C. Condition of forest and environment

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C2. Soil chemistry

C3. Water quality

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C5. Water yield and stream flows

C6. River habitat quality

C7. Pollution incidents

C8. Crown density

C9. Damage by living organisms

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Condition of forest and environment – Summary

Public concern in the 1980s about the growth and condition of European forests was focused on the possible impacts of air pollution on forest health. Although the levels of sulphur pollutants that triggered this concern have declined in recent years, they and other substances still have the potential to affect forests and the soil and water environments that interact with them.

In addition to direct monitoring of pollution input (C1), there are indicators of soil and water quality (C2 – C4). These indicators are also designed to pick up the effects of forests themselves on soil and water. Forest ecosystems are generally robust and may react very slowly to change. It is particularly important to bear this in mind in relation to the indicators of soil and water condition. So important are the potential interactions between forests and water that two further indicators are added: flows in watercourses out of the forest (C5) and river habitat quality (C6). The latter integrates possible impacts on water quality and quantity into their effect on the plants and animals of the freshwater environment.

Forestry operations have the capacity to cause serious pollution of soil and water. Although pollution incidents are generally accidental, they will nonetheless compromise the sustainability of forest management if they happen frequently. Indicator C7 reflects the intention that they remain rare.

The condition of the trees themselves is obviously of prime importance to sustainable forestry, as well as a reflection of the health of the wider forest environment. The remaining indicators (C8 - C10) cover this. Crown density measures the amount and condition of visible foliage and basic indicators of tree condition. The other two indicators are direct observations of the occurrence of serious damage caused by fire, storms, pests or diseases.

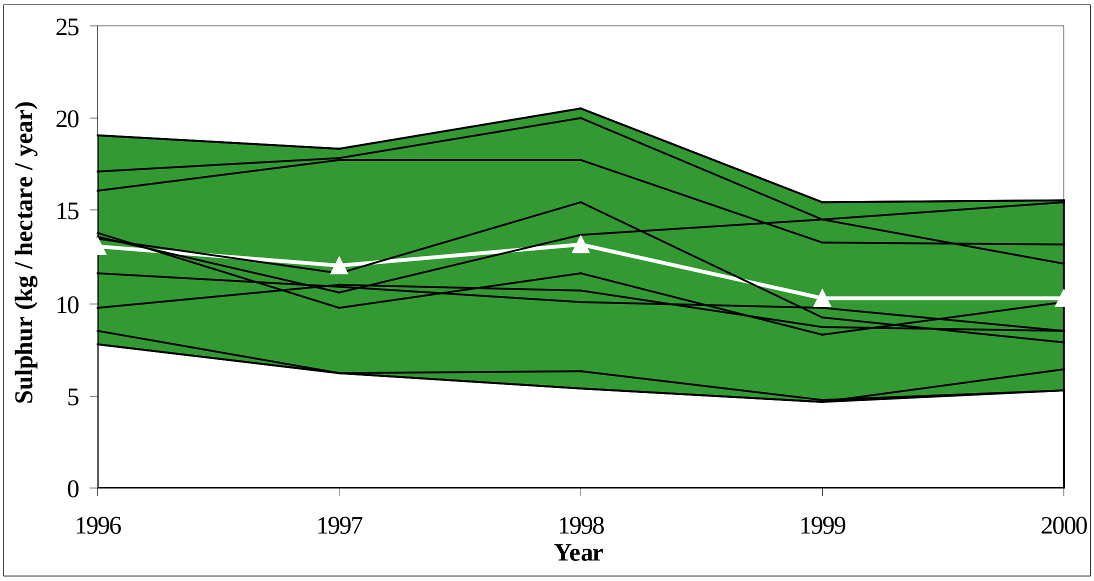
This set of indicators does not include estimates of the extent of protected or protective forest areas. The UK interpretation of the proposed international definitions is still under discussion, and indicators will be developed for pan-European reporting.

C1. Air pollutants

Relevance Air pollution is a potential driver of change in woodland condition. Changes in crown density of trees (see indicator C8) in the UK have not been linked to air pollution. However, other forest health parameters, such as the occurrence of insect damage and needle retention, have (NEGTAP, 2001). Air pollution may also predispose trees to the effects of drought and attack by fungi.

Key Points Emissions of sulphur dioxide have been decreasing since the 1970s and emissions of nitrogen oxides have been decreasing throughout the 1990s (NEGTAP, 2001). As a consequence, deposition of sulphur and nitrogen on woodland in GB has also decreased. Mean sulphur deposition decreased from 13.1 to 10.3 kilograms per hectare per year between 1996 and 2000, and mean nitrogen deposition decreased from 13.2 to 8.5 kilograms per hectare per year.

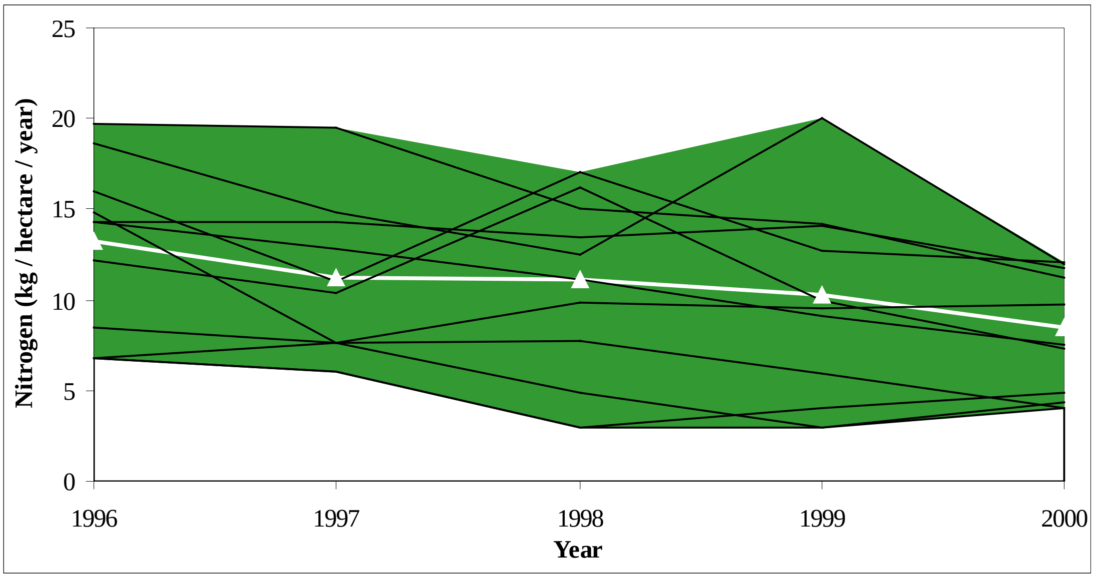
Annual deposition of sulphur at 10 sites in GB[1]



Source: Forest Condition Survey

[1]Shaded area shows the maximum and minimum deposition rates of the 10 sites and the white line with triangles shows the mean of the 10 sites. Individual sites are shown by black lines.

Annual deposition of nitrogen at 10 sites in GB[1]



Source: Forest Condition Survey

[1]Shaded area shows the maximum and minimum deposition rates of the 10 sites and the white line with triangles shows the mean of the 10 sites. Individual sites are shown by black lines.

Background Sulphur dioxide and nitrogen oxides are emitted mainly by burning of fossil fuels and road transport. Once in the atmosphere, these pollutants can be deposited back on the earth's surface either by dry deposition (contact with the ground) or wet deposition (rain). More pollutants can be deposited on woodland than on open land or grassland due to the nature of the land cover. Deposition of pollutants in woodland has implications for the condition of the soil (Indicator C2) as well as acidification of streams and rivers (Indicator C4).

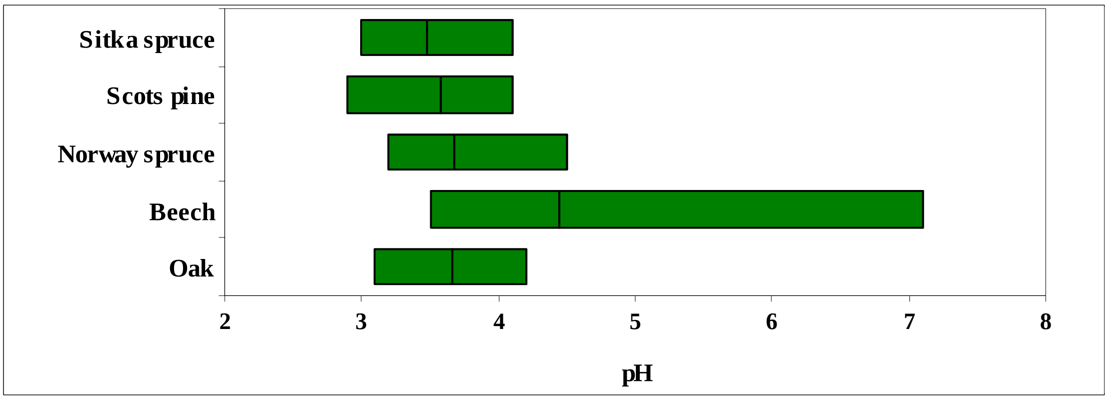
Since mid-1995, air quality and pollutant deposition have been monitored at 10 Forest Condition Survey (FCS) 'level II' plots, mostly in FC forests. These are part of the ICP Forests (International Co-operative Programme on Assessment and Monitoring of Air Pollution Effects on Forests) network (see ICP Forests website), designed for intensive monitoring of forest condition in Europe. The concentrations of several ions (NO_3^-, NH_4^+ and SO_4^{2-}) are measured above and below the forest canopy, to estimate annual deposition (dry and wet) of sulphur and nitrogen to the forest canopy.

C2. Soil chemistry

Relevance Forestry is often beneficial or has no effect on soils, but it can have a negative impact in some situations. Examples of damage are drying of peat, acidification (see indicator C4) and damage from forestry operations – the last includes disturbance, erosion and compaction from harvesting, cultivation and road building. It is important to monitor soil, even if the implications of a particular change are not yet understood.

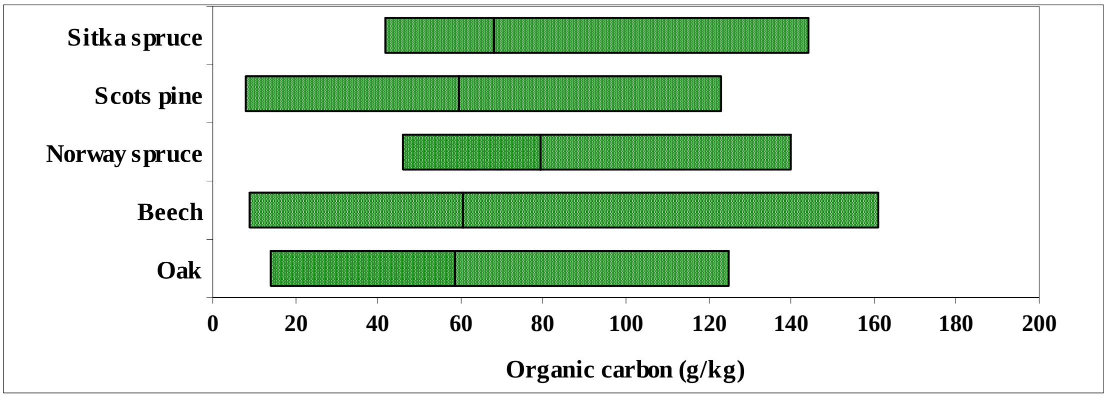
Key Points Soil measurements presented here were taken as part of the Forest Condition Survey (FCS) in 1995 (Moffat *et al.* 1997). Differences between species in soil pH, organic carbon and nitrogen content are likely to be due to a number of factors, including the effect of the tree species itself, and silvicultural decision making at the time of planting where certain species were chosen for certain soil types.

pH of the mineral soil (0-5cm) layer in GB woodland[1]



Source: Forest Condition Survey, 1995, level 1 plots

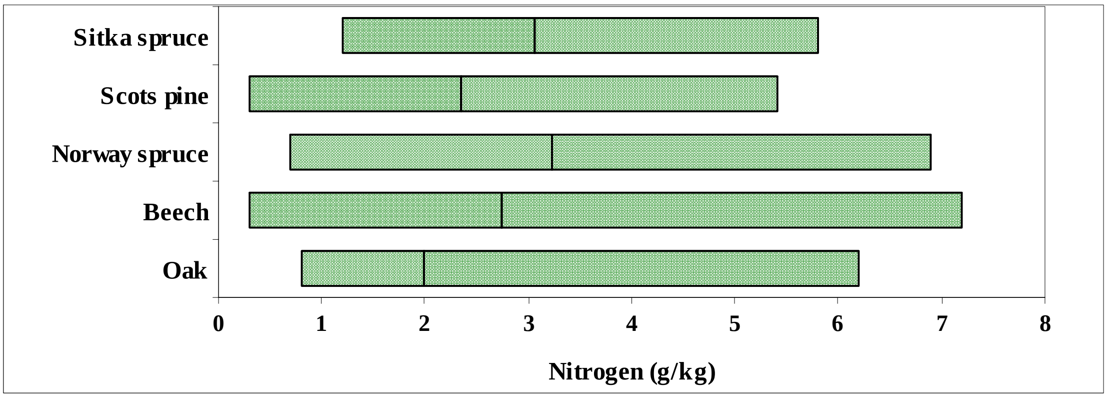
Organic carbon in the mineral soil (0-5cm) layer in GB woodland[1]



Source: Forest Condition Survey, 1995, level 1 plots

[1] In figures, each bar shows the range (minimum to maximum) of values recorded in the survey, with the mean shown by a vertical line.

Nitrogen in the mineral soil (0-5cm) layer in GB woodland[1]



Source: Forest Condition Survey, 1995, level 1 plots

Background Soil properties were measured in 1995 at 67 plots in the FCS Level I network. pH was measured using the Soil Survey for England and Wales $CaCl_2$ method, organic carbon was based on loss on ignition, and nitrogen was measured using the Kjeldahl method. 15 oak, 12 beech, 14 Norway spruce, 12 Scots pine and 11 Sitka spruce plots were included in the figures. These FCS measurements are due to be repeated in 2005. Soil chemistry is also measured continuously as soil solution at 7 FCS level II plots.

pH measures the acidity or alkalinity of soil, which influences its interaction with substances which are added to it. Crop yields, water quality and habitat diversity are all related to the underlying pH of the soil.
Soil organic carbon is an indicator of a number of soil functions and related processes. It is related to the yield of food and fibre and the range and composition of soil-related habitats, among others.
Nitrogen is broad indicator of fertility. Coupled with organic carbon, it has some potential to define nitrogen mobility and potential risk of loss in soil solution.

Future Forest Research have been working with the Environment Agency on the development of a set of soil indicators and hope to include future measurements of soil condition in forests within this framework (Loveland and Thompson, 2001). pH and soil organic carbon are among the Environment Agency's recommended 'minimum indicator set'. Nitrogen and base saturation are also included in their list of biological soil indicators. Base saturation is an indicator of base status. It indicates the 'reserves' left in the soil to buffer against further additions of, for example, acidifying substances.

It may also be possible to access data from the early 1980s, when the National Soil Inventory made measurements in the upper 15 cm of mineral soil, including pH and organic carbon at over 6,000 sites around GB. There were 483 forested sites in England and Wales (209 coniferous and 274 broadleaved) and 332 forested sites in Scotland.

C3. Water quality

Relevance The protection of the freshwater environment is a key requirement for sustainable forestry. Most forest operations can affect the quality and quantity of drainage waters. Benthic invertebrates are affected by a range of chemical and physical impacts and thus provide a good measure of the health of the freshwater environment.

Key Points The diversity and abundance of benthic invertebrates will give an indication of the biological condition of waterways in and downstream of woodland.

Measures Diversity and abundance of benthic invertebrates. Benthic invertebrates are animals without a backbone that live on the bottom of streams during all or part of their lifetime. They include snails, worms, the larvae and nymphs of mayflies and dragonflies, waterbugs and beetles.

Available information

The Environment Agency (EA) and Scottish Environment Protection Agency (SEPA) regularly survey benthic invertebrate populations in a large number of streams and rivers across the UK as part of their River Habitat Survey (RHS). Information for forest sites will be extracted from the RHS database.

The diversity and abundance of the benthic invertebrate population at any given site can be compared with what would be expected on the basis of the natural physical habitat features using the ‘River Invertebrate Prediction And Classification System’. This should highlight any physical or chemical impacts resulting from forestry operations.

Background Poor forest management can lead to increased soil erosion, greater water turbidity, nutrient enrichment and sedimentation within watercourses. These can pollute water supplies and damage wildlife and fisheries. The FC's Forests and Water Guidelines (FC, 2000a) provide advice on the best management practices for protecting and enhancing the water resource.

Chemical monitoring can often miss polluting events, which are frequently of short duration and related to adverse weather conditions.

In contrast, the benthic invertebrate fauna remains exposed to all perturbations and provides a better indicator of site disturbance. A wide range of biological scoring systems and indices based on the abundance and diversity of benthic invertebrates have been developed as a means of assessing ecological quality and the impact of water pollution.

This work has been facilitated by the development of the 'River Invertebrate Prediction And Classification System', which uses information on physical habitat characteristics to predict the type of benthic community that could be expected at an unpolluted site. An assessment is based on sampling the benthic invertebrate fauna present in a stream, identifying to species or family level, and counting the number of individuals.

C4. Surface water acidification

Relevance Acidification remains a serious problem in a number of areas of the UK. The primary cause is the deposition of acidic sulphur and nitrogen compounds derived from the combustion of fossil fuels. Forest canopies can significantly increase the capture (scavenging) of some of these pollutants in the atmosphere. This has led to concern that forestry may contribute to further acidification in sensitive areas or delay recovery in response to ongoing emission reductions.

Key Points The individual datasets have not yet been brought together to form this indicator.

Measures Acid Neutralising Capacity (ANC), pH, or aluminium

Available information

Various acid water monitoring networks, including:

- 12 sites (10 forest, 2 moorland) in upland Wales, monitored since 1991 (FC / EA)
- 22 sites (5 forest) in UK Acid Waters Monitoring Network, monitored since 1988 (see Monteith and Evans, 2001)
- 3 / 4 sites (forest and moorland) at Lynn Brianne, Wales, monitored since early 1980s (EA)
- 2 sites (forest and moorland) at Loch Dee, Galloway, monitored since early 1980s (SEPA)
- 7 sites (6 forest) at Loch Ard, monitored since late 1970s (Freshwater Fisheries Laboratory)
- 2 sites (forest and moorland) in NW Scotland, monitored since 1983 (Freshwater Fisheries Laboratory)
- 2 sites (forest and moorland) at Halladale in north Scotland, monitored since 1993 (FC)

Background A number of long-term studies have been established to monitor the response of acidified streams to ongoing reductions in emissions of acid pollutants. Some of the studies involve forested catchments to determine the magnitude of the forest scavenging effect and to assess how this will affect the recovery process.

Acid neutralising capacity provides the most robust measure of acid status. It is proposed that the annual mean ANC data for 4 or 5 forest streams will be combined for each of Wales and Scotland and the trend compared with an equivalent number of moorland sites.

Future Long-term trends in ANC for a select number of acid sensitive moorland and forest streams could be compared. This would give a measure of how forestry affects the expected recovery in water quality in response to continued reductions in pollutant emissions.

Alternative measures include the pH or aluminium concentration.

C5. Water yield and stream flows

Relevance Water flows and levels in forested catchments may differ from those in moorland catchments. Forests can help to prevent flooding, but reduced water flows can have environmental effects, and also affect public water supplies. These flows can be monitored to ensure that the presence of a forest does not adversely affect the flow and amount of water in the catchment and further downstream.

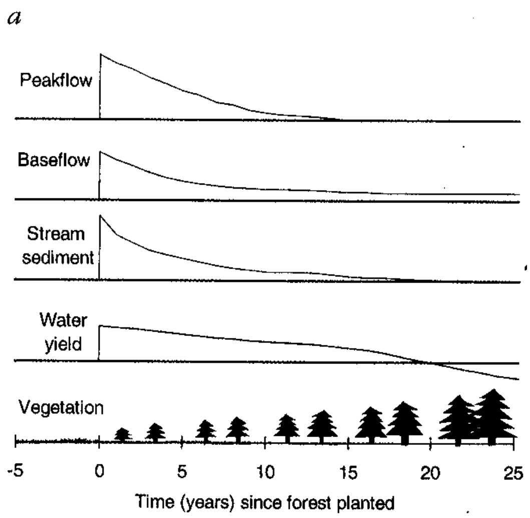
Key Points Overall, research suggests that there may be some 1.5-2.0% reduction of potential water yield for every 10% of a catchment under mature forest. The individual datasets still need to be brought together to formulate this indicator.

Measures Information from the catchment studies can be used to assess the effect of the complete forest cycle on:

- Catchment water yield
- Peak/flood flows
- Summer low flows

The figure is a schematic diagram explaining the trends in water yield and peak and low flows that have occurred since afforestation of the Coalburn catchment in 1972.

Summary of main hydrological changes at Coalburn over time as the forest is planted and grows. Source: Robinson *et al.* (1998).



Background Compared with moorland or grassland, closed canopy conifer forests cause a higher proportion of precipitation to evaporate before it reaches the ground. The quantity of water supplied from catchments containing closed canopy conifer forest may therefore be less than from moorland or grassland catchments. This loss of water in the catchment increases with forest height and canopy development and is greatest in the wetter, upland areas of Britain. There are also concerns that summer low flows will be reduced. Peak flows could be lowered or increased, depending on the scale and nature of forest practices.

There are 3 long-term catchment studies in GB which consider the effects of forestry on water yield and river flows:

- Coalburn, near Kielder, north England (Robinson *et al.,* 1998)
- Plynlimon, mid Wales (Kirby *et al*, 1991)
- Balquhidder, mid Scotland (Johnson, 1991)

The catchment studies were established to quantify the hydrological effects of forestry in upland Britain. These cover different phases of the forest cycle, from pre-planting cultivation and drainage, through establishment and forest growth, to eventual harvesting and restocking. Monitoring is continuing to enable the results for each phase to be compared between sites, as well as to assess the effects of forest restructuring and the second rotation on catchment hydrology.

Measurements include precipitation and stream discharge, covering various stages of forest development and growth. The record for Plynlimon extends back to 1967 and spans the period from forest establishment to clearfelling and restocking. Balquhidder has the shortest record, starting in 1981, and covers the effects of clearfelling and restocking. Coalburn is the only site to include a baseline period (from 1967) of measurements when the catchment was under moorland; the record covers afforestation in 1972 and the subsequent growth of the crop to 30 years age. Both the Plynlimon and Balquhidder studies include neighbouring moorland control sites, although the one at Balquhidder has now been partly afforested.

Future The annual run-off and indices of low and high flows can be plotted to identify the presence of any trend. Background variation in weather patterns can be removed using the data from neighbouring moorland control catchments.

C6. River habitat quality

Relevance The UK Forestry Standard (FC, 1998) and FC Forests and Water Guidelines (FC, 2000a) recognise the high value of the riparian zone for nature conservation, landscape and recreation, and the key role that it plays in protecting the freshwater environment. Forest management should aim to maintain about half the length of streams open to sunlight by creating a mix of mainly broadleaved woodland and open space in the riparian zone. The condition of riparian and river habitat is an indicator of the overall quality of the aquatic environment, while the length of riparian woodland is a useful measure of progress in restructuring the riparian zone.

Key Points River habitat quality scores will give an overall indication of the condition of waterways in and downstream of woodland.

Measures River habitat quality at woodland and non-woodland sites.

Available information

- The River Habitat Survey, carried out by the Environment Agency (EA) and Scottish Environment Protection Agency (SEPA), measures 'habitat quality' on selected stretches of UK rivers. Information can be extracted for wooded sites and could possibly use a habitat modification score to assess change. The initial River Habitat Survey was undertaken during the 1990s and involved over 5,000 sites across the UK.
- CS2000 has several stream bankside plots in broadleaved and conifer woodland. Several scores of vegetation condition are calculated similar to those shown in indicator B5. The 1990-1998 change in condition has been calculated for 230 broadleaved plots. Measures include soil moisture, light score, competitor score, stress-tolerator score, ruderal score, vegetation species richness and butterfly food scores.

Background Riparian woodland is woodland along river and stream banks. Past planting of conifers close to streams resulted in dense shading and the loss of herbaceous riparian and aquatic vegetation. This reduced the biodiversity and productivity of streams and led to increased bank erosion. The felling of first rotation stands presents an important opportunity to reverse these and other effects through restructuring the riparian zone. The wetness of riparian soils and characteristic instability of stream banks mean that the zone is very sensitive to disturbance. Management must aim to protect the zone from the potentially damaging effects of forest operations on the adjacent land.

The River Habitat Survey involves a detailed description of the physical features of the river corridor. This information can then be used to assess the extent of change or damage over time. It may be possible to adapt the habitat modification scoring system that has been developed by SEPA.

Future Riparian zones are not currently identified in the WGS database, Forest Enterprise systems or NIWT.

Work is ongoing to identify riparian woodland (using GIS) for FC woodland, and for all woodland over 2 hectares in NIWT. It should be possible to identify the following:

- Area of FC woodland, and non-FC woodland from NIWT, within 50 metres, say, of a water course
- A breakdown of land use types within this riparian zone
- A breakdown of species present within this riparian zone

Maps of these riparian zones would also be available. With NIWT it should also be possible to identify the sample squares which fall within the riparian zones, allowing more information to be given.

It may be possible to include a riparian marker in future national inventories to allow separate analysis of riparian woodland plots.

C7. Pollution incidents

Relevance Forestry operations have the potential to cause serious soil and water pollution. Sustainable forestry minimises disturbance to soils and water courses and avoids pollution and siltation.

Key Points Pollution incidents to water, air and land due to forestry are a very small proportion of the total number of incidents. This has been the case throughout the last decade.

Pollution incidents: total and those due to forestry operations

Year	England & Wales[1]		Scotland[2]		N. Ireland[3]	
	Total Substantiated	Forestry	Total Substantiated	Forestry	Total substantiated	Forestry
1990					1,623	0
1991					1,959	0
1992					1,845	0
1993		1			1,877	0
1994		20[4]			2,216	0
1995		20[4]			2,380	0
1996		15[4]	2,878		2,055	0
1997		31	3,535		1,823	0
1998		23	2,590		1,641	0
1999	30,922	82	2,588		1,506	0
2000	36,406	113	2,663			
2001	33,723	46				

[1]**Source: EA (2002) and previous years.** Figures for 1999 to 2001 are all pollution events to air, water and land; previous years are water only.
[2]**Source: SEPA (2001).** Pollution events to water only. Data for financial years beginning April.
[3]**Source EHS (2000).** Pollution events to water only. "Total substantiated" is substantiated + unsubstantiated 1990-1995 and substantiated only in 1996 and subsequent years.
[4] Figures are estimated from graph.

Background The Forestry Commission and Northern Ireland Environment and Heritage Service (EHS) have published guidelines for forest managers aimed at minimising disturbance to water courses and avoiding pollution and siltation (FC, 2000a). Guidelines also aim to keep pollution to soil and air to a minimum.

The EA, SEPA and EHS record all pollution incidents which are reported and which may later be substantiated. SEPA and EHS currently record pollution incidents to water, as did the EA. However in the last 3 years the EA has recorded pollution incidents to water, air and land combined.

In 2001 in England and Wales, there were a total of 33,723 substantiated pollution incidents to water air and land. Pollution incidents due to forestry operations (42) account for 0.1 % of the total number of substantiated pollution events in England & Wales.

EHS are not aware of any pollution events to water due to forestry operations in Northern Ireland in recent years.

Future In 2000/01 in Scotland there were 2,663 substantiated pollution incidents to water. Forestry is not considered as a separate category by SEPA, suggesting that numbers of pollution incidents due to forestry operations are small. However, this information should be obtainable in future.

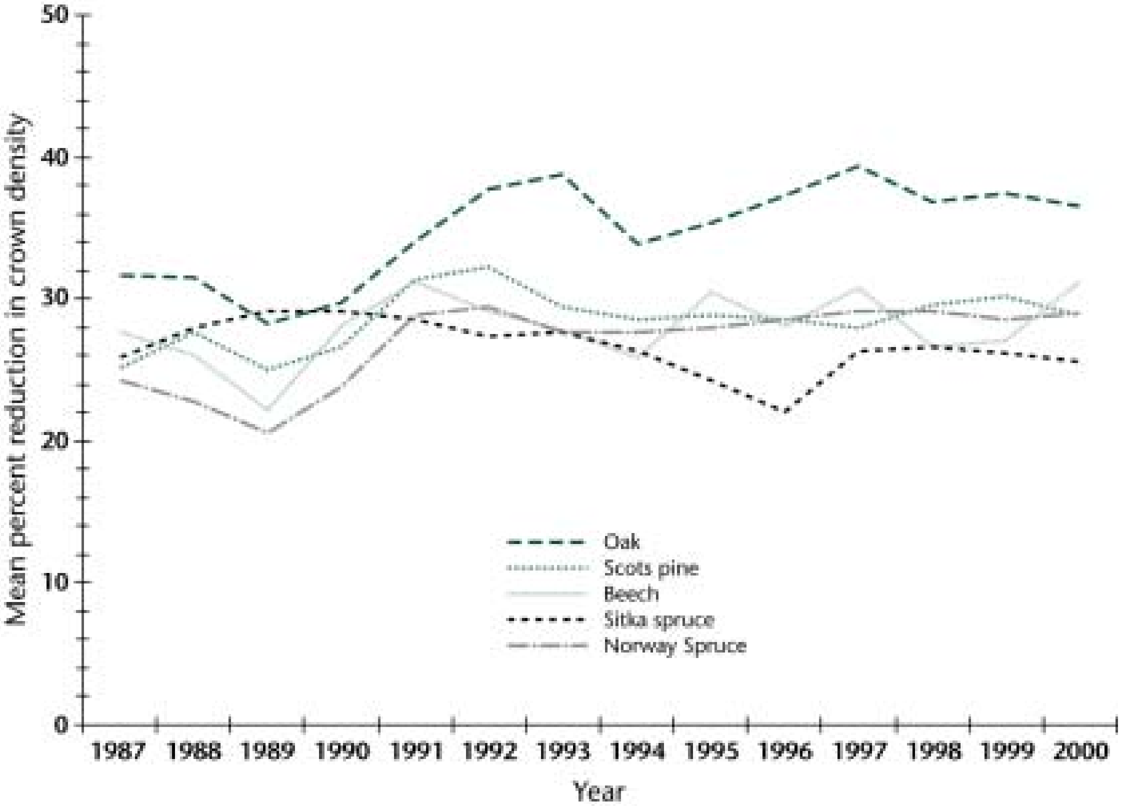
Also available from the EA, SEPA and EHS is the number of breaches of legislation which have resulted in prosecution in the UK. There are understood to be very few prosecutions related to forestry operations.

C8. Crown density

Relevance Sustainable forest management requires the forest itself to be in good health. 'Crown density' is an overall measure of tree condition, indicating the amount of foliage on a tree.

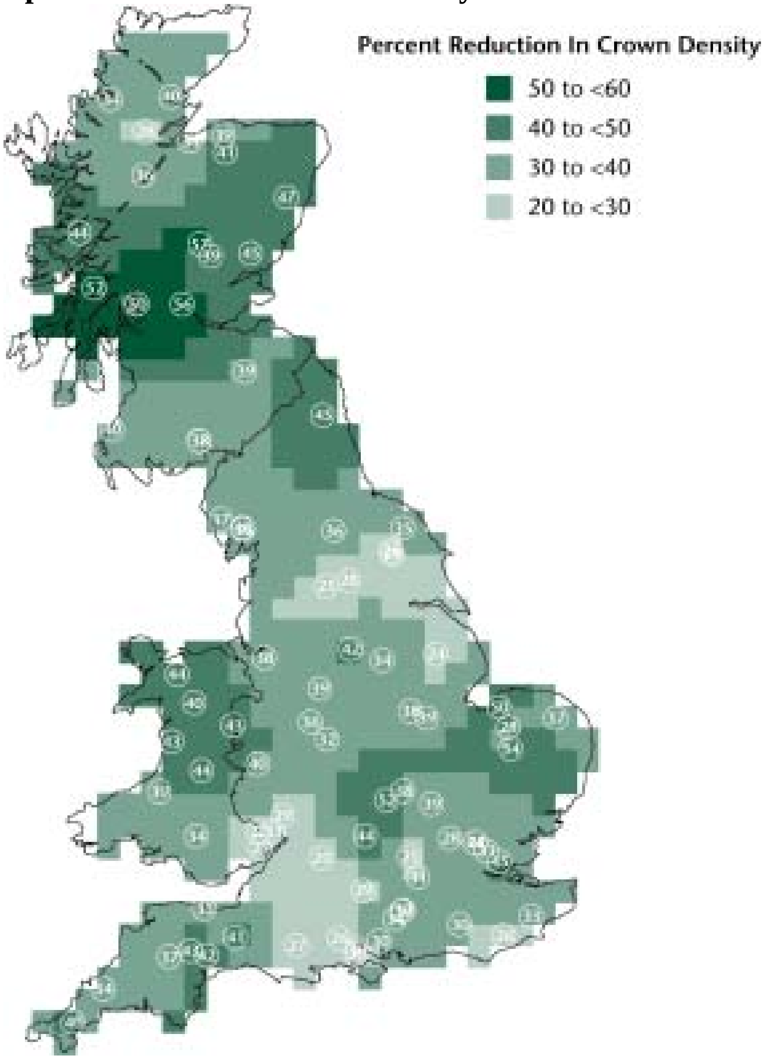
Key Points Oak was in slightly better condition in 2000 than any year since 1995, but is still in poor condition in central Scotland, north-east England, south-west England, north Wales and East Anglia (see map). However, both oak and Norway spruce show slight deterioration from 1987 to 2000. Sitka spruce has improved slightly in recent years probably due to recovery from a severe attack by insects in 1997, but shows no longer-term trend. Beech condition declined significantly in 2000 and shows statistically significant and marked declines and improvements from year to year, with no overall longer-term trend. Scots pine showed a minor improvement in 2000, after little change in condition from 1994 to 1999.

Change in crown density of 5 species in GB.



Source: Forest Condition Survey (Hendry *et al.* 2001)
Note: An upward gradient with time represents a deterioration in condition

Geographical variation of crown density for oak in 2000



Source: FCS (Hendry *et al.* 2001)
Areas of more healthy oak are shown in light green, and those in poorer condition are shown in dark green.

Background Crown density is measured as part of the Forest Condition Survey (FCS). Since 1987 the FC has annually re-assessed five tree species in FCS 'level I' plots distributed throughout Britain, as part of the ICP Forests (International Co-operative Programme on Assessment and Monitoring of Air Pollution Effects on Forests) network, designed for monitoring of forest condition in Europe (see ICP Forests website).

In 2000 the FCS assessed a total of 8,376 trees in woodland on a total of 349 plots. The density of the tree crown is measured relative to an 'ideal' tree with full (100 %) foliage, hence 'reduction in crown density' is taken as a departure from the ideal. Such reductions are not necessarily due to ill-health - in some years, heavy flowering or seed-set, for example, can lead to a marked reduction in foliation. Further information can be found in Hendry *et al.* 2001.

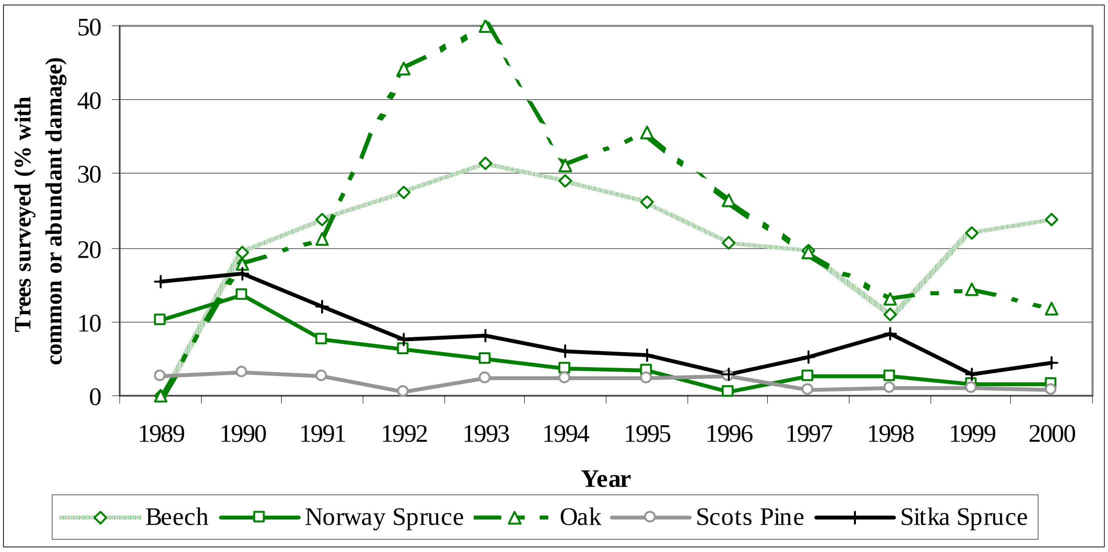
Crown density is monitored across Europe, but the crown density is measured relative to a 'local' tree unlike the data presented here. GB measurements relative to a 'local' tree have also been made since 1993. There are only 3 Sitka spruce plots in Northern Ireland where measurements are taken relative to a 'local' tree, so are not comparable to the results presented here.

C9. Damage by living organisms

Relevance Crown density (Indicator C8) gives an overall measure of the condition of the trees in our forests. Damage by living organisms gives information about some of the reasons for poor condition.

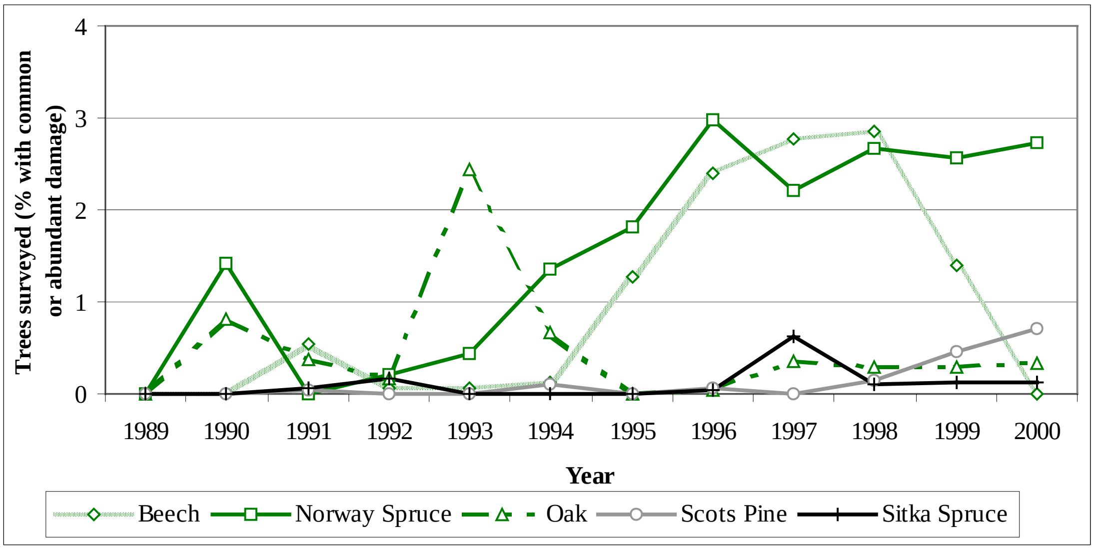
Key Points The main causes of damage reported in the Forest Condition Survey (FCS) are damage by insects and fungi. Mammals such as deer and squirrel can also damage woodland and inhibit natural regeneration. Around 6 % of woodland suffers from browsing by mammals and around 6 % suffers from bark damage.

Common or abundant damage by insects in GB



Source: Forest Condition Survey (Hendry *et al.*, 2001)

Common or abundant damage by fungi in GB



Source: Forest Condition Survey (Hendry *et al.*, 2001)

Mammal[1] damage (bark stripping and browsing) in GB

% of high forest area[2]

	England	Scotland	Wales	GB
Mammal Bark Stripping – Total	**5.2**	**7.2**	**0.9**	**5.7**
< 20 % of trees with bark stripping	2.5	5.6	0.2	3.8
20-80 % of trees with bark stripping	2.1	1.1	0.5	1.4
> 80 % of trees with bark stripping	0.6	0.5	0.2	0.5
Mammal Browsing – Total	**0.9**	**11.0**	**0.1**	**5.7**
< 20 % of trees browsed	0.5	6.6	0.0	3.4
20-80 % of trees browsed	0.3	2.3	0.1	1.3
> 80 % of trees browsed	0.1	2.1	0.0	1.1

Source: NIWT 1995-1999

[1] Mammal damage includes damage from livestock, squirrels, deer, rodents and humans.

[2] High forest is woodland excluding open land and coppice.

Background Damage to trees by insects and fungi are measured as part of the FCS and can be recorded as rare, infrequent, common or abundant. Since 1987 the FC has annually re-assessed 5 tree species in FCS 'level 1' plots distributed throughout Britain, as part of the ICP Forests (International Co-operative Programme on Assessment and Monitoring of Air Pollution Effects on Forests) network, designed for monitoring of forest condition in Europe (see ICP Forests website).

In 2000 the FCS assessed a total of 8,376 trees in woodland on a total of 349 plots. The insect and fungi results represent the percentage of trees of each species that were affected.

Oak has suffered particularly by insect damage, although this has been less of a problem since 1997. Beech also suffered from insect damage in 1999, especially in Scotland. Beech trees are regularly attacked by the beech leaf miner (*Rhynchaenus fagi*), but the actual damage to the health of the tree is only slight. However, attacks of the green spruce aphid (*Elatobium abietinum*) on Sitka spruce can severely damage the health of the tree and the effects are long-lasting - such an event occurred in 1997. Norway spruce plots in north England, Scotland and south west England, suffered from fungal damage in 2000. More information about the FCS can be found in Hendry et *al.* 2001.

Mammal damage is recorded in NIWT. Occurrences of bark stripping and browsing damage are recorded. It can include damage by livestock, squirrels, deer, rodents and humans. In addition to the area damaged, the frequency of damage and severity are also recorded, as is the height of bark stripping.

The FCS also records damage to the bark of a tree, damage by game, pollution, fire, frost & wind and humans. In each case, the proportion of trees damaged is small and has remained so during the last decade.

Future There are only 3 Sitka spruce FCS plots in Northern Ireland – information regarding the condition of these plots could be added.

C10. Other damage (wind and fire)

Relevance Wind damage is a threat to managed forests because it results in loss of timber yield, landscape quality and wildlife habitat. Prediction and prevention of wind damage are important elements of forest management. Damage by fire is not a serious problem in the UK, unlike some other European countries. There is very little natural fire.

Key Points Wind damage is sporadic and occurs when large storms affect the UK. In the NIWT survey, areas of blown woodland which remained uncleared made up 0.2 % of the high forest area in GB, and 6% of the high forest area showed signs of windblow. Fire statistics are only available for FC/FS woodland, in which 540 hectares of woodland per year on average was burned in the 1980s, falling to 360 hectares per year in the 1990s. Both fire and wind damage are likely to be influenced by the climate to a high degree (e.g. 1995 was a drought year and suffered from more fires than previous or subsequent years).

Forest windblown in GB

hectares and % of high forest[1]

		England	Scotland	Wales	GB
Blown woodland which remains uncleared and not regenerated	**ha**	1,140	4,319	48	**5,507**
	%	0.1%	0.4%	0.0%	**0.2%**
Woodland with signs of windblow (e.g. blown trees, cracking around the root plate, trees at unusual angles, trees leaning on other stems)	**ha**	21,950	105,726	6,028	**133,704**
	%	2.4%	9.7%	2.4%	**5.9%**

Source: NIWT 1995-1999

[1]High forest is woodland excluding open space and coppice.

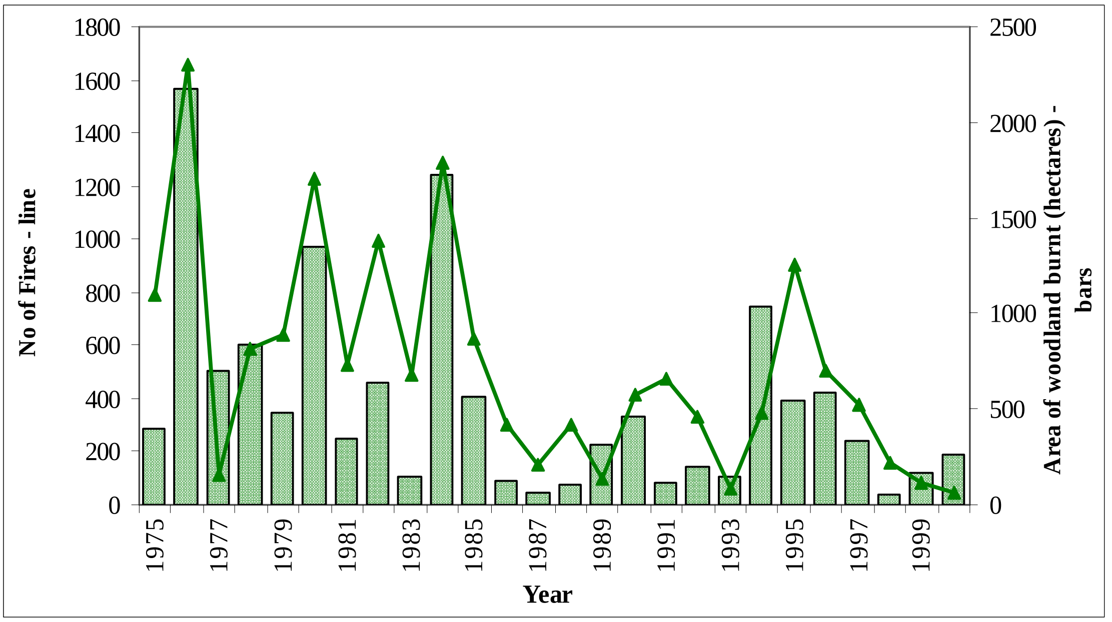
Summary information for catastrophic storms affecting GB since 1945

Date of storm	Area affected by 36 m s^{-1} gusts[1] (hectares)	Maximum gust recorded (m s^{-1})	Volume of windthrown timber (million m^3)	Growing stock windthrown in affected area (%)
31 January 1953	37,000	50	1.80	10 – 25
15 January 1968	51,000	52	1.64	15 – 30[2]
2 January 1976	89,000	47	0.96	< 5
16 October 1987	22,000	51	3.91[3]	13 – 24
25 January 1990	69,000	48	1.26[3]	1 – 3

Source: Quine *et al.* (1995)

[1] 36 m s^{-1} (metres per second) is equivalent to 130 kilometres per hour or about 80 miles per hour.
[2] Percentage of crops aged 31 years and over.
[3] Known to include non-woodland trees.

Number of fires and area burnt on Forestry Commission and Forest Service land



Source: UNECE (2001).
Note: Number of fires shown by a line; total area burnt is shown by bars.

Background Windblow includes damage where both stem and roots of the trees overturn (windthrow) and damage where the tree stem breaks above the ground (windsnap). Wind damage normally occurs during a large storm. Some significant damage tends to occur around once every three years. NIWT measures the area of woodland where trees are windblown and remain uncleared, and also measures the area of woodland that shows signs of windblow; these are both shown in the top table. Major damage caused to woodland in GB by the most catastrophic storms is shown in the bottom table.

A large proportion of the fire damage reported here is due to arson or carelessness of woodland visitors. Information on fires is only available for FC/FS woodland. Since there is less public access to private woodland (see indicator E2), it is thought that fire damage is less of a problem in private woodland than in FC/FS woodland.

Future One possible source for the number of fires in private woodland is from the Fire Services.