total for each species has been largely maintained throughout that period (Figure 14.19).

Key sources: Scottish Agricultural College Veterinary Investigations Centre; Mayer (1996); Weighell *et al.* (2000)

Cetacean strandings may occur for a variety of reasons. The number of strandings on Scottish shores has changed little since formal recording began in 1992.

Figure 14.17 Possible causes of sperm whale strandings in the North Sea



Source: OSPAR Commission (2000)

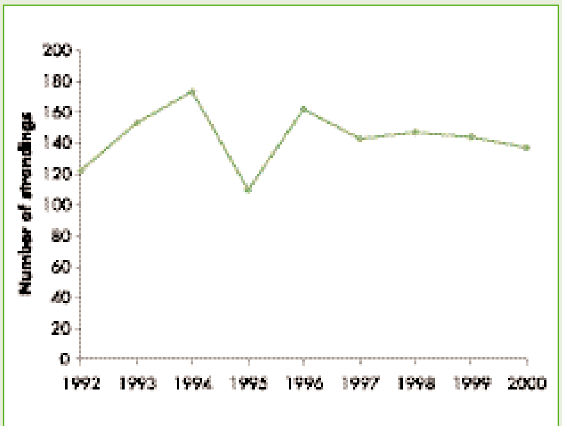


Figure 14.18 Total recorded Scottish cetacean strandings (1992-2000)

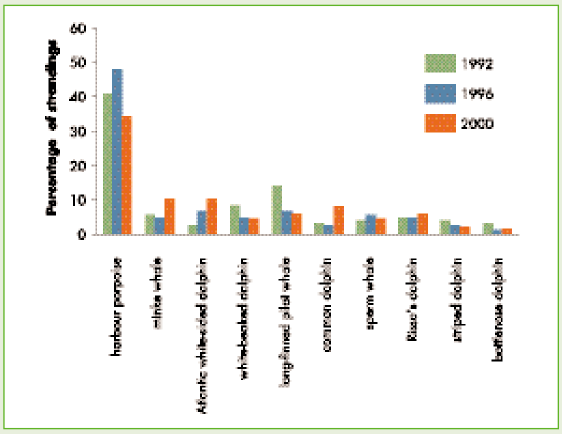


Figure 14.19 The ten species most commonly stranded on Scottish coasts represented as a percentage of all Scottish strandings for 1992, 1996 and 2000

Grey seal populations increased between 1984 and 1997 by an average of about 6% per year.

Box 14.4 Seals

Two species, the grey seal and harbour or common seal, are present around the coast of Scotland in internationally important numbers. For thousands of years they were hunted for their pelts, oil and meat, but over-exploitation by the early 1900s forced the establishment of a closed season for grey seals to prevent extinction (McGillivray, 1995). A UK-wide annual grey seal cull was maintained from 1962 until 1979, when it was abandoned in the face of sustained public protest. Harbour seals continued to be hunted for their skins until the early 1970s, when at some locations up to 90% of pups were taken annually. A ban on UK seal fur trading was established in 1973.

UK seal populations are monitored regularly by the Sea Mammal Research Unit (SMRU) on behalf of the Natural Environment Research Council (NERC). The NERC provides advice to the UK government on the size and status of the British seal population under the Conservation of Seals Act, 1970. This, together with the EU Habitats Directive, provides protection to seals when they come ashore to pup, breed and moult. Recent monitoring has largely been carried out by aerial survey and mainly at Scottish locations. Since seals spend a large proportion of their time in the open sea, counting is carried out at times of greatest shore-based activity; during the pupping season for grey seals and moulting for harbour seals. Total population estimates are derived from these data.

Table 14.5 Minimum harbour seal population estimates for selected SMRU-defined subregions

	Year of count							
Subregion	**1989**	**1991**	**1992**	**1993**	**1996**	**1997**	**2000**	**2001**
Shetland		4,797		6,227		5,991		4,900**
Orkney	7,137*			8,436		8,523		7,750**
Outer Hebrides			2,329		2,820		2,413	

*Visual helicopter count **Provisional figures

UK coastal waters support some 40% of the European harbour seal subspecies *Phoca vitulina vitulina* and 5% of the world population. About 90% of the UK harbour seal population is found in Scottish waters. In 1988, a viral epidemic swept through the North Sea harbour seal population. Phocine distemper virus was previously unknown but related to canine distemper virus, and was probably a natural event, since similar epidemics are known to have occurred in the past. The disease reduced overall North Sea populations by over 40% and was most severe along the continental coasts (OSPAR Commission, 2000). In England, 50% of seals resident in The Wash were reported to have died. Scottish populations were less affected, with mortality estimates for the Moray Firth population varying between 10-20% (Thompson & Miller, 1992). Throughout Europe and the UK, harbour seal numbers have rapidly returned to, or exceeded, pre-epidemic levels. In Scotland, 29,600 were recorded between 1996 and 1999. Periodic estimates for areas with the highest concentrations suggest that populations have largely remained stable (Table 14.5).

In 1999 the British grey seal population was estimated at 123,000 animals aged one year or older. About 40% of the world's grey seals breed at well-established sites around Britain. Of these, over 90% are associated with Scottish coasts. Overall, British grey seal populations increased steadily between 1984 and 1997 with an average rise of about 6% per year (Figure 14.20). Since the 1970s, pup production has increased greatly in the Orkney Isles and the Outer Hebrides, with a lesser expansion in the Inner Hebrides and North Sea (Figure 14.21).

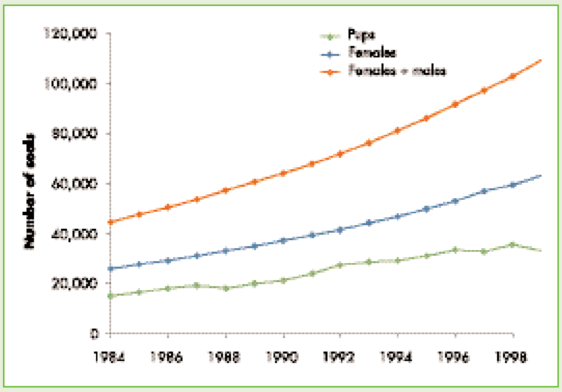


Figure 14.20 British grey seal populations at annually monitored sites

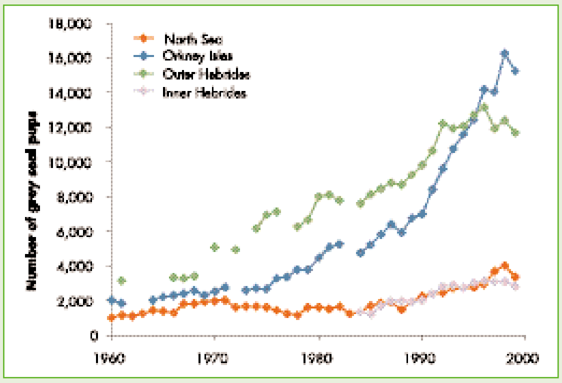


Figure 14.21 Grey seal pup production at main breeding sites

Key sources: Sea Mammal Research Unit; Sea Mammal Research Unit (2001).

Box 14.5 Breeding seabirds

Scotland's breeding seabird populations are internationally important, accounting for more than half of the world's great skuas and North Atlantic gannets, over one third of Europe's Manx shearwaters and at least 10% of the European breeding populations of ten other species[2] (Lloyd *et al.*, 1991). Together, seabird numbers exceed four million birds, in hundreds of colonies around the coast.

There have been only two comprehensive seabird surveys in Britain; in 1969-70 and 1985-87. A third survey, 'Seabird 2000', is now underway, and is due to be completed in 2002. These are augmented by annual surveys within a sample of seabird colonies (Thompson *et al.*, 1999).

Although the following figures describe changes in seabird abundance throughout Scotland, trends sometimes vary markedly between Scottish regions, for example between populations in the North Sea and Irish Sea/Atlantic Ocean.

Between 1969-70 and 1985-87, 11 out of 18 seabird species showed a marked increase in their breeding populations (i.e. by at least 10%), and four showed a marked decline (Figure 14.22). Note, however, that these figures apply to coastal populations only; two species, the black-headed and common gull, breed predominantly inland, where trends may have differed.

Several of those showing marked increases (great skua, Arctic tern and gannet) have especially large populations in Scotland.

The greatest proportional decline was that of the roseate tern, whose numbers in Scotland fell from 134 pairs in 1969-70 to nine in 1999.

Population increases have occurred despite occasional, local breeding failures in some species. These are usually attributed to a catastrophic decline in the food supply, in particular, the availability of sandeels. The breeding success of Arctic terns in Shetland fluctuated greatly during the 1980s-90s (Figure 14.23), with some 4,020 pairs fledging just 45 young in 1998 (Thompson *et al.*, 1999).

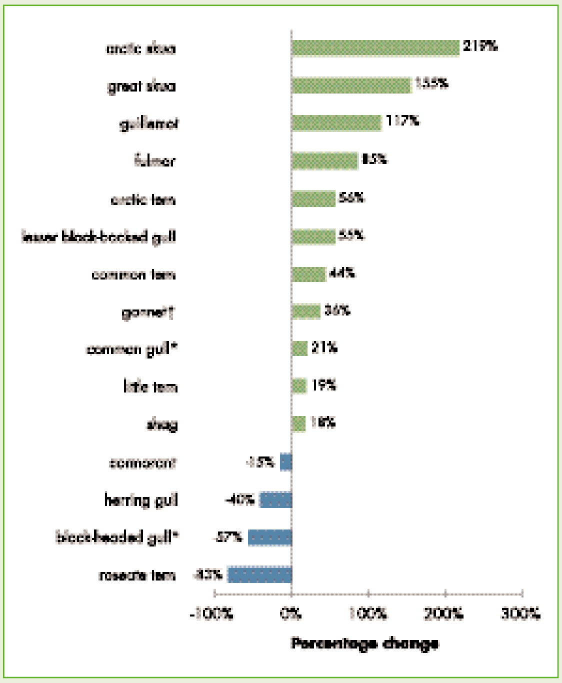
Most seabird species are relatively long-lived, however, and are therefore normally able to withstand occasional breeding failures.

The main factors influencing population trends in Scotland's seabirds are as follows.

- ***Food availability***. This has a major influence on breeding performance, and is in turn affected by commercial fisheries and climatic fluctuations. Two-thirds of seabirds in the North Sea in summer are thought to feed to some extent on fishery waste, and the abundance of commercial fishing discards has been linked to population increases in some species. Conversely, commercial fisheries, particularly for sandeels, can have a substantial, negative impact on food availability.
- ***Predation***. Rats, feral cats, ferrets and American mink can have a severe impact on breeding and, or adult survival.
- ***Drowning***. Nets, particularly monofilament drift nets, were considered the main cause of unnatural deaths among auks in the 1980s.

[2] Excluding the storm and Leach's petrel, for which adequate Scottish population estimates do not exist. Note, however, that 66-75% of the world's storm petrel population is thought to breed in Britain and Ireland, with sizeable colonies in Scotland.

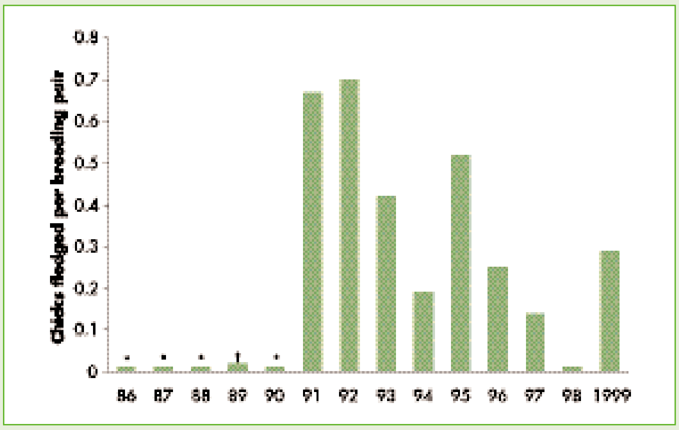
Figure 14.22 Seabird species showing changes of at least 10% in their Scottish breeding populations between 1969-70 and 1985-87.



† Percentage change between 1969-70 and 1984-85.
* Changes in coastal colonies only; the majority of the population of these species breeds inland.

Sources: Lloyd *et al.*, (1991), Murray & Wanless (1997).

Figure 14.23 Variation in the mean number of Arctic tern chicks fledged per breeding pair, at a sample of colonies in Shetland.



* < 0.01, † < 0.02 chicks fledged per breeding pair

Source: Annual joint reports of JNCC, RSPB & Shetland Oil Terminal Environmental Advisory Group, on seabird numbers and breeding success in Britain and Ireland.

- ***Pollution***. Chronic oil pollution from illegal discharges have had a greater impact than occasional accidental spills. Pesticide residues and other toxic chemicals have been implicated in population crashes.
- ***Culling***. Egg collection, and the hunting for food, feathers and sport, has historically had a major impact on populations, but is now controlled through legislation.

Population trends are driven by a wide range of factors, and may differ markedly between colonies of the same species. Species trends for Scotland, from 1969-70 to 1985-87, were as follows.

Increases of greater than 50%

- Apparent increases in **Arctic skua** and **great skua** populations partly reflect a change in survey methodology, both species having been under-recorded in 1969-70.

The Scottish population of the **great skua** was reduced to two small colonies in Shetland in the 1890s, but now numbers about 7,900 breeding pairs; more than half of the world population.

- Increases in **Arctic tern** numbers partly reflect earlier census difficulties, and mask substantial local declines during the 1980s. In 1980 about 85% of the British and Irish population bred in Orkney and Shetland, where, by 1989, numbers had fallen by 42% and 55% respectively (Avery *et al.*, 1993). In Shetland, these declines coincided with very low breeding success, associated with a lack of sandeel prey.
- The **guillemot, fulmar** and **lesser black-backed gull** showed increases of greater than 50% between 1969-70 and 1985-87. East coast populations of guillemots continued to rise substantially during 1986-99 (Upton *et al.*, 2000).

Increases of 10-50%

- Apparent increases in **common tern** numbers partly reflect improved survey coverage during the 1980s.
- The **gannet** has shown a recovery from historical persecution. Between 1969-70 and 1984-85 its Scottish population increased by about 36%, and by a further 27% between 1984-85 and 1994-95 (Murray & Wanless, 1997).
- Although **common gull** numbers increased at coastal colonies, inland colonies, which hold the majority of the Scottish population, were not included in the two seabird surveys.
- **Shag** numbers increased by 10-50% during 1969-70 to 1985-87. However, in Shetland, which held about 20% of the Scottish population in 1985-87, numbers fell by more than 50% between 1986 and 1999. East coast populations also showed a dramatic drop in numbers following a winter 'wreck' in 1993/94.
- **Little tern** numbers increased by 19% between 1969-70 and 1985-87.

Changes of less than 10%

- Although the Scottish **kittiwake** population showed little change between 1969-70 and 1985-87, colonies in Shetland, which held about 14% of the Scottish population in 1985-87, showed a 50% decline during 1981-97. This was attributed to poor breeding success, due to low availability of sandeels, and to increased predation by great skuas (Heubeck *et al.*, 1999).
- **Great black-backed gull** and **Sandwich tern** numbers appeared to change by less than 10% between 1969-70 and 1995-97.

Declines of 10-50%

- The **cormorant** declined by 15% overall. Although the cause of this decline has not been established, disturbance and persecution are important factors in the control of its breeding numbers and output.
- **Herring gull** numbers on the Isle of May were substantially reduced by culling in the 1970-80s, but also declined around most of Scotland's coastline.

Declines of 50% or more

- **Black-headed gull** numbers declined by more than 50% at coastal colonies. However, like the common gull, the bulk of the black-headed gull population breeds inland, and was not covered by the two seabird surveys.
- The number of breeding **roseate terns** (a Biodiversity Action Plan priority species) fell by 83% between 1969-70 and 1985-87, and by 59% between 1987 and 1999. Its decline in Scotland has been attributed, in part, to emigration to Irish colonies, predation in its breeding colonies and to adult mortality associated with human persecution in its West African wintering grounds. However, its overall population in Britain and Ireland increased during the late 1990s.

In 1970 there were 134 breeding pairs of **roseate tern** in Scotland. This figure had dropped to nine breeding pairs by 1999.

Reliable national trend data for **Manx shearwater**, **storm petrel**, **Leach's petrel**, **razorbill**, **puffin** and **black guillemot** were not available. In the case of **razorbill** and **puffin** this was due to a change in the methods used during the two survey periods. Nonetheless, the figures suggest that there may have been an increase in the number of **razorbills**, and little change in the **puffin** population.

Key sources: this profile has been developed using Lloyd *et al.*, (1991), annual joint reports of JNCC, RSPB & Shetland Oil Terminal Environmental Advisory Group, on seabird numbers and breeding success in Britain and Ireland, and information provided by K.R. Thompson (JNCC), and M.A. Ogilvie.

Table 14.6 Summary of marine trends

Topic	Trends	Decreasing	Static	Increasing	Reliability of trend[3]
Marine exploration and survey	**1954-1998** The MNCR database of marine surveys began development in 1987. Data from a number of previous surveys have been entered. Between 1987 and 1998 the number of marine surveys around Scotland increased from 70 to 191 and the number of survey stations from 2,530 to 6,184.			⇧	**T**
	1975-1998 The oil and gas industry biological survey effort is held in the UKOOA database. Between 1975 and 1998 the number of surveys completed rose from four to 508 and the number of survey stations from 19 to 6,181.			⇧	**T**
Cetacea	**c.1986-2000** Of 21 species that have been recorded alive and more than once in the waters around Scotland the status of 16 is unknown. A decline has been reported for three species and a post-whaling recovery for two.	**3 Species** ⇩		2 Species ⇧	c
	1992-2000 Reported cetacean strandings increased from 122 to 137			**12%** ⇧	
Breeding seabirds	**1967-1987**: of 18 Scottish breeding seabird species for which trend data are available, 11 increased by more than 10% between 1969 and 1987, three varied by less than 10%, and four declined by more than 10% (from Lloyd *et al.*, 1991).	22% ⇩	17% ⇔	**61%** ⇧	**C**
Marine Environment Quality	**1996-1999** *Coastal environmental quality:* Overall quality has remained good or excellent with little more than 260 km, or 3% classified as unsatisfactory or seriously polluted in 1999. Overall quality improved slightly with the length classified as seriously polluted decreasing from 49.8 km to 45.3 km (-9%)			⇧	**C**
	1996-1999 *Estuarine environmental quality:* The majority of estuarine areas retained their favourable rating. Overall quality improved, with areas classified as unsatisfactory or worse declining from 35 km^2 to 32.5 km^2 in 1999. Seriously polluted areas declined by 40% during this period.			⇧	**C**
	1995-1999 *Clyde estuary environmental quality:* Overall quality improved with a major reduction in seriously polluted areas.			⇧	**C**
	1970s-1980s Changes in the quality of benthic and fish fauna in the Clyde: Improving water quality of the Clyde resulted in an increase in the diversity of invertebrate communities and increasing fish species, and a decrease in the once dominant pollution tolerant species.				
	Fish species increased from 25 in the late 1970s to 40 in the late 1990s.			**62.5%** ⇧	**C**

[1]Reliability of change or trend between the specified years: **T** = an increasing (or decreasing) trend established; **C** = change clearly established between first and last year, but no clear evidence for a trend; **c** = change probable but not fully-established; c = changed indicated but not well-established. A blank indicates that assessment of change was not appropriate. Statistical significance was tested where possible (at the 5% level).

Table 14.6 Summary of marine trends (continued)

Topic	Trends	Decreasing	Static	Increasing	Reliability of trend[3]
Mariculture	**1979-1999** Scottish production of farmed salmon increased from 1,789 tonnes to around 133,000 tonnes			⇧	**T**
	1979-1999 The total number of salmon farm sites increased from 17 to 351			⇧	**T**
	1986-1999 Production of farmed shellfish for the table increased, with 237 production sites reported in 1999. Mussel production increased from 262 tonnes in 1986 to 1400 tonnes in 1999			**43%** ⇧	**T**
Climate and sea level Change	**1862-1999** Tidal records from Aberdeen have recorded an overall sea level rise of 0.6 mm per year.			**0.6mm/yr** ⇧	**C**
	At 2001 the rate of relative sea level change for some southern mainland coasts is uncertain or unchanging but is estimated to be rising by 1mm per year for the Northern Isles and Outer Hebrides.		⇔ Greater central Scotland	⇧ North and eastern extremities	**c**
	1969-1999 There was an increase in storminess, indicated by an increase in wave height of 2.5-7.0 mm per year.			**2.5-7mm/yr** ⇧	**T**
	1980-1998 Average Summer sea temperature increased by 0.5°C every 10 years, while average winter temperatures increased by 1.0°C.			**0.5°C (Summer) 1.0°C (Winter)** ⇧	**C**
	Beyond 2001, 20 southern marine species may extend their range into Scottish coastal waters.			**20 species** ⇧	
	A further 72 southern species currently recorded in Scotland may extend their distribution or increase their abundance.			**72 species** ⇧	
	A decrease in abundance and extent, or complete disappearance has been predicted for 34 species.	**34 species** ⇩			
Basking Shark	**1946-1953** Scottish west coast fisheries recorded a reduction in catch of around 30%.	**30%** ⇩			**C**
	1982-1994 A Firth of Clyde fishery recorded a decline in catch of around 90% in 12 years.	**90%** ⇩			**C**
	1946-1996 The combined North Atlantic fishery recorded a decline in catch of around 90% in the period between the late 1960s and early 1980s.	**90%** ⇩			**C**
Seals	**1989-2000** Harbour or common seal populations remained stable at around 29,600.		⇔		
	1984-1997 Grey seal populations increased steadily at an average rise of 6% per year.			**6% per year** ⇧	**T**

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15 Scottish marine fisheries

The scale of marine capture fisheries, both geographically and quantitatively, represents one of the greatest human-induced modifications of maritime ecosystems. Globally, over 80 million tonnes (including shellfish) were estimated to have been landed in 1999 (FAO, 2000). More than a quarter of world fish stocks are considered to be either overfished or in imminent danger of stock collapse.

In view of their ecological importance UK commercial fish species have been identified for conservation action through a Grouped Species Biodiversity Action Plan.

Marine fisheries have been extremely important to the economy and culture of Scotland.

Over a thousand species of fish have been recorded in the NE Atlantic and North Sea region. Of these about 5% are considered to be commercially exploitable. Around 20 species constitute approximately 95% of total fish biomass. In the North Sea, of an estimated 10 million tonnes of fish, approximately 2.5 million tonnes (excluding discarded fish) are landed annually (Box 15.1).

Exploitation of marine species in Scottish waters has a long history, with a wide range of species being taken from intertidal, coastal and offshore habitats. The fishing industry continues to be of great importance to the economy and culture of Scotland. For example, in 1999:

- landings by Scottish-based vessels were valued at around £400 million or about 0.7% of Scotland's' GDP;
- Scottish vessels accounted for over 60% of the value of all landings by the UK fleet;
- 71% of all fish landings in the UK were made in Scotland;
- the Scottish fleet employed approximately 7,330 people working on a total of 2,585 vessels.

The number of people employed in the Scottish fishing industry declined by almost 13% between 1995 and 1999, largely due to an inability to sustain catch levels and attempts to limit catches of stocks that had become dangerously depleted.

The fishing industry comprises three main sectors:

Demersal - species that live mainly close to the seabed, such as cod, haddock, whiting and flatfishes. Caught principally with trawls, but static gill and tangle nets may also be used. Demersal fish have historically attracted a greater value per unit weight and have been preferentially harvested. Overexploitation has resulted in a steady decline in demersal fish landings, with a decrease of greater than 10% for 16 of the 34 commercially important species between 1995 and 1999.

Pelagic - species that may range over considerable depths, such as herring or mackerel, but are caught either close to the surface or in mid-water using seine nets or pelagic trawls. Catches of pelagic fish have increased steadily since the 1960s, partly due to the decline in demersal populations. Depleted herring stocks forced a six-year fishery closure in the latter part of the 1970s (Box 15.4), but overall pelagic species have continued to grow in importance. Landings of five of the nine most commercially important species increased by more than 10% between 1995 and 1999.

Shellfish - traditionally includes species that have either a hard shell, such as scallops, cockles, mussels, winkles and buckies (whelks), or an exoskeleton, such as edible crabs, velvet crabs, crayfish, lobster and Norway lobster. Shellfish are caught using trawls, baited creels or pots and occasionally bottom-set nets. The harvesting of shellfish has increased considerably in recent times. Between 1984 and 1997 the total UK shellfish catch more than doubled to over 142,000 tonnes. Landings of five of the ten most commercially important species in Scotland increased by greater than 10% between 1995 and 1999.

Four main characteristics of exploited populations are currently examined on an annual basis (Box 15.2).

The effects of overfishing are compounded by the practice of discarding unmarketable fish. Fleets subject to EU regulations are obliged to discard undersized fish, but fish of commercially acceptable size may also be discarded if catches are in excess of quotas, or if the condition of a proportion of the catch threatens to affect grading and thus reduce economic returns. The great majority of the returned fish do not survive.

In the North Sea demersal fishery the estimated average proportions of discarded cod and haddock are 22 and 36% respectively by weight, representing 51% and 49% by numbers. Only approximately half of the plaice caught by beam trawl may be retained, decreasing to 20% in shallower inshore grounds. For every tonne of Norway lobster landed from the Irish Sea trawl fishery just under half a tonne of whiting are discarded as bycatch.

Apart from effects on the target species, dredging or trawling is known to have a significant impact on seabed habitats and their associated biota. The functional design of most bottom trawls or dredges is such that both the seabed surface and the underlying sediment, perhaps to a depth of 25 cm, may be disrupted.

For over a century the North Sea has been one of the most intensively fished areas of the world. In general, trawling activities have been concentrated in a small proportion of the total area which are swept repeatedly over a short space of time. The long-term effects have recently been evaluated by combining data from a range of sources. The major conclusions were as follows:

- Parts of the North Sea have undergone a change in the species composition of the seabed community between the start of the 20th century and 1986, with an overall replacement of bivalve molluscs with scavenging crustaceans and seastars.

- There has been a fishing mortality-associated decline in large, long-lived species, but an overall increase in total benthic biomass resulting from an increase in abundance of opportunistic species.

Trends

None of the species commercially exploited within Scottish waters are currently considered to be in danger of global extinction, since they often have a wide geographical range with established populations thousands of kilometres apart. However, many species maintain genetically discrete stocks, differentiated by the areas in which they choose to spawn, develop and feed. Depletion of individual stocks has brought some to the point of collapse.

- Of the 12 species for which Scottish data are available, nine are currently considered to be outside safe biological limits (Table 15.1).

- In the ten-year period between 1989 and 1999 spawning stock biomass of some stocks of cod (Box 15.3), whiting and plaice declined substantially (Table 15.2).

- Landings of almost all species have declined (Table 15.2), either because of imposed catch restrictions or an inability to locate adequate supplies.

- Depletion of stocks of traditionally-fished species has stimulated the targeting of previously unexploited species, such as monkfish and a number of species only found in the deeper, offshore grounds (Box 15.5).

Trends in Scottish marine fisheries are summarised in Table 15.4.

Key sources: Food and Agriculture Organization of the United Nations; Frid *et al.* (2000); ICES (2000); OSPAR Commission (2000a); Rumohr & Kujawski (2000); FRS Marine Laboratory, Aberdeen; Scottish Executive (2000).

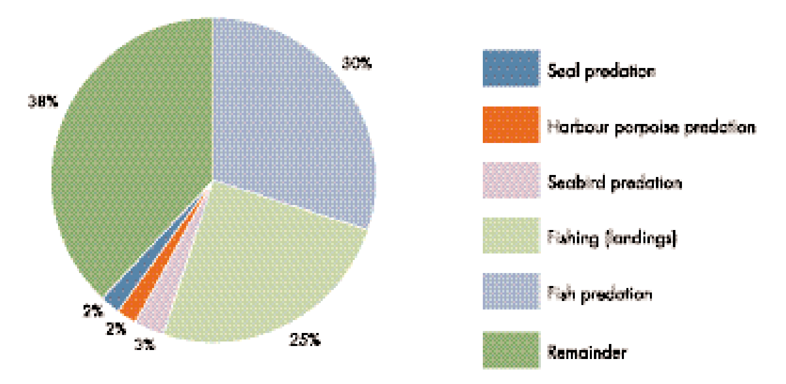
Box 15.1 The fate of fish in the North Sea

The removal of commercially exploited fish species from the North Sea has been variously reported as between 25 and 30% by weight. When compared against available estimates for removal by natural predation, fishing activities constitute a significant extraction of North Sea fish resources (Figure 15.1).

Estimates are based on:

- A total estimate of 10,000,000 tonnes of commercially exploited and non-target fish in the North Sea (Fifth International Conference on the Protection of the North Sea, 1997)
- Annual consumption by predatory fish of 3,000,000 tonnes per year (Anon., 1991)
- North Sea fish landings of 2,500,000 tonnes (excluding discards) per year (Fifth International Conference on the Protection of the North Sea, 1997)
- Annual seabird consumption of 250,000 tonnes per year (Camphuysen & Garthe, 2000)
- Approximately 300,000 harbour porpoises (Hammond *et al.*, 1995) consuming 2 kg of fish per day (Hislop, 1992)
- Approximately 36,000 harbour and 61,000 grey seals within the North Sea area (OSPAR Commission, 2000b) consuming 6 kg of fish per day (SMRU, pers. comm.).
- Remainder comprised of removal by other predators, natural mortality, fishery discards and survivors

Figure 15.1 Annual fate of fish in the North Sea



Box 15.2 Characteristics used to determine the state of commercially exploited fish stocks.

Landings	The total annual reported tonnage of fish removed from the stock and landed by the fishing fleet.
Spawning stock levels	Measured as Spawning Stock Biomass which is the total estimated weight of fish that are mature enough to be able to spawn.
Fishing mortality	A measure of the total amount of fish that are removed from a particular stock each year by fishing activities. A fishing mortality of 1.0 corresponds to a 60 – 70% reduction in stock over the course of one year.
Recruitment	The number of young fish produced each year that survive to become adults and enter the fishery.

Source: FRS Marine Laboratory, Aberdeen

Table 15.1 The state of fisheries of greatest commercial importance

Species	Stock Assessment	Stock Health
Herring (P)	● Spawning stock level below the proposed precautionary stock biomass level (data available for North Sea only) ● Fishing mortality is close to or below the proposed precautionary level ● Recent recruitment has been above average	North Sea stocks are considered to be outside safe biological limits. The status of the west of Scotland stocks is uncertain.
Cod (D)	● Spawning stock level below the proposed precautionary stock biomass level ● Fishing mortality is above the proposed precautionary level for west of Scotland stocks, but below for the North Sea stocks ● Recent recruitment below average	Currently considered to be outside safe biological limits.
Haddock (D)	● Spawning stock level are below the proposed precautionary stock biomass level in the North Sea, but above for west of Scotland stocks ● Fishing mortality is above the proposed precautionary level ● Recent recruitment near to, or below average	Currently considered to be outside safe biological limits.
Whiting (D)	● Spawning stock level below the proposed precautionary stock biomass level ● Fishing mortality is above the proposed precautionary level for west of Scotland stocks, but below for the North Sea stocks ● Large fluctuations in recruitment, but a consistent decline has been observed for a number of years	Currently considered to be outside safe biological limits.
Saithe (D)	● Spawning stock level below the proposed precautionary stock biomass level ● Fishing mortality is above the proposed precautionary level ● Recruitment considered to be stable	Currently considered to be outside safe biological limits.
Norway pout (D)	● Spawning stock level currently low but expected to increase ● Fishing mortality considered to be low ● Large fluctuations in recruitment with no real trend	North Sea stocks are considered to be within safe biological limits. The status of the west of Scotland stocks is uncertain.
Sandeel (P)	● For the past 20 years spawning stock biomass, fishing mortality and recruitment has fluctuated without trend	North Sea stocks are considered to be within safe biological limits. The status of the west of Scotland stocks is unknown.
Monkfish (D)	● Current spawning stock levels uncertain ● Fishing mortality is above the proposed precautionary level ● No data available on recruitment	Currently considered to be outside safe biological limits.
Mackerel (P)	● Spawning stock level well above the proposed precautionary stock biomass level ● Fishing mortality is above the proposed precautionary level ● Recent recruitment has been above average	Currently considered to be outside safe biological limits.
Plaice (D)	● Spawning stock level below the proposed precautionary stock biomass level (data available for North Sea only) ● Fishing mortality is above the proposed precautionary level ● Recent recruitment at or above average	Currently considered to be outside safe biological limits.
Sole (D)	● Spawning stock level above the proposed precautionary stock biomass level ● Fishing mortality is above the proposed precautionary level ● Recent recruitment at or above average	Currently considered to be outside safe biological limits.
Norway Lobster	● Catch rates suggest current levels of fishing are acceptable ● Recruitment largely stable	Status of stocks variable, although most stocks are considered to be fully exploited.

Bracketed letters: (D) demersal species, (P) pelagic species

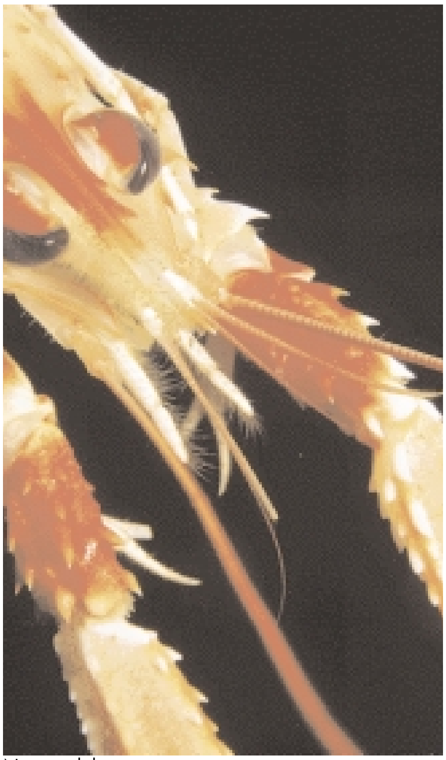
Source: ICES, 2000

Table 15.2 Characteristics of important commercially exploited fish stocks: ten-year trend (1989-1999)

Species	Area of Assessment	Landings	Fishing Mortality	Spawning Stock Biomass
Herring	North Sea	53% ⇩	37% ⇩	27% ⇩
Cod	North Sea	31% ⇩	4% ⇩	27% ⇩
Cod	West of Scotland	76% ⇩	11% ⇩	76% ⇩
Haddock	North Sea	3% ⇧	8% ⇩	3% ⇩
Haddock	West of Scotland	22% ⇩	22% ⇩	18% ⇩
Whiting	North Sea	52% ⇩	36% ⇩	46% ⇩
Whiting	West of Scotland	36% ⇩	5% ⇩	1% ⇩
Saithe	North Sea & west of Scotland	3% ⇩	34% ⇩	76% ⇧
Norway pout	North Sea	46% ⇩	22% ⇩	74% ⇧
Sandeel	North Sea	31% ⇩	28% ⇩	109% ⇧
Mackerel	North Sea	4% ⇧	2% ⇧	40% ⇧
Plaice	North Sea	52% ⇩	13% ⇩	47% ⇩
Sole	North Sea	19% ⇧	7% ⇧	48% ⇧

Source: ICES (2000)

Sandeels

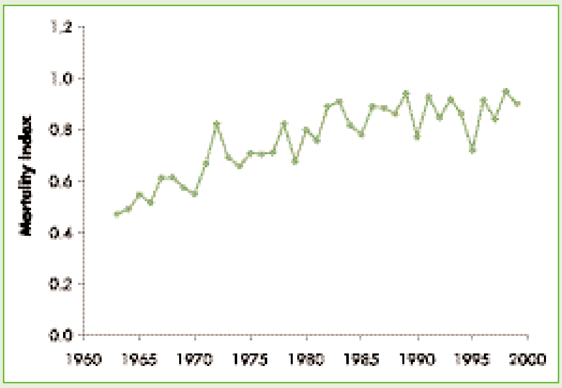


Norway lobster

Box 15.3 Cod stocks

Figure 15.2 Changes in cod fishing mortality

a) North Sea (ages 2-8)



b) West of Scotland (ages 2-5)

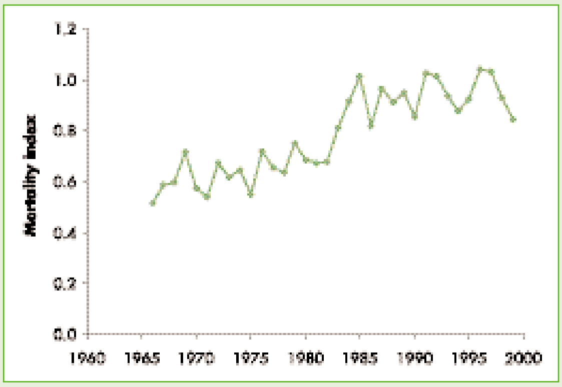
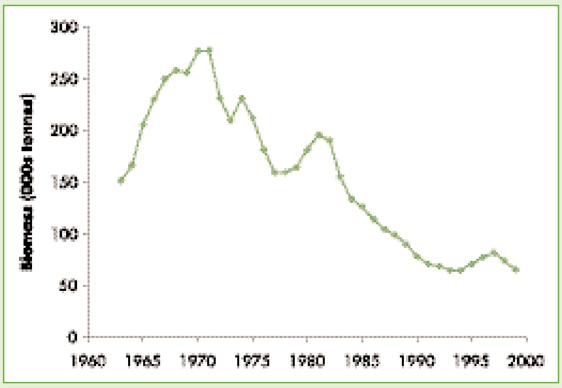
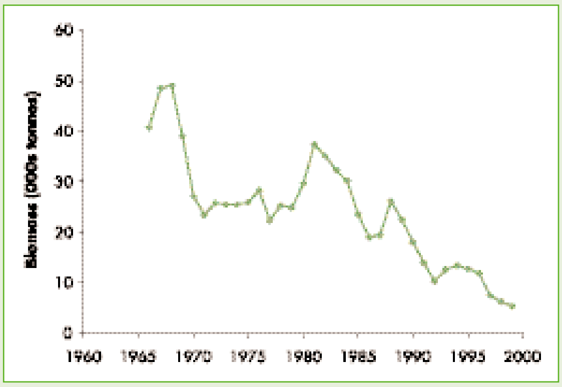


Figure 15.3 Changes in cod spawning stock biomass

a) North Sea



b) West of Scotland



By 1999 the status of cod stocks from all UK sectors was giving cause for concern. Fishing mortality had increased steadily since the 1960s (Figure 15.2) with a notable increase for the west of Scotland stocks in the first half of the 1980s.

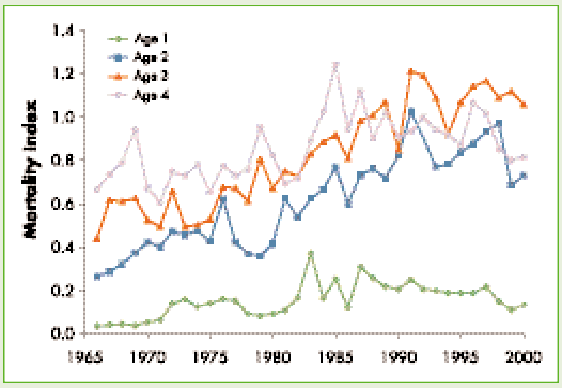
Spawning stock biomass of North Sea stocks had been declining since the early 1970s, and was followed by west of Scotland populations in the 1980s (Figure 15.3). Some stocks fell below estimated precautionary levels in 1984 and continued to decline thereafter. Recruitment, although variable, was consistently poor in the 1990s, with the 1997 North Sea year class being the poorest on record. By 1999, all cod stocks within UK waters were considered to be outside safe biological limits. Continued exploitation at current levels is thought likely to risk imminent stock collapse.

Increasing pressure has been exerted on cod populations by the removal of young fish. By the time they reach their second year, the still immature cod are fully exploited and many will not reach maturity. As little as 0.05% of all one year old fish survive to reach their fourth year. Although fishing mortality has increased across all age groups, the two- and three-year age groups have been removed at disproportionately greater rates (Figure 15.4).

Moreover, the growth rate of North Sea cod has declined for reasons which are not clear. This, combined with high mortality of juvenile cod due to discarding, is likely to delay a future recovery of spawning stock biomass levels and leave stocks highly vulnerable to over-exploitation.

Key sources: ICES (2000); FRS Marine Laboratory, Aberdeen.

Figure 15.4 Trends in fishing mortality of different age groups of the west of Scotland cod stock



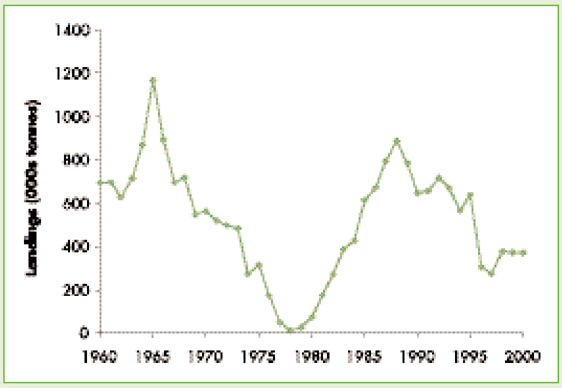
Box 15.4 Herring stocks

The Scottish herring fishery has a very long history, with records of significant trading extending back to at least the 12th Century. Today, herring continues to be an important catch for Scottish fishermen with a combined annual value of around £22 million for west of Scotland and North Sea landings. By weight, herring is the second most abundant species, after mackerel, landed by the pelagic fleet, with the major fishing effort concentrated around Shetland and to the north and west of Scotland. They are caught either by purse seine or pelagic trawl.

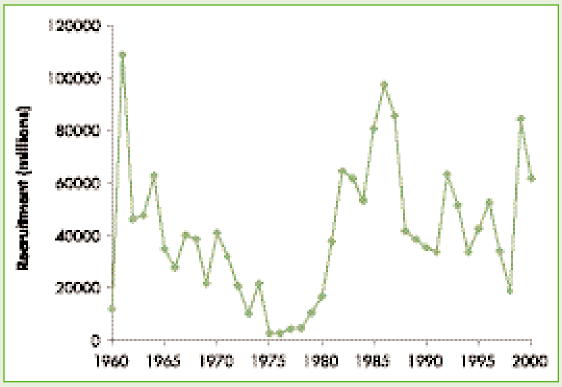
North Sea stocks declined drastically between the early 1960s and 1976 (Figure 15.5), largely as a result of the combined effects of poor survival of young herring and overfishing of adults and immature fish on their nursery grounds. A ban on fishing for herring was initiated in 1977 to allow stocks to recover. This continued until 1983, by which time a recovery appeared to be in progress. By 1996, however, exploitation levels in the North Sea had increased to a level where measures had to be reintroduced to reduce fishing mortality.

Currently, North Sea herring stocks are considered to be outside safe biological limits but a gradual recovery may be in progress. Information has been insufficient to fully assess populations exploited to the west of Scotland, but reports suggest that stocks remain stable and fishing mortality may be decreasing, perhaps because of a poor market for herring compared to other pelagic fish.

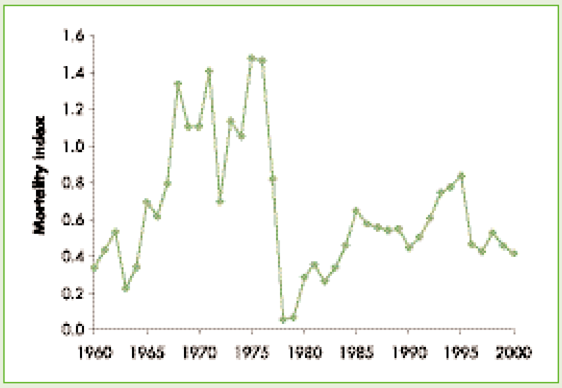
Source: ICES (2001); FRS Marine Laboratory, Aberdeen.



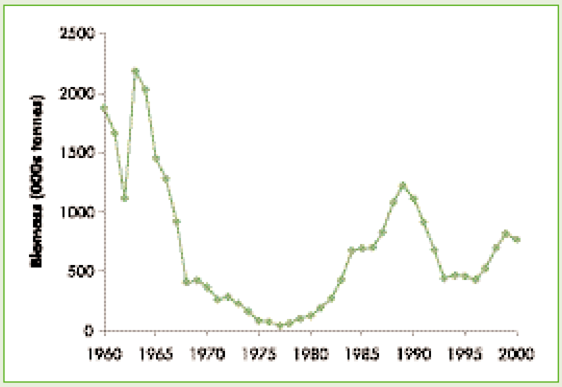
a) Landings



b) Recruitment (age 0)



c) Fishing mortality (ages 2-6)



d) Spawning stock biomass

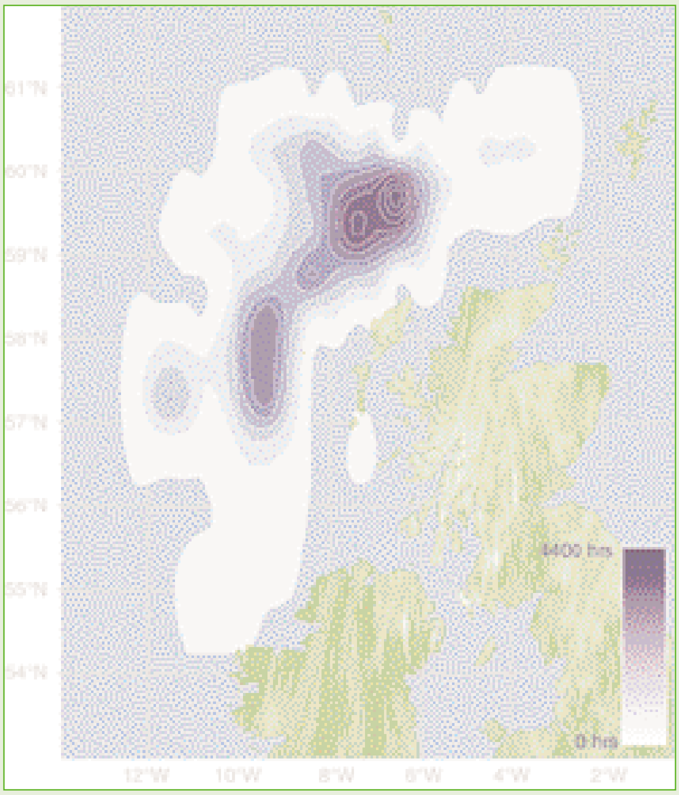
Figure 15.5
Changes in landings, recruitment, fishing mortality and spawning stock biomass for North Sea herring

Box 15.5 Deep-water fisheries

Figure 15.6 Hours fished by French Trawlers landing in Scotland in 1998

As the traditional fisheries of the European continental shelf have declined, catch unreliability and the introduction of fishing quotas has stimulated a growing interest in the exploitation of species that are considered largely outside the range of conventional fishing gear. Despite often being portrayed as a dark and relatively lifeless environment, the zone below 400 metres depth – defined as 'deep-water' by the International Council for the Exploration of the Seas – supports a diverse and abundant fish community. Towed fine-mesh nets deployed for research purposes in the Rockall Trough and along the continental slope have recovered over 130 species, with an abundance peak roughly corresponding to the 1,000-metre depth contour. Of these, around 12 –15 species are of a sufficient individual size and abundance to be considered marketable (Table 15.3).

Some deep-water fisheries are historically well established, notably around oceanic islands with steep inshore slopes such as Madeira and the Azores, but the fishery to the north-west and west of Scotland represents a relatively recent development. Bottom trawling along the continental slopes of northern Europe began in the late 1960s, when the former Soviet Union and other eastern European countries began catching roundnose grenadier. Rapidly increasing catches peaked in the 1970s, but the break-up of the Soviet Union, coupled with the introduction of 200-mile fishery limits around Europe and Iceland contributed to a decline of the fishery. Attempts by other nations, notably Germany and the UK to develop deep-water fisheries failed through lack of consumer interest. However, in the late 1970s French trawlers, traditionally operating along the outer shelf, had begun moving into deeper water, establishing a market for blue ling. By the late 1980s a fishery had developed for other deep-water species formerly landed as bycatch. By 1992 larger French vessels had extended their fishing activities still deeper, exploiting the valuable orange roughy stocks. This fishery has continued to the present and has remained an almost exclusively French enterprise, with the major effort concentrated around the Rockall Trough and Rosemary Bank (Figure 15.6). A number of Scottish vessels fish alongside the French but, in general, deep-water landings are largely derived from bycatch resulting from the targeting of monkfish.



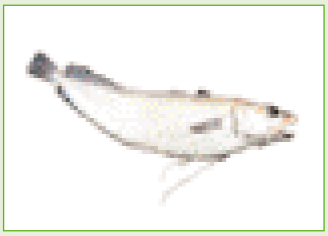
Source: FRS Marine Laboratory, Aberdeen.

Many deep-water organisms are long-lived, slow growing and only achieve maturity at a high age or large size. Consequently, there are concerns that the current level of exploitation may be unsustainable. In addition, the rapid pressure transition associated with recovery from such great depths and the delicate nature of much of the deep-water biota means that there is a high bycatch mortality. The passage of trawl gear may represent a major destructive event to species and habitats in an environment that rarely experiences change. Tracks left by trawling activity are thought to have become a common feature of deep-sea sediments. The damaging effects of fishing activity on the deep-water reef structures constructed by the coral *Lophelia pertusa* are of international concern. Such concerns are reflected in the development of UK Biodiversity Action Plans for both *Lophelia* reefs and deep-water fish. Furthermore, identification of Special Areas of Conservation under the EU Habitats Directive for the protection of these reefs is currently underway.

Key sources: FRS Marine Laboratory, Aberdeen; ICES (2000); Roberts *et al.* (in press); Gordon (2001); Gordon & Hunter (1994).

Box 15.5 Deep-water fisheries (continued)

Blue whiting

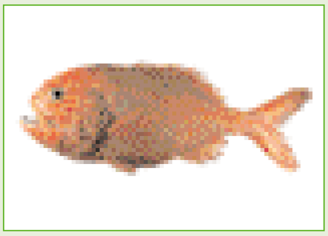


Greater forkbeard

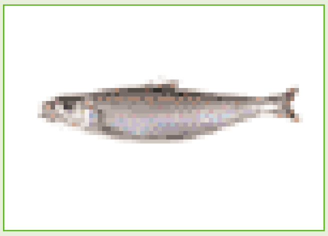
Blue hake

Roundnose grenadier

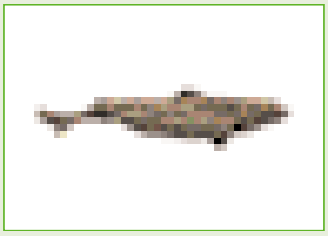
Black scabbardfish



Orange roughy



Greater silver smelt or **argentine**



Portuguese dogfish

Table 15.3 Commercially exploited deep-water fish species

Species	Common Name	State of Stock/Fishery
Micromesistius poutassou	Blue whiting	Considered to be harvested outside safe biological limits.
Molva dyptergia	Blue ling	Total French landings peaked in 1985 at 14,000 tonnes, but fell to only 3,000 tonnes in 1994 and have since remained stable. Currently considered to be harvested outside safe biological limits.
Phycis blennoides	Greater forkbeard	Status of stock unknown.
Mora moro	Mora	Status of stock unknown.
Antimora rostrata	Blue hake	Due to the technical problems of fishing at the depth of greatest density, commercial exploitation is currently not considered viable.
Coryphaenoides rupestris	Roundnose grenadier	Considered to be harvested outside safe biological limits.
Aphanopus carbo	Black scabbardfish	Catches currently stable at around 6,000 tonnes but considered to be harvested outside safe biological limits.
Hoplostethus atlanticus	Orange roughy	Landings by French vessels in the Rockall trough peaked at 3,500 tonnes in 1991, but then declined rapidly to less than 500 tonnes as concentrations became heavily depleted. Currently considered to be harvested outside safe biological limits.
Argentina silus	Greater silver smelt or argentine	Status of stock unknown.
Brosme brosme	Tusk	Considered to be harvested outside safe biological limits.
Centroscymnus coelolepsis *Centrophorus squamosus*	Portuguese dogfish Leafscale gulper shark	French landings of both shark species combined reached a maximum of approximately 3,000 tonnes in 1993, and have remained stable at this level.

Sources: FRS Marine Laboratory, Aberdeen; ICES (2000); Gordon (2001); Gordon & Hunter (1994)

Table 15.4 Summary of trends in fisheries

Topic	Trends	Decreasing	Static	Increasing	Reliability of trend[5]
Landings	**1989-99** Nine fish populations have shown a substantial decline (i.e. of at least 10%) in the annual reported tonnage landed, either because of imposed catch restrictions or an inability to locate adequate supplies. One population has shown a substantial increase, while three have shown relatively little change (Table 15.2).	**9 populations** ⇩	3 populations ⇔	2 populations ⇧	**C**
Fishing mortality	**1989-99** Eight fish populations have shown a substantial decrease in fishing-related mortality, while five have shown relatively little change (Table 15.2).	**8 populations** ⇩	5 populations ⇔	0 populations ⇧	**C**
Spawning stock biomass	**1989-99** Six fish populations have shown a substantial decline in the total estimated weight of individuals mature enough to be able to spawn. Five populations have shown a substantial increase, while two have shown relatively little change (Table 15.2).	**6 populations** ⇩	2 populations ⇔	5 populations ⇧	**C**
Stock health	**1999** Populations of nine of the 12 fish and shellfish species for which Scottish data are available are considered to be outside of safe biological limits (Table 15.3).				

[4] Reliability of change or trend between the specified years: **T** = an increasing (or decreasing) trend established; **C** = change clearly established between first and last year, but no clear evidence for a trend; **c** = change probable but not fully-established; **c** = changed indicated but not well-established. A blank indicates that assessment of change was not appropriate. Statistical significance was tested where possible (at the 5% level).

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Air pollution

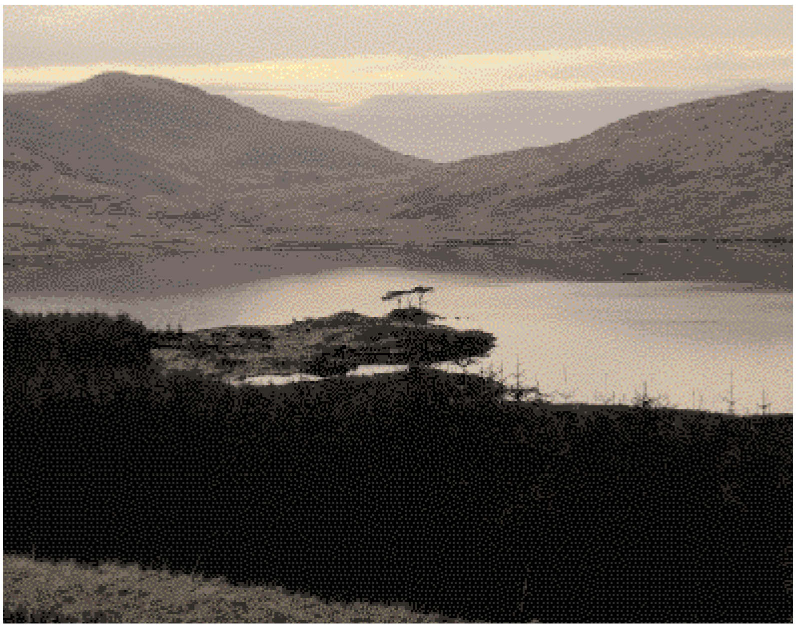
Air pollution in Scotland is a local and an international concern. The social issues of urban air pollution have received prominent attention, but the potential impacts of air pollution in rural areas and on the natural heritage are less well known. Air pollution may lead to degradation of habitats, loss of species, a reduction in agricultural and forestry productivity, and damage to fish stocks.

The climate and geography of Scotland leads to marked gradients in air pollutant concentrations from the relatively unpolluted areas of the north-west, remote from pollutant sources, to the more polluted regions of the Forth and Clyde lowlands.

Air pollutants which can pose a threat to the natural heritage and the problems with which they are associated include:

- acidification of soils and fresh waters from acidifying pollutants dominated by sulphur and nitrogen compounds (Box 16.1 and 16.2);
- eutrophication of natural ecosystems by nitrogen compounds (Box 16.3); and
- damage to vegetation from photochemical oxidants (summer smog) dominated by ground level ozone (Box 16.4).

Some of the Galloway lochs, such as Loch Fleet have become acidic. Invertebrates and fish have suffered declines.



These pollutants present country-scale problems. Other pollutants, such as heavy metals, are more local in nature, or are restricted to urban areas.

The pollutant emissions which influence Scotland come from both domestic and European sources. The geographical position of Scotland at the north-west fringe of the European continent provides a source of largely clean air and rain from the west. Only with easterly or southerly winds do heavily polluted air masses reach Scotland from industrial areas in Europe, as occurred in 1986 following the Chernobyl accident. The rapid transport of pollutants by wind (typically 800 km per day) leads to the exchange of large quantities of pollutants across national boundaries.

The long range transport of pollutants in Europe has been the subject of extensive research, and methods to assess the threat to natural ecosystems have been developed for individual countries including the UK (CLAG, 1997) and at the European scale (EMEP, 2000). The scale of damage to natural ecosystems by acidifying pollutants led to an international protocol in 1985 to reduce the main contributor (sulphur) to the problem. Since then, further protocols have been negotiated and gradually, new agreements have included a wider range of the pollutants contributing to acidification (sulphur and nitrogen oxides). The more recent protocols, including the Gothenburg protocol of 1999, have been extended to address problems of eutrophication of natural ecosystems by the deposition of nitrogen compounds and the formation of summer smog (low level ozone).

Trends

Protocols have reduced emissions of sulphur and nitrogen oxides throughout Europe during the last two decades. The air quality in Scotland is therefore improving and, in particular, the amounts of sulphur and acidity deposited throughout the country are projected to decline further in response to the reduced emissions in the UK and continental Europe (Table 16.1).

- **Sulphur** (S): emissions in the UK declined from a peak in 1970 of approximately three million tonnes to 780,000 tonnes in 1998, a reduction of 74%. Concentrations and deposition of sulphur in Scotland have also declined throughout the country. Sulphur emissions are set to decline by a further 50% over the coming decade as a result of the Gothenburg protocol.

- **Oxidised nitrogen**: emissions peaked much later (1990) than those of sulphur and by 1998 declined by about 30%. They are scheduled in the Gothenburg protocol to decline by a further 50% to 1,181,000 tonnes by 2010.

- **Reduced nitrogen** (ammonia): emissions changed little in the last decade. The Gothenburg protocol target for reductions by 2010 is 16% reduction on emissions based on 1990 values.

- **Ozone**: peak concentrations declined by about 30% between the 1980s and 1990s. However, mean concentrations remained constant or increased slightly. Whilst peak concentrations will probably decrease further by 2010, mean concentrations are likely to increase.

Effects of air pollution on the natural heritage include: acidification of soils and freshwaters resulting in reduced freshwater biodiversity; changes in the species composition of the semi-natural flora of Scotland as a consequence of the deposition of nitrogen, with a reduction in the number of species; and physiological and productivity effects on the flora resulting from exposure to elevated ozone concentrations.

'Critical loads' provide a quantitative estimate of the maximum load of a pollutant that an ecosystem can receive without causing damage. Exceedance maps compare critical loads with measured or modelled inputs of pollutants. Thus the potential for damaging effects in ecosystems (soil, fresh waters, vegetation) can be quantified.

The modelled depositions of pollutants for the year 2010 are a guide to expected environmental improvements resulting from the most recent international protocol signed at Gothenburg in 1999.

- The total acidifying inputs to rural Scotland have decreased since 1970. By 2010, expected reductions in acid deposition are 50% for sulphur and oxidised nitrogen, and 14% for reduced nitrogen relative to 1995/97 values.

- The area where critical loads for acidity for soils is exceeded will decrease in Scotland by 12% between 1995/97 and 2010.

- The area where critical loads for acidity for fresh waters is exceeded will decrease in Scotland by 67% between 1995/97 and 2010.

- By 2010, nitrogen deposition is expected to decline by between 20 and 35%. Deposition will become increasingly dominated by reduced nitrogen.

- The area where critical loads for nutrient nitrogen (leading to eutrophication) is exceeded for peatlands will decrease by 37% between 1995/97 and 2010.

- Predicted trends in the exceedance of critical levels of ozone for semi-natural vegetation indicate a reduction in exceedance of about 20% over the coming decade.

Key sources: trends in concentration and deposition to the present day are derived from measurements. Projections for the future are based on the agreed Gothenburg protocol emissions. The projected emissions are used with the Hull Acid Rain Model (HARM) for sulphur and oxidised nitrogen (Metcalfe *et al.* 1998) and the Fine Resolution Ammonia Exchange Model (FRAME) (Singles *et al.*, 1998).

Sources include emissions data from the DETR National Air Quality Archive, deposition of pollutants data from CEH Edinburgh, Critical Loads and exceedance data from CEH Monks Wood and modelling of pollutant concentrations from The Department of Geography Edinburgh University and CEH Edinburgh.

Other key sources are: NEGTAP (in prep.), CLAG (1994, 1995, 1996a,1996b, 1997), DETR (1998, 1999), EMEP (2000), Fowler *et al.* (1997) and Monteith *et al.* (2000).

Box 16.1 Acidification of soils

Acid deposition from the atmosphere can cause the acidification of soils. This effect has been documented throughout Europe in regions where acidifying inputs (essentially sulphur and nitrogen compounds) have exceeded the buffering capacity of soils. For some acid-sensitive soils, large reductions in soil pH have been recorded during the latter half of the 20th century. Thus, in the case of Scotland, the soils which are most at risk are those which weather slowly, releasing only limited quantities of base cations which neutralise acidity.

Many upland soils are naturally acidic. The carnivorous sundew, a peatland plant, is adapted to extremely low nutrient levels.

The annual acid deposition (averaged over the period 1995 to 1997) has been compared with the critical loads for soils, and exceedances of the critical loads mapped (Figure 16.1). Substantial areas of exceedance in 1995/97 occurred in the uplands of south-west Scotland, centred on Galloway, in the west central highlands and in the eastern Grampian mountains.

- Projections for 2010 (Figure 16.2), based on the 1999 Gothenburg protocol show reductions in the areas and the magnitude of exceedance, especially in those areas with largest exceedances for the 1995/1997 period.
- Between 1995/97 and 2010, the predicted area for which critical loads for acidity for soils are exceeded in Scotland will decline from 68,376 km^2 to 59,937km^2. This reduction of 12% will be important in reducing potential damage to semi-natural ecosystems throughout Scotland.
- Areas that will still remain in exceedance (78% of Scotland) will include large tracts of the west central highlands and south west Scotland. Substantial areas of the lowlands to the north east of the Cairngorm mountains will be also in exceedance of critical loads, largely from the deposition of ammonia.
- A marked change has been from acidic deposition dominated by sulphur in the l980s and early 1990s to acidifying inputs dominated by nitrogen compounds by the turn of the 21st century and beyond.

Figure 16.1 Exceedance of acidity critical loads for soils in Scotland for 1995/97 using non-marine sulphur and total nitrogen (NO_x + NH_x).

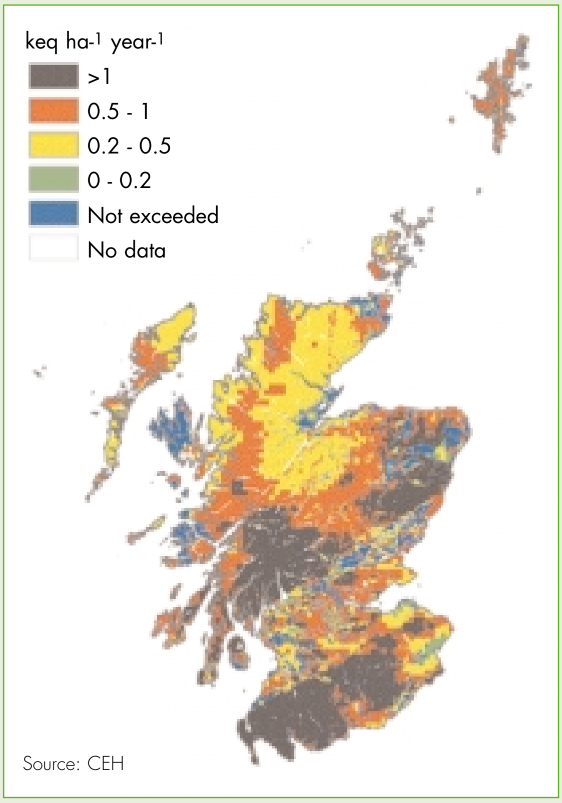
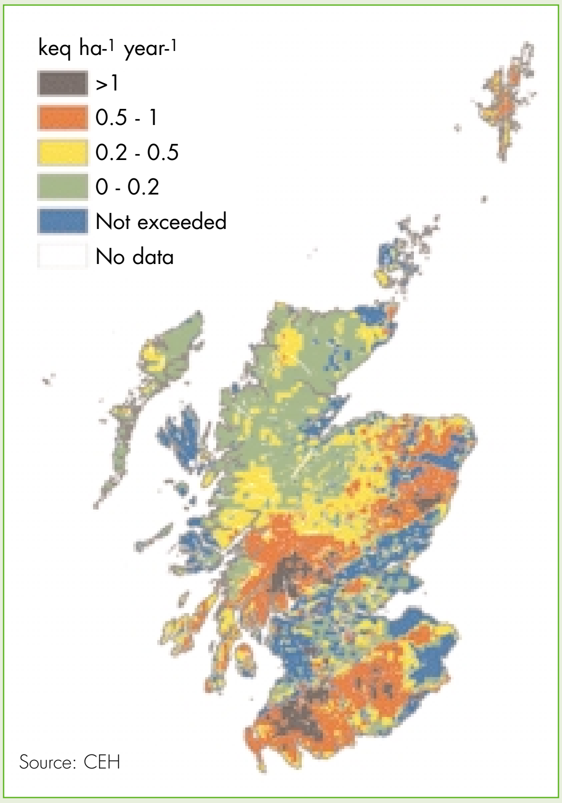


Figure 16.2 Exceedance of acidity critical loads for soils in Scotland for 2010 using non-marine sulphur and total nitrogen (NO_x + NH_x).



Box 16.2 Freshwater acidification

The acidification of freshwaters in Scandinavia and loss of important fish populations were the first major ecological effects documented in the early days of acid deposition research. Many of Scotland's freshwaters subsequently showed a similar degree of sensitivity to acid deposition. In Scotland, effects have been noticed in the wildlife, including invertebrates, fish, birds and diatoms.

A model was used to calculate catchment-based freshwater critical loads (Curtis *et al.*, 1988). The areas of greatest sensitivity of freshwaters to acid deposition follow the same geographical patterns as those of soils because the buffering of soils regulates freshwater sensitivity.

Future projections based on the 1999 Gothenburg protocol require the application of emission, transport, transformation and deposition models.

- Current (1995-1997) deposition of acidifying pollutants to fresh waters by sulphur and nitrogen compounds has resulted in exceedance of the critical load for acidity of freshwaters in 12% (461 km^2) of the area examined (3,755 km^2). The areas in exceedance of critical loads, like those for the soils, are mainly in the high wet deposition areas of the west central highlands and south-west Scotland, as well as in the Cairngorm mountains and the southern uplands.
- The commitment by the UK and other European countries to reduce emissions by the year 2010 will result in a marked reduction in deposition of acidifying pollutants, especially sulphur. Critical loads for freshwater will be exceeded in about 4% of the ecosystem area assessed.
- Between 1995/97 and 2010, the predicted decrease in the measured areas for which the critical loads for acidity for freshwaters are exceeded in Scotland is from 461 km^2 to 152 km^2, representing a reduction of 67% (309 km^2) compared to 1995/97 figures.
- The areas in exceedance will be restricted to Galloway and the high deposition area of the west central highlands, but in both regions the magnitude of the exceedance will be small relative to the values for 1995-1997.

The recovery of the freshwaters will depend not only on a reduction in the acidifying inputs. Substantial quantities of sulphur adsorbed by soils may be released to the soil water, thus slowing the chemical recovery of freshwaters. The time scale for changes in freshwater chemistry differs from that of biota. It will take longer for freshwater chemistry and biology to recover than the timescale over which reductions in pollution exceedance occurs.

Dippers feed on freshwater invertebrates and prefer fast-flowing upland rivers. Acidification of such water bodies has reduced the dipper's invertebrate food source and its breeding success in acidified waters.

Brown trout have declined in a number of lochs due to water acidification. Deformed trout were found in Loch Enoch in Galloway, which no longer supports fish.

Box 16.3 **Eutrophication of peatlands**

As emissions of sulphur have declined, and with it the problems of acidification, the focus of attention has moved from sulphur to nitrogen compounds. The emission, long range transport and deposition of nitrogen has been present throughout the last 100 years, but was until recently a minor contributor to acidification relative to sulphur. The prominence of nitrogen has however been steadily growing so that by the late 1990s the potential acidification from nitrogen compounds exceeded that of sulphur in Scotland.

Nitrogen compounds are deposited at rates in the range 2 to 50 kg per hectare per annum. Such inputs of a major plant nutrient can affect semi-natural plant communities, many of which are adapted to an environment in which nitrogen has been the limiting nutrient and where natural atmospheric inputs were smaller than 2 kg per hectare annually.

Racomitrium lanuginosum has been adversely affected by increased deposition of nitrogen.

Nitrogen inputs to these plant communities can cause change in species composition, such as from heathland to grassland (Heil & Bobbink, 1993). In general, species adapted to low levels of nitrogen are most at risk. Changes in species composition in Scotland have been readily observed along deposition gradients close to major sources of NH_3 (Pitcairn *et al.*, 1998). There is further evidence from national surveys (Firbank *et al.*, 2000) that deposition of nitrogen has regional scale effects.

The main contributors to the critical load exceedance is dry deposition of ammonia (NH_3) and wet deposition of ammonium (NH_4). A 14% decline in reduced nitrogen emissions (ammonia), largely from agricultural sources, is expected by 2010.

Peatlands are sensitive to atmospheric nitrogen inputs (Heil & Bobbink, 1993), with a critical load taken to be 10 kg of nitrogen per hectare per year (Hall *et al.*, 1998).

- Critical load exceedance for nutrient nitrogen on peatlands in Scotland amounts to an area of 22,125 km^2 exceeded (Figure 16.3), or about 45% of the area examined (49,625km^2)in which peatland ecosystems were present. Critical loads were exceeded in central and southern Scotland and less so in north-west Scotland.
- Emission reductions to be achieved by the year 2010 (Figure 16.4) are predicted to lead to a 37% decrease in the area of exceedance from 22,125 km^2 to 13,975 km^2. The predicted area of 13,975 km^2 represents 28% of the area examined by the analysis in which peatland ecosystems were present.

Figure 16.3 Exceedance of nutrient nitrogen critical loads for peatlands in Scotland for 1995/97 using deposition data.

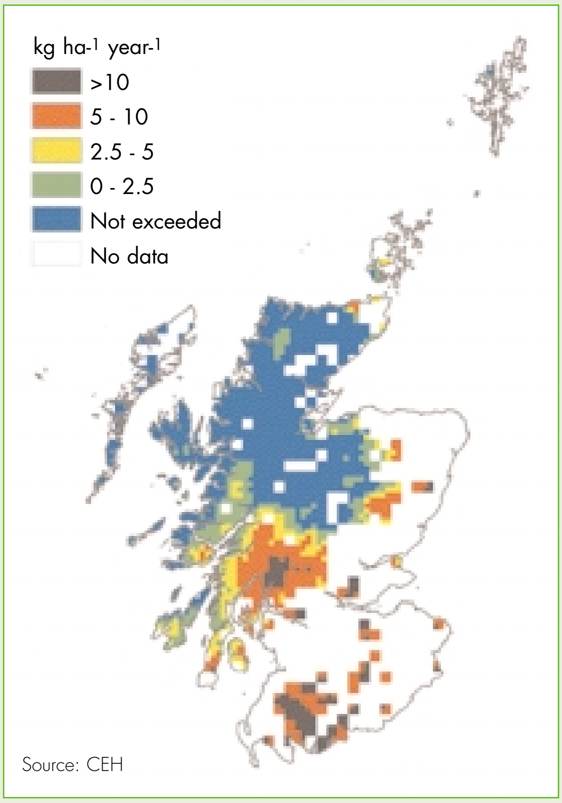
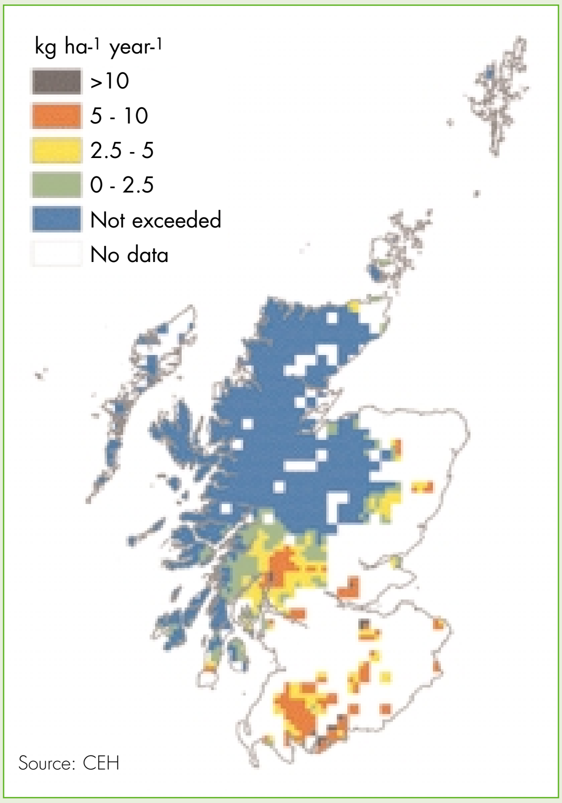


Figure 16.4 Exceedance of nutrient nitrogen critical loads for peatlands in Scotland for 2010 using deposition data (scaled from 1995/97 data).



Box 16.4 Ground level ozone

Ground level ozone is present naturally and as a consequence of human activity. Since the turn of the 20th century average concentrations of ozone in surface air have doubled to values close to 30 parts per billion (ppb). Elevated ozone concentrations have been shown to be damaging to human health. The average ambient concentrations of ozone are close to health effects thresholds, but these are exceeded throughout Scotland on warm summer days with wind bringing pollutants from source areas in the south and east.

The threshold for effects of ozone on vegetation is not known precisely because the range of sensitivity in semi-natural vegetation is large.

- A decline of around 30% in peak concentrations, from values of around 140 ppb in the 1980s to values closer to 100 ppb in the late 1990s, resulted from the reductions in emissions of ozone precursor gases (nitrogen oxides and volatile organic compounds).

- However, while the peak concentrations of ozone were declining, average concentrations remained constant or increased. As the threshold for plant (and human health) effects is close to ambient concentrations, even a small increase in mean ozone concentration can be important.

The potential for effects of ozone on vegetation is generally expressed as a cumulative exposure to ambient concentrations in excess of 40 ppb (AOT_{40}). A critical level of 3,000 parts per billion hours (ppbh) accumulated during daylight hours during a 3 month growing season has been defined for both crop and semi-natural vegetation. Mapped AOT_{40} exposures for semi-natural vegetation in Scotland show values ranging from 1,000 ppbh in the west and the north of the country, increasing towards the east and south to values in the range 4,000 ppbh to 5,000 ppbh.

Semi-natural vegetation on some of Scotland's mountains tops is potentially at risk from exposure to high levels of ozone.

- There are substantial areas of Scotland where critical levels for ground level ozone are exceeded, with the tops of mountains, especially in the east of the country, receiving some of the largest exposures (Figure 16.5).

- Between 1986 and 1998, ozone concentrations exceeded critical levels for effects on semi-natural vegetation across approximately 30% of Scotland, with some of the largest exceedances in the eastern uplands.

Based on the 1999 Gothenburg protocol:

- Emissions of the two main ozone precursor pollutants will be reduced substantially by 2010. This is predicted to result in a reduction in the AOT_{40} in the UK by about 1,000 ppbh, representing a 20 - 30 % reduction in exposure.

- Exceedance of critical levels for semi-natural vegetation is predicted to fall by about 20% over the coming decade.

Modelling at global scales suggests that the global background concentration of ozone is steadily increasing (Collins *et al.*, 2000). So, while a reduction in ozone in Scotland is predicted by current regional models, these benefits may disappear as the global mean background ozone concentration increases.

Figure 16.5 Ozone: Exceedance of AOT_{40} above the critical level of 3,000 ppb hours for semi-natural ecosystems and crops (1992-1996).

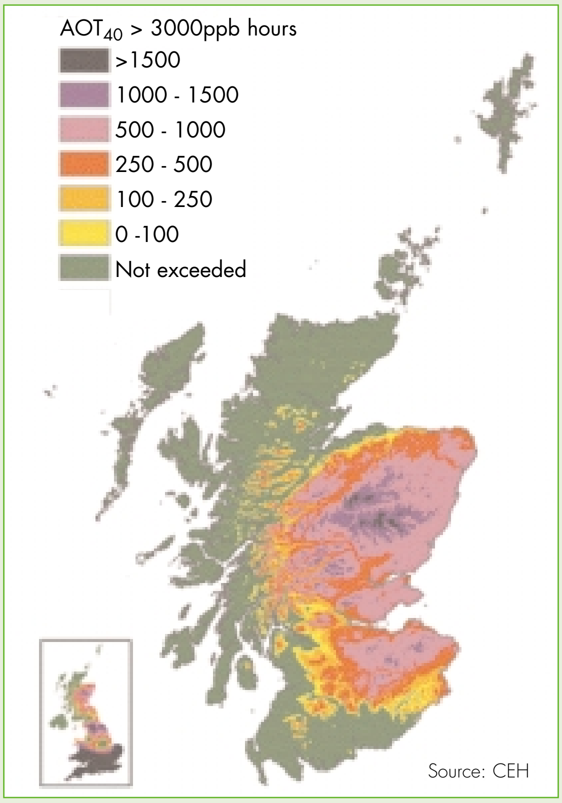


Table 16.1 Air pollutant emissions and concentrations in rural Scotland

Measure	Trends	Decreasing	Static	Increasing	Reliability of trend[1]
Sulphur (S)	**1970-1998**: sulphur emissions in the UK, which dominate deposition in Scotland, declined from a peak in 1970 of approximately three million tonnes to 780,000 tonnes in 1998, a reduction of 74%.	74% ⇩			C
	1995/97 - 2010: a further decline of 50% is expected by 2010 relative to 1995/97 levels.	50% ⇩			
Oxidised nitrogen (NO_x,NO_2)	**1990-1998**: oxidised nitrogen emissions peaked around 1990, but declined by 30% by 1998. Post 1990, emissions and concentrations of nitrogen dioxide declined in rural areas. Concentrations have exceeded those of sulphur dioxide almost everywhere.	30% ⇩			C
	1995/97 - 2010: a further decline of 50% of oxidised nitrogen is expected by 2010, relative to 1995/97 levels.	50% ⇩			
Reduced nitrogen (NH_3)	**1990-2000**: reduced nitrogen concentrations changed little in the last decade.		⇔		
	2000-2010: a decline of 16% in reduced nitrogen emissions is expected by 2010 relative to 1990 levels.	16% ⇩			
Ozone (O_3)	***Peak ozone***	30%			C
	1980s-1990s: peak ozone concentrations declined by around 30% from values typically 140 parts per billion (ppb) in the 1980s to 100 ppb in the late 1990s.	⇩			
	2000-2010: peak ozone concentrations will probably decline.	⇩			
	Ambient ozone				
	1980s-1990s: there were no significant trends in accumulated exceedances of exposures to ambient concentrations greater than a threshold of 40 ppb (AOT_{40}).		⇔		
	2000-2010: AOT_{40} is expected to decline in the UK by about 1,000 ppbh, representing a 20% to 30% reduction in exposure.	20%-30% ⇩			
	Mean ozone				
	1980s-1990s: mean ozone concentrations were constant or increased slightly.		⇔		
	2000-2010: mean ozone concentrations are likely to increase.			⇧	

[1]Reliability of change or trend between the specified years: **T** = an increasing (or decreasing) trend clearly established; **C** = change clearly established between first and last year, but no clear evidence for a trend; **c** = change probable but not fully-established; c = change suggested but not well-established. A blank indicates that assessment of change was not appropriate. Statistical significance was tested where possible (at the 5% level).

Table 16.1 Air pollutant emissions and concentrations in rural Scotland (continued)

Feature	Trends	Decreasing	Static	Increasing	Reliability of trend[1]
Acid deposition	**1970-2000:** total acidifying input to rural Scotland declined, mainly due to a reduction in sulphur emissions. Nitrogen compounds now dominate acidifying inputs.	⇩			**C**
	1995/97 - 2010: expected reduction in acid deposition of >50% for sulphur and oxidised nitrogen relative to 1995-1997 values.	**50%** ⇩			
	1995/97 - 2010: expected reduction in acid deposition of 14% for reduced nitrogen relative to 1995-1997 values.	**14%** ⇩			
	1995/97 - 2010: critical load exceedance modelling predicts a decrease of 12% (68,376 km^2 to 59,937 km^2) in the area of soils for which the acidity critical loads are exceeded.	**12%** ⇩			
	1995/97 - 2010: deposition of acidifying pollutants to fresh waters in 1995-97 resulted in exceedance of the critical load for acidity of fresh waters in 12% of the ecosystem area examined. By 2010, and under current emission reduction targets, this area will be reduced to 4%, representing a decrease of 67% (461 km^2 to 152 km^2) compared to the 1995-97 figure.	**67%** ⇩			
Eutrophi-cation	**1990-2010:** values for nitrogen deposition in Scotland between 1990 – 1995 represented a peak in existing record. Nitrogen deposition is expected to decline by 2010 by between 20% and 35%. The magnitude of reduction is uncertain due to uncertainties in reduced nitrogen (NH_x) emission and deposition. Nitrogen deposition to semi-natural vegetation will be increasingly dominated by reduced nitrogen as emissions of oxidised nitrogen (NO_y) decline more than reduced nitrogen.	**20%-35%** ⇩			
	1995/97 - 2010: emission and deposition reductions will lead to a decrease in the area of exceedance of the nitrogen critical load for peatland by approximately 37% (22,125 km^2 to 13,975 km^2).	**37%** ⇩			
Ground level Ozone	**1980s-1990s:** mean ozone concentrations were constant or increased slightly with ambient concentrations close to the threshold for plant and human health effects.		⇔		
	1992/96 - 2010: between 1992 and 1996, ozone concentrations exceeded critical levels for effects on semi-natural vegetation across approximately 30% of Scotland. However, by 2010 predicted trends indicate a reduction in exceedance of about 20%.	**37%** ⇩			

[1]Reliability of change or trend between the specified years: **T** = an increasing (or decreasing) trend established; **C** = change clearly established between first and last year, but no clear evidence for a trend; **c** = change probable but not fully-established; c = changed indicated but not well-established. A blank indicates that assessment of change was not appropriate. Statistical significance was tested where possible (at the 5% level).

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17 A changing climate

Scotland lies close to the boundary, the polar front, between cold polar air flows and warmer westerly winds (Figure 17.1). Latitudinal shifts in the polar front determine whether polar or more maritime weather prevails across Scotland. Usually westerlies predominate, their characteristics affected by the warm ocean current, the North Atlantic Drift, over which they pass. This ensures that Scotland has a more temperate climate than other places at these latitudes.

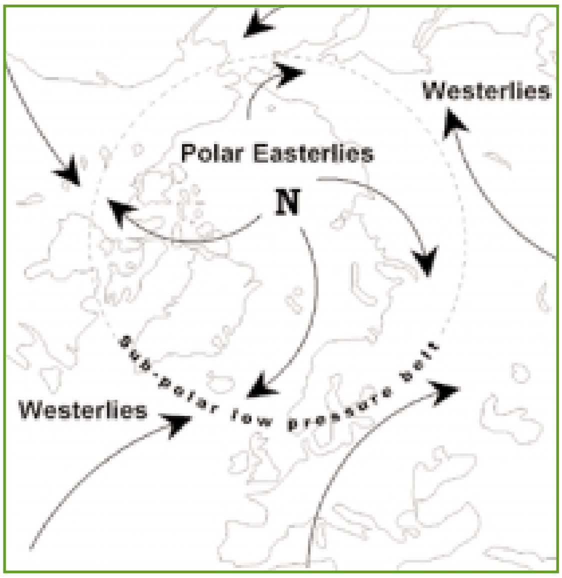


Figure 17.1 The location of the polar front, the boundary between polar airflows and westerly winds, showing the direction of polar easterlies and the mid-latitudinal westerlies.

Cycles in the Earth's orbit and axis of spin have caused global glacial and inter-glacial periods. About 10,000 years before present (bp), the Earth emerged from the latest glacial period. Scottish temperatures in January probably rose by 1˚C with July temperatures rising by 5˚C over a time-frame of about 500 years (Bishop & Coope, 1977). By 5,000 years bp, annual temperatures in Scotland were possibly 1-1.5˚C higher than those of the mid-20th century (Price, 1983). Since then Scotland's average winter and summer temperatures have fluctuated by small amounts, notable periods being between 1150 and 1300 AD when summer temperatures increased by 0.5-0.9˚C and winters were mild (Price, 1983), and between 1300 to 1700 AD when conditions were colder, wetter and stormier.

Between 1900-1950 Scotland's average annual temperature was 0.4˚C warmer than at any time since the 15th century (Price, 1983) and increased by a further 0.4˚C by 1996 (Harrison, 1997). The climatic trend across Scotland by the end of the 20th century was of a rapid warming.

Naturally occurring gases in the atmosphere absorb thermal radiation without which the average temperature of the Earth today would be -6˚C instead of about 15˚C. These are termed 'greenhouse gases' and include water vapour, carbon dioxide and trace quantities of methane and nitrous oxide. The concentrations of these, and other greenhouse gases, have increased over the last two centuries. There is now firm evidence that these are responsible for the current climatic changes rather than the natural changes in the Earth's orbit (IPCC, 2001).

Over the last century, global temperatures rose by 0.3-0.6˚C. This is an average rise across the globe and includes areas of cooling that have also occurred, for instance, over some parts of the North Atlantic Ocean (Houghton *et al.*, 1996). This rise in temperature has been associated with changes in seasonal and diurnal weather patterns around the Earth.

Trends

Increases in greenhouse gas emissions and various climatic variables have occurred since the 19th century (Table 17.1).

- During the 20th century, countries in latitudes north of 55˚ (which includes Scotland) experienced a temperature rise greater than the global average, for example, Europe warmed by 0.8˚C (Beniston & Tol, 1998). Within Scotland, the diurnal temperature range decreased with a spring temperature rise of 0.5˚C having occurred between 1960 and 2000 (Harrison, pers comm) (Box 17.1).

- During the 20th century, precipitation over land increased in the high latitudes of the northern hemisphere, contrasting with a decline in rainfall in the sub-tropics (Nicholls *et al.*, 1996). Within Scotland, the wettest decades on record occurred during the 1990s (Box 17.2).

- Although there has been little evidence of any increase in mean annual wind speed or maximum gust strength within Scotland (Tabony, 1993), westerly air flows and the frequency of days with gales have both increased (Mayes, 1994).
- Over the 20th century, cloud cover has increased in many parts of the World, including Scotland (Nicholls *et al.*, 1996). Days with bright sunshine in Scotland have decreased in winter since the 1970s, particularly in the west (Harrison, 1997).

Box 17.1 Temperature

The benchmark of a change in climate is the change in air temperature measured at the surface of the planet. Temperature is usually a significant determinant of the limit of a species' distribution, for example in governing whether a physiological process can occur (such as pollen tube growth) or determining water availability (freezing temperatures can be as much a stress factor as excessive evaporation caused by high temperatures). Temperature is also important in activating life cycle processes such as bud burst or egg laying.

The greatest warming has been in winter, particularly in the high-mid latitudes of the northern hemisphere (Nicholls *et al.*, 1996). From 1988, the extent of snow cover in the northern hemisphere has been below the 1974-1994 average (Nicholls *et al.*, 1996). Within Scotland, the number of air frosts during the winter half year have correspondingly declined (Harrison, 1997).

Globally, the difference between the maximum (day) and minimum (night) diurnal temperatures has decreased. This is due to a faster rise in night-time temperatures, which has been particularly marked in the northern hemisphere (Nicholls *et al.*, 1996).

As winters have become milder, **Snowdrops** have been emerging earlier in the Spring.

Within Scotland the decrease in diurnal temperature range has been most pronounced in spring, with a rise of 0.5˚C between 1960 and 2000 (Harrison, pers. comm.).

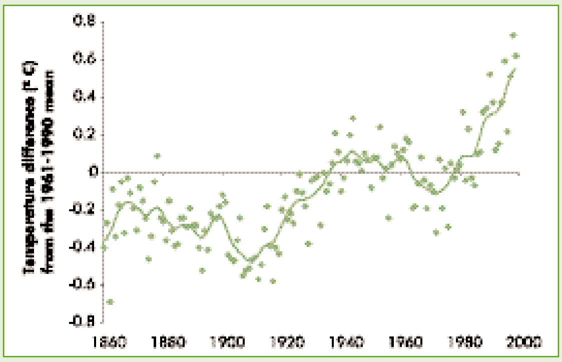
Changes in minimum temperatures have a greater ecological effect than any other temperature change.

Coastal and off-shore temperatures around Scotland have also increased since the 1970s. Coastal sea temperatures increased by around 1˚C, with warming most apparent in winter (Turrell, 1999). Off-shore sea temperatures increased by 1-1.5˚C (Turrell, 1999).

Minimum temperatures of oceanic waters during the 1990s were the highest recorded during the 20th century (Turrell, 1999). This closely matched the trend of the near-surface air temperature of the northern hemisphere of the 1900s.

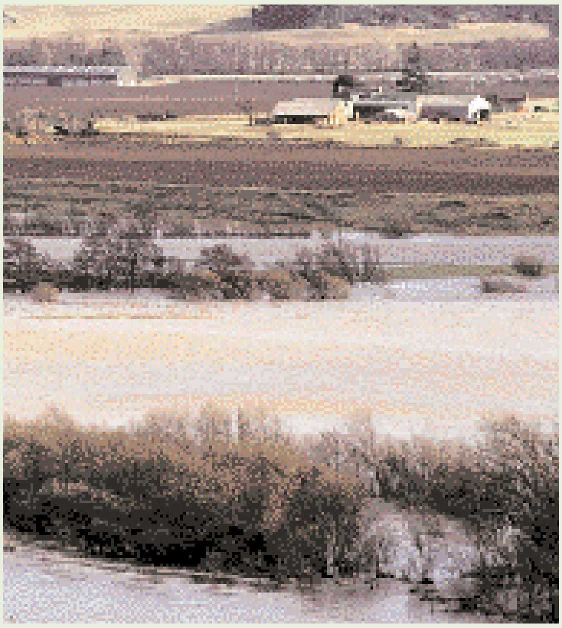
Warming in Scotland is expected to continue to be greater in winter than in summer. Globally, increases of 1.5-5.8˚C are projected for the next century (IPCC, 2001).

Figure 17.2 Annual combined land surface air and sea surface temperature anomalies (˚C) for the period 1860-1999, relative to the average for 1961-1990 for the northern hemisphere north of 20˚C .



Source: Parker *et al.* (2000). Reproduced by SNH with permission from the Meteorological Office, Bracknell. Crown copyright.

Box 17.2 Precipitation



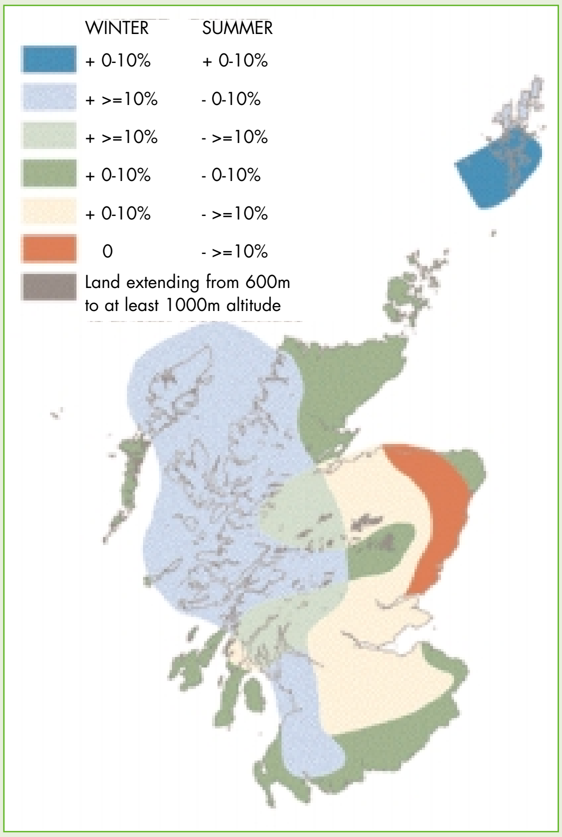
Flood plain of the River Earn in Perthshire

The amount and seasonality of precipitation (this includes rain, sleet, hail and snow) is a major influence on vegetation. High rainfall may promote peatland or forest whilst areas of low water availability are associated with vegetation adapted to water stress. The volume and intensity of precipitation can also affect the physical structure of a habitat and rates of erosion, whilst the chemical quality (determined by levels of pollutants) affects terrestrial and freshwater ecosystems.

Across Scotland there is a west-to-east precipitation gradient due to the prevalence of westerly winds. There are marked contrasts between the lowlands and uplands with areas above 400 metres in elevation generally receiving more than 1,000 mm a year.

Although there has been an increase in precipitation across the northern hemisphere during the twentieth century, the level seems to have been much greater within Scotland. By 1993, the two wettest decades on record ended in 1990 and 1992, both of which had 14% more than the average decadal value (Smith & Werritty, 1994).

Figure 17.3 Trends in precipitation patterns between 1941-1970 and 1961-1990.



Source: SNH. Derived from Mayes (1996).

Both geographical and seasonal trends were observed across Scotland during the 20th century. In summary, the west became wetter and the east drier, whilst winters became wetter and summers drier (Figure 17.3).

The largest change in precipitation for any individual month occurred in March when average rainfall increased by nearly 32% between the average for the 1940s-1960s to that for the 1960s-1980s. In contrast May-June and July became distinctly drier (Mayes, 1996).

The increase in total annual precipitation in Scotland has been associated with an increase in the number of heavy rainfall events as well as a greater number of days with rain (Smith & Werritty, 1994). This is a pattern that is appearing in other countries in the northern hemisphere (Nicholls *et al.*, 1996).

On average, the total annual precipitation in Scotland is expected to increase by 3-7% by 2010-2040 (Hulme & Jenkins, 1998). Autumn and winter are expected to receive the greatest increase. It is possible that summer precipitation may continue to decline in some areas. Trends from last century indicate that this may occur in the north-east around Aberdeenshire but UK models predict that it might occur in the Borders.

Table 17.1 Historic trends in greenhouse gas emissions and climate change, globally and across Scotland

Measure	Trends	Increased	Decreased	Reliability of trend[1]
Greenhouse gases	**Carbon dioxide** **1750-1992**: global CO_2 concentrations increased by nearly a third through the use of fossil fuels and changes in land use.		**30%** ⇧	**T**
	Methane **1750-1992**: methane concentrations more than doubled due to agriculture, waste disposal, fossil fuel production and use.		**146%** ⇧	**T**
	CFCs During the early 1900s, the atmospheric concentration of CFCs was zero. By 1992, the concentration was 0.882 ppbv (parts per billion by volume) as a result of use in refrigerators and aerosol spray cans.		**83%** ⇧	**T**
	Nitrous oxide **1750-1992**: agricultural and industrial processes caused a 15% rise in N_2O.		**15%** ⇧	**T**
Climate variables	**Temperature** On average, the Earth warmed by 0.3-0.6˚C over the 20th century. The high mid-latitudes increased by more than the global average, for example Europe warmed by about 0.8˚C. Minimum temperatures, which have the most effect on species, have risen faster than maximum temperatures. In Scotland, the minimum temperature in spring rose by 0.5˚C between 1960 and 2000.		**Spring 0.5˚C** ⇧	**T**
	Precipitation During the 20th century, precipitation over land generally increased outside the tropics and declined in the sub-tropics. In Scotland, precipitation patterns changed seasonally and spatially. Precipitation declined in the summer half-year from the 1970s but annual totals increased due to the higher levels received in the winter half-year. Highest annual rainfalls on record occurred in the 1990s.		**Winter 32%** ⇧	**T**
	Winds In Scotland the number of gales has increased since 1972/73, as have the frequency and strength of westerly winds since 1981.		**Variable** ⇧	**C**
	Cloud cover Over the 20th century, cloud cover has increased in many parts of the world, including Scotland. Days with bright sunshine in Scotland have decreased in winter since the 1970s, particularly in the west.		**Up to 16%** ⇧	**T**

[1] Reliability of change or trend between the specified years: **T** = an increasing (or decreasing) trend established; **C** = change clearly established between first and last year, but no clear evidence for a trend.

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Climate change impacts on habitats and species

The ice sheets that had covered Scotland disappeared by about 10, 000 years before present (bp)[1]. At this time, the climate across Scotland was not dissimilar to that of the 20th century. Over the next few hundred years, grasses and sedges colonised from the south, followed by crowberry, juniper and patches of willow scrub. Birch was the first dominant tree, reaching to the far north by 9,000 years bp (Peglar, 1979). In the lowlands, hazel also occurred in hazel-birch stands (Lowe, 1993; Whittington *et al.*, 1991). Oak colonised later, around 7,800 years bp.

By 7,500-5,000 years bp, Scotland had its greatest extent of woodland cover (Bennett, 1989). At this time, pine covered the Highlands (Bennett, 1984; Bridge *et al.*, 1990). However, cooler, wetter conditions occurred about 5,000-4,000 years bp causing large areas of woodland to be replaced by peatlands (Price, 1983). This loss of woodland may also have occurred because of human activities.

Since then, there have been only slight fluctuations in climate. For example, there is evidence of cultivation in some of Scotland's hills during 1200-1300 AD that have not been cultivated since, suggesting that the climate may have been more favourable at this time (Parry, 1978).

The distribution of a species is usually limited by its temperature and precipitation requirements, further to other factors such as soil type and/or the presence of another species. Temperature and precipitation influence the timing of a number of life-cycle events such as leaf burst and egg laying, these often being more important than factors such as day length. Changes in climate are therefore likely to affect species in terms of their distributional patterns, abundance, and the timing of life-cycle events. Examples of such changes have been observed across a range of species during the 20th century.

Plants and animals have a limited ability to adapt to multiple changes in their environment. Historic evidence indicates that species have responded to past climatic changes at rates less than that required to keep pace with the current and predicted rates of climate change.

Species also respond individualistically to climatic change such that the fine synchronism of inter-specific relationships within ecosystems can be disrupted. This may result in the reduction in numbers of some species but in other cases can encourage high numbers of pest species. Other effects arising from climate change, such as changes in habitat structure through erosion or water chemistry, are likely to exacerbate the differences in the individual responses of species.

For some species, expansion northward may be arrested by barriers such as seas, transport networks, and human settlements. This is not particularly problematic for species that are capable of rapid and large-scale migration or dispersal, but will affect less mobile species, including trees and other plants.

There are, therefore, four key issues for habitats and species in the face of the new climatic changes. These are (i) the rate of climate change, (ii) barriers to migration, (iii) the loss of synchrony between species, and (iv) changes in habitat.

Trends

Responses by habitats and species observed over the last century are as follows. These are summarised in Table 18.1.

- Across Europe, a 6-day advancement of leafing in spring occurred between the 1960s and 1998 (Menzel & Fabian, 1999).
- Simultaneously, autumn events have become later. On average across Europe, leaf colouring and leaf fall are occurring nearly 5 days later than they did in the 1960s, extending the growing season by about 10 days (Menzel & Fabian, 1999).
- The extension in the length of the growing season has been even more marked across the British Isles, which had gained three more weeks by 1998 in comparison to 1962 (Rötzer & Chmielewski, 2000).

[1] The dating of events is mostly undertaken by measuring the natural rate of decay of the unstable carbon-14 isotope in fossil samples. Since radiocarbon years do not match calendar years, it is more usual to refer to years 'before present' (bp) referenced from 1950 than to refer to 'years ago'. This radiocarbon technique is believed to be the most reliable dating technique for samples up to 70,000 years old.

- As a consequence, the breeding distributions of a number of bird and butterfly species have shifted northwards across Britain during the 20th century. However, the fast rate of warming means that not all species are able to keep pace with the northward shift of their climatic space (Box 18.1).

- A number of British species have responded to earlier spring warming either in producing leaves earlier, earlier arrival by migrant birds, or earlier reproduction (Box 18.2).

- Heavier downpours of rain cause rapid stream discharges. This has altered the physical structure of habitats such as riverbanks and floodplains (Werritty & Acreman, 1985), in places washing out young fish and uprooting beds of freshwater pearl mussels (Hastie *et al.*, 2001).

- Wetter winters and drier summers are also believed to have affected the structure of peatlands. Whilst gullying is a natural phenomenon, there are signs that there are now more frequent and larger forms of peatland erosion.

An uphill shift in climate zone may reduce the amount of habitat available for montane species such as the mountain hare.

On average across Europe, leaf colouring and leaf fall are occuring nearly five days later than they did in the 1960s.

Box 18.1 Rates of responses by species

Rapid rates of temperature increases occurred at the end of the last Ice Age across Scotland, between 13,000 and 10,000 years bp. These are believed to have been so rapid because of changes in ocean currents. With the exception of last century, any increase in temperature per century has been no greater than about 0.5 ˚C. A predicted rise of 1.5-5.8˚C over the next century is therefore rapid (IPCC, 2001) (Table 18.2).

Table 18.2 Past and future rates of temperature change across Scotland

Time period	Warming ˚C	Rate ˚C/century
Medieval warm period, AD 900 – AD 1200[1]	1.0-2.0	c.0.5
Last 100 years[2]	0.8	0.8
Next 100 years[2]	1.5-5.8	1.5-5.8

Source: [1]Mayes and Wheeler, 1997; [2]IPCC (2001)

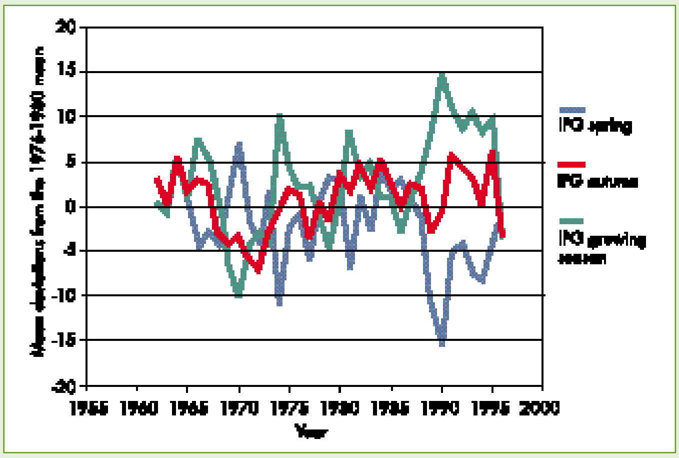
If species are to remain within their optimal temperature range, for each 1˚C rise in mean surface air temperature, they would need to shift northwards by 250-400 km or uphill by 200-275 m. There is no evidence that species are shifting at such rates and there is concern that the rate of climate change could be too rapid for many species to adapt. This means that species may be stranded in locations where conditions are sub-optimal for their survival.

Historic evidence indicates that tree species with wind-borne seeds (e.g. elm and maple) may be capable of expanding their ranges northwards by about 100 km a century (Hinckley & Tierney, 1992). This is much less than even the lowest estimate of 375 km for a 1.5˚C rise over the next century. Palaeobotanical records indicate that dispersal rates for species with large nuts, such as oak and beech, are even less - in the order of 20-50 km a century (Hinckley & Tierney, 1992). It is estimated that the rate of northward expansion across Scotland of Scots pine circa 4,000 years ago was 37-80 km a century (derived from Gear & Huntley, 1991).

Bird and other winged species are the most capable of rapid dispersal, given suitable habitat. A comparison of the breeding distributions of bird species between two time periods, 1968-1972 and 1988-1991, showed that terrestrial and freshwater bird species with southerly distributions in Britain had, on average, expanded northwards by 19 km over the intervening two decades (Thomas & Lennon, 1999). This approximately equates to a potential rate of 95 km a century.

Over the last century, the northern limits of 34 species of butterflies shifted 35-240 km northwards across Europe (Parmesan *et al.*, 1999). Only 10 of these species showed any northward shift of their southerly limits, indicating that most of these butterfly species had expanded in range.

Figure 18.1 Annual departures from the 1976-1980 mean spring phases and autumn phases, and the resulting annual departure from the mean length of the growing season in the International Phenological Gardens (IPG) of Europe.



Source: Menzel, A. & Fabian, P. (1999). Reprinted with permission from the International Journal of Biometeorology.

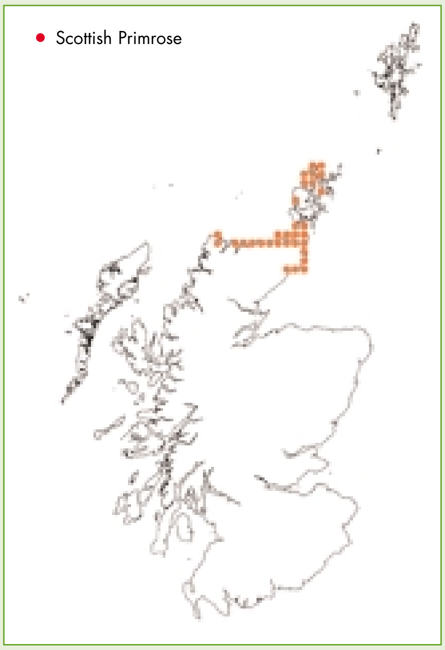


Figure 18.2 The Scottish populations of northern plant species, such as Scottish primrose, Scottish scurvygrass or twinflower, may diminish as northerly limits are reached.

Source: Biological Records Centre

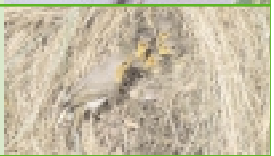
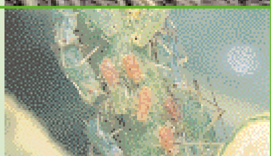
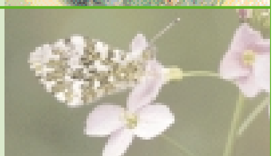
Scottish primrose

Box 18.2 Synchrony between species in spring

Species depend upon various cues from the environment to initiate life-cycle events such as reproduction and bud burst. A number of species rely upon the occurrence of an appropriate temperature, such as a minimum spring temperature. Some species, such as trees, also require a period of chill over the winter months.

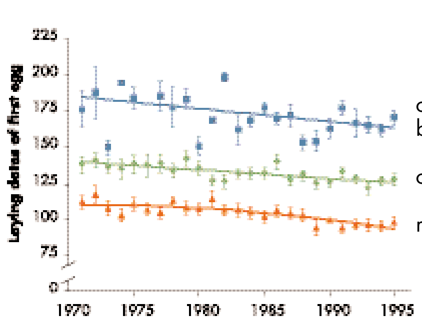
As warmer spring temperatures mean earlier attainments of required springtime temperatures, life-cycle events in some species have become correspondingly earlier. However, a steady increase in spring temperature does not affect species uniformly (Table 18.2).

Table 18.2 Examples of earlier springtime events in Britain related to an increase of 1˚C in annual mean air surface temperature

Springtime Event	Days earlier/1˚C	
Trees in leaf [1]	5-7	
Robins and chaffinches laying eggs[2]	3 & 2 resp.	
Swallows arriving in Britain[3]	2-3	
Springtime arrival of newts to ponds[4]	9-10	
Spawning by the natterjack toad[4]	9-10	
Emergence of the peach-potato aphid[5]	16	
First flights of the butterflies: painted lady, small copper and orange tip[6]	10, 9 & 6 resp.	
First flight of the common footman moth [5]	8	

Sources: [1]Sparks & Carey, 1995; [2]Crick, 1999; [3]Sparks & Loxton, 1999; [4]Beebee, 1995; [5]Sparks & Woiwod, 1999; [6]Sparks & Yates, 1997

Figure 18.3 Changes in laying dates of early-season nesters (magpie), mid-season (chiffchaff) and late-season (corn bunting). Laying date is numbered such that day 60 is 1 March, 121 is 1 May and so on. Points show means ± standard error.



Source: Crick, H.Q.P., Dudley, C., Glue, D.E. & Thomson, D.L. (1997). UK birds are laying eggs earlier. Nature, 388, 526. Reprinted by SNH with permission from Nature and the lead author. Copyright (1997) Macmillan Magazines Limited.

A study assessing the capacity of Scottish populations of birch with earlier spring warming indicated that the predicted rate of change in temperature will be too rapid for native populations of birch to evolve earlier dates of bud burst (Billington & Pelham, 1991). Birch has been found to delay bud burst following summers of drought (Sparks, Carey & Combes, 1997).

It is not expected that Scottish populations of birch will produce earlier leaves at the same rate as the springs become warmer.

Table 18.1 Trends in UK and European species' distributions, abundances and lifecycle events that have been attributed wholly or partly to recently observed trends in climate.

Measure	Trends	Decreasing	Stable	Increasing	Reliability of trend[1]
Growing season of trees and shrubs	Growing seasons have extended since the early 1960s with, on average, a 6 day advancement of leafing in spring and a delay in autumnal events, such as leaf colouring, by about 5 days (Menzel & Fabian, 1999). This is associated with a 0.8°C increase in temperature across Europe during the 20th century.			**c.11 days per 0.8°C** ⇧	**T**
Abundance of an arctic-alpine species	The abundance of Iceland purslane in one location in Scotland has declined between 1997-1999, associated with recent warm temperatures and heavier rainfalls (Meatyard, pers. comm.).	**43-79%** ⇩			**C**
Abundance of a northern bird species	Heavier rain downpours and the associated chilling of chicks, along with the mis-timing of hatch with their invertebrate food source, have been two factors implicated in the decline of capercaillie numbers in the 1990s (Kortland, 2000).	**16% p.a.** ⇩			**T**
Migrant arrival	Swallows are arriving in Britain earlier after winter migration (Sparks & Loxton, 1999).			**2-3 days earlier per 1°C** ⇧	**T**
Bird reproduction	Some species, such as the robin or chaffinch, are laying their eggs earlier (Crick, 1999).			**2-3 days earlier per 1°C** ⇧	**T**
Amphibian reproduction	Spawning dates for newts, frogs and toads have become earlier (Beebee, 1995).			**c.10 days earlier per 1°C** ⇧	**T**
Invertebrate reproduction	The first appearance of 13 butterfly species has been found to be occurring significantly earlier than the dates of first appearance noted in the mid-1970s. These have been associated with warmer spring or summer temperatures (Roy & Sparks, 2000).			**2-10 days earlier per 1°C** ⇧	**T**
Distribution range of southern birds	Terrestrial and freshwater species have, on average, expanded their northerly limits across the British Isles by c.19 km over 20 years (Thomas & Lennon, 1999).			**Northern limits** ⇧	**T**
Distribution range of invertebrates	The northern limits of some 34 species of butterflies have migrated northwards by 35-240 km over the last 30-100 years (Parmesan *et al.*, 1999).		**Southern limits** ⇔	**Northern limits** ⇧	**T**

[1]Reliability of change or trend between the specified years: **T** = an increasing (or decreasing) trend established, **C** = change clearly established between first and last year, but no clear evidence for a trend.

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19 Synthesis

Many of the environmental issues encountered in Scotland are also relevant in other parts of Europe. Twelve prominent European environmental problems, identified in the mid-1990s, are climate change, loss of biodiversity, acidification (and eutrophication), photochemical pollution, and stresses in fresh water, forest, coastal zone and urban environments (Stanners & Bourdeau, 1995).

How do we compare?

As in many other parts of Europe, land use and development pressure have been the main drivers of change in Scotland. Typically, farming, forestry or urban development account for around 80% of the land area in European countries (EEA, 1999). In Scotland the proportion might be as much as 94% (Chapter 5), including large tracts of open hill land which are utilised for extensive grazing, sport and recreation.

Some 60% of Scotland's land (and fresh water) area in 1988 could still be regarded as semi-natural The four decades from the late 1940s to the late-1980s was a period of especially rapid expansion in Scottish farming, forestry and urban development. Consequently, the area of semi-natural habitats was reduced by an estimated 17% over that period (Chapter 4). The 1998 estimate of semi-natural broad habitats, albeit from a very different survey, was similar to and possibly even slightly greater than the 1988 estimate (Chapter 5).

Farmland

Trends in European agriculture point to agricultural polarisation through intensive farming and land marginalisation, both impacting on the environment (EEA, 1999). About 40% of EU land was agricultural and the rural economy, as in Scotland, had become increasingly diversified. In comparison, 71% of Scotland was bounded within agricultural holdings in 2000, but 62% of that was rough grazing (Chapter 10). Agriculture in the EU accounted for slightly more than 5% of employment compared with around 3% in Scotland.

In addition to altering the appearance of the countryside, intensification and specialisation removed habitats for wild plants and animals, such as hedges and field margins. Mixed farming has declined in recent decades, with the west becoming more dominantly pastoral and the east more dominantly arable. As an indication of reduced habitat diversity, hedgerow length was reduced by more than half between around 1947 and 1988 (Chapter 4). Temporary grassland declined by 22% between 1991 and 2000 and permanent grassland increased by 20%. The mixed farm area decreased by 23% between 1987 and 1999.

Higher yielding, autumn-sown wheat and barley eliminate feeding grounds of winter stubble. Concern was expressed in the 1970s that the steady elimination of non-productive land, and the increased efficiency of production, posed threats to nature conservation (Ratcliffe, 1977). Arable weeds declined between 1930-1960 and 1987-1988 (Chapter 10). Reduced hay production (by 34%) and increased silage production (by 8%) between 1991 and 2000 reflect intensified grassland management. An estimated 16% reduction in the extent of calcareous grassland between 1990 and 1998 (although only weakly significant), was due mainly to its conversion to more intensively managed grassland (Chapter 5). Intensified land-use is likely to have been detrimental to species diversity. The contraction of the corncrake has been reversed in Scottish 'Core Areas' under more environmentally friendly farming (Chapter 6).

Since 1992, between 5 and 15% of arable farmland has been set-aside from production on large arable farms. By weight, pesticide use (excluding desiccants on potatoes) declined by 15% between 1982 and 1998, with increased frequency of spraying at lower concentrations. Fertiliser use remained little changed between 1983 and 1998. Nevertheless, agricultural run-off has been implicated in increased nitrate levels in some rivers between 1980 and 2000, with a 17% average increase in the east and a 28% average increase in the north.

An estimated 19% expansion of fen, marsh & swamp between 1990 and 1998 suggests reduced or abandoned grassland drainage in wetter, more economically marginal, areas. Weaker evidence of a 5% decline in the extent of heather moorland points to a continued decline of habitat quality, associated mainly with forest or canopy closure and conversion to grassland (Chapter 5). A 23% decline in the number of crofters between 1960 and 1985, reduced tillage and replacement of cattle grazing by sheep, have changed habitat management in the north-west of Scotland.

Declines in farmland birds from the early-1970s to the late 1990s have been linked to agricultural intensification (Chapter 10). Conversely, wintering wildfowl have benefited from intensively managed grasslands in the west (Chapter 3).

Forest and woodland

In 1995, the average forest and woodland cover in European countries was 33% (Ireland with 6% and Finland with 66% being at extreme ends of the scale). At 17% (in 2000), woodland cover in Scotland was therefore relatively, but not exceptionally, low. Having been reduced to less than 5% by the early 1900s, its expansion to 17% had been due largely to conifer afforestation between the 1940s and 1980s (Chapter 4). In Europe as a whole, the extent of forest and timber production had continued to increase by 1998, predominantly associated with replacement of old and semi-natural woodlands by more intensive and uniform forest management systems based on exotic species. The two most important causes of degradation to natural forests were air pollution (Central, Eastern and to a lesser extent Northern Europe) and fire (Southern Europe).

In Scotland during the 1990s, opportunities had been taken to restructure plantations and, through a greater emphasis on broadleaved planting and local progeny, to restore habitat diversity, connectivity and the naturalness of woodland. A 9% expansion of broadleaved, mixed & yew woodland between 1990 and 1998 (Chapter 5) is in contrast to a 26% decline in broadleaved woodland over the previous four decades (Chapter 4). The area of native woodland in Scotland increased by one third between 1984 and 1999 (Chapter 11), and the area of farm woodland doubled between 1991 and 2000 (Chapter 10), creating and restoring habitat diversity in both lowland and upland environments.

Five out of 14 widespread woodland birds increased in abundance between 1994 and 1999, while one species (pheasant, a managed non-native species) declined.

Urban land

In 1995 it was concluded that sustainability in Europe required urban activities to be brought more into balance with the capacity of ecosystems to provide life support services important to human health. By 1999, improvements had been made in air and water quality but urban greenspace, which ranged from 2% to 70% of European cities, remained at risk from development.

One difficulty in making comparisons is that so little is known about urban greenspace, for example in terms of its extent and composition; its quality for wildlife, relaxation and recreation; its accessibility, particularly into areas of tranquility; or its connectivity for movement on foot or by bicycle. Where it is known, greenspace ranges from around 10-40% of the major Scottish towns and cities (Chapter 9). By the end of 2001, the towns and cities of the Central Belt will be connected by a restored canal network to provide a corridor of greenspace that is remarkable for its diversity and richness, and opportunities for recreation and relaxation. Community woodlands and local nature reserves have increased in number over the past decade. Major improvements have been achieved in water quality since the 1970s, but rivers still classified as polluted tend to be in the urban, industrial and agricultural parts of central Scotland.

Between the mid-1960s and the mid-1990s, tranquility was reduced throughout 45% of a rural-urban case study area in the north-east of Scotland (Chapter 7). Since the 1990s, greater emphasis has been placed on vacant and derelict land for re-development or restoration. Although the number of households rose by 18% between 1981 and 1999 (Landrock *et al.*, 2001), the 1990-98 Countryside Survey detected no clear evidence of urban expansion (a 2.1% increase in built and gardens in rural areas was not statistically significant). With gap sites becoming utilised, a projected 12% expansion in housing demand from 1989 to 2012 indicates continued development pressure on rural land in the future.

Fresh waters

By 1995, water supply problems, sufficient to meet demand and fit for drinking, were prevalent in many parts of Europe. In Nordic and some Western European countries, improvements in sewage and waste-water treatment had reduced point-source pollution and heavy metal contamination, bringing about improvements to river water oxygenation and water quality.

Nevertheless, diffuse pollution from intensive farming, together with spills of slurry and silage liquor, threatened the quality of European inland waters and small streams. Eutophication due to phosphorus and nitrogen in wastewater and agricultural run-off was widespread in European rivers, lakes, reservoirs, coastal and marine waters. Nitrate thresholds for drinking water were frequently exceeded in ground-waters, and concentrations of synthetic chemicals, such as pesticides, exceed proscribed standards in many areas of intensive agriculture. In some countries, groundwater quality was also threatened by heavy metals, hydrocarbons and chlorinated hydrocarbons. With improved waste water treatment and reduced emissions from industry between 1980 and 1995, phosphorus discharges into rivers fell by 40-60% in several European countries. Phosphorus concentrations in surface waters fell significantly, but at a quarter of river monitoring sites remained ten times higher than for water of good quality. By 1999, most countries classified 80% - 95% of their river water as good or fair quality, but some classified as much as 25% as poor or bad quality (CEC, 1999). The concentration of nitrate in EU rivers remained approximately constant from 1980 to 1999.

Water quality in the formerly indistrialised rivers of Scotland has been greatly improved in recent decades. The otter has been able to re-occupy much of its former range in the Central Belt (Chapter 13). By 1999, about 90% of Scotland's rivers were of excellent or good quality. Nevertheless, around 30% of river lengths had been substantially modified from their natural state and 4,000 km were polluted (SEPA pers. comm.).

By 2000, some 50% of native freshwater fish were thought to have declined. This contrasts with expansions among non-native species. Eutrophication of the only loch in which it was found led to the extinction of the vendace in Scotland (subsequently re-introduced to two other lochs). By 1996, the number of sites where great crested newts had been recorded since 1876 had declined by 55%. About half of the world's functional populations of freshwater pearl mussel are found in Scotland, but by the late-1990s, 65% had no juveniles and only 7% were classified as near-natural. Nine breeding bird species dependant on fresh waters expanded their range markedly between around 1970 and 1990, while five species showed marked range contractions. Species trends are therefore mixed, but benefits may begin to flow from the increasing number of river restoration works.

The sea

At the interface between land and sea, and between fresh and salt water, a considerable amount of European activity is concentrated around the coastal zone. In 1995, the greatest pressures on the coast were urbanisation and transport, agriculture, tourism and recreation, fisheries and aquaculture, industry and energy production. Associated problems included local alterations to the natural balance of erosion and sedimentation, habitat loss and degradation, chemical and organic pollution, contamination by human pathogens, nutrient enrichment leading to algal and phytoplanktonic blooms with deoxygenation and toxic poisoning, bioaccumulation of organochlorine pesticides and PCBs, oil spills from shipping and land-based sources, and environmental and amenity degradation through littering. By 1998 the North Sea was considered to be threatened by over-fishing, high nutrient and pollutant concentrations (EEA, 1998).

Much of the population and infrastructure of Scotland are located on or close to the coast. By the late 1990s it has been estimated that around 10% of Scotland's coastline was affected by intensive urban or industrial use, although the visual impact and perception of development can be greater (Chapter 7). Land-claim has historically resulted in losses of intertidal mudflats: by as much as 50% within the inner Forth estuary (upstream of the Forth Road Bridge) over the past two centuries. High nitrate levels have a greater impact on marine and coastal waters than fresh water. Excessive growth of green algae in the River Ythan estuary, to the north-east of Scotland, has formed extensive, dense mats which have caused changes to invertebrate communities living in the mud (SEPA, 1999). In 2000 the catchment was designated a Nitrate Vulnerable Zone, requiring reductions in water pollution from agricultural sources. However, since the 1970s some of the most polluted parts of the Forth and Clyde estuaries and their tributaries have been considerably cleaned up, resulting in recolonisation by invertebrates and fish (Chapter 14). Whilst improvements to water quality continue, bathing water quality has not yet fully achieved mandatory compliance for all identified bathing waters, with 85% compliance in 2000 (SEPA, 2000). Within the clean, sheltered waters of the west coast and Northern Isles, fish farming expanded in the 1980s. Whilst marine survey coverage has increased greatly in recent decades, the extent, abundance, status and ecology of most marine habitats and species remain poorly known. An exception is the commercially exploited fish species. By 2001, most commercial fish species in the seas around Scotland, including some deep-water species, were in decline and outside of safe biological limits (Chapter 15).

Acidification

Reductions in acidifying pollutants throughout Europe have been brought about mainly by industrial restructuring in Eastern Europe, a shift from coal burning power stations to nuclear and other fuels, the desulphurisation of petroleum products, flue-gas desulphurisation and advanced combustion technologies. Sulphur dioxide emissions fell by 50% between 1980 and 1995. The growing transport sector became the dominant source of nitrogen oxides which, with ammonia (mainly from livestock production), fell by only 15%. By 2010, emissions of all major gasses contributing to acidification and eutrophication are expected to be reduced, but hotspots of critical load exceedance for sulphur and nitrogen will remain. Within the EU, ecosystems that receive damaging levels of acid deposition could decrease from 25% area affected in 1990 to 7% in 2010, and critical load exceedance for nitrogen could decrease from 55% to 39%.

Prevailing westerly winds protect much of Scotland from air pollution. Nevertheless, a predominantly hard rock geology gives rise to low buffering capacity in many soils, and high rainfall causes rapid nutrient leaching. Many plants, and the habitats of which they are a part, are adapted to low nutrient status in soils and fresh waters. Throughout most of the uplands they are inherently sensitive to acidification and eutrophication. By 1998, UK sulphur emissions were 74% lower than they had been at their 1970 peak. In contrast, nitrogen emissions were at their greatest in the 1990s and consequently became the main acidifying pollutant. Nitrogen oxides (a combustion product of transport, power generation and heating) started to decline in the 1990s but reduced nitrogen (the ammonia form, mainly from livestock farming) remained unchanged.

Between 1990 and 1998, the species richness of acid grassland increased due to an increased abundance of plants of less-acid conditions. A decrease in species richness in dwarf shrub heaths was due to a decline in stress-tolerant species and a (smaller) increase in competitors. Both changes point to slight declines in habitat quality, influenced by land management but consistent with rising pH and nutrient enrichment (Chapter 5). Sulphur and nitrogen deposition are projected to decline by 2010. Compared with the mid-1990s, the area damaged by soil acidification is projected to be reduced by 12%; the area of acid-damaged fresh waters to be reduced by 67%; and the area of peatland damaged by nitrogen enrichment to be reduced by 37% (Chapter 16).

Photochemical pollution

At ground level, ozone (O_3) is a strong oxidant that can be harmful to human health, materials and plants. In the northern hemisphere, the concentration of surface ozone in the atmosphere more than doubled over the past century. Threshold concentrations for vegetation damage are frequently exceeded throughout much of Europe. Despite rising traffic levels throughout Europe, a 14% reduction in ozone precursors was achieved between 1990 and 1995. By 2010, reductions in precursor emissions are projected to lead to a 25% reduction in critical levels of ozone, but target values will still be widely exceeded in rural and urban areas.

Compared with central Europe, severe summer smogs are infrequent in Scotland. Nevertheless, between 1986 and 1989 ozone concentrations exceeded critical levels for semi-natural vegetation across 30%-or-so of Scotland. Some of the largest exceedances occur in the eastern uplands. Projected reductions in pre-cursor pollutants by 2010 should result in a 20% reduction in critical-level exceedance for semi-natural vegetation, but benefits may gradually disappear as global ozone concentrations rise (Chapter 16).

Climate change

In the 1995 assessment, global emissions of most greenhouse gasses were expected to rise, leading to a doubling of greenhouse gas concentrations by 2030. Signals from an enhanced greenhouse effect had been weak in relation to natural climatic fluctuations but it was argued that a precautionary approach, based on the conservation of natural resources and energy, would be inherently beneficial and undoubtedly more effective than corrective action later. By 1998, reductions in greenhouse gas emissions had been brought about mainly by closure of heavy industry in Eastern Europe and by a switch from coal to gas in some Western European countries. The 1999 assessment made it clear that much more concerted action would be needed to achieve the 8% reduction in greenhouse gasses (1990 - 2012) agreed at Kyoto in 1997. Furthermore, a 20-40% reduction would be required by 2020, leading to a long-term goal of a 70% reduction in emissions set by the Intergovernmental Panel on Climate Change (CEC, 2001a).

The latest predictions are that climate change is likely to be more rapid and more profound than had been thought in the past (Chapter 17). Scotland will probably be affected less severely than many parts of the world. Nevertheless, weather patterns over recent decades appear to foreshadow warmer, wetter, windier conditions ahead. The growing season in the British Isles has extended by three weeks in the decade between 1989 and 1998 (Chapter 18). Some mobile species have extended their range northwards, but northerly and montane species are likely to become less abundant. Wetter and stormier conditions, particularly in the autumn and winter, have implications for soil and water conservation, land, coast and floodplain management. A rapid rate of climate change may leave non-winged species stranded in sub-optimal locations.

Biodiversity

Biological diversity has been defined as the variation in genes, species and ecosystems; diversity promoting stability and sustainability in natural systems (Stanners & Bourdeau, 1995). Stresses on European ecosystems, such as those from land use and urbanisation, have been linked to declines in diversity within ecosystems (loss of habitats), within habitats (loss of species) and among species (loss of genetic diversity and decline of species abundance). Pressures on biodiversity from intensive agriculture, forestry, urbanisation, infrastructure development, and from pollution have increased, with a growing number of native species in decline (EEA, 1998). Generalist and invasive species continue to spread. The introduction of non-native, or 'alien', species has caused problems in marine, inland water and terrestrial habitats. By the turn of the century, biodiversity remained under threat from habitat reduction, degradation and fragmentation (EEA, 1999).

Direct evidence of a widespread change in the diversity and abundance of native species is available for only a few of the more charismatic species groups in Scotland (Chapter 3). These include rare and endemic vascular plants (predominantly declining), butterflies (specialist species contracting, generalists spreading), freshwater fish (mainly declining), birds (showing mixed fortunes) and mammals (predominantly declining). Comparatively little is known of trends in the abundance or diversity of several species groups for which Scotland is particularly important internationally. These include the mosses, liverworts and lichens, many of which have their European stronghold along Scotland's Atlantic seaboard.

Alien plant species, mainly originating as garden cast-outs, have invaded all major habitats in Scotland (Chapter 3). Many have little impact and can be relatively benign but some, such as Japanese knotweed, are pernicious. Problems exerted by aliens include competition for territory, evident between the native red squirrel and the American grey squirrel in Scotland. Predation by the American mink has contributed to the decline of the water vole (Chapter 13). Ruffe, probably introduced by anglers into Loch Lomond as a bait fish, threaten the local powan population. American signal crayfish, which are now known in at least two rivers in the south-west of Scotland, threaten native crayfish populations. Interbreeding may compromise the genetic integrity of Scottish red deer (by non-native sika deer) and salmon populations (by non-indigenous fish farm escapes). The introduction of mammals that are not locally native, such as hedgehogs into the Western Isles in the mid-1970s, is potentially devastating to ground nesting birds.

Some successes have been achieved in re-establishing breeding populations of species that had become extinct in Scotland, such as the red kite and the white-tailed eagle (Chapter 3). Reduced persecution has been at least in-part responsible for increases in geese (chapter 3) and grey seal (Chapter 14) populations. Raptors have benefited from tighter controls on insecticide use, but many continue to be suppressed by persecution in some areas (Chapter 12). Commercial fish stocks are threatened by over-exploitation (Chapter 15).

Conclusion

Scotland retains a rich complement of habitats and species, many elements of which are of international importance. Threats to biodiversity and the causes of species declines are often similar to those in the rest of Europe. That holds true on land and in fresh waters, and in the ecology of marine life. Effects of air and water pollution on ecological functioning and human health vary in severity, but are common throughout Europe. Tackling the causes of climate change is clearly a global issue.

The polarisation of intensive and marginal farming may appear to be different between Scotland and the rest of Europe, but trends are similar and must often be influenced by common causes. Progress in extending, diversifying and restructuring Scotland's forest and woodland networks has brought about positive wildlife and landscape benefits. A need to bring urban activities more into balance with the capacity of ecosystems to sustain life and life support services could be a guiding principle for urban renewal in Scotland. A shining example of that is the restoration of the canal network in central Scotland (Chapter 9). Pointers to the future, from a European perspective, are set out in the proposed 6th Environment Action Programme and Sustainable Development Strategy (Box 19.1). They identify 'economic decoupling' as part of the solution to sustainable development. That means breaking the historical link between economic growth and environmental damage, for example through opportunities afforded by technology, more efficient resource use and environmental protection.

An early example of the application of technology in Scotland might be the increased importance of renewable energy, in part through appropriately designed and sited wind farms. The broader benefits of a diverse forest and woodland network for landscape, recreation, biodiversity, and soil and water protection, could be held up as an example of more efficient resource use. Benefits to wildlife and amenity are becoming evident through protection of the environment, by reducing air and water pollution and by taking greater care in the use of land and water resources.

Major issues still need to be tackled for safeguarding quality of life, amenity, ecological functions and wildlife in Scotland. Some problems may become more severe and new ones may emerge. We should be encouraged by examples of what can be achieved, and recognise that more needs to be done if we are to find ways of improving the quality of life in Scotland without causing harm to the environment, to future generations, and to people of both the rich and developing world. That is the key to sustainable development, as expressed in the 6th Environment Action Programme.

Box 19.1 Looking ahead

The proposed 6th Environment Action Programme 2001 - 2010 (CEC, 2001a) and Sustainable Development Strategy (CEC, 2001b) are founded upon a systematic analysis of trends and prospects. Four areas have been identified where new effort and impetus are needed to secure our long-term welfare, in Europe and around the world.

Tackling climate change

With 5% of the world's population, the European Union generates 15% of global greenhouse gasses. The objective is to stabilise concentrations of greenhouse gasses at a level that will not cause unnatural variations in the earth's climate. Compared with the 1990 baseline, it will be necessary to reduce greenhouse gas emissions by the 8% agreed at Kyoto by 2008-12, to reduce emissions by 20-40% by 2020, and to achieve a long-term reduction of 70%.

Protecting nature and wildlife

In the European Union, 38% of bird species and 45% of butterflies are threatened. In north and western Europe, 60% of wetlands have been lost. Two thirds of trees are suffering from pollution. Soil erosion is a major problem in the south. Care of the seas is required to tackle over-fishing, damage to the seabed and pollution. Objectives are to protect or restore the structure and functioning of natural systems, to halt the loss of biodiversity, and to protect soils against erosion and pollution.

Action for the environment and health

Continued improvements to air and water quality (surface, ground and coastal) will be required to achieve an environment where contaminants do not pose risks to human health. This will include reducing risks from pesticide and chemical use, and taking account of noise pollution in planning decisions.

Natural resources and waste

For the conservation of natural resources, targets include a need to reduce the quantity of waste going to land fill by 20% on 2000 levels by 2010 and 50% by 2050.

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Abbreviations

°C	degrees Centigrade
ACWG	Aculeate Conservation Working Group
AOT_{40}	cumulative exposure to ambient concentrations in excess of 40 ppb
ASNO	Ancient woods of Semi-Natural Origin
BAP	Biodiversity Action Plan
BBS	Breeding Bird Survey
BC	Butterfly Conservation
BHS	British Herpetological Society
bp	before present
BRC	Biological Records Centre
BSBI	Botanical Society of the British Isles
BSFP	British Survey of Fertiliser Practice
BTO	British Trust for Ornithology
BWB	British Waterways Board
c.	circa
C.	Century
CA	Countryside Agency
CAP	Common Agricultural Policy
CBC	Common Birds Census
CCW	Countryside Council for Wales
CEC	Commission of the European Communities (EC)
CEH	Centre for Ecology and Hydrology
CITES	Convention on International Trade in Endangered Species
CLAG	Critical Loads Advisory Group
CO_2	Carbon Dioxide
COSLA	Convention of Scottish Local Authorities
CPS	Countryside Premium Scheme
CRU	Climate Research Unit
Cs^{137}	Caesium
CS1990	Countryside Survey 1990
CS2000	Countryside Survey 2000
DETR	Department of the Environment, Transport and the Regions
EA	Environment Agency
EC	European Community
EEA	European Environment Agency
EHS	Environment and Heritage Service
EMEP	European cooperative programme for Monitoring and Evaluation of the long range transmission of air Pollutants in Europe
EN	English Nature
ESA	Environmentally Sensitive Area
EU	European Union
FC	Forestry Commission
FCC	Fish Conservation Centre
FE	Forest Enterprise
FFL	Freshwater Fisheries Laboratory
FRS	Fisheries Research Services
FWPS	Farm Woodland Premium Scheme
GB	Great Britain
GCR	Geological Conservation Review
GCT	Game Conservancy Trust
GDP	Gross Domestic Product
GIS	Geographical Information System
GW	Gigawatts
ha	Hectares
HCT	Herpetological Conservation Trust
HMSO	Her Majesty's Stationery Office (now The Stationery Office)
ICES	International Council for the Exploration of the Sea
IMM	Intermediate Ministerial Meeting
IPCC	Intergovernmental Panel on Climate Change
IPG	International Phenological Gardens
ISA	Infectious Salmon Anaemia
ITE	Institute of Terrestrial Ecology (now part of the Centre for Ecology and Hydrology)
IUCN	International Union for the Conservation of Nature
IWRB	International Waterfowl and Wetlands Research Bureau (now Wetlands International)
JNCC	Joint Nature Conservation Committee
keq	kilogram equivalents
kg	kilograms
km	kilometres
km^2	square kilometres
kt	kilo-tonnes
LBAP	Local Biodiversity Action Plan
LCA	Landscape Character Assessment
LCS88	Land Cover of Scotland 1988
LEPO	Long-Established woods of Plantation Origin
LFA	Less Favoured Area
LNR	Local Nature Reserve
m	metres
mm	millimetres
MAFF	Ministry of Agriculture, Fisheries and Food
MCS	Marine Conservation Society
MLURI	Macaulay Land Use Research Institute
MNCR	Marine Nature Conservation Review
MS	Mammal Society
MW	Megawatts
NCMS	National Countryside Monitoring Scheme
NEGTAP	National Expert Group on Transboundary Air Pollution
NERC	National Environmental Research Council
NH_3	ammonia
NH_4	ammonium
NH_x	Reduced nitrogen

NHM	Natural History Museum (London)
NO_x	Nitrogen oxides
NT	National Trust
NTS	National Trust for Scotland
O_3	Ozone
OSPAR	Oslo and Paris Commission for the protection of the marine environment of the NE Atlantic
PA	Pond Action
PAWS	Plantations on Ancient Woodland Sites
ppb	parts per billion
ppbh	parts per billion hours
ppbv	parts per billion by volume
RBBP	Rare Breeding Birds Panel
RBGE	Royal Botanic Garden, Edinburgh
RBGK	Royal Botanic Garden, Kew
RoW	Rights of Way
rsl	relative sea level
RSPB	Royal Society for the Protection of Birds
RSS	Rural Stewardship Scheme
S	Sulphur
SAC	Scottish Agricultural College
SASA	Scottish Agricultural Science Agency
SBG	Scottish Biodiversity Group
SCPR	Social and Community Planning Research
SE	Scottish Executive
SEERAD	Scottish Executive Environment and Rural Affairs Department
SEPA	Scottish Environment Protection Agency
SGCWG	Scottish Golf Course Wildlife Group
SMRU	Sea Mammal Research Unit
SNH	Scottish Natural Heritage
SOAEFD	Scottish Office Agriculture, Environment and Fisheries Department (now incorporated into SEERAD)
SOAFD	Scottish Office Agriculture and Fisheries Department (now incorporated into SEERAD)
SRO	Scottish Renewables Orders
SSSI	Site of Special Scientific Interest
SWT	Scottish Wildlife Trust
t	tonnes
UK	United Kingdom
UKOOA	UK Offshore Operators Association
UNEP	United Nations Environment Programme
WeBS	Wetland Bird Survey
WGS	Woodland Grant Scheme
WWF	Worldwide Fund for Nature
WWT	Wildfowl and Wetlands Trust
yr	year

Species mentioned in the text

allis shad	*Alosa alosa*
Alpine bearberry	*Arctostaphylos alpinus*
Alpine gentian	*Gentiana nivalis*
American mink	*Mustela vison*
Arctic skua	*Stercorarius parasiticus*
Arctic tern	*Sterna paradisaea*
argentine (greater silver smelt)	*Argentina silus*
Atlantic salmon	*Salmo salar*
Atlantic white-sided dolphin	*Lagenorhynchus acutus*
barn owl	*Tyto alba*
barnacle goose	*Branta leucopsis*
bar-tailed godwit	*Limosa laponica*
basking shark	*Cetorhinus maximus*
beech	*Fagus sylvatica*
Bewick's swan	*Cygnus columbianus*
birch sp.	*Betula* sp.
black grouse	*Tetrao tetrix*
black guillemot	*Cepphus grylle*
black scabbardfish	*Aphanopus carbo*
blackbird	*Turdus merula*
blackcap	*Sylvia atricapilla*
black-headed gull	*Larus ridibundus*
black-tailed godwit	*Limosa limosa*
blaeberry	*Vaccinium myrtillus*
blue hake	*Antimora rostrata*
blue ling	*Molva dyptergia*
blue tit	*Parus caeruleus*
blue whale	*Balaenoptera musculus*
blue whiting	*Micromesistius poutassou*
bottlenose dolphin	*Tursiops truncatus*
bracken	*Pteridium aquilinum*
brown hare	*Lepus europaeus*
brown trout	*Salmo trutta*
bullfinch	*Pyrrhula pyrrhula*
buzzard	*Buteo buteo*
capercaillie	*Tetrao urogallus*
carrion crow	*Corvus corrone*
chaffinch	*Fringilla coelebs*
chequered skipper	*Carterocephalus palaemon*
chiffchaff	*Phylloscopus collybita*
coal tit	*Parus ater*
cod	*Gadus morhua*
collared dove	*Streptopelia decaocto*
common crossbill	*Loxia curvirostra*
common dolphin	*Delphinus delphis*
common footman moth	*Eilema lurideola*
common gull	*Larus canus*
common mussel	*Mytilus edulis*
common scoter	*Melanitta nigra*
common seal (harbour seal)	*Phoca vitulina*
common tern	*Sterna hirundo*
cormorant	*Phalacrocorax carbo*
corn bunting	*Miliaria calandra*
corncrake	*Crex crex*
crested tit	*Parus cristatus*
crossbill species	*Loxia* sp.
crowberry	*Empetrum nigrum*
curlew	*Numenius arquata*
Cuvier's beaked whale	*Ziphius cavirostris*
dingy skipper	*Erynnis tages*
dipper	*Cinclus cinclus*
dogwhelk	*Nucella lapillus*
dotterel	*Charadrius morinellus*
dunlin	*Calidris alpina*
dunnock	*Prunella modularis*
dwarf juniper	*Juniperus communis* ssp. *nana*
edible frog	*Rana kl. esculenta*
elm	*Ulmus* sp.
European beaver	*Castor fiber*
European otter	*Lutra lutra*
false killer whale	*Pseudorca crassidens*
feral cat	*Felis cattus*
feral pigeon	*Columbia livia*
ferret	*Mustela furo*
field maple	*Acer campestre*
fin whale	*Balaenoptera physalus*
flat oyster (native oyster)	*Ostrea edulis*
flounder	*Pleuronectes flesus*
fox	*Vulpes vulpes*
freshwater pearl mussel	*Margaretifera margaretifera*
fulmar	*Fulmarus glacialis*
gadwall	*Anas strepera*
gannet	*Morus bassanus*
garden warbler	*Sylvia borin*
goldcrest	*Regulus regulus*
golden eagle	*Aquila chrysaetos*
goldeneye	*Bucephala clangula*
goldfinch	*Carduelis carduelis*
goosander	*Mergus merganser*
goshawk	*Accipiter gentilis*
great black-backed gull	*Larus marinus*
great crested newt	*Triturus cristatus*
great scallop	*Pecten maximus*
great skua	*Stercorarius skua*
great spotted woodpecker	*Dendrocopos major*
great tit	*Parus major*
greater forkbeard	*Phycis blennoides*
greater silver smelt (argentine)	*Argentina silus*

green shield-moss	*Buxbaumia viridis*
green woodpecker	*Picus viridis*
greenfinch	*Carduelis chloris*
Greenland white-fronted goose	*Anser albifrons flavirostris*
grey partridge	*Perdix perdix*
grey plover	*Pluvialis squatarola*
grey seal	*Halichoerus grypus*
grey squirrel	*Sciurus carolinensis*
greylag goose	*Anser anser*
guillemot	*Uria aalge*
haddock	*Melanogrammus aeglefinus*
harbour porpoise	*Phocoena phocoena*
harbour seal (common seal)	*Phoca vitulina*
hazel	*Corylus avellana*
heather	*Calluna vulgaris*
heather beetle	*Lochmaea suturalis*
hedgehog	*Erinaceus europaeus*
hen harrier	*Circus cyaneus*
herring	*Clupea harengus*
herring gull	*Larus argentatus*
horse mussel	*Modiolus modiolus*
house martin	*Delichon urbica*
house sparrow	*Passer domesticus*
Humpback whale	*Megaptera novaengliae*
Iceland-purslane	*Koenigia islandica*
jackdaw	*Corvus monedula*
Japanese knotweed	*Fallopia japonica*
jay	*Garrulus glandarius*
juniper	*Juniperus communis*
kestrel	*Falco tinnunculus*
killer whale	*Orcinus orca*
kingfisher	*Alcedo atthis*
kittiwake	*Rissa tridactyla*
knot	*Calidris canutus*
lapwing	*Vanellus vanellus*
large heath	*Coenonympha tullia*
large skipper	*Ochlodes venatus*
Leach's petrel	*Oceanodroma leucorhoa*
leafscale gulper shark	*Centrophorus squamosus*
lesser black-backed gull	*Larus fuscus*
linnet	*Carduelis cannabina*
little tern	*Sterna albifrons*
long-eared owl	*Asio otus*
long-finned pilot whale	*Globicephala melas*
long-tailed tit	*Aegithalos caudatus*
mackerel	*Scomber scombrus*
maerl spp.	*Lithothamnion glaciale, Phymatolithon calcareum*
magpie	*Pica pica*
mallard	*Anas platyrhynchos*
Manx shearwater	*Puffinus puffinus*
marsh fritillary	*Eurodryas aurinia*
merlin	*Falco columbarius*
minke whale	*Balaenoptera acutorostrata*
monkfish	*Lophius piscatorius*
mora	*Mora moro*
mountain hare	*Lepus timidus*
mountain ringlet	*Erebia epiphron*
mountain willow	*Salix arbuscula*
mute swan	*Cygnus olor*
native oyster (flat oyster)	*Ostrea edulis*
natterjack toad	*Bufo calamita*
netted mountain moth	*Semiothisa carbonaria*
New Zealand pigmyweed	*Crassula helmsii*
newts	*Triturus* spp.
nightjar	*Caprimulgus europaeus*
northern bottlenose whale	*Hyperoodon ampullatus*
northern brown argus	*Aricia artaxerxes*
northern right whale	*Eubalaena glacialis*
Norway lobster	*Nephrops norvegicus*
Norway pout	*Trisopterus esmarki*
oak sp.	*Quercus* sp.
orange roughy	*Hoplostethus atlanticus*
orange-tip	*Anthocharis cardamines*
osprey	*Pandion haliaetus*
otter	*Lutra lutra*
oystercatcher	*Haematopus ostralegus*
Pacific oyster	*Crassostrea gigas*
painted lady butterfly	*Vanessa cardui*
parrot crossbill	*Loxia pytyopsittacus*
peach-potato aphid	*Myzus persicae*
peacock butterfly	*Inachis io*
pearl-bordered fritillary	*Boloria euphrosyne*
peregrine	*Falco peregrinus*
pheasant	*Phasianus colchicus*
pied flycatcher	*Ficedula hypoleuca*
pied wagtail	*Motacilla alba*
pine	*Pinus* sp.
pink-footed goose	*Anser brachyrhynchus*
pintail	*Anas acuta*
plaice	*Pleuronectes platessa*
pochard	*Aythya ferina*
polecat	*Mustela putorius*
Portuguese dogfish	*Centroscymnus coelolepsis*
puffin	*Fratercula arctica*
queen scallop	*Aequipecten opercularis*
rabbit	*Oryctolagus cuniculus*
rat	*Rattus* sp.
raven	*Corvus corax*
razorbill	*Alca torda*
red deer	*Cervus elaphus*
red grouse	*Lagopus lagopus*
red kite	*Milvus milvus*
red squirrel	*Sciurus vulgaris*
red-backed shrike	*Lanius collurio*
red-breasted merganser	*Mergus serrator*
red-necked phalarope	*Phalaropus lobatus*
redpoll	*Carduelis flammea*
redshank	*Tringa totanus*
redstart	*Phoenicurus phoenicurus*
redwing	*Turdus iliacus*
reed bunting	*Emberiza schoeniclus*
reindeer	*Rangifer tarandus*
ring ouzel	*Turdus torquatus*
ringed plover	*Charadrius hiaticula*
ringlet	*Aphantopus hyperantus*
Risso's dolphin	*Grampus griseus*

robin	*Erithacus rubecula*
roe deer	*Capreolus capreolus*
rook	*Corvus frugilegus*
roseate tern	*Sterna dougallii*
roundnose grenadier	*Coryphaenoides rupestris*
ruffe	*Gymnocephalus cernus*
rye grass	*Lolium* sp.
saithe	*Pollachius virens*
salmon	*Salmo salar*
sandeel	*Ammodytes marinus*
sanderling	*Calidris alba*
Sandwich tern	*Sterna sandvicensis*
Scotch argus	*Erebia aethiops*
Scots pine	*Pinus sylvestris*
Scottish crossbill	*Loxia scotica*
Scottish primrose	*Primula scotica*
Scottish scurveygrass	*Cochlearia scotica*
sea trout	*Salmo trutta*
sei whale	*Balaenoptera borealis*
shag	*Phalacrocorax aristotelis*
shelduck	*Tadorna tadorna*
short-eared owl	*Asio flammeus*
shoveler	*Anas clypeata*
signal crayfish	*Pacifastacus leniusculus*
sika	*Cervus nippon*
siskin	*Carduelis spinus*
Sitka spruce	*Picea sitchensis*
skylark	*Alauda arvensis*
small blue	*Cupido minimus*
small copper	*Lycaena phlaeas*
smelt	*Osmerus eperlanus*
snowdrop	*Galanthus nivalis*
sole	*Solea solea*
song thrush	*Turdus philomelos*
Sowerby's beaked whale	*Mesoplodon bidens*
speckled wood	*Pararge aegeria*
sperm whale	*Physeter macrocephalus*
spotted flycatcher	*Muscicapa striata*
sprat	*Sprattus sprattus*
starling	*Sturnus vulgaris*
stock dove	*Columba oenas*
storm petrel	*Hydrobates pelagicus*
striped dolphin	*Stenella coeruleoalba*
sundew sp.	*Drosera* sp.
swallow	*Hirundo rustica*
swift	*Apus apus*
sycamore	*Acer pseudoplatanus*
tawny owl	*Strix aluco*
teal	*Anas crecca*
tree pipit	*Anthus trivialis*
tree sparrow	*Passer montanus*
treecreeper	*Certhia familiaris*
True's beaked whale	*Mesoplodon mirus*
tufted duck	*Aythya fuligula*
turbot	*Scophthalmus maximus*
turnstone	*Arenaria interpres*
turtle dove	*Streptopelia turtur*
tusk	*Brosme brosme*
twinflower	*Linnaea borealis*
twite	*Carduelis flavirostris*
vendace	*Coregonus albula*
water vole	*Arvicola terrestris*
white-beaked dolphin	*Lagenorhynchus albirostris*
white-tailed eagle	*Haliaeetus albicilla*
whitethroat	*Sylvia communis*
whiting	*Merlangius merlangus*
whooper swan	*Cygnus cygnus*
wigeon	*Anas penelope*
willow	*Salix* sp.
willow tit	*Parus montanus*
willow warbler	*Phylloscopus trochilus*
wood pigeon	*Columba palumbus*
wood warbler	*Phylloscopus sibilatrix*
woodcock	*Scolopax rusticola*
wren	*Troglodytes troglodytes*
wryneck	*Jynx torquilla*
yellow wagtail	*Motacilla flava*
yellowhammer	*Emberiza citrinella*
yew	*Taxus baccata*

Appendix 1

The 41 habitats occurring in Scotland for which a habitat action plan has been published as part of the UK Biodiversity Action Plan.

Habitat	Publication[1]	Lead Agency
Ancient and/or species-rich hedgerows	Tr 1, p 243	MAFF
Blanket bog	Tr 2, vol VI, p 205	SNH
Cereal field margins	Tr 1, p 235	MAFF
Coastal and floodplain grazing marsh	Tr 1, p 251	EN
Coastal saltmarsh	Tr 2, vol V, p 129	EA
Coastal sand dunes	Tr 2, vol V, p 105	SNH
Coastal vegetated shingle	Tr 2, vol V p 117	EN
Eutrophic standing waters	Tr 2, vol II, p 31	EA
Fens	Tr 1, p 241	EN
Limestone pavements	Tr 1, p 246	CA
Lophelia pertusa reefs	Tr2, vol V, p 195	DETR
Lowland calcareous grassland	Tr 2, vol II, p 57	CCW
Lowland dry acid grassland	Tr 2, vol II, p 51	CCW
Lowland heathland	Tr 1, p 248	To be determined
Lowland meadows	Tr 2, vol II, p 39	CCW
Lowland raised bog	Tr 2, vol VI, p 197	EN
Lowland wood-pasture and parkland	Tr 2, vol II, p 63	EN
Machair	Tr 2, vol V, p 111	SNH
Maerl beds	Tr 2, vol V, p 161	SNH
Maritime cliff and slopes	Tr 2, vol V, p 99	CCW
Mesotrophic lakes	Tr 1, p 265	SEPA
Modiolus modiolus beds	Tr 2, vol V, p 153	CCW
Mudflats	Tr 2, vol V, p 135	EA
Mud habitats in deep water	Tr 2, vol V, p 179	SNH
Native pine woodlands	Tr 1, p 259	FC
Purple moor grass and rush pastures	Tr 1, p 253	CCW
Reedbeds	Tr 1, p 230	EN
Sabellaria alveolata reefs	Tr 2, vol V, p 125	EN
Sabellaria spinulosa reefs	Tr 2, vol V, p 145	EN
Saline lagoons	Tr 1, p 233 & Tr 2, vol V, p 165	EN
Seagrass beds	Tr 1, p 262 & Tr 2, vol V, p 157	EHS
Serpulid reefs	Tr 2, vol V, p 185	SNH
Sheltered muddy gravels	Tr 2, vol V, p 141	To be determined
Sublittoral sands and gravels	Tr 2, vol V, p 189	EN
Tidal rapids	Tr 2, vol V, p 149	EHS
Upland calcareous grasslands	Tr 2, vol VI, p 213	CCW
Upland hay meadows	Tr 2, vol II, p 45	CCW
Upland heathland	Tr 2, vol VI, p 217	EN
Upland mixed ashwoods	Tr 2, vol II, p 75	FC
Upland oakwood	Tr 1, p 256	FC
Wet woodland	Tr 2, vol II, p 69	FC

[1] Biodiversity Action Plans have been published in two tranches, the first of which appears in: Anon. (1995). *Biodiversity: the UK Steering Group Report. Volume 2: Action Plans.* London: HMSO. Subsequent plans appear in: UK Biodiversity Group (1998-99). *UK Biodiversity Group. Tranche 2 Action Plans. Volumes 1-4.* Peterborough: English Nature. The abbreviations used are as follows. Tr: the tranche, either I or II; Vol: the volume number, applicable only to Tranche II; p: the page number within the publication.

Appendix 2

The 261 species occurring (or known to have occurred) in Scotland, for which either a species action plan or a species statement has been published as part of the UK Biodiversity Action Plan. Species known to have been introduced into Scotland are indicated (†).

Species		Publication[1]	Contact point	Lead Partner
Scientific name	**Common name**			
Invertebrate animals				
Maritime species				
Amphianthus dohrnii	sea-fan anemone	Tr 2, vol V, p 77	EN	WWF & Wildlife Trusts
Atrina fragilis	a fan shell	Tr 2, vol V, p 63	EHS	MCS
Funiculina quadrangularis	a sea pen	Tr 2, vol V, p 183		Species Statement
Ostrea edulis	native oyster	Tr 2, vol V, p 67	EN	EN
Styela gelatinosa	a sea squirt	Tr 2, vol V, p 184		Species Statement
Tenellia adspersa	lagoon seaslug	Tr 2, vol V, p 173		Species Statement
Thyasira gouldi	northern hatchet shell	Tr 2, vol V, p 71	SNH	MCS
Beetles				
Bembidion testaceum	a ground beetle[2]	Tr 2, vol VI, p 49	CCW	EA
Bidessus minutissimus	a diving beetle	Tr 2 vol VI, p 29	CCW	EA
Ceutorhynchus insularis	a weevil	Tr 2, vol VI, p 60		Species Statement
Cryptocephalus decemmaculatus	leaf beetle	Tr 2, vol VI, p 62		Species Statement
Cryptocephalus primarius	a leaf beetle	Tr 2, vol IV, p 55	EN	Leeds University
Cryptocephalus sexpunctatus	a leaf beetle	Tr 2, vol IV, p 59	EN	Leeds University
Donacia aquatica	a reed beetle	Tr 2, vol IV, p 67	EN	SNH
Dromius quadrisignatus	a ground beetle	Tr 2, vol VI, p 63		Species Statement
Dyschirius angustatus	a ground beetle	Tr 2, vol IV, p 141		Species Statement
Hydroporus rufifrons	a diving beetle	Tr 2, vol IV, p 91	EN	to be determined
Melanapion minimum	a weevil	Tr 2, vol IV, p 103	EN	EN
Meotica anglica	a rove beetle[2]	Tr 2, vol VI, p 49	CCW	EA
Perileptus areolatus	a ground beetle[2]	Tr 2, vol VI, p 49	CCW	EA
Procas granulicollis	a weevil	Tr 2, vol IV, p 119	CCW	CCW
Protapion ryei	a weevil	Tr 2, vol VI, p 70		Species Statement
Rhynchaenus testaceus	a jumping weevil	Tr 2, vol IV, p 135	EN	to be determined
Thinobius newberyi	a rove beetle[2]	Tr 2, vol VI, p 49	CCW	EA
Bees, Wasps and Ants				
Andrena gravida	banded mining bee[3]	Tr 2, vol IV, p 201	EN	EN & ACWG
Bombus distinguendus	great yellow bumblebee	Tr 2, vol IV, p 209	SNH	RSPB & *Bombus* Working Group
Chrysura hirsuta	a cuckoo wasp	Tr 2, vol IV, p 281	SNH	Species Statement
Colletes floralis	northern colletes	Tr 2, vol IV, p 237	SNH	RSPB & *Bombus* Working Group
Formica aquilonia	Scottish wood ant	Tr 2, vol IV, p 241	SNH	FC
Formica exsecta	narrow-headed wood ant	Tr 1, p 140	SNH	SNH & SWT

Species		Publication[1]	Contact point	Lead Partner
Scientific name	**Common name**			
Formica lugubris	northern wood ant	Tr 2, vol VI, p 81	Species Statement	
Formicoxenus nitidulus	shining guest ant	Tr 2, vol VI, p 82	Species Statement	
Nomada ferruginata	a cuckoo bee[2]	Tr 2, vol IV, p 284	Species Statement	
Osmia inermis	a mason bee	Tr 2, vol IV, p 261	SNH	SNH & ACWG
Osmia parietina	a mason bee	Tr 2, vol IV, p 265	EN	EN & ACWG
Osmia uncinata	a mason bee	Tr 2, vol IV, p 269	SNH	RSPB
Butterflies and Moths				
Aricia artaxerxes	northern brown argus	Tr 2, vol IV, p 411	Species Statement	
Boloria euphrosyne	pearl-bordered fritillary	Tr 1, p 126	SNH	BC
Carterocephalus palaemon	chequered skipper	Tr 2, vol IV, p 303	SNH	BC
Epione parallelaria	dark bordered beauty	Tr 2, vol IV, p 335	SNH	BC & RSPB
Eurodryas aurinia	marsh fritillary	Tr 1, p 136	CCW	BC
Hemaris tityus	narrow-bordered bee hawk-moth	Tr 2, vol IV, p 343	CCW	BC
Hydrelia sylvata	waved carpet	Tr 2, vol VI, p 87	EN	BC
Noctua orbona	lunar yellow underwing	Tr 2, vol VI, p 95	EN	BC
Paradiarsia sobrina	Cousin German	Tr 2, vol IV, p 418	Species Statement	
Plebejus argus	silver-studded blue	Tr 2, vol IV, p 379	EN	BC
Rheumaptera hastata	argent and sable	Tr 2, vol VI, p 99	EN	BC
Semiothisa carbonaria	netted mountain moth	Tr 2, vol IV, p 387	SNH	BC
Trichopteryx polycommata	barred tooth-stripe	Tr 2, vol VI, p 103	EN	BC
Xestia alpicola alpina	northern dart	Tr 2, vol IV, p 422	Species Statement	
Xestia rhomboidea	square-spotted clay	Tr 2, vol VI, p 107	EN	BC
Xylena exsoleta	sword-grass	Tr 2, vol IV, p 399	SNH	BC
Zygaena loti scotica	slender Scotch burnet	Tr 2, vol IV, p 403	SNH	SNH & BC
Zygaena viciae argyllensis	New Forest burnet moth	Tr 2, vol IV, p 407	SNH	SNH & BC
Flies				
Blera fallax	a hoverfly	Tr 2, vol IV, p 145	SNH	RSPB
Doros profuges (= conopseus)	a hoverfly	Tr 2, vol IV, p 161	EN	EN
Dorycera graminum	a picture-winged fly	Tr 2, vol IV, p 165	EN	EN
Hammerschmidtia ferruginea	a hoverfly	Tr 2, vol IV, p 173	SNH	RSPB
Lipsothrix ecucullata	a cranefly	Tr 2, vol IV, p 177	EN	SNH
Lipsothrix errans	a cranefly	Tr 2, vol IV, p 191	Species Statement	
Lipsothrix nervosa	a cranefly[3]	Tr 2, vol IV, p 181	EN	CCW
Rhabdomastrix laeta (= hilaris)	a cranefly	Tr 2, vol IV, p 193	Species Statement	
Spiriverpa (Thereva) lunulata	a stiletto fly	Tr 2, vol VI, p 127	CCW	EA
Tipula serrulifera	a cranefly	Tr 2, vol IV, p 194	Species Statement	
Other Invertebrates				
†Austropotamobius pallipes	white-clawed crayfish	Tr 1, p 157	EA	GCT
Brachyptera putata	a stonefly	Tr 2, vol VI, p 119	SNH	to be determined
Clubiona subsultans	a spider	Tr 2, vol IV, p 457	Species Statement	
Gryllotalpa gryllotalpa	mole cricket	Tr 1, p 143	EN	EN & NHM
Hirudo medicinalis	medicinal leech	Tr 1, p 161	SNH	RSPB
Margaritifera margaritifera	freshwater pearl mussel	Tr 1, p 162	SNH	SNH & EA
Triops cancriformis	tadpole shrimp	Tr 2, vol VI, p 131	EN	FE
Vertigo angustior	narrow-mouth whorl snail	Tr 1, p 169	CCW	CCW

Species		Publication[1]	Contact point	Lead Partner
Scientific name	**Common name**			
Vertigo genesii	round-mouthed whorl snail	Tr 1, p 170	SNH	SNH
Vertigo geyeri	Geyer's whorl snail	Tr 1, p 171	CCW	CCW

Vertebrate animals

Amphibians and Reptiles

Bufo calamita	natterjack toad	Tr 1, p 114	EN	HCT
Caretta caretta	loggerhead turtle[4]	Tr 2, vol V, p 37	SNH	MCS & HCT
Chelonia mydas	green turtle[4]	Tr 2, vol V, p 37	SNH	MCS & HCT
Dermochelys coriacea	leatherback turtle[4]	Tr 2, vol V, p37	SNH	MCS & HCT
†*Lacerta agilis*	sand lizard	Tr 1, p 110	EN	EN & HCT
Lepidochelys kempii	Kemp's ridley turtle[4]	Tr 2, vol V, p 37	SNH	MCS & HCT
Triturus cristatus	great crested newt	Tr 1, p 112	EN	HCT, Froglife & BHS

Birds

Alauda arvensis	skylark	Tr 1, p 97	MAFF	RSPB
Caprimulgus europaeus	nightjar	Tr 2, vol I, p 53	FC	RSPB
Carduelis cannabina	linnet	Tr 2, vol I, p 57	MAFF	RSPB
Crex crex	corncrake	Tr 1, p 102	Scottish Executive	SE & RSPB
Emberiza schoeniclus	reed bunting	Tr 2, vol I, p 65	EN	RSPB
Jynx torquilla	wryneck	Tr 2, vol I, p 69	SNH	RSPB
Lanius collurio	red-backed shrike	Tr 1, vol I, p 73	SNH & EN	RSPB
Loxia scotica	Scottish crossbill	Tr 1, p 104	SNH	RSPB
Melanitta nigra	common scoter	Tr 1, vol I, p 81	SNH	RSPB & WWT
Miliaria calandra	corn bunting	Tr 2, vol I, p 85	MAFF	RSPB & EN
Muscicapa striata	spotted flycatcher	Tr 2, vol I, p 89	EN & CCW	RSPB
Passer montanus	tree sparrow	Tr 2, vol I, p 93	MAFF	RSPB
Perdix perdix	grey partridge	Tr 1, p 105	MAFF	GCT
Phalaropus lobatus	red-necked phalarope	Tr 2, vol I, p 97	SNH	RSPB
Pyrrhula pyrrhula	bullfinch	Tr 1, vol I, p 101	MAFF	RSPB
Sterna dougallii	roseate tern	Tr 1, vol I, p 105	EN & EHS	RSPB
Streptopelia turtur	turtle dove	Tr 2, vol I, p 109	MAFF	RSPB & EN
Tetrao tetrix	black grouse	Tr 2, vol VI, p 17	SNH	GCT & RSPB
Tetrao urogallus	capercaillie	Tr 1, p 106	SNH	ITE & RSPB
Turdus philomelos	song thrush	Tr 1, p 107	EN	RSPB

Fish

Alosa alosa	allis shad	Tr 1, p 116	MAFF	MAFF & EA
Alosa fallax	twaite shad	Tr 1, p 117	MAFF	MAFF & EA
Cetorhinus maximus	basking shark	Tr 2, vol V, p43	EN	SWT, WWF, Shark Trust & Wildlife Trusts
Coregonus albula	vendace	Tr 1, p 119	EA	EA (Penrith)
Raja batis	common skate	Tr 2, vol V, p 47	SNH	Shark Trust
-	Commercial marine fish	Tr 2, vol V, p 51	MAFF	MAFF
-	Deep water fish	Tr 2, vol V, p 57	MAFF	Scottish Executive

Mammals

Arvicola terrestris	water vole	Tr 1, p 82	EA	EA
Balaenoptera acutorostrata	minke whale[5]	Tr 2, vol V, p 23	DETR	JNCC

Species		Publication[1]	Contact point	Lead Partner
Scientific name	**Common name**			
Balaenoptera borealis	sei whale[5]	Tr 2, vol V, p 23	DETR	JNCC
Balaenoptera musculus	blue whale[5]	Tr 2, vol V, p 23	DETR	JNCC
Balaenoptera physalus	fin whale[5]	Tr 2, vol V, p 23	DETR	JNCC
Delphinus delphis	common dolphin[6]	Tr 2, vol V, p 27	DETR	JNCC
Eubalaena glacialis	northern right whale[5]	Tr 2, vol V, p 23	DETR	JNCC
Globicephala melas	long-finned pilot whale[7]	Tr 2, vol V, p 31	DETR	JNCC
Grampus griseus	Risso's dolphin[6]	Tr 2, vol V, p 27	DETR	JNCC
Hyperoodon ampullatus	northern bottlenose whale[7]	Tr 2, vol V, p 31	DETR	JNCC
Lagenorhynchus acutus	Atlantic white-sided dolphin[6]	Tr 2, vol V, p 27	DETR	JNCC
Lagenorhynchus albirostris	white-beaked dolphin[6]	Tr 2, vol V, p 27	DETR	JNCC
Lepus europaeus	brown hare	Tr 1, p 83	CCW	MS & GCT
Lutra lutra	otter	Tr 1, p 84	EA	Worcestershire Wildlife Trust & EA (Cardiff)
Megaptera novaeangliae	humpback whale[5]	Tr 2, vol V, p 23	DETR	JNCC
Mesoplodon bidens	Sowerby's beaked whale[7]	Tr 2, vol V, p 31	DETR	JNCC
Mesoplodon mirus	True's beaked whale[7]	Tr 2, vol V, p 31	DETR	JNCC
Orcinus orca	killer whale[7]	Tr 2, vol V, p 31	DETR	JNCC
Phocoena phocoena	harbour porpoise	Tr 1, p 93 & Tr 2, vol V, p 21	DETR	JNCC
Physeter macrocephalus	sperm whale[7]	Tr 2, vol V, p 31	DETR	JNCC
Pipistrellus pipistrellus	pipistrelle bat	Tr 1, p 89	EN	Bat Conservation Trust
Sciurus vulgaris	red squirrel	Tr 1, p 91	EN	UK Red Squirrel Group
Stenella coeruleoalba	striped dolphin[6]	Tr 2 vol V, p 27	DETR	JNCC
Tursiops truncatus	bottlenose dolphin[6]	Tr 2, vol V, p 27	DETR	JNCC
Ziphius cavirostris	Cuvier's beaked whale[7]	Tr 2, vol V, p 31	DETR	JNCC

Non-vascular plants and fungi

Algae and Stoneworts				
Ascophyllum nodosum ecad *mackaii*	a brown alga	Tr 2,vol V, p 93	SNH	Plantlife
Chara baltica	Baltic stonewort	Tr 2, vol V, p 174	Species Statement	
Chara canescens	bearded stonewort	Tr 2, vol V, p 175	Species Statement	
Chara curta	lesser bearded stonewort	Tr 2, vol III, p 297	EN	Plantlife
Chara muscosa	mossy stonewort	Tr 1, p 228	RBGE	RBGE
Lamprothamnium papulosum	foxtail stonewort	Tr 2, vol V, p 177	Species Statement	
Nitella gracilis	slender stonewort	Tr 2, vol III, p 303	EA	Plantlife
Tolypella nidifica	bird's nest stonewort	Tr 2, vol V, p 178	Species Statement	
Fungi				
Bankera fuligineoalba	drab tooth fungus[8]	Tr 2, vol III, p 37	SNH	Plantlife
Boletopsis leucomelaena	a poroid fungus	Tr 2, vol VI, p 141	Species Statement	
Hydnellum aurantiacum	orange corky spine fungus[8]	Tr 2, vol III, p 37	SNH	Plantlife
Hydnellum caeruleum	blue corky spine fungus[8]	Tr 2, vol III, p 37	SNH	Plantlife
Hydnellum concrescens	concrescent corky spine fungus[8]	Tr 2, vol III, p 37	EN	Plantlife
Hydnellum ferrugineum	reddish-brown corky spine fungus[8]	Tr 2, vol III, p 37	SNH	Plantlife
Hydnellum peckii	brown corky spine fungus[8]	Tr 2, vol III, p 37	SNH	Plantlife
Hydnellum scrobiculatum	pitted corky spine fungus[8]	Tr 2, vol III, p 37	EN	Plantlife
Hydnellum spongiospies	a corky spine fungus[8]	Tr 2, vol III, p 37	EN	Plantlife
Hygrocybe calyptriformis	pink meadow waxcap	Tr 2, vol III, p 43	CCW	Plantlife

Species		Publication[1]	Contact point	Lead Partner
Scientific name	**Common name**			
Hygrocybe spadicea	date-coloured waxcap	Tr 2, vol III, p 47	CCW	Plantlife
Hypocreopsis rhododendri	hazel gloves	Tr 2, vol III, p 51	SNH	to be determined
Microglossum olivaceum	an earth-tongue	Tr 2, vol III, p 55	CCW	Plantlife
Phellodon confluens	strongly scented pine fungus[8]	Tr 2, vol III, p 37	SNH	Plantlife
Phellodon melaleucus	black & white scented pine fungus[8]	Tr 2, vol III, p 37	SNH	Plantlife
Phellodon tomentosus	goblet scented pine fungus[8]	Tr 2, vol III, p 37	SNH	Plantlife
Sarcodon glaucopus	green footed spiny-cap fungus[8]	Tr 2, vol III, p 37	SNH	Plantlife
Sarcodon imbricatus	scaly tooth fungus[8]	Tr 2, vol III, p 37	SNH	Plantlife
Sarcodon scabrosus	bitter spiny cap fungus[8]	Tr 2, vol III, p 37	EN	Plantlife
Tulostoma niveum	white stalk puffball	Tr 1, p 203	SNH	SNH
Lichens				
Alectoria ochroleuca	alpine sulphur-tresses	Tr 2, vol III, p 61	SNH	Cairngorm Partnership & RSPB
Arthothelium dictyosporum	a lichen	Tr 2, vol III, p 65	SNH	RBGE
Arthothelium macounii	a lichen	Tr 2, vol III, p 69	SNH	RBGE
Bacidia incompta	a lichen	Tr 2, vol III, p 73	SNH	Plantlife
Bellemerea alpina	a lichen	Tr 2, vol III, p 149	Species Stat ement	
Biatoridium monasteriense	a lichen	Tr 2, vol III, p 81	SNH	Plantlife
Bryoria smithii	a lichen	Tr 2, vol III, p 85	EN	EN
Caloplaca luteoalba	orange fruited elm lichen	Tr 1, p 207	EN	NHM
Caloplaca nivalis	snow caloplaca	Tr 2, vol III, p 150	Species Statement	
Catapyrenium psoromoides	tree catapyrenium	Tr 2, vol III, p 97	RBGE	RBGE
Cladonia botrytes	stump lichen	Tr 2, vol III, p 101	SNH	RBGE & RSPB
Cladonia peziziformis	a lichen	Tr 2, vol III, p 109	EN	Plantlife
Collema dichotomum	river jelly lichen	Tr 1, p 208	EA	EA (Cardiff)
Gyalecta ulmi	Elm gyalecta	Tr 1, p 209	RBGE	RBGE
Gyalideopsis scotica	Scottish snot lichen	Tr 2, vol VI, p 149	SNH	SNH
Halecania rhypodiza	a lichen	Tr 2, vol VI, p 153	SNH	NTS
Hypogymnia intestiniformis	a lichen	Tr 2, vol VI, p 161	Species Statement	
Opegrapha paraxanthodes	a lichen	Tr 2, vol VI, p157	CCW	to be determined
Peltigera lepidophora	ear-lobed dog-lichen	Tr 2, vol III, p 133	SNH	SNH
Pertusaria bryontha	alpine moss pertusaria	Tr 2, vol III, p 151	Species Statement	
Pseudocyphellaria norvegica	Norwegian speckleberry	Tr 1, p 211	RBGE	RBGE
Schistmatoma graphidiodes	speckled script lichen	Tr 1, p 212	RBGE	RBGE
Thelenella modesta	warty wax-lichen	Tr 2, vol III, p 145	SNH	Plantlife
Mosses and Liverworts				
Acrobolbus wilsonii	Wilson's pouchwort	Tr 2, vol III, p 155	SNH	FC
Adelanthus lindenbergianus	Lindenberg's featherwort	Tr 2, vol III, p 159	SNH	SNH
Andreaea frigida	icy rock-moss	Tr 2, vol III, p 185	SNH	Cairngorm Partnership & RSPB
Atrichum angustatum	lesser smoothcap	Tr 2, vol VI, p 173	Species Statement	
Bartramia stricta	rigid apple moss[3]	Tr 2, vol III, p 189	CCW	CCW
Bryoerythrophyllum caledonicum	Scottish beard-moss	Tr 2, vol III, p 197	SNH	NTS
Bryum calophyllum	matted bryum	Tr 2, vol VI, p 174	Species Statement	
Bryum neodamense	long-leaved thread moss	Tr 2, vol III, p 205	EN	Plantlife
Bryum turbinatum	pear-fruited moss	Tr 2, vol VI p 175	Species Statement	

Species		Publication[1]	Contact point	Lead Partner
Scientific name	**Common name**			
Bryum uliginosum	cernuous bryum	Tr 2, vol VI, p 176	Species Statement	
Bryum warneum	sea bryum	Tr 2, vol III, p 211	EN	Plantlife
Buxbaumia viridis	green shield moss	Tr 1, p 214	SNH	SNH
Campylopus setifolius	silky swan-neck moss	Tr 2, vol VI, p 177	Species Statement	
Didymodon mamillosus	Perthshire beard-moss	Tr 2, vol III, p 223	SNH	SNH
Ditrichum plumbicola	lead-moss	Tr 2, vol III, p 231	EN	EN & NHM
Drepanocladus vernicosus (= Hamatocaulis vernicosus)	slender green feather-moss	Tr 1, p 219	CCW	CCW
Herbertus borealis	northern prongwort	Tr 2, vol III, p 167	SNH	SNH
Jamesoniella undulifolia	marsh earwort	Tr 1, p 222	SNH	SNH
Lejeunea mandonii	Atlantic lejeunea	Tr 1, p 224	EN	Plantlife
Lophozia rutheana	Norfolk flapwort		EN	Norfolk Wildlife Trust
Marsupella stableri	Stabler's rustwort	Tr 2, vol VI, p 180	Species Statement	
Orthodontium gracile	slender thread-moss	Tr 2, vol III, p 243	EN	EN & RBGK
Orthotrichum gymnostomum	Aspen brittle-moss	Tr 2, vol VI, p 182	Species Statement	
Orthotrichum obtusifolium	blunt-leaved bristle-moss	Tr 2, vol III, p 247	SNH	Plantlife
Orthotrichum pallens	pale bristle-moss	Tr 2, vol III, p 251	SNH	Plantlife
Orthotrichum sprucei	Spruce's brittle-moss	Tr 2, vol VI, p 183	Species Statement	
Petalophyllum ralfsii	petalwort	Tr 1, p 226	CCW	Plantlife
Pictus scoticus	Pict-moss	Tr 2, vol VI, p 184	Species Statement	
Plagiothecium piliferum	hair silk moss	Tr 2, vol VI, p 185	Species Statement	
Pohlia scotica	Scottish pohlia	Tr 2, vol III, p 255	SNH	SNH
Riccia huebeneriana	violet crystalwort	Tr 2, vol III, p 175	EA	Plantlife
Seligeria carniolica	water rock-bristle	Tr 2, vol III, p 263	EA	Plantlife
Sphagnum balticum	Baltic bog-moss	Tr 2, vol III, p 271	EN	Plantlife
Sphagnum skyense	Skye bog-moss	Tr 2, vol VI, p 187	Species Statement	
Weissia rostellata	beaked beardless-moss	Tr 2, vol VI, p 169	EA	to be determined
Weissia squarrosa	spreading-leaved beardless-moss	Tr 2, vol VI, p 189	Species Statement	

Vascular plants

Arabis glabra	tower mustard	Tr 2, vol I, p 125	EN	Plantlife
Artemisia norvegica	Norwegian mugwort	Tr 1, p 176	SNH	SNH
Athyrium flexile	Newman's lady fern	Tr 1, p 196	SNH	SNH
Calamagrostis scotica	Scottish small-reed	Tr 2, vol I, p 137	SNH	RBGE
Carex muricata ssp muricata	prickly sedge	Tr 2, vol I, p 141	EN	EN
Centaurea cyanus	cornflower	Tr 2, vol I, p 149	MAFF	Plantlife
Cerastium nigrescens	Shetland mouse-ear	Tr 2, vol I, p 153	SNH	SNH
Cochlearia micacea	mountain scurvy-grass	Tr 1, p 177	SNH	Plantlife
Cochlearia scotica	Scottish scurvy-grass	Tr 2, vol VI, p 193	Species Statement	
†Dianthus armeria	Deptford pink	Tr 2, vol I, p 161	EN & CCW	Plantlife
Epipactis youngiana	Young's helleborine	Tr 1, p 182	EN	Plantlife
Euphrasia campbelliae	an endemic euphrasia	Tr 1, p 183	RBGE	RBGE
Euphrasia heslop-harrisonii	an endemic euphrasia	Tr 1, p 183	RBGE	RBGE
Euphrasia rotundifolia	an endemic euphrasia	Tr 1, p 183	RBGE	RBGE
†Filago pyrimidata	broad-leaved cudweed	Tr 2, vol I, p 169	MAFF	Plantlife & EN
Fumaria purpurea	purple ramping-fumitory	Tr 2, vol I, p 173	MAFF	EN
Galeopsis angustifolia	red hemp nettle	Tr 2, vol I, p 177	MAFF	Plantlife

Species		Publication[1]	Contact point	Lead Partner
Scientific name	**Common name**			
Galium tricornutum	corn cleavers	Tr 2, vol I, p 181	MAFF	Plantlife
Gentianella uliginosa	dune gentian	Tr 2, vol I, p 185	CCW	CCW
Hieracium Sect. *Alpestria*	Shetland hawkweeds	Tr 2, vol I, p 189	SNH	Shetland Amenity Trust
Juniperus communis	juniper	Tr 2, vol III, p 325	FC	Plantlife
Limonium endemic taxa (*L. recurvum* ssp. *humile)*	a rock sea lavender	Tr 2, vol I, p 201	CCW & EN	NT & BSBI
Linnaea borealis	twinflower	Tr 2, vol III, p 331	FC	Plantlife
†Luronium natans	floating water-plantain	Tr 1, p 187	CCW	BWB
Lycopodiella inundata	marsh clubmoss	Tr 2, vol I, p 205	CCW & EN	Plantlife
Melampyrum sylvaticum	small cow-wheat	Tr 2, vol III, p 335	FC	SWT
†Mentha pulegium	pennyroyal	Tr 2, vol I, p 209	EN	EN
Najas flexilis	slender naiad	Tr 1, p 189	SNH	SNH
Pilularia globulifera	pillwort	Tr 2, vol I, p 213	SNH	CCW & Plantlife
Potamogeton compressus	grass-wrack pondweed	Tr 2, vol I, p 217	EN	BWB
Potamogeton rutilis	Shetland pondweed	Tr 1, p 191	SNH	SNH
Salix lanata	woolly willow	Tr 2, vol I, p 221	SNH	NTS
Saxifraga hirculus	yellow marsh saxifrage	Tr 1, p 194	SNH	SNH
Scandix pecten-veneris	shepherd's needle	Tr 2, vol I, p 225	MAFF	Plantlife
Silene gallica	small-flowered catchfly	Tr 2, vol I, p 237	MAFF	Plantlife
Sium latifolium	greater water-parsnip	Tr 2, vol I, p 241	EN	EA
Spiranthes romanzoffiana	Irish lady's-tresses	Tr 2, vol III, p 339	EHS	Plantlife
†Torilis arvensis	spreading hedge-parsley	Tr 2, vol I, p 253	MAFF	Plantlife
Trichomanes speciosum	Killarney fern	Tr 1, p 197	CCW	EN & NHM
Valerianella rimosa	broad-fruited corn-salad	Tr 2, vol I, p 257	MAFF	Plantlife
Woodsia ilvensis	oblong woodsia	Tr 2, vol I, p 261	SNH	RBGE

[1] Biodiversity Action Plans have been published in two tranches, the first of which appears in: Anon. (1995). Biodiversity: the UK Steering Group Report. Volume 2: Action Plans. London: HMSO. Subsequent plans appear in: UK Biodiversity Group (1998-99). UK Biodiversity Group. Tranche 2 Action Plans. Volumes 1-4. Peterborough: English Nature. The abbreviations used here as follows. Tr: the tranche, either I or II; Vol: the volume number, applicable only to Tranche II; p: the page number within the publication.

[2] Species included in the river shingle beetles grouped action plan.

[3] Scottish records for these species need confirmation.

[4] Marine turtles grouped species action plan.

[5] Baleen whales grouped species action plan.

[6] Small dolphins grouped species action plan.

[7] Toothed whales (other than small dolphins) grouped species action plan.

[8] Threatened 'tooth' (or stipitate hydnoid) fungi – 14 species – action plan.

Appendix 3

Forces for change in the mid-1990s Scottish landscape

Key: ▲ Frequent, widespread and/or increasing ● Occasional, localised and/or declining

Force	Farmland	Fresh Waters	Mountains & Moorland	The Coast	The Sea	Urban	Woodlands
Agriculture / Aquaculture							
Loss of agricultural land to forestry	▲		▲	▲			▲
Loss of agricultural land to urban development	▲	●		▲		▲	●
Loss of agricultural land to other land uses	▲			▲			
Loss of or "improvement" of semi-natural, unimproved or semi-improved grasslands	▲	●	●				▲
Conversion of grassland to arable	▲						
Conversion of permanent pasture to ley grass / rotations				▲			
Drainage of agricultural fields	●						
Drainage of semi-natural areas	●	●	●				●
Flood prevention works	●	▲				●	
Decline of traditional drainage / irrigation methods	●			▲			
Conversion of coastal habitats to agriculture		●		●			
Conversion of woodland to agriculture							●
Abandonment of hill farming / grazing	●	▲	▲				▲
Changes in type or density of grazing	▲		▲	▲		●	
Changes in practice of muirburn	●		▲				
Loss of heather moorland or heather cover on moorland, improvement of outbye land	▲		▲				▲
Enlargement of field size / pattern	▲	●		▲			
Removal of field boundaries	▲		▲				●
Neglect of hedgerows	▲	▲		▲		▲	
Neglect of stone dykes	▲	▲	▲	▲			▲
Neglect of ditches / drains	▲			▲			
Loss of small farm woodlands						▲	
Loss of shelterbelts				▲			
Loss of hedgerow trees	●	▲				●	●
Neglect of hedgerow trees	▲	▲				▲	●
Neglect of shelterbelts	▲			●			▲
Planting new farm woodlands							
Planting new shelterbelts							
Decline / redundancy / dereliction of farm buildings / steadings	▲	●	▲	●		●	
Conversion of steadings	▲			●		▲	
Addition / replacement of (large) new agricultural buildings	▲	●				▲	

Force	Farmland	Fresh Waters	Mountains & Moorland	The Coast	The Sea	Urban	Woodlands
Decline of crofting	▲	●	▲	●			●
Disposal of agricultural wastes							
New or extended or intensified fish farming installations		▲		▲	▲		
Accumulation of shoreline debris and litter from fishing boats etc.							
Inappropriate use or poor maintenance or redundancy of post and wire fences	▲		▲	▲			
Extensive pig farming, clutter of arcs and changes to fields and surfaces							
General intensification of arable cultivation with loss or incremental erosion of semi-natural habitats and vegetation	▲						
Overgrazing by rabbits							
Effects of set-aside on arable land	▲						
Decline of horticulture and orchards							
Development							
Major urban expansion	▲			▲		▲	
Edge of town development (incremental)	▲	▲		▲		▲	▲
Housing generally	▲	●					●
Industrial, Business, Retail and Warehousing		▲		▲		▲	▲
Neglect / decline of countryside around towns						▲	
Village expansion (incremental)	▲	▲		▲			▲
New settlement(s)							
Airfield new or extended / improved							
Port or harbour or pier new or extended / improved		▲		▲			
Linear developments along roads	●	▲		▲			
Tourism related developments generally	●	▲	▲	▲			▲
Tourism related development along tourist routes and at tourist attractions		▲	▲	▲			
General development pressure related to scenic value		▲	▲				
Caravan and Camping sites		▲	●	▲			
Golf Courses				▲			●
Water sports		▲					
Motorised vehicles off road			●				
Skiing and related infrastructure			●				
Leisure or recreational developments generally	●	▲	▲	▲		▲	▲
New or extended waste management schemes		▲		▲			
Telecommunication and other masts / towers	▲	●	▲	▲			
Fish Farming related development onshore		▲		▲			
New or replacement (large) agricultural buildings		●					
Industrial decline and dereliction	●	●					

Force	Farmland	Fresh Waters	Mountains & Moorland	The Coast	The Sea	Urban	Woodlands
Redevelopment of derelict / unused vacant land							
Redevelopment of rural buildings (eg. MoD, Hospitals)						▲	
Redevelopment of airfields or MoD land			●				
Conversion / redevelopment of farm steadings	▲	●	▲				▲
New main road / bridge construction	●	▲		▲		▲	
New minor road / bridge construction	●	●	●				●
Incremental improvement / upgrading of roads	▲	▲	▲	▲		▲	▲
Increasing urbanisation through roadside clutter	▲	▲				▲	
Increase in redundant telecommunication, navigation or military installations and structures							
Erosion of vegetation owing to recreational pressure			▲	●			●
New single houses in the countryside	▲	▲	▲	▲			▲
Erosion of road verges and roadside features		●					
New or extended marinas		●		●			
New built development - unspecified				▲			
Coast defence works		▲		▲			
Loss or erosion of landscape character due to inappropriate siting, design or building materials in new development	▲	▲		▲		▲	
Development of the valley floor							
Canal related development		▲					
Reservoir and water supply infrastructure		▲					
Forestry							
New large scale coniferous afforestation			▲	▲			▲
New medium-large scale coniferous afforestation	▲	▲	▲	▲			▲
New small-medium scale coniferous afforestation		▲		▲			▲
New large scale mixed or broadleaved woodland planting			▲				
New small-medium scale mixed or broadleaved woodland planting	●		▲				▲
New shelterbelt planting							
New farm woodland planting							●
New hedgerow tree planting							
New ornamental tree planting							
Planting of open / wild land			▲				▲
Planting of moorland			▲				▲
Planting of marginal hill farmland	▲						▲
Planting of other semi-natural habitats	▲	●	▲				
New / extension of native woodlands		●	●	●			▲
Planting obscuring landform							▲
Planting obscuring other landscape / historical features			▲				▲
Planting obscuring views			●				▲

Force	Farmland	Fresh Waters	Mountains & Moorland	The Coast	The Sea	Urban	Woodlands
Neglect / decline of semi-natural or native woodland	▲	▲	●	▲			▲
Neglect / decline of other broadleaved / mixed woodland	▲	▲		▲		●	▲
Neglect / decline of farm woodland	▲	●				●	▲
Neglect / decline of policy woodland	▲	▲					▲
Neglect / decline of shelterbelts	▲						▲
Neglect / decline of avenues / tree lines / roadside trees / copses	▲	●		▲		▲	▲
Replanting of semi-natural woodland with inappropriate species							●
Replanting of other broadleaved / mixed woodland with inappropriate species		●					●
Replanting of policy woodland with inappropriate species	●	●					
Replanting of shelterbelts with inappropriate species							
Maturity and potential decline of broadleaved / mixed woodland	▲	▲		▲		▲	▲
Maturity and potential decline of policy woodland	▲			▲		●	▲
Maturity and potential decline of shelterbelts	▲						▲
Maturity and potential decline of avenues / tree lines / roadside trees	▲	●					▲
Changes in forestry management as plantations near / reach commercial maturity		●	▲	●			▲
Changes in extent and character of woodland							
Changes in character of woodland edges							▲
Fragmentation of woodland				▲			▲
Severance of woodland by roads / pipelines / overhead wires etc.				▲		●	▲
Restoration and replacement of policy woodlands							
Lowland crofting							
Biomass planting for fuel production							
New or improved forestry tracks			▲				▲
New woodland planting / afforestation of unspecified scale or type	●	▲	▲				
Loss of woodland to new built development and changes of use other than agriculture							▲
Felling of plantations without re-planting							
Energy							
New Power Station							
Redevelopment of power station							
Medium-large scale wind farms							
Potential for tidal barrages		●			●		
Wind farms generally or unspecified	▲	▲	▲	▲	▲		▲
Single wind turbine generators		▲					

Force	Farmland	Fresh Waters	Mountains & Moorland	The Coast	The Sea	Urban	Woodlands
Hydro electric power schemes		▲	▲				
Biomass planting for energy production	●						
Petro-chemical / Gas installations		▲		▲	●		
Overhead lines	▲	▲	▲	▲			●
Pipelines		▲		▲	●	▲	
Decommissioning of oil and gas installations							
Minerals							
New or extended Sand and Gravel – below ground extraction	●	▲	●	▲			▲
New or extended Sand and Gravel – extraction from features eg. kames, eskers etc.		▲		▲			
New or extended Sand and Gravel – extraction from dunes				▲			
New or extended crushed rock aggregates quarries							
New or extended Hard rock quarries	●	●	●	▲			●
New or extended vein and rare mineral extraction							●
New or extended open cast coal extraction	●	●					▲
New or extended peat extraction (commercial)	●		●	▲			
New or extended peat extraction (domestic)			●				
Decline of mineral extraction and dereliction	●			▲			
Potential for superquarry developments							
Unspecified mineral extraction			●				
Aggregate extraction but source/type unspecified					●		
New or extended gold mines							
Landfill after-use in mineral workings							
Mineral waste disposal							
Other							
Neglect or decline of gardens and designed landscapes		●		▲		▲	▲
Loss of gardens and designed landscapes						●	
Development in gardens and designed landscapes						●	
Loss or decline of historic / archaeological features	▲			▲		▲	
Loss or neglect of historic buildings / archaeological sites		▲	●	▲			
New, extended or intensification of military activities							
Overgrazing by / overpopulation of deer		●	●				▲
Natural erosion of coast and coastal habitats		▲		▲			
Reclamation of coastal edge		●		▲			
River Engineering for fishing		▲					

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