Assessment of the environmental impacts associated with the UK Air Quality Strategy

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April 2006

Executive Summary

The UK Air Quality Strategy (AQS) sets air quality standards and objectives for eight key pollutants, two of which (SO_2 and NO_x**)** are responsible for acidification and eutrophication**.** The objectives for these pollutants are those relevant to the protection of vegetation and ecosystem. No objective has been set for NH_3. However, this investigation considers how NH_3 concentrations in the United Kingdom compare with the limits recommended by the World Health Organisation (WHO).

This report contributes to the aims of the AQS by:

- Providing current estimates and future forecasts of the concentrations and deposition of the key pollutants responsible for acidification and eutrophication.
- Assessing the potential impacts of current and future gaseous concentrations of SO_2, NO_x, and NH_3 on designated sites in the UK.
- Assessing the potential impacts of current and future acid deposition and nitrogen deposition on sensitive habitats in the UK including a current policy baseline and eight possible emission reduction measures.
- Considering various different emissions scenarios, selected to represent a range of measures including reductions of NO_x emissions from vehicles and small combustion plants and of SO_2 from international shipping as well as both single and combined measures.

Future estimates of emissions of SO_2 and NO_x in the UK predict reductions of 64% and 45% respectively between 2002 and 2020 for the baseline. However, emissions of these pollutants from shipping are forecast to increase at a rate of 2.5% per year, increasing the contribution from shipping to sulphur and nitrogen deposition. For NH_3 a reduction of 10% in emissions between 2002 and 2020 is forecast.

The average concentrations of SO_2 in the UK are forecast to decrease by 52% between 2002 and 2020. By 2020 the higher concentrations will be located in the coastal areas of the south-east of England due to the influence of international shipping. The NH_3 concentrations are predicted to decrease by 10% over this time period with no significant change in the spatial distribution.

Assessment of the air quality objectives for SO_2 (20μg m^{-3}) and NO_x (30μg m^{-3}) presented in this report identify some areas (typically <1%) where the objectives are exceeded in 2003 for designated sites falling outside the exclusion zone. Areas are classified as being outside the zone if they are more than 20km from agglomerations and 5km from motorways, other urban areas and industrial installations. The concentration data used in this report are of 1km and 5km resolution and include urban areas (i.e., areas within the exclusion zone). This result is in contrast to reporting under the EU Daughter Directive (DD) in which no exceedance is recorded. However, the reporting for the DD is based on 30km resolution mean concentration data calculated for rural areas only to prevent the influence of any urban area appearing unrealistically large on adjacent vegetated areas.

The potential impact of reducing the SO_2 objective to 10μg m^{-3} was also examined using 1km and 5km concentration data; this resulted in some small areas of exceedance but represented <1% of the areas of designated sites outside the exclusion zone. For NH_3, the objective of 8μg m^{-3}, as recommended by the World Health Organisation, was investigated. This was exceeded in only a few areas, coinciding with <0.1% of the area of designated sites in the UK, both for 2002 and 2020.

Total deposition of SO_x and NO_y in the UK are forecast to decrease by 45% and 35% respectively between 2002 and 2020. Of eight emission abatement scenarios examined for 2020, implementation of Scenario B (Euro high) will give the largest decreases in deposition with a 12% reduction in NOy.

Critical load exceedances were calculated for the years 2001-03, 2010 and 2020. For acidity, 54.8% of UK sensitive habitats are exceeded for 2001-03, decreasing to 39.4% in 2020. For nutrient nitrogen there is a slightly smaller decrease over this time period, from 59.5% exceeded in 2001-03 to 48.1% in 2020, reflecting the smaller reductions expected in nitrogen deposition.

The eight emission abatement scenarios for 2020 gave similar results; differences in the habitat areas exceeded were only 0.8% for acidity and 2.2% for nutrient nitrogen. Overall, Scenario B (Euro high) with the large reductions in nitrogen deposition gave the lowest areas exceeded for both acidity and nutrient nitrogen and for all countries within the UK. Scenario N (shipping emission reductions) gave the smallest reduction in areas exceeded for acidity in England and NI, and in all countries for nutrient nitrogen since nitrogen deposition was only decreased by 1.7% for this scenario. However this scenario gave the greatest reduction in area of exceedance in Scotland. However, the results need to be interpreted with care; the area of habitat exceeded can be the same for different scenarios, but the magnitude of that exceedance can differ. The accumulated exceedance (AE) integrates both the area exceeded and the magnitude of exceedance, but different combinations of these two parameters, such as a large area with a small exceedance, or a small area with a large exceedance, may give the same AE value.

Table of Contents

Appendix 1:
Critical load exceedance statistics for baseline years:

1. 2001-2003
2. 2010
3. 2020

Critical load exceedance statistics for 2020 scenarios:

A. Euro low
B. Euro high
C. Early Euro low
K. Large Combustion Plant
N. Shipping
O. Early Euro low & low emission vehicles
P. Early Euro low & small combustion plant
Q. Early Euro low & low emission vehicles & small combustion plant

1. Introduction

The emission of pollutant gases (SO_2, NO_X and NH_3) from the United Kingdom, from European sources and from international shipping result in the deposition of acidifying and eutrophying species to sensitive ecosystems. The emitted gases are chemically transformed in the atmosphere to particulate matter, comprising sulphate, nitrate and ammonium aerosol, which is subject to long range transport. Deposition exceeding the critical loads for acidification and eutrophication may occur, even in regions remote from the source of emissions, such as the Scottish Highlands. Acidification affects soils and freshwater, particularly in upland areas where soils tend to be derived from base-poor rocks and annual precipitation is high. Deposition of both reduced and oxidised nitrogen results in eutrophication leading to changes in plant species composition and water quality in semi-natural habitats.

Emissions of SO_2 and NO_X in the United Kingdom have fallen by 88% and 43% during the period 1970-2005. Further reductions of 44% and 38% respectively are forecast over the next 15 years according to current predictions based on existing legislation. Despite these improvements to the quality of the atmosphere, deposition of sulphate and nitrate by precipitation has responded with smaller changes than those in land-based emissions (Fowler *et al.,* 2005). One factor which may contribute to this observation is the role of shipping emissions of SO_2 and NO_X which, in contrast to land based emissions, have shown increases over recent decades of approximately 2.5% per year (Johnson, 2000). Additionally, non-linearities in atmospheric chemical reaction rates, such as the oxidation of sulphur and nitrogen, may play an important role. Emissions of ammonia in the UK have shown a more modest decrease of 19% between 1990 and 2003, whilst emissions of SO_2 and NO_X from Europe have shown similar decreases to those from the UK.

Sulphur and nitrogen compounds can be removed from the atmosphere by direct turbulent deposition to vegetation (dry deposition) which is an important pathway for deposition of gaseous species, SO_2, NO_2 and NH_3. For ammonia the deposition rate is particularly sensitive to the vegetation type, with high deposition rates to forest and moorland. For aerosols, as well as soluble gases (SO_2, HNO_3, NH_3) removal by precipitation (wet deposition) is an important pathway for deposition. Transport distances of chemicals may be several thousand km from their emissions source before they are deposited, depending on the chemical reactions and dry and wet removal rates of individual chemical species. Numeric atmospheric transport models are increasingly being used as a key tool to estimate the transport and deposition of nitrogen and sulphur.

Estimates of present day S and N deposition may be derived from measurements, for example as shown for the UK by the **N**ational **E**xpert **G**roup on **T**ransboundary **A**ir **P**ollution (**NEGTAP**, 2001). The use of a canopy compensation point to generate maps of gaseous deposition to vegetation for the United Kingdom is described in Smith *et al*. (2000). Smith and Fowler (2001) describe a technique to generate maps of wet deposition for the United Kingdom by interpolation of measured concentrations of ions in precipitation. The combination of these two measurement-based data sets is referred to as **CBED** (**C**oncentration **B**ased **E**stimated **D**eposition). This technique, based on accurate measurements of gas concentrations and wet deposition, is the preferred method for estimating acid and nitrogen deposition to

inform DEFRA about current levels of nitrogen and sulphur deposition in the United Kingdom.

Assessment of future scenarios, however, requires the application of models linked to atmospheric emission changes. Measurements also have a limited spatial resolution, and uncertainty arises in the interpolation of concentrations and deposition between measurement sites. Furthermore, for the assessment of the terms in mass-consistent budgets (emissions, deposition, import and export), atmospheric transport models are invaluable. Models are necessary for the establishment of source–receptor relationships for integrated assessment modelling and for estimating the contribution to S and N deposition from international shipping and from import from European sources. The model currently used by DEFRA to estimate sulphur and nitrogen deposition in the United Kingdom for future emissions scenarios is the **F**ine **R**esolution **A**tmospheric **M**ulti-pollutant **E**xchange model (**FRAME**).

The importance of protecting sensitive ecosystems from environmental damage has led to several international and European agreements. These include the 1999 Protocol to Abate Acidification, Eutrophication and Ground-level Ozone, under the UNECE **C**onvention on **L**ong-**R**ange **T**ransboundary **A**ir **P**ollution (**CLRTAP**) and the European Community **N**ational **E**missions **C**eiling **D**irective (**NECD**). These agreements lay down targets for nation states to achieve reductions of emissions of SO_2, NO_X and NH_3 by the year 2010. The UK Government and the devolved administrations published an **A**ir **Q**uality **S**trategy for England, Scotland, Wales and Northern Ireland (**AQS**) in 2000 (DETR, 2000) in January 2000. It sets air quality standards and objectives for eight key pollutants to be achieved between 2003 and 2008. For seven of these pollutants local authorities are charged with the task of working towards the objectives in a cost effective way. The standards and objectives are subject to regular review to take account of the latest information on the health effects of air pollution and technical and policy developments.

The AQS aims to:

- Map out as far as possible future ambient air quality policy in the UK in the medium term
- Provide best practicable protection to human health by setting health-based objectives for air pollutants
- Contribute to the protection the natural environment through objectives for the protection of vegetation and ecosystems
- Describe current and future levels of air pollution
- Provide a framework to help identify what we can all do to improve air quality.

The current study is focused on assessing the future role of emissions of SO_2, NO_x and NH_3 in contributing to damage of the natural environment through acid deposition and nitrogen deposition. CBED has been employed to estimate the deposition of sulphur and nitrogen for the UK averaged over the period 2001-03. FRAME has been employed to estimate changes in deposition using future emissions estimates of SO_2 and NO_x for the years 2010 and 2020. Eight emissions reductions scenarios for the

year 2020 have been modelled using FRAME, including abatement of emissions of NO_x from vehicles and small combustion plants and of SO_2 from international shipping. The eight scenarios were chosen from an original list of 21 to reflect a variety of single and combined measures likely to have a significant impact on environmental criteria and with a reasonable probability of being brought into legislation. Estimates of present day exceedances of critical loads for acidity and nutrient nitrogen are based on the CBED 2001-03 data, and for 2020 on the FRAME modelled data. The FRAME results for 2002 have been included for comparison with the CBED 2001-03 data and have been used in the calibration of future 2020 emissions scenarios to ensure sensible comparison between deposition data for future and recent scenarios. The influence of the 2020 abatement measures on the exceedance of critical loads has also been assessed. The air quality objectives (critical level gas concentrations) for SO_2, and NO_x have been assessed with FRAME and with mapping techniques (Abbot and Vincent, 1999), for a recent year and using future emissions estimates for the year 2020.

2. Description of FRAME and CBED

2.1 FRAME

2.1.1 History of FRAME

The FRAME (Fine Resolution Atmospheric Multi-pollutant Exchange) model is a Lagrangian atmospheric transport model used to assess the long-term annual mean deposition of reduced and oxidised nitrogen and sulphur over the United Kingdom. A detailed description of the FRAME model is contained in Singles et al. (1998). Fournier et al. (2003) describe the development of a parallelised version of the model with an extended domain that includes Northern Ireland and the Republic of Ireland. The model was developed from an earlier European scale model, TERN (Transport over Europe of Reduced Nitrogen, ApSimon et al. 1994). FRAME was developed initially to focus, in particular, on transport and deposition of reduced nitrogen and was named the Fine Resolution AMmonia Exchange model. Subsequently, FRAME was developed to improve the representation of sulphur and oxidised nitrogen (Fournier et al., 2005). The developments included: the introduction of a fine angular resolution of 1^{o} between trajectories; the generation of a point source database including stack parameters (stack height, stack diameter, exit temperature, exit velocity); the introduction of shipping emissions of SO_2 and NO_x. Following these changes, a robust multi-chemical species tool was developed. The new name reflects these changes whilst preserving the familiar acronym. For this study, FRAME version 5.5 was used.

2.1.2 FRAME Model Domain

The domain of FRAME covers the British Isles with a grid resolution of 5 km and grid dimensions of 172 x 244. Input gas and aerosol concentrations at the edge of the UK FRAME domain are calculated using **FRAME-EUROPE**, a larger scale European simulation which was developed from TERN to run a statistical model over the entirety of Europe with a 150 km scale resolution.

While FRAME is usually referred to as a Lagrangian model, strictly speaking it combines elements of both Lagrangian and Eulerian approaches: the lateral dispersion is Lagrangian, so that the model simulates an air column moving along straight-line trajectories over the UK. However, the model atmosphere is divided into 33 separate layers extending from the ground to an altitude of 2500 m, and the diffusion between these layers (using the finite volume approach) is calculated explicitly. FRAME has a detailed vertical resolution with layer thicknesses vary from 1 m at the surface to 100 m at the top of the domain. Separate trajectories are run at a 1^{o} resolution for all grid edge points. Wind frequency and wind speed roses generated from radiosonde ascents are used to give the appropriate weighting to directional deposition and concentration for calculation of total deposition and average concentration.

2.1.3 Emissions

Emissions of ammonia are estimated for each 5 km grid square using national data of farm animal numbers (cattle, poultry, pigs, sheep and horses), as well as fertiliser application, crops and non-agricultural emissions (including traffic and contributions from human sources, wild animals etc). The ammonia emissions inventory is described in Dragosits *et al*. (1998). NH_3 is input to the lowest layer for emissions from sheep, fertiliser application and non-agricultural sources. Emissions from cattle, poultry and pigs are input to deeper surface layers depending on the relative time spent grazing and in housing. Emissions of SO_2 and NO_X are taken directly from the **N**ational **A**tmospheric **E**missions **I**nventory (**NAEI**, www.naei.org.uk). 900 individual point sources are included with detailed information on stack parameters from 250 of these. SO_2 and NO_X background emissions are divided into **SNAP** (**S**ource **N**omenclature **A**ctivity **P**rofile) code emissions sector with the depth of surface layer into which emissions are input selected according to emissions source. This division of emissions in FRAME directly into the SNAP codes allows ready exchange of information with the NAEI, and smooth running of scenarios based on emission controls applied to particular source sectors.

2.1.4 Plume Rise

Point source emissions of SO_2 and NO_X are treated individually with a plume rise model which uses stack height, stack diameter, exit temperature and exit velocity to calculate an 'effective emissions height'. The plume reaches its maximum height when its temperature is equal to that of the surrounding environment and its momentum is dissipated. Buoyancy forces dominate the plume rise, which is parameterised separately for stable conditions and for neutral and unstable conditions according to the Pasquill-Gifford stability classes. The incorporation of this parameterisation into FRAME led to a substantial improvement in model performance for predicted SO_2 concentrations in relation to measurements from the rural SO_2 network (Vieno 2005)

2.1.5 Diffusion

Diffusion of gaseous and particulate species in the vertical is calculated using K-theory eddy diffusivity and solved with a Finite Volume Method (Vieno, 2005). The vertical diffusivity K_Z has a linearly increasing value up to a specified height H_Z and then remains constant (K_{max}) to the top of the boundary layer. During daytime, when diffusivity depends on a combination of mechanical and convective mixing, H_Z is taken as 200 m and K_{max} is a function of the boundary layer depth and the geostrophic wind speed. At night time these values depend on the Pasquill stability class.

2.1.6 Chemistry

The chemical scheme in FRAME is similar to that employed in the EMEP Lagrangian model (Barrett and Seland, 1995). The prognostic chemical variables calculated in FRAME are: NH_3, NO, NO_2, HNO_3, PAN, SO_2, H_2SO_4, as well as NH_4^+, NO_3^- and

$SO_4^{=}$aerosol. For oxidised nitrogen, a suite of gas phase reactions is considered. These include photolytic dissociation of NO_2, oxidation of NO by O_3, formation of PAN (peroxyacetyl nitrate) and the creation of nitric acid by reaction with the $OH^{\cdot}$ free radical. NH_4NO_3 aerosol is formed by the equilibrium reaction between HNO_3 and NH_3. A second category of large nitrate aerosol is present and simulates the deposition of nitric acid on to soil dust or marine aerosol. The formation of H_2SO_4 by gas phase oxidation of SO_2 is represented by a predefined oxidation rate. H_2SO_4 then reacts with NH_3 to form ammonium sulphate aerosol. The aqueous phase reactions considered in the model include the oxidation of S(IV) by O_3, H_2O_2 and the metal catalysed reaction with O_2.

2.1.7 Wet Deposition

FRAME employs a constant drizzle approach using precipitation rates calculated from a climatological map of average annual precipitation for the British Isles. Wet deposition of chemical species is calculated using scavenging coefficients based on those used in the EMEP model. An enhanced washout rate is assumed over hill areas due to the scavenging of cloud droplets by the seeder-feeder effect. The washout rate for the orographic component of rainfall is assumed to be twice that calculated for the non-orographic component (Dore *et al*., 1992). The model incorporates the directional dependence of orographic rainfall by considering two components of rainfall: non-orographic precipitation, which has no directional dependence, and orographic precipitation, which is directionally dependent and stronger for wind directions associated with humid air masses. The directional orographic rainfall model is described in detail by Fournier *et al.* (2005).

2.1.8 Dry Deposition

Dry deposition of SO_2, NO_2 and NH_3 is calculated individually to five different land categories (arable, forest, moor-land, grassland and urban). For ammonia, dry deposition is calculated individually at each grid square using a canopy resistance model (Singles *et al.,* 1998), although a new optional bi-directional canopy compensation point model has now been incorporated in FRAME and is awaiting parameterization and testing at the UK scale (Vieno 2005). In the current standard version, the NH_3 deposition velocity is generated from the sums of the aerodynamic resistance, the laminar boundary layer resistance and the surface resistance. Dry deposition of SO_2 and NO_2 is calculated using maps of deposition velocity derived by the CEH 'big leaf' model, CBED (Smith *et al.* 2000), which takes account of surface properties as well as the geographical and altitudinal variation of wind-speed. Other species are assigned constant values of deposition velocity.

2.1.9 Diurnal Cycle

The depth of the boundary layer in FRAME is calculated using a mixed boundary layer model with constant potential temperature capped by an inversion layer with a discontinuity in potential temperature. Solar irradiance is calculated as a function of latitude, time of the year and time of the day. At night time, a single fixed value is

used for the boundary layer depth according to Pasquill stability class and surface wind speed.

2.1.10 Wind Rose

The wind rose employed in FRAME uses 6-hourly operational radiosonde data from the stations of Stornoway, Hillsborough, Camborne and Valentia spanning a ten-year period (1991-2000) to establish the frequency and harmonic mean wind speed as a function of direction for the British Isles. This is illustrated in Figures 2(a) and 2(b) for data averaged over the ten year period. The radiosonde wind frequency rose was found to have close agreement with the Jenkinson objective classification for a 120-year data set.

2.1.11 Computational Performance

The FRAME model code is written in High Performance FORTRAN 90 and executed in parallel on a Linux Beowulf cluster comprising of 60 dual processors, (i.e. 120 processors in total). Run time for a simulation employing 100 processors is approximately 25 minutes.

2.2 CBED

The **CBED** data used in this report are based upon 3-year averages of interpolated measurements of gas concentrations and of ion concentrations in precipitation. The 3-year averaged data smooth out some of the inter-annual variability related primarily to meteorology. The methodology (Smith *et al.*, 2000; Smith and Fowler, 2001; NEGTAP, 2001) has been used to generate deposition maps on a 5 km x 5 km grid for the UK for a number of years (1996-2004), and the 3-year averaged data for 2001-2003 are currently used for critical load exceedance calculations. The methods include estimates of the orographic enhancement of pollutant wet deposition at higher altitudes, which is a major component of deposition over hill areas such as the southern Pennines, and allow for the bi-directional exchange of NH_3, where crops can emit as well as deposit ammonia through the stomatal cavity. While modelled wet deposition is relatively similar across all land uses, modelled dry deposition rates depend on several properties of the vegetation (the maximum stomatal conductance, the response of stomata to light, temperature and humidity, and the leaf and surface area indices) as well as to the roughness of the landscape (related to the canopy height of the vegetation). These effects vary with differing land use, and so three separate data sets are produced for the calculation of critical load exceedances:

(i) total deposition to the whole square, using the estimated proportions of 5 land cover categories in the square (arable, forest, grass, moor, urban);
(ii) total deposition to any "moorland" in the square, i.e. assuming the whole square covered with low, semi-natural vegetation;
(iii) total deposition to any "woodland" in the square, i.e. assuming the whole square covered with 10 m high coniferous forest.

In the calculation of critical load exceedances (see Section 5) the values in (ii) are applied to all non-woodland terrestrial habitats and those in (iii) to all woodland

habitats. The land-use averaged deposition data (i) are used for freshwater habitats (lakes, rivers).

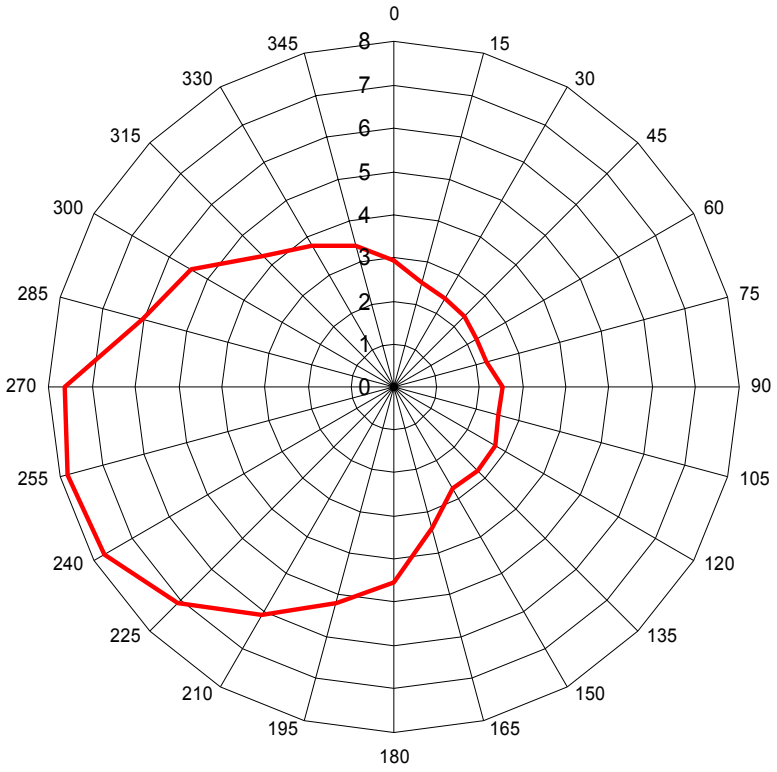


Figure 2(a) Wind frequency rose derived from radiosonde data as used in FRAME.

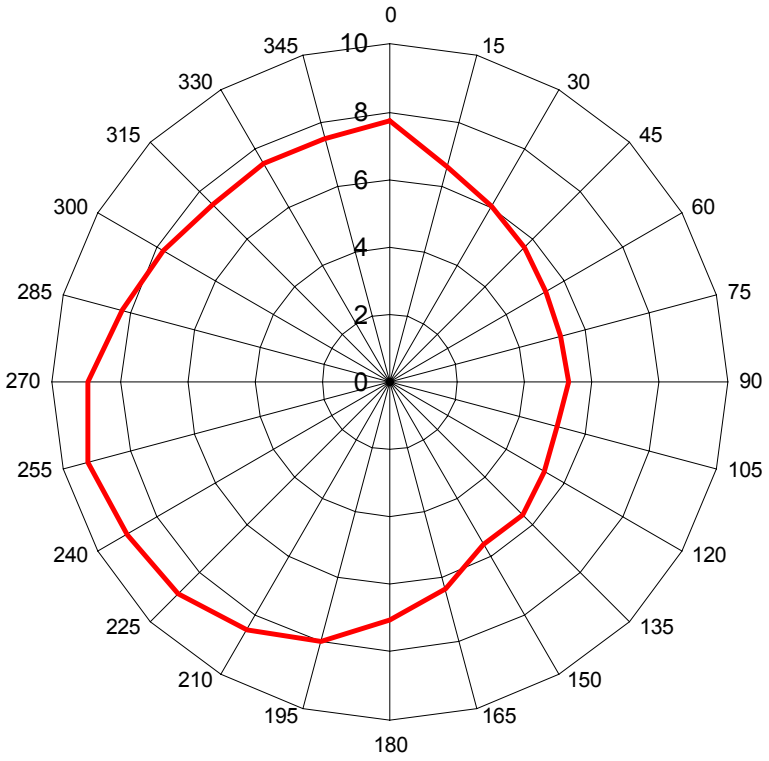


Figure 2(b) Wind speed rose derived from radiosonde data as used in FRAME.

3. Concentration data

The concentrations of SO_2 and NH_3 have been modelled at a 5 km resolution for the UK using FRAME for years 2002 and 2010. The mapping techniques of Abbot and Vincent (1999) have been employed to generate maps of SO_2 and NO_x concentrations at a 1 km resolution for the UK for the year 2003. FRAME is the preferred technique for mapping NH_3 concentrations nationally due to its fine scale 1m vertical spacing of the model grid at the surface and the model's ability to estimate surface concentrations from gridded NH_3 emissions data. The mapping technique is the preferred technique for estimating NOx concentrations due to the fine 1km horizontal resolution which is necessary for resolving the contributions from road transport. For SO_2, both techniques have been included for comparison. In this case, the mapping technique benefits from high horizontal resolution whereas FRAME is able to explicitly include the contribution to SO_2 concentrations from international shipping.

3.1 Concentrations modelled with FRAME

Concentrations of SO_2 and NH_3 for the UK were modelled using FRAME for the years 2002 and 2020. The maps of SO_2 concentration for FRAME are illustrated in Figures 3.1(a) and 3.1(b). For the year 2002, significant regions of the country have average annual concentrations in excess of 4 $\mu g\ m^{-3}$, notably in the industrial areas of northern England and in coastal regions, particularly in the south east due to the influence of emissions from international shipping. A different pattern emerges for the year 2020, with land based emissions projected to be significantly reduced but emissions from international shipping projected to rise by 2.5% per year. These changes result in significantly lower concentrations in northern England. Coastal regions of the south east, however, retain areas with concentrations exceeding 4 $\mu g\ m^{-3}$. This is due to the heavy volume of international shipping through the English Channel.

High Concentrations of ammonia are associated with regions of intensive agriculture, in particular areas with cattle, pig and poultry farming, as illustrated in Figure 3.2(a). Areas of high NH_3 concentration of 6-8 $\mu g\ m^{-3}$ are evident in west England, south-west England, north-east England and East Anglia. In these areas the NH3 concentrations approach the WHO recommended critical limit of 8 $\mu g\ m^{-3}$ for NH_3. Projected emissions of NH_3 for the year 2020 forecast a 10% fall from 248 kT N-NH3 in 2002 to 222 kT N-NH3 in 2020. The reduction in emissions is however strongest from non-agricultural emissions, in particular road transport. A somewhat smaller reduction in emissions from agricultural sources of 7% (from 209 kT $N\text{-}NH_x$ in 2002 to 192 kT N-NHx in 2020) is forecast. The map of annual NH_3 concentrations for 2020 illustrates somewhat lower concentrations than for 2002 in response to the change in emissions.

For the purpose of assessing the exceedance of the WHO recommended critical level for ammonia, the ground level concentrations calculated by FRAME have been calibrated according to measured values from the ammonia monitoring network. Ammonia is monitored at 112 sites in the UK using **DELTA** samplers (**DE**nuders for **L**ong **T**erm **A**nalysis; Sutton *et al.*, 2001) and diffusion tubes (www.cara.ceh.ac.uk). Figure 3.3 shows the comparison of average 2001-2003 NH_3 concentrations from the

measurement network with FRAME 2002 predicted concentrations for the 5 km x 5 km square containing the measurement site. The correlation gives a best line of fit with a slope of 0.654. This factor has therefore been applied uniformly to the ammonia concentrations calculated by FRAME, as illustrated in Figures 3.2(a) and 3.2(b), prior to the assessment of exceedance of critical levels.

The SO_2 concentrations modelled with FRAME for the year 2002 have been compared with concentrations measured with the 12 DELTA samplers in the UK national nitric acid monitoring network averaged during the period 2001-2003 (figure 3,4).

3.2 Mapped Concentrations of SO_2 and NO_x

Annual average SO_2 and NO_x concentrations have been calculated for the years 2003 and 2020 using a mapping methodology developed by Abbott and Vincent (1999). This procedure involved modelling emissions from point and area sources separately using a dispersion model and compared the modelled concentrations to measured concentrations at sampling sites located throughout the United Kingdom. At each sampling site the modelled concentrations were subtracted from the measured concentrations and the resulting values interpolated to produce a map of residual values. A calibration, procedure was also used to ensure that the predicted concentration at a measurement site corresponded to the measured concentration at that site. Concentrations for 2020 were predicted using the same calibration factors, meteorological data and concentration residual maps as used for the Daughter Directive Reporting Assessment (Stedman *et al.,* 2005). The only input parameter to change was the emission from power stations; emissions from all other point sources and area sources were assumed to remain constant. The forecast sulphur dioxide emission was the baseline scenario submitted to the European Union Commission as part of the Clean Air for Europe Programme. The 1km resolution mapped concentrations of SO_2 and NO_x for the years 2003 and 2020 are illustrated in Figures 3.5(a)-(d). For NOx, the high concentration areas are linked closely to major urban areas and motorways. In 2003, concentrations exceed 40 $\mu g\ m^{-3}$ in the vicinity of major thoroughfares. However for 2020, these high levels of concentrations arte present only in greater London. For SO_2, the areas of highest concentration are northern England and greater London, where concentrations exceed 8 $\mu g\ m^{-3}$ in 2003. For 2020 only a small number of grid squares have concentrations which exceed 8 $\mu g\ m^{-3}$.

Figure 3.1(a) FRAME modelled concentrations of SO_2 for the year 2002 ($\mu g\ m^{-3}$)

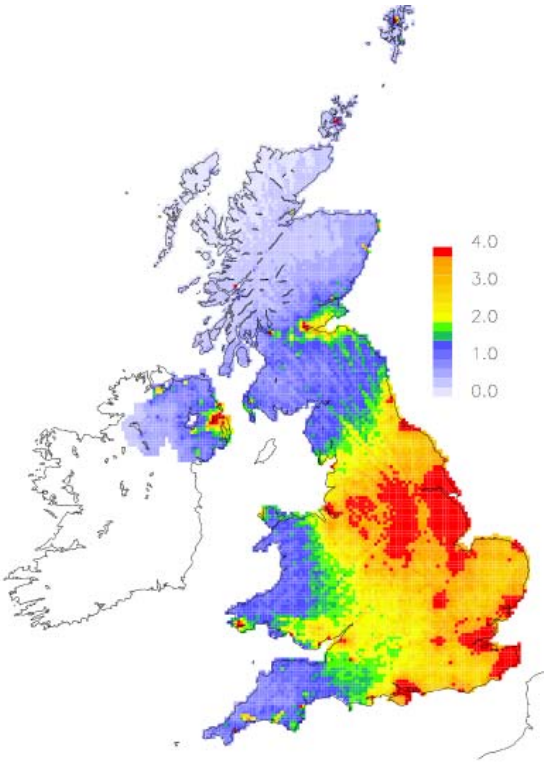


Figure 3.1(b) FRAME modelled concentrations of SO_2 for the year 2020 ($\mu g\ m^{-3}$)

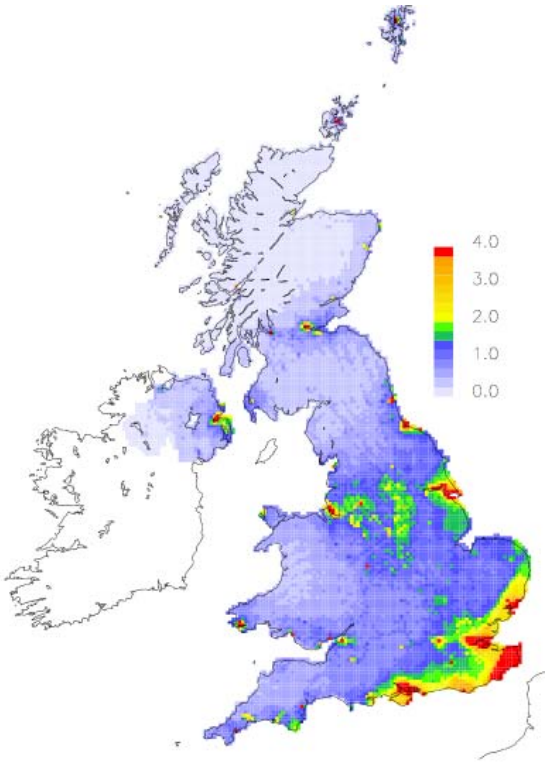


Figure 3.2(a) FRAME modelled concentrations of NH_3 for the year 2002 ($\mu g\ m^{-3}$)

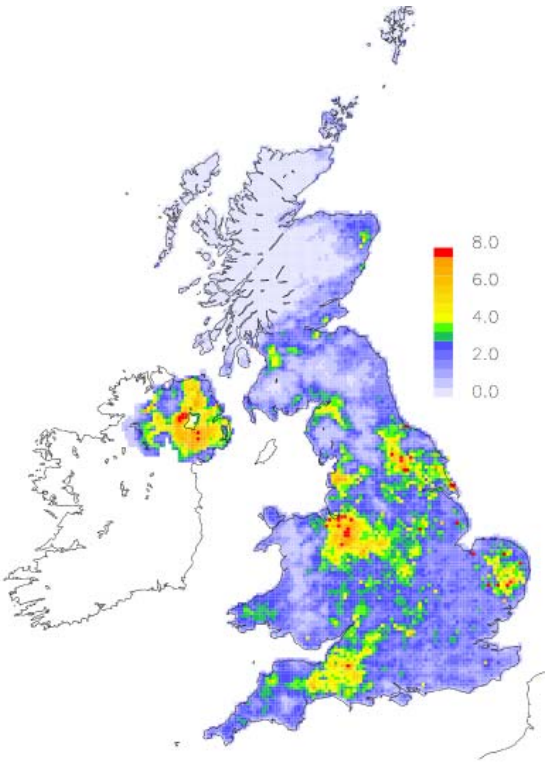


Figure 3.2(b) FRAME modelled concentrations of NH_3 for the year 2020 ($\mu g\ m^{-3}$)

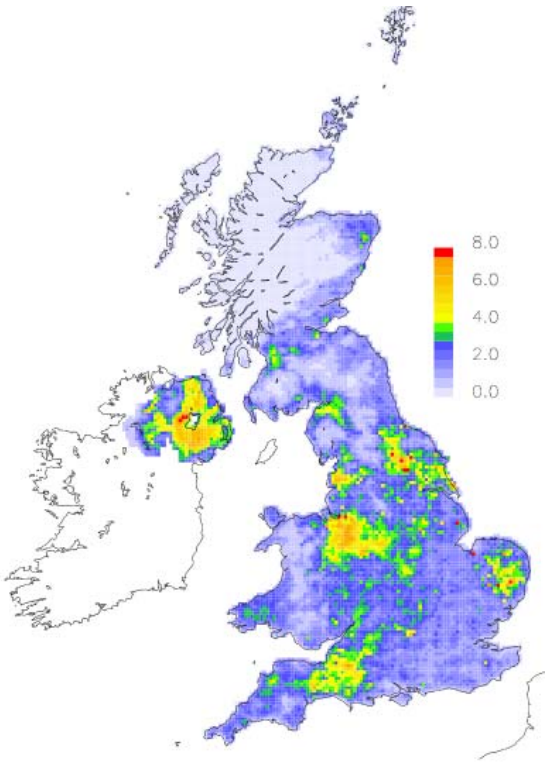


Figure 3.3 Correlation of 2001-03 average measurements of NH_3 concentrations with FRAME 2002 estimates ($\mu g\ m^{-3}$)

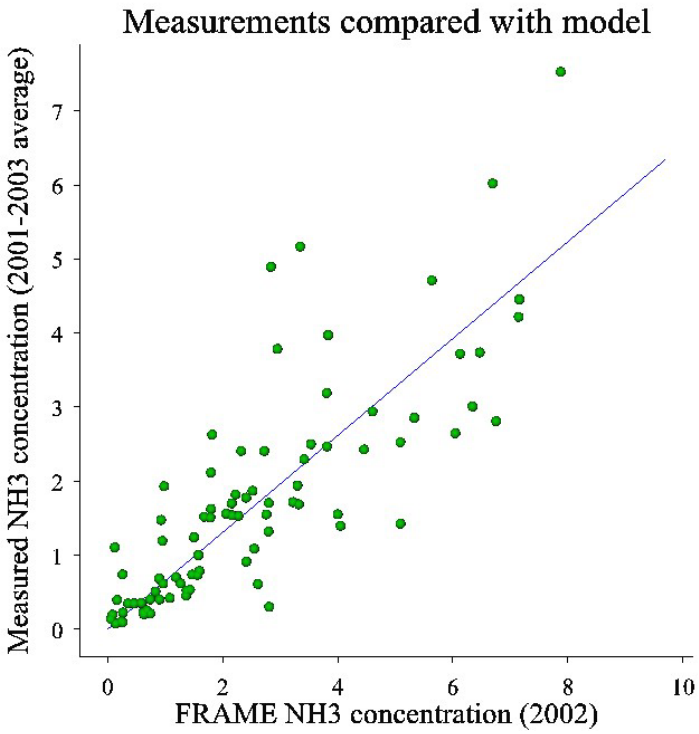


Fig. 3.4 Modelled SO_2 concentrations for the year 2002 compared with measurements for the period 2001-03

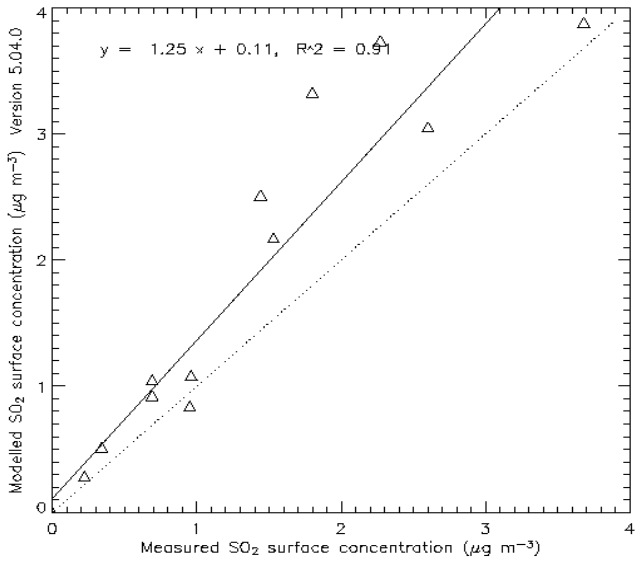


Figure 3.5(a) NETCEN Estimated annual mean background NO_x concentration for 2003 (μg m^{-3})

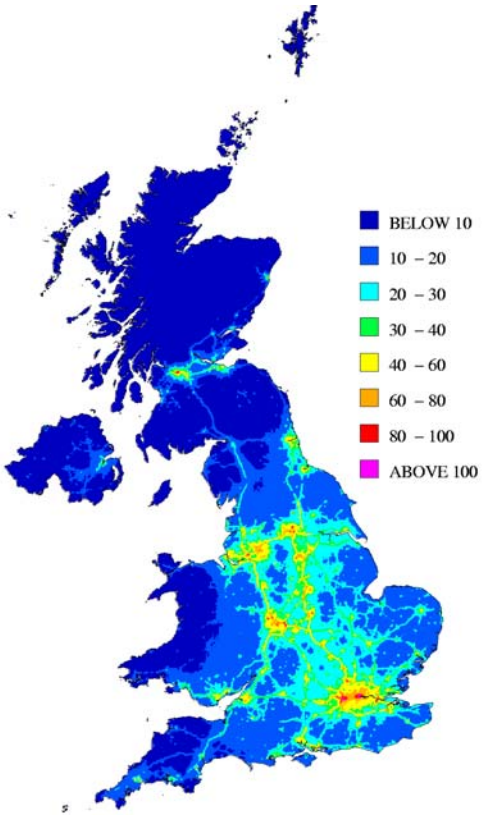


Figure 3.5(b) NETCEN Estimated annual mean background NO_x concentration for 2020 (μg m^{-3})

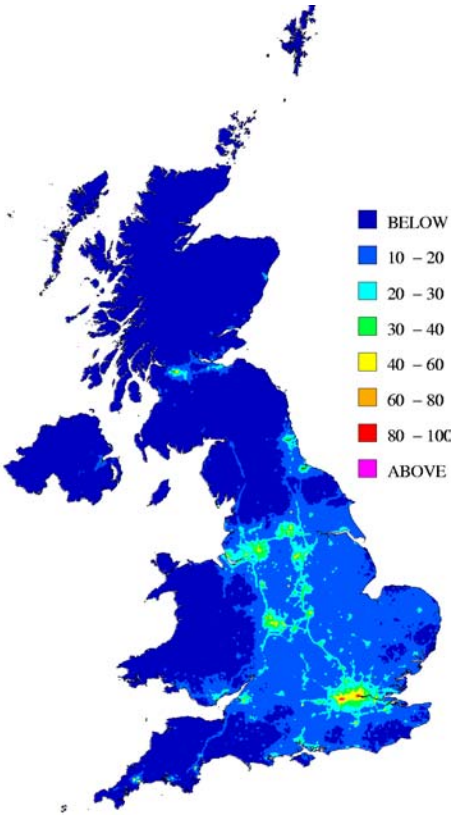


Figure 3.5(c) NETCEN Estimated annual mean background SO_2 concentration for 2003 (μg m^{-3})

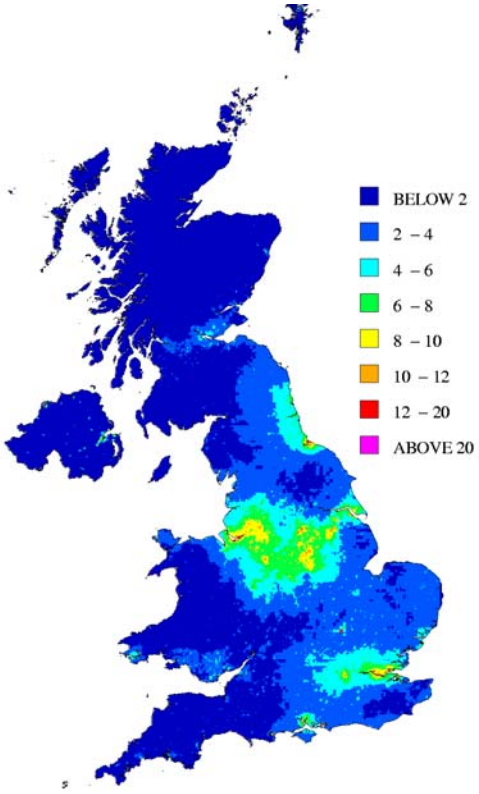
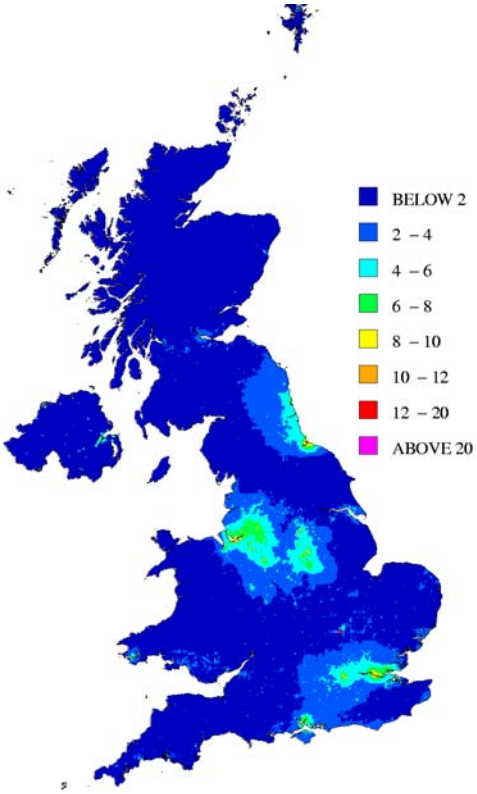


Figure 3.5(d) NETCEN Estimated annual mean background SO_2 concentration for 2020 (μg m^{-3})



4. Deposition Data

The chemical species which contribute to nitrogen deposition are reduced nitrogen, NH_x (comprising NH_3 gas and NH_4^+ aerosol) and oxidised nitrogen, NO_y (comprising NO_2 gas, HNO_3 vapour and NO_3^- aerosol, NO is not considered as it is insoluble and not dry deposited to vegetation). Both NO_y and NH_x were included in the calculations of acid deposition (which makes the assumption that reduced nitrogen is oxidised in soil) in addition to sulphur compounds (SO_2 gas, H_2SO_4 vapour and SO_4^{2-} aerosol). The CBED data set for sulphur and nitrogen deposition was used to assess the exceedance of critical loads averaged over the three year period 2001-03. FRAME was run for the middle year of this three year period (2002) , the year 2010 and for nine future emissions scenarios for the year 2020. The relative changes in deposition calculated by FRAME between 2002 and 2010 and between 2002 and 2020 were applied to the CBED deposition data for each model grid square to generate 'calibrated' deposition estimates for the future scenarios. The calibrated deposition data were subsequently used to assess the exceedance of critical loads for nitrogen deposition and acidic deposition.

4.1 Concentration Based Estimated Deposition (CBED) data

The grid-averaged **CBED** wet and dry deposition data for sulphur and oxidised and reduced nitrogen for the three-year average 2001-2003 are illustrated in Figures 4.1(a)-(f). The maps show that both wet and dry deposition processes make an important contribution to total deposition of SOx, NO_y and NH_x. Dry deposition of sulphur is highest in the industrial regions of northern England, and in the region of greater London (Figure 4.1(a)). The major component of dry deposition of oxidised nitrogen is HNO_3, a product of the atmospheric oxidation of NO_2 gas. This results in high deposition of NO_y in southern and central England where road traffic is heaviest (Figure 4.1(c)). Dry deposition of reduced nitrogen demonstrates a fine spatial pattern due to the dispersed nature of the primarily agricultural sources of NH_3. For wet deposition (Figures 4.1(b), 4.1(d) and 4.1(f))), the highest deposition occurs in the hill areas of Wales, the Pennines, Cumbria, the Southern Uplands and the Scottish Highlands. These high rainfall areas are prone to the formation of polluted boundary layer hill cloud which is known to be efficiently washed out by precipitation (Dore *et al*., 1992). In the case of emissions of SO_2 and NH_3, the primary pollutants are soluble and wet deposition can be high in lowland source regions, whereas the high wet deposition over the hill regions is mostly due to the long range transport of sulphate, nitrate and ammonium aerosol.

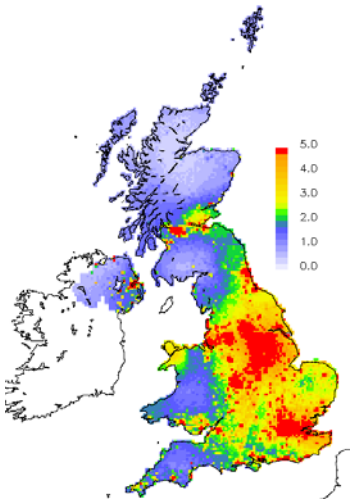


Figure 4.1(a) CBED 2001-03 SO_X dry deposition (kg S ha^{-1})

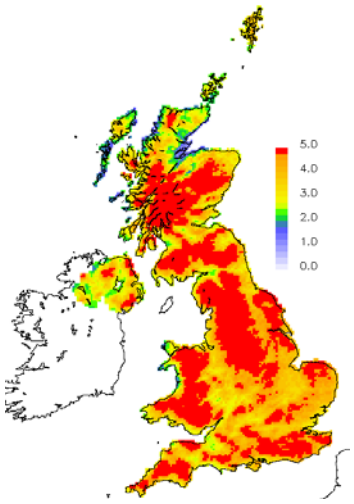


Figure 4.1(b) CBED 2001-03 SO_X wet deposition (kg S ha^{-1})

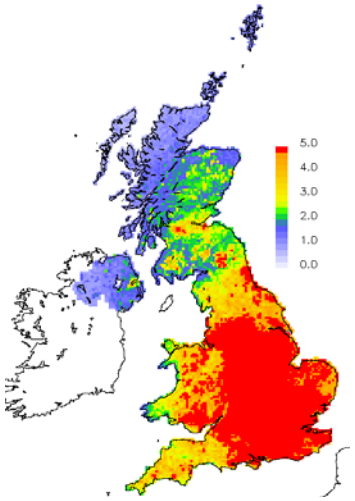


Figure 4.1(c) CBED 2001-03 NO_Y dry deposition (kg N ha^{-1})

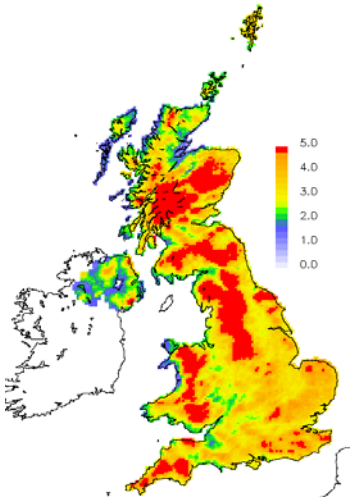


Figure 4.1(d) CBED 2001-03 NO_Y wet deposition (kg N ha^{-1})

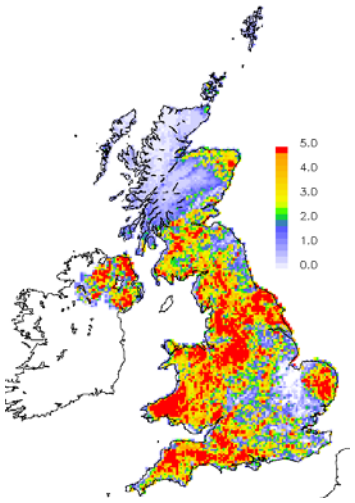


Figure 4.1(e) CBED 2001-03 NH_X dry deposition (kg N ha^{-1})

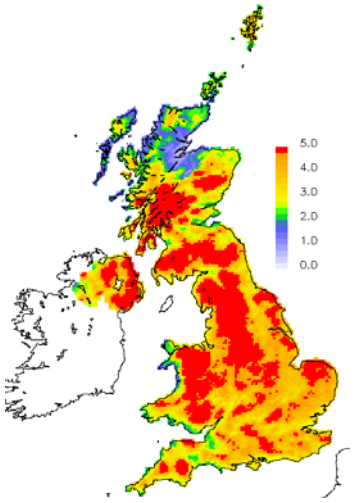


Figure 4.1(f) CBED 2001-03 NH_X wet deposition (kg N ha^{-1})

4.2 FRAME data

4.2.1 Methods

FRAME was used to calculate the deposition of SO_X, NO_Y and NH_X to the United Kingdom for future emissions scenarios defined by the Air Quality Strategy. A detailed inventory of emissions from 242 individual point sources was provided by the Environment Agency, the Scottish Environmental Protection Agency the Environment Heritage Service Northern Ireland. The data included, where available, information on stack height, diameter, temperature and exit velocity of emissions, as well as annual emissions of SO_2 and NO_X. Where stack parameters were missing, typical default values were assigned. Remaining emissions of SO_2 and NO_X were taken from the National Atmospheric Emissions Inventory (NAEI) using data for 2002. These included a further 766 small point sources as well as gridded background emissions for different snap codes (Energy production and transformation; Commercial, institutional and residential combustion; Industrial combustion; Industrial processes; Production and distribution of fossil fuels; Road transport; Other transport; Waste treatment and disposal). The input of ammonia emissions to the model used the AENEID inventory of Dragosits *et al.* (1998), which separately calculates spatial emissions from cattle, pigs, poultry, sheep, horses, crops and grassland and non-agricultural sources Due to the unavailability of detailed future emissions estimates of NH_3 for the year 2020 at the time of this study, these were set to the **N**ational **E**missions **C**eiling **D**irective (**NECD**) target for the UK. Subsequently future emissions estimates of NH_3 became available and have been included to update the assessment of NH3 concentrations only. The republic of Ireland is included in the FRAME domain and future emissions of SO_2, NO_x and NH_3 for Ireland for the year 2020 were set according to the NECD targets. The initial concentrations of trajectories in FRAME are set the edge of the domain according to calculations from the European scale model FRAME-Europe.

The future emissions estimates for the year 2020 were used to generate scaling factors for each snap code emissions sector. These scaling factors were used to convert the 2002 emissions maps to a 2020 scenario. Emissions of SO_2 and NO_x from international shipping were assumed to increase from 2002 by a rate of 2.5% per annum, according to the assessment of Johnson *et al.* (2000). Eight emissions abatement strategies were investigated with FRAME, as well as the baseline 2020 scenario (Table 4.1) and the 2002 scenario used to represent a 'recent emissions year'. Emissions abatement factors were applied to individual snap code sectors according to the total emissions forecast as a result of applying the emissions controls.

Table 4.1 Air Quality Strategy emissions abatement scenarios for the year 2020

Scenario	Abatement measure
Base case	Base case scenario with no additional measures applied
A	Euro low: Proposes a 20% reduction in NOx emissions from all new diesel Light Duty Vehicles (LDVs) and a 50% reduction in NOx emissions from new diesel Heavy Duty Vehicles (HDVs) to be introduced in 2010 and 2013 respectively.
B	Euro high: Proposes: reductions of NO_x emissions of 50% from new petrol LDVs and 40% from new diesel LDVs from 2010 and 68% reduction in NO_x emissions from all new LDVs from 2015; a 75% reduction in NO_x emissions from new HDVs from 2013.
C	Early Euro low: Assumes a programme of incentives for early introduction of measure A is introduced in 2006 for LDVs and 2010 for HDVs.
K	Large Combustion Plant (LCP): Assumes power stations and combustion plants fit low NO_x burners and introduce other combustion modifications by 2010.
N	Shipping: Assumes that international shipping in the North Sea will use low sulphur fuel (1% instead of 1.5%) and the reduction of NO_x emissions by 25% from new ships from 2010.
O	Early Euro Low & LEV: Assumes a combination of measure C and a programme of incentives to increase the penetration of Low Emission Vehicles
P	Early Euro Low & SCP: Assumes a combination of measure C and a 50% reduction in NO_x and SO_2 emissions from Small Combustion Plants from 2013.
Q	Early Euro Low & LEV &SCP: Assumes a combination of measures P and Q.

4.2.2 Results

The emissions scenarios were used as input to the FRAME model and maps of wet and dry deposition of SO_X, NO_Y and NH_X were generated at a 5 km resolution for three vegetation types: moor-land, forest and grid-averaged deposition. Grid-averaged dry and wet deposition of SO_x, NO_y and NH_x are illustrated in Figures 4.2(a)-(f) for the year 2002 (representing a 'recent emissions year') and in Figures 4.3(a)-(f) for the year 2020 baseline projection. Dry deposition occurs in the vicinity of the major sources (road transport for NO_Y and industrial regions and power stations for SO_Y). Wet deposition is associated with the longer-range transport of aerosols and occurs in upland regions where annual precipitation is highest In general, the FRAME 2002 deposition maps show good agreement with CBED 2001-03, the standard to which FRAME deposition for future scenarios is calibrated. However it is notable in Figure 4.2(c) that FRAME generates lower values for NO_y dry deposition than CBED (Figure 4.1(a)). This is due to the lower concentrations of HNO_3 in CBED than in FRAME.

According to future emissions projections, significant reductions in UK emissions of SO_2 (from 501 to 180 kT S) and NO_x (from 481 to 265 kT N) are forecast during the period 2002 to 2020. These changes are reflected in the maps of deposition. In 2002 significant areas of eastern England are subject to dry deposition in excess of 3kg S Ha^{-1} and wet deposition in excess of 5 kg S Ha^{-1}. For 2020, the dry deposition remains above these thresholds only in localised areas, particularly in southeast England due to the increased influence of shipping emissions. The areas with wet deposition exceeding 5 kg S Ha^{-1} are shown to have retreated to upland areas by 2020. A similar situation is apparent for NO_y deposition, with significant areas of the country subject to wet and dry deposition in excess of 5 kg N Ha^{-1} for 2002. By 2020, only restricted areas near major urban centres or subject to heavy annual precipitation have NO_y

deposition in excess of 5 kg N Ha^{-1}. A different picture emerges, however, for deposition of NH_x. Only a small reduction in emissions of 4% has been applied for the future 2020 scenario. More recent estimates forecast a reduction in NH_3 emissions of 10% between 2002 and 2020, considerably less than the forecast reductions in emissions of SO_2 and NO_x. The new forecast for reduction in emissions of NH_3 has been employed to update the assessment of critical levels exceedances, section 3. The move from a 2002 scenario to a 2020 scenario therefore represents a change in which deposition of potentially acidifying and eutrophying pollutants is increasingly shifted towards reduced nitrogen.

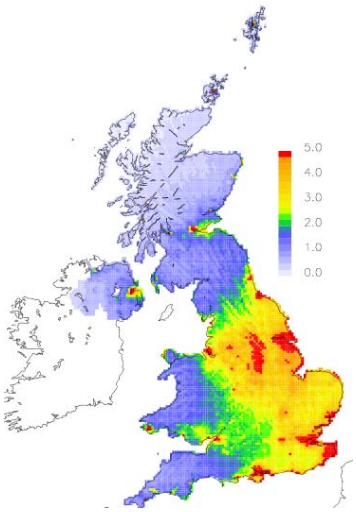


Figure 4.2(a) FRAME 2002 SO_X dry deposition (kg S ha^{-1})

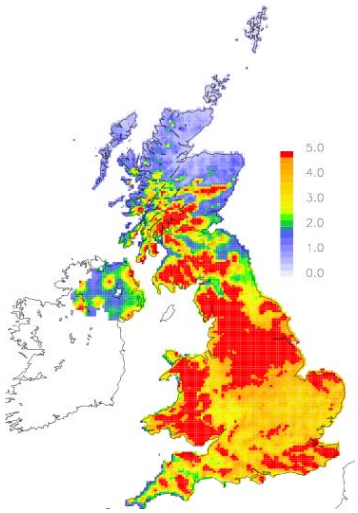


Figure 4.2(b) FRAME 2002 SO_X wet deposition (kg S ha^{-1})

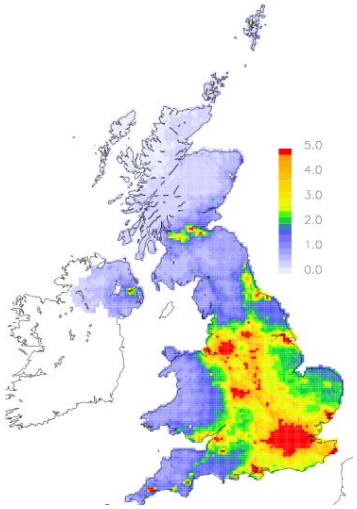


Figure 4.2(c) FRAME 2002 NO_Y dry deposition (kg N ha^{-1})

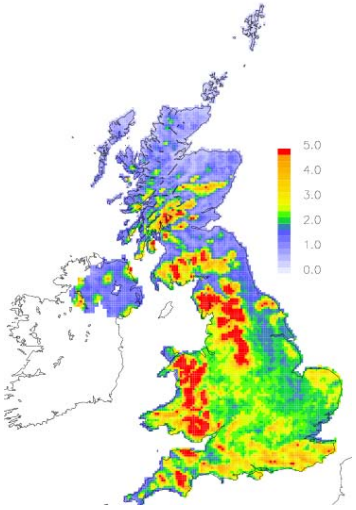


Figure 4.2(d) FRAME 2002 NO_Y wet deposition (kg N ha^{-1})

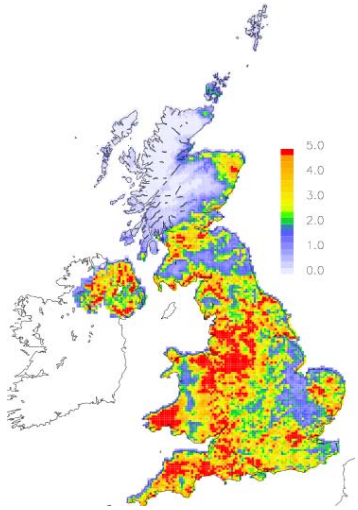


Figure 4.2(e) FRAME 2002 NH_X dry deposition (kg N ha^{-1})

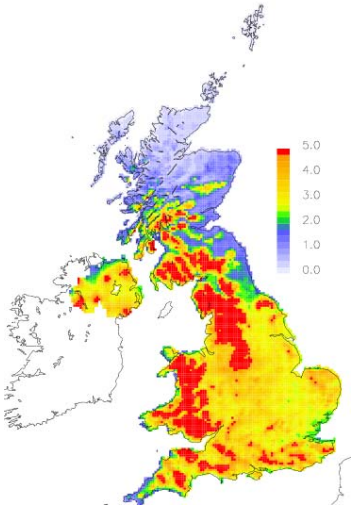


Figure 4.2(f) FRAME 2002 NH_X wet deposition (kg N ha^{-1})

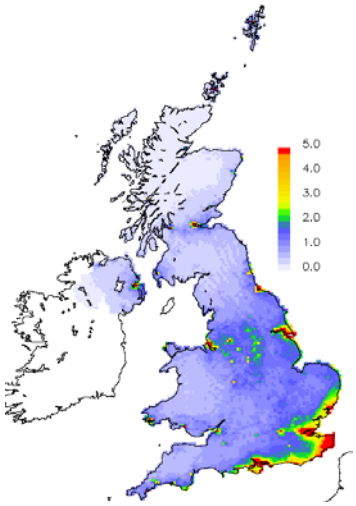


Figure 4.3(a) FRAME 2020 SO_X dry deposition (kg S ha^{-1})

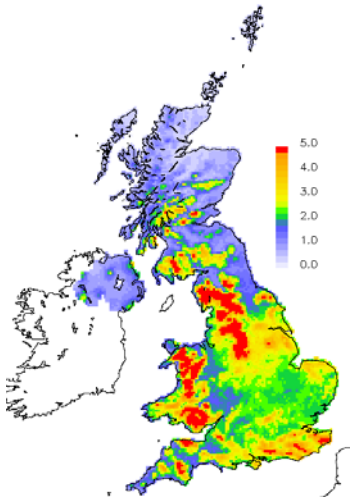


Figure 4.3(b) FRAME 2020 SO_X wet deposition (kg S ha^{-1})

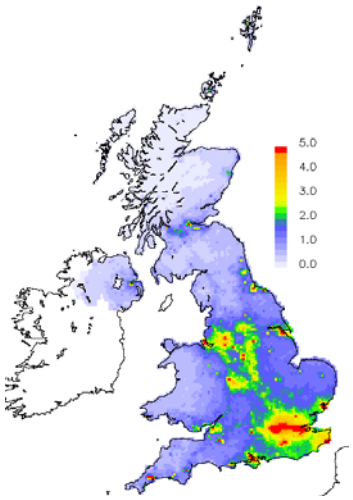


Figure 4.3(c) FRAME 2020 NO_Y dry deposition (kg N ha^{-1})

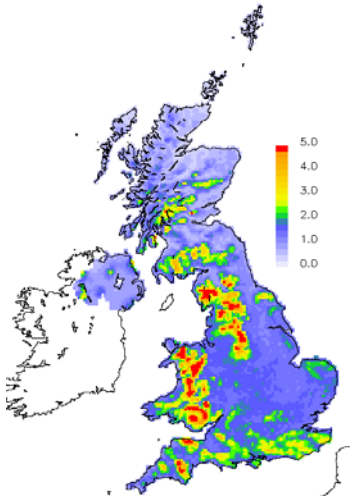


Figure 4.3(d) FRAME 2020 NO_Y wet deposition (kg N ha^{-1})

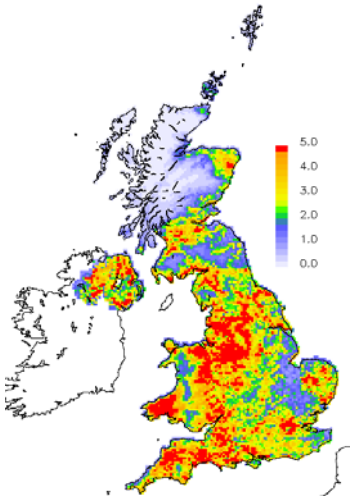


Figure 4.3(e) FRAME 2020 NH_X dry deposition (kg N ha^{-1})

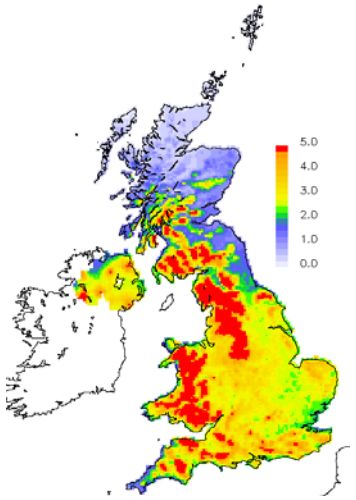


Figure 4.3(f) FRAME 2020 NH_X wet deposition (kg N ha^{-1})

The results of the FRAME simulations can be illustrated simply in the form of tables of total UK deposition of oxidised nitrogen and sulphur (Table 4.2). Significant changes in deposition are forecast between 2002 and 2020 with SO_x deposition falling by 45%, a decrease in NO_y deposition of 35% and a small decrease in NH_x deposition of 5%. In comparison, the additional emissions reductions scenarios result in much smaller changes in deposition. The greatest change occurs due to the implementation of scenario B (Euro high) with an 11.7% reduction in NO_y deposition. Scenario Q with a combination of emissions reduction measures (Euro low, LEV and SCP) results in a 7.6% reduction in NO_y deposition and a 1.5% reduction in SO_x deposition. The implementation of measures to abate emissions from international shipping (scenario N) leads to a 5.9% reduction in SO_x deposition and a 1.7% reduction in NO_y deposition.

Table 4.2 UK deposition budgets (kT N and kT S) for FRAME and CBED

Scenario	SOx dry deposition	SOx wet deposition	SOx total deposition	NO_Y dry deposition	NO_Y wet deposition	NO_Y total deposition
2001-03 CBED	64	117	181	98	95	193
2002	55.9	103.7	159.6	46.7	64.8	111.5
2020	27.9	59.6	87.5	29.9	42.8	72.7
A	27.8	59.7	87.5	27.9	40.9	68.8
B	27.8	59.8	87.6	25.5	38.7	64.2
C	27.8	59.7	87.5	27.8	40.8	68.6
K	27.8	60.0	87.8	28.2	38.3	66.5
N	25.6	56.7	82.6	29.5	42.0	71.5
O	27.8	59.7	87.5	27.4	40.4	67.8
P	27.1	59.1	86.2	27.4	40.5	67.9
Q	27.0	59.2	86.2	27.0	40.2	67.2

4.2.3 Calibration of FRAME deposition data

When FRAME data are used for calculating critical loads exceedances, a ‘calibration procedure’ (NEGTAP 2001) is applied. This approach is based on the convention that the official data sets of nitrogen and sulphur deposition for the UK are based on the CBED methodology, whereas FRAME is used to provide estimates of deposition for future years. In estimating changes in pollutant deposition over time, it is important to compare equivalent data sets. Comparing FRAME deposition estimates for the year 2020 with CBED deposition for the period 2001-03 could result in misleading conclusions due to the differences in the approaches used. It is for this reason that a calibration is applied to FRAME deposition to normalise the modelled data to the CBED estimates. In essence ‘calibration’ means that FRAME is used to estimate the relative change to deposition for each 5 km grid square in the UK during a specified time period. Future estimates of deposition are then calculated by applying the modelled change to the CBED measurement-based deposition for a recent year for

each individual UK 5km grid square. For this work, the calibration procedure used is described in equation (1).

$$DEP_{(CAL,2020)} = DEP_{(UNC,2020)} * (DEP_{(CBED,2001\text{-}2003)}/DEP_{(UNC,2002)}) \quad \ldots\ldots\ldots\ldots\ldots\ldots (1)$$

Where $DEP_{(UNC,2002)}$ refers to uncalibrated FRAME deposition data for the emissions simulation year 2002, $DEP_{(UNC,2020)}$ refers to uncalibrated FRAME deposition data for the emissions simulation year 2020, $DEP_{(CBED,2001\text{-}2003)}$ is the CBED deposition data for the period 2001-2003 and $DEP_{(CAL,2020)}$ is the calibrated deposition for the year 2020.

This calibration is applied to the FRAME average, moorland and woodland deposition estimates (using CBED average, moorland and woodland data) to provide the habitat deposition values required to calculate critical load exceedances (Section 6.2).

5. Critical levels and their exceedances

5.1 Critical levels

Critical levels are defined as the gaseous concentrations of pollutants below which significant harmful effects will not occur to sensitive elements of the environment (i.e. vegetation). Critical levels developed under the UNECE Convention on Long-Range Transboundary Air Pollution (UBA, 2004) have been adopted as the European limit values for the EC Air Quality Daughter Directive and by the UK Government and devolved administrations as the air quality objectives for the UK Air Quality Strategy.

In this assessment critical levels of sulphur dioxide (SO_2), nitrogen oxides (NO and NO_2 added together and expressed as NO_2), and ammonia (NH_3) have been considered. The critical levels for each pollutant are given in Table 5.1 below.

Table 5.1 Critical levels for NO_x, SO_2 and NH_3

Pollutant	Receptor	Critical level ($\mu g\ m^{-3}$)	Time periods
SO_2	Cyanobacterial lichens[#]	10	Annual mean
	Forest ecosystems*[+]	20	Annual mean and Half-year mean (Oct-Mar)
	Semi-natural vegetation[+]	20	Annual mean and Half-year mean (Oct-Mar)
	Agricultural crops	30	Annual mean and Half-year mean (Oct-Mar)
NO_x	All vegetation types[+]	30 as NO_2	Annual mean
NH_3	All vegetation types[#]	8	Annual mean

* Includes understorey vegetation

[+] AQS objective for protection of vegetation and ecosystems

[#] Level recommended by ICP vegetation and WHO

Source: UBA, 2004

Currently the air quality objective for SO_2 is 20$\mu g\ m^{-3}$, though the impact of reducing this to 10$\mu g\ m^{-3}$ was also examined in this exercise.

5.2 Critical level exceedance statistics

The results for each pollutant are described separately below together with the data used in the assessment of each one.

5.2.1 SO_2 exceedances

The aim of this exercise was to calculate the areas of designated sites where the critical levels (10 and 20 $\mu g\ m^{-3}$) were exceeded across the UK as a whole, and in rural areas outside an "exclusion zone". The designated sites include **S**ites of **S**pecific **S**cientific **I**nterest (**SSSI**s), **S**pecial **A**reas of **C**onservation (**SAC**s) and **S**pecial

Protection **A**reas (**SPA**s). The regions falling outside the exclusion zone are defined as being more than:

- 20km from agglomerations
- 5km from motorways, other urban areas, and industrial installations.

Figure 5.1 shows the designated areas (SSSIs, SACs, and SPAs) overlaid on the "exclusion zone". The exclusion zone has been defined for the assessment of compliance with the limit values for the protection of ecosystems and vegetation within the first Daughter Directive with reference to the requirements for the location of monitoring sites.

The boundaries of the designated sites were obtained from the relevant conservation agencies (English Nature, Countryside Council for Wales, Scottish Natural Heritage, Environment and Heritage Service NI). The boundary data were converted to 1km gridded maps giving the areas of the different types of designated site within each grid square; this enabled the subsequent analysis to be run quickly and efficiently. These maps were then overlaid on the gridded concentration maps and using a macro within the geographic information system (GIS) the total areas of sites exceeded determined across the UK and outside the exclusion zone. The exceedance results for SO_2 below are based on the May 2001 versions of the SAC and SPA data and the May 2004 version of the SSSI data.

Two sets of SO_2 concentration data (Section 3) were used in this assessment:

(i) 1km grid resolution data from Netcen for the years 2003, 2010 and 2020.
(ii) 5km resolution data from the FRAME model for the years 2002 and 2020.

The exceedance statistics based on using the two different data sets are compared in Tables 5.2 and 5.3. Results for 2010 based on Netcen data only are given in Table 5.4.

The Netcen and FRAME data give different results due to:

- The different resolutions of the concentration data; larger grid squares with higher concentration values will result in larger areas of designated sites being exceeded.
- the different ways the two models deal with maritime emissions: the Netcen model does not have an explicit treatment of the international maritime contribution to ambient SO_2, Instead it makes up part of the residual SO_2 concentrations derived from the difference between measured values and the concentration derived from modelled sources.

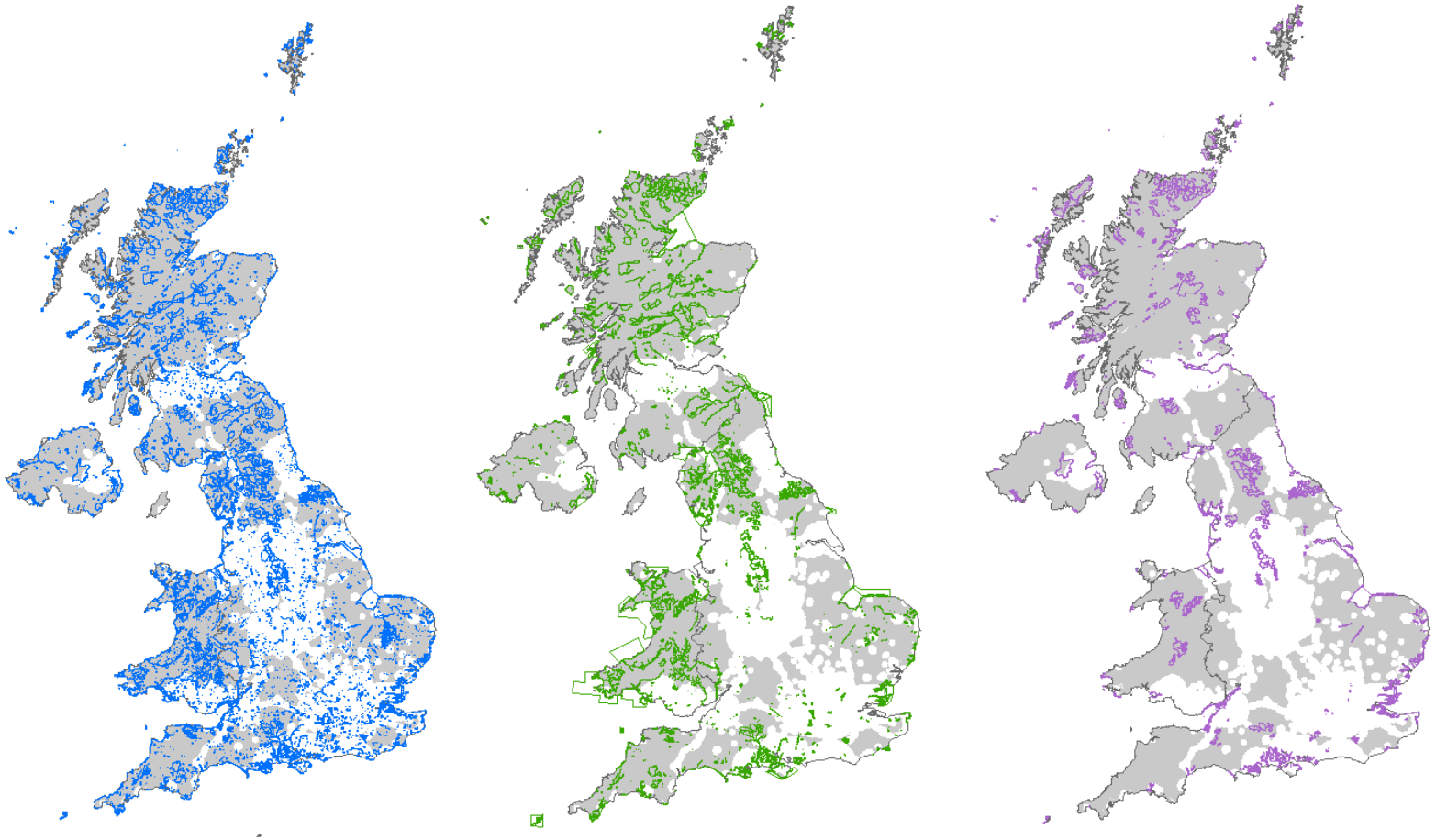
Hence, in general using FRAME 5km SO_2 data leads to larger areas of exceedance than using the Netcen 1km data. However, neither the FRAME nor the Netcen data for 2003 (or subsequent years) resulted in any exceeded areas outside the exclusion zone for the 20 μg m^{-3} objective (Tables 5.2-5.4).

This is also consistent with the annual air quality assessment for the EU first Daughter Directive which also includes assessing the exceedance of the SO_2 objective of 20 μg m^{-3}. The assessment was based on the annual mean SO_2 concentrations for 2004 in ecosystem areas (i.e., the rural areas outside the exclusion zone). The concentration map was calculated by removing the non-vegetation areas (i.e., those inside the exclusion zone) from the background SO_2 map and calculating the zonal mean of the 1 km grid values for each 30km square. Mean concentrations on a 30 km grid have

been used to prevent the influence of any urban area appearing unrealistically large on adjacent vegetation areas. Thus the modelled concentrations in vegetation areas should be representative of approximately 1000km^2 as specified in Directive 1999/30/EC for monitoring sites used to assess concentrations for the vegetation limit value (Stedman et al, 2005). Using these SO_2 data there are no exceedances of the 20 μg m^{-3} objective in the ecosystem (vegetated) areas of the UK.

The FRAME 5km SO_2 data and the Netcen 1km SO_2 data for 2003 for the whole country (i.e., areas both inside and outside the exclusion zone) include some values >20 μg m^{-3}. This is due to the resolution of the data (compared to the 30km data used for the Daughter Directive reporting) and the fact the 1km and 5km data include urban and rural areas, whereas the 30km data are for the rural areas only.
The potential impact of reducing the SO_2 objective to 10 μg m^{-3} was explored using the FRAME 5km and Netcen 1km data sets (Tables 5.2 to 5.4). Some small areas of exceedance occurred, but were less than 1% of the area of the designated sites falling outside the exclusion zone.

Figure 5.1 Designated areas overlaid on the "exclusion zone" (white areas).
Objectives apply in the grey areas



(a) SSSIs (b) SACs (c) SPAs

Table 5.2 Exceedance of air quality objectives for SO_2 (10 and 20 μg m^{-3}) for 2003

Parameter	SO_2 concentration data	Critical level (μg m^{-3})	Sites		
			SSSIs	SACs	SPAs
Area of sites in the UK (ha)			2415424	2411095	1436196
Area of sites exceeded in the UK (ha) [percentage]	Netcen 1km	20	76 [0.003]	0	72 [0.005]
	FRAME 5km	20	968 [0.04]	109 [0.005]	511 [0.04]
	Netcen 1km	10	2911 [0.12]	238 [0.01]	1896 [0.13]
	FRAME 5km	10	2726 [0.11]	783 [0.03]	1671 [0.12]
Area of sites outside the exclusion zone (ha)			1609785	1079668	891524
Area of sites exceeded outside the exclusion zone (ha) [percentage]	Netcen 1km	20	0	0	0
	FRAME 5km	20	0	0	0
	Netcen 1km	10	6 [<0.001]	0	0
	FRAME 5km	10	39 [0.002]	163 [0.007]	0

Table 5.3 Exceedance of air quality objectives for SO_2 (10 and 20 μg m^{-3}) for 2020

Parameter	SO_2 concentration data	Critical level (μg m^{-3})	Sites		
			SSSIs	SACs	SPAs
Area of sites in the UK (ha)			2415424	2411095	1436196
Area of sites exceeded in the UK (ha) [percentage]	Netcen 1km	20	76 [0.003]	0	72 [0.005]
	FRAME 5km	20	840 [0.03]	109 [0.005]	511 [0.04]
	Netcen 1km	10	1371 [0.06]	169 [0.01]	1005 [0.07]
	FRAME 5km	10	1047 [0.04]	321 [0.01]	519 [0.04]
Area of sites outside the exclusion zone (ha)			1609785	1079668	891524
Area of sites exceeded outside the exclusion zone (ha) [percentage]	Netcen 1km	20	0	0	0
	FRAME 5km	20	0	0	0
	Netcen 1km	10	6 [<0.001]	0	0
	FRAME 5km	10	0	49 [0.002]	0

Table 5.4 Exceedance of air quality objectives for SO_2 (10 and 20 μg m^{-3}) for 2010; results available based on Netcen 1km concentration data only.

Parameter	Critical level (μg m^{-3})	Sites		
		SSSIs	SACs	SPAs
Area of sites in the UK (ha)		2415424	2411095	1436196
Area of sites exceeded in the UK (ha) [percentage]	20	76 [0.003]	0	72 [0.005]
	10	1371 [0.06]	169 [0.01]	1005 [0.07]
Area of sites outside the exclusion zone (ha)		1609785	1079668	891524
Area of sites exceeded outside the exclusion zone (ha) [percentage]	20	0	0	0
	10	6 [<0.001]	0	0

5.2.2 NO_x exceedances

This assessment was completed after the SO_2 work and an updated set of the designated boundary data were used (June 2005 versions), including RAMSAR sites (i.e., wetlands of international importance) in the UK. The boundary data were again converted to 1km gridded area data for the analysis. The NO_x concentration data are described in Section 3. The exceedances of the NO_x critical level of 30 μg m^{-3} presented below are based on the Netcen 1 km data for 2003, 2010 and 2020.

A small area of sites outside the exclusion zone were exceeded for 2003, 2010 and 2020 (Tables 5.5-5.7) when using the 1km resolution concentration data. The assessment of the NO_x objective for the first Daughter Directive (based on NO_x concentrations for 2004) did not identify any exceedances in the UK (Stedman et al, 2005) because as with the SO_2 data above, the derivation of the 30km mean NO_x concentrations for 2004 excluded areas within the exclusion zone, whereas the data used in this exercise included all areas so that exceedances could be determined across the whole of the UK and not just areas outside or inside the exclusion zone. Not surprisingly the areas of sites exceeded are greater inside the exclusion zone than outside, reflecting the higher NO_x concentrations in urban areas and along motorways.

Table 5.5 NOx exceedances 2003

Parameter	Resolution of NOx data	Sites			
		SSSIs	SACs	SPAs	RAMSARs
Area of sites in UK (ha)		2416875	2498423	1481068	759163
Area of sites exceeded in UK (ha) [percentage]	1km	41625 [1.72]	13214 [0.53]	11751 [0.79]	5219 [0.69]
Area of sites outside exclusion zone (ha)		1513613	1052840	854629	320868
Area of sites exceeded outside exclusion zone (ha) [percentage]	1km	288 [0.012]	65 [0.003]	0	0
Area of sites inside exclusion zone (ha)		903262	1445583	626439	438296
Area of sites exceeded inside exclusion zone (ha) [percentage]	1km	41338 [1.71]	13150 [0.53]	11751 [0.79]	5219 [0.69]

Table 5.6 NOx exceedances 2010

Parameter	Resolution of NOx data	Sites			
		SSSIs	SACs	SPAs	RAMSARs
Area of sites in UK (ha)		2416875	2498423	1481068	759163
Area of sites exceeded in UK (ha) [percentage]	1km	16370 [0.68]	5948 [0.24]	4685 [0.32]	2304 [0.30]
Area of sites outside exclusion zone (ha)		1513613	1052840	854629	320868
Area of sites exceeded outside exclusion zone (ha) [percentage]	1km	21 [0.001]	65 [0.003]	0	0
Area of sites inside exclusion zone (ha)		903262	1445583	626439	438296
Area of sites exceeded inside exclusion zone (ha) [percentage]	1km	16349 [0.68]	5884 [0.24]	4685 [0.32]	2304 [0.30]

Table 5.7 NOx exceedances 2020

Parameter	Resolution of NOx data	Sites			
		SSSIs	SACs	SPAs	RAMSARs
Area of sites in UK (ha)		2416875	2498423	1481068	759163
Area of sites exceeded in UK (ha) [percentage]	1km	5115 [0.21]	2049 [0.08]	1278 [0.09]	1254 [0.17]
Area of sites outside exclusion zone (ha)		1513613	1052840	854629	320868
Area of sites exceeded outside exclusion zone (ha) [percentage]	1km	6 [<0.001]	65 [0.003]	0	0
Area of sites inside exclusion zone (ha)		903262	1445583	626439	438296
Area of sites exceeded inside exclusion zone (ha) [percentage]	1km	5109 [0.21]	1985 [0.08]	1278 [0.09]	1254 [0.17]

5.2.3 NH_3 exceedances

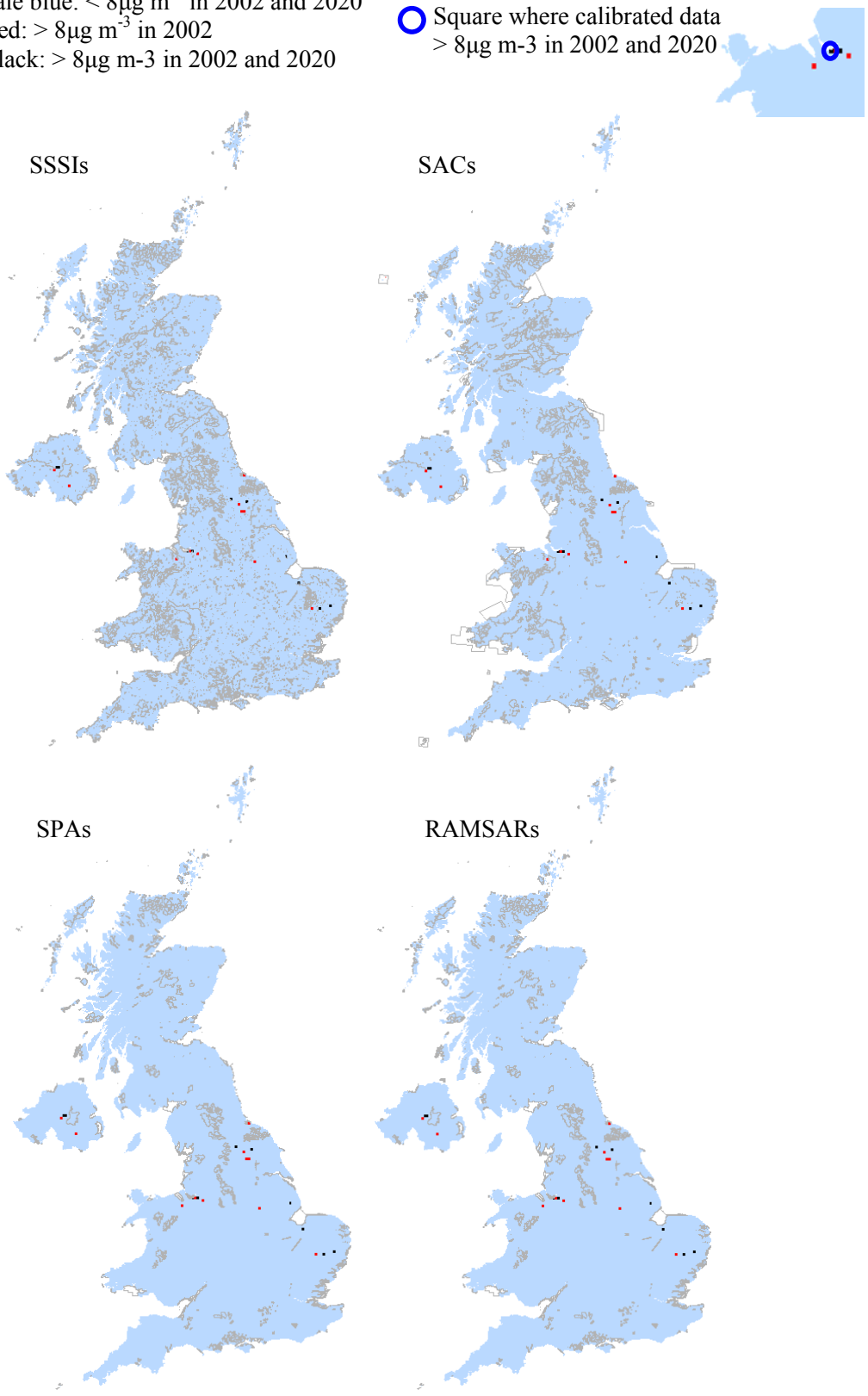
The calculation of exceedances of NH_3 concentrations used the same approach as for NO_x and also used the June 2005 version of the designated area data. Section 3 describes the concentration data in more detail.

Table 5.8 summarises the exceedance results by designated site type; the exclusion zone was not used in this analysis so the results are for the whole of the UK. Following application of the calibration procedure, the number of grid squares with concentrations exceeding 8μg m^{-3} in 2002 is reduced from 21 to one. This location corresponds to high levels of non-agricultural emissions from a nitrogen processing plant and the NH_3 concentration at this location also exceeds the critical level in 2020. For the calibrated data only one grid square in the UK has a value above 8μg m^{-3}, both in 2002 and 2020. Figure 5.2 illustrates the location of this grid square as well as grid squares exceeding the critical level for the uncalibrated NH_3 concentrations. Calibrating modelled concentrations to measured values for assessment of critical loads exceedances is a recommended procedure. However it should be noted that a measurement made at a site is not always representative of grid-averaged concentrations. Many measurement sites in rural monitoring networks are situated at nature reserves and these are known to measure NH_3 concentrations which can be significantly lower than the surrounding agricultural areas (Vieno, 2005). Although only a single calibrated model grid square has a mean annual concentration exceeding 8μg m^{-3}, ammonia concentrations are known to have a strong local variability on a scale unresolved by the model. For 2020, in 6% of the model grid squares the annual concentration exceeded half the critical level (4μg m^{-3}). In these grid squares, local exceedance of the critical level is highly likely. However, areas of local exceedance can be expected to be in the vicinity of agricultural emissions sources.

Table 5.8 Exceedance of air quality objective of 8μg m^{-3} NH_3 for 2002 and 2020, using uncalibrated and calibrated concentration data.

Parameter	Sites			
	SSSIs	SACs	SPAs	RAMSARs
Area of sites in UK (ha)	2416875	2498423	1481068	759163
Exceeded area (ha) 2002 calibrated	1351	0	1059	1059
(percentage)	(0.06)		(0.07)	(0.14)
Exceeded area (ha) 2020 calibrated	1351	0	1059	1059
(percentage)	(0.06)		(0.07)	(0.14)

Figure 5.2 Designated areas overlaid on FRAME uncalibrated NH_3 concentrations:
Pale blue: < 8µg m^{-3} in 2002 and 2020
Red: > 8µg m^{-3} in 2002
Black: > 8µg m-3 in 2002 and 2020



6. Critical loads and their exceedances

6.1 Critical loads

Critical loads are calculated and mapped in the UK for the Biodiversity Action Plan Broad Habitats sensitive to acidification and eutrophication. The habitats considered are listed in Table 6.1; however, there are a few sensitive Broad Habitats not listed, for which there is either a lack of data to enable their distribution to be mapped nationally or for which no suitable critical loads method is currently available. Critical load values are calculated for each 1km grid square containing an area of sensitive habitat, so there may be several habitat critical load values for each 1km square of the country. The national data were last updated in February 2004; for further information on the methods used to derive and calculate critical loads refer to Hall et al (2004).

Table 6.1 Critical loads by broad habitat

Broad Habitat	Critical loads calculated for:	
	Acidity	Nutrient nitrogen
Calcareous grassland	✓	✓
Acid grassland	✓	✓
Dwarf shrub heath	✓	✓
Bog	✓	✓
Montane	✓	✓
Managed coniferous woodland	✓	✓
Managed broadleaved woodland	✓	✓
Unmanaged woodland	✓	✓
Freshwaters	✓	×
Supralittoral sediment (dune grass)	×	✓

6.2 Calculating critical load exceedances for terrestrial habitats

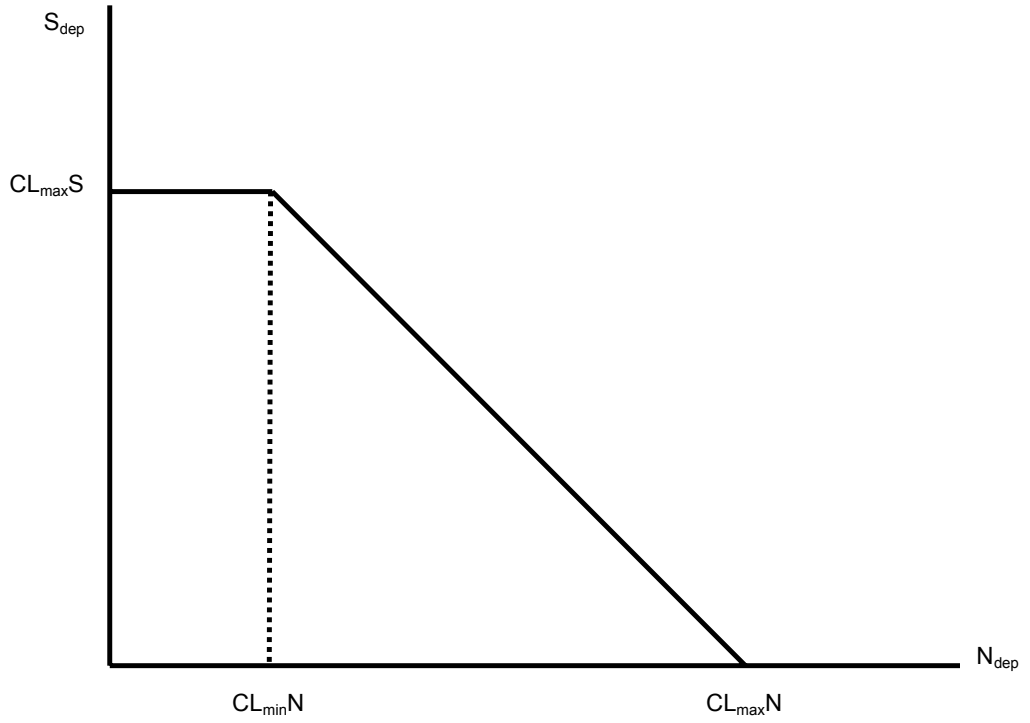
The amount of excess deposition above the critical load is called the exceedance. Critical load exceedances are calculated separately for each 1 km grid square in which each habitat is mapped nationally. The deposition values are assumed to be constant across the whole of the 5km square. Deposition values to "acid grassland" are applied to all low-growing vegetation (i.e., all non-woodland terrestrial habitats), and deposition values for "Norway Spruce" applied to all woodland habitats. The exceedance results are summarised to provide statistics on the area and percentage area of habitats exceeded by country and for the UK as a whole. For nutrient nitrogen, the exceedance is the amount of excess total nitrogen deposition (oxidised plus reduced, wet, dry and cloud droplet deposition) above the critical load:

$$(CL_{nut}N)_{exc} = N_{dep} - CL_{nut}N$$

Deposition of both sulphur and nitrogen compounds can contribute to exceedance of acidity critical loads. The Critical Load Function (CLF), developed under the

UNECE CLRTAP (Posch et al, 1999; Posch & Hettelingh, 1997; Posch et al, 1995; Hettelingh et al, 1995) defines combinations of sulphur and nitrogen deposition that will not cause harmful effects. The CLF is a three-node line graph representing the acidity critical load (Figure 6.1).

Figure 6.1 The acidity Critical Load Function (CLF)



The intercepts on the CLF on the sulphur and nitrogen axes define the following critical load values:

(i) The maximum critical load of sulphur ($CL_{max}S$) is the acidity critical load in terms of sulphur only, i.e., when nitrogen deposition is zero. $CL_{max}S$ is based on the acidity critical load for the habitat (see Hall et al, 2004) but also takes into account the base cation deposition to the soil system and base cation removal from the system:

$CL_{max}S = CL_A + BC_{dep*} - BC_u$

Where:

CL_A = the acidity critical load for the habitat

BC_{dep}^* = non-marine base cation deposition minus non-marine chloride deposition

BC_u = base cation removal and uptake by vegetation

(ii) The minimum critical load of nitrogen ($CL_{min}N$) is the sum of the long-term nitrogen processes in the soil:

$CL_{min}N = N_u + N_i + N_{de}$

Where:

N_u = nitrogen removal and uptake by vegetation

N_i = nitrogen immobilisation

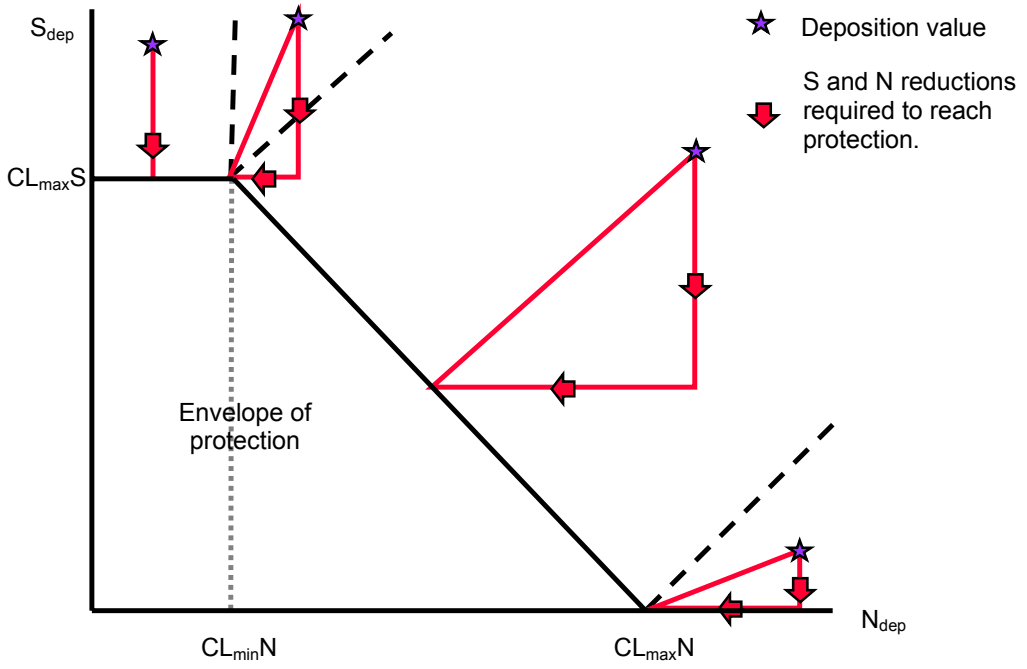
N_{de} = denitrification

(iii) The maximum critical load of nitrogen ($CL_{max}N$) is the acidity critical load in terms of nitrogen only, i.e., when sulphur deposition is zero. It is calculated as:

$CL_{max}N = CL_{min}N + CL_{max}S$

Combinations of sulphur and nitrogen deposition above the CLF exceed the critical load, while all areas on or below the CLF line represent an "envelope of protection" where critical loads are not exceeded (Figure 5.2). Using the CLF exceedances are calculated for the habitat critical load values in each 1km square in which they occur across the country. Figure 6.2 shows the principles of the calculations; the "shortest distance" exceedance is comprised of the amount of sulphur plus nitrogen deposition reductions required to reach the CLF line.

Figure 6.2 Calculating exceedances of acidity critical loads using the CLF



6.3 Calculating critical load exceedances for freshwater habitats

The First-Order Acidity Balance (Henriksen & Posch, 2001) model is used to calculate the nodes of the CLF for freshwaters. Acidity critical loads data exist for 1722 freshwaters (upland lakes or streams) across the UK (Hall et al, 2004). The equations used to derive $CL_{max}S$ and $CL_{max}N$ include catchment-specific parameters and also depend on the deposition load relative to $CL_{min}N$. The calculations of acidity exceedances therefore also depend on whether there is nitrate leaching occurring in the catchment or not:

Case 1: No terrestrial nitrate leaching ($N_{dep} <= CL_{min}N$)

$N_{export} = (1 - \rho_N) * LC_{ratio} * N_{dep}$
$S_{export} = (1 - \rho_S) * S_{dep}$
Exceedance = $N_{export} + S_{export} - L_{crit}$

Where:
ρ_N = in-lake retention of nitrogen
ρ_S = in-lake retention of sulphur
LC_{ratio} = lake to catchment (area) ratio
L_{crit} = critical leaching rate of acid anions
The above parameters are determined using the FAB model.

Case 2: Terrestrial nitrate leaching occurs ($N_{dep} > CL_{min}N$)

$N_{export} = (1 - \rho_N) * (N_{dep} - CL_{min}N)$
$S_{export} = (1 - \rho_S) * S_{dep}$
Exceedance = $N_{export} + S_{export} - L_{crit}$

The values of S_{dep} (non-marine) and N_{dep} (sum of oxidised and reduced) are calculated as catchment-weighted mean values from the national (CBED or FRAME) 5km deposition data, using the average values for all habitat types.

6.4 Deriving exceedance statistics and maps

Sections 6.2 and 6.3 above outline the calculation of critical load exceedances for acidity and nitrogen for terrestrial and freshwater habitats. These exceedance values can be mapped by habitat type or alternatively exceedances can be calculated using critical load values for all the habitat types combined. For example, the 5th-percentile values (i.e., the critical load values that will protect 95% of the total sensitive habitat area within each 1km grid square) of CLmaxS, CLminN, CLmaxN and CLnutN for all terrestrial habitats can be used to calculate and map exceedances (see Section 6.6.1).

Whilst maps are useful for providing the spatial patterns of exceedance, they are less useful when comparing the results of different deposition scenarios, since the maps may look very similar to one another. An alternative is to present summary statistics of the exceedance results; three measures are used in this report:

- The area of sensitive habitats exceeded (by country and UK)
- The percentage area of sensitive habitats exceeded (by country and UK)
- The Accumulated Exceedance: AE (by country and UK)

AE is calculated as:
AE (keq year^{-1}) = exceedance (keq ha^{-1} year^{-1}) * exceeded area (ha)

Thus AE is a measure of both the magnitude of exceedance and the area exceeded. This can be a more useful term to consider when comparing scenarios, since different scenarios may lead to the same area of habitat being exceeded, but the magnitude of exceedance may be different.

6.5 Exceedance and damage

The critical loads data on which exceedance calculations are currently based, are derived from empirical or steady-state mass balance methods, which are used to define long-term critical loads for systems at steady-state. Therefore, exceedance is an indication of the potential for harmful effects to systems at steady-state, and a habitat that is currently exceeding its critical load is not necessarily already showing the signs of damage. In addition, reducing deposition to below the critical load does not mean the habitats immediately recover. There are time lags before chemical recovery takes place, and further delays before biological recovery. The timescales for both chemical and biological recovery could be very long, particularly for the most sensitive ecosystems.

6.6 Results

The exceedance results are summarised in the sections below, beginning with a comparison of exceedances based on current (2001-03) deposition using CBED and the baseline estimates for 2010 and 2020 using calibrated FRAME deposition, followed by the acidity and nutrient nitrogen results for the 2020 scenarios. The results in this section focus mainly on the UK; full exceedance statistics by individual country and habitat are provided in Appendix 1.

6.6.1 Comparison of results for 2001-03, 2010 and 2020

In addition to exceedance statistics (below) maps of exceedance for 2001-03, 2010 and 2020 have also been generated. These maps are based on the 1km 5th percentile critical loads for the terrestrial habitats (see Section 6.4) and the average deposition values for all vegetation types; vegetation-specific deposition estimates are not used in generating these exceedance maps as the percentile critical loads (CLmaxS, CLminN and CLmaxN) can include values for different habitats within each 1km grid square. Thus the maps give a broad picture of exceedance, but may over- or underestimate the true exceedance for some habitats in some grid squares. The maps are described below together with the exceedance statistics; the statistics are based on vegetation-specific deposition as described in Section 6.2 and 6.3.

The exceedance maps for acidity for 2001-03, 2010 and 2020 are shown in Figure 6.3. The decreases in the magnitude of exceedance over time are very clear from the maps, particularly in central Scotland, Wales and south-west England. This is also reflected in the exceedance statistics (Tables 6.2, 6.3, 6.4) which show a decrease in both the areas exceeded and accumulated exceedance, with the largest reductions for Scotland and Wales. The results also show:

- The reductions in habitat areas exceeded are greater between 2001-03 and 2010, than between 2010 and 2020, in line with reductions in deposition.
- The largest reduction (18.5%) in habitat area exceeded is for Scotland.
- The smallest reduction (8.9%) in habitat area exceeded is for England.

- The reductions in habitat area exceeded for Wales and Northern Ireland are similar.
- The habitat area exceeded for the UK decreases by 15.4% between 2001-03 and 2020.
- Of all the habitat types the largest reduction in the area exceeded is for montane (25.8% reduction), decreasing from 2520km^2 exceeded to 1733km^2.
- The smallest reduction in area exceeded is for the freshwater habitats, decreasing by 9.1% (from 1646km^2 to 938km^2).

Table 6.2 Percentage area of sensitive habitats exceeded for acidity by country

	Percentage area exceeded for:			**Percentage decrease in area exceeded for:**		
Country	**2001-03**	**2010**	**2020**	**2001-03 to 2010**	**2010 to 2020**	**2001-03 to 2020**
England	72.1	65.6	63.3	6.5	2.4	8.9
Wales	81.6	72.3	67.8	9.3	4.5	13.8
Scotland	42.6	28.8	24.1	13.8	4.7	18.5
NI	71.3	61.9	59.7	9.4	2.1	11.6
UK	54.8	43.4	39.4	11.4	4.0	15.4

Table 6.3 Accumulated exceedance for acidity for sensitive habitats by country

	Accumulated Exceedance (keq yr^{-1})			**Percentage decrease in AE for:**		
Country	**2001-03**	**2010**	**2020**	**2001-03 to 2010**	**2010 to 2020**	**2001-03 to 2020**
England	1913679	1408878	1079010	26	23	44
Wales	630330	380575	304347	40	20	52
Scotland	1112583	556238	374873	50	33	66
NI	192898	155608	116820	19	25	39
UK	3849490	2501299	1875050	35	25	51

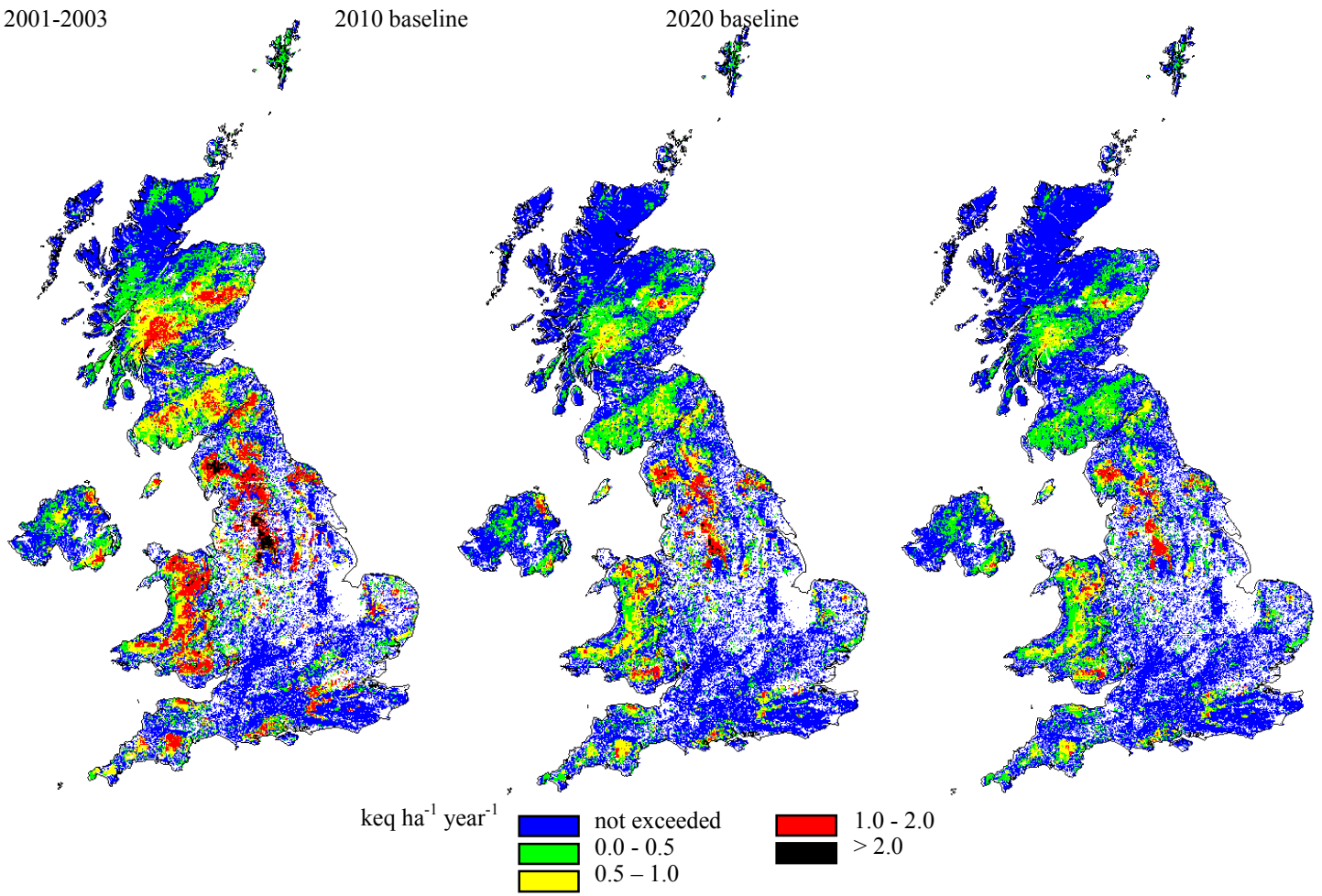
Accumulated exceedance results by individual habitat type are given in Appendix 1.

Table 6.4 Percentage area of habitats exceeded for acidity by habitat for the UK

	Percentage area exceeded for:			**Percentage decrease in area exceeded for:**		
Broad Habitat	**2001-03**	**2010**	**2020**	**2001-03 to 2010**	**2010 to 2020**	**2001-03 to 2020**
Acid grassland	79.8	69.7	66.4	10.1	3.3	13.4
Calcareous grassland	0.0	0.2	0.0	+0.2	0.2	0.0
Dwarf shrub heath	39.7	25.6	21.7	14.1	4.0	18.0
Bog	62.4	47.5	43.8	14.9	3.7	18.6
Montane	82.5	65.5	56.7	17.0	8.8	25.8
Coniferous woodland*	67.0	56.2	49.6	10.8	6.6	17.4
Broadleaved woodland*	69.6	60.0	57.2	9.6	2.8	12.4
Unmanaged woods	58.9	47.0	42.8	12.0	4.2	16.1
Freshwaters	21.1	15.3	12.0	5.9	3.2	9.1
All habitats	54.8	43.4	39.4	11.4	4.0	15.4

* managed woodlands

Figure 6.3 Exceedance of 5th percentile acidity critical loads by acid deposition for:



The exceedance maps for nutrient nitrogen for the years 2001-03, 2010 and 2020 are shown in Figure 6.4. Although significant areas still remain exceeded in 2020 the decrease in the magnitude of exceedance is clear, particularly in Wales, southern and central England. The exceedance statistics for the UK show the reductions in areas exceeded and in accumulated exceedance between 2001-03 and 2020 are smaller than the reductions seen for acidity. The key points are:

- The reductions in habitat areas exceeded are greater between 2001-03 and 2010, than between 2010 and 2020, in line with reductions in deposition.
- The reductions in habitat areas exceeded are similar for Wales (12.2%), Scotland (13%) and Northern Ireland (11.6%).
- The smallest reduction (7.8%) in habitat area exceeded is for England.
- The habitat area exceeded for the UK decreases by 11.4% between 2001-03 and 2020.
- Of all the habitat types the largest reduction in the area exceeded between 2001-03 and 2020 is for calcareous grassland (26.5% reduction), decreasing from 2822km^2 exceeded to 1874km^2.
- The overall reduction in exceeded area between 2001-03 and 2020 is less than 5% for bog, managed broadleaved woodland and unmanaged woods.

Table 6.5 Percentage area of sensitive habitats exceeded for nutrient nitrogen by country

	Percentage area exceeded for:			**Percentage decrease in area exceeded for:**		
Country	**2001-03**	**2010**	**2020**	**2001-03 to 2010**	**2010 to 2020**	**2001-03 to 2020**
England	93.1	87.2	85.3	5.9	1.9	7.8
Wales	87.4	80.4	75.2	7.0	5.2	12.2
Scotland	37.5	29.0	24.6	8.5	4.5	13.0
NI	82.0	71.4	70.4	10.6	1.0	11.6
UK	59.5	51.8	48.1	7.7	3.7	11.4

Table 6.6 Accumulated exceedance for nutrient nitrogen for sensitive habitats by country

	Accumulated Exceedance (keq yr^{-1})			**Percentage decrease in AE for:**		
Country	**2001-03**	**2010**	**2020**	**2001-03 to 2010**	**2010 to 2020**	**2001-03 to 2020**
England	2541219	2283955	1891349	10	17	26
Wales	515198	407985	332107	21	19	36
Scotland	755450	562890	405342	25	28	46
NI	185141	182967	142993	1	22	23
UK	3997008	3437797	2771792	14	19	31

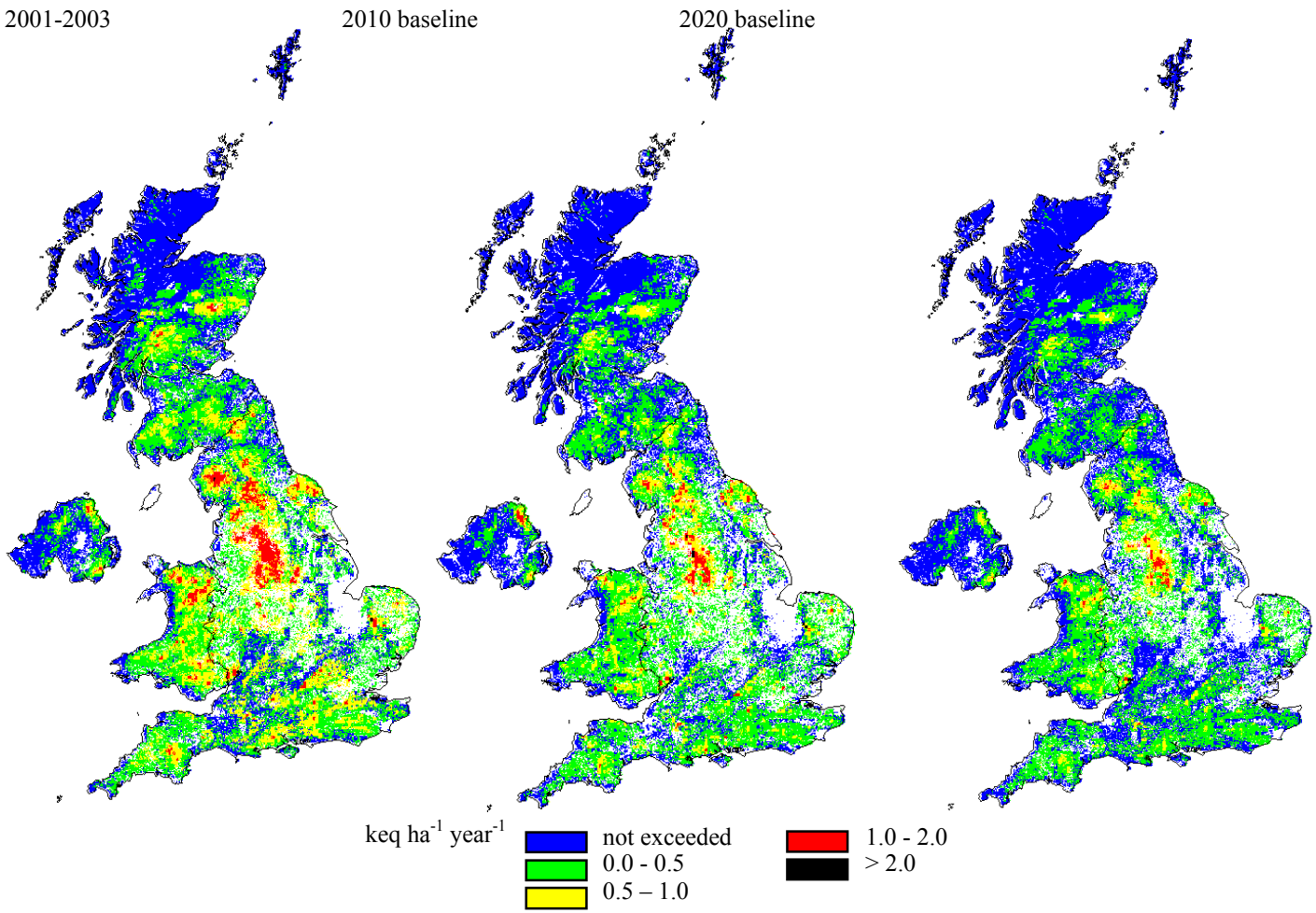
Accumulated exceedance results by individual habitat type are given in Appendix 1.

Table 6.7 Percentage area of habitats exceeded for nutrient nitrogen by habitat for the UK

Broad Habitat	Percentage area exceeded for:			Percentage decrease in area exceeded for:		
	2001-03	2010	2020	2001-03 to 2010	2010 to 2020	2001-03 to 2020
Acid grassland	58.0	45.5	38.9	12.5	6.6	19.1
Calcareous grassland	78.9	58.0	52.4	20.9	5.6	26.5
Dwarf shrub heath	32.4	24.6	21.3	7.8	3.3	11.1
Bog	42.4	40.3	39.5	2.0	0.9	2.9
Montane	89.0	77.9	71.4	11.0	6.5	17.6
Coniferous woodland[a]	90.6	85.6	83.9	4.9	1.8	6.7
Broadleaved woodland[a]	97.4	96.4	96.2	1.0	0.2	1.2
Unmanaged woods[b]	95.5	94.1	93.7	1.4	0.3	1.8
Atlantic oak[c]	91.3	77.5	70.8	13.7	6.7	20.5
Supralittoral sediment	31.3	28.2	17.6	3.1	10.6	13.7
All habitats	59.5	51.8	48.1	7.7	3.7	11.4

[a] managed woodlands
[b] effects on ground flora
[c] effects on epiphytic lichens

Figure 6.4 Exceedance of 5th percentile nutrient nitrogen critical loads by acid deposition for:



6.6.2 Scenarios for 2020

Eight scenarios were compared with the 2020 baseline; the deposition budgets for each are given in Table 6.8 below. For more information on the scenarios see Section 4.2, Table 4.1.

Table 6.8 Deposition budgets for the 2020 scenarios

Scenario	Deposition budgets		Percentage reduction in deposition relative to 2020 baseline		Description of scenario
	Total NOy (kT N)	Total SOx (kT S)	NOy-N	SOx-S	
Baseline	72.7	87.5	-	-	2020 baseline
A	68.8	87.5	5.4%	0	Euro low: Reductions in traffic emissions
B	64.2	87.5	12%	0	Euro high: Reductions in traffic emissions
C	68.6	87.5	5.6%	0	Early Euro low: Reductions in traffic emissions
K	66.5	87.5	9%	0	Large Combustion Plant (LCP)
N	71.5	82.6	1.7%	5.9%	Shipping: Abatement of shipping emissions
O	67.8	87.5	6.7%	0	Early Euro low & LEV: Reductions in traffic emissions
P	67.9	86.2	6.6%	1.5%	Early Euro low & SCP: Combined traffic & SCP
Q	67.2	86.2	7.6%	1.5%	Early Euro low & LEV & SCP: Combined traffic. LEV & SCP

Notes:
LEV = Low Emission Vehicles
SCP = Small Combustion Plant

The differences in the areas exceeded between the 8 scenarios are very small: 0.8% for acidity and 2.2% for nutrient nitrogen. The areas of sensitive habitats these differences represent are 621km^2 for acidity and 1650km^2 for nutrient nitrogen.

However, comparing the scenarios by area (or percentage area) exceeded may not highlight the differences between one scenario and another, unless the differences in areas exceeded are quite large. When summing the areas exceeded, the habitat area is included whether the critical load is only just exceeded or exceeded by a large amount. Therefore two scenarios could give the same area exceeded, but the magnitude of exceedance (and hence the deposition reductions required) could be very different. The accumulated exceedance (AE) can help by integrating the area exceeded with the magnitude of exceedance (see Section 6.4). However, it is important to recognise that large areas with a small exceedance could lead to the same AE value as smaller areas with a large exceedance value. For example, (a) and (b) below give the same AE value:

(a) Exceeded habitat area: 1000 ha
Exceedance: 0.1 keq ha^{-1} year^{-1}
AE: 100 keq year^{-1}

(b)	Exceeded habitat area:	100 ha
	Exceedance:	1.0 keq ha^{-1} $year^{-1}$
	AE:	100 keq $year^{-1}$

Although not all large habitat areas will have a small exceedance, nor will all small areas a large exceedance, different combinations could give quite different AE values:

(c)	Exceeded habitat area:	1000 ha
	Exceedance:	1.0 keq ha^{-1} $year^{-1}$
	AE:	1000 keq $year^{-1}$
(d)	Exceeded habitat area:	100 ha
	Exceedance:	0.1 keq ha^{-1} $year^{-1}$
	AE:	10 keq $year^{-1}$

Therefore some caution is required in interpreting the exceedance statistics for the eight scenarios.

The results for acidity are summarised in Tables 6.9 – 6.11 and those for nutrient nitrogen in Tables 6.12 – 6.14. The full statistics by country and habitat are given in Appendix 1. The key conclusions of the analysis are:

- All scenarios give very similar results: for acidity, the habitat areas exceeded range from 37.9% for scenario B (the most stringent reductions in NOy) to 39.4% of habitats exceeded for the 2020 baseline. For nutrient nitrogen 45.6% of habitats are exceeded for scenario B and 48.1% for the 2020 baseline.
- Overall Scenario B (reducing NOy from road traffic by 12%) gives the best results (i.e., smallest exceedances) for both acidity and nutrient nitrogen, for all countries and for all habitats, except montane, where scenario K (reduction in NOy from road traffic by 9%) gives marginally better results.
- For acidity, the difference in the habitat area exceeded between the 2020 baseline scenario and scenario B is only 1.5%, equivalent to 1159km^2 of sensitive habitats across the UK. The difference in AE for the UK between the 2020 baseline and scenario B is 166113 keq $year^{-1}$, equivalent to a decrease in AE of 9%.
- For nutrient nitrogen, the difference in habitat area exceeded between the 2020 baseline scenario and scenario B is only 2.5%, equivalent to 1883km^2 of sensitive habitats across the UK. The difference in AE for the UK between the 2020 baseline and scenario B is 228205 keq $year^{-1}$, equivalent to a decrease in AE of 8%.
- Scenario N (shipping emissions abatement) gives the greatest exceedances for acidity for acid grassland and woodland habitats. For other habitats, Scenario A (5.4% reduction in NOy from road traffic) gives the greatest exceedances for acidity.
- Scenario N also gives the greatest exceedances for nitrogen in all countries, and for acidity in England and NI.
- Scenario A gives the highest exceedance for Scotland for acidity.

Table 6.9 Percentage areas exceeded for acidity for 2020 baseline and scenarios by country

	Percentage exceeded area for scenario:								
Country	Baseline	A	B	C	K	N	O	P	Q
England	63.3	62.4	61.3	62.3	62.0	62.6	62.1	62.0	61.9
Wales	67.8	66.9	65.7	66.9	66.3	66.8	66.8	66.6	66.4
Scotland	24.1	23.5	22.9	23.5	22.9	23.1	23.4	23.3	23.2
NI	59.7	59.3	58.9	59.3	59.1	59.5	59.2	59.2	59.2
UK	39.4	38.7	37.9	38.7	38.2	38.5	38.6	38.5	38.4

Table 6.10 Accumulated exceedance for acidity for 2020 baseline and scenarios by country

	Accumulated Exceedance (keq $year^{-1}$) for scenario:								
Country	Baseline	A	B	C	K	N	O	P	Q
England	1079010	1037127	989206	1035127	1022364	1051684	1027283	1022014	1014938
Wales	304347	291131	276006	290470	283632	294284	288011	286431	284207
Scotland	374873	354370	331152	353357	331605	354187	349585	345824	342406
NI	116820	114890	112574	114769	113299	115747	114401	114096	113744
UK	1875050	1797517	1708937	1793724	1750900	1815902	1779281	1768364	1755295

Table 6.11 Percentage areas of habitats exceeded for acidity for 2020 baseline and scenarios by habitat for the UK

	Percentage exceeded area for scenario:								
Broad Habitat	Baseline	A	B	C	K	N	O	P	Q
Acid grassland	66.4	66.0	65.5	66.0	65.5	65.9	65.9	65.8	65.7
Calcareous grassland	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Dwarf shrub heath	21.7	21.1	20.3	21.1	20.3	20.8	20.9	20.8	20.7
Bog	43.8	43.5	43.1	43.5	43.0	42.7	43.4	43.3	43.3
Montane	56.7	55.6	55.2	55.6	55.1	55.6	55.6	55.5	55.5
Coniferous woodland (managed)	49.6	48.2	46.7	48.1	47.0	48.6	47.9	47.8	47.5
Broadleaved woodland (managed)	57.2	56.0	54.6	56.0	56.0	56.7	55.7	55.6	55.4
Unmanaged woods	42.8	41.7	40.2	41.7	41.5	42.2	41.5	41.3	41.2
Freshwaters	12.0	11.8	11.5	11.8	11.6	9.9	11.8	11.7	11.7
All habitats	39.4	38.7	37.9	38.7	38.2	38.5	38.6	38.5	38.4

Table 6.12 Percentage areas exceeded for nutrient nitrogen for 2020 baseline and scenarios, by country.

	Percentage exceeded area for scenario:								
Country	Baseline	A	B	C	K	N	O	P	Q
England	85.3	84.1	82.8	84.0	83.5	85.2	83.9	83.9	83.7
Wales	75.2	73.3	71.8	73.3	72.7	75.0	73.2	73.2	73.1
Scotland	24.6	23.4	22.2	23.2	22.0	24.1	22.9	23.0	22.8
NI	70.4	68.3	66.5	68.3	66.9	70.0	67.9	68.2	67.8
UK	48.1	46.8	45.6	46.7	45.7	47.8	46.5	46.5	46.3

Table 6.13 Accumulated exceedance for nutrient nitrogen for 2020 baseline and scenarios, by country.

	Accumulated Exceedance (keq year^{-1}) for scenario:								
Country	Baseline	A	B	C	K	N	O	P	Q
England	1891349	1825719	1749661	1822511	1809095	1884856	1810138	1813324	1802132
Wales	332107	316461	298545	315706	308070	328025	312804	312938	310302
Scotland	405342	382757	357527	381628	360641	397636	377515	377486	373758
NI	142993	140624	137853	140483	138777	142207	140042	140124	139715
UK	2771792	2665562	2543587	2660327	2616583	2752724	2640500	2643873	2625908

Table 6.14 Percentage areas exceeded for nutrient nitrogen for 2020 baseline and scenarios by habitat for the UK

	Percentage exceeded area for scenario:								
Broad Habitat	Baseline	A	B	C	K	N	O	P	Q
Acid grassland	38.9	36.8	35.1	36.8	35.3	38.5	36.5	36.6	36.2
Calcareous grassland	52.4	47.7	43.7	47.6	47.0	52.3	47.2	47.3	46.4
Dwarf shrub heath	21.3	20.1	19.1	20.0	19.0	20.9	19.9	19.9	19.8
Bog	39.5	39.1	38.8	39.1	38.7	39.3	38.9	38.9	38.9
Montane	71.4	69.7	66.4	68.2	65.1	70.6	67.2	67.2	67.2
Coniferous woodland (managed)	83.9	83.2	82.3	83.2	82.6	83.7	83.1	83.1	83.0
Broadleaved woodland (managed)	96.2	96.1	95.9	96.1	96.0	96.2	96.1	96.1	96.0
Unmanaged woods (ground flora)	93.7	93.7	93.6	93.7	93.6	93.7	93.7	93.7	93.6
Atlantic oak (epiphytic lichens)	70.8	67.9	65.1	67.6	65.9	70.1	66.2	66.2	66.2
Supralittoral sediment	17.6	17.1	16.4	17.1	16.6	17.6	16.8	17.0	16.7
All habitats	48.1	46.8	45.6	46.7	45.7	47.8	46.5	46.5	46.3

7. Conclusions

The main conclusions of the assessment of the environmental impacts associated with the UK Air Quality Strategy are summarised below.

Changes in emissions, deposition and concentrations:

- Future estimates of emissions of SO_2 and NO_X in the United Kingdom forecast significant reductions of 64% and 45% between 2002 and 2020. Emissions of SO_2 and NO_x from international shipping, however, are expected to increase at a rate of 2.5% per year, making an increasing contribution to sulphur and nitrogen deposition. A more moderate reduction in NH_3 emissions of 10% between 2002 and 2020 is forecast.
- The average concentration of SO_2 for the United Kingdom modelled with FRAME is forecast to reduce by 52% between 2002 and 2020. The areas of highest SO2 concentration for 2002 were associated with the industrial regions of northern England. For 2020, high concentrations areas are particularly in the coastal areas of south-east England due to the influence of international shipping. NH_3 concentrations are forecast to decrease by 10% between 2002 and 2020 with no significant change in spatial distribution.
- The total deposition of SO_x and NO_y to the UK were forecast to decrease by 45% and 35% respectively between 2002 and 2020. Eight emissions abatement scenarios were run. The greatest change was found to occur due to the implementation of scenario B (Euro high) with a further 12% reduction in NO_y deposition for 2020.

Critical levels (air quality objectives):

- An assessment of the air quality objectives for SO_2 (20 μg m^{-3}) and NO_x (30 μg m^{-3}) for the EU Daughter Directive (Stedman et al, 2005) does not show any areas of exceedance of the objectives in 2004 for designated sites (SSSIs, SACs, SPAs) located outside the exclusion zone (i.e., in rural areas). These results are based on 30km resolution mean concentration data for rural areas only (i.e., those outside the exclusion zone). Mean concentrations on a 30km grid have been used to prevent the influence of any urban area appearing unrealistically large on adjacent vegetated areas. This provides modelled concentrations for vegetated areas that are representative of 1000km^2 as specified in Directive 1999/30/EC for assessing the air quality objectives.
- The 1km (Netcen) and 5km (FRAME) SO_2 concentration data for 2003 include some grid squares with values exceeding 20 μg m^{-3}, however this is attributable to the resolution of the data and the inclusion of data from both urban and rural areas
- The potential impact of reducing the SO_2 objective to 10 μg m^{-3} was explored using the 1km (Netcen) and 5km (FRAME) data sets. Some small areas of exceedance occurred but represented less than 1% of the areas of designated sites falling outside the exclusion zone.
- Small areas of designated sites outside the exclusion zone exceeded the NO_x objective of 30 μg m^{-3} for 2003, 2010 and 2020 using 1km (Netcen) concentration data, however this is attributable to the resolution of the data and the inclusion of data from both urban and rural areas

- Assessment of NH_3 was based on the WHO critical level of 8 μg m^{-3} using the FRAME 5km "calibrated" concentration data. Only one 5km square has a concentration above 8 μg m^{-3} for 2003 and also in 2020. SACs are only exceeded using the calibrated data for 2002, but the area is <0.1%. For other sites there is only a small reduction in the area exceeded between 2002 and 2020 using the uncalibrated data, but the areas are small, <0.1% for each site type. However, it should be recognised that ammonia concentrations are known to be strongly variable locally on a scale unresolved by the current models. Increasing the resolution of these calculations is expected to result in an increased number of grid squares with NH_3 concentrations exceeding the critical level.

Critical loads: trends from 2001-03 to 2020

- Critical loads are currently exceeded (i.e., using deposition for 2001-03) for 54.8% of sensitive habitats for acidity, and 59.5% for nutrient nitrogen. The areas exceeded are predicted to decrease by 15.4% for acidity and 11.4% for nutrient nitrogen by 2020.
- For acidity, the greatest improvements are for the montane habitat, with a 25.8% decrease in the area currently exceeded (i.e., 2001-03) by 2020. The least improvement is for the freshwaters where only an additional 9.1% of the habitat will be "protected" by 2020.
- For nutrient nitrogen the largest reductions in the area exceeded (26.5%) between the present day (2001-03) and 2020 is for calcareous grassland. There will be a less than 5% improvement in the area exceeded for bog, managed broadleaved woodland and unmanaged (coniferous and broadleaved) woodlands.
- The largest reductions in the areas of sensitive habitats exceeded by 2020 are predicted to be in Scotland. Overall in the UK there are greater improvements in reducing the area exceeded between 2001-03 and 2010, than 2010 and 2020.
- Accumulated exceedance decreases by 51% for acidity and 31% for nutrient nitrogen between 2001-03 and 2020.

Critical loads: 2020 scenarios

- Differences in the habitat areas exceeded between the eight scenarios for 2020 are small: only 0.8% for acidity and 2.2% for nutrient nitrogen.
- The differences in habitat area exceeded between the baseline 2020 scenario and scenario B (most stringent reductions in nitrogen emissions: 12% reduction in NOy deposition from road traffic) is only 1.5% for acidity and 2.5% for nutrient nitrogen, equivalent to 1159km^2 and 1883km^2 respectively.
- The accumulated exceedance decreases by 9% for acidity and 8% for nutrient nitrogen between the baseline 2020 scenario and scenario B.
- Overall, scenario B gives the best results (i.e., smallest exceedances) for both acidity and nitrogen in all countries and all habitats except the montane habitat, for which scenario K gives marginally better results.
- Scenario N (abetment of shipping emissions: reductions in deposition of NOy by 1.7% and SOx of 5.9%) gives the highest exceedances for nutrient nitrogen in all countries, and for acidity in England and NI.
- In terms of habitats, for acidity, scenario N gives the least effective reduction in exceedances for acid grassland and woodland and scenario A gives the least effective reduction in exceedances for other habitat types.

- Scenario A (5.4% reduction in NOy deposition from road traffic) gives the greatest exceedance for Scotland for acidity.
- However, because the differences between these 2020 scenarios are small the results need to be interpreted with particular care. The area of habitat exceeded can be the same when the magnitude of the exceedance is different. The accumulated exceedance integrates the area and magnitude of exceedance, but different combinations of exceeded area and magnitude of exceedance can give the same result, such that a large area with a very small exceedance could give the same accumulated exceedance value as a small area with a high exceedance.

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APPENDIX 1

Critical load exceedance statistics for baseline years:

4. 2001-2003
5. 2010
6. 2020

Critical load exceedance statistics for 2020 scenarios:

A. Euro low
B. Euro high
C. Early Euro low
K. Large Combustion Plant
N. Shipping
O. Early Euro low & low emission vehicles
P. Early Euro low & small combustion plant
Q. Early Euro low & low emission vehicles & small combustion plant

1. Acidity exceedance statistics for 2001-2003

Acidity exceedances for England

Broad Habitat	Habitat Area (km^2)	Exceeded Area (km^2)	Percentage Area Exceeded	Accumulated Exceedance (keq/year)
Acid grassland	2669	2550	95.5	351650
Calcareous grassland	1714	0	0.0	0
Dwarf shrub heath	2462	2287	92.9	237505
Bog	1006	997	99.1	153786
Montane	2	2	100.0	327
Coniferous woodland (managed)	1716	1532	89.3	253784
Broadleaved woodland (managed)	5565	3986	71.6	640978
Unmanaged woods	2392	1535	64.2	201913
Freshwaters	1042	504	48.4	73736
All habitats	18568	13392	72.1	1913679

Acidity exceedances for Wales

Broad Habitat	Habitat Area (km^2)	Exceeded Area (km^2)	Percentage Area Exceeded	Accumulated Exceedance (keq/year)
Acid grassland	3143	3017	96.0	314298
Calcareous grassland	45	0	0.0	0
Dwarf shrub heath	1078	933	86.5	67103
Bog	56	55	97.6	5742
Montane	18	18	100.0	2846
Coniferous woodland (managed)	1048	1006	96.0	117042
Broadleaved woodland (managed)	790	602	76.1	66222
Unmanaged woods	395	309	78.2	32898
Freshwaters	1225	423	34.6	24180
All habitats	7798	6363	81.6	630330

Acidity exceedances for Scotland

Broad Habitat	Habitat Area (km^2)	Exceeded Area (km^2)	Percentage Area Exceeded	Accumulated Exceedance (keq/year)
Acid grassland	8336	5711	68.5	345640
Calcareous grassland	7	0	0.0	0
Dwarf shrub heath	20190	5891	29.2	220541
Bog	3959	1959	49.5	67856
Montane	3034	2500	82.4	180559
Coniferous woodland (managed)	5111	2739	53.6	199318
Broadleaved woodland (managed)	1096	600	54.7	42069
Unmanaged woods	1016	409	40.3	26555
Freshwaters	5338	686	12.9	30044
All habitats	48086	20496	42.6	1112583

Acidity exceedance statistics for 2001-2003 (continued)

Acidity exceedances for Northern Ireland

Broad Habitat	Habitat Area (km^2)	Exceeded Area (km^2)	Percentage Area Exceeded	Accumulated Exceedance (keq/year)
Acid grassland	1187	954	80.4	69940
Calcareous grassland	42	0	0.0	0
Dwarf shrub heath	973	694	71.3	39735
Bog	442	397	90.0	28801
Montane	0	0	0.0	0
Coniferous woodland (managed)	503	334	66.5	35359
Broadleaved woodland (managed)	0	0	0.0	0
Unmanaged woods	208	111	53.2	15298
Freshwaters	186	32	17.4	3764
All ecosystems	3539	2523	71.3	192898

Acidity exceedances for the United Kingdom

Broad Habitat	Habitat Area (km^2)	Exceeded Area (km^2)	Percentage Area Exceeded	Accumulated Exceedance (keq/year)
Acid grassland	15334	12232	79.8	1081529
Calcareous grassland	1808	0	0.0	0
Dwarf shrub heath	24703	9805	39.7	564884
Bog	5463	3408	62.4	256185
Montane	3054	2520	82.5	183732
Coniferous woodland (managed)	8377	5612	67.0	605502
Broadleaved woodland (managed)	7452	5188	69.6	749269
Unmanaged woods	4011	2363	58.9	276664
Freshwaters	7790	1646	21.1	131725
All habitats	77991	42773	54.8	3849490

Nutrient nitrogen exceedances for 2001-2003

Nutrient nitrogen exceedances for England

Broad Habitat	Habitat Area (km^2)	Exceeded Area (km^2)	Percentage Area Exceeded	Accumulated Exceedance (keq/year)
Acid grassland	2620	2558	97.6	166229
Calcareous grassland	3312	2740	82.7	109274
Dwarf shrub heath	2466	2381	96.5	153103
Bog	1007	1006	99.9	106522
Montane	2	2	100.0	250
Coniferous woodland (managed)	1719	1719	100.0	310969
Broadleaved woodland (managed)	5588	5588	100.0	1191944
Unmanaged woods (ground flora)	2252	2252	100.0	463941
Atlantic oak (epiphytic lichens)	150	150	100.0	27513
Supralittoral sediment	1183	494	41.7	11474
All habitats	20299	18889	93.1	2541219

Nutrient nitrogen exceedances for Wales

Broad Habitat	Habitat Area (km^2)	Exceeded Area (km^2)	Percentage Area Exceeded	Accumulated Exceedance (keq/year)
Acid grassland	3146	2685	85.4	117127
Calcareous grassland	171	68	39.9	1648
Dwarf shrub heath	1094	1012	92.5	52135
Bog	56	54	95.8	3591
Montane	18	18	100.0	2083
Coniferous woodland (managed)	1052	1052	100.0	162243
Broadleaved woodland (managed)	798	797	99.9	111842
Unmanaged woods (ground flora)	226	226	100.0	36375
Atlantic oak (epiphytic lichens)	171	171	100.0	25926
Supralittoral sediment	369	123	33.3	2227
All habitats	7102	6207	87.4	515198

Nutrient nitrogen exceedances for Scotland

Broad Habitat	Habitat Area (km^2)	Exceeded Area (km^2)	Percentage Area Exceeded	Accumulated Exceedance (keq/year)
Acid grassland	8283	2734	33.0	51237
Calcareous grassland	24	2	7.2	24
Dwarf shrub heath	20284	3839	18.9	88363
Bog	4005	856	21.4	32550
Montane	3109	2764	88.9	124157
Coniferous woodland (managed)	5111	4336	84.8	330793
Broadleaved woodland (managed)	1096	903	82.4	77085
Unmanaged woods (ground flora)	570	426	74.7	33889
Atlantic oak (epiphytic lichens)	501	429	85.7	16930
Supralittoral sediment	547	33	6.0	422
All habitats	43530	16322	37.5	755450

Nutrient nitrogen exceedances for 2001-2003 (continued)

Nutrient nitrogen exceedances for Northern Ireland

Broad Habitat	Habitat Area (km^2)	Exceeded Area (km^2)	Percentage Area Exceeded	Accumulated Exceedance (keq/year)
Acid grassland	1192	870	73.0	30295
Calcareous grassland	69	12	17.6	750
Dwarf shrub heath	976	803	82.2	37738
Bog	473	430	91.0	23650
Montane	0	0	0.0	0
Coniferous woodland (managed)	504	488	96.8	57189
Broadleaved woodland (managed)	0	0	0.0	0
Unmanaged woods (ground flora)	247	242	97.9	34735
Atlantic oak (epiphytic lichens)	0	0	0.0	0
Supralittoral sediment	29	16	56.7	784
All ecosystems	3491	2862	82.0	185141

Nutrient nitrogen exceedances for the United Kingdom

Broad Habitat	Habitat Area (km^2)	Exceeded Area (km^2)	Percentage Area Exceeded	Accumulated Exceedance (keq/year)
Acid grassland	15241	8847	58.0	364888
Calcareous grassland	3577	2822	78.9	111696
Dwarf shrub heath	24820	8035	32.4	331339
Bog	5541	2347	42.4	166313
Montane	3129	2784	89.0	126491
Coniferous woodland (managed)	8385	7594	90.6	861195
Broadleaved woodland (managed)	7482	7288	97.4	1380872
Unmanaged woods (ground flora)	3296	3147	95.5	568939
Atlantic oak (epiphytic lichens)	822	750	91.3	70369
Supralittoral sediment	2128	666	31.3	14907
All habitats	74422	44279	59.5	3997008

1. Acidity exceedances for 2010

Acidity exceedances for England

Broad Habitat	Habitat Area (km^2)	Exceeded Area (km^2)	Percentage Area Exceeded	Accumulated Exceedance (keq/year)
Acid grassland	2669	2494	93.4	260247
Calcareous grassland	1714	4	0.2	1830
Dwarf shrub heath	2462	2086	84.7	154766
Bog	1006	993	98.7	111368
Montane	2	2	100.0	219
Coniferous woodland (managed)	1716	1420	82.8	187221
Broadleaved woodland (managed)	5565	3495	62.8	496072
Unmanaged woods	2392	1242	51.9	149651
Freshwaters	1042	447	42.9	47503
All habitats	18568	12182	65.6	1408878

Acidity exceedances for Wales

Broad Habitat	Habitat Area (km^2)	Exceeded Area (km^2)	Percentage Area Exceeded	Accumulated Exceedance (keq/year)
Acid grassland	3143	2903	92.4	205837
Calcareous grassland	45	0	0.0	0
Dwarf shrub heath	1078	742	68.8	29734
Bog	56	51	91.6	3531
Montane	18	18	100.0	1880
Coniferous woodland (managed)	1048	839	80.1	65526
Broadleaved woodland (managed)	790	519	65.7	44239
Unmanaged woods	395	266	67.4	21418
Freshwaters	1225	300	24.5	8409
All habitats	7798	5638	72.3	380575

Acidity exceedances for Scotland

Broad Habitat	Habitat Area (km^2)	Exceeded Area (km^2)	Percentage Area Exceeded	Accumulated Exceedance (keq/year)
Acid grassland	8336	4438	53.2	183876
Calcareous grassland	7	0	0.0	0
Dwarf shrub heath	20190	2938	14.6	71631
Bog	3959	1191	30.1	35854
Montane	3034	1980	65.3	93159
Coniferous woodland (managed)	5111	2167	42.4	112812
Broadleaved woodland (managed)	1096	459	41.9	34084
Unmanaged woods	1016	275	27.1	16552
Freshwaters	5338	413	7.7	8270
All habitats	48086	13862	28.8	556238

Acidity exceedances for 2010 (continued)

Acidity exceedances for Northern Ireland

Broad Habitat	Habitat Area (km^2)	Exceeded Area (km^2)	Percentage Area Exceeded	Accumulated Exceedance (keq/year)
Acid grassland	1187	850	71.6	53679
Calcareous grassland	42	0	0.0	0
Dwarf shrub heath	973	569	58.5	29489
Bog	442	360	81.4	22782
Montane	0	0	0.0	0
Coniferous woodland (managed)	503	282	56.1	33766
Broadleaved woodland (managed)	0	0	0.0	0
Unmanaged woods	208	100	48.3	13497
Freshwaters	186	29	15.6	2395
All ecosystems	3539	2189	61.9	155608

Acidity exceedances for the United Kingdom

Broad Habitat	Habitat Area (km^2)	Exceeded Area (km^2)	Percentage Area Exceeded	Accumulated Exceedance (keq/year)
Acid grassland	15334	10685	69.7	703640
Calcareous grassland	1808	4	0.2	1830
Dwarf shrub heath	24703	6334	25.6	285619
Bog	5463	2595	47.5	173536
Montane	3054	2000	65.5	95258
Coniferous woodland (managed)	8377	4709	56.2	399326
Broadleaved woodland (managed)	7452	4472	60.0	574395
Unmanaged woods	4011	1884	47.0	201118
Freshwaters	7790	1189	15.3	66578
All habitats	77991	33872	43.4	2501299

Nutrient nitrogen exceedances for 2010

Nutrient nitrogen exceedances for England

Broad Habitat	Habitat Area (km^2)	Exceeded Area (km^2)	Percentage Area Exceeded	Accumulated Exceedance (keq/year)
Acid grassland	2620	2395	91.4	138877
Calcareous grassland	3312	2000	60.4	99687
Dwarf shrub heath	2466	2176	88.2	126513
Bog	1007	1005	99.9	92945
Montane	2	2	100.0	204
Coniferous woodland (managed)	1719	1718	100.0	279705
Broadleaved woodland (managed)	5588	5580	99.9	1083013
Unmanaged woods (ground flora)	2252	2252	100.0	412019
Atlantic oak (epiphytic lichens)	150	150	100.0	26897
Supralittoral sediment	1183	414	35.0	24094
All habitats	20299	17692	87.2	2283955

Nutrient nitrogen exceedances for Wales

Broad Habitat	Habitat Area (km^2)	Exceeded Area (km^2)	Percentage Area Exceeded	Accumulated Exceedance (keq/year)
Acid grassland	3146	2334	74.2	77103
Calcareous grassland	171	58	33.7	2299
Dwarf shrub heath	1094	895	81.8	31782
Bog	56	53	94.4	2585
Montane	18	18	100.0	1701
Coniferous woodland (managed)	1052	1051	99.9	131361
Broadleaved woodland (managed)	798	785	98.3	97378
Unmanaged woods (ground flora)	226	225	99.5	31675
Atlantic oak (epiphytic lichens)	171	169	98.9	22720
Supralittoral sediment	369	119	32.3	9381
All habitats	7102	5707	80.4	407985

Nutrient nitrogen exceedances for Scotland

Broad Habitat	Habitat Area (km^2)	Exceeded Area (km^2)	Percentage Area Exceeded	Accumulated Exceedance (keq/year)
Acid grassland	8283	1508	18.2	27927
Calcareous grassland	24	4	17.3	452
Dwarf shrub heath	20284	2325	11.5	46320
Bog	4005	786	19.6	24870
Montane	3109	2419	77.8	84124
Coniferous woodland (managed)	5111	3978	77.8	261843
Broadleaved woodland (managed)	1096	849	77.4	74009
Unmanaged woods (ground flora)	570	393	69.0	29904
Atlantic oak (epiphytic lichens)	501	318	63.5	10943
Supralittoral sediment	547	49	9.0	2498
All habitats	43530	12628	29.0	562890

Nutrient nitrogen exceedances for 2010 (continued)

Nutrient nitrogen exceedances for Northern Ireland

Broad Habitat	Habitat Area (km^2)	Exceeded Area (km^2)	Percentage Area Exceeded	Accumulated Exceedance (keq/year)
Acid grassland	1192	697	58.5	28644
Calcareous grassland	69	13	18.4	1111
Dwarf shrub heath	976	711	72.8	38094
Bog	473	390	82.5	22812
Montane	0	0	0.0	0
Coniferous woodland (managed)	504	433	85.9	58389
Broadleaved woodland (managed)	0	0	0.0	0
Unmanaged woods (ground flora)	247	229	92.7	33001
Atlantic oak (epiphytic lichens)	0	0	0.0	0
Supralittoral sediment	29	18	61.0	918
All ecosystems	3491	2491	71.4	182967

Nutrient nitrogen exceedances for the United Kingdom

Broad Habitat	Habitat Area (km^2)	Exceeded Area (km^2)	Percentage Area Exceeded	Accumulated Exceedance (keq/year)
Acid grassland	15241	6935	45.5	272551
Calcareous grassland	3577	2075	58.0	103548
Dwarf shrub heath	24820	6106	24.6	242709
Bog	5541	2234	40.3	143212
Montane	3129	2439	77.9	86029
Coniferous woodland (managed)	8385	7179	85.6	731297
Broadleaved woodland (managed)	7482	7213	96.4	1254401
Unmanaged woods (ground flora)	3296	3100	94.1	506599
Atlantic oak (epiphytic lichens)	822	637	77.5	60561
Supralittoral sediment	2128	600	28.2	36891
All habitats	74422	38518	51.8	3437797

2. Acidity exceedances for 2020

Acidity exceedances for England

Broad Habitat	Habitat Area (km^2)	Exceeded Area (km^2)	Percentage Area Exceeded	Accumulated Exceedance (keq/year)
Acid grassland	2669	2485	93.1	212278
Calcareous grassland	1714	0	0.0	0
Dwarf shrub heath	2462	1994	81.0	111906
Bog	1006	991	98.5	89007
Montane	2	2	99.8	191
Coniferous woodland (managed)	1716	1313	76.5	148276
Broadleaved woodland (managed)	5565	3383	60.8	374582
Unmanaged woods	2392	1146	47.9	105724
Freshwaters	1042	431	41.4	37047
All habitats	18568	11745	63.3	1079010

Acidity exceedances for Wales

Broad Habitat	Habitat Area (km^2)	Exceeded Area (km^2)	Percentage Area Exceeded	Accumulated Exceedance (keq/year)
Acid grassland	3143	2852	90.8	173832
Calcareous grassland	45	0	0.0	0
Dwarf shrub heath	1078	681	63.2	23905
Bog	56	52	93.0	3144
Montane	18	18	100.0	1671
Coniferous woodland (managed)	1048	737	70.4	48971
Broadleaved woodland (managed)	790	494	62.6	32137
Unmanaged woods	395	244	61.7	14941
Freshwaters	1225	209	17.1	5745
All habitats	7798	5288	67.8	304347

Acidity exceedances for Scotland

Broad Habitat	Habitat Area (km^2)	Exceeded Area (km^2)	Percentage Area Exceeded	Accumulated Exceedance (keq/year)
Acid grassland	8336	4011	48.1	133723
Calcareous grassland	7	0	0.0	0
Dwarf shrub heath	20190	2165	10.7	39993
Bog	3959	988	25.0	24416
Montane	3034	1713	56.5	72733
Coniferous woodland (managed)	5111	1833	35.9	72352
Broadleaved woodland (managed)	1096	387	35.3	16914
Unmanaged woods	1016	230	22.7	8813
Freshwaters	5338	269	5.0	5929
All habitats	48086	11595	24.1	374873

Acidity exceedances for 2020 (continued)

Acidity exceedances for Northern Ireland

Broad Habitat	Habitat Area (km^2)	Exceeded Area (km^2)	Percentage Area Exceeded	Accumulated Exceedance (keq/year)
Acid grassland	1187	835	70.4	43790
Calcareous grassland	42	0	0.0	0
Dwarf shrub heath	973	518	53.2	19316
Bog	442	364	82.4	17735
Montane	0	0	0.0	0
Coniferous woodland (managed)	503	271	54.0	22394
Broadleaved woodland (managed)	0	0	0.0	0
Unmanaged woods	208	96	46.4	11185
Freshwaters	186	29	15.6	2399
All ecosystems	3539	2114	59.7	116820

Acidity exceedances for the United Kingdom

Broad Habitat	Habitat Area (km^2)	Exceeded Area (km^2)	Percentage Area Exceeded	Accumulated Exceedance (keq/year)
Acid grassland	15334	10184	66.4	563623
Calcareous grassland	1808	0	0.0	0
Dwarf shrub heath	24703	5357	21.7	195120
Bog	5463	2395	43.8	134302
Montane	3054	1733	56.7	74595
Coniferous woodland (managed)	8377	4154	49.6	291993
Broadleaved woodland (managed)	7452	4264	57.2	423632
Unmanaged woods	4011	1717	42.8	140663
Freshwaters	7790	938	12.0	51120
All habitats	77991	30742	39.4	1875050

Nutrient nitrogen exceedances for 2020

Nutrient nitrogen exceedances for England

Broad Habitat	Habitat Area (km^2)	Exceeded Area (km^2)	Percentage Area Exceeded	Accumulated Exceedance (keq/year)
Acid grassland	2620	2351	89.7	99648
Calcareous grassland	3312	1828	55.2	55106
Dwarf shrub heath	2466	2119	85.9	90738
Bog	1007	1006	99.9	75501
Montane	2	2	100.0	184
Coniferous woodland (managed)	1719	1719	100.0	236156
Broadleaved woodland (managed)	5588	5586	100.0	943996
Unmanaged woods (ground flora)	2252	2252	100.0	363345
Atlantic oak (epiphytic lichens)	150	150	100.0	21131
Supralittoral sediment	1183	294	24.8	5544
All habitats	20299	17306	85.3	1891349

Nutrient nitrogen exceedances for Wales

Broad Habitat	Habitat Area (km^2)	Exceeded Area (km^2)	Percentage Area Exceeded	Accumulated Exceedance (keq/year)
Acid grassland	3146	2068	65.7	55221
Calcareous grassland	171	33	19.0	494
Dwarf shrub heath	1094	878	80.2	27094
Bog	56	53	94.3	2321
Montane	18	18	100.0	1541
Coniferous woodland (managed)	1052	1051	99.9	114680
Broadleaved woodland (managed)	798	790	99.0	82778
Unmanaged woods (ground flora)	226	226	99.9	27393
Atlantic oak (epiphytic lichens)	171	171	99.9	19580
Supralittoral sediment	369	52	14.1	1005
All habitats	7102	5339	75.2	332107

Nutrient nitrogen exceedances for Scotland

Broad Habitat	Habitat Area (km^2)	Exceeded Area (km^2)	Percentage Area Exceeded	Accumulated Exceedance (keq/year)
Acid grassland	8283	844	10.2	7616
Calcareous grassland	24	1	5.2	4
Dwarf shrub heath	20284	1597	7.9	21851
Bog	4005	733	18.3	17549
Montane	3109	2215	71.2	68698
Coniferous woodland (managed)	5111	3823	74.8	206446
Broadleaved woodland (managed)	1096	821	74.9	53286
Unmanaged woods (ground flora)	570	377	66.2	21855
Atlantic oak (epiphytic lichens)	501	261	52.1	7887
Supralittoral sediment	547	13	2.5	149
All habitats	43530	10686	24.6	405342

Nutrient nitrogen exceedances for 2020 (continued)

Nutrient nitrogen exceedances for Northern Ireland

Broad Habitat	Habitat Area (km^2)	Exceeded Area (km^2)	Percentage Area Exceeded	Accumulated Exceedance (keq/year)
Acid grassland	1192	666	55.9	19480
Calcareous grassland	69	12	17.6	575
Dwarf shrub heath	976	694	71.1	26638
Bog	473	396	83.7	18205
Montane	0	0	0.0	0
Coniferous woodland (managed)	504	441	87.5	47304
Broadleaved woodland (managed)	0	0	0.0	0
Unmanaged woods (ground flora)	247	233	94.2	30233
Atlantic oak (epiphytic lichens)	0	0	0.0	0
Supralittoral sediment	29	15	52.2	558
All ecosystems	3491	2458	70.4	142993

Nutrient nitrogen exceedances for the United Kingdom

Broad Habitat	Habitat Area (km^2)	Exceeded Area (km^2)	Percentage Area Exceeded	Accumulated Exceedance (keq/year)
Acid grassland	15241	5929	38.9	181965
Calcareous grassland	3577	1874	52.4	56180
Dwarf shrub heath	24820	5288	21.3	166322
Bog	5541	2187	39.5	113577
Montane	3129	2235	71.4	70423
Coniferous woodland (managed)	8385	7033	83.9	604585
Broadleaved woodland (managed)	7482	7198	96.2	1080059
Unmanaged woods (ground flora)	3296	3089	93.7	442826
Atlantic oak (epiphytic lichens)	822	582	70.8	48598
Supralittoral sediment	2128	374	17.6	7257
All habitats	74422	35789	48.1	2771792

Scenario A (Euro low): acidity exceedances

Acidity exceedances for England

Broad Habitat	Habitat Area (km^2)	Exceeded Area (km^2)	Percentage Area Exceeded	Accumulated Exceedance (keq/year)
Acid grassland	2669	2476	92.8	206895
Calcareous grassland	1714	0	0.0	0
Dwarf shrub heath	2462	1965	79.8	107461
Bog	1006	990	98.4	86471
Montane	2	2	99.8	186
Coniferous woodland (managed)	1716	1280	74.6	142563
Broadleaved woodland (managed)	5565	3315	59.6	357961
Unmanaged woods	2392	1120	46.9	99961
Freshwaters	1042	431	41.4	35629
All habitats	18568	11580	62.4	1037127

Acidity exceedances for Wales

Broad Habitat	Habitat Area (km^2)	Exceeded Area (km^2)	Percentage Area Exceeded	Accumulated Exceedance (keq/year)
Acid grassland	3143	2848	90.6	168418
Calcareous grassland	45	0	0.0	0
Dwarf shrub heath	1078	668	61.9	22545
Bog	56	52	92.6	3043
Montane	18	18	100.0	1632
Coniferous woodland (managed)	1048	717	68.5	45857
Broadleaved woodland (managed)	790	483	61.1	30308
Unmanaged woods	395	235	59.5	14012
Freshwaters	1225	198	16.2	5316
All habitats	7798	5219	66.9	291131

Acidity exceedances for Scotland

Broad Habitat	Habitat Area (km^2)	Exceeded Area (km^2)	Percentage Area Exceeded	Accumulated Exceedance (keq/year)
Acid grassland	8336	3968	47.6	127643
Calcareous grassland	7	0	0.0	0
Dwarf shrub heath	20190	2060	10.2	36475
Bog	3959	969	24.5	23281
Montane	3034	1678	55.3	69628
Coniferous woodland (managed)	5111	1773	34.7	67659
Broadleaved woodland (managed)	1096	376	34.3	15964
Unmanaged woods	1016	221	21.7	8207
Freshwaters	5338	261	4.9	5513
All habitats	48086	11307	23.5	354370

Scenario A (Euro low): acidity exceedances (continued)

Acidity exceedances for Northern Ireland

Broad Habitat	Habitat Area (km^2)	Exceeded Area (km^2)	Percentage Area Exceeded	Accumulated Exceedance (keq/year)
Acid grassland	1187	832	70.1	43151
Calcareous grassland	42	0	0.0	0
Dwarf shrub heath	973	511	52.5	18876
Bog	442	362	82.1	17460
Montane	0	0	0.0	0
Coniferous woodland (managed)	503	267	53.2	21977
Broadleaved woodland (managed)	0	0	0.0	0
Unmanaged woods	208	96	46.2	11056
Freshwaters	186	29	15.6	2370
All ecosystems	3539	2097	59.3	114890

Acidity exceedances for the United Kingdom

Broad Habitat	Habitat Area (km^2)	Exceeded Area (km^2)	Percentage Area Exceeded	Accumulated Exceedance (keq/year)
Acid grassland	15334	10124	66.0	546109
Calcareous grassland	1808	0	0.0	0
Dwarf shrub heath	24703	5204	21.1	185357
Bog	5463	2374	43.5	130254
Montane	3054	1698	55.6	71446
Coniferous woodland (managed)	8377	4038	48.2	278056
Broadleaved woodland (managed)	7452	4174	56.0	404233
Unmanaged woods	4011	1673	41.7	133236
Freshwaters	7790	919	11.8	48827
All habitats	77991	30204	38.7	1797517

Scenario A (Euro low): nutrient nitrogen exceedances

Nutrient nitrogen exceedances for England

Broad Habitat	Habitat Area (km^2)	Exceeded Area (km^2)	Percentage Area Exceeded	Accumulated Exceedance (keq/year)
Acid grassland	2620	2313	88.3	94302
Calcareous grassland	3312	1664	50.2	50993
Dwarf shrub heath	2466	2083	84.5	85758
Bog	1007	1006	99.9	72889
Montane	2	2	100.0	179
Coniferous woodland (managed)	1719	1718	100.0	228620
Broadleaved woodland (managed)	5588	5586	100.0	915784
Unmanaged woods (ground flora)	2252	2252	100.0	351564
Atlantic oak (epiphytic lichens)	150	150	100.0	20522
Supralittoral sediment	1183	291	24.6	5108
All habitats	20299	17065	84.1	1825719

Nutrient nitrogen exceedances for Wales

Broad Habitat	Habitat Area (km^2)	Exceeded Area (km^2)	Percentage Area Exceeded	Accumulated Exceedance (keq/year)
Acid grassland	3146	1976	62.8	50792
Calcareous grassland	171	29	17.2	427
Dwarf shrub heath	1094	847	77.5	25076
Bog	56	53	94.3	2216
Montane	18	18	100.0	1501
Coniferous woodland (managed)	1052	1051	99.9	110198
Broadleaved woodland (managed)	798	789	98.8	79883
Unmanaged woods (ground flora)	226	226	99.8	26460
Atlantic oak (epiphytic lichens)	171	169	98.9	18983
Supralittoral sediment	369	47	12.8	926
All habitats	7102	5206	73.3	316461

Nutrient nitrogen exceedances for Scotland

Broad Habitat	Habitat Area (km^2)	Exceeded Area (km^2)	Percentage Area Exceeded	Accumulated Exceedance (keq/year)
Acid grassland	8283	702	8.5	6182
Calcareous grassland	24	1	5.2	2
Dwarf shrub heath	20284	1378	6.8	18997
Bog	4005	715	17.9	16510
Montane	3109	2161	69.5	64892
Coniferous woodland (managed)	5111	3767	73.7	196594
Broadleaved woodland (managed)	1096	815	74.3	51254
Unmanaged woods (ground flora)	570	377	66.1	20873
Atlantic oak (epiphytic lichens)	501	239	47.6	7315
Supralittoral sediment	547	11	2.0	138
All habitats	43530	10165	23.4	382757

Scenario A (Euro low): nutrient nitrogen exceedances (continued)

Nutrient nitrogen exceedances for Northern Ireland

Broad Habitat	Habitat Area (km^2)	Exceeded Area (km^2)	Percentage Area Exceeded	Accumulated Exceedance (keq/year)
Acid grassland	1192	616	51.7	18953
Calcareous grassland	69	12	17.6	566
Dwarf shrub heath	976	673	69.0	26054
Bog	473	393	83.1	17900
Montane	0	0	0.0	0
Coniferous woodland (managed)	504	441	87.4	46666
Broadleaved woodland (managed)	0	0	0.0	0
Unmanaged woods (ground flora)	247	233	94.2	29940
Atlantic oak (epiphytic lichens)	0	0	0.0	0
Supralittoral sediment	29	15	52.2	545
All ecosystems	3491	2383	68.3	140624

Nutrient nitrogen exceedances for the United Kingdom

Broad Habitat	Habitat Area (km^2)	Exceeded Area (km^2)	Percentage Area Exceeded	Accumulated Exceedance (keq/year)
Acid grassland	15241	5607	36.8	170229
Calcareous grassland	3577	1707	47.7	51988
Dwarf shrub heath	24820	4981	20.1	155885
Bog	5541	2167	39.1	109515
Montane	3129	2181	69.7	66572
Coniferous woodland (managed)	8385	6977	83.2	582077
Broadleaved woodland (managed)	7482	7190	96.1	1046921
Unmanaged woods (ground flora)	3296	3088	93.7	428838
Atlantic oak (epiphytic lichens)	822	558	67.9	46820
Supralittoral sediment	2128	364	17.1	6717
All habitats	74422	34819	46.8	2665562

Scenario B (Euro high): acidity exceedances

Acidity exceedances for England

Broad Habitat	Habitat Area (km^2)	Exceeded Area (km^2)	Percentage Area Exceeded	Accumulated Exceedance (keq/year)
Acid grassland	2669	2470	92.5	200644
Calcareous grassland	1714	0	0.0	0
Dwarf shrub heath	2462	1931	78.4	102370
Bog	1006	989	98.3	83520
Montane	2	2	99.8	180
Coniferous woodland (managed)	1716	1233	71.8	136055
Broadleaved woodland (managed)	5565	3243	58.3	339014
Unmanaged woods	2392	1080	45.2	93439
Freshwaters	1042	426	40.9	33984
All habitats	18568	11373	61.3	989206

Acidity exceedances for Wales

Broad Habitat	Habitat Area (km^2)	Exceeded Area (km^2)	Percentage Area Exceeded	Accumulated Exceedance (keq/year)
Acid grassland	3143	2827	90.0	162135
Calcareous grassland	45	0	0.0	0
Dwarf shrub heath	1078	651	60.4	21012
Bog	56	52	91.9	2926
Montane	18	18	100.0	1587
Coniferous woodland (managed)	1048	697	66.5	42303
Broadleaved woodland (managed)	790	466	59.0	28233
Unmanaged woods	395	228	57.6	12959
Freshwaters	1225	188	15.3	4851
All habitats	7798	5125	65.7	276006

Acidity exceedances for Scotland

Broad Habitat	Habitat Area (km^2)	Exceeded Area (km^2)	Percentage Area Exceeded	Accumulated Exceedance (keq/year)
Acid grassland	8336	3912	46.9	120692
Calcareous grassland	7	0	0.0	0
Dwarf shrub heath	20190	1926	9.5	32607
Bog	3959	951	24.0	21995
Montane	3034	1665	54.9	66042
Coniferous woodland (managed)	5111	1714	33.5	62347
Broadleaved woodland (managed)	1096	362	33.0	14892
Unmanaged woods	1016	211	20.7	7528
Freshwaters	5338	257	4.8	5049
All habitats	48086	10998	22.9	331152

Scenario B (Euro high): acidity exceedances (continued)

Acidity exceedances for Northern Ireland

Broad Habitat	Habitat Area (km^2)	Exceeded Area (km^2)	Percentage Area Exceeded	Accumulated Exceedance (keq/year)
Acid grassland	1187	830	69.9	42385
Calcareous grassland	42	0	0.0	0
Dwarf shrub heath	973	504	51.9	18351
Bog	442	361	81.8	17110
Montane	0	0	0.0	0
Coniferous woodland (managed)	503	266	52.8	21493
Broadleaved woodland (managed)	0	0	0.0	0
Unmanaged woods	208	96	46.0	10905
Freshwaters	186	29	15.6	2329
All ecosystems	3539	2086	58.9	112574

Acidity exceedances for the United Kingdom

Broad Habitat	Habitat Area (km^2)	Exceeded Area (km^2)	Percentage Area Exceeded	Accumulated Exceedance (keq/year)
Acid grassland	15334	10039	65.5	525856
Calcareous grassland	1808	0	0.0	0
Dwarf shrub heath	24703	5013	20.3	174340
Bog	5463	2353	43.1	125551
Montane	3054	1685	55.2	67809
Coniferous woodland (managed)	8377	3909	46.7	262197
Broadleaved woodland (managed)	7452	4071	54.6	382139
Unmanaged woods	4011	1614	40.2	124831
Freshwaters	7790	899	11.5	46213
All habitats	77991	29583	37.9	1708937

Scenario B (Euro high): nutrient nitrogen exceedances

Nutrient nitrogen exceedances for England

Broad Habitat	Habitat Area (km^2)	Exceeded Area (km^2)	Percentage Area Exceeded	Accumulated Exceedance (keq/year)
Acid grassland	2620	2273	86.8	88179
Calcareous grassland	3312	1523	46.0	46576
Dwarf shrub heath	2466	2024	82.1	80047
Bog	1007	1006	99.9	69841
Montane	2	2	100.0	173
Coniferous woodland (managed)	1719	1718	100.0	219806
Broadleaved woodland (managed)	5588	5585	100.0	882806
Unmanaged woods (ground flora)	2252	2252	100.0	337805
Atlantic oak (epiphytic lichens)	150	150	100.0	19811
Supralittoral sediment	1183	276	23.3	4618
All habitats	20299	16810	82.8	1749661

Nutrient nitrogen exceedances for Wales

Broad Habitat	Habitat Area (km^2)	Exceeded Area (km^2)	Percentage Area Exceeded	Accumulated Exceedance (keq/year)
Acid grassland	3146	1902	60.5	45853
Calcareous grassland	171	27	15.5	358
Dwarf shrub heath	1094	819	74.9	22803
Bog	56	53	94.3	2093
Montane	18	18	100.0	1455
Coniferous woodland (managed)	1052	1051	99.9	104959
Broadleaved woodland (managed)	798	787	98.6	76515
Unmanaged woods (ground flora)	226	226	99.7	25375
Atlantic oak (epiphytic lichens)	171	169	98.9	18291
Supralittoral sediment	369	47	12.6	844
All habitats	7102	5097	71.8	298545

Nutrient nitrogen exceedances for Scotland

Broad Habitat	Habitat Area (km^2)	Exceeded Area (km^2)	Percentage Area Exceeded	Accumulated Exceedance (keq/year)
Acid grassland	8283	588	7.1	4816
Calcareous grassland	24	0	0.0	0
Dwarf shrub heath	20284	1230	6.1	16096
Bog	4005	697	17.4	15335
Montane	3109	2057	66.2	60585
Coniferous woodland (managed)	5111	3701	72.4	185234
Broadleaved woodland (managed)	1096	802	73.2	48899
Unmanaged woods (ground flora)	570	374	65.6	19730
Atlantic oak (epiphytic lichens)	501	216	43.1	6706
Supralittoral sediment	547	11	2.0	126
All habitats	43530	9676	22.2	357527

Scenario B (Euro high): nutrient nitrogen exceedances (continued)

Nutrient nitrogen exceedances for Northern Ireland

Broad Habitat	Habitat Area (km^2)	Exceeded Area (km^2)	Percentage Area Exceeded	Accumulated Exceedance (keq/year)
Acid grassland	1192	583	48.9	18366
Calcareous grassland	69	12	17.6	552
Dwarf shrub heath	976	658	67.4	25370
Bog	473	393	83.1	17512
Montane	0	0	0.0	0
Coniferous woodland (managed)	504	429	85.1	45926
Broadleaved woodland (managed)	0	0	0.0	0
Unmanaged woods (ground flora)	247	233	94.1	29599
Atlantic oak (epiphytic lichens)	0	0	0.0	0
Supralittoral sediment	29	15	52.2	528
All ecosystems	3491	2323	66.5	137853

Nutrient nitrogen exceedances for the United Kingdom

Broad Habitat	Habitat Area (km^2)	Exceeded Area (km^2)	Percentage Area Exceeded	Accumulated Exceedance (keq/year)
Acid grassland	15241	5346	35.1	157213
Calcareous grassland	3577	1562	43.7	47486
Dwarf shrub heath	24820	4731	19.1	144316
Bog	5541	2149	38.8	104781
Montane	3129	2077	66.4	62214
Coniferous woodland (managed)	8385	6899	82.3	555925
Broadleaved woodland (managed)	7482	7174	95.9	1008221
Unmanaged woods (ground flora)	3296	3085	93.6	412508
Atlantic oak (epiphytic lichens)	822	535	65.1	44808
Supralittoral sediment	2128	348	16.4	6116
All habitats	74422	33906	45.6	2543587

Scenario C (Early Euro low): acidity exceedances

Acidity exceedances for England

Broad Habitat	Habitat Area (km^2)	Exceeded Area (km^2)	Percentage Area Exceeded	Accumulated Exceedance (keq/year)
Acid grassland	2669	2476	92.8	206644
Calcareous grassland	1714	0	0.0	0
Dwarf shrub heath	2462	1965	79.8	107257
Bog	1006	990	98.4	86351
Montane	2	2	99.8	186
Coniferous woodland (managed)	1716	1278	74.5	142285
Broadleaved woodland (managed)	5565	3312	59.5	357153
Unmanaged woods	2392	1119	46.8	99683
Freshwaters	1042	431	41.4	35568
All habitats	18568	11573	62.3	1035127

Acidity exceedances for Wales

Broad Habitat	Habitat Area (km^2)	Exceeded Area (km^2)	Percentage Area Exceeded	Accumulated Exceedance (keq/year)
Acid grassland	3143	2848	90.6	168137
Calcareous grassland	45	0	0.0	0
Dwarf shrub heath	1078	668	61.9	22475
Bog	56	52	92.6	3038
Montane	18	18	100.0	1631
Coniferous woodland (managed)	1048	715	68.3	45707
Broadleaved woodland (managed)	790	482	60.9	30220
Unmanaged woods	395	235	59.5	13968
Freshwaters	1225	198	16.2	5295
All habitats	7798	5215	66.9	290470

Acidity exceedances for Scotland

Broad Habitat	Habitat Area (km^2)	Exceeded Area (km^2)	Percentage Area Exceeded	Accumulated Exceedance (keq/year)
Acid grassland	8336	3964	47.6	127356
Calcareous grassland	7	0	0.0	0
Dwarf shrub heath	20190	2059	10.2	36307
Bog	3959	969	24.5	23232
Montane	3034	1678	55.3	69455
Coniferous woodland (managed)	5111	1770	34.6	67416
Broadleaved woodland (managed)	1096	376	34.3	15916
Unmanaged woods	1016	220	21.7	8177
Freshwaters	5338	261	4.9	5497
All habitats	48086	11298	23.5	353357

Scenario C (Early Euro low): acidity exceedances (continued)

Acidity exceedances for Northern Ireland

Broad Habitat	Habitat Area (km^2)	Exceeded Area (km^2)	Percentage Area Exceeded	Accumulated Exceedance (keq/year)
Acid grassland	1187	832	70.1	43109
Calcareous grassland	42	0	0.0	0
Dwarf shrub heath	973	510	52.5	18845
Bog	442	362	82.1	17442
Montane	0	0	0.0	0
Coniferous woodland (managed)	503	267	53.2	21955
Broadleaved woodland (managed)	0	0	0.0	0
Unmanaged woods	208	96	46.2	11050
Freshwaters	186	29	15.6	2368
All ecosystems	3539	2097	59.3	114769

Acidity exceedances for the United Kingdom

Broad Habitat	Habitat Area (km^2)	Exceeded Area (km^2)	Percentage Area Exceeded	Accumulated Exceedance (keq/year)
Acid grassland	15334	10119	66.0	545247
Calcareous grassland	1808	0	0.0	0
Dwarf shrub heath	24703	5202	21.1	184885
Bog	5463	2374	43.5	130062
Montane	3054	1698	55.6	71272
Coniferous woodland (managed)	8377	4031	48.1	277363
Broadleaved woodland (managed)	7452	4170	56.0	403290
Unmanaged woods	4011	1670	41.7	132878
Freshwaters	7790	919	11.8	48727
All habitats	77991	30183	38.7	1793724

Scenario C (Early Euro low): nutrient nitrogen exceedances

Nutrient nitrogen exceedances for England

Broad Habitat	Habitat Area (km^2)	Exceeded Area (km^2)	Percentage Area Exceeded	Accumulated Exceedance (keq/year)
Acid grassland	2620.48	2311.03	88.19	94053.9
Calcareous grassland	3312.12	1660.69	50.14	50791.85
Dwarf shrub heath	2466.29	2080.04	84.34	85526.22
Bog	1006.82	1005.9	99.91	72762.98
Montane	1.91	1.91	100	179.02
Coniferous woodland (managed)	1718.51	1718.48	100	228244.41
Broadleaved woodland (managed)	5587.59	5585.85	99.97	914392.75
Unmanaged woods (ground flora)	2252.49	2252.38	100	350985.71
Atlantic oak (epiphytic lichens)	149.91	149.91	100	20492.67
Supralittoral sediment	1182.64	290.75	24.58	5081.51
All habitats	20298.8	17056.92	84.03	1822511.01

Nutrient nitrogen exceedances for Wales

Broad Habitat	Habitat Area (km^2)	Exceeded Area (km^2)	Percentage Area Exceeded	Accumulated Exceedance (keq/year)
Acid grassland	3146	1976	62.8	50576
Calcareous grassland	171	29	17.2	423
Dwarf shrub heath	1094	847	77.5	24979
Bog	56	53	94.3	2210
Montane	18	18	100.0	1500
Coniferous woodland (managed)	1052	1051	99.9	109979
Broadleaved woodland (managed)	798	789	98.8	79743
Unmanaged woods (ground flora)	226	226	99.7	26415
Atlantic oak (epiphytic lichens)	171	169	98.9	18956
Supralittoral sediment	369	47	12.8	925
All habitats	7102	5206	73.3	315706

Nutrient nitrogen exceedances for Scotland

Broad Habitat	Habitat Area (km^2)	Exceeded Area (km^2)	Percentage Area Exceeded	Accumulated Exceedance (keq/year)
Acid grassland	8283	700	8.5	6119
Calcareous grassland	24	1	5.2	2
Dwarf shrub heath	20284	1372	6.8	18873
Bog	4005	715	17.9	16461
Montane	3109	2115	68.0	64681
Coniferous woodland (managed)	5111	3767	73.7	196096
Broadleaved woodland (managed)	1096	815	74.3	51150
Unmanaged woods (ground flora)	570	376	66.1	20823
Atlantic oak (epiphytic lichens)	501	237	47.3	7286
Supralittoral sediment	547	11	2.0	137
All habitats	43530	10109	23.2	381628

Scenario C (Early Euro low): nutrient nitrogen exceedances (continued)

Nutrient nitrogen exceedances for Northern Ireland

Broad Habitat	Habitat Area (km^2)	Exceeded Area (km^2)	Percentage Area Exceeded	Accumulated Exceedance (keq/year)
Acid grassland	1192	616	51.7	18920
Calcareous grassland	69	12	17.6	565
Dwarf shrub heath	976	673	69.0	26014
Bog	473	393	83.1	17881
Montane	0	0	0.0	0
Coniferous woodland (managed)	504	441	87.4	46630
Broadleaved woodland (managed)	0	0	0.0	0
Unmanaged woods (ground flora)	247	233	94.2	29927
Atlantic oak (epiphytic lichens)	0	0	0.0	0
Supralittoral sediment	29	15	52.2	544
All ecosystems	3491	2383	68.3	140483

Nutrient nitrogen exceedances for the United Kingdom

Broad Habitat	Habitat Area (km^2)	Exceeded Area (km^2)	Percentage Area Exceeded	Accumulated Exceedance (keq/year)
Acid grassland	15241	5604	36.8	169668
Calcareous grassland	3577	1704	47.6	51782
Dwarf shrub heath	24820	4972	20.0	155393
Bog	5541	2167	39.1	109315
Montane	3129	2135	68.2	66359
Coniferous woodland (managed)	8385	6977	83.2	580950
Broadleaved woodland (managed)	7482	7189	96.1	1045286
Unmanaged woods (ground flora)	3296	3088	93.7	428151
Atlantic oak (epiphytic lichens)	822	556	67.6	46734
Supralittoral sediment	2128	364	17.1	6688
All habitats	74422	34755	46.7	2660327

Scenario K (Large Combustion Plant): acidity exceedances

Acidity exceedances for England

Broad Habitat	Habitat Area (km^2)	Exceeded Area (km^2)	Percentage Area Exceeded	Accumulated Exceedance (keq/year)
Acid grassland	2669	2469	92.5	202239
Calcareous grassland	1714	0	0.0	0
Dwarf shrub heath	2462	1933	78.5	102630
Bog	1006	989	98.3	83709
Montane	2	2	99.8	181
Coniferous woodland (managed)	1716	1238	72.1	139841
Broadleaved woodland (managed)	5565	3328	59.8	358754
Unmanaged woods	2392	1123	47.0	100443
Freshwaters	1042	427	41.0	34567
All habitats	18568	11509	62.0	1022364

Acidity exceedances for Wales

Broad Habitat	Habitat Area (km^2)	Exceeded Area (km^2)	Percentage Area Exceeded	Accumulated Exceedance (keq/year)
Acid grassland	3143	2839	90.3	164307
Calcareous grassland	45	0	0.0	0
Dwarf shrub heath	1078	656	60.8	21615
Bog	56	52	91.9	2969
Montane	18	18	100.0	1601
Coniferous woodland (managed)	1048	707	67.5	44492
Broadleaved woodland (managed)	790	478	60.4	29898
Unmanaged woods	395	233	58.9	13764
Freshwaters	1225	188	15.3	4985
All habitats	7798	5169	66.3	283632

Acidity exceedances for Scotland

Broad Habitat	Habitat Area (km^2)	Exceeded Area (km^2)	Percentage Area Exceeded	Accumulated Exceedance (keq/year)
Acid grassland	8336	3905	46.9	120369
Calcareous grassland	7	0	0.0	0
Dwarf shrub heath	20190	1916	9.5	32069
Bog	3959	947	23.9	21979
Montane	3034	1662	54.8	65110
Coniferous woodland (managed)	5111	1730	33.8	63906
Broadleaved woodland (managed)	1096	368	33.5	15352
Unmanaged woods	1016	214	21.0	7748
Freshwaters	5338	257	4.8	5071
All habitats	48086	10998	22.9	331605

Scenario K (Large Combustion Plant): acidity exceedances (continued)

Acidity exceedances for Northern Ireland

Broad Habitat	Habitat Area (km^2)	Exceeded Area (km^2)	Percentage Area Exceeded	Accumulated Exceedance (keq/year)
Acid grassland	1187	830	69.9	42567
Calcareous grassland	42	0	0.0	0
Dwarf shrub heath	973	508	52.2	18477
Bog	442	362	81.9	17169
Montane	0	0	0.0	0
Coniferous woodland (managed)	503	266	53.0	21732
Broadleaved woodland (managed)	0	0	0.0	0
Unmanaged woods	208	96	46.2	11018
Freshwaters	186	29	15.6	2336
All ecosystems	3539	2091	59.1	113299

Acidity exceedances for the United Kingdom

Broad Habitat	Habitat Area (km^2)	Exceeded Area (km^2)	Percentage Area Exceeded	Accumulated Exceedance (keq/year)
Acid grassland	15334	10044	65.5	529482
Calcareous grassland	1808	0	0.0	0
Dwarf shrub heath	24703	5013	20.3	174791
Bog	5463	2349	43.0	125826
Montane	3054	1682	55.1	66893
Coniferous woodland (managed)	8377	3941	47.0	269972
Broadleaved woodland (managed)	7452	4173	56.0	404003
Unmanaged woods	4011	1665	41.5	132973
Freshwaters	7790	900	11.6	46960
All habitats	77991	29767	38.2	1750900

Scenario K (Large Combustion Plant): nutrient nitrogen exceedances

Nutrient nitrogen exceedances for England

Broad Habitat	Habitat Area (km^2)	Exceeded Area (km^2)	Percentage Area Exceeded	Accumulated Exceedance (keq/year)
Acid grassland	2620	2281	87.1	89697
Calcareous grassland	3312	1638	49.4	49332
Dwarf shrub heath	2466	2028	82.3	80382
Bog	1007	1006	99.9	69956
Montane	2	2	100.0	174
Coniferous woodland (managed)	1719	1718	100.0	224669
Broadleaved woodland (managed)	5588	5586	100.0	916969
Unmanaged woods (ground flora)	2252	2252	100.0	352977
Atlantic oak (epiphytic lichens)	150	150	100.0	20255
Supralittoral sediment	1183	281	23.8	4686
All habitats	20299	16943	83.5	1809095

Nutrient nitrogen exceedances for Wales

Broad Habitat	Habitat Area (km^2)	Exceeded Area (km^2)	Percentage Area Exceeded	Accumulated Exceedance (keq/year)
Acid grassland	3146	1941	61.7	47372
Calcareous grassland	171	29	17.2	404
Dwarf shrub heath	1094	840	76.8	23654
Bog	56	53	94.3	2134
Montane	18	18	100.0	1468
Coniferous woodland (managed)	1052	1051	99.9	107927
Broadleaved woodland (managed)	798	788	98.7	79194
Unmanaged woods (ground flora)	226	226	99.8	26303
Atlantic oak (epiphytic lichens)	171	169	98.9	18702
Supralittoral sediment	369	47	12.7	912
All habitats	7102	5162	72.7	308070

Nutrient nitrogen exceedances for Scotland

Broad Habitat	Habitat Area (km^2)	Exceeded Area (km^2)	Percentage Area Exceeded	Accumulated Exceedance (keq/year)
Acid grassland	8283	566	6.8	4732
Calcareous grassland	24	1	5.2	1
Dwarf shrub heath	20284	1175	5.8	15689
Bog	4005	693	17.3	15411
Montane	3109	2016	64.8	59312
Coniferous woodland (managed)	5111	3723	72.9	188339
Broadleaved woodland (managed)	1096	806	73.5	50074
Unmanaged woods (ground flora)	570	374	65.7	20098
Atlantic oak (epiphytic lichens)	501	223	44.4	6856
Supralittoral sediment	547	11	2.0	129
All habitats	43530	9589	22.0	360641

Scenario K (Large Combustion Plant): nutrient nitrogen exceedances (continued)

Nutrient nitrogen exceedances for Northern Ireland

Broad Habitat	Habitat Area (km^2)	Exceeded Area (km^2)	Percentage Area Exceeded	Accumulated Exceedance (keq/year)
Acid grassland	1192	587	49.3	18489
Calcareous grassland	69	12	17.6	557
Dwarf shrub heath	976	659	67.5	25514
Bog	473	393	83.1	17564
Montane	0	0	0.0	0
Coniferous woodland (managed)	504	435	86.4	46284
Broadleaved woodland (managed)	0	0	0.0	0
Unmanaged woods (ground flora)	247	233	94.2	29839
Atlantic oak (epiphytic lichens)	0	0	0.0	0
Supralittoral sediment	29	15	51.9	529
All ecosystems	3491	2334	66.9	138777

Nutrient nitrogen exceedances for the United Kingdom

Broad Habitat	Habitat Area (km^2)	Exceeded Area (km^2)	Percentage Area Exceeded	Accumulated Exceedance (keq/year)
Acid grassland	15241	5377	35.3	160290
Calcareous grassland	3577	1680	47.0	50294
Dwarf shrub heath	24820	4703	19.0	145239
Bog	5541	2144	38.7	105065
Montane	3129	2036	65.1	60954
Coniferous woodland (managed)	8385	6928	82.6	567220
Broadleaved woodland (managed)	7482	7180	96.0	1046237
Unmanaged woods (ground flora)	3296	3086	93.6	429217
Atlantic oak (epiphytic lichens)	822	542	65.9	45812
Supralittoral sediment	2128	354	16.6	6255
All habitats	74422	34029	45.7	2616583

Scenario N (Shipping): acidity exceedances

Acidity exceedances for England

Broad Habitat	Habitat Area (km^2)	Exceeded Area (km^2)	Percentage Area Exceeded	Accumulated Exceedance (keq/year)
Acid grassland	2669	2475	92.7	207024
Calcareous grassland	1714	0	0.0	0
Dwarf shrub heath	2462	1950	79.2	107669
Bog	1006	990	98.4	87119
Montane	2	2	99.8	187
Coniferous woodland (managed)	1716	1291	75.2	145070
Broadleaved woodland (managed)	5565	3354	60.3	365834
Unmanaged woods	2392	1133	47.4	102376
Freshwaters	1042	432	41.5	36406
All habitats	18568	11627	62.6	1051684

Acidity exceedances for Wales

Broad Habitat	Habitat Area (km^2)	Exceeded Area (km^2)	Percentage Area Exceeded	Accumulated Exceedance (keq/year)
Acid grassland	3143	2849	90.7	169367
Calcareous grassland	45	0	0.0	0
Dwarf shrub heath	1078	668	62.0	22633
Bog	56	52	92.6	3057
Montane	18	18	100.0	1643
Coniferous woodland (managed)	1048	724	69.1	47226
Broadleaved woodland (managed)	790	490	62.0	31173
Unmanaged woods	395	239	60.4	14463
Freshwaters	1225	166	13.5	4721
All habitats	7798	5205	66.8	294284

Acidity exceedances for Scotland

Broad Habitat	Habitat Area (km^2)	Exceeded Area (km^2)	Percentage Area Exceeded	Accumulated Exceedance (keq/year)
Acid grassland	8336	3952	47.4	128472
Calcareous grassland	7	0	0.0	0
Dwarf shrub heath	20190	2010	10.0	35888
Bog	3959	927	23.4	22494
Montane	3034	1678	55.3	69380
Coniferous woodland (managed)	5111	1785	34.9	69040
Broadleaved woodland (managed)	1096	381	34.8	16307
Unmanaged woods	1016	224	22.1	8317
Freshwaters	5338	146	2.7	4288
All habitats	48086	11103	23.1	354187

Scenario N (Shipping): acidity exceedances (continued)

Acidity exceedances for Northern Ireland

Broad Habitat	Habitat Area (km^2)	Exceeded Area (km^2)	Percentage Area Exceeded	Accumulated Exceedance (keq/year)
Acid grassland	1187	834	70.3	43350
Calcareous grassland	42	0	0.0	0
Dwarf shrub heath	973	513	52.7	18998
Bog	442	363	82.2	17547
Montane	0	0	0.0	0
Coniferous woodland (managed)	503	270	53.7	22165
Broadleaved woodland (managed)	0	0	0.0	0
Unmanaged woods	208	96	46.3	11125
Freshwaters	186	29	15.9	2562
All ecosystems	3539	2105	59.5	115747

Acidity exceedances for the United Kingdom

Broad Habitat	Habitat Area (km^2)	Exceeded Area (km^2)	Percentage Area Exceeded	Accumulated Exceedance (keq/year)
Acid grassland	15334	10109	65.9	548213
Calcareous grassland	1808	0	0.0	0
Dwarf shrub heath	24703	5140	20.8	185189
Bog	5463	2333	42.7	130217
Montane	3054	1698	55.6	71211
Coniferous woodland (managed)	8377	4070	48.6	283501
Broadleaved woodland (managed)	7452	4225	56.7	413314
Unmanaged woods	4011	1692	42.2	136281
Freshwaters	7790	773	9.9	47977
All habitats	77991	30040	38.5	1815902

Scenario N (Shipping): nutrient nitrogen exceedances

Nutrient nitrogen exceedances for England

Broad Habitat	Habitat Area (km^2)	Exceeded Area (km^2)	Percentage Area Exceeded	Accumulated Exceedance (keq/year)
Acid grassland	2620	2349	89.7	98212
Calcareous grassland	3312	1825	55.1	54945
Dwarf shrub heath	2466	2114	85.7	89516
Bog	1007	1006	99.9	74849
Montane	2	2	100.0	183
Coniferous woodland (managed)	1719	1719	100.0	235151
Broadleaved woodland (managed)	5588	5586	100.0	942556
Unmanaged woods (ground flora)	2252	2252	100.0	362916
Atlantic oak (epiphytic lichens)	150	150	100.0	20970
Supralittoral sediment	1183	293	24.8	5560
All habitats	20299	17297	85.2	1884856

Nutrient nitrogen exceedances for Wales

Broad Habitat	Habitat Area (km^2)	Exceeded Area (km^2)	Percentage Area Exceeded	Accumulated Exceedance (keq/year)
Acid grassland	3146	2061	65.5	53923
Calcareous grassland	171	33	19.0	486
Dwarf shrub heath	1094	871	79.6	26499
Bog	56	53	94.3	2288
Montane	18	18	100.0	1527
Coniferous woodland (managed)	1052	1051	99.9	113507
Broadleaved woodland (managed)	798	789	98.9	82142
Unmanaged woods (ground flora)	226	226	99.9	27234
Atlantic oak (epiphytic lichens)	171	171	99.9	19422
Supralittoral sediment	369	52	14.1	996
All habitats	7102	5324	75.0	328025

Nutrient nitrogen exceedances for Scotland

Broad Habitat	Habitat Area (km^2)	Exceeded Area (km^2)	Percentage Area Exceeded	Accumulated Exceedance (keq/year)
Acid grassland	8283	799	9.7	7089
Calcareous grassland	24	1	5.2	4
Dwarf shrub heath	20284	1506	7.4	20659
Bog	4005	724	18.1	17171
Montane	3109	2191	70.5	67073
Coniferous woodland (managed)	5111	3806	74.5	203378
Broadleaved woodland (managed)	1096	820	74.8	52856
Unmanaged woods (ground flora)	570	377	66.1	21591
Atlantic oak (epiphytic lichens)	501	255	50.9	7668
Supralittoral sediment	547	13	2.4	146
All habitats	43530	10493	24.1	397636

Scenario N (Shipping): nutrient nitrogen exceedances (continued)

Nutrient nitrogen exceedances for Northern Ireland

Broad Habitat	Habitat Area (km^2)	Exceeded Area (km^2)	Percentage Area Exceeded	Accumulated Exceedance (keq/year)
Acid grassland	1192	658	55.2	19294
Calcareous grassland	69	12	17.6	572
Dwarf shrub heath	976	689	70.6	26433
Bog	473	393	83.1	18103
Montane	0	0	0.0	0
Coniferous woodland (managed)	504	441	87.4	47094
Broadleaved woodland (managed)	0	0	0.0	0
Unmanaged woods (ground flora)	247	233	94.2	30158
Atlantic oak (epiphytic lichens)	0	0	0.0	0
Supralittoral sediment	29	15	52.2	554
All ecosystems	3491	2442	70.0	142207

Nutrient nitrogen exceedances for the United Kingdom

Broad Habitat	Habitat Area (km^2)	Exceeded Area (km^2)	Percentage Area Exceeded	Accumulated Exceedance (keq/year)
Acid grassland	15241	5868	38.5	178519
Calcareous grassland	3577	1872	52.3	56007
Dwarf shrub heath	24820	5181	20.9	163107
Bog	5541	2176	39.3	112411
Montane	3129	2211	70.6	68783
Coniferous woodland (managed)	8385	7016	83.7	599130
Broadleaved woodland (managed)	7482	7196	96.2	1077553
Unmanaged woods (ground flora)	3296	3088	93.7	441899
Atlantic oak (epiphytic lichens)	822	576	70.1	48060
Supralittoral sediment	2128	374	17.6	7255
All habitats	74422	35556	47.8	2752724

Scenario O (Early Euro low & Low Emission Vehicles): acidity exceedances

Acidity exceedances for England

Broad Habitat	Habitat Area (km^2)	Exceeded Area (km^2)	Percentage Area Exceeded	Accumulated Exceedance (keq/year)
Acid grassland	2669	2474	92.7	205639
Calcareous grassland	1714	0	0.0	0
Dwarf shrub heath	2462	1960	79.6	106427
Bog	1006	990	98.4	85873
Montane	2	2	99.8	185
Coniferous woodland (managed)	1716	1270	74.0	141210
Broadleaved woodland (managed)	5565	3297	59.2	354052
Unmanaged woods	2392	1114	46.6	98609
Freshwaters	1042	431	41.4	35290
All habitats	18568	11539	62.1	1027283

Acidity exceedances for Wales

Broad Habitat	Habitat Area (km^2)	Exceeded Area (km^2)	Percentage Area Exceeded	Accumulated Exceedance (keq/year)
Acid grassland	3143	2847	90.6	167129
Calcareous grassland	45	0	0.0	0
Dwarf shrub heath	1078	664	61.6	22224
Bog	56	52	92.6	3019
Montane	18	18	100.0	1623
Coniferous woodland (managed)	1048	713	68.1	45124
Broadleaved woodland (managed)	790	480	60.7	29880
Unmanaged woods	395	234	59.2	13795
Freshwaters	1225	198	16.2	5217
All habitats	7798	5207	66.8	288011

Acidity exceedances for Scotland

Broad Habitat	Habitat Area (km^2)	Exceeded Area (km^2)	Percentage Area Exceeded	Accumulated Exceedance (keq/year)
Acid grassland	8336	3958	47.5	126221
Calcareous grassland	7	0	0.0	0
Dwarf shrub heath	20190	2033	10.1	35674
Bog	3959	965	24.4	23022
Montane	3034	1677	55.3	68876
Coniferous woodland (managed)	5111	1765	34.5	66559
Broadleaved woodland (managed)	1096	375	34.2	15741
Unmanaged woods	1016	219	21.6	8067
Freshwaters	5338	259	4.9	5425
All habitats	48086	11252	23.4	349585

Scenario O (Early Euro low & Low Emission Vehicles): acidity exceedances (continued)

Acidity exceedances for Northern Ireland

Broad Habitat	Habitat Area (km^2)	Exceeded Area (km^2)	Percentage Area Exceeded	Accumulated Exceedance (keq/year)
Acid grassland	1187	832	70.1	42986
Calcareous grassland	42	0	0.0	0
Dwarf shrub heath	973	510	52.5	18763
Bog	442	362	81.9	17387
Montane	0	0	0.0	0
Coniferous woodland (managed)	503	267	53.2	21879
Broadleaved woodland (managed)	0	0	0.0	0
Unmanaged woods	208	96	46.2	11025
Freshwaters	186	29	15.6	2360
All ecosystems	3539	2096	59.2	114401

Acidity exceedances for the United Kingdom

Broad Habitat	Habitat Area (km^2)	Exceeded Area (km^2)	Percentage Area Exceeded	Accumulated Exceedance (keq/year)
Acid grassland	15334	10111	65.9	541975
Calcareous grassland	1808	0	0.0	0
Dwarf shrub heath	24703	5168	20.9	183088
Bog	5463	2369	43.4	129301
Montane	3054	1697	55.6	70684
Coniferous woodland (managed)	8377	4016	47.9	274772
Broadleaved woodland (managed)	7452	4152	55.7	399673
Unmanaged woods	4011	1663	41.5	131496
Freshwaters	7790	917	11.8	48292
All habitats	77991	30093	38.6	1779281

Scenario O (Early Euro low & Low Emission Vehicles): nutrient nitrogen exceedances

Nutrient nitrogen exceedances for England

Broad Habitat	Habitat Area (km^2)	Exceeded Area (km^2)	Percentage Area Exceeded	Accumulated Exceedance (keq/year)
Acid grassland	2620	2309	88.1	93059
Calcareous grassland	3312	1644	49.6	50057
Dwarf shrub heath	2466	2077	84.2	84593
Bog	1007	1006	99.9	72271
Montane	2	2	100.0	178
Coniferous woodland (managed)	1719	1718	100.0	226809
Broadleaved woodland (managed)	5588	5586	100.0	909039
Unmanaged woods (ground flora)	2252	2252	100.0	348752
Atlantic oak (epiphytic lichens)	150	150	100.0	20378
Supralittoral sediment	1183	285	24.1	5004
All habitats	20299	17030	83.9	1810138

Nutrient nitrogen exceedances for Wales

Broad Habitat	Habitat Area (km^2)	Exceeded Area (km^2)	Percentage Area Exceeded	Accumulated Exceedance (keq/year)
Acid grassland	3146	1970	62.6	49779
Calcareous grassland	171	29	17.2	412
Dwarf shrub heath	1094	846	77.3	24609
Bog	56	53	94.3	2191
Montane	18	18	100.0	1492
Coniferous woodland (managed)	1052	1051	99.9	109129
Broadleaved woodland (managed)	798	788	98.7	79198
Unmanaged woods (ground flora)	226	226	99.7	26238
Atlantic oak (epiphytic lichens)	171	169	98.9	18843
Supralittoral sediment	369	47	12.8	912
All habitats	7102	5198	73.2	312804

Nutrient nitrogen exceedances for Scotland

Broad Habitat	Habitat Area (km^2)	Exceeded Area (km^2)	Percentage Area Exceeded	Accumulated Exceedance (keq/year)
Acid grassland	8283	671	8.1	5880
Calcareous grassland	24	1	5.2	2
Dwarf shrub heath	20284	1340	6.6	18391
Bog	4005	702	17.5	16269
Montane	3109	2082	67.0	63985
Coniferous woodland (managed)	5111	3762	73.6	194264
Broadleaved woodland (managed)	1096	812	74.1	50769
Unmanaged woods (ground flora)	570	376	65.9	20637
Atlantic oak (epiphytic lichens)	501	225	44.9	7184
Supralittoral sediment	547	11	2.0	135
All habitats	43530	9982	22.9	377515

Scenario O (Early Euro low & Low Emission Vehicles): nutrient nitrogen exceedances
(continued)

Nutrient nitrogen exceedances for Northern Ireland

Broad Habitat	Habitat Area (km^2)	Exceeded Area (km^2)	Percentage Area Exceeded	Accumulated Exceedance (keq/year)
Acid grassland	1192	607	50.9	18825
Calcareous grassland	69	12	17.6	563
Dwarf shrub heath	976	671	68.8	25908
Bog	473	393	83.1	17820
Montane	0	0	0.0	0
Coniferous woodland (managed)	504	440	87.3	46514
Broadleaved woodland (managed)	0	0	0.0	0
Unmanaged woods (ground flora)	247	233	94.2	29872
Atlantic oak (epiphytic lichens)	0	0	0.0	0
Supralittoral sediment	29	15	52.2	541
All ecosystems	3491	2371	67.9	140042

Nutrient nitrogen exceedances for the United Kingdom

Broad Habitat	Habitat Area (km^2)	Exceeded Area (km^2)	Percentage Area Exceeded	Accumulated Exceedance (keq/year)
Acid grassland	15241	5557	36.5	167542
Calcareous grassland	3577	1687	47.2	51033
Dwarf shrub heath	24820	4934	19.9	153502
Bog	5541	2153	38.9	108550
Montane	3129	2102	67.2	65655
Coniferous woodland (managed)	8385	6971	83.1	576717
Broadleaved woodland (managed)	7482	7186	96.1	1039006
Unmanaged woods (ground flora)	3296	3087	93.7	425499
Atlantic oak (epiphytic lichens)	822	544	66.2	46404
Supralittoral sediment	2128	358	16.8	6592
All habitats	74422	34580	46.5	2640500

Scenario P (Early Euro low & Small Combustion Plant): acidity exceedances

Acidity exceedances for England

Broad Habitat	Habitat Area (km^2)	Exceeded Area (km^2)	Percentage Area Exceeded	Accumulated Exceedance (keq/year)
Acid grassland	2669	2471	92.6	204662
Calcareous grassland	1714	0	0.0	0
Dwarf shrub heath	2462	1952	79.3	105532
Bog	1006	990	98.4	85370
Montane	2	2	99.8	184
Coniferous woodland (managed)	1716	1268	73.9	140838
Broadleaved woodland (managed)	5565	3292	59.2	352451
Unmanaged woods	2392	1109	46.4	98109
Freshwaters	1042	431	41.4	34869
All habitats	18568	11516	62.0	1022014

Acidity exceedances for Wales

Broad Habitat	Habitat Area (km^2)	Exceeded Area (km^2)	Percentage Area Exceeded	Accumulated Exceedance (keq/year)
Acid grassland	3143	2847	90.6	166340
Calcareous grassland	45	0	0.0	0
Dwarf shrub heath	1078	659	61.2	21965
Bog	56	52	91.9	3003
Montane	18	18	100.0	1618
Coniferous woodland (managed)	1048	712	68.0	44884
Broadleaved woodland (managed)	790	479	60.7	29747
Unmanaged woods	395	234	59.2	13727
Freshwaters	1225	191	15.6	5147
All habitats	7798	5194	66.6	286431

Acidity exceedances for Scotland

Broad Habitat	Habitat Area (km^2)	Exceeded Area (km^2)	Percentage Area Exceeded	Accumulated Exceedance (keq/year)
Acid grassland	8336	3940	47.3	125017
Calcareous grassland	7	0	0.0	0
Dwarf shrub heath	20190	2013	10.0	34870
Bog	3959	962	24.3	22756
Montane	3034	1676	55.2	68306
Coniferous woodland (managed)	5111	1757	34.4	65982
Broadleaved woodland (managed)	1096	371	33.9	15565
Unmanaged woods	1016	218	21.5	7971
Freshwaters	5338	261	4.9	5356
All habitats	48086	11199	23.3	345824

Scenario P (Early Euro low & Small Combustion Plant): acidity exceedances (continued)

Acidity exceedances for Northern Ireland

Broad Habitat	Habitat Area (km^2)	Exceeded Area (km^2)	Percentage Area Exceeded	Accumulated Exceedance (keq/year)
Acid grassland	1187	832	70.1	42875
Calcareous grassland	42	0	0.0	0
Dwarf shrub heath	973	509	52.3	18685
Bog	442	362	81.9	17333
Montane	0	0	0.0	0
Coniferous woodland (managed)	503	267	53.2	21839
Broadleaved woodland (managed)	0	0	0.0	0
Unmanaged woods	208	96	46.2	11011
Freshwaters	186	29	15.6	2353
All ecosystems	3539	2095	59.2	114096

Acidity exceedances for the United Kingdom

Broad Habitat	Habitat Area (km^2)	Exceeded Area (km^2)	Percentage Area Exceeded	Accumulated Exceedance (keq/year)
Acid grassland	15334	10091	65.8	538894
Calcareous grassland	1808	0	0.0	0
Dwarf shrub heath	24703	5133	20.8	181052
Bog	5463	2365	43.3	128461
Montane	3054	1696	55.5	70108
Coniferous woodland (managed)	8377	4004	47.8	273542
Broadleaved woodland (managed)	7452	4143	55.6	397764
Unmanaged woods	4011	1658	41.3	130818
Freshwaters	7790	912	11.7	47725
All habitats	77991	30003	38.5	1768364

Scenario P (Early Euro low & Small Combustion Plant): nutrient nitrogen exceedances

Nutrient nitrogen exceedances for England

Broad Habitat	Habitat Area (km^2)	Exceeded Area (km^2)	Percentage Area Exceeded	Accumulated Exceedance (keq/year)
Acid grassland	2620	2310	88.2	93200
Calcareous grassland	3312	1648	49.8	50315
Dwarf shrub heath	2466	2078	84.2	84702
Bog	1007	1006	99.9	72289
Montane	2	2	100.0	178
Coniferous woodland (managed)	1719	1718	100.0	227148
Broadleaved woodland (managed)	5588	5586	100.0	910617
Unmanaged woods (ground flora)	2252	2252	100.0	349431
Atlantic oak (epiphytic lichens)	150	150	100.0	20400
Supralittoral sediment	1183	289	24.4	5044
All habitats	20299	17039	83.9	1813324

Nutrient nitrogen exceedances for Wales

Broad Habitat	Habitat Area (km^2)	Exceeded Area (km^2)	Percentage Area Exceeded	Accumulated Exceedance (keq/year)
Acid grassland	3146	1970	62.6	49814
Calcareous grassland	171	29	17.2	416
Dwarf shrub heath	1094	846	77.3	24603
Bog	56	53	94.3	2190
Montane	18	18	100.0	1493
Coniferous woodland (managed)	1052	1051	99.9	109139
Broadleaved woodland (managed)	798	789	98.8	79252
Unmanaged woods (ground flora)	226	226	99.7	26251
Atlantic oak (epiphytic lichens)	171	169	98.9	18857
Supralittoral sediment	369	47	12.8	923
All habitats	7102	5197	73.2	312938

Nutrient nitrogen exceedances for Scotland

Broad Habitat	Habitat Area (km^2)	Exceeded Area (km^2)	Percentage Area Exceeded	Accumulated Exceedance (keq/year)
Acid grassland	8283	678	8.2	5871
Calcareous grassland	24	1	5.2	3
Dwarf shrub heath	20284	1343	6.6	18346
Bog	4005	702	17.5	16254
Montane	3109	2082	67.0	63967
Coniferous woodland (managed)	5111	3762	73.6	194290
Broadleaved woodland (managed)	1096	812	74.1	50789
Unmanaged woods (ground flora)	570	376	65.9	20647
Atlantic oak (epiphytic lichens)	501	225	44.9	7183
Supralittoral sediment	547	11	2.0	137
All habitats	43530	9992	23.0	377486

Scenario P (Early Euro low & Small Combustion Plant): nutrient nitrogen exceedances (continued)

Nutrient nitrogen exceedances for Northern Ireland

Broad Habitat	Habitat Area (km^2)	Exceeded Area (km^2)	Percentage Area Exceeded	Accumulated Exceedance (keq/year)
Acid grassland	1192	614	51.5	18847
Calcareous grassland	69	12	17.6	562
Dwarf shrub heath	976	672	68.9	25930
Bog	473	393	83.1	17820
Montane	0	0	0.0	0
Coniferous woodland (managed)	504	441	87.4	46537
Broadleaved woodland (managed)	0	0	0.0	0
Unmanaged woods (ground flora)	247	233	94.2	29887
Atlantic oak (epiphytic lichens)	0	0	0.0	0
Supralittoral sediment	29	15	52.2	541
All ecosystems	3491	2380	68.2	140124

Nutrient nitrogen exceedances for the United Kingdom

Broad Habitat	Habitat Area (km^2)	Exceeded Area (km^2)	Percentage Area Exceeded	Accumulated Exceedance (keq/year)
Acid grassland	15241	5572	36.6	167732
Calcareous grassland	3577	1691	47.3	51295
Dwarf shrub heath	24820	4939	19.9	153581
Bog	5541	2153	38.9	108553
Montane	3129	2102	67.2	65638
Coniferous woodland (managed)	8385	6971	83.1	577115
Broadleaved woodland (managed)	7482	7187	96.1	1040659
Unmanaged woods (ground flora)	3296	3087	93.7	426215
Atlantic oak (epiphytic lichens)	822	544	66.2	46440
Supralittoral sediment	2128	362	17.0	6645
All habitats	74422	34608	46.5	2643873

Scenario Q (Early Euro low & Low Emission Vehicles & Small Combustion Plant): acidity exceedances

Acidity exceedances for England

Broad Habitat	Habitat Area (km^2)	Exceeded Area (km^2)	Percentage Area Exceeded	Accumulated Exceedance (keq/year)
Acid grassland	2669	2471	92.6	203729
Calcareous grassland	1714	0	0.0	0
Dwarf shrub heath	2462	1951	79.2	104774
Bog	1006	990	98.4	84926
Montane	2	2	99.8	183
Coniferous woodland (managed)	1716	1256	73.2	139885
Broadleaved woodland (managed)	5565	3284	59.0	349667
Unmanaged woods	2392	1106	46.2	97149
Freshwaters	1042	429	41.2	34625
All habitats	18568	11490	61.9	1014938

Acidity exceedances for Wales

Broad Habitat	Habitat Area (km^2)	Exceeded Area (km^2)	Percentage Area Exceeded	Accumulated Exceedance (keq/year)
Acid grassland	3143	2839	90.3	165415
Calcareous grassland	45	0	0.0	0
Dwarf shrub heath	1078	658	61.0	21743
Bog	56	52	91.9	2985
Montane	18	18	100.0	1612
Coniferous woodland (managed)	1048	709	67.6	44357
Broadleaved woodland (managed)	790	477	60.4	29441
Unmanaged woods	395	233	58.9	13572
Freshwaters	1225	191	15.6	5082
All habitats	7798	5176	66.4	284207

Acidity exceedances for Scotland

Broad Habitat	Habitat Area (km^2)	Exceeded Area (km^2)	Percentage Area Exceeded	Accumulated Exceedance (keq/year)
Acid grassland	8336	3930	47.1	123999
Calcareous grassland	7	0	0.0	0
Dwarf shrub heath	20190	1994	9.9	34305
Bog	3959	961	24.3	22565
Montane	3034	1675	55.2	67785
Coniferous woodland (managed)	5111	1747	34.2	65196
Broadleaved woodland (managed)	1096	370	33.7	15406
Unmanaged woods	1016	217	21.3	7867
Freshwaters	5338	259	4.9	5283
All habitats	48086	11151	23.2	342406

Scenario Q (Early Euro low & Low Emission Vehicles & Small Combustion Plant): acidity exceedances (continued)

Acidity exceedances for Northern Ireland

Broad Habitat	Habitat Area (km^2)	Exceeded Area (km^2)	Percentage Area Exceeded	Accumulated Exceedance (keq/year)
Acid grassland	1187	832	70.1	42758
Calcareous grassland	42	0	0.0	0
Dwarf shrub heath	973	509	52.3	18605
Bog	442	362	81.9	17275
Montane	0	0	0.0	0
Coniferous woodland (managed)	503	267	53.2	21770
Broadleaved woodland (managed)	0	0	0.0	0
Unmanaged woods	208	96	46.2	10989
Freshwaters	186	29	15.6	2347
All ecosystems	3539	2094	59.2	113744

Acidity exceedances for the United Kingdom

Broad Habitat	Habitat Area (km^2)	Exceeded Area (km^2)	Percentage Area Exceeded	Accumulated Exceedance (keq/year)
Acid grassland	15334	10072	65.7	535900
Calcareous grassland	1808	0	0.0	0
Dwarf shrub heath	24703	5112	20.7	179428
Bog	5463	2365	43.3	127751
Montane	3054	1695	55.5	69580
Coniferous woodland (managed)	8377	3979	47.5	271208
Broadleaved woodland (managed)	7452	4131	55.4	394513
Unmanaged woods	4011	1651	41.2	129578
Freshwaters	7790	908	11.7	47337
All habitats	77991	29911	38.4	1755295

Scenario Q (Early Euro low & Low Emission Vehicles & Small Combustion Plant): nutrient nitrogen exceedances

Nutrient nitrogen exceedances for England

Broad Habitat	Habitat Area (km^2)	Exceeded Area (km^2)	Percentage Area Exceeded	Accumulated Exceedance (keq/year)
Acid grassland	2620	2298	87.7	92282
Calcareous grassland	3312	1618	48.9	49648
Dwarf shrub heath	2466	2073	84.1	83844
Bog	1007	1006	99.9	71830
Montane	2	2	100.0	177
Coniferous woodland (managed)	1719	1718	100.0	225865
Broadleaved woodland (managed)	5588	5586	100.0	905792
Unmanaged woods (ground flora)	2252	2252	100.0	347425
Atlantic oak (epiphytic lichens)	150	150	100.0	20294
Supralittoral sediment	1183	282	23.8	4975
All habitats	20299	16986	83.7	1802132

Nutrient nitrogen exceedances for Wales

Broad Habitat	Habitat Area (km^2)	Exceeded Area (km^2)	Percentage Area Exceeded	Accumulated Exceedance (keq/year)
Acid grassland	3146	1968	62.6	49084
Calcareous grassland	171	29	17.2	405
Dwarf shrub heath	1094	846	77.3	24274
Bog	56	53	94.3	2172
Montane	18	18	100.0	1486
Coniferous woodland (managed)	1052	1051	99.9	108367
Broadleaved woodland (managed)	798	788	98.7	78757
Unmanaged woods (ground flora)	226	226	99.7	26092
Atlantic oak (epiphytic lichens)	171	169	98.9	18756
Supralittoral sediment	369	47	12.8	910
All habitats	7102	5194	73.1	310302

Nutrient nitrogen exceedances for Scotland

Broad Habitat	Habitat Area (km^2)	Exceeded Area (km^2)	Percentage Area Exceeded	Accumulated Exceedance (keq/year)
Acid grassland	8283	648	7.8	5662
Calcareous grassland	24	1	5.2	2
Dwarf shrub heath	20284	1319	6.5	17921
Bog	4005	702	17.5	16087
Montane	3109	2082	67.0	63333
Coniferous woodland (managed)	5111	3750	73.4	192606
Broadleaved woodland (managed)	1096	812	74.1	50440
Unmanaged woods (ground flora)	570	375	65.8	20477
Atlantic oak (epiphytic lichens)	501	225	44.9	7095
Supralittoral sediment	547	11	2.0	135
All habitats	43530	9925	22.8	373758

Scenario Q (Early Euro low & Low Emission Vehicles & Small Combustion Plant): nutrient nitrogen exceedances (continued)

Nutrient nitrogen exceedances for Northern Ireland

Broad Habitat	Habitat Area (km^2)	Exceeded Area (km^2)	Percentage Area Exceeded	Accumulated Exceedance (keq/year)
Acid grassland	1192	609	51.1	18758
Calcareous grassland	69	12	17.6	561
Dwarf shrub heath	976	666	68.2	25829
Bog	473	393	83.1	17757
Montane	0	0	0.0	0
Coniferous woodland (managed)	504	440	87.3	46434
Broadleaved woodland (managed)	0	0	0.0	0
Unmanaged woods (ground flora)	247	233	94.2	29837
Atlantic oak (epiphytic lichens)	0	0	0.0	0
Supralittoral sediment	29	15	52.2	538
All ecosystems	3491	2368	67.8	139715

Nutrient nitrogen exceedances for the United Kingdom

Broad Habitat	Habitat Area (km^2)	Exceeded Area (km^2)	Percentage Area Exceeded	Accumulated Exceedance (keq/year)
Acid grassland	15241	5523	36.2	165786
Calcareous grassland	3577	1661	46.4	50616
Dwarf shrub heath	24820	4904	19.8	151868
Bog	5541	2153	38.9	107846
Montane	3129	2102	67.2	64997
Coniferous woodland (managed)	8385	6959	83.0	573272
Broadleaved woodland (managed)	7482	7186	96.0	1034989
Unmanaged woods (ground flora)	3296	3086	93.6	423830
Atlantic oak (epiphytic lichens)	822	544	66.2	46145
Supralittoral sediment	2128	355	16.7	6558
All habitats	74422	34473	46.3	2625908