Implementing the Habitats Directive

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Abstract

The European Union Habitats Directive requires Member States to review existing authorisations and consents that are likely to have a significant impact on designated conservation areas. Such areas may have one or more features designated for protection, for example a single species such as the Marsh Fritillary butterfly or a particular plant community such as oak woodland. A database of the sensitivity of each feature to acidification was compiled, together with the ecosystem type considered to be its most sensitive habitat requirement. Relevant critical loads were calculated from soil distribution and soil chemistry data. Deposition from individual large combustion sources emitting more than 300 tonnes of sulphur or nitrogen per year was modelled. Comparison with the critical load data allowed exceedances to be identified. Both critical loads and modelled deposition are uncertain. We have attempted to evaluate these uncertainties and take account of them in estimating the degree of critical load exceedance and, thereby, prioritising those sites requiring detailed ecological investigation.

Keywords: acidity, critical loads, Habitats Directive, uncertainty.

1 Introduction

The European Union Habitats Directive requires competent authorities to review all existing consents and authorisations that are likely to have a significant effect on designated conservation sites. There are 397 such sites in England and Wales. The Directive defines a ‘likely significant effect’ as:

The onset of physiological and/or biological changes which are expected to be of ecological relevance.

The onset of decline/increase of growth, vitality and quality in individual species.

The onset of significant changes in ecosystem structure and/or function such as productivity decline, population changes, genetic diversity.
This paper considers acidic emissions from large combustion sources, such as power stations and oil refineries, which can impact sensitive ecosystems over large areas. We describe a methodology to rank sites according to the risk of ecological damage, based on the sensitivity of the habitat and species for which it is designated, and the level of acid deposition at the site. Sites identified as being at risk will be subject to detailed site-specific investigations. The method is not intended as a substitute for site investigations, but to allow the Agency to prioritise sites that may be impacted by processes that it regulates.

2 Method

The risk assessment comprised of five stages: assessing the sensitivity of each designated feature to acidification; assigning the most important habitat type to the sensitive features; assigning a critical load to the habitat type; calculating the exceedance of the critical load using modelled deposition and calculating the proportion of that exceedance due to large combustion sources.

2.1 Natura 2000 sites and designations

Sites to be assessed under the Habitats Regulations (Natura 2000 sites) fall into two categories: Special Areas of Conservation (SAC) and Special Protection Areas (SPA). Each site has a list of designated ‘features’ which must be protected. A feature can be either a single species, or a particular collection of species. In general, SAC sites are designated for habitat features such as oak woodland, and SPA sites for single species, generally birds. A site may be both a SPA and a SAC and may contain several different designated features. For example, the New Forest in southern England has twenty-eight designated features ranging from bullheads (a fish) to alder woodland. Natura 2000 sites may be very small, consist of a number of linked but not contiguous sites, or contain small areas of sensitive vegetation that may not be protected by the dominant land-use type within a grid square. To ensure that the sensitivity of all species was considered, a database of the sensitivity of each designated feature to acidification was compiled, together with the ecosystem type which was considered to be the most sensitive habitat requirement of that species. For example, four sites are listed in Table 1 with the features for which they were designated.

To determine the sensitivity of a designated feature to acidity, it was first compared with the European Nature Information System (EUNIS) habitat classes [1]. Most designated habitats have been linked to these Broad Habitat Types, but where this was not the case the most similar habitat type was assigned. Where a Broad Habitat Type is considered to be sensitive to acidity, it has been linked to the eight classes of acid critical load identified for the United Kingdom by the National Focal Centre for Critical Loads [2]. Some Broad Habitat Types are not considered sensitive to acidification. These were not considered further.

Critical loads are intended to protect the soil underlying an ecosystem, and the link between species and critical load types is on this basis. For example, a
short grassland habitat may be considered the most important habitat type for a particular bird species, and the critical load for acid grassland may be used. This does not imply that acid deposition above this level will cause direct damage to the birds themselves, but that damage may occur to the grassland ecosystem on which they rely or with which they are associated. Assigning critical loads to species was more complex than habitat assignments. Some species, for example bats, require a mosaic of habitats. Habitat requirements were reviewed to identify the most important and/or most sensitive habitat that the species required; this was used to assign a critical load from the EUNIS Broad Habitat Type.

Freshwater habitats required a different method to assess sensitivity, since the critical loads calculated for freshwaters in the UK are based on the sensitivity of Brown Trout, and a designated freshwater feature may be more or less sensitive. The assessment of sensitivity of freshwater features to acidification and the critical load exceedance has been described by Curtis et al [3].

Table 1:  Example sites and designations.

<table>
<thead>
<tr>
<th>Name</th>
<th>Designated Feature</th>
<th>Broad Habitat Type</th>
<th>Sensitive to Acidification?</th>
<th>Acidity Class (UK NFC)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Burnham Beeches</td>
<td>(Quercion robur-petraeae or ilic-Fagenion)</td>
<td>Broad-leaved, mixed and yew woodland</td>
<td>Y</td>
<td>Broadleaved/Coniferous unmanaged woodland</td>
</tr>
<tr>
<td>Crymlyn</td>
<td>Transition mires and quaking bogs, Alluvial forests with Alnus glutinosus and Fraxinus excelsior, (Alno-Padion, Alnion incanae, Salicion albae) Calcareous fens with Cladium mariscus and species of the Caricion davallianae</td>
<td>Bogs, Broad-leaved, mixed and yew woodland</td>
<td>Y</td>
<td>Bogs</td>
</tr>
<tr>
<td>North York Moors</td>
<td>Blanket bogs, Northern Atlantic wet heaths with Erica tetralix, European dry heaths</td>
<td>Bogs</td>
<td>Y</td>
<td>Dwarf shrub heath, Dwarf shrub heath</td>
</tr>
<tr>
<td>Strensall Common</td>
<td>Northern Atlantic wet heaths with Erica tetralix, European dry heaths</td>
<td>Dwarf shrub heath, Dwarf shrub heath</td>
<td>Y</td>
<td>Dwarf shrub heath, Dwarf shrub heath</td>
</tr>
</tbody>
</table>

Bird species designated at SPA sites posed problems, particularly where the bird ‘overwinters’ at the site and is not resident there. In some instances it was not possible to assign a critical load, as the habitat requirements were too wide, and in some instances too uncertain, to assign a single critical load to a species. In these cases the bird feature was noted as potentially sensitive and, if it was designated for a site for which there were no other sensitive features, the site was added to the list of those where further investigation was required.

2.2 Development of ‘site relevant’ critical loads

Nilsson and Grennfelt [4] have defined a critical load (CL) as ‘a quantitative estimate of an exposure to one or more pollutants below which significant harmful effects on specified sensitive elements of the environment do not occur according to present knowledge’. If deposition is above the threshold, harm may occur. The CL represents the long-term capacity of ecosystems to absorb...
pollutants. This assumes that (a) the rate of deposition is less than that which might cause direct damage to particular plants and (b) the acidity balance of the soils is at a steady state. The ecosystem itself might not be at a steady state for other reasons, including intrinsic dynamics (e.g. succession).

In the United Kingdom national scale calculations of critical loads have been published for nine acid ecosystem types (acid grassland, bogs, dwarf shrub heath, broadleaf/coniferous unmanaged woodland, calcareous grassland, managed coniferous woodland, managed broadleaved woodland, Montane) and for freshwaters. The national mapping of these critical loads is based on soil type and includes a filter to give a value for each 1 km grid square based on the vegetation types present in the square. The vegetation data are taken from processed satellite imagery and used to assign the dominant land-use type for each kilometre grid square to determine the critical load as described by Fuller et al [5] and Hall et al [6]. For the Habitats Directive assessment, we could not assume that the dominant vegetation type in a grid square was the designated habitat, or that a critical load designed to protect the dominant habitat type would protect the designated feature. For this reason, a set of national maps was produced which calculated critical loads without using the dominant vegetation type in each grid square. For example, a map was produced assuming that acid grassland could be present in any 1km square over the whole country. This allowed an assessment to be made at each Natura 2000 site with the knowledge that if the site was designated for a feature protected by that acidity class, a critical load could be calculated for that site. This approach is precautionary, since it also acknowledges uncertainty as to the location of designated features within the site, and allows a critical load to be calculated which would protect the feature anywhere in the site.

Initially, critical loads were calculated for single pollutants, such as sulphur. But as both sulphur and nitrogen contribute to acidification, and their effect is not directly additive, it is not possible to define a single ‘acidity critical load’. To overcome this a 'critical load function' has been developed as shown in Figure 1. The shaded area is below the critical load. Below CL_{min}(N), nitrogen sinks, such as immobilisation and uptake, balance the rate of atmospheric N deposition by soil and vegetation. In this area acidification is due to sulphur alone. Above this level N exerts an acidifying effect, and the deposition of both S and N needs to be taken into account in assessing acidification. The exceedance of the Critical Load is then a combination of the total deposition of sulphur and nitrogen (oxidised and reduced). Posch et al [7] have provided a set of functions for calculating exceedance.

### 2.3 Deposition modelling

To maintain continuity with earlier national assessments, sulphur and oxidised nitrogen deposition was modelled using the HARM model described by Metcalfe et al [8]. In brief: the model represents ‘packets’ of air moving along fixed trajectories that pick up and deposit sulphur and nitrogen in each 10km grid
Figure 1: The critical load function for acidity.

Three critical loads (generally expressed in keqH⁺ha⁻¹year⁻¹) are shown:
the maximum sulphur critical load (CL_{max}(S))
the maximum nitrogen critical load (CL_{max}(N))
and the minimum nitrogen critical load (CL_{min}(N))

square. 360° trajectories are modelled, based on a UK average windrose. The model represents the chemical processes involved in wet and dry deposition and assumes a ‘constant drizzle’ across the country. The drizzle is scaled from the annual rainfall for the year under consideration, to give an average daily rainfall. Deposition velocities for oxidised sulphur and nitrogen vary with the land cover and are averaged across each grid square according to the proportion of each ecosystem type present. Increased deposition due to higher rainfall over high ground is included in the model. While the HARM model includes the chemical processes for oxidised and reduced nitrogen, the model has only one vertical layer (to 800m). This is not sufficiently accurate to represent the emission and deposition of reduced nitrogen, where emissions tend to be diffuse and at low altitude. The FRAME (Fine Resolution Ammonia Exchange) model of Nemitz et al [9] was used. The results from the two models were combined to give an estimate of total N deposition. The performance of these models has been reviewed elsewhere [10] [11].

2.3.1 Model scenarios
Deposition from the 42 individual sources in England and Wales with emissions greater than 300 tonnes year⁻¹ of combined sulphur and nitrogen was modelled. Emissions for the year 2000 were used in the assessment. Sources in Scotland and Northern Ireland were modelled with the background emissions. Large point sources of ammonia, such as pig and poultry units, are not currently regulated, but will be included under future regulations and were included as background emissions. The EMEP (Co-operative Programme for Monitoring and Evaluation of the Long-Range Transmission of Air pollutants in Europe) model grid was
used to estimate trans-boundary deposition from Europe. Diffuse sources such as traffic, urban areas and local industries were included as background emissions.

Large combustion sources were modelled separately to provide individual ‘footprints’ and considered against all designated sites. Smaller sources were modelled individually where they were close to a Natura 2000 site and could potentially have a significant impact. By adding the deposition due to individual sources to the deposition arising from background emissions it was possible to calculate what proportion of the deposition was due to each individual source and what to background emissions. Due to the treatment of chemical processes, it was likely that the model output would be ‘non-linear’; that is, the deposition footprint from a group of sources would differ from the sum of the footprints of the individual sources.

Table 2: Modelled cluster and added individual deposition (keqH⁺ha⁻¹ year⁻¹).

<table>
<thead>
<tr>
<th></th>
<th>SOx deposition Modelled using the HARM Model</th>
<th>NOx deposition Modelled using the HARM Model</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Summary Statistics of Modelled Cluster 1 and Added Cluster 1</td>
<td>Summary Statistics of Modelled Cluster 1 and Added Cluster 1</td>
</tr>
<tr>
<td></td>
<td>Including Background</td>
<td>Without Background</td>
</tr>
<tr>
<td></td>
<td>Modelled</td>
<td>Added</td>
</tr>
<tr>
<td>Average</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Average</td>
<td>0.1019</td>
<td>0.1015</td>
</tr>
<tr>
<td>Maximum</td>
<td>1.7170</td>
<td>1.7721</td>
</tr>
<tr>
<td>Minimum</td>
<td>0.0000</td>
<td>0.0000</td>
</tr>
<tr>
<td>SD</td>
<td>0.1547</td>
<td>0.1540</td>
</tr>
<tr>
<td>Variance</td>
<td>0.0239</td>
<td>0.0237</td>
</tr>
<tr>
<td>Total</td>
<td>926.9930</td>
<td>923.2412</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Average</td>
<td>0.1137</td>
<td>0.1141</td>
</tr>
<tr>
<td>Maximum</td>
<td>0.8630</td>
<td>0.8781</td>
</tr>
<tr>
<td>Minimum</td>
<td>0.0000</td>
<td>0.0000</td>
</tr>
<tr>
<td>SD</td>
<td>0.1732</td>
<td>0.1737</td>
</tr>
<tr>
<td>Variance</td>
<td>0.0300</td>
<td>0.0302</td>
</tr>
<tr>
<td>Total</td>
<td>1034.3090</td>
<td>1037.8760</td>
</tr>
</tbody>
</table>

To determine if such differences were significant, sources were modelled both individually and in geographical groups. Summary statistics, over all grid
squares, from a comparison of \( \text{SO}_x \) and \( \text{NO}_x \) emissions from a group of power stations in the Aire Valley modelled (a) as a cluster and (b) individually and then added, are shown in Table 2. The analysis showed that while there was a difference between modelling clusters of power stations together and adding individual deposition footprints, it was small both relative to the total modelled deposition and uncertainties in the models.

### 2.4 Uncertainty in critical loads and deposition modelling

In previous assessments critical loads have been used as absolute standards and deposition greater than the critical load taken to constitute exceedance. The critical load has therefore been used in the same manner as toxicological standards. Critical loads, however, are calculated from soil distribution and soil chemistry maps, and this mapping has its own uncertainty. Moreover, a critical load is not a short-term standard, but assumes that a soil has a capacity to neutralise acid deposition. So, even if deposition is large, damage to the ecosystem may not occur for many years. Once the soil is acidified, recovery rates may be slow even if the level of acid deposition is reduced. The recovery rates of soils and ecosystems are not well understood, and there may be instances where damage to an ecosystem continues for some years after the level of acid deposition has reduced to a ‘safe’ level. This type of uncertainty is difficult to quantify and has not been considered in the risk assessment, although long-term changes will be considered in detailed site investigations.

![Figure 2: Variation in critical load within a Natura 2000 site.](image)
The critical load can vary across a site as it is calculated on a 1km grid square basis reflecting national soil mapping. A larger site may therefore have a range of critical loads within its boundary and this range has been used to improve the assessment of risk to the site. Three critical loads are calculated for each site: the minimum critical load for the site; the maximum critical load for the site; and a weighted mean of the critical loads within the site, based on the land area of each critical load value.

Figure 3: Uncertainty in the calculation of critical loads and deposition.
Deposition estimates are also uncertain. In a study commissioned by the Environment Agency [12], first order Monte-Carlo analysis of the HARM model parameters and input data has been used to derive a range of uncertainties in model output so that average, ‘minimum’ and ‘maximum’ values for the modelled deposition can be estimated. These three values are compared with the three critical load functions to give an indication of the level of confidence that can be attributed to an apparent exceedance. The two scenarios shown in Figure 3 illustrate this. In scenario 1, the minimum modelled deposition exceeds the maximum critical load function calculated for the site, giving a high degree of confidence that the critical load is exceeded. In scenario 2, the maximum deposition exceeds the minimum critical load, but no other deposition value exceeds the critical load range. In this case a low level of confidence is given to the critical load exceedance. Consideration of the uncertainty in the assessment assists in prioritising sites for further ecological investigation.

3 Results

Of the 367 SAC sites examined, 244 were found to have acid sensitive features for which a critical load could be assigned. At only 55 of these did modelled deposition exceed the critical load with high confidence, that is minimum deposition exceeded the maximum critical load function (scenario 1). Average deposition exceeded the average critical load function at 170 sites. Maximum modelled deposition exceeded the minimum critical load function at 239 sites (scenario 2). This analysis allowed prioritisation of the sites to be analysed in greater detail, as described below.

Figure 4 compares modelled deposition and critical load function at one SAC site, Strensall Common. The graph shows the modelled deposition at the site with the range of possible deposition as error bars, and the maximum, minimum and site-averaged critical load functions. At this site the minimum total deposition exceeds the maximum critical load function, *i.e.* it is a site for which there is a high level of confidence that the critical load, in this case for dwarf shrub heath, is exceeded. The modelled deposition can be broken down into its components so that the contribution of background, large combustion sources and diffuse ammonia can each be compared with the critical load function. At this site, the contributions of large combustion sources and low-level local sources to total deposition are small. Reducing emissions from these sources alone would not reduce the risk at the site, unless ammonia emissions, arising primarily from agriculture, were also reduced.

To comply with the terms of the Habitats Directive, the percentage contribution of each large combustion source is calculated for each site where the critical load is exceeded. Where the total contribution of Agency-regulated combustion sources exceeds 10% of the sulphur or nitrogen critical load, or where an individual site exceeds 1% of the critical load, Agency-regulated sources are considered to make a significant contribution to acid deposition at the site. These sites and sources will be subject to more detailed assessment.
4 Conclusions

The European Union Habitats Directive requires Member States to review existing authorisations and consents that are likely to have a significant impact on designated conservation areas. Given the number of sources and conservation areas this is a significant task and some form of screening is helpful to direct attention to those sites at greatest risk. The approach described here has provided the Agency with a method to screen the impact of acidic emissions from large combustion plant on Natura 2000 sites on a national scale. The method attempts to take some account of the uncertainty inherent in both deposition modelling and the estimation of critical load functions. By doing so it was possible to rank sites in terms of the likelihood of critical load exceedance and prioritise those which require further ecological investigation.

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References


