4

ASSESSING NITROGEN IMPACTS ON CONSERVATION STATUS (THEME 2)

4.1 Background document

C. Whitfield[1] and I. Strachan[2]

1 Joint Nature Conservation Committee (JNCC), UK

2 Scottish Natural Heritage (SNH), UK

Summary

- The Habitats Directive requires Member States to take measures to maintain at, or restore to, favourable conservation status, the natural habitats and species of Community Importance. Member States are required to report on the implementation of the Directive every six years, including an assessment of conservation status (Article 17).
- Nitrogen deposition impacts are considered to be a significant threat to sensitive habitats across Europe. Therefore, it is necessary to understand the effects of nitrogen deposition on attaining favourable conservation status. In turn, this should inform air pollution policy development, helping to target it appropriately to account for the objectives of the Habitats Directive.
- For the last Article 17 reporting round, which covered 2001-2006, a number of Member States included an assessment of nitrogen deposition impacts based on an application of critical loads. Other Member States used evidence from field surveys or a combination of these alongside critical loads assessments. However, the detection and attribution of nitrogen deposition impacts is not straightforward, and the application of critical loads in this context also raises a number of challenging questions.
- This background paper identifies some of the key issues concerning the assessment of nitrogen impacts on conservation status. These were discussed at the workshop with a view to sharing experience and good practice, and with a forward look to improving methodologies and consistency in their application for the next reporting round in 2013 (as reported by Whitfield *et al*., this volume).

4.1.1 Introduction

The Habitats Directive (92/43/EEC) together with the Birds Directive (79/409/EEC) are the main drivers of Europe's nature conservation policy. The Habitats Directive promotes the maintenance of biodiversity and requires Member States to take measures to maintain or restore the threatened natural habitats and wild species listed in the Directive at favourable conservation status, introducing robust protection for those habitats and species of European importance.

The provisions of Article 17 of the Habitats Directive require Member States to produce a report every six years on the implementation of the Directive, including the assessment of **conservation**

status of all the relevant habitats and species listed in the Annexes of the Directive. The second report, which covered the period 2001-2006, included such assessments for the first time. The methodology for assessing the impacts of nitrogen deposition on conservation status is the subject of this paper.

Nitrogen deposition remains a threat to biodiversity across large areas of Europe (CCE, 2008). This concern is reflected in the incorporation of an indicator for nitrogen deposition under the Streamlining European Biodiversity Indicators 2010 (SEBI, 2010) programme (EEA, 2007), which helps measure progress towards the European target to halt the loss of biodiversity by 2010. Common assessment methods, such as critical loads, are already well established for use in European air pollution policy development. Critical load exceedance maps identify areas at risk from atmospheric nitrogen deposition. They show that a substantial area of semi-natural habitat in Europe exceeds the critical loads (see Figure 4.1).

Since the Habitats Directive is one of the priorities in European nature conservation policy, it is important to understand the risks from nitrogen deposition to achieving the Directive's objectives. An assessment of nitrogen deposition impacts on attaining favourable conservation status, based on a robust assessment approach, is essential to inform air pollution policy development and to ensure that it is targeted appropriately to help achieve the objectives of the Habitats Directive.

In this background paper we provide an introduction to the reporting of conservation status and consider how nitrogen deposition may impact on conservation status. We then provide a summary of the approaches taken by a selection of Member States to assess nitrogen deposition impacts on conservation status. An overview is then presented of the preliminary results from the most recent reporting round, in relation to the reporting of "air pollution" and "eutrophication" as a "pressure" or a "threat". Building on this experience and anticipating the next reporting round in 2013, we aim to begin to identify some key questions and challenges, concerning assessment methodology and procedures, which require further development to ensure a harmonized, robust and consistent approach between countries. Overall, the aim is to share experience and to open up discussion on the methods and mechanisms for future assessments.

4.1.2 An introduction to conservation status assessments

Background to reporting

The Habitats Directive requires Member States to report every six years on the conservation status of the habitats listed in Annex I and the species listed in Annexes II, IV and V of the Directive. The methodology for reporting conservation status is determined by the EC Habitats Committee. Supplementary guidelines were produced by the European Commission in collaboration with Member States (European Commission, 2006) to ensure that the reporting is done on a consistent and comparable basis. The reporting format requires a separate analysis for each habitat and species in each biogeographical region that a country covers.

Favourable Conservation Status (FCS) of a habitat is defined in Article 1(e) of the Directive as being when:

- its natural range, and areas it covers within that range, are stable or increasing; and,
- the specific structure and functions which are necessary for its long-term maintenance exist and are likely to continue to exist for the foreseeable future; and,
- the conservation status of its typical species is favourable as defined in Article 1(I).

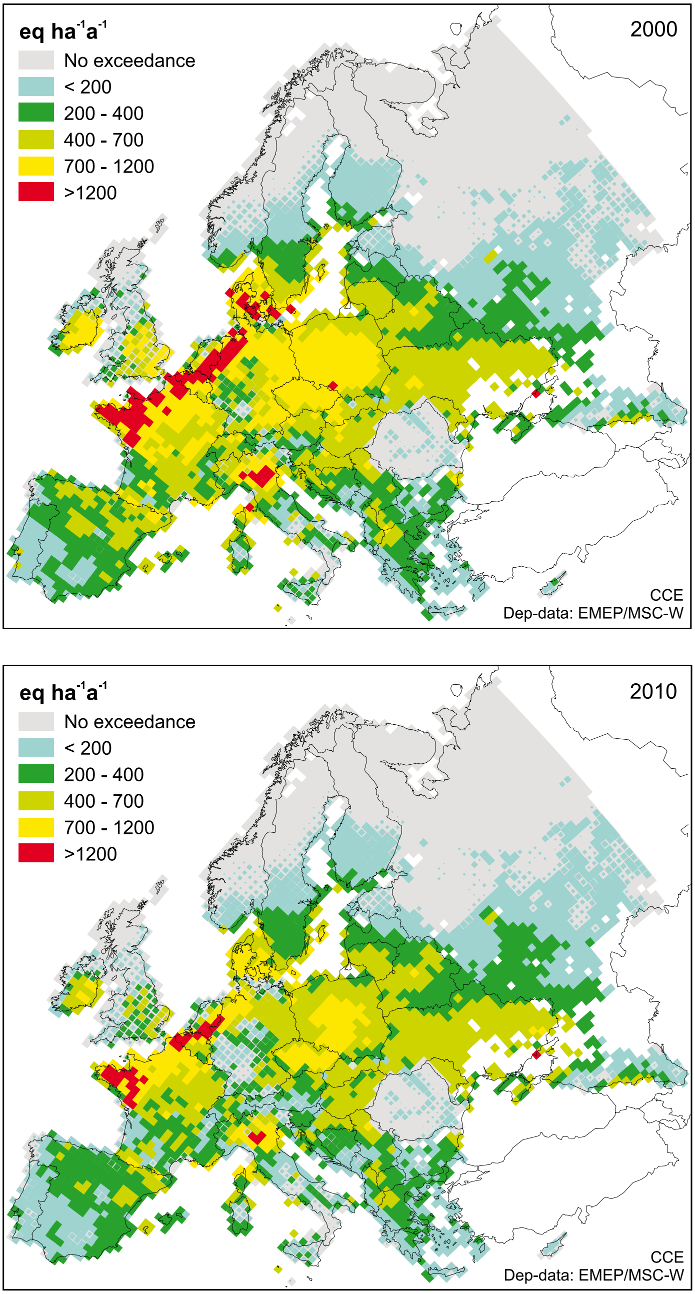

Figure 4.1: Exceedance of critical loads for eutrophication by nitrogen deposition in 2000 and 2010 under current legislation (courtesy of CCE, 2008).

FCS for a species is defined in Article 1(I) of the Directive as being when:

- population dynamics data on the species concerned indicate that it is maintaining itself on a long-term basis as a viable component of its natural habitats; and,
- the natural range of the species is neither being reduced nor is likely to be reduced for the foreseeable future; and,
- there is, and will probably continue to be, a sufficiently large habitat to maintain its population on a long-term basis.

In other words, in simple terms it can be described “as a situation where a habitat type or species is prospering (in both quality and extent/population) and with good prospects to do so in future as well” (European Commission, 2006).

The Commission guidance states that the range and area of the listed habitats, and the range and population of the listed species, should be at least maintained at their status when the Directive came into force or, where the status at that time was not viable in the long term, should be restored to a position where it would be viable. The six-yearly reports are intended to measure the effectiveness of the Directive in meeting its aims, which are essentially to secure favourable conservation status. The 2001-2006 report provides a baseline by which future assessments can be judged.

It is very important to recognise that the assessment of conservation status for a habitat or species should be made across the whole of its range, rather than being confined to Special Areas of Conservation (SAC) (which together with Special Areas of Protection make up the Natura 2000 network). The proportion of a feature which occurs within SACs will vary on a case by case basis and between countries and biogeographic areas. In many cases a substantial proportion occurs outside SACs in the ‘wider countryside’ or seas.

The Commission guidance stipulates four parameters for assessing the conservation status of habitats. These are:

- range,
- area,
- specific structures and functions including typical species,
- future prospects.

For species, the parameters are:

- range,
- population,
- habitat for the species,
- future prospects.

Each of these parameters is assessed as being in one of the following conditions: Favourable, Unfavourable-Inadequate, Unfavourable-Bad, or Unknown, according to agreed standards (European Commission, 2006). In addition to assessing the individual parameters referred to above, Member States are also required to make an overall assessment of the conservation status of each of the habitats and species following an agreed method. This overall assessment is determined by reference to the conclusions for the individual parameters, and, in general, reflects the least favourable of the individual parameter conclusions.

Taking nitrogen deposition into account

As stated above, for the conservation status of a habitat to be favourable, "the specific structure and functions which are necessary for its long-term maintenance exist and are likely to continue to exist for the foreseeable future". Habitat structure and habitat function varies widely between different habitats, but it is clear that the various ecological processes essential for a habitat have to be present and functioning for the habitat to be considered to be at favourable conservation status (European Commission, 2006).

A large number of the habitats (and species, either directly or indirectly) listed under the Habitats Directive are sensitive and potentially vulnerable to atmospheric nitrogen deposition. Nitrogen deposition may cause changes to composition, often including a reduction in species richness and a loss of sensitive 'lower plants'; changes to soil microbial processes; changes to plant and soil biochemistry; increased susceptibility to abiotic stresses (such as winter injury) and biotic stresses (such as pests and pathogens); and it also contributes towards acidification (NEGTAP, 2001). It is clear that such impacts could adversely affect the "specific structures and functions" element of conservation status, as well as threatening the future prospects, for sensitive habitats and species. In some cases nitrogen deposition may also have affected the range of a habitat (through a change in species composition) or species.

Under the assessment of "specific structures and functions" for habitats, Member States are required to provide a list of the "main pressures" currently acting on each habitat. Similarly, for the "future prospects" assessment, future threats (to the range, extent, structures and functions) must be documented. The guidance (European Commission, 2006) provides an example under the notes for "future prospects" for defining "unfavourable-bad" (i.e. the habitat's prospects are bad, severe impact from threats expected; long-term viability not assured) as "under pressure from significant adverse influences, e.g. critical loads of pollution exceeded".

The EC guidance lists a suite of pressures and threats (European Commission, 1997) including "air pollution" (code 702). "Eutrophication" (code 952) is also listed separately, but in the context of biocenotic evolution (ecological succession). However, there is no guidance on the definitions of the listed pressures/threats, which are open to inconsistent interpretation, nor are there criteria for judging whether the severity of threat warrants its inclusion (but note that this is to be addressed by the EC Expert Group on Reporting). Presumably "air pollution" would be expected to include consideration of acidic and eutrophying deposition (and direct effects of the gases associated with these pollutant species) and ozone, in so far as an assessment is possible. However, the categories "eutrophication," "acidification," and "fertilisation" may also have been used to record the effects of nitrogen deposition.

As documented in the introduction to this paper, the most recent reporting round for Article 17 was 2007/8 and covered the period 2001-2006. The European Commission has produced a composite report providing an analysis of the results of the 2007 reporting round (European Commission, 2009). Prior to the publication of the composition report, the European Topic Centre (ETC) on Biodiversity provided the authors of this paper with a working draft copy of a database of the results of the conservation status assessments. This allowed an analysis across the EU, Member States and biogeographic regions of where "air pollution" and/or "eutrophication" was identified as a pressure or threat for each habitat assessment.

The main focus of this background paper is on the assessment for Annex I habitats, rather than species, since most information is available for these; and a comparison to other assessment tools, such as critical loads, is more straightforward. However, an assessment is also required for species.

4.1.3 Examples of the methodology used by a selection of Member States

Introduction
Member States were required to submit Article 17 reports, including conservation status assessments, in 2007. Each individual habitat and species assessment (by country and biogeographic region) is available on the ETC's website (http://biodiversity.eionet.europa.eu/article17). However, as stated earlier, the EC guidance (European Commission, 2006) on Article 17 reporting did not include guidance or criteria for identifying and assigning the main pressures and threats, and there was no obligation to provide details of the methodology used for such purposes. As a consequence, whilst it is possible to query the results of the individual habitat/species assessments, information on the generic approach to nitrogen deposition assessment is only available for a small number of countries (notably UK and Denmark) through the ETC website (http://rod.eionet.europa.eu/countrydeliveries?actDetailsId=269).

In an attempt to present an overview of approaches taken by different Member States, the authors requested details of the methodology used by a selection of Member States from members of the workshop advisory committee and other contacts. The summaries below reflect responses received. The paper describes methods of the UK, Denmark, Belgium, Austria, Germany and Netherlands. Contacts from some other countries have indicated that there was no explicit consideration of the issue (i.e. Czech Republic and Portugal). However, overall 18 Member States have reported air pollution as a threat or pressure for at least one habitat assessment (and likewise all 25 reported eutrophication, although this may include non-atmospheric inputs and discharges to water in marine and freshwater/wetland habitats).

Country Summaries

UK
The UK assessment of "specific structures and functions" for habitats was made based on the main pressures currently acting on the habitat, information on the habitat condition and, where relevant information was available, the status of typical species associated with the habitat.

Information on habitat condition from site condition monitoring formed a major component of the assessment. However, since the approaches used for site condition monitoring in the UK are largely based on fairly rapid visual assessment of key attributes of the habitat, it is acknowledged that this is not a sensitive tool for detecting and, in particular, attributing nitrogen deposition impacts (Williams, 2006). Therefore, a nitrogen deposition assessment, based on the use of empirical nutrient nitrogen critical loads and modelled nitrogen deposition from the UK models FRAME (Singles *et al*., 1998) and CBED (Smith *et al*., 2000), was also undertaken. This also has the advantage of providing a predictive approach for assessing 'future threats'. The methodology is reported in a technical annex to the UK's submission (http://www.jncc.gov.uk/pdf/FCS2007_techIII_airpollution.pdf) and in Whitfield (this volume), but a brief summary is given below.

The critical loads based assessment was carried out for Annex I habitats only. Species were excluded because of the difficulty in linking habitat-based critical loads to effects on individual species. Habitats judged not to be sensitive to nitrogen deposition (and acidification) impacts were also excluded from the assessment. In addition, habitats which could not be assigned a critical load (see later) were excluded.

The UK does not have nutrient nitrogen critical load maps for Annex I habitats, so existing critical loads information was adapted for the purposes of the conservation status assessments. The UK was in a fortunate position having undertaken a substantial exercise to assign relevant critical loads to interest features on SACs known as Site Relevant critical loads (SRCL) (Bealey *et al*., 2007). Exceedance data for all sensitive Annex I habitats as they occur in SACs is therefore available. In this exercise, the ‘relevant’ critical loads were assigned to Annex I habitats where there is adequate equivalence with a EUNIS class for which critical loads have been assigned (UNECE, 2003). A few Annex I habitats which are potentially sensitive had to be excluded because there is not a habitat for which a critical load is set, which has sufficient equivalence with the Annex I habitat. This assignment of ‘relevant’ critical loads to Annex I habitats based on the EUNIS habitat classification is critical; it is a common theme amongst those countries which have used a critical loads based assessment for conservation status reporting, and will be considered in the workshop discussion.

However, the UK’s SRCL exceedance data only provides information for the proportion of habitats which occur within SACs. To ensure the assessment adequately represented the risk to the whole Annex I habitat resource, a combined approach was used which drew on UK national critical loads exceedance mapping (Hall *et al*., 2003) in addition to the SRCL data. Difficulties with different habitat classifications, resolution of mapping and so on meant that only a qualitative assessment was possible.

Where ‘relevant’ critical loads are exceeded over a significant area for a particular habitat, air pollution was listed as a current “pressure” and future “threat” (future/foreseeable impacts). Any field evidence of impacts on the habitats, or other impacts information, was also used to inform whether air pollution would be listed as a current pressure or future threat. In practice, this was largely confined to coastal habitats, which were not well represented by the critical loads exceedance assessment, and freshwater habitats, for which there were no applicable critical loads.

Denmark

Denmark has established a new national monitoring programme (NOVANA) (Svendsen *et al*., 2005) which includes systematic monitoring of terrestrial habitats (and species). This aims not only to provide information on status and trends, but also to provide insight into natural and anthropogenic pressures in order to inform management. For each Annex I habitat, a set of measurable indicators of favourable conservation status has been developed. These define favourable biological status for the habitat type in question and what physical-chemical conditions are required for this favourable status to be maintained. The programme is not only designed to detect any changes in conservation status, but also to give answers as to why the changes have happened. The programme combines intensive and extensive monitoring. The intensive monitoring will elucidate cause-effect relationships between trends, pressures and conservation status. The extensive monitoring provides representative data at a national scale. Some of the parameters measured between the two are the same, but the frequency is lower in the extensive monitoring.

A number of the indicators relate to nutrient effects because of the established concern over eutrophication. These typically include nitrogen deposition (which should not exceed the relevant critical load (based on UNECE, 2003)), C:N ratio in soil, tissue N content and pH, as well as species composition parameters. Relevant empirical critical loads have been assigned to each Annex I habitat based on equivalence between habitat types. Further information is given in Nielsen (this volume).

In the Article 17 report, Denmark reported “unknown” future prospects for forest habitats, because the positive effects of better pollution control, nature and forest restoration/protection might outweigh the negative effects of air pollution within the next 20-30 years. However, it is recognised that there is uncertainty concerning this and little quantification of the true extent of critical load exceedance of forest habitats. As a result air pollution has not been listed as a pressure/threat on the forest habitat types in the Danish Article 17 report.

Netherlands

There is no specific documentation within the Netherlands' Article 17 submission in respect of the approach for N deposition assessment. However, the results have shown that nitrogen deposition is a pressure and threat for several habitat types. This was based on a scientific report providing an approach for assessing nitrogen deposition impacts in Natura 2000 areas (Van Dobben and Van Hinsberg, 2008), which was subsequently adopted by the Dutch government (Dick Bal, pers comm.) (see also, Van Hinsberg and Van Dobben, this volume).

Van Dobben and Van Hinsberg (2008) provide a basis for setting critical loads for all Annex I habitat types based on a phased application of empirical critical loads for nutrient nitrogen (UNECE, 2003), model results and expert opinion:

- *Phase 1*. The Annex I habitat is compared to the habitat types (based on EUNIS habitat classification) for which empirical critical loads have been set (UNECE, 2003). There are two possible outcomes (a) the Annex I habitat is equivalent to, is part of, or sufficiently resembles a habitat type defined under EUNIS for which a critical load range is set (referred to as "UN type"); or (b) the Annex I type does not resemble, or does not sufficiently resemble a UN type.
- *Phase 2*. The result from Phase 1 needs to be further refined (a) (i.e. value set within range) or estimated (b). As far as possible this is done on the basis of model results (from the SMART2 model). Where there are no sufficiently reliable model results a Phase 3 is required.
- *Phase 3*. This uses expert opinion to set the critical load (and indicates uncertainty) on the absence of reliable estimates from the model.

Austria

The conservation status assessments in Austria were undertaken by nine separate States. There was no common countrywide approach to reporting "air pollution" or "eutrophication" pressures or threats across a range of habitat types. These assessments were done exclusively by expert knowledge for all species and habitats (Thomas Dirnböck, pers. comm.).

Germany

Germany has not directly used critical loads, as such, for Article 17 reporting, but nitrogen deposition and eutrophication play an important role for assessing conservation status, being taken into account mainly in the assessment of structure and function, including typical species, via a series of evaluation matrices for every habitat/species that were negotiated with experts and the Federal Länder in order to ensure at least within Germany a homogenous approach of the 16 Federal States (Länder) (Axel Ssymank, pers. comm.). Germany also has recently published a national guideline (VDI, 2008), which is aimed at identifying and monitoring unwanted N-eutrophication effects (also with regards Article 6.3). However, it is unclear whether or how this has been used to inform the nitrogen assessment for Article 17 reporting (Jürgen Franzaring pers. comm.).

Portugal

There is only one record of air pollution and two records of eutrophication as a pressure/threat on Portuguese habitats. These relate to grasslands. It was not possible to find any reports specific to this subject from the Portuguese Institute for Nature Conservation and Biodiversity (ICBN) or through direct contact, so the underlying assessment is unknown presently. However, the view of some of the Portuguese scientific research community is that the impact of nitrogen on biodiversity is not a priority subject for conservation biology and management, in the ICBN. Thus, nitrogen deposition was unlikely to have been considered in habitat conservation status reporting. However, there is more widespread concern from Portuguese scientists regarding nitrogen (particularly ammonia) deposition impacts on biodiversity (Cristina Branquinho, pers. comm.). A range of publications document the use of lichens as biomonitors and the impacts on epiphytic lichen communities (Pinho *et al*., 2008 and 2008).

Belgium

The Article 17 reporting for Belgium has been conducted separately for the Atlantic and Continental biogeographical regions in Belgium. The Research Institute for Nature and Forest (INBO) was responsible for the conservation status assessments of habitats and species in the Atlantic region of Belgium, which encompasses nearly the whole of Flanders.

In Flanders, reports on nitrogen deposition and critical load exceedance in a number of ecosystems (forests, grassland, heathland) are published annually (see www.milieurapport.be, www.natuurindicatoren.be). These reports are based on modelled deposition rates (1 km^2 spatial resolution, OPS-model) and on a geographically distributed set of point locations for which 'exact' critical load values are available. 'Exact' means that detailed soil profile information and vegetation characteristics have been taken into account to determine the part of the critical load range to apply for each of these points.

For the Article 17 reporting, a somewhat more empirical and simplified approach was used to assess the pressures and threats from nitrogen deposition. For each Annex I habitat type, a single empirical critical load for nutrient nitrogen was put forward, based on critical load literature and expert judgement. This critical load value was compared to average nitrogen deposition rates during the period 2001–2006 . Hence, spatial variation was not accounted for in N deposition or for differences in critical loads between locations or between Natura-2000 sites.

Habitat types for which the average 2001–2006 deposition exceeded their critical load where identified. For these types, fertilisation ('120') and air pollution ('702') were listed among the main pressures and as threat in the habitat assessment. Subsequently, the conservation status at biogeographical level regarding both 'specific structures and functions' and 'future prospects' was scored as either inadequate (U1) or bad (U2), depending on other pressures and threats.

Although roughly in line with common practice among Member States, INBO is aware that this pragmatic approach should be refined and improved for future conservation status assessments. INBO is currently looking into ways to improve the spatial resolution of model-based assessments and to complement this approach with measurements of N enrichment effects (cause-effect monitoring).

4.1.4 Illustrations of the results from the 2007 Article 17 report

The preliminary results from the 2001-2006 conservation status assessments, amounting to some 2771 habitat records, have been provided by the ETC. This has allowed an analysis across Member States and biogeographic regions of when "air pollution" and "eutrophication" have been identified as a pressure or threat for each habitat assessment.

The tables below provide an illustration of some potential outputs from the dataset. However, interpretation of the results should be made with caution: different methodologies have been used (as presented in Section 3); the use of pressure/threat categories "air pollution" and "eutrophication" appear to have been used variably between countries; and some countries made no assessment of the impacts of nitrogen deposition (whether because of no evidence/concern of nitrogen deposition impacts or because of no methodology, is not usually clear). Therefore, the results do not necessarily give an accurate representation of nitrogen deposition impacts on conservation status across the European Union. No comparison has been made with other pressures or threats as there is no

Table 4.1: Proportion (per cent) of records (habitat/biogeographic region/country) which record air pollution (code 702) or eutrophication (code 952) as a pressure or threat in Article 17 reporting for 20001-2006.

Broad Habitat Class	Pressure (per cent)	Threat (per cent)	Total number of records
Marine, coastal and halophytic habitats	25	25	351
Coastal sand dunes and continental dunes	36	37	258
Freshwater habitats	37	40	362
Temperate heath and scrub	30	31	134
Sclerophyllous scrub (matorral)	10	10	116
Natural and semi-natural grassland formations	27	29	416
Raised bogs and mires and fens	36	37	275
Rocky habitats and caves	18	19	276
Forests	21	22	583

guidance on prioritisation or weighting the relative importance (see comment in Section 2: this is to be addressed by the EC Expert Group).

Table 4.1 presents the proportion of records per broad habitat class across all Member States which have listed air pollution or eutrophication as a pressure to structure and function or as a threat to the future viability of the habitat. It is important to note that results also reflect other sources of eutrophication (and other nutrients for example phosphates) as well as atmospheric nitrogen deposition, particularly for habitats dominated by water and land-based sources such as marine, coastal and halophytic habitats and freshwater habitats.

Table 4.2 presents, by country, the proportion of habitat assessments for four broad habitat classes (as defined under Annex I of the Habitats Directive) which report air pollution or eutrophication as a pressure. These four broad habitat classes have been selected for illustration as they will tend to be dominated by atmospheric inputs (but not exclusively) of reactive nitrogen. These results can be compared to an estimate of risk from nutrient nitrogen deposition for each country, based on critical load exceedance in 2000 (EMEP domain) (CCE, 2008). The critical loads data incorporates all "natural ecosystem" area (as used by CCE, 2008), and care should be taken when comparing these with the columns presenting Article 17 assessment results which are presented as a proportion of the number of records per country which identify air pollution/eutrophication as a pressure (i.e. are illustrative of sensitivity and vulnerability) and are not illustrative of area. However, the table usefully shows that there are a number of countries where critical loads are exceeded over a substantial proportion of natural habitat, but where there are no records of air pollution or eutrophication being listed as a pressure (or threat – data not shown).

4.1.5 Identification and discussion of key issues

Introduction

In this paper, we have provided an introduction to conservation status reporting and have attempted, in so far that it has been possible, to provide examples of the methods used by a selection of countries to assess whether nitrogen deposition is a 'pressure' or 'threat', as well as an illustration

Table 4.2: Proportion (per cent) of assessment records for each Member State's Article 17 reports for 2001-2006, which show air pollution (code 702) or eutrophication (code 952) as a pressure for the broad habitat classes: forests; temperate heath and scrub; natural and semi-natural grassland formations; raised bogs and mires and fens.

Final column shows per cent of natural ecosystem area at risk of eutrophication based on critical loads exceedance in 2000 (CCE, 2008), this figure is not directly comparable with previous columns which show per cent of records not of area.

Country	Code	Proportion of assessments (per cent) showing air pollution or eutrophication as a pressure				Per cent 'natural ecosystem' area exceeding nutrient N CL in 2000
		Forests	Temperate heath and scrub	Natural and semi-natural grassland formations	Raised bogs and mires and fens	
Austria	AT	69 (32)	50 (4)	21 (24)	33 (15)	100
Belgium	BE	50 (20)	100 (4)	40 (15)	54 (13)	100
Bulgaria	BG	No data	No data	No data	No data	94
Cyprus	CY	0	0	25 (4)	0	68
Czech Republic	CZ	72 (25)	71 (7)	71 (21)	56 (9)	100
Germany	DE	86 (36)	33 (9)	23 (30)	64 (22)	84
Denmark	DK	0	100 (4)	44 (9)	85 (13)	100
Estonia	EE	0	0	0	13 (8)	67
Greece	EL	7 (27)	0	0	0	98
Spain	ES	6 (53)	0	6 (33)	47 (19)	95
Finland	FI	6 (17)	0	0	6 (16)	47
France	FR	2 (62)	16 (19)	30 (46)	44 (27)	98
Hungary	HU	0	0	0	20 (5)	100
Ireland	IE	0	33 (3)	0	0	88
Italy	IT	0	0	0	0	69
Lithuania	LT	15 (13)	0	0	0	100
Luxembourg	LU	0	100 (1)	29 (7)	100 (3)	100
Latvia	LV	11 (9)	0	0	14 (7)	99
Malta	MT	0	0	0	0	No data
Netherlands	NL	100 (7)	100 (2)	75 (8)	100 (7)	94
Poland	PL	28 (25)	25 (8)	37 (19)	0	100
Portugal	PT	0	0	19 (16)	0	97
Romania	RO	No data	No data	No data	No data	19
Sweden	SE	26 (35)	100 (8)	100 (31)	65 (23)	56
Slovenia	SI	0	0	11 (18)	0	98
Slovakia	SK	0	0	0	11 (9)	100
United Kingdom	UK	91 (11)	83 (6)	78 (9)	67 (9)	26*

**** UK figure is considered an underestimate (see Hicks et al., 2008) and national estimate is 61 per cent (Hall pers comm.). Number of assessment records is shown in parenthesis.***

of the results. However, in this collation, and in our own work for the UK's assessment of nitrogen deposition impacts, a number of issues and challenges have become apparent.

In this section we attempt to identify and summarise some of the key issues and challenges to assessing nitrogen deposition impacts on conservation status. These were discussed at the workshop and are reported in Whitfield *et al*., (this volume). A set of questions discussed at the workshop is given in Appendix 4.1.

Field evidence and confidence in attribution

Since historic/cumulative nitrogen deposition impacts should be evident in the current condition of habitats and their range and extent, consideration of the impacts is, in theory, implicit in conservation status assessments which are based on field surveys and monitoring. However, unless field sampling techniques are designed explicitly to do so, and are sufficiently representative to be scaled up, it is difficult to attribute nitrogen deposition effects and this can lead to significant under-reporting, or the reliance on risk assessment approaches such as critical loads. Nitrogen deposition impacts are particularly challenging to attribute because of the interplay between pollution impacts, management and abiotic and biotic stresses. Whilst there may be examples of some well researched sites where nitrogen deposition impacts can clearly be demonstrated and attributed, scaling this up to country level reporting and subsequently the biogeographic region is difficult. This leads to the question as to how confident we need to be to record something as a pressure or a threat and ultimately to engender a policy response?

Denmark specifically includes a range of nitrogen biomonitoring measures in conservation objectives and undertakes monitoring of these as part of representative sampling across habitats. This represents the most rigorous approach (on the basis of reports available at the time of writing) to assessing nitrogen deposition impacts on conservation status. However, there remain questions regarding the robustness of biomonitoring methods (Sutton *et al*., 2004; Leith *et al*., 2005; and see background paper for Topic 3), in addition to significant resource implications if they were to be widely applied.

Two key topics for discussion are therefore (a) interpreting field evidence and the attribution of nitrogen deposition, and (b) use of bioindicators.

Use of critical loads

A number of countries have used critical loads exceedance mapping (with various adaptations) as a basis for assessing whether nitrogen deposition is a current pressure or future threat. This is unsurprising, and advantageous, since critical loads are an established tool (i.e. under the Convention on Long-Range Transboundary Air Pollution) and used routinely in European air pollution policy development. However, there are a number of issues concerning the application of critical loads and exceedance estimates. For example:

- They are a risk assessment tool and do not provide actual evidence of impacts (conversely this is useful for predictions of threats to future viability). There needs to be good confidence in the relationship between exceedance and effects on conservation status (e.g. structure and function, viability) of sensitive habitats and at present this is variable.
- Critical loads need to be assigned to Annex I habitats, since they are currently based on the EUNIS habitat classification. Many habitats will not have a 'relevant' critical load, others have a very weak equivalence with the habitats for which critical loads are set (which are often a lower EUNIS level). Furthermore, the research underpinning the 'relevant' critical load may be poorly indicative of impacts on a specific Annex I habitat.

- Countries' mapping of habitats for critical loads assessments may not correspond well with Annex I habitat mapping.
- Deposition modelling resolution varies and may not be appropriate for habitat/site level reporting.
- Critical loads are difficult to apply to species as they are habitat based and the relationship between habitat level responses and effects on species is complex.
- Dynamic models for nitrogen deposition impacts are under development and have been used by some countries to refine critical loads for Annex I habitats (and subsequently inform conservation status assessments). Their potential for a wider application in conservation status assessments should be discussed.

Defining impacts on structure and function and viability

For the conservation status of a habitat to be favourable, the assessment must show that "the specific structure and functions which are necessary for its long-term maintenance exist and are likely to continue to exist for the foreseeable future". There is little guidance on the definition of structure and function. Nitrogen deposition potentially represents a pressure to this parameter, but the mechanisms for this need articulating. Furthermore, the relevance and appropriateness of bioindicators (including biochemical measures) and critical loads exceedance, as measures of impact of nitrogen deposition on this parameter, need to be considered.

The Directive defines when the conservation status of a habitat is to be considered as favourable. It requires that the range and area of the habitat should be at least maintained at their status when the Directive came into force or, where the status at that time was not viable in the long term, should be restored to a position where it would be viable.

Since there may have been significant changes in plant communities and species distribution prior to the Directive in areas exposed historically to high deposition, it is interesting to consider the requirement for recovery. This raises the question of what the objectives for recovery should be in order to fulfil the Directive's aims. It is unlikely that there is scope for highly aspirational targets in relation to conservation status i.e. a return to a former pristine state. Therefore, perhaps a more relevant question to consider is that of demonstrating the further/continuing risks to habitat viability. Understanding the impacts on habitat viability against a generally improving background deposition is an important consideration.

However, it is important to consider potential for recovery in the context of the 'future prospects' parameter. How should a declining background nitrogen deposition be accounted for even when critical load exceedance remains over large areas?

A further question to consider is whether there is cross linkage between conservation status assessment, and effects on structure and function, and consideration of ecosystem services and this will be considered in Theme 5 (see Section 7).

Definitions of threat and pressure

In the assessments of conservation status, Member States were required to list the main pressures and threats from a list in the EC guidance. However, for the 2007 reporting round there was no guidance as to how to judge which are the 'main' pressures and threats (i.e. how to prioritise), nor any on the definitions themselves. It is apparent that two categories, those of "air pollution" and "eutrophication", have been used in respect of nitrogen deposition impacts (and possibly "acidification" and "fertilisation"). However, eutrophication is also commonly used with respect to water quality issues. It is therefore difficult to untangle the various sources of nitrogen inputs and compare results, thus limiting the degree of analysis which is possible. Looking forward to the next reporting round this is clearly an area which could be improved. This is being addressed for the next reporting round.

4.1.6 Conclusions

The results presented above illustrate that 'air pollution' or 'eutrophication' have been recorded as a pressure or threat on a significant number of habitat assessments across Europe. It is not possible to undertake a detailed analysis of this and examine the relative importance of specific pathways of pollutant inputs (e.g. for eutrophication this may be water, land-based or atmospheric inputs), or to compare to other pressures and threats, and thus draw out many useful conclusions. However, a focus on habitats which are only vulnerable to atmospheric inputs supports the case that nitrogen deposition is an important pressure to habitat structure and function and a threat to future prospects.

The Habitats Directive is a cornerstone of European biodiversity legislation. A robust assessment of the effects of nitrogen deposition on conservation status is necessary. In turn, this can be used as a driver for air pollution policy development and mitigation. Because of the transboundary nature of air pollution and the active policy agenda on this issue in the European Union, it would be reasonable to advocate that a consistent methodology for assessing nitrogen deposition impacts on conservation status be agreed and implemented.

There are common assessment tools such as critical loads, used for example in impact analysis and optimisation under the Convention on Long-Range Transboundary Air Pollution and the National Emissions Ceilings Directive. However, there is a need to strengthen the collaboration and, establish as common set of objectives, between the different communities working on nitrogen impacts assessment. It is recommended that the possibility of further work on improving/developing the use of critical loads, in the context of conservation status assessments, is explored.

This paper has presented the methodologies used by some Member States for assessing the effects of nitrogen deposition on conservation status. 18 Member States reported that 'air pollution' was a pressure or threat in at least one habitat assessment (and all 25 reported "eutrophication" for at least one habitat record). However, it was difficult to get access to information on the approaches that different countries used for this assessment. Despite large critical load exceedance, in many countries only a small proportion of sensitive habitats, or some cases none, were recorded as being affected by nitrogen deposition. This raises the question as to whether it reflects a low level of recognition of the pressure in many countries, or whether it reflects that the effects, which are evident on the research scale and indicated by critical loads exceedance maps, are not widely detected, and/or attributed, in the field at the broad scale.

In the previous section, we identified some of the issues and challenges concerning the assessment of nitrogen deposition on conservation status. Looking ahead to the next reporting round in 2013, the aim of the workshop session is to agree a focussed list of issues/challenges, to explore how they may be addressed and to provide recommendations for taking this forward, including how it could feed into the current review and improvement of the reporting guidance. This will include discussing scientific questions (for example, regarding field evidence and application of critical loads) and also exploring the mechanisms/routes for delivery and the potential organisations involved.

Acknowledgements

The authors would like to thank the following people for information supplied to inform this paper: Thomas Dirnböck, Cristina Branquinho, Carlos Romao, Doug Evans, Angelika Rubin, Maarten Hens, Axel Ssymank; Erik Buchwald, Helle Vibeke Andersen, Dick Bal, Petr Roth, Jean-Paul Hettelingh, Jürgen Franzaring.

References

Bealey, W.J, Dore, A., Vieno, M. and Sutton, M.A. (2007) *Source attribution and critical loads assessment for Special Areas of Conservation and Special Protection Areas in the UK*. SNIFFER Project AQ02.

CCE (2008) CCE Status Report 2008: *Critical load, Dynamic Modelling and Impact Assessment in Europe*. Coordination Centre for Effects, Netherlands Environmental Assessment Agency (available at http://www.mnp.nl/en/themasites/cce/publications/cce-status-report-2008/index.html).

European Commission (1997) Appendix E of the Explanatory Notes of the Natura 2000 Standard Data Form. Commission Decision of 18 December 1996 concerning a site information format for proposed Natura 2000 sites. Official Journal of the European Communities, 97/266/EC (available at: http://ec.europa.eu/environment/nature/legislation/habitatsdirective/docs/standarddataforms/form_notes_en.pdf).

European Commission (2006) *Assessment, monitoring and reporting under Article 17 of the Habitats Directive: Explanatory Notes & Guidelines* (available at: http://circa.europa.eu/Public/irc/env/monnat/library?l=/habitats_reporting/reporting_2001-2007/guidlines_reporting&vm=detailed&sb=Title).

European Commission (2009) *Composite Report on the Conservation Status of Habitat Types and Species as required under Article 17 of the Habitats Directive*. COM(2009) 358 Final, Brussels, Belgium (available at: http://ec.europa.eu/environment/nature/knowledge/rep_habitats/docs/com_2009_358_en.pdf).

EEA (2007) *Halting the loss of biodiversity by 2010: proposal for a first set of indicators to monitor progress in Europe*. Technical report No 11/2007 (available at: http://biodiversity-chm.eea.europa.eu/information/indicator/F1090245995).

Hall, J., Ullyett, J., Heywood, L., Broughton, R., Fawehinmi, J. and 31 UK Experts (2003) *Status of UK critical loads: critical loads methods, data and maps*. Report to Defra, Contract EPG1/3/185.

Hicks, K., Harmens, H., Ashmore, M., Hall, J., Cinderby, S., Rowe, E., Frey, S., Cooper, D. and Emmet B. (2008) *Impacts of nitrogen on vegetation*. Final Report Work Package 5. The UNECE International Cooperative Programme on Vegetation. Defra Contract AQ0810.

Leith, I.D., van Dijk, N., Pitcairn, C.E.R., Wolseley, P.A., Whitfield, C.P. and Sutton, M.A (2005) *Biomonitoring methods for assessing the impacts of nitrogen pollution: refinement and testing*. JNCC Report No. 386, Peterborough, United Kingdom (available at: http://www.jncc.gov.uk/page-3886).

NEGTAP (2001) *Transboundary Air Pollution: Acidification, Eutrophication and Ground-level Ozone in the UK.* National Expert Group on Transboundary Air Pollution. DEFRA, Contract EPG 1/3/153.

Pinho, P., Augusto, S., Martins-Loução, M.A., João-Pereira, M., Soares, A., Máguas, C. and Branquinho, C. (2008) Causes for change in nitrophytic and oligotrophic lichens species in Mediterranean climate: impact of land-cover and atmospheric pollutants, *Environmental Pollution*, 154, 380-389.

Pinho, P., Branquinho, C., Cruz, C., Tang, S., Dias, T., Rosa, A.P., Máguas, C., Martins-Loução, M.A. and Sutton, M. (2009) Assessment of critical levels of atmospherically ammonia for lichen diversity in cork-oak woodland, Portugal. Chapter:Critical loads. In: *Atmospheric Ammonia - Detecting emission changes and environmental impacts - Results of an Expert Workshop under the Convention on Long-range Transboundary Air Pollution* (eds. Sutton, M., Reis, S. and Baker, S.). Springer.

Singles, R., Sutton MA. and Weston, K.J. (1998) A multi-layer model to describe the atmospheric transport and deposition of ammonia in Great Britain. *Atmospheric Environment,* 32, 393-399.

Smith, R.I., Fowler, D., Sutton, M.A., Fechard, C. and Coyle, M. (2000) Regional estimation of pollutant gas deposition in the UK: model description, sensitivity analyses and outputs. *Atmospheric Environment*, 34, 3757-3777.

Sutton, M.A., Pitcairn, C.E.R. and Whitfield, C.P. (2004) *Bioindicator and biomonitoring methods for assessing the effects of atmospheric nitrogen on statutory nature conservation sites*. JNCC Report No. 356, Peterborough, United Kingdom (available at: http://www.jncc.gov.uk/page-3236).

Svendsen, L.M., Bijl, L van der, Boutrup, S. and Norup, B. (2005) NOVANA: National *Monitoring and Assessment Programme for the Aquatic and Terrestrial Environments. Programme Description - Part 2.* National Environmental Research Institute, NERI Technical Report No. 537, Denmark (available at: http://www.dmu.dk/NR/rdonlyres/5EC5E735-724E-4769-A560-D53613C89536/0/FR537_www_S_H.pdf).

UNECE (2003) *Empirical critical loads For Nitrogen*. Proceedings from Expert Workshop Berne 11-13 November 2002. Swiss Agency for Environment, Forest and Landscape (SAEFL), Berne, Switzerland.

Van Dobben, H. and van Hinsberg, A. (2008) Overzicht van kritische depostiewaarden voor stikstof, toegepast op habitattypen en Natura 2000-gebieden. Alterra-rapport 1654. Alterra, Wageningen, Netherlands.

VDI (2008) *Vegetation as an indicator of nitrogen input - assessment of nitrogen availability by Ellenberg indicator values of forest ground vegetation*. VDI/DIN Manual Air Pollution Prevention Volume 1 A: Maximum Emission Values, Düsseldorf, Germany (available at: http://www.beuth.de/cmd?workflowname=CSVList&websource=vdin&artid=111917291&languageid=en).

Williams, J.M. (2006) *Common Standards Monitoring for Designated Sites: First Six Year* Report. JNCC, Peterborough, United Kingdom.

Appendix 4.1 – List of questions discussed at the workshop

Priority questions in ***bold***

1. ***Why is an assessment of nitrogen deposition as a 'pressure' or 'threat' in the assessment of conservation status under Article 17 necessary? Is a common approach across Member States necessary?***

2. Pressures and threats list – definitions and recommendations. Capturing other air pollutants?

3. Evidence from survey and monitoring including:

a. How does N deposition effect habitat structure and function, and habitat viability.

b. How to measure/assess from field evidence:

   i. scaling from site to habitat/broad scale;
   ii. monitoring/surveillance approaches
   iii. attribution of N as a causal factor (versus other multiple drivers)

iv. use of bioindicators: 'exposure' indicators; 'effect' indicators – linking response to habitat structure and function or viability.

4. Use of critical loads including:

a. **Relationship to structure and function.**
b. Assignment to Annex I habitats – methods and challenges.
c. Habitat mapping issues.
d. Resolution of deposition mapping – suitable?
e. What proportion of habitat area needs to be exceeded to trigger inclusion as a significant pressure or threat?
f. What extent/proportion of exceedance is needed to trigger conclusion of unfavourable?
g. Assignment of critical loads to species – methods and challenges
h. Dynamic modelling – what potential does it offer. Development requirements.

5. Recovery (including level of ambition) and viability

6. Declining emissions/deposition – what does this mean for future prospects judgements?

7. What should be the approach for species listed in Annex II, IV and V of the Directive?

*8. **What is the process for developing this approach and subsequent guidance?***

4.2 Working group report

C. Whitfield[1], I. Strachan[2] (Chair), J. Aherne[3], T. Dirnböck[4], N. Dise[5], J. Franzaring[6], J. Hall[7], M. Hens[8] (Rapporteur), A. van Hinsberg[9], A. Mansat[10], M. A. Martins-Louçao[11], B. Mohaupt-Jahr[12], K. E. Nielsen[13], R. Pesch[14], E. Rowe[7] and J. M. Santamaría[15]

1 Joint Nature Conservation Committee, UK
2 Scottish Natural Heritage, UK
3 Trent University, Canada/ University College Dublin, Ireland
4 Austrian Environment Agency, Austria
5 Manchester Metropolitan University, UK
6 Universität Hohenheim, Germany
7 Centre for Ecology and Hydrology, UK
8 Research Institute for Nature and Forest, Belgium
9 PBL, Netherlands Environmental Assessment Agency, Netherlands
10 CNRS EcoLab, France
11 Universidade de Lisboa, Portugal
12 German Federal Environment Agency – UBA, Germany
13 National Environmental Research Institute, Denmark
14 University of Vechta, Germany
15 University of Navarra, Spain

4.2.1 Conclusions and recommendations of group discussions

It was concluded that nitrogen deposition represents a major threat to semi-natural vegetation across Europe. There is widespread exceedance of critical loads for nutrient nitrogen and acidification and substantial field and experimental evidence of the impacts. Such responses threaten the achievement of favourable conservation status for a large number of Annex I habitats.

It was concluded that the impact of nitrogen deposition on conservation status should be explicitly considered in Article 17 reporting, and the results should inform air pollution policy development.

It was concluded that there is a need for a common methodology for assessing the threat from nitrogen deposition to conservation status to be developed for application across Europe. This requires an improved dialogue between air pollution and biodiversity communities, building on recent progress in this area such as the development of a nitrogen deposition indicator under the Streamlining European Biodiversity Indicators (SEBI) programme.

It is recommended that a harmonisation of the methodology for nitrogen deposition assessment in conservation status reporting is required.

It is recommended that the lists of pressures and threats used for Article 17 reporting of conservation status should include nitrogen deposition explicitly and be more clearly defined.

It was noted that there is a requirement for greater clarity in the definition of 'favourable conservation status' for different habitats or groups of habitats, particularly with respect to defining important elements of structure and function. It is recommended that a series of habitat working groups should be established between interested Member States to take this forward.

It is recommended that the Working Group on Effects (WGE) of the UNECE Convention on Long -range Transboundary Air Pollution (CLRTAP) and the Expert Group on Reporting under the Nature Directives should be brought together in order to develop a methodology for the assessment of nitrogen deposition impacts on conservation status. A two-tiered approach is recommended as the basis of further development:

- Tier 1: An assessment based on empirical critical loads for nutrient nitrogen deposited to sensitive Annex I habitats. This would build on the already established critical loads exceedance methodologies developed under the CLRTAP, but requires further development to apply the concept consistently to Annex I habitats of the Habitats Directive and to recommend the most appropriate deposition data. It would enable identification of nitrogen deposition as a "threat to future prospects" and also be used to help interpret species or biogeochemical based monitoring data in order to identify whether nitrogen deposition is a 'pressure to current structure and function'.
- Tier 2: Monitoring (likely to be non-mandatory) should be made up of biotic and abiotic variables to determine where nitrogen deposition is a significant pressure on structure and function. This would require agreement of abiotic and biotic variables/values relating to favourable conservation status and the production of a first set of European guidelines on this topic.

4.2.2 Introduction to structure of discussions

The Habitats Directive requires Member States to take measures to maintain at, or restore to, favourable conservation status, the natural habitats and species of Community Importance. Member States are required to report on conservation status every six years. This requires an assessment in respect of the range, area, structure and function and future prospects of habitats (including 'typical species'), and includes a consideration of the pressures and threats to their conservation status. Assessing the pressure or threat of nitrogen deposition impacts on conservation status is important if it is to inform air pollution policy development and to ensure that it is targeted appropriately to help achieve the objectives of the Habitats Directive. Therefore, the overarching objectives of Working Group 2 were to share experience and good practice with respect to the approaches taken in the 2007 reporting round and to discuss harmonising approaches and recommended methods for future reporting rounds.

At the start of the meeting, the members of the group agreed a list of questions or issues that were to be discussed during the meeting. An introduction to the issues and the context can be found in Whitfield and Strachan (this volume). The questions are listed below and those in bold were seen as a priority for discussion:

a. Why is an assessment of nitrogen deposition as a 'pressure' or 'threat' in the assessment of conservation status under Article 17 necessary? Should there be a common approach across Member States?

b. Pressures and threats list – definitions and recommendations.

c. Using evidence from survey and monitoring.

d. Use of critical loads/levels.

e. Recovery (including level of ambition) and viability.

f. Declining emissions/deposition – what does this mean for future prospects judgements?

g. What should be the approach for species listed in Annex II, IV and V of the Directive?

h. What is the process for developing this approach and subsequent guidance?

To lead into the main discussion, group members were given the opportunity to give presentations concerning the approach taken in their country for Article 17 reporting, or to present the methods and results of research or monitoring which potentially could inform the assessments in the future. Some of the presentations are published as papers in this volume and their content is not recorded in this report of the meeting. However, some of the points raised and conclusions from the presentations are reflected in the discussion of the questions.

4.2.3 Highlights of discussion and views expressed

Why is an assessment of nitrogen deposition as a 'pressure' or 'threat' in the assessment of conservation status under Article 17 necessary? Should there be a common approach across Member States?

Nitrogen deposition represents a major threat to semi-natural habitats across Europe. It is agreed by scientists and national authorities that widespread eutrophication is responsible for ecological change and the loss of important taxa. Large areas of semi-natural/natural ecosystems including Natura 2000 sites, exceed the critical load for nutrient nitrogen and acidification (CCE, 2008). A number of recent studies have shown a decline in species richness of habitats related to nitrogen deposition (for example, Stevens *et al*., 2004; Maskell *et al*, 2010, Van Hinsberg *et al*., 2008, Dupre *et al.,* 2009). Many natural habitats and species of conservation interest thrive in nutrient poor habitats (e.g. BfN 1998, Bunce *et al*., 1999, Ellenberg *et al*., 2001, Preston *et al*., 2002, Braithwaite *et al*., 2006, EEA 2007; Dias *et al*., this volume) and conservation of many keystone species relies on reducing nitrogen loads on the long term. Nitrogen deposition rates are predicted to remain high in Europe for the coming decades.

The Habitats Directive is a cornerstone of European biodiversity policy, it is important that the effects of nitrogen deposition are considered in relation to the Directive's objectives and this should influence the development of air pollution policy. However, if there is an under-reporting of the scale and threat of nitrogen deposition, this will serve to weaken the drivers for further policy in this area.

A common approach is necessary to provide a consistent and comparable assessment across Europe. However, in establishing guidelines, it must be recognised that Member States are likely to have access to different levels of capacity with respect to assessment tools.

There are several bodies working on air pollution impacts in Europe, including the Working Group on Effects (WGE) of the Convention on Long-Range Transboundary Air Pollution (CLRTAP) and work undertaken for the review of the National Emissions Ceilings Directive. There has been some coming-together of groups for the development of indicators of nitrogen deposition impacts e.g. through the Streamlining European Biodiversity Indicators (SEBI) 2010 programme (EEA, 2007). There is recognition within CLRTAP that improved links to biodiversity research are needed, and the 19th workshop of the Coordination Centre for Effects (CCE) recently recommended that the WGE explore the applicability of a European scale of indicators for damage to biodiversity. Nonetheless there needs to be an improved dialogue between the air pollution communities and those working on biodiversity policy such as the Habitats Directive, in order to ensure the evidence of nitrogen deposition impacts is fully considered in relation to assessments of conservation status.

List of Pressures and threats – definitions and recommendations
There was not sufficient time to discuss this in detail and provide recommendations on categories and definitions. It was noted that there is currently no guidance on the use of the categories and their definitions, but that this is being reviewed. It was evident that Member States had used different categories to represent nitrogen deposition in the 2007 reporting round. Nitrogen deposition could potentially be recorded under ‘air pollution’, ‘eutrophication’, ‘acidification’, or ‘fertilisation’. There was also concern that there was no way to prioritise or scale the various pressures or threats. The consensus of the group was that there needs to be a single category to which nitrogen deposition is clearly attributable. It is important that the categorisation can be used to inform subsequent policy response, and this needs to be borne in mind when combining pressures/threats (i.e. nitrogen deposition needs to be explicit).

Using evidence from survey and monitoring
Nitrogen deposition can affect the structure and function of sensitive habitats. Excessive inputs may impact sensitive species directly; may change species composition through altering competitive interactions or the soil chemical environment; and may increase susceptibility to other abiotic/biotic stresses such as disease and herbivory. Direct toxic effects are greater from dry deposition than from wet nitrogen deposition, and from reduced than from oxidised forms of nitrogen for the same relative dose. The different types of deposition also affect competitive interactions, since different plant species are adapted to using nitrate, ammonium or dissolved organic nitrogen. A major effect of increased N deposition is to increase the growth of competitive, tall-growing species, and hence species most at risk are those requiring high levels of light at ground level such as short-growing plants and associated invertebrates, other nutrients and water stress may play an important role (sections 5.1 and 5.2).

The group discussed a number of challenges regarding how to interpret evidence from surveys and monitoring in terms of identifying impacts of nitrogen deposition on conservation status. This ranged from the difficulty of attributing nitrogen effects from species-based monitoring, applying biomonitoring techniques and scaling up site-specific measurements to habitat level assessments.

One of the difficulties in defining the assessment and any monitoring that may be required is the need for more clarity on the definition of favourable conservation status for different habitats or groups of habitats. In particular, what are the important elements of structure and function? Nitrogen deposition impacts could then be related to these conditions if they were defined. However, it was highlighted that this element had previously been left open to Member States. It was recommended that a series of habitat-specific working groups should be established between interested Member States to take this forward.

A range of bio-indicators are available. The topic was discussed by Working Group 3 (Bobbink and Hettlelingh, 2010) and so individual methods were not discussed in detail in Working Group 2. It was agreed that when considering the use of bio-indicators and results from vegetation surveys it is necessary to differentiate whether the method is indicative of 'exposure' (which might help to refine deposition/concentration estimates in relation to the critical load/level or to verify exposure estimates in spatially variable areas) or 'response' (in terms of elements of structure and function). With respect to 'response' it was agreed that interpreting cause and effect from species level changes is extremely hard because of multiple drivers. Biogeochemical responses may have more potential with regards to attribution, but the relationship between the abiotic and biotic variables and conservation status is poorly defined (but note that Denmark have defined this for various habitats and response variables and they are monitored through the NOVANA network (Svendsen *et al*., 2005).

It is difficult to prescribe response variables and monitoring requirements because of a lack of a definition of structure and function for different habitats, and because the approach taken in Member States is variable. Any bio-indicators should be practical, simple, robust, specific and cost-effective. Sampling and vegetation relevées need to be representative and with sufficient statistical power to detect and attribute pressures. Interpreting species responses, which can be influenced by many factors, is difficult, therefore biogeochemical measurements are also recommended (particularly when considering the broad scale effects where there are multiple sources of nitrogen). However, requiring additional mandatory sampling of nitrogen response variables is unlikely to be accepted by Member States.

Use of critical loads exceedance

Critical loads (and levels for concentrations) are established tools for air pollution policy development (i.e. under the CLRTAP). The CCE (CCE, 2008) maps critical loads and exceedance across European countries. Each of the Member States which undertook an explicit assessment of nitrogen deposition impacts on conservation status in the 2007 reporting round had used critical loads, in some form, as part of their assessment methodology. The working group agreed that critical loads and critical loads exceedance should be an element of any recommended methodology. The group discussed some of the issues and questions regarding the use of critical loads (e.g. as raised by Whitfield and Strachan, this volume) with respect to assessing nitrogen deposition as a pressure on current structure and function and a threat to future prospects, as follows.

a. <u>Relationship to structure and function</u>. Critical loads exceedance mapping is a risk assessment tool to identify areas or habitats where there may be adverse effects from nitrogen deposition at some point. The principal focus of Working Group 2 was eutrophication effects. However, it was noted that nitrogen deposition also contributes to acidification and some studies (e.g. Dupre, 2009) have identified pH and nitrogen deposition as the main variables explaining declines in species richness. It was agreed by the group that critical loads were a suitable assessment tool for predicting effects on the functioning of habitats. There are a number of uncertainties in critical loads and estimates of exceedance. One significant limitation is the lack of temporal definition. Empirical nutrient nitrogen critical loads are protective for 20-30 years and this is consistent with the timeframe for the 'future prospects' parameter (European Commission, 2006). Exceedance of the critical load infers that damage will occur at some point, but does not indicate when. In the case of nitrogen deposition, effects may have occurred before the implementation of the Habitats Directive, particularly in high deposition areas. Thus problems can arise with regard to a reference year. The group were confident in the application of critical loads exceedance as a tool to identify nitrogen deposition as a threat to 'future prospects' (see recommendations below concerning improving the application of critical loads to Annex I habitats). Information on critical loads exceedance may also be a useful aid to interpreting species or biogeochemical responses. However, there was less confidence in the application of critical loads exceedance in respect of assessing effects on current structure and function, in the absence of corroborative evidence from species composition/structure data and/or biogeochemical indicators. For example, if the species composition and structure of a habitat are both judged to be favourable, is critical load exceedance sufficient to turn assessment for the parameter "structure and function" to unfavourable-inadequate or unfavourable-bad?

b. Assignment to Annex I habitats – methods and challenges There was general concern that countries currently use different methods to generate nitrogen critical loads (e.g. calculated (mass balance), empirical and dynamic models) as set out in the CCE Mapping Manual (UBA, 2004). It was recommended that the empirical critical loads (UNECE, 2003) are the most applicable in respect of effects on structure and function, since many are set on the basis of species change end points or ecosystem processes *vs.* critical nitrogen concentration in soil for calculated nitrogen critical loads.

However, empirical critical loads are set for habitats classified under EUNIS and this requires a conversion to Annex I habitats. There are examples from the UK (Bealey *et al*., 2007), Netherlands (see van Hinsberg and van Dobben, this volume), Denmark (Svendsen *et al*., 2005) and the German Land of Brandenburg (LUA, 2008). This conversion introduces possible inconsistencies. Furthermore, some Annex I habitats do not have a relationship with any of the EUNIS classes for which a critical load is set and so it is not possible to assign a critical load. An update of the UNECE 2003 empirical critical loads for nutrient nitrogen was conducted in 2010 (Bobbink et al., 2010). Ideally empirical critical loads should be developed with favourable conservation status as an endpoint.

The group recommended that the proposed review of critical loads includes the assignment of empirical critical loads for nutrient nitrogen to Annex I habitats with the concept of favourable conservation status as an 'end-point'. This could include the following steps:

- Identify which Annex I habitats are potentially sensitive to nitrogen enrichment (from nitrogen deposition)
- Assign 'relevant' empirical nitrogen critical load to Annex I habitat types
- Provide information on the confidence in this allocation where based on comparison of EUNIS and Annex I habitat classifications.
- Where it is not possible to assign a critical load provide recommendations on sensitivity if possible.
- Provide further guidance on applying the modifying factors to help steer which part of the range might be more applicable for certain conditions/locations/management regimes.

c. Habitat mapping issues. Digital mapping of Annex I habitat distribution is required in order to map associated empirical critical loads for nitrogen and exceedance. However, currently these are not available for all countries. The Explanatory Notes (European Commission, 2006) recommend using grid based data, typically at 10 km scale to estimate range and these could be used to map critical loads. It was reinforced that the concept of conservation status is not confined to Natura 2000 sites since the habitat resource outside the sites may make a significant contribution to the overall status (the extent of which varies on a case-by-case basis). This aspect would need further consideration when refining the approach for mapping critical loads for Annex I habitats.

d. Resolution of deposition mapping – suitability. There was concern over the resolution of deposition mapping (EMEP = 50x50km grid; but 10x10km grid under development) which misses much of the sub-grid variation of nitrogen emissions and deposition and the patchy distribution of Natura 2000 sites. This is particularly important with dry deposition of ammonia and for assessments at the site or habitat scale. Because of this relatively low resolution, results may differ to those from national-scale higher resolution models which provide a more representative estimate of exceedance at a more appropriate resolution (e.g. 5x5km, 250x250m). This may lead to an under- or overestimate of the habitat area exceeded when using deposition from the EMEP model.

e. What proportion of habitat area needs to be exceeded to trigger inclusion as a significant pressure or threat? And what extent/proportion of exceedance is needed to trigger a conclusion of ‘unfavourable’? It was agreed that guidance on this would be necessary, but no recommendations were made at the meeting. It was noted that the guidance for the 2007 reporting round (European Commission, 2006) stipulated the “unfavourable-bad is where more than 25 per cent of the areas of the habitat is unfavourable as regards its specific structures and functions (including typical species)”. An example is given as “by discontinuation of former management, or is under pressure from significant adverse influences, e.g. critical loads of pollution exceeded”.

f. Assignment of critical loads to species – methods and challenges. Not discussed due to time constraints.

g. Dynamic modelling – what potential does it offer. National Focal Centres are being encouraged to use dynamic models by the CCE. Netherlands have used them to refine/develop critical loads for Annex I habitats (see van Hinsberg, and van Dobben, this volume) and such an approach was supported by the group. There was some discussion over the requirement to develop end points directly related to impacts on a habitat’s species (or specifically ‘typical species’) (see Rowe, *et al.*, this volume) and how these could be defined. Models predicting environmental suitability for plant species are available (de Vries, *et al.*, 2010), but to make use of such forecasts it is necessary to define which species are important for the conservation status of each Annex I habitat. The Habitats Directive Interpretation Manual (European Commission, 2007) lists characteristic species for different habitat types, but these are not necessarily the most appropriate to use in many cases. Member States had been required to identify typical species for each habitat at a national/regional level as part of the 2006 Article 17 reporting, based on guidance in the Explanatory Notes (European Commission, 2006). This had not been straightforward to do and there was a risk of circularity in their use. There was debate as to whether it is necessary to predict effects on species ‘end points’, raising the question of how to define which species (or species attributes such as cover) are critical to an Annex I habitat, and by inference its conservation status; or whether a biogeochemical measure such as C:N is sufficient, as this represents effects on ecosystem processes, which are an instrumental part of the concept of structure and function.

Recovery and viability. Since nitrogen deposition in many parts of Europe has exceeded critical loads for many decades, it may be expected that changes have occurred to habitats, for example with a loss of sensitive species, prior to the Directive coming into force. This led to the question of what the ambitions for recovery should be in the context of the objectives of the Directive. It was agreed that any assessment of recovery or ongoing effects on viability needs to define a desired state. This could define a habitat in terms of a desired species composition or biogeochemical status and that would be the basis of defining whether the status is favourable. Whilst in high deposition areas some sensitive elements may have been lost and the objective (in the context of the Habitats Directive requirements) may not be for their recovery, it may still be possible to show that ongoing high nitrogen inputs are affecting the ecosystem functioning by failing to sustain the low nutrient conditions essential for the supporting processes of a viable Annex I habitat.

Declining emissions/deposition – what does this mean for 'future prospects' judgements?
There was not time to discuss this in detail as priority was given to other questions. Discussions led on from those on recovery and viability and in relation to future prospects and also in relation to critical loads (see Section 5.2). Even where deposition is decreasing, it still poses a risk of harmful effects where it exceeds the critical loads. Furthermore, even where deposition has fallen below the critical loads, this does not mean that habitats will have recovered (see Figure 4.2 and associated text for fuller explanation of this point).

It was noted that in Spain emissions of some pollutants, for example ammonia, have been increasing over recent years and in Portugal ammonia emissions are stable. Therefore, it is not the case that there is reduction in reactive nitrogen emissions across all countries.

What should be the approach for species?
There was not time to discuss an approach for assessing nitrogen deposition impacts on conservation status of species (Annex II, IV and V). There was a consensus that it should be considered, but is likely to be more complex than for habitats, which should be the first priority.

What is the process for developing this approach and subsequent guidance?
Having considered the potential use of field evidence, monitoring, critical loads/dynamic modelling, and issues surrounding the timing of impacts, the group discussed how this could fit into a framework for conservation status assessments.

The recommendations were for a two-tiered system:

Tier 1:An assessment based on empirical critical loads for nutrient nitrogen applied to sensitive Annex I habitats. This would build on the already established critical loads exceedance methodologies developed under the CLRTAP, but requires further development to apply the concept consistently to Annex I habitats of the Habitats Directive and to recommend the most appropriate deposition data. It would enable identification of nitrogen deposition as a "threat to future prospects" and also be used to help interpret species or biogeochemical based monitoring data in order identify whether nitrogen deposition is a 'pressure to current structure and function'

Tier 2: Monitoring (likely to be non-mandatory) should be made of biotic/abiotic variables to determine where nitrogen deposition is a significant pressure on structure and function. This would require agreement of abiotic and biotic variables/values relating to favourable conservation status and the production of a first set of European guidelines on this topic.

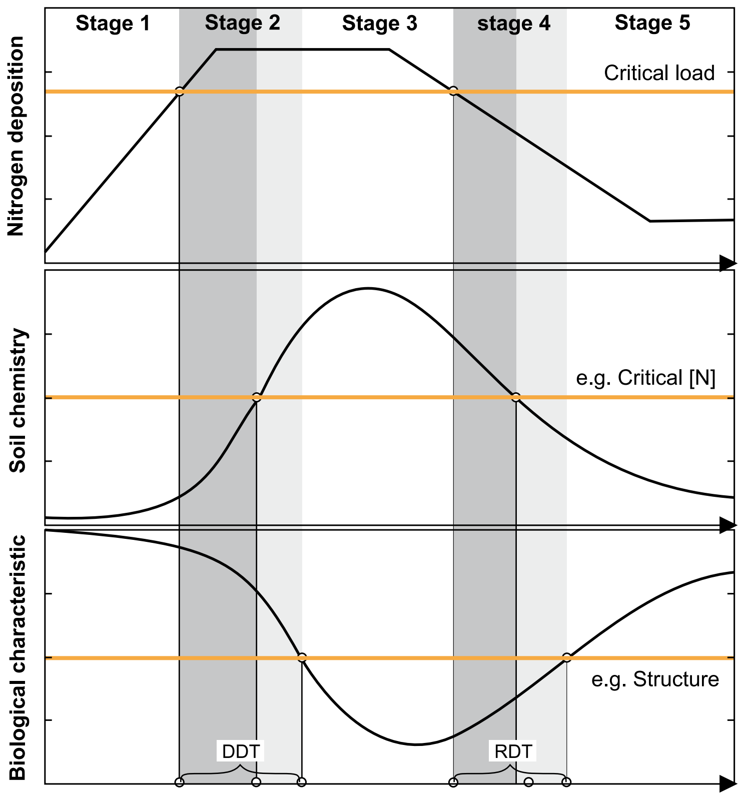

Figure 4.2: Possible stages of influence of N-deposition on conservation status. Adapted from CCE[1]

1 http://www.mnp.nl/en/themasites/cce/methods_and_models/dynamic-modeling/index.html

The discussion and conclusions of the group are explained below. Figure 4.2 is provided to support this and help with the conceptual understanding.

Five stages can be distinguished (see Table 4.3):

1 Nitrogen deposition is and has been below the critical load for a long period. Nitrogen deposition related chemical and biological variables (e.g. litter and soil C/N-ratio, nitrogen availability in the soil, presence of typical nitrogen-sensitive species) associated with favourable conservation status, are not influenced by deposition. As long as deposition stays below the critical load, the habitat is, with respect to nitrogen deposition, in favourable conservation status.

2 Deposition is above the critical load, but the critical chemical and biological variables are not yet violated. However, due to exceedance of the critical load the chemical and biological conditions are changing. The occurring changes are within the natural range of favourable conservation status, but risk of future negative effects on conservation status (i.e. changes in vegetation structure and functioning) are present. We call the time between the first exceedance of the critical load and first violation of the critical criteria the Damage Delay Time (DDT). This stage can be subdivided into two sub-stages: a

Table 4.3

Stage	Critical load exceed-ance	Chemical deterior-ation	Biological deterior-ation	Conservation status with respect to nitrogen deposition	Measures Required
1	No	No	No	Favourable	Normal management
2a	Yes	Starting	No	Risk for future effects	Reduction in deposition
2b	Yes	Starting	Starting	Risk for effect in the near future	Reduction in deposition
3	Yes	Yes	Yes	Unfavourable	Reduction in deposition and/or removal of nitrogen required
4a	No	Ending	Yes	Unfavourable, with (good) prospects for the future	Further reduction in deposition and/or removal of nitrogen would speed up recovery
4b	No	Ending	Ending	Unfavourable with (good) prospects for the near future	Further reduction in deposition and restoration would speed up recovery
5	No	No	No	favourable	Normal management

stage where chemical changes occur and a stage where biological changes can also be observed. Besides the monitoring of any future changes, measures have to be taken to avoid damage to favourable conservation status in the future.

3 The deposition is above critical load and both the critical chemical and biological criteria associated with favourable conservation status are violated. Further measures have to be taken to avoid a (further) deterioration of the ecosystem.

4 Deposition is below the critical load, but the chemical and biological criteria are still violated due to the earlier exceedance. Recovery has not yet occurred. We call the time between the first non-exceedance of the critical load and the subsequent non-violation of both criteria the Recovery Delay Time (RDT). Like Stage 2 this stage can also be subdivided. Recovery Delay Time can be shortened by reduction of deposition below critical load or restoration management.

5 This stage is similar to Stage 1. Deposition is below the critical load and both criteria are no longer violated. Only at this stage can one begin to speak of full ecosystem recovery, although retention of nitrogen within the ecosystem and dispersal limitations may mean that sensitive species do not return for some time.

As shown above, risks and effects of nitrogen deposition can be best shown if information is available from monitoring deposition (and therefore having an accurate measure of exposure and critical load exceedance) and monitoring relevant abiotic and biotic variables (i.e. response: this would need to be over a representative sample of the habitat). Relevant abiotic variables are those variables influenced by nitrogen deposition and related to favourable conservation status. The guidelines[1] for reporting on the monitoring and modelling of air pollution effects name some of the relevant variables like total soil N, total carbon / N ratio, available N content and pH

1 http://www.unece.org/env/documents/2008/EB/EB/ece.eb.air.2008.11.e.pdf

for terrestrial ecosystems. However, whilst pH is a good indicator of acidification, there is less consensus on biogeochemical indicators of eutrophication. Bulk soil N and C/N may lag behind changes to vegetation processes. Numerous measures of soil available N and plant tissue assays have been proposed as indicators of nitrogen exposure. For aquatic ecosystems, variables such as nitrate concentration, acid neutralizing capacity (ANC), pH, alkalinity, aluminium concentration ([Al]) and total organic carbon (TOC) are relevant. Several countries, such as Denmark (Svendsen *et al*., 2005), Germany (VDI, 2008) and Netherlands (van Hinsberg and van Dobben, this volume), have already listed variables and have established methods to determine the adverse effects of nitrogen deposition in various ecosystems and in some cases defined critical values for favourable conservation status. Ideally, there would be collaboration between the Habitats Directive community (i.e. currently the Expert Group for reporting under the Nature Directives) and the WGE of CLRTAP to agree on abiotic and biotic variables and values relating to favourable conservation status in the different EU biogeographic regions. Monitoring the difference between current values and desired values can be used to determine the influence of nitrogen deposition. In many European countries, such information is available for aquatic ecosystems. Such values have been used to compute habitat-specific critical loads by the use of dynamic ecosystem modelling. Examples of such approaches have been described by De Vries *et al*., (2007) and are used in the Netherlands. Biological monitoring is also very important for determining conservation status and the influence of nitrogen deposition on that status. In each Member State, habitats have to be described in terms of typical species and vegetation composition and structure. Since each species occurs in its own environmental niche, the occurrence of species gives information of the abiotic and biotic conditions. Some species can for example only be found in nutrient poor conditions in open vegetation (e.g. some nitrogen sensitive mosses or nitrogen sensitive herbs in dune grasslands). However, whilst much has been done within the European Vegetation Survey (http://www.iavs.org/part_groups_euroveg.asp) to define characteristic species of habitats and many national lists of habitats and their species composition exist, a clear guideline on how it can be used for nitrogen assessment is missing. Monitoring changes in species occurrence, frequency and cover (vegetation relevées) can, in combination with abiotic monitoring, give important information on changes caused by nutrient enrichment over time. However, this is complicated by interactions with other factors, such as management, and in practice it is often very difficult to attribute the cause or the relative importance of multiple factors. Furthermore, there may be cases where management is 'holding the line' i.e. suppressing nitrogen impacts.

Monitoring is expensive and time consuming and often not (yet) available. At the same time the number of experts who are able to determine the keystone taxa is decreasing. Without information on nitrogen deposition and its effects on Annex I habitats it was recommended that estimated critical load exceedance should be used as a first indicator as to whether to record nitrogen deposition as a threat to conservation status. This is especially true in those situations where critical load exceedances are high and exceedances have occurred for several years.

It was agreed that there were outstanding areas which need further development before a more specified approach can be recommended. Nitrogen deposition should be included explicitly in the lists of 'pressures' and 'threats'. Recommendations regarding the review of nutrient nitrogen empirical critical loads and their application to Annex I features have been made which, if implemented, will facilitate a more consistent critical loads exceedance assessment. It was thought that such an exercise is relatively straight-forward and achievable. Furthermore, it has been identified that there should be a collaboration between the Habitats Directive community and the WGE to agree abiotic and biotic variables/values relating to favourable conservation status. Member States would then be free to use these in a monitoring programme and/or for development of dynamic models. These recommendations should be highlighted in the workshop synthesis report and workshop summary information and raised with the Commission and relevant groups including the Expert Group on Reporting under the Nature Directives developing guidance for the 2013 reporting round.

References

Bealey, W.J, Dore, A., Vieno, M. and Sutton, M.A. (2007) *Source attribution and critical loads assessment for Special Areas of Conservation and Special Protection Areas in the UK.* SNIFFER Project AQ02.

BfN (1998) Ursachen des Artenrückgangs von Wildpflanzen und Möglichkeiten zur Erhaltung der Artenvielfalt. Schriftenreihe für Vegetationskunde, Heft 29. Bundesamt für Naturschutz, Germany.

Bobbink R and Hettelingh JP, (eds.) (2011) Review and revision of empirical critical loads and dose-response relationships, Coordination Centre for Effects, National Institute for Public Health and the Environment (RIVM), RIVM report 680359002, www.rivm.nl/cce. Braithwaite, M.E., Ellis, R.W. and Preston, C.D. (2006) *Change in the British Flora 1987-2004.* Botanical society of the British Isles, London.

Bunce, R. G. H., Smart, S. M., van de Poll, H. M., Watkins, J. W. and Scott, W. A. (1999) *Measuring change in British vegetation*. ECOFACT Volume 2. Institute of Terrestrial Ecology, Huntingdon, United Kingdom.

CCE (2008) *CCE Status Report 2008: Critical load, Dynamic Modelling and Impact Assessment in Europe*. Coordination Centre for Effects, Netherlands Environmental Assessment Agency (available at http://www.mnp.nl/en/themasites/cce/publications/cce-status-report-2008/index.html).

De Vries, W., Kros, H., Reinds, G.J., Wamelink, V., Mol, J., Van Dobben, H., Bobbink, R., Emmett, B., Smart, S., Evans, C., Schlutow, A., Kraft, P., Belyazid, S., Sverdrup, H., Van Hinsberg, A., Posch, M. and Hettelingh, J.-P. (2007) *Development in deriving critical limits and modelling critical loads of nitrogen for terrestrial ecosystems in Europe*. Alterra-rapport 1382. Alterra, Wageningen, Netherlands (available at: http://nora.nerc.ac.uk/1779/1/rapport_1382.pdf).

De Vries, W., Wamelink, W., van Dobben, H., Kros, H., Reinds, G., Mol-Dijkstra, J., Smart, S., Evans, C., Rowe, E., Belyazid, S., Sverdrup, H., van Hinsberg, A., Posch, M., Hettelingh, J.-P., Spranger, T. and Bobbink, R. (2010) Use of dynamic soil-vegetation models to assess impacts of nitrogen deposition on plant species composition and to estimate critical loads: an overview. *Ecological Applications*, 20, 60-79.

Dupre, C., Stevens, C., Ranke, T., Bleeker, A., Peppler-Lisbach, C., Gowing, D., Dise, N., Dorland, E., Bobbink, R. and Diekmann, M. (2009) Changes in species richness and composition in European acidic grasslands over the past 70 years: the contribution of cumulative atmospheric nitrogen deposition. *Global Change Biology*, 16, 344-357.

EEA (2007) Halting the loss of biodiversity by 2010: proposal for a first set of indicators to monitor progress in Europe. Technical report No 11/2007 (available at: http://biodiversity-chm.eea.europa.eu/information/indicator/F1090245995).

Ellenberg, H., Weber, E.H., Düll, R., Wirth, V., Werner, W., Paulissen, D. (2001) Zeigerwerte der Pflanzen in Mitteleuropa, *Scripta Geobotanica* XVIII, 262 S., 3. Auflage. Verlag Erich Goltze, Göttingen

European Commission (2006) *Assessment, monitoring and reporting under Article 17 of the Habitats Directive: Explanatory Notes & Guidelines* (available at: http://circa.europa.eu/Public/irc/env/monnat/library?l=/habitats_reporting/reporting_2001-2007/guidlines_reporting&vm=detailed&sb=Title).

European Commission (2007) *Interpretation Manual of European Union Habitats*. EUR 27, July 2007 (available at: http://ec.europa.eu/environment/nature/legislation/habitatsdirective/index_en.htm#interpretation).

LUA (2008) Vollzugshilfe zur Ermittlung erheblicher und irrelevanter Stoffeinträge in Natura 2000-Gebiete. Stand der Fortschreibung November 2008 (available at: http://www.mluv.brandenburg.de/cms/media.php/2338/vh2008e.pdf).

Maskell, L.C., Smart, S.M., Bullock, J.M., Thompson, K. and Stevens, C.J. (2010) Nitrogen Deposition causes widespread species loss in British Habitats. *Global Change Biology,* 16, 671-679.

Preston, C.D., Telfer, M.G., Carey, P.D., Cooper, J.M., Dines, T.D., Hill, M.O., Pearman, D.A., Roy, D.B., Smart, S.M. (2002) *The changing flora of the UK*. Department for Environment, Food and Rural Affairs (DEFRA), 19 pp., London.

Stevens, C.J., Dise, N.B., Mountford, J.O. and Gowing, D.J. (2004) Impact of Nitrogen Deposition on the Species Richness of Grasslands. *Science*, 303, 1876-1879.

Svendsen, L.M., Bijl, L van der, Boutrup, S. and Norup, B. (2005) *NOVANA: National Monitoring and Assessment Programme for the Aquatic and Terrestrial Environments. Programme Description - Part 2*. National Environmental Research Institute, NERI Technical Report No. 537, Denmark (available at: http://www.dmu.dk/NR/rdonlyres/5EC5E735-724E-4769-A560-D53613C89536/0/FR537_www_S_H.pdf).

UBA (2004) *Manual on methodologies and criteria for modelling and mapping critical loads and levels and Air Pollution Effects, Risks and Trends*. (available at http://www.rivm.nl/en/themasites/icpmm/manual-and-downloads/manual-english/index.html).

UNECE (2003) *Empirical critical loads For Nitrogen*. Proceedings from Expert Workshop Berne 11-13 November 2002. Swiss Agency for Environment, Forest and Landscape (SAEFL), Berne, Switzerland.

Van Hinsberg, A., Reijnen, R., Goedhart, P., de Knegt, B. and van Esbroek, M. (2008) *Relation between critical load Exceedance and Loss of Protected Species*. In: CCE Status Report 2008: Critical load, Dynamic Modelling and Impact Assessment in Europe (eds. Hettelingh, J.P., Posch, M. and Slootweg, J.) Coordination Centre for Effects, Netherlands Environmental Assessment Agency (available at http://www.mnp.nl/en/themasites/cce/publications/cce-status-report-2008/index.html).

VDI (2008) *Vegetation as an indicator of nitrogen input - assessment of nitrogen availability by Ellenberg indicator values of forest ground vegetation*. VDI/DIN Manual Air Pollution Prevention Volume 1 A: Maximum Emission Values, Düsseldorf, Germany (available at: http://www.beuth.de/cmd?workflowname=CSVList&websource=vdin&artid=111917291&languageid=en).

4.3 Setting critical loads for Dutch Natura 2000 sites using empirical information and dynamic modelling

A. van Hinsberg[1] and H.F. van Dobben[1]

1 Netherlands Environmental Assessment Agency, PO Box 303, 3720 AH Bilthoven, Netherlands.

Abstract

- In the Netherlands, critical loads were set for all Annex I habitat types using both internationally accepted empirical critical loads and dynamic ecosystem models.
- Habitat specific critical loads could be modelled using information on chemical soil conditions and plant species composition in habitats at favourable conservation status.
- The calculated critical loads have been adopted by the Dutch Government, and used for calculating threats to biodiversity and risks of significant negative effects on conservation status.

4.3.1 Introduction

Nitrogen deposition levels in the Netherlands are among the highest in Europe. Assessments have indicated that high deposition levels have negatively affected Dutch flora and fauna. For example, research using field data has shown that significant negative correlations between nitrogen deposition and occurrence of protected bird, plant and butterfly species exist (Van Hinsberg, *et al*., 2008). This paper describes how current scientific knowledge was used to derive critical loads of nitrogen deposition for Annex I habitat types in the Netherlands. The term 'critical load' here refers to the level of nitrogen deposition above which the risk of significant damage to the quality of a habitat type cannot be excluded. This is in close accordance which the internationally accepted definition, namely, 'a quantitative estimate of 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' (Nilsson & Grennfelt, 1988). The use of critical loads in assessing risks for significant damage is very straightforward. A nitrogen critical load can be compared to the current or future nitrogen deposition in order to obtain insight into the threats for eutrophication and/or acidification. If the atmospheric deposition at a location is higher than the critical load for a specific, existing (or desired) habitat type, then there is a clear risk of significant negative effects. In other words, the conservation objectives may not be achieved. The greater the critical load exceedance, and the longer the duration of this exceedance, the higher the risk of undesirable negative effects on habitats. Exceedances of the critical load of nitrogen have been used in European pollution abatement policy for defining emission-reduction targets, namely, in the UNECE Convention on Long-range Transboundary Air Pollution (LRTAP Convention) and the European Union (National Emission Ceilings Directive). The exceedance of critical loads of nitrogen is also used as an indicator for risk of biodiversity loss by the European Environment Agency (EEA, 2007).

4.3.2 Aims and objectives

In 2008, a study was conducted for setting habitat specific critical loads for all Annex I habitat types which occur in the Netherlands, based on the latest scientific knowledge on thresholds and conservation status.

4.3.3 Results and discussion

Within the LRTAP Convention covering the UNECE region, procedures have been developed to set and map critical loads for airborne nitrogen deposition. Based on the UNECE mapping manual of the International Cooperative Programme on Modelling and Mapping and recent scientific publications (e.g. De Vries *et al*., 2010) on dynamic modelling, the following methods were identified as being important for setting critical loads:

- *The empirical method.* Empirical critical deposition loads have been published for international use, most recently on the basis of a workshop, held in 2010 to review critical loads under the UN-ECE Convention on Long-range Transboundary Air Pollution (Bobbink and Hettelingh, 2011) . This source contains critical loads derived from field experiments in combination with indication of the inputs. Based on available information, this method yielded ranges of critical loads for 21 broadly defined ecosystem types (based on the EUNIS classification system). The ranges describe the variation in critical loads due to variation within the EUNIS ecosystem type, variation caused by abiotic conditions which vary across locations and uncertainties. Furthermore, when data is insufficient for setting critical load values for specific ecosystems, it is suggested to use the lower, middle or upper part of the ranges, depending on general relationships between abiotic conditions and critical loads (Table 4.4).
- *Dynamic ecosystem modelling*. Ecosystem models can be used for calculating critical loads (De Vries *et al*., 2010). Results from the SMART2 model are available for the majority of vegetation types in the Netherlands (Van Dobben *et al*., 2006). In addition, for some ecosystems, specific models have been developed (AquAcid for heathland pools, Calluna for dry heaths).
- *Expert judgement*. In addition to empirical evidence, expert judgement has been used for setting critical load.As described in Bobbink *et al*., (2003), information on abiotic conditions can be used for setting specific critical loads for sub-ecosystems within the broad EUNIS ecosystem types for which critical load ranges are known (Table 4.4). In the Netherlands it

Table 4.4: General relations between abiotic conditions and critical loads, which can be used for deciding whether the lower, middle or upper part of a critical load range is applicable for a particular ecosystem type *After Bobbink et al., 2003 **

Action	Temperature/ Frost period	Soil wetness	Base cations availability	P limitation	Management Intensity
Use lower part	Cold/Long	Dry	Low	N-limited	Low
Use middle part	Intermediate	Normal	Intermediate	Unknown	Usual
Use higher part	Hot/None	Wet	High	P-limited	High

** updated in 2010 (Bobbink et al. 2010)*

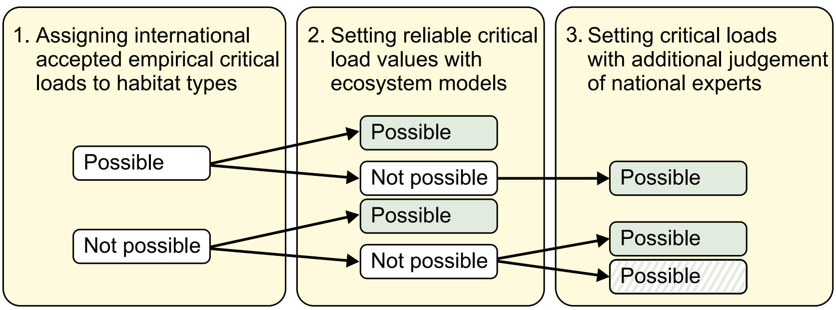

Figure 4.3: Procedure used for setting critical loads for Annex I habitat types.
In most cases, reliable critical loads could be set after steps 1 and 2 (green boxes). In some cases, additional judgement from national experts was used for setting reliable or quite reliable critical loads (green boxes), or even to give a best possible estimate (striped box).

was attempted to derive unique critical load values per Annex I habitat type within the ranges per EUNIS type as in Bobbink *et al*., (2003) by combining the empirical and simulation approaches, and using expert knowledge where necessary (Van Dobben & Van Hinsberg, 2008). The procedure that was used is depicted in Figure 4.3.

The procedure yielded critical loads for most Annex I habitat types. In most of the cases, empirical ranges and/or reliable model estimates were present, and critical loads could be set based on published information. In about 70 per cent of all the habitats, models yielded critical load values within the given empirical range. In those cases where simulated critical loads were outside the empirical range, the critical load was set to the nearest extreme of the empirical values. The difference between the middle of the empirical range and the modelled values per habitat type was on average less than one kg $ha^{-1}yr^{-1}$.

4.3.4 Conclusions and discussion

In most of the cases, empirical ranges and/or reliable model estimates were present and critical loads could be set for the vast majority of habitat types.

The set critical loads can be used for calculating exceedances, which indicate future threats or present negative effects on habitat structure and/or functioning. Monitoring data on nitrogen-related abiotic and/or biotic conditions are needed to show whether negative effects are already occurring.

The detailed habitat specific critical loads can only be used together with detailed maps of habitat occurrences and detailed deposition maps.

References

Bobbink, R., Ashmore, M., Braun, S., Flückiger, W. and Van den Wyngaert, I.J.J. (2003) Empirical nitrogen critical loads for natural and semi-natural ecosystems: 2002 update. In: *Empirical critical loads for nitrogen* (eds. Achermann, B. and Bobbink, R.). Swiss Agency for Environment, Forest and Landscape (SAEFL), Berne, Switzerland.

Bobbink R and Hettelingh JP, (eds.) (2011) *Review and revision of empirical critical loads and dose-response relationships*, Coordination Centre for Effects, National Institute for Public Health and the Environment (RIVM), RIVM report 680359002, www.rivm.nl/cce.

Bal, D., Beije, H.M., Fellinger, M., Haveman, R., van Opstal, A.J.F.M. and van Zadelhoff, F.J. (2001) *Handboek Natuurdoeltypen*. EC-LNV, Wageningen, Netherlands.

De Vries, W., Wamelink, W., van Dobben, H., Kros, H., Reinds, G., Mol-Dijkstra, J., Smart, S., Evans, C., Rowe, E., Belyazid, S., Sverdrup, H., van Hinsberg, A., Posch, M., Hettelingh, J.-P., Spranger, T. and Bobbink, R. (2010) Use of dynamic soil-vegetation models to assess impacts of nitrogen deposition on plant species composition and to estimate critical loads: an overview. *Ecological Applications,* 20, 60-79.

EEA (2007) *Halting the loss of biodiversity by 2010: proposal for a first set of indicators to monitor progress in Europe.* Technical report No 11/2007 (available at: http://biodiversity-chm.eea.europa.eu/information/indicator/F1090245995).

Nilsson, J. and Grennfelt, P. (1988) *Critical loads for sulphur and nitrogen*. Report from a workshop held at Skokloster, Sweden, 19-24 March, 1988.

Van Dobben, H.F., van Hinsberg, A., Schouwenberg, E.P.A.G., Jansen, M., Mol-Dijkstra, J.P., Wiegers, H.J.J., Kros, J. and de Vries, W. (2006) Simulation of critical loads for Nitrogen for Terrestrial Plant Communities in The Netherlands. *Ecosystems*, 9, 32-45.

Van Dobben, H. and van Hinsberg, A. (2008) Overzicht van kritische depostiewaarden voor stikstof, toegepast op habitattypen en Natura 2000-gebieden. Alterra-rapport 1654. Alterra, Wageningen, Netherlands.

Van Hinsberg, A., Reijnen, R., Goedhart, P., de Knegt, B. and van Esbroek, M. (2008) *Relation between critical load Exceedance and Loss of Protected Species*. In: CCE Status Report 2008: Critical load, Dynamic Modelling and Impact Assessment in Europe (eds. Hettelingh, J.P., Posch, M. and Slootweg, J.) Coordination Centre for Effects, Netherlands Environmental Assessment Agency (available at http://www.mnp.nl/en/themasites/cce/publications/cce-status-report-2008/index.html).

4.4 Monitoring terrestrial habitat types in Denmark

K. E. Nielsen, C. Damgaard, C. Kjær, M. Bruus, R. Ejrnæs, and B. Nygaard,

Topic centre for habitat-types and species, National Environmental Research Institute, Aarhus University, Denmark

Abstract

- The terrestrial programme, which started in 2004, includes a systematic and representative monitoring of terrestrial habitat types as well as species. This presentation will focus on concepts for monitoring of habitat nature types. The habitats are exposed to a large number of pressures like eutrophication, change in land use, fragmentation, climate change etc. Some of these changes are anthropogenic, others are attributable to natural development, but are, nonetheless, influenced by man. The effects of such pressures are reflected in the overall criteria defined in the directive - area, structure and function of the habitats. The 28 semi-natural habitat types and 10 forest types included in the present programme consist of approximately 1200 randomly selected monitoring stations within Natura 2000 areas as well as areas outside of Natura 2000 in order to give a representative picture of the conservation status. Each station has 20-60 sampling points defined by UTM coordinates.
- To understand the causes behind observed changes in the habitats, it is necessary to combine both biotic and abiotic criteria. The ambition of the monitoring programme is to “bridge the gap” between traditional biodiversity monitoring and monitoring of cause indicators.
- The favourable conservation status is defined on the basis of a number of threshold values which have proven important in ecological research and other monitoring programmes. The selected parameters are: coverage of the vegetation (point intercept method), lichen/moss ratio, nitrogen content in lichens, mosses and shoots of dwarf scrubs (reflector of short-time changes), C/N ratio and pH of the upper organic soil horizons (long-term impacts). Nitrate is measured in some water, dependent terrestrial habitat types (e.g. rich fens, raised bogs and springs) together with monitoring of water tables. As often as possible, a value, or interval, that identifies a favourable conservation status, is attached to each of these parameters – mainly based on literature values.
- The conservation status of a specific habitat depends on many parameters, and some of these are measured in the monitoring programme. The aggregation of the measured indicators into an overall assessment of the conservation status of the habitant is a non-trivial task. However, research on different multi-criteria approaches to assess conservation status has been initiated.

4.4.1 Aims and objectives

In the NATURA2000 areas, Member States must undertake surveillance of the conservation status and take the appropriate steps to maintain or restore favourable conservation status of the habitats. The overall concept behind the “favourable conservation status” (FCS) comprise criteria for area, structure and function. The national task is to translate these general criteria to operational criteria

Table 4.5: Criteria for favourable conservation status on local/site level for the habitat type 2130 – the grey dunes. Indicators marked with (P) are pressure indicators.

Type 2130	Property	Unit of measurement	Criteria	Comments
Area	Area (hectares)	Number of hectares	Stable or increasing	
Structure and function	Naturally low nutrient level	Nitrogen deposition (kg/N/ hectare/year)	Not exceeding the critical load	The critical load 10-20 kg/N/ hectare/ year, UNECE 2003
	Naturally low nutrient level	Nitrogen content (mg/g) in Cladonia portentosa. Damages on foliage leaf are observed by N >8 mg/g and by N=13 mg/m lichen are dying	Within the natural range of the habitat type in Denmark. Stable or improving	Should be less than six mg/g. level in countries without N-load 2-4 mg/g, in Denmark 5.3-9.6 mg/g, lowest in Western Jutland, highest in Mid-Jutland
	Acidity	pH	The pH must be stable and not considerably lower than the natural acidity of the locality.	If no historical information is available, the natural pH can be predicted by model
	(P) Mechanical impact	Proportion of area influenced by wear and tear from e.g. tourism	Stable or decreasing	Should not exceed 10 per cent
	Open, herbal dominated vegetation	Coverage of non-indigenous trees and bushes	Stable or decreasing	Overgrowth is partly due to seed-pressure from plantations and invasive species. Mountain pine, dune pine, Norway spruce and Japanese rose should be removed
	Cryptogams	Lichen/moss-ratio in grey dune	Within the natural range of the habitat type in Denmark. Stable or improving	Should be higher than 3:1. The grey dune is characteristic of a rich lichen flora. The criterion is preliminary, but studies have shown that eutrophication is increasing the proportion of mosses
	Species composition of plants	Deviation from the species composition of this habitat type in reference condition	The deviation is within the expected variation of the natural habitat type in Denmark	The species composition is a diversity indicator of changes in the environment factors
Characteristic species	Population of characteristic species	Index of populations of characteristic species present	Long-term maintenance on a stable or increasing level	Register by species, e.g. using the DAFOR scale. Variations are natural. In special cases declines may be acceptable / targeted.

and to implement surveillance of the habitats and species in order to follow the direction of the conservation status – which should be stable or improving (Søgaard *et al*., 2007).

No efforts have been made to reach a common European agreement on how to define FCS for the different habitat-types and species. In Denmark, the suggested criteria are an important background for monitoring, planning, and managing nature, and for carrying out assessments of potential setbacks or disturbances to the quality of the habitat within the specific areas. Table 4.5 is an example of criteria for habitat-type 2130; the grey dune heath.

We have defined structural features to include vegetation structure and composition, i.e. spatial distribution, age structure and biomass. Functional features include processes related to nutrient content and cycling. The starting point in defining FCS has been to list the different types of pressures affecting the different semi-natural habitat-types and forests. Natural and semi-natural habitats in Denmark are exposed to a large number of pressures like eutrophication, change in land use, fragmentation of habitat, drainage and invasive species. Some of these causes are anthropogenic; others are attributable to natural development. The effects of such pressures are reflected in the structure and function of the individual ecosystems/natural habitats, including the size of the nutrient pools, water table, etc. Terrestrial natural habitat monitoring aims not only to provide information about status and trends, but also to provide insight into both the natural and the anthropogenic pressures that is necessary in order to be able to carry out appropriate management.

4.4.2 Criteria of favourable conservation status

Criteria relevant indicators/properties for the habitat type in question with sets of specific values or intervals needed to be fulfilled to obtain favourable conservation status. These habitat type-specific criteria are based on the following:

- should form the basis for development of adequate monitoring leading to assessment of the conservation status
- should be scientifically based, biologically relevant and lead to the wanted state of conservation, i.e. support the goal for the monitoring
- should be simple and easy to understand, i.e. based on scientific justifiable simplifications
- should be operational, quantitative, objective and reproducible
- should be transparent – robust and precise
- should be sensitive enough to detect changes within a short time span
- should be thoroughly tested
- should be able to come up with a diagnosis as well as a prognosis of the conservation status of the habitat type

4.4.3 Discussion and some results

Table 4.5 is an example of criteria of favourable conservation status for habitat no. 2130 – "the grey (and green) dunes". Examples of the definition of favourable conservation status for a selected number of habitat types can be found in - http://www.dmu.dk/Udgivelser/Faglige+rapporter/Nr.+600-649/Abstracts/FR647.htm.

The Danish monitoring programme comprises about 1200 monitoring randomly selected stations, each having 20-60 random sampling points defined by UTM co-ordinates. An overview of parameters collected in sampling points and the 5-m circle is seen in Table 4.6 and in Figure 4.4.

Monitoring is carried out on the basis of recommended methods, called "technical instructions", that provide detailed instructions as to how the specific parameters in the criteria for favourable conservation status and the conservation objectives shall be monitored. The Agency for Spatial and

Figure 4.4: Data is sampled in a pinpoint frame supplied with data from a surrounding five metre circle. *© K. E. Nielsen*

Environmental Planning are carrying out the practical monitoring programme and the results are reported to the Topic Centre on Terrestrial Nature and Biodiversity placed within NERI, University of Aarhus. Together with the Agency, the Topic Centre is currently developing a database to store all data collected through the programme. The Topic Centre is responsible for quality control and aggregation of data for assessment of conservation status and reporting the results to national and regional authorities.

In most cases, the transition between the different habitat-types is gradual and only one method, or "technical instructions," has been developed for all habitat-types, including specific elements for the forest types, fen types etc. The fundamental object in the monitoring are is sample plot and the surrounding five m circle. Table 4.6 and Figure 4.4 show which element is investigated in the two categories.

Table 4.6: Parameter which are measured in sample points and in the surrounding circle.

Observations in the sample plots	Observations in the 5 m circle:
Cover of species	Frequency of species
Supplemental species	Vegetation height
pH in soil/water	Pct. cover of woody species
Conductivity	pct. flooding
C/N - ratio	pct. gaps in vegetation
Phosphorous	pct. cover of invasive species
Nitrate in soil/water	pct. cover of herbivori
N in shoots, mosses and lichens	pct. hollows in bog structure

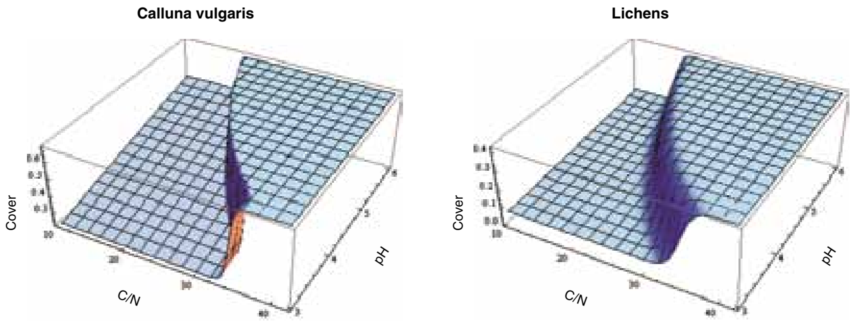

Figure 4.5: Effect of pH and C/N on cover of Calluna vulgaris and lichens on dry dune heathland. The majority of data is around pH 4. The favourable conservation status for C:N ratio in the organic topsoil is > 30 which is clearly seen as a threshold

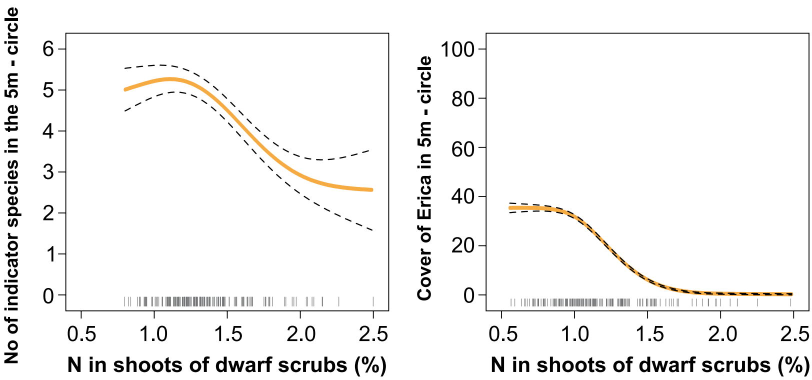

Figure 4.6: Nitrogen content in per cent in young shoots of Erica tetralix on wet heath – habitat no. 4010. The uncertainties of the regression model are shown by the upper and lower limit of the curve.

Figure 4.4 shows the field work in a wet dune slack. Information on species cover is sampled by the point-intercept method, i.e. counting the species touched by a thin pin transferred vertically through the vegetation in a grid formed by equidistantly crossed threads extended on a pin-point frame placed over the vegetation. The pinpoint frame is 50 x 50 cm with 16-grid points. The pinpoint method was chosen because data is robust and objective (Damgaard, 2008). The main objective of vegetation monitoring is to follow increases and decreases of the more dominant species over decades. A 5 m circle is made around the sample plot. In the 5 m circle, supplementary species and the cover of trees is noted.

As examples of the kind of results, which are achieved in habitat monitoring, Figure 4.5 shows the effect of pH and C/N on cover of Calluna vulgaris and lichens on dry dune heathland. The majority of data is around pH 4. The favourable conservation status for CN ratio in the organic topsoil is > 30. A spectacular threshold around the value of 30 supports the chosen value for the heathland habitat-type.

The left part of figure 4.6 shows the relation between the number of indicator species for wet heath (no 4010) and nitrogen content in the new shoots of *Erica tetralix*. The right figure shows the relation between nitrogen content in the shoots and cover of *Erica tetralix*.

Often, in many ecological connections, the relations between cause and effects are not linear. The examples shown in Figure 4.6 suggest a relation between cover of a dwarf scrub; number of indicator species and nitrogen content in shoots. The steeper the slopes, the bigger the importance of the indicator "nitrogen in shoots" have for the variation in number of indicator species. A lack of, or a weak relation, between biotic and abiotic indicators can, however, be due to time delay between cause and effect in relation to changes in species compositions. Changes in nitrogen content or changes in biomass of the vegetation are among the first indicators to react opposed to changes in species compositions.

4.4.4 Conclusion

The purpose of the proposed criteria is to make a first attempt to define favourable conservation status. Upon these criteria, a systematic national monitoring programme comprising a selected number of habitat-types is developed. The criteria are preliminary and will be adjusted from time to time, as data will be reported from the ongoing monitoring and the knowledge increases.

A value outside the acceptable limits/value should, then, act as a trigger for restoration of a given location. A monitoring programme should not only be designed to detect any changes in conservation status for species and habitats, but also to give answers as to why the changes have happened involving habitat-related parameters. Within the work of reducing the effects of the transboundary air-pollution and to achieve nitrogen deposition below the critical load, (Løkke *et al*, 1996) points to the lack of well-defined biological criteria. Combining elements from the monitoring of forest ecosystems with elements from monitoring of biodiversity, the concept behind the Danish model seeks to "bridge the gap" between traditional biodiversity monitoring and monitoring of effects on air-pollution. The choice of criteria must reflect the ability of diagnosis as well as prognosis.

References:

Damgaard, C.F. (2008) Modelling pin-point plant cover data along an environmental gradient. *Ecological Modelling*, 214, 404-410.

Løkke, H., Bak, J., Falkengren-Grerup, U., Finlay, R.D., Ilvesniemi, H., Nygaard, P.H. and Starr, M. (1996) Critical loads of acidic deposition for forest soils: Is the current approach adequate? *Ambio*, 25, 510-516.

Søgaard, B., Skov, F., Ejrnæs, R., Pihl, S., Fredshavn, J., Nielsen, K.E., Clausen, P., Laursen, K., Bregnballe, T., Madsen, J., Baatrup-Pedersen, A., Søndergaard, M., Lauridsen, T.L., Aude, E., Nygaard, B., Møller, P.F., Riis-Nielsen, T. and Buttenschøn, R.M. (2007) *Criteria for favourable conservation status in Denmark.* Natural habitat types and species covered by the EEC Habitats Directive and birds covered by the EEC Birds Directive. NERI Technical report No. 647, Denmark (available at: http://www2.dmu.dk/Pub/FR647.pdf).

4.5 Assessment of nitrogen deposition impacts in support of conservation status assessments in the UK

C. Whitfield
Joint Nature Conservation Committee; Monkstone House; City Road; Peterborough; PE1 1JY; UK

Abstract
- In the UK, an assessment of nitrogen deposition effects on conservation status of Annex I habitats was undertaken for the 2007 Article 17 reporting round.
- The assessment was based on critical load exceedance. Relevant empirical nutrient nitrogen critical loads were applied to sensitive Annex I habitats, where possible. An assessment of critical load exceedance was then based on a combined approach using data on exceedance of the Annex I habitat resource within Special Areas of Conservation and national mapping of critical load exceedance based on a broader habitat classification.
- The critical loads assessment informed whether to list "air pollution" as a pressure to "structure and function" or a threat to "future prospects" of each habitat. Field evidence and expert judgement were also taken into account.
- Air pollution was listed as a pressure and threat for a large proportion of sensitive Annex I habitats and contributed to a conclusion of unfavourable status for many of these habitats.
- Further method development is required and it is recommended that a robust and consistent approach needs to be developed and adopted across Member States.

4.5.1 Introduction
This paper describes the approach to assessing nitrogen deposition impacts on the conservation status of Annex I habitats, in support of the second report by the UK under Article 17 of the Habitats Directive. A full account of the UK's methodology for assessing conservation status and the results are available at http://www.jncc.gov.uk/page-4060.

The UK assessment of the "specific structures and functions" parameter of conservation status for habitats was made based on the main pressures currently acting on the habitat (including nitrogen deposition), information on the habitat condition and, where relevant information was available, the status of typical species associated with the habitat.

Information on habitat condition from site condition monitoring formed a major component of the assessment. However, since the approaches used for site condition monitoring in the UK are largely based on a fairly rapid visual assessment of key attributes of the habitat, it is acknowledged that this is not a sensitive tool for detecting and, in particular, attributing nitrogen deposition impacts (Williams, 2006). Therefore, a nitrogen deposition assessment, based on the use of empirical nutrient nitrogen critical loads and modelled nitrogen deposition was also undertaken. Additionally, this has the advantage of providing a predictive approach for assessing 'future threats'. The methodology and results are described in this paper and reported more fully in a technical annex to the UK's submission, along with a description of the main uncertainties (http://www.jncc.gov.uk/pdf/FCS2007_techIII_airpollution.pdf). This nitrogen deposition assessment was combined with an acidification assessment and supplemented by evidence of air pollution impacts were available to provide an overall judgement as to whether "air pollution" (category 702; European Commission, 1997) would be listed as a threat or pressure.

4.5.2 Method
The critical loads based assessment was carried out for Annex I habitats only. Species were excluded because of the difficulty in linking habitat-based critical loads to effects on individual species.

Habitats judged not to be sensitive to nitrogen impacts were also excluded from the assessment. In addition, habitats which could not be assigned a critical load were excluded.

The UK does not have nutrient nitrogen critical load maps for Annex I habitats, so existing critical loads resources were adapted for the purposes of the conservation status assessments. These consisted of "Site Relevant critical loads" exceedance data for Special Areas of Conservation (SAC) and national critical loads exceedance maps produced by the UK National Focal Centre. Both of these are based on empirical critical loads for nutrient nitrogen (UNECE, 2003). The datasets are described in more detail below, followed by an explanation of how they were used to inform the overall assessment of nitrogen deposition impacts on Annex I habitats.

Site Relevant critical loads

The UK regulatory and conservation agencies have developed a database of 'Site Relevant critical loads' (SRCL). This database is used for assessments under Article 6.3 as described in Masters *et al*., this volume (Russel *et al*., this volume). Relevant critical loads are assigned to interest features on SACs and information provided on deposition (at five km resolution, based on UK FRAME model; Singles *et al*., 1998) to each site, attributed to different sources or source sectors (Bealey *et al*., 2007). Exceedance data for all sensitive Annex I habitats as they occur in SACs is therefore available. In this exercise, critical loads are assigned to sensitive Annex I habitats where there is adequate equivalence with a EUNIS class for which a critical load has been assigned (UNECE, 2003) (see http://www.jncc.gov.uk/page-1425). For the purpose of exceedance estimates, it is assumed that each Annex I habitat covers the whole of each SAC for which it is designated, which in practice is unlikely since many sites include a number of Annex I and Annex II features. It is important to note that some Annex I habitats are well matched to EUNIS habitats for which critical loads are assigned and there can be a lot of confidence in the critical load assigned. For others, this is much more tenuous. Although the Annex I habitats may nest within particular EUNIS classes (at level 2) they are often only a small part, and not necessarily a representative subset, of the wider EUNIS classification. This represents a significant uncertainty. A few Annex I habitats which are potentially sensitive had to be excluded from the assessment because there is not a EUNIS habitat for which a critical load is set, which has sufficient equivalence with the Annex I habitat.

National maps of nutrient nitrogen critical load exceedance

The UK's SRCL database only provides information for the proportion of habitats which occur within SACs. To ensure the assessment adequately represented the risk to the whole Annex I habitat

Table 4.7

Annex I Broad Habitat Class	Proportion of assessments which record Air Pollution as a threat or pressure
Marine, coastal and halophytic habitats	6 (17)
Coastal sand dunes and continental dunes	85 (13)
Freshwater habitats	88 (8)
Temperate heath and scrub	83 (6)
Sclerophyllous scrub (matorral)	25 (4)
Natural and semi-natural grassland formations	78 (9)
Raised bogs and mires and fens	67 (9)
Rocky habitats and caves	50 (10)
Forests	91 (11)

resource, including that outside of SACs, the assessment also drew on UK national critical loads exceedance mapping (Hall *et al*., 2003) in addition to the SRCL data.

National critical loads maps are produced for Broad Habitats defined under the UK Biodiversity Action Plan according the method described in Hall *et al*., (2003). Deposition is modelled at 5km resolution using the CBED method (Smith *et al*., 2000) to provide exceedance estimates based on 2002-04 data for this assessment. The Broad Habitats are related to EUNIS categories in order to assign the appropriate critical load, in same way as described above for Annex I habitats. Since Annex I habitats are only a component of the wider BAP broad habitat classification, the broad habitat distribution maps and Annex I distribution maps were compared as part of the assessment.

Assessment Procedure

The individual habitat assessments were based on a combination of exceedance of SRCLs and national critical loads exceedance mapping. Where the extent of the habitat is primarily within the SAC series, it is reliable to base the assessment solely on the SAC exceedance data. Where not, more emphasis has to be put on the national critical loads mapping. There are a number of limitations and uncertainties with both these approaches including the habitat mapping; distribution of habitats within SACs; deposition modelling and the relationships between the various habitat classifications. In practice, these differences are unlikely to affect the overall outcome of individual assessments.

In order to use the two datasets to derive a conclusion for whether nitrogen deposition should be included as a pressure or threat, the following questions were addressed for each habitat:

- Is the Annex I habitat sensitive to atmospheric inputs of nutrient nitrogen or acidity?
- Is there an appropriate critical load i.e.
    - is there a reasonable equivalence between the EUNIS habitats, for which critical loads are set, and the Annex I habitat? If so,
    - is the research upon which critical loads are based representative of potential impacts on the Annex I habitat?
- What is the exceedance of nutrient nitrogen critical loads of the habitat within the SAC series?
- What is the extent of the habitat which occurs in the SAC series (per cent)?
- How does the distribution of the Annex I habitat compare with the distribution of the relevant BAP Broad Habitat mapped for critical load exceedance if applicable.
- What is the critical load exceedance of the relevant Broad Habitat.

The judgement is then based on critical load exceedance for SACs and for relevant BAP habitats, but qualified by the level of certainty in the above steps. The assessment is based on national modelling of deposition and provides a national overview. Some Annex I habitats which are not identified as 'at risk' at a national level may still be under threat on a local/site specific basis.

Where 'relevant' critical loads are exceeded over a significant area for a particular Annex I habitat, air pollution was listed as a current "pressure" and future "threat" (future/foreseeable impacts). Any field evidence of impacts on the habitats, or other impacts information, was also used to inform whether air pollution would be listed as a current pressure or future threat. In practice, this was largely confined to coastal habitats, which were not well represented by the critical loads exceedance assessment, and freshwater habitats, for which there were no applicable critical loads.

4.5.3 Results and discussion

Table 4.6 Results of the air pollution assessment (incorporating nitrogen deposition) for UK conservation status reporting in 2007: the proportion of assessments which record air pollution (code 702) as a pressure for the Annex I broad habitat classes. Number of assessment records per broad habitat class is shown in parenthesis. This includes the 10 habitats in the Gibraltar report which forms part of the UK's territorial boundary and the UK Article 17 submission, but for which a specific assessment of air pollution has not been undertaken.

It was possible to undertake a nutrient nitrogen critical loads assessment for 51 Annex I habitats out of a total of 87 (77 excluding Gibraltar) habitats for which the UK has to report under Article 17. This means that the habitats were sensitive and a 'relevant' critical load could be assigned. Air pollution was recorded as pressure and threat in the assessments for 33 of the 51 habitats based on critical load exceedance. Air pollution was also listed for a further 20 habitats, based on expert judgement including, where available, field-based evidence.

This shows the severity of the threat that nitrogen deposition poses in the UK and is consistent with national critical loads reporting, survey and experimental evidence (NEGTAP, 2001)

In this context, the application of critical loads represents a risk assessment to identify the areas and habitats 'at risk' from nutrient nitrogen deposition. This is an appropriate tool for judging the future prospects parameter of conservation status, particularly where the exceedance can be calculated for future emissions based on implementation of currently agreed legislation. However, given the uncertainties and the definition and purpose of critical loads, the approach on its own, without field evidence, is less robust in terms of current pressure on structure and function. It cannot prove there is actually currently biological or biogeochemical 'damage' to a habitat area just that this will occur at some point.

Therefore, ideally the critical loads assessment would be combined with representative field-based evidence of effects on the habitat structure and function. At the time of the assessment for the second round of reporting for Article 17 this was not available in the UK in a form that could be readily used. These principles are discussed in Whitfield *et al*., (this volume).

Air pollution was included as a pressure and a threat for a large number of the Annex I conservation status assessments in the UK and contributed to a conclusion of unfavourable status for many of these habitats. However, on no occasion did it tip the balance of an assessment outcome from favourable to unfavourable, for the structure and function parameter, because there were also other factors contributing to this. As a result, the qualitative approach using critical loads was fit for purpose and to identify nutrient nitrogen deposition as an important pressure/threat. In future, if other pressures/threats to structure and function are addressed, there may be a greater scrutiny on the air pollution assessment and a more quantitative approach may be required.

Air pollution was one of a large number of pressures and threats listed for UK habitats. The scale of each and their relative priority or importance is difficult to judge and cannot be established from the assessments.

4.5.4 Conclusions

In the UK Article 17 report; 'air pollution' (incorporating nitrogen deposition) was listed as pressure to the current structures and functions, or a threat to future prospects, of 53 Annex I habitats out of a total of 87 records.

The results show a widespread risk from nitrogen deposition and this is consistent with other evidence from the UK (NEGTAP, 2001). It should provide a strong policy driver for targeted reductions in emissions of nitrogen pollutants.

The nitrogen assessment method was based on critical load exceedance using two datasets: site relevant critical loads and national exceedance maps. The method was fit for purpose: to highlight the importance of nitrogen deposition.

However, a number of questions about the approach and the uncertainties remain. These are consistent with those reported in Whitfield *et al*., (this volume) and a robust and consistent approach needs to be developed and adopted across Member States to report on the range and extent of nitrogen deposition impacts under Article 17 of the Habitats Directive.

References

Bealey, W.J, Dore, A., Vieno, M. and Sutton, M.A. (2007) *Source attribution and critical loads assessment for Special Areas of Conservation and Special Protection Areas in the UK.* SNIFFER Project AQ02.

European Commission (1997) Appendix E of the Explanatory Notes of the Natura 2000 Standard Data Form. Commission Decision of 18 December 1996 concerning a site information format for proposed Natura 2000 sites. Official Journal of the European Communities, 97/266/EC (available at: http://ec.europa.eu/environment/nature/legislation/habitatsdirective/docs/standarddataforms/form_notes_en.pdf).

Hall, J., Ullyett, J., Heywood, L., Broughton, R., Fawehinmi, J. and 31 UK Experts (2003) *Status of UK critical loads: critical loads methods, data and maps*. Report to Defra, Contract EPG1/3/185.

NEGTAP (2001) *Transboundary Air Pollution: Acidification, Eutrophication and Ground-level Ozone in the UK.* National Expert Group on Transboundary Air Pollution. DEFRA, Contract EPG 1/3/153.

Singles, R., Sutton MA. and Weston, K.J. (1998) A multi-layer model to describe the atmospheric transport and deposition of ammonia in Great Britain. *Atmospheric Environment,* 32, 393-399.

Smith, R.I., Fowler, D., Sutton, M.A., Fechard, C. and Coyle, M. (2000) Regional estimation of pollutant gas deposition in the UK: model description, sensitivity analyses and outputs. *Atmospheric Environment,* 34, 3757-3777.

UNECE (2003) *Empirical critical loads For Nitrogen*. Proceedings from Expert Workshop Berne 11-13 November 2002. Swiss Agency for Environment, Forest and Landscape (SAEFL), Berne, Switzerland.

Williams, J.M. (2006) *Common Standards Monitoring for Designated Sites: First Six Year Report.* JNCC, Peterborough, United Kingdom.

Acknowledgements

The author would like to thank Simon Bareham of the Countryside Council for Wales for his helpful comments on the draft manuscript.