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APPROACHES TO ASSESSING THE IMPACT OF NEW PLANS AND PROJECTS ON NATURA 2000 SITES (THEME 1)

3.1 Background document

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Summary
The Habitats Directive provides a high level of protection to the Natura 2000 network by taking a precautionary approach to permitting "plans or projects" which may have a likely significant effect on a site. Article 6.3 of the directive provides a mechanism by which plans and projects can only be permitted if they are shown to have no adverse effect on a Natura 2000 site.

Emissions of nitrogen are considered to be a significant threat to sensitive habitats across Europe. Many countries have adopted approaches to assessing these threats which include the use of critical load thresholds, the appraisal of the conservation objectives, and the determination of site specific conditions. These decisions include the need to understand and develop approaches for answering questions such as: what is a likely significant effect on the site; what is a significant contribution of a pollutant load to the site; and how to judge whether a project or plan will have an adverse effect on the integrity of a Natura 2000 site?

This background paper looks at Article 6 of the Habitats Directive focussing in particular on Article 6.3. An introduction to the requirements of Article 6.3 is given, followed by a consideration of the assessment of nitrogen deposition impacts in relation to these requirements. The paper compares the assessment and decision-making approaches taken by a number of EU Member States.

3.1.1 Introduction
The Habitats Directive (Council Directive 92/43/EEC on the Conservation of natural habitats and of wild fauna and flora) and the Birds Directive (Council Directive 79/409/EEC) provide a high level of protection to the Natura 2000 network by taking a precautionary approach to controlling polluting activities. Plans and projects can only be permitted if they are shown to have no adverse effect on a Natura 2000 site, unless there is some form of overriding public interest why it should proceed.

While emphasis has been directed at reducing on-site activities, there is also a requirement for the assessment of off-site activities including the polluting effect of local and transboundary air pollution sources. Emissions of nitrogen primarily from combustion and agricultural processes clearly present off-site pressures on the Natura 2000 network. Moreover, due to the proximity of the network to agricultural sources (both being present in the rural setting) nitrogen, particularly in the form of ammonia, contributes to widespread effects. Across the EU there is large exceedance of the critical load for nitrogen deposition for sensitive ecosystems. By 2020, 64 per cent of the natural ecosystem areas across the EU27 will be at risk from excessive nutrient N deposition (CCE, 2008).

3.1.2 The Habitats Directive

The provisions of the Habitats Directive require Member States to take measures to maintain or restore at favourable conservation status the natural habitats and species of Community importance. Additionally, Member States are obligated to designate the most suitable sites for these habitats and species under a network of sites across their respective countries. The Natura 2000 network is comprised of Special Areas of Conservation (SAC) designated under the Habitats Directive, and incorporates Special Protection Areas (SPAs) (classified under the 1979 Birds Directive). Together SACs and SPAs cover around 15 per cent of the territory of the EU. Under Article 6 of the Habitats Directive, Member States are required to establish the necessary conservation measures which correspond to the ecological requirements and conservation objectives of the site. These may be in the form of appropriate management plans or integration of other development plans, but essentially the deterioration of the habitats or species, including the disturbance of species, must be avoided. In addition, under Article 6.3 all plans and projects likely to affect a Natura 2000 site should be subjected to an assessment of the implications for the conservation objectives of the site. A plan or project can only be permitted after having ascertained that it will not adversely affect the integrity of the site concerned subject to the provisions of Article 6.4.

3.1.3 Article 6.3 and nitrogen deposition

> *Article 6.3 - Any plan or project not directly connected with or necessary to the management of the site but likely to have a significant effect thereon, either individually or in combination with other plans or projects, shall be subject to appropriate assessment of its implications for the site in view of the site's conservation objectives. In the light of the conclusions of the assessment of the implications for the site and subject to the provisions of paragraph 4, the competent national authorities shall agree to the plan or project only after having ascertained that it will not adversely affect the integrity of the site concerned and, if appropriate, after having obtained the opinion of the general public.*

Article 6.3 establishes the application of the precautionary principle for the first time for protected areas across Europe; that is, that projects can only be permitted if it has been ascertained that there will be no adverse effect on the integrity of the site. Projects may still be permitted if there are no alternative solutions, and there are imperative reasons of overriding public interest. In such cases compensation measures will be necessary to ensure the overall integrity of network of sites. Official guidance on Article 6.3 (European Commission, 2000) states that the geographical scope is not restricted to plans and projects which exclusively occur on a protected site ('on-site activities'), but they also target developments situated outside the site ('off-site activities'). Examples of on-site activities may include a highway intersecting a designated site or extraction of minerals. These represent actual physical damage to a site directly caused by the action of that activity.

Emissions of reactive nitrogen compounds from industrial and agricultural installations represent impacts from off-site activities. In respect of sources of nitrogen emissions, applications for permissions issued through various regulatory and planning instruments, give rise to a plan or project under the definition of the Directive. For example, an application for a permit under the IPPC Directive (Integrated Pollution Prevention and Control - EC Directive (96/61)).

In some cases, the sources may be many kilometres away (50-100 km) from the potentially affected site(s). The long-range transport potential of nitrogen pollutant species can trigger appropriate assessments where source and site are many kilometres from each other. In addition, localised impacts can also be important, for example local sources of ammonia from intensive agricultural units (<2 km). Furthermore, since these sources are usually located in rural areas, their potential for impacting a Natura 2000 site is more likely than in an industrial or urban area.

An overview of the requirements under Article 6.3 is given in the following sections:

'likely significant effect'

The first step is to consider whether the plan or project is likely to have a significant effect on a Natura 2000 site alone or in-combination. However, it is often hard to define what is **significant.** To assess a likely significant effect, the sites' conservation objectives and designated features should be considered. Finally the **likeliness** of a significant effect brings in the precautionary principle and an appropriate assessment should be carried out unless the likeliness of a significant effect(s) can be ruled out.

'subject to appropriate assessment'

For plans and projects that are likely to have a significant effect on a site, an appropriate assessment should be undertaken. The appropriate assessment should focus on the implications for the site in view of the site's conservation objectives. 'In combination' effects also need to be addressed in an assessment and account, needs to betaken of cumulative impacts (i.e. prevailing environmental conditions).

'not adversely affect the integrity of the site concerned'

The integrity of the site refers directly to the site's conservation objectives of the Annex I habitats or the Annex II species for which the site was designated (Annexes refer to the Habitats Directive). Integrity can be defined as: "*the ability of a site to maintain a coherent structure as a habitat or for supporting a complex of habitats and species*" (EC, 2000). The degradation of these features and their associated ecological functions would negatively affect the site's integrity. Assessments for sites designated as SPAs (Special Protection Areas - for birds) have to take into account the broad spectrum of habitats in which the protected bird nests, feeds or roosts.

The decision – compensation and overriding public interest.

Under Article 6.4 the competent authority (which will vary according to the type of plan or project and between Member States) is required to arrive at a conclusion regarding the consequences of the plan or project in relation to the integrity of the site concerned. If it is concluded that the plan or project would have no adverse effect, then the plan or project can proceed. If an appropriate assessment identifies that any activity cannot be proven to have no adverse effect, then the competent authority must refuse permission for the proposed plan or project.

In exceptional circumstances, a plan or project may still be allowed to go ahead, inspite of a negative assessment, provided there are no alternative solutions and the plan or project is considered to be of overriding public interest. In such cases, the Member State must take appropriate compensatory measures to ensure that the overall coherence of the Natura 2000 network is protected.

3.1.4 Comparison of approaches to Article 6.3 across the EU – country case studies

The approaches to Article 6.3 were compared across a number of EU countries. Comparisons were made between approaches taken in the UK, Germany, Netherlands and Denmark. These countries appear to have the most formalised procedures in respect of nitrogen deposition assessments required under Article 6.3. It was not possible to get details of the practices in other countries and in some cases it is unclear how nitrogen deposition impacts from plans and projects are assessed, if at all. A full detailed approach for each of the countries that presented at the workshop is provided in Appendix 3.1, with the findings summarised in Table 3.1 below.

It is not surprising to find that most countries reviewed share some common approaches in the assessment of new/existing plans and projects and their impacts on Natura 2000 sites. Some key approaches are summarised below:

Site Relevant critical loads

Each country reviewed has carried out a process of linking designated features (habitats and species) and empirical critical loads for nitrogen. This has also included the assessment of whether a particular habitat/species is sensitive to nitrogen deposition. This approach is commonly used for determining likely significant effects and to assist with an assessment of potential effects on site integrity.

Distance parameter

Threshold distances are used by some countries as an initial step to identify relevant sources. This supports the screening process to exclude sources that are not going to impact on a particular Natura 2000 site. However, such distances take a rather different form between countries. In the UK, 10 and 15 km are generally used as distances that require screening assessment of individual activities regulated under the IPPC directive. In Denmark and the Netherlands, thresholds of one and three km are used for assessment of farm activities, though larger distances can apply in some circumstances.

Application of threshold factors

Critical loads and levels are typically used for comparing thresholds. They serve both to identify likely significant effects to a Natura site, and to determine whether an adverse effect will occur. There are a number of things to consider in assessing likely significant effects. The principle of what is a significant effect is defined by what is *de minimis* (trivial/inconsequential). In other words *de minimis* can be described as a process contribution that is small enough to be ignored For example, the <1 per cent contribution of a critical load/level (as used for some installations in the UK) could be seen as *de minimis* and having no significant effect as this represents 0.05 kg N $ha^{-1}yr^{-1}$ for the lowest empirical critical load (or 0.01 $\mu g/m^3$ for the lowest critical level for NH_3). However, there remains the question of what would be *de minimis* for the consideration of the cumulative effect of multiple projects. This presumably depends on the distribution of projects contributing to overall deposition (e.g. a few large combustion plants or many small farms).

In addition, there still needs to be a judgement on whether the plan or project is causing no adverse effect. This leads to the key question - what is an acceptable contribution? For Germany the extra nitrogen deposition for a project or plan has been set to 10 per cent of the critical load. This represents around one kg N $ha^{-1}yr^{-1}$ for a ‘typical’ critical load of 10 kg N $ha^{-1}yr^{-1}$ and is seen as within the precision of measurement. In the UK an acceptable process contribution of 20 per cent (in combination) of the critical level/load has been used in the assessment of impacts from existing installations from intensive livestock sector, but no per cent threshold has been set yet for generic application. The basis for choosing different per cent thresholds for different source types is one of the key areas that requires discussion. However, there are still numerous factors that influence these potential outcomes and decisions under the Habitats Directive should be based on the site-specific situation and should be precautionary. If there is any reasonable scientific doubt about there being no risk to the integrity of the Natura 2000 site it should not be possible to conclude that there is no adverse effect. This provides a challenge for the risk assessment process, since where critical

Table 3.1: Comparison of approaches to the implementation of Article 6.3 of the Habitats Directive, in respect of nitrogen impacts, across four EU Member States. The table reflects the situation in mid-2009.

Questions	Denmark*	Germany	Netherlands	United Kingdom
Is/are distance criteria set to identify relevant sources?	Farm projects within buffer zones of 300 meters and 1000 meters from wet and dry heath/dunes, dry grassland, raised bogs and nutrient poor waters in Natura 2000 sites are evaluated. Larger projects need assessment regardless of distance if they can affect a Natura 2000 site.	For appropriate assessments there are at the moment no official distance criteria, because it always depends on the project type, the emissions and a case by case assessment. Independently, air pollution law prescribes that nitrogen deposition effects caused by new or to-be-expanded existing sources on sensitive areas within the evaluation area (generally one km for agricultural sources) have to be assessed if a likely significant effect is likely.	In the current procedure for the Netherlands no clear distance criteria are set. According to Dutch jurisprudence every source that can lead to a (further) exceedance of the critical load is relevant, regardless of the distance. However, for other nature areas (part of the National Ecological Network, but outside Natura 2000) ammonia sources outside a three km zone are considered to be not relevant.	The following criteria are used to screen for relevant sources. Any large combustion process within 15km of a European site. 10km for any other large industrial installation (including intensive farming) regulated under the Integrated Pollution Prevention and Control Directive. Reduced distances applied to smaller processes. A long-range assessment is also required for Large Combustion Plant.
Are critical loads/levels used at a site assessment level across the Natura network?	Yes, the UNECE critical loads have been translated into a national list of critical loads for all Natura 2000 habitat types. Critical levels have not been used.	Yes. Empirical critical loads have been used for the assessment of nitrogen deposition based on habitat type. But they are not directly used as levels for adverse effects (see below: " per cent contribution from project").	The critical loads for habitats have been assigned across the Natura 2000 network. This work included the assessment of habitat sensitivity to nitrogen deposition (van Dobben & van Hinsberg, 2008)	Critical loads have been assigned to designated features and mapped across the Natura network and compared with deposition values (Bealey *et al.*, 2007). Critical levels for ammonia have been assigned to Natura 2000 sites where potentially impacted by intensive farming installations.
Are Exclusion Zones used around sensitive Natura 2000 sites?	300 metres zone is prohibited for new farms and capped emissions for existing farms within this zone.	No	No	No

Questions	Denmark*	Germany	Netherlands	United Kingdom
Does the assessment take into account multi-sources in-combination with each other?	Within 300-1000 metres the allowable extra contribution of deposited NH_3 from each farm is 0.3 kg N $ha^{-1}yr^{-1}$, for three or more farms (0.5 kg N $ha^{-1}yr^{-1}$ for two farms and 0.7 kg N $ha^{-1}yr^{-1}$ if there is only one farm)	In general yes, but there are still major methodological problems.	It is important to include all relevant activities to determine cumulative effects. This cumulative effect also takes into consideration any background deposition.	In combination effects (multi-sources) are taken into consideration.
Is location of interest feature and extent of impacts assessed?	No, same regulation is applied regardless of current state of the habitat, as deposition has to be lowered for habitats in a bad state in order for them to recover.	A concept of assessing the size of the affected area could be introduced for future guidance	The location of a particular feature is taken into account as much as possible when assessing the impacts	An assessment is made of the size of the site and the location of a particular feature in relation to the predicted pollution footprint
Is a per cent contribution of nitrogen deposition from the project compared with critical loads/ levels?	No, per cent contribution is not used. Instead allowable extra contribution of deposited NH_3 from each farm is defined (see above).	For appropriate assessments, a project or plan contribution of 10 per cent of the critical load is tolerable even if the background (or background + the source) is already exceeded. This not applicable if the site is in unfavourable status caused by nitrogen inputs. These cases are assessed on a case by case basis.	At the moment no particular per cent nitrogen deposition in comparison with critical loads is taken into account	Yes, likely significant effect based on a proportional contribution of the critical load or level. Intensive farming – 1 per cent-4 per cent, depending on how conservative the screening model used is. Other large IPPC Installations – 1 per cent..
Is the legal status of a designated site taken into consideration when comparing thresholds (e.g. Natura site vs a local nature reserve*)? **[* Appropriate Assessments are only carried out for Natura 2000 sites]**	Yes. Natura sites have more strict protection, but all oligotrophic lakes (type 3110), all raised bogs (type 7110+7120), and all large (>10 ha) heaths & grasslands also have buffer zones with similar protection even outside Natura 2000 sites.	Appropriate Assessments are only carried out for Natura 2000 sites. In general the Natura 2000 sites are protected the most strictly. The assessment of nitrogen deposition effects in German air pollution abatement law sets a mandatory target based on the critical load (x1). Other lower designation status sites can vary between x1 to x3 of the critical load.	These assessments are only carried out for Natura 2000 sites. For non-Natura sites, 'normal' Dutch legislation applies, taking into account emission ceiling zones around nature areas.	Yes – precautionary approach for Natura 2000 sites. For example, for ammonia impacts from (existing) intensive farming the allowable process contribution of the critical load or level is 20 per cent for SACs/SPAs, 50 per cent for SSSIs, 100 per cent for county wildlife sites.

Questions	Denmark*	Germany	Netherlands	United Kingdom
Are abiotic conditions taken into account?	Roughness of surface of the habitat and of the area between the source and the habitat is entered into calculation of the deposition contribution from a farm. In some cases hydrology, roughness of habitat or e.g. harvest of biomass are checked in order to better resolve local deposition and/or local critical loads.	The abiotic conditions that are important to a habitat or species are taken into account. The focus is on the most important abiotic condition(s). But until now which abiotic factors are relevant for the assessment of nitrogen deposition has not been determined.	The abiotic conditions that are important to the continued integrity of a habitat or species are identified. The initial focus is on the most limiting abiotic condition(s). Abiotic conditions include acidity, water content, salinity, nutrient availability, tolerance to flooding, groundwater level.	Any potential hazard from the proposal, which could affect the interest features are noted. This includes some 'abiotic' factors e.g. toxic contamination, nutrient enrichment, acidification, changes in salinity regime and changes in thermal regime.
Is the site assessed for current condition status? (favourable/ unfavourable)	The Annex 1 habitats are mapped including condition assessment. Habitats have protection whether or not they are in favourable condition.	A project contribution of 10 per cent of the critical load is not applicable if the habitats or species of a site are in unfavourable conservation status caused by nitrogen inputs. These cases are assessed on a case by case basis.	The present condition of the habitat or species is assessed.	The condition of the site is taken into account to a certain degree but it is recognised that current UK site Common Standards Monitoring (condition assessment) is not sensitive enough to detect and attribute air pollution effects (it was not designed for this). Questions asked include how long the project has been there, has there been any monitoring done on site and its relevance in relation to impact from the project.
Are long-range effects taken into account?	In general, total deposition and critical load exceedances are not used in the assessment. Yet, large sources at larger distances from a Natura site should also be included in the assessment of nitrogen deposition.	Yes – sources at larger distances from a Natura site are also included in the assessment of nitrogen deposition if there is a possible causal connection.	Yes – sources at larger distances from a Natura site are also included in the assessment of nitrogen deposition	Yes – long-range contribution taken into account in determining background pollutant contributions. Long-range process contributions taken account of for major combustion processes beyond 15 km.

The situation in Denmark has changed since the workshop. For an update please see the Danish country report, Section 3.3.

loads and levels are already exceeded, it remains a matter of doubt for example, whether to apply a threshold of 10 per cent or 5 per cent etc.

The need to deal with cumulative effects of multiple projects also remains a challenge for the decision-making process and Table 3.1 shows that there are a range of approaches in Europe The appropriate assessment needs to consider in-combination effects as well as prevailing environmental conditions (European Commission, 2000). Plans and projects may not be significant on their own but their authorisation could lead to 'critical load exceedance creep'.

Alternatively, an approach could be to place limits on total deposition rather than a per cent contribution to a critical load. Denmark applies a threshold based deposition where any new agricultural 'installation' within 300-1000 metres of a Natura 2000 site is allowed an additional contribution of x kg N $ha^{-1}yr^{-1}$ to a sensitive Natura 2000 site depending on how many farms are involved (see Table 3.1).This is an interesting alternative and eliminates the use of critical loads/ levels (although they were considered in the derivation of the thresholds see Bjerregaard *et al*., this volume).

Conservation objectives and favourable status

For most countries, consideration is given to the conservation status of the site. Further additions of nitrogen are avoided when a site is deemed to be at unfavourable status, particularly when this is caused by nitrogen inputs. The Habitats Directive requires that judgements of 'likely significant effect' and 'no adverse effect' must be made in relation to the interest features for which the Natura site is designated, focusing on the conservation objectives of each feature. Country assessments often examine the ecological requirements a feature may have, looking at ecological function, sensitivities to nitrogen and the extent of impact across the site.

3.1.5 Conclusions and recommendations for workshop discussion topics

We have been able to present information in this paper for four European Member States, but the question may be asked how these regulatory practices compare in other Member States. The countries reviewed above are the most prominent in terms of guidance and practice in tackling the issue of atmospheric nitrogen deposition and ecosystem impacts.

It is clear from the country reviews that there are some key issues that are important in assessing impacts of nitrogen on the Natura 2000 network. Article 6.3 of the Habitats Directive brings to light a number of important challenges for assessing any plan or project impact on a Natura 2000 site. Recommended discussion topics for the workshop were:

1 What is a likely significant effect and how is it defined?

2 What is a significant contribution from a project or plan in relation to either a habitat critical load or an emission target?

3 What if the background is already exceeded? How much more additional nitrogen is seen as having no adverse impact on the integrity of a site?

4 How should in-combination (multi-source) effects be handled? For example, can *de minimis* values be set for the consideration of individual project contributions where the cumulative effect of many projects is being considered?

5 Is there sufficient knowledge within the scientific community on effects to be able to guide practitioners into making decisions on site integrity and what constitutes a likely significant effect?

6 Where are the relevant gaps in this scientific knowledge?

7 Are critical loads and levels fit for the purpose of site relevant assessments since they were originally developed for national risk assessments to inform the UNECE Convention on Long-range Transboundary Air Pollution (LRTAP)?

8 What rules should apply for new plans or projects where background critical loads and levels are already exceeded? How should *de mimimis* be defined and cumulative (and in combination) effects be handled in this instance?

One theme running through the country reviews is that decisions often have to be made at the site specific level. Each site is has its own set of ecological requirements and sensitivities.

1 Is there enough information at every site to be able to inform a regulator/site manager about these requirements when it comes to nitrogen deposition?

2 Is sufficient information available on conservation status to conduct an appropriate assessment for different Member States?

3 What would constitute an outline of 'best practice' in conducting such assessments, and what are the main limitations among the Member States to implementing this?

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Appendix 3.1: Country case studies

The following sections provide further detail of the approaches used by some Member States for assessing nitrogen deposition impacts on Natura 2000 sites in respect of Article 6(3). This reflects the situation in mid-2009, in some cases there has been further development of the approaches since the workshop.

United Kingdom – W.J. Bealey, Centre for Ecology and Hydrology, UK

In the UK the Habitats Directive is transposed into national law by means of the Conservation (Natural Habitats & c.) Regulations 1994 (as amended, known as the Habitats Regulations), including separate, but related regulations for the devolved regions Scotland and Northern Ireland.

In relation to assessing emissions of air pollutants from new plans and projects, including nitrogen emissions, the responsibility lies with a range of competent authorities depending on the relevant licensing regime. New plans or projects require planning permission which is often the responsibility of local planning authorities. In addition, polluting activities above a certain size will require a pollution control permit from the appropriate local or national regulator. The UK Habitats Regulations require that an assessment of the impact of the site for Habitat Directive purposes is carried out by the most appropriate authority.

This country review focuses on the application of Article 6.3 by the Environment Agency in England and Wales of applications for pollution control permits under the IPPC Directive (such as power stations and agricultural installations). For this, the Environment Agency and the statutory conservation agencies (Natural England and Countryside Council for Wales) have developed a staged risk assessment requiring increasing detail at each stage if effects have not been discounted, in line with the tests of the Habitat Regulations. The exact form of the assessment will depend on the characteristics of the industrial sector concerned. Furthermore, in this approach, critical loads and levels are instrumental to the assessment of nitrogen impacts from industrial and agriculture installations. The four stage process outlined below uses the concept of critical loads and levels to assess impacts on designated features making up a given Natura 2000 site.

Stage 1 – Identification of all 'relevant' permissions.

This initial stage has been set up to identify any projects or plans, which need further assessment, based on distance-based criteria from a designated site. These are:

- any application within the boundary of a Natura 2000 site ,
- any centrally dispatched coal or oil-fired power station within 15km of a Natura 2000 site,
- any other major installation (including intensive livestock farms) within 10km of a Natura 2000 site.

Additionally, long-range effects of major combustion processes should also be taken into account for a project or plan beyond 15km.

Stage 2 – Assessment of whether the permission is likely to have a significant effect (alone and/or in combination).

This is the key Stage in determining whether a project requires an appropriate assessment. Under the Habitat Regulations a likely significant effect is described as:

> *"..any effect that may reasonably be predicted as a consequence of a plan or project that may affect the conservation objectives of the features for which the site was designated, but excluding trivial or inconsequential effects."*

Stage 2 is based on source modelling to predict the process contribution of the concentration and deposition to the Natura 2000 site(s). This procedure acts as a screening process to separate out inconsequential sources. In the UK critical loads and levels are used as an 'environmental benchmark' to assess the potential impact on a site. The significance of the effect of an emission will depend on both the ambient (background) concentration/deposition at the site and the relative contribution of the process under consideration. Atmospheric dispersion models are often used to estimate the process contribution at the site. The critical loads/levels of the designated features of the site are established (Bealey *et al.,* 2007) and are then compared with the modelled process contribution and the background. This procedure is often described by the following equation:

PEC = PC + BC

where PEC is the Predicted Environmental Concentration, PC is the Process Contribution and BC is the current background concentration (for Concentration you can also read Deposition PED, PD etc.).

The Environment Agency and conservation bodies have allocated an initial test threshold of between one and four per cent of a critical load or level depending on the industrial sector and how conservative the screening model used is. Therefore, a process contribution of less than one - 4 per cent of the critical load or level is seen as not significant, alone or in combination. If the PEC < 70 per cent of the critical load/level then there is also an assumption of no likely significant effect (even if PC > 1-4 per cent of critical load/level).

Stage 3 –Where 'a likely significant effect' on the site has been identified, undertake an appropriate assessment to determine adverse effect.

The outcome for an appropriate assessment, under Article 6.3, is to determine that there is no adverse effect on the integrity of the site concerned from the project or plan proposed. The assessment should be carried out in view of the site's Conservation Objectives. It should take into account uncertainties in the modelling and the critical load/levels and must clearly demonstrate how a specific impact on an interest feature then relates to the integrity of the interest feature and thus the site. There are however some general assumptions which the decision should be based upon, all of which rely on the basis of scientific uncertainty and what is a **significant/acceptable contribution:**

1 If the PEC < 100 per cent of the CL then there is an assumption of no adverse effect.

2 If the BC < CL, but a small PC leads to an exceedance then a decision should be made on the basis of local circumstances, taking into account the magnitude of exceedance, the likely ecological effect of exceedance on the features and site integrity, relative contributions from different sources (in combination) and whether the environmental criteria are likely to be met at some future date.

3 If the BC > CL and the PC will cause an additional small increase then, as above, the decision will have to be made on a case by case basis and on individual circumstances.

4 If the BC < CL, but the PC is significant and leads to an exceedance, then the application should be refused. The PC can be viewed as adding a significant additional risk to the site's integrity.

The decision as to when it can be concluded that there is no adverse effect on the integrity of the site will be a matter of judgement for the competent authority. However, in some circumstances, for example, intensive livestock farms, specific assessment criteria have been developed to enable decisions to be taken in a consistent manner when dealing with a large number of permit applications over a short period.

Stage 4 –Determination of the application

The appropriate assessment of the impacts of a plan or project on a site, provided for in Stage three enables the competent authorities to arrive at a conclusion whether the project or plan has an adverse effect on the integrity of the site. In cases where it is not possible to conclude no adverse effect on integrity, the competent authority has to consider if there are alternative ways that a conclusion of no adverse effect can be reached. For example, in some cases, permit conditions have been set to reduce emissions by a certain deadline. Failing this, further provisions of Article 6.4 would be considered e.g. overriding public interest. Article 6.4 of the Habitats Directive allows the competent authority to permit the project on reasons of overriding public interest, including those of a social or economic nature, which require the realisation of the plan or project in question. Under such circumstances compensatory measures should be taken.

References:

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Netherlands – A. Bleeker, Energy Research Centre of the Netherlands (ECN)

The Habitats Directive is transposed into national law by means of the Nature Conservation Law (1998). The Nature Conservation Law makes it possible to address the Habitats Directive requirements, by means of maintenance plans for individual nature areas (under the Habitats Directive) and/or via specific environmental permit procedures for activities that potentially contribute to a decrease of the quality of the habitat or a significant disturbance of species. The responsibility for the implementation of these regulations lies with different competent authorities, but mainly with the local administrative level (as far as environmental permits are concerned).

The overall procedure with respect to the implementation of the Habitats Directive (and especially the procedure concerning the assessment of activities in the vicinity of nature areas) has been subject to much debate in the Netherlands over the last few years; especially the implementation of the Habitats Directive in relation to regulation of existing ammonia sources. This is mainly due to the fact that the existing regulation of ammonia emissions is not strictly effects based, while the Habitats Directive implementation definitely requires some sort of effects based approach. The method for dealing with nitrogen impacts, under the Habitats Directives, continues to be developed.

Because of the many problems that emerged during the implementation phase, a guidance document was developed describing possibilities of judging environmental permit applications in relation to existing and/or future activities in the context of the maintenance plans. This guidance document focuses mainly on nitrogen deposition and its purpose is to guide the legal authorities at a local, provincial and national level in the construction of maintenance plans. The basis for this guidance document forms the recommendation from the so-called ‘Task Force Trojan’ that for judging existing use and possible future activities (where nitrogen deposition is involved), all factors that influence meeting the ecosystem targets need to be taken into account. Nitrogen deposition is only one of these factors.

The guidance document does not provide a complete solution for the overall process of judging environmental permits and therefore the legal authorities are responsible for making 'site specific' decisions, taking into account all relevant factors. In the following text, a further description of the guidance document is given in relation to the maintenance plans.

Role of the Habitats Directive maintenance plan

In the maintenance plan, the overall picture with respect to meeting the ecological targets is laid down and choices are made: which factors are the most important for meeting the targets; which measures are needed; what is the relation with existing use; what are the local conditions; what are the site specific objectives of the habitat types with regard to total area covered, exact locations and time (i.e.: how fast do we have to reach the targets)?

The maintenance plans give a better understanding about which activities are allowed and which activities are (without further conditions) not possible in relation to the targets.

Question to be answered:
The legal authorities are responsible for judging permit requests for individual situations with respect to potentially harmful (future) activities and to include (as much as possible) all the relevant factors. The following questions are important:

1. What are the targets for nitrogen deposition for the species and habitat types under protection and sensitive to nitrogen deposition?
Not all species and habitat types are equally sensitive to nitrogen deposition. An overview of the sensitivity of Habitat types is given in Van Dobben & Van Hinsberg (2008). If the species or habitat type is not sensitive to nitrogen deposition, a new activity that is being investigated can be permitted (unless other effects of the activity are not meeting the targets for the habitat types).

2. What is the location within the Natura 2000 site of these species and habitat types?
For judging the activities, it is important to know where the nitrogen sensitive habitat types and species are located within the site. This is important since nitrogen deposition can vary significantly between different locations in a site.

3. What is the present state for these species and habitat types?
The present state describes the condition of the habitat type or species. The relevant aspects of the local condition are described in the national 'Natura 2000 Profiles Document', which consists of detailed descriptions of the habitat types and species and their environmental requirements (Ministry of ANF, 2008). The quality of habitats and the threats in all Natura 2000 sites has been assessed to a certain extent (because this was important for setting the targets), but the legal authority has to collect further information. When this information is not available from e.g. the provincial authorities or conservation organisations, further ecological research is needed.

4. What are the abiotic conditions that are important for these species and habitat types and which (limiting) conditions determine the present state?
In the Profiles Document the 'ecological demands' describe the abiotic conditions needed for an optimal development of habitat types and species. The ecological demands look at the following abiotic conditions:

- acidity,
- water content,
- salinity,
- nutrient availability,

- tolerance for flooding,
- groundwater level.

Nitrogen deposition influences the abiotic conditions related to acidity and nutrient availability. Nitrogen deposition has an acidifying and nitrifying effect. Habitat types and species have demands with regards to different abiotic conditions. When judging existing use or future activities it is important to find out which abiotic conditions are important for the development of habitat types and/or species and which abiotic conditions are limiting with regard to realising the targets. This means: which abiotic conditions are important for the specific habitat types and species and need to be improved or maintained to reach the targets. In first instance the focus is on the most limiting abiotic condition(s). However, eventually all abiotic conditions that are limiting for the targets have to be optimal.

5. What is the prognosis for the development of the relevant abiotic conditions?
Based on an ecological analysis and recent developments of the abiotic conditions, a prognosis can be made for the future. This prognosis can be used for assessing existing or future activities and can be based on information about:

- recent or proposed measures on national or area scale,
- recent development of (economical) activities on national or area scale.

For the assessment also the timescale for reaching the targets for the nitrogen sensitive habitats and species is important. If the abiotic conditions of a habitat in a Natura 2000 siteare clearly improving and these improvements are sufficient with respect to reaching the targets, the effects of the (future) activities do not need to be judged as being significant. At the moment of permitting an activity no reasonable scientific doubt may exist about the positive effects occurring and that the extent of these permitted activities is thus not significant.

6. What is the effect of the (future) activities on the abiotic conditions?
Here only the effect of nitrogen deposition due to the (future) activity is of relevance. This amount of nitrogen deposition can be assessed by means of dispersion and deposition models. For the Dutch local situation the model “Aagrostacks” and OPS is used.

7. What are relevant activities in and near the Natura 2000 site and what is their cumulative effect?
When assessing the cumulative effect of different relevant activities, it is important to include all effects that have an influence on the different abiotic conditions relevant for the specific habitat type or species. The cumulative effect deals with both the additional negative effects of other nearby activities as well as the positive effects of mitigating measures.

When assessing the cumulative effect of nitrogen deposition, not only the deposition due to sources in or around the Habitat area has to be considered but also the background deposition. For the effect on the abiotic conditions it does not make a difference if the deposition is caused by a source located nearby or at larger distances from the nature area. It also does not make a difference if the deposition is caused by an agricultural source, industry, energy producer or traffic. The total amount of deposition is what is relevant and the effect it has on the nitrogen sensitive habitats or species.

The more complete the answers are to the questions above, the more likely it is that a decision can be made on whether or not a permit for new activity can be given.

Judging these seven points/questions in an integrated way is very important. The factors that are important for question six (effect of the activity) is different for each situation, but the final 'answer' also depends on e.g. the accumulation of effects of other activities (question 7).

8. What if the (future) activity doesn't meet the targets?
The outcome of the integrated investigation (based on answering the seven questions) can be that the (future) activities near a Natura 2000 site will result in non attainment of the targets for that site.

The legal authority than has the following options:

- Start discussing further conditions for the (future) activity. The applicant can be advised to take emission reduction measures, by which a sufficient nitrogen deposition can be achieved.
- Start discussing alternatives for the (future) activity. The applicant can be advised to start looking for an alternative, like e.g. move to another location.
- Take additional measures, enabling meeting the targets to be achieved despite the (future) activity. It should be monitored however, that these measures are indeed implemented.

If these options do not bring a solution, the plan or project cannot be permitted. In the case of existing activities the legal authorities can facilitate the moving of the activity, e.g. by subsidizing the relocation of farms.

References:

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.

Denmark – E. Buchwald, Ministry of Environment

In Denmark two national regulations are relevant for assessing plans and projects regarding air pollution in relation to Article 6.3 of the Habitats Directive. One is a general regulation requiring appropriate assessment of all plans and projects which might significantly affect a Natura 2000 site. The other is a regulation dealing with livestock farms. Livestock production can only be established or enlarged/changed if the local authority grants permission. Permission may only be granted if the farm uses Best Available Technology for pollution control (BAT) and the authority ascertains that the plan/project will not adversely affect any Natura 2000 site.

In Denmark there is a list of critical loads of nitrogen deposition for all Natura 2000 habitat types (Annex I habitats) on the Ministry of Environment website. They are in line with the UN-ECE critical loads. This list together with assumptions and modelling of deposition to each type forms the basis for which selected habitats are included as vulnerable to ammonia in the regulations - see below. These habitats appear on existing maps of all nature areas in Denmark, and a map of them with buffer zones of 300 meter and 1000 meter is important in the evaluation of farm projects.

As part of the preparation for the upcoming Danish Natura 2000 plans, several studies have looked into the deposition of N compared to critical loads of the most vulnerable habitats. Nitrogen deposition in Denmark ranges from about 14 to about 25 kg N $ha^{-1}yr^{-1}$ modelled as a mean deposition in a 16 x 16 km grid. More detailed studies have revealed that many Natura 2000 sites have lower actual deposition than modelled, due to fewer farms and other local factors, whereas other sites have a higher deposition. Nevertheless, several habitats have problems with deposition exceeding the critical load in parts of Denmark.

The regulation on livestock farms includes many details including how to find out what are the thresholds in relation to adverse effects regarding ammonia, phosphorus and nitrate. Existing permissions to farms must be updated at least every 8-10 years in order to comply with the newest regulations and thresholds. In general, thresholds have become stricter over time, and there are plans to make them even stricter yet. Farms with three or fewer animals are not regulated.

The thresholds are set in a way that it can be assumed that no significant adverse effects on the integrity of Natura 2000 sites can be anticipated when keeping below them. In exceptional cases, the thresholds may not be strict enough, and in such cases, according to present legislation, the local authority may only permit the farm project on stricter conditions preventing adverse effects.

For ammonia, the following thresholds are listed in the regulation:

- Compared to BAT in 2005/2006 ammonia emissions must be 15 per cent lower in 2007, 20 per cent lower in 2008 and 25 per cent lower in 2009.
- Within 300 meters from habitat types vulnerable to ammonia/nitrogen deposition in Natura 2000 sites, new farms are not allowed, and emissions must not increase from existing farms.
- The vulnerable habitat types defined in the law include heath and dry grassland, raised bogs, nutrient poor lakes.
- Within 300 - 1000 meters from the vulnerable habitats in Natura 2000 sites, the allowable extra deposition of ammonia from a farm project is 0.7 kg N $ha^{-1}yr^{-1}$ if there are no other farms within one km, 0.5 kg N $ha^{-1}yr^{-1}$ if there is one other farm within one km and down to 0.3 kg N/ha if there are more than two other farms.

The Environmental Approval Act has recently been changed (2011) and now introduces a new concept for regulation of N-emissions in the neighbourhood of Natura 2000 sites. In the new regulation, the concept of buffer zones is abolished. The total allowable contribution from one livestock production unit is 0.7 kg N $ha^{-1}yr^{-1}$ if there are no other livestock farms within a certain distance of the applicant farm. If there is one other livestock farm within this distance, a total of 0.4 kg N $ha^{-1}yr^{-1}$ is allowed, and if there are two or more other livestock farms, a total of only 0.2 kg N $ha^{-1}yr^{-1}$ is allowed. The exclusion zone is proposed to be reduced from 300 m to 10 m. This implies that outside 10 m N-emissions are no longer capped and the establishment of new livestock farms is no longer prohibited, providing that the above requirements to total contribution are met. For phosphorus and nitrates all of Denmark has been mapped in relation to sensitive soils and sensitive Natura 2000 sites including marine sites. Depending on their location in Denmark farms must comply with thresholds for these issues also.

Germany - D. Bernotat, Federal Agency for Nature Conservation and Till Spranger, Federal Environment Agency

Nitrogen deposition in Natura 2000 sites is currently a high priority issue in Germany. In several court decisions regarding road projects the judges ruled that nitrogen deposition might lead to significant effects and therefore will likely affect the integrity of the site. Examples are the ruling of the Federal Court of Justice (BVerwG) on the Highway A 143 west bypass Halle (from January 17, 2007) and the highway A 44 Lichtenauer Hochland (from March 12, 2008). The Court also notes that there currently seem to be no generally accepted effect assessment standards, and that methods should be considered with regard to competence, impartiality and objectivity.

The Association of the German Länder´s nature conservation authorities (LANA) has therefore audited currently available approaches with a view to their possible applicability to the Appropriate Assessment.

Assessment of Nitrogen Deposition effects in German air pollution abatement law
The TA Luft (Technical Instruction Air), despite not being a law in legal terms, is used to directly implement source-related air pollution laws and regulations in Germany, e.g. for licensing newly built or extended air pollution sources. Section 4.8 states that "significant impediments" caused by nitrogen deposition due to new/extended sources have to be assessed - in practice in the ca. one km² surroundings of the source.

A consensus-oriented expert group mandated by the responsible Federal/Länder body (LAI) designed a methodology (which presently undergoes a two (three) year test phase mandated by the Conference of Federal and Länder Environment Ministers) which is based inter alia on critical loads: Total deposition (i.e. "background" deposition without the source plus the deposition diagnosed to be caused by the source) is compared to critical loads or a multiple (x) of critical loads.

The magnitude of the factor x (which characterises the "significance" of N deposition in the individual case) varies between one and three; it is determined by 1) the legal status of the area to be protected, and 2) the biochemical status (e.g. presence of N indicating species, pH, nitrate concentrations etc.) of the area to be protected.

For N sensitive protected areas (e.g. Natura 2000 sites), $x = 1$, i.e. for these areas, critical loads are used as the mandatory target value for total deposition. In addition, it is recommended to apply standard procedures within the nature conservancy law framework (see below).

The Länder have implemented the regulation in various ways, some as a standard procedure in present licensing cases, some only for ex-post analyses of cases where licenses have been issued.

Appropriate Assessment of Nitrogen Deposition effects regarding Article 6.3 HD in German nature conservation law

The nature conservation authorities (LANA) decided that the described approach, designed for licensing of air pollution sources, in its present form does not have sufficient explanatory power for the necessary assessment of nitrogen inputs into Natura 2000 sites in the context of Appropriate Assessments. The present procedure cannot meet the special requirements of the precautionary principle which is necessary for the protection of Natura 2000 sites under the Habitats Directive.

For Appropriate Assessments, the LANA recommends at the moment a guideline of the Brandenburg State Office for the Environment (Landesumweltamt Brandenburg, 2008). It also uses empirical critical loads for the assessment of nitrogen deposition in habitat types, but in a modified way: If critical loads of nitrogen are already exceeded - which happens in many parts of Germany - or will be reached by the project, the exceedance of the critical load would still be tolerable, if the additional load of the project is less than 10 per cent of the critical load.

There is an exception if a habitat or species is already in an unfavourable conservation status caused by nitrogen inputs. In this case an individual case by case decision is necessary, which in particular has to take into consideration whether the achievement of conservation objectives and the improvement of the situation may be at risk.

A revision of the concept in the future may particularly aim at further preventing a creeping deterioration due to cumulative effects of projects.

Furthermore, the concept could be improved by assessing the size of the affected area in relation to the total size of the Natura 2000 site. Moreover, it is suggested that this approach could be integrated with the scientific standard / guideline of the Federal Agency for Nature Conservation dealing with permanent losses of habitat types in Natura 2000 sites (Lambrecht & Trautner, 2007, http://www.bfn.de/0316_ffhvp.html).

In addition, in 2009 a research project of Federal Highway Research Institute (BASt) was initiated to produce a guideline for the emissions of nitrogen along roads in the context of Appropriate Assessments.

References:

Landesumweltamt Brandenburg (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).

3.2 Working group report

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3.2.1 Conclusions and recommendations of group discussions

- It is recommended that a staged approach is applied to the impact assessment, including: i) a relevance screen, ii) test of likely significant effect, iii) appropriate assessment and iv) final decision. Modelling predictions should be compared against the relevant critical loads and critical levels (applied at the Natura 2000 site scale).
- It is recommended that assessment needs to consider 'in combination' effects. Therefore, the plan/project should be considered both alone and in combination with other plans and projects, as well as in the context of existing ambient air quality (and prevailing environmental conditions). An integrated management/assessment plan (at, for example, the province/region scale) could assist with this.
- It is recommended that all relevant EU Directives and national regulations should be considered during the assessment, to ensure the requirements of the IPPC Directive, Nitrates Directive, Water Framework Directive, EIA Directive etc, are considered alongside those of the Habitats Directive, allowing an integrated approach to be applied.
- It was concluded that ongoing problematic issues include whether consideration of the spatial scale of impact, survey data, and/or application of *de minimis* criteria, in respect to the plan or project contribution, are appropriate. A Member State might choose to apply a *de minimis* criterion to allow new plans or projects in situations where the critical load/level is already exceeded. In the absence of any sound ecological justification for such a position, this would have to be a policy decision.

- It was concluded that further work is required on the development and dissemination of a best practice approach, including the involvement of a larger number of Member States.

3.2.2 Introduction and discussion objectives

The Habitats Directive (Article 6.3) requires that all 'plans and projects' be assessed in relation to possible impacts on Natura 2000 sites and that, except where there are reasons of overriding public interest, the plans and projects can only be approved where they are shown to have no adverse effect on the integrity of a site. At present, however, there is no common approach across Europe for assessing the effects of reactive nitrogen concentrations and deposition resulting from such plans and projects. While some countries are pro-active in the mitigation of nitrogen emissions through various legislation, other countries in the EU are yet to develop guidance and mechanisms for dealing with the effects of nitrogen emitting sources.

The objectives for Working Group 1 were as follows:

1. To compare impact assessment and decision making approaches across Member States in determining the nitrogen deposition impacts of plans and projects in the context of the obligations under Habitats Directive Article 6.3.

2. To discuss what could be considered as a best practice approach to assessing nitrogen impacts on the Natura 2000 network.

3. To identify any particular problems associated with the implementation of the Habitats Directive in different countries.

In addition to these objectives, a number of specific questions were raised in the background document (Bealey *et al.*, this volume), which the group prioritised into five key questions and addressed under discussion of the second objective (above):

1. What is a likely significant effect and how is it defined?

2. What is a significant contribution from a 'plan or project' in relation to either a habitat's critical load or level?

3. If the background nitrogen deposition already exceeds the critical load, what rules should apply for new plans or projects? How much more additional nitrogen is seen as having an adverse effect on the integrity of a site?

4. How should sources in-combination be handled in the process?

5. What would constitute an outline of 'best practice' in conducting such an assessment?

Objective 1: A comparison of assessment approaches

The comparison of impact assessment approaches identified a number of differences but also some common factors (see Table 3.2). For example, all of the countries represented at the workshop use critical loads and/or critical levels in their impact assessments of nitrogen effects on Natura 2000 sites, either directly (UK, Germany & Netherlands) or indirectly as in Denmark where critical loads have been used to choose the most vulnerable habitats and in setting the deposition thresholds for new and existing farms.

Three of the countries compared employ assessment thresholds or allow small increases (*de minimis*) in nitrogen deposition in situations where the critical load is already exceeded (UK, Germany and partly Denmark). In the Netherlands, however, assessments currently work on the principle of allowing no net increase in nitrogen deposition (nitrogen additions are only acceptable where complementary actions are secured to reduce existing nitrogen deposition levels). This arose from a court case in the Netherlands that ruled that new and existing farms cannot be permitted when the critical load for a habitat is already exceeded (200802600/1/R2 and 200807857/1/R2). In Denmark a different approach is applied for agricultural sources of nitrogen, where increments of nitrogen deposition are allowed based on the number of farms within a 300 m -1 km radius from a sensitive habitat (see Section 3.3). In some cases, municipalities allow no net increase to Natura 2000 sites.

All countries use a staged process for handling plans or projects with an initial screening of plans or projects to assess the likelihood of a significant effect. In addition, at the site level, Annex 1 habitat features have been assessed for their sensitivity to nitrogen deposition and then allocated a relevant critical load. This assists the assessment process at the screening and the appropriate assessment level where the most sensitive features can be identified and any critical load exceedances evaluated.

Table 3.2: Comparison of nitrogen impact assessments in different Member States in 2009

	Dk	De	NL	UK
Staged assessment approach	✔	✔	✔	✔
Critical loads/levels applied	✔	✔	✔	✔
Buffer Zones Around Natura 2000 sites	✔	x	x	x
Multi-source, in-combination tests	✔	✔	✔	✔
Long Range/Short Range N deposition considered	✔	✔	✔	✔
Status/condition of Natura 2000 site considered	✔	✔	✔	✔
Size of impact (area) considered	x	✔	✔	(✔)
De-minimis thresholds applied/allowable increments	✔	✔	✔	✔

Further details on the approaches applied in individual countries are provided for the UK (see Appendix 3.1 and Russell *et al.*, this volume), Netherlands (see Appendix 3.1), Denmark (see Appendix 3.1 and Bjerregaard *et al.*, this volume) and Germany (see see Appendix 3.1 and Uhl, this volume). It is worth noting that the approaches adopted by some of the Member States have been significantly influenced by court decisions, while each approach also clearly reflects national policy and national goals.

Objective 2: Best practice approach for assessing N impacts to Natura 2000 sites.

A Staged Approach

Based on the countries' assessment approaches and the requirements of Article 6.3, the working group developed an assessment framework consisting of a number of discrete stages:

- Stage 1 – Relevance screen
- Stage 2 – Likely significant effect test
- Stage 3 – Appropriate Assessment
- Stage 4 – Final decision (i.e. can it be ascertained that the plan/project will not adversely affect the integrity of the site?).

Stage 1 is an initial screen to filter out those permissions that by virtue of their nature or location could not affect the interest features of the Natura 2000 site. Stage 2 and 3 mirror the terms set out in Article 6.3 of the Habitats Directive. The assessment includes an iterative process, as consideration should be given to potential conditions, restrictions or management measures that may be applied to the plan or project to enable a conclusion of no adverse effect on site integrity to be reached. Each stage is described in more detail in the guidance note in Appendix 3.2. The following sections report the discussions on some of the key issues by the working group:

Use of critical loads and levels

Critical loads and levels are useful as an environmental limit to be used in impact assessments. They can be applied at the site level, although they were originally developed for use in national/international risk assessments. Further refinement to make them more applicable to a specific habitat of an individual Natura 2000 site and its conservation objectives is, however, recommended. Such research has been carried out by many countries and other Member States may benefit from their approaches. These include:

- Research in the UK on defining 'site relevant' critical loads for the Natura 2000 network (Bealey *et al*., 2007).
- The Netherlands has defined critical loads for every Annex I habitat (Van Dobben & Van Hinsberg, 2008).
- In Denmark, critical loads have been allocated to all Annex I habitats. For precautionary reasons, the critical loads for Annex I habitats are normally placed at the lower end of the range. A more exact critical load may be assessed by collecting all existing information on N-sensitive plant species, mosses, lichens, soil, aerial photos etc., and, if necessary, field surveys. http://www.skovognatur.dk/NR/rdonlyres/78C70731-71A2-40B6-B611-2F1340CB922A/14951/Ammoniakmanual02122005.pdf
- Research in Germany on appropriate assessments has considered soil and vegetation at the site level to give expert judgement about more exact, site-specific values within the span of the empirical critical load values. Another approach that has been used in Germany

is the application of model outcomes (BERN vegetation model coupled to DECOMP biogeochemical model by ÖkoData).

- On-going developments carried out by the Coordination Centre for Effects (CCE) of the Convention of on Long-range Transboundary Air Pollution (LRTAP) (http://www.mnp.nl/en/themasites/cce/index.html)

Determining a 'Likely Significant Effect'

A 'likely significant effect' can be described as any effect that may reasonably be predicted as a consequence of a plan or project that may affect the conservation objectives of the features for which a site was designated. Here it should be underlined that the conservation objectives may require some improvement in state/quality, not just preservation of the current state/quality.

The ECJ Waddense ruling (http://curia.eu.int/en/content/juris/index_form.htm case number C-172/02'), said that where a plan or project not directly connected with or necessary to the management of a site is likely to undermine the site's conservation objectives, it must be considered likely to have a significant effect on that site.

Where an exceedance already occurs

Where local background levels of nitrogen are already in exceedance of the critical loads/levels, a policy decision may be required on how to interpret this. On one hand it can be argued that any further increase in nitrogen deposition would give rise to a greater risk to the site or worsen effects, and therefore a conclusion of 'no adverse effect' on site integrity cannot be reached (see Chapter 5). On the other hand, given the uncertainty in model predictions and the absence of critical loads specifically evaluated for many Annex I habitats, some countries argue that allowing a certain 'degree of tolerance' is acceptable (i.e the *de minimis* principle). It should be noted that critical loads have already been set with habitat management practices in mind so management options, such as grazing or mowing, should not be seen as a mitigation solution for critical load exceedance (R. Bobbink pers. comm.).

The In-Combination Test

Article 6.3 of the Habitat Directive specifies that plans or projects should be considered individually and in combination with other plans and projects. Article 6(3) does not explicitly define which other plans and projects are within the scope of the combination provision. However, in the Natura 2000 guidance notes (European Commission, 2000a) the underlying intention of this combination provision is to take account of cumulative impacts, and these will often only occur over time. In that context, one can consider plans or projects which are completed; approved but uncompleted; or not yet proposed.

Many existing sources are often already part of the background deposition or concentration that are mapped by Member States. However, there are occasions where recent permitted sources are not taken into account in the background, and there are sources that may escape the modelling or mapping process.

Integrated Management Plans

The use of an 'integrated management plan', an approach taken with many other activities affecting Natura 2000 sites, could represent an effective way to achieve a full consideration of in combination and cumulative effects. The plan, at a wider geographical scale (regional or by province), would integrate projects over time and space, and allow detailed consideration of cumulative effects.

Integrated management plans (IMPs) (as e.g. under art. 6(1) of Directive 92/43/EEC) offer the opportunity to unify all known, current and future projects in a given territory under one scheme.

This means that instead of following Article 6(3) and 6(4) procedures for each individual site and project, one plans ahead (10 years is a common time frame) and conducts Article 6(3) and 6(4) procedures only once for the entire planning area and all its known projects. Experience with sites where economic activities overlap with nature protection shows that IMPs are best devised employing a bottom up approach. This means fixed goals for each indivisible sub-unit, contributing to overall targets.

The working group determined that IMPs have advantages and disadvantages:

Advantages:
- They bring planning and legal certainty.
- IMPs offer the possibility to take so called accompanying preventive measures, which are aimed at improving the overall conservation status of a managed site, thereby reducing the likelihood of significant effects and critical load exceedances.
- In principal, IMPs should also enable the integration of many forms of nitrogen, as IMPs consider a provincial/regional area in its entirety and not just individual Natura 2000 sites.

Disadvantages:
- Spontaneous projects cannot be integrated into the plan, once it has been approved. They still need individual Article 6(3) and 6(4) procedures.
- The relevant sites often transcend federal and national borders. There is yet no successful example of a trans-border IMP, however this may change in the future.
- Where critical loads are exceeded due to long-range transboundary air pollution, an IMP cannot be handled at a national scale.

An integrated approach would also ensure that the impact assessment seeks to consider and satisfy all relevant EU Directives and national regulations, e.g. the EIA-Directive, the IPPC-Directive, the Habitat Directive, the Bird Directive, the Water Frame Directive, the Nitrate Directive, and the SEA Directive (See Section 7.1, 7.2).

Objective 3 – implementation

It was recognised that the working group included representatives from a limited number of Member States and therefore wider consultation on this best practice approach is required. Further work is also needed to establish a mechanism for disseminating the approach. Finally, it was acknowledged that there are a number of issues raised that require further detailed discussion and resolution:

- Emissions to air may have effects over both long and short ranges. How to consider long range effects when assessing a source's impacts requires further consideration. The spatial variability of ammonia and its effects are complex, and understanding the relation between Natura 2000 site location and deposition is important. For example, while sites situated near an agriculture source may be vulnerable to dry deposition of ammonia, Natura 2000 sites in upland areas away from the source may be subject to wet deposition of ammonium ions from it.
- The extent of habitats or species population affected - for some features any area of impact could be judged as unacceptable, however it is perceivable that in other cases very small scale impacts may not be considered to affect the structure and function of the site. Site specific judgement may be influenced by extent of damage and extent of site. Some examples of this are provided in European Commission (2000b).
- Short term impacts - in the majority of cases, standards or benchmarks for the protection of vegetation or ecosystems are based on long-term exposures (annual means). However, short-term exposure to high concentrations can sometimes be significant (i.e. to lichens).

- How to assess cumulative effects, especially from a large number of relatively small plans or projects, and to consider effects that may be additive or synergistic.
- Use of site survey information and the role of monitoring. Monitoring has long been seen as a best practice in EIA, and is a requirement of the recently adopted directive on Strategic Environmental Assessment, but how does it fit with Habitats Directive (Article 6(3)) requirements?

References and further reading

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Appendix 3.2: Proposed guidance for determining the nitrogen deposition impacts of plans and projects, in the context of Article 6(3) of the Habitats Directive

This guidance provides a framework to assist with making robust, transparent and consistent decisions that meet the requirements of the Article 6(3) of the Habitats Directive. The impact assessment approach consists of four distinct stages (see Figures 3.1).

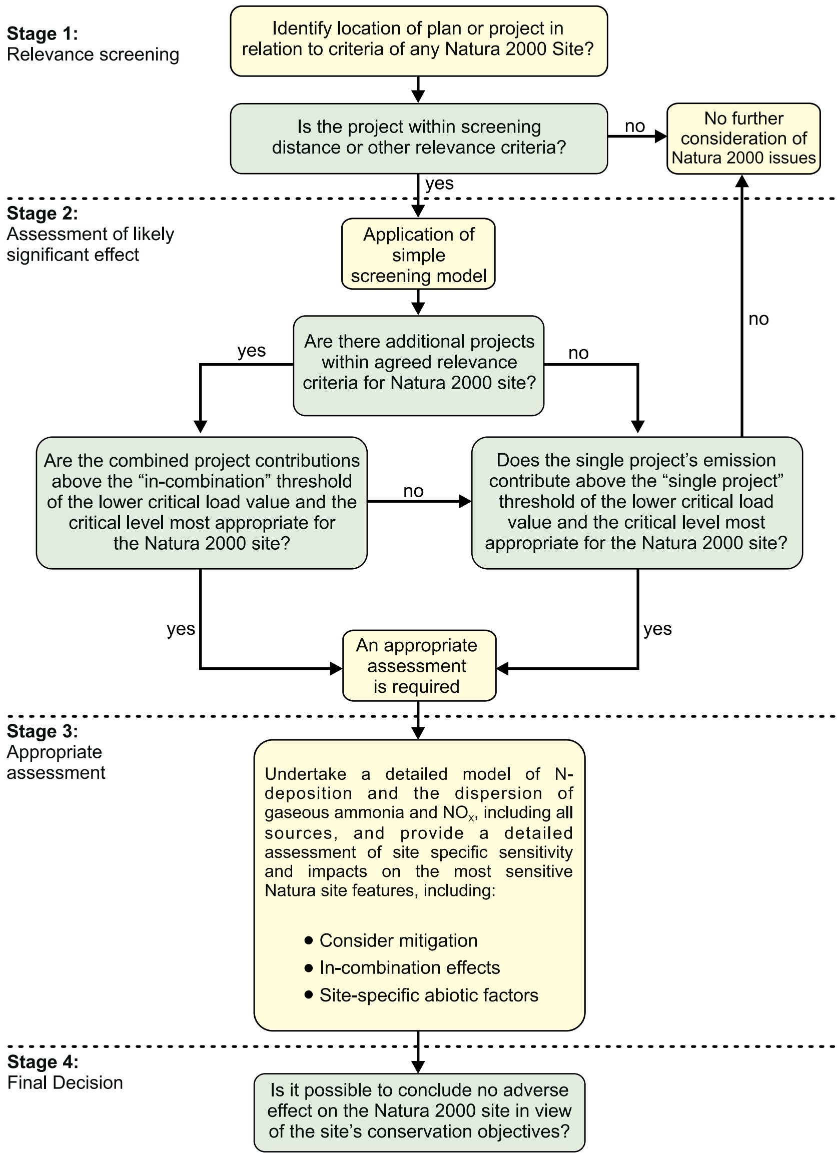

Figure 3.1: Proposed guidance for determining the nitrogen deposition impacts of plans and projects in the context of Article 6.3 of the Habitat Directive

3.3 Impact assessment and regulation of N-emissions from livestock farms in Denmark

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Abstract
- In Denmark, screening according to the EIA directive of all applications for establishment/extension/change of livestock production units, including impact assessment of N-deposition to Special Area of Conservation (SACs), was initiated in 2001.
- In 2007 this method was replaced by a new Environmental Approval Act for livestock farms.
- This law contains both specific regulation in buffer zones around selected habitats as well as general reduction demands and Best Available Technology (BAT) requirements.
- The municipalities have to carry out additional Natura 2000 impact assessment.

3.3.1 Introduction
In Denmark screening of all applications for establishment/extension/change of livestock production units according to the EIA directive was initiated in 2001. The screening included impact assessment of N-deposition to SACs and was carried out by the regional authorities (14 counties). By the end of 2006 the regional authorities were closed down as part of a municipal reform, and the local authorities were enlarged to comprise 98 municipalities.

Simultaneously, a new Environmental Approval Act for livestock farms was passed in 2007 (Ministry of Environment, 2007), replacing the former EIA-screening of livestock farms. The new law is a joint implementation of six EU directives: the EIA-Directive, the IPPC-Directive, the Habitat Directive, the Bird Directive, the Water Frame Directive, and the Nitrate Directive .

The Environmental Approval Act was amended in March 2009 to establish more exact criteria for impact assessment of Natura 2000 habitats and Annex IV species. Furthermore, a new concept for regulation of N-emissions in the neighbourhood of SACs has recently been introduced.

3.3.2 Screening of livestock farms according to the EIA Directive (2001-2006)
The EIA-screening carried out by the regional authorities from 2001-2006 included all livestock categories including pigs, poultry, dairy, mink and other farm animals. The impact assessment of N deposition comprised a staged approach, which might have been slightly different from county to county. The example below is from the former County of Aarhus:

a. Initial screening.
The increase in N-emissions from the farm unit in question is used to determine a modelled “0.1 kg consequence radius” which is the maximal distance from the farm with a risk of a >0.1 kg N $ha^{-1}yr^{-1}$ increase in deposition (ΔD). Further assessment was applied if Natura 2000 habitats or other very N-sensitive habitats were situated within this distance. A less restrictive ‘0.5 kg consequence radius’ was used to identify non-Natura 2000 nitrogen sensitive habitats for further assessment.

b. Actual assessment
1. The total contribution from each farm unit and the increase in N-deposition (ΔD) was calculated in spreadsheet including data on increase in N-emission, distance, wind data,

modelled dispersion factors and estimated surface roughness for both the habitat and the adjacent area.

2. Total Deposition (TD) was calculated by adding ΔD to the local background deposition.

3. In Denmark the UNECE CL ranges have been "translated" to all habitats occurring in Denmark. For precautionary reasons, the CLs of Natura 2000 habitats are normally placed in the lower end of the range. A more exact critical load may be estimated by collecting all existing information on N-sensitive plant species, mosses, lichens, soil, aerial photos etc., and, if necessary, field investigations.

c. Field sources (area sources)

The contribution of N-deposition from application of manure to neighbouring fields was calculated in a separate spreadsheet and added to the contribution from the point source (ΔD) and is assessed jointly according to the criteria above.

d. Decision step 1: Increment significant by itself

A $\Delta D \geq 0.5$ kg N $ha^{-1}yr^{-1}$ was considered to be a significant contribution to most N-sensitive habitats, whereas one kg N $ha^{-1}yr^{-1}$ or 10 per cent of background was used for less N-sensitive habitats. These thresholds were applied even if the critical load was not exceeded as moving towards the exceedance of the critical load was generally not accepted. This practise was to be seen both as some kind of "quota" where one farm is not allowed to use up all of the possibilities to increase production in a local area, and as a precautionary principle (which can be shown to be in accordance with the critical level approach, which has not been included in the Danish assessment so far).

e. Decision step two - In-combination effects

Contribution of ammonia from other nearby livestock farms was not calculated independently, but was considered to be included in the modelled background deposition.

1) If TD>CL: Any increment is considered to be significant to Natura 2000 habitats and to very N-sensitive non-Natura 2000 habitats. This practice was established after decisions by the Nature Protection Board of Appeal, where increments down to 0.09 kg N $ha^{-1}yr^{-1}$ to Natura 2000 habitats were judged to be significant. In practice, ΔD would then have to be 0.00 kg N $ha^{-1}yr^{-1}$, as results were given with a precision of two decimal points.

2) If TD≤CL and $\Delta D < 0.5$ kg N $ha^{-1}yr^{-1}$ a decision of no significant effect was made.

3.3.3 Regulation and impact assessment of N-emission from livestock farms (2007-2011)

The practise of EIA-screening was substituted by the Environmental Approval Act in 2007. This law contains both general reduction demands and BAT requirements as well as specific regulation in buffer zones around selected habitats. According to the law, environmental permits have to be renewed every 8-10 years, and accordingly it is estimated that the main part of livestock production units will have been subject to environmental assessment and approval within 10 years. Applications are entered in an electronic, web-based application system, where increments of N-deposition to the nearest habitats area calculated automatically (for more details on the modelling in Denmark see NERI report in Appendix 6.1).

a. The use of buffer zones in impact assessment of N-deposition

A selection of N-sensitive habitats automatically generate buffer zones of 300 m and 1000 m (Figure 3.2). These include most - but not all - of the habitat types with a critical load ≤10 kg N

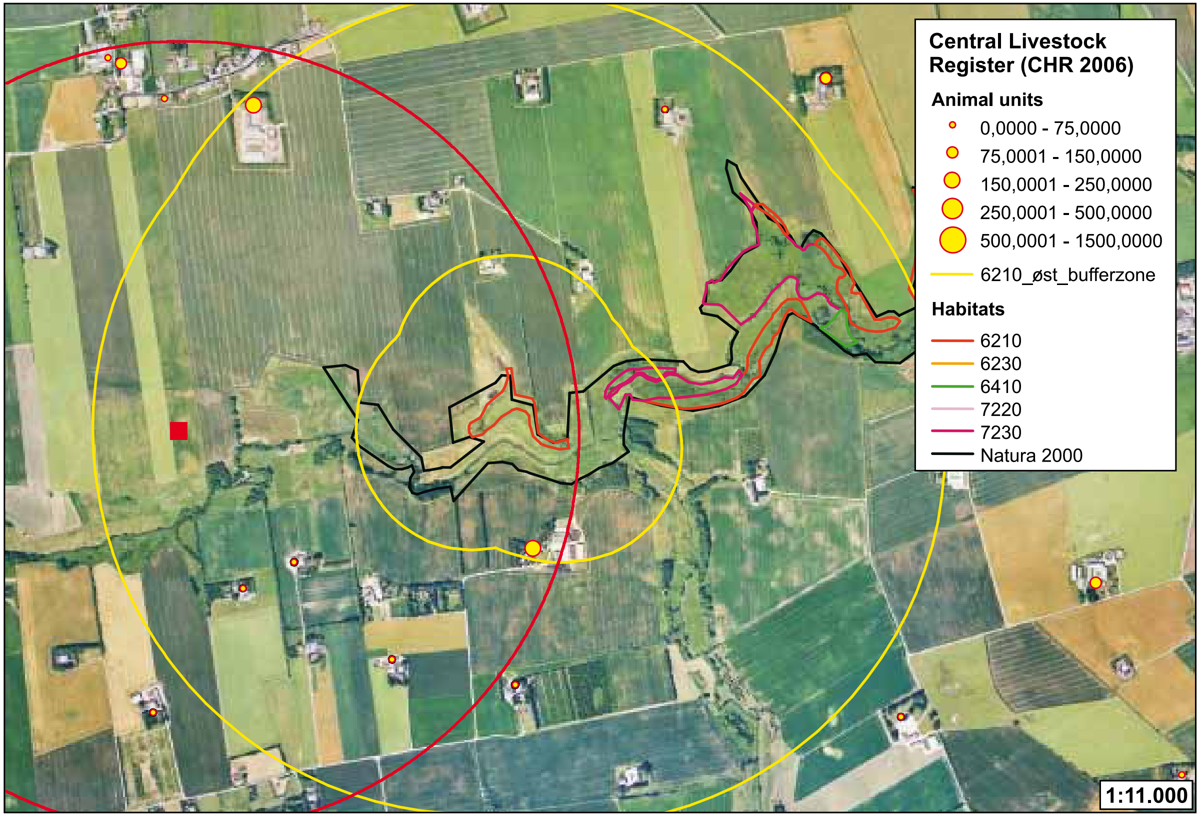

Figure 3.2: In this example, the applicant farm (red square) is situated within the 1000 m buffer zone (yellow line) around a calcareous grassland in Natura 2000 (but outside the 300 m buffer zone). As two other livestock farms with more than 75 animal units (AU) are situated <1000 m from the applicant farm (red line) and within the same buffer zone, the allowable increment is only 0.3 kg N $ha^{-1}yr^{-1}$.

ha^{-1}yr^{-1} (low end of range): Raised bogs, oligotrophic mineral poor waters (code 3110), heaths > 2500 m^2, dry grassland > 2500 m^2, hard oligo-mesotrophic waters > 100 m^2 and dystrophic waters > 100 m^2 (codes 3140 and 3160) are designated as habitats sensitive to ammonia. Outside SAC only heaths > 10 ha and dry grassland > 2½ ha are considered. Within the buffer zones applications are met with special restrictions.

- 1) The 300 m buffer zone is an exclusion zone where establishment of new livestock farms with > 15 AU (animal units) is prohibited (for mink farms the threshold is three AU). Likewise increased emissions from existing point sources (housing and storage) is prohibited.
- 2) Within the 1000 m buffer zone the allowable increment to the nearest habitat is 0.7 kg N ha^{-1}yr^{-1} if there are no other farms with > 75 AU within a distance of 1000 m from the applicant farm (Table 3.3). In-combination effects are handled by setting a limit of 0.5 kg N ha^{-1}yr^{-1} if there is one other farm with > 75 AU within the buffer zone and <1000 m from the applicant farm, and only 0.3 kg N ha^{-1}yr^{-1} if there are two or more other farms within this area.

b. Additional Natura 2000 impact assessment

Local authorities are responsible for preventing adverse effects to all designated habitats and species of a SAC as well as any habitat of Annex IV species. In each case, the municipality has to make an assessment and decide:

1. If buffer zone-regulations (like above) have to be employed to other sensitive habitat types than the ones mentioned above, such as forest habitat types, quaking bogs, oligotrophic/ calcareous fens/meadows etc. – or occurrences below the size criteria mentioned above (3a).

2. If very large sources beyond the 1000 m buffer zone have to be regulated by the threshold values mentioned above.

3. If the general threshold values are strict enough to prevent adverse effects to designated Natura 2000 habitats or habitats with Annex IV species - otherwise the municipality is required to refuse the project.

Administration differs quite a lot among the 98 different municipalities, and there is not yet any generally approved approach for the impact assessment. It is unclear when effects after application of the general threshold values are so adverse that a project must be refused. In at least one case, a municipality has considered an increase of 0.1 kg N ha^{-1}yr^{-1} to be a significant increment to a species rich alkaline fen in combination with the existing load above the critical load, and reason enough to refuse approval of the project. Future decisions from the Environmental Board of Appeal are expected to bring more clarity to setting the level of protection, but so far too few decisions on this matter have been made.

c. Impact assessment to non-Natura 2000 habitats

According to the Environmental Approval Act, heaths > 10 ha, grassland > 2½ ha, all raised bogs and oligotrophic waters (only Annex I habitat type 3110) outside Natura 2000 sites also automatically generate 300 m and 1000 m buffer zones. These are subject to the same thresholds as for Natura 2000 habitats (see a).

In addition, the local authorities are required to prevent adverse effects to N-sensitive habitats of Annex IV species (in Denmark amphibians and sand lizards are most relevant in this context) by applying the buffer zone regulation. Likewise adverse effects to all protected nature areas comprised by the Danish Nature Protection Act have to be prevented. These include heaths, moors, dry grassland, meadows, fens, salt marches, bogs > 2500 m^2 and all lakes > 100 m^2.

As for the additional Natura 2000 impact assessment, administration among the municipalities differ quite a lot and is awaiting decisions from the Environmental Board of Appeal. A recent decision, though, has attached importance to 1) exceedance of the lower end of the critical load range of a species rich alkaline fen, and 2) an overall unfavourable conservation status of alkaline fens in Denmark according to the Article 17 reporting. In this specific case, increased deposition was > 0.8 kg N $ha^{-1}yr^{-1}$.

d. Field sources (area sources)

All fields belonging to a livestock production unit are contained in the environmental approval, and the municipality can decide on conditions for application of manure to the fields. The municipality can deny application of manure to specific fields situated close to sensitive habitats. There is no common procedure for conducting impact assessment of N-deposition from application of manure to fields. In some cases municipalities apply conditions in the approval like slurry injection of all applied manure or manure-free buffer zones bordering Natura 2000 sites.

General rules imply an obligation to inject slurry on grass fields and bare soil within the 1000 m buffer zone. By 2011 this obligation is due to be extended to apply outside the buffer zones as well.

In Denmark surface broadcasting of slurry manure has long been prohibited, instead band spreading (the most widespread method) and slurry injection is used. Manure has to be incorporated into bare soil within six hours to reduce N-emission, but since a very large part of the manure is spread on growing fields of winter wheat, which is by far the most common crop in Denmark, the main part is neither injected nor incorporated. Consequently a prominent spring peak in N-emissions from manure spreading is observed.

e. General N-emission reduction requirements

Apart from the specific impact assessment of livestock production units in the neighbourhood of sensitive habitats, all applicant farm projects with > 75 AU have to comply with general N-emission reduction demands. This general approach complies with the demands of the NEC Directive to reduce national emission, as a large number of farm units are not situated close to SACs and thus not covered by the specific regulation mentioned above.

Only a relatively small part of the total N-emission from a livestock farm is deposited close to the source, most is transformed into other nitrogen compounds and transported over longer distances. As such it contributes significantly to the general background deposition, and it is clear that in many cases it is not possible to eliminate critical load exceedances without considerable reductions of the background.

Weighed up against the environmentally most efficient housing system in 2005/06, ammonia emission from an applicant farm project with >75 AU has to be reduced by 25 per cent (this has been increased from 15 per cent in 2007 to 20 per cent in 2008). The environmentally most efficient housing system in 2005/06 is defined in an executive order for different types of livestock.

f. BAT requirements

Another means to reduce the background is the general demand for use of BAT (Best Available Technology), and all applications (projects >75 AU) must include an account for the use of BAT. This is seen as a very important – perhaps the most important - means of reducing the background

Table 3.3: Past and present regulation of livestock farms in Denmark

Habitat types	2009 level of protection	level of protection according to new regulation 2011
Ammonia sensitive Natura 2000 habitats, covered by present regulation	Max. increment in deposition of 0.3-0.7 kg N $ha^{-1}yr^{-1}$ in bufferzone II No increment of emission in bufferzone I.	Max. total deposition depending on number of animal units nearby*: 0.2 kg N $ha^{-1}yr^{-1}$ by > 1 animal unit 0.4 kg N $ha^{-1}yr^{-1}$ by > 1 animal units 0.7 kg N $ha^{-1}yr^{-1}$ by 0 animal units
Ammonia sensitive Natura 2000 habitats, not covered by present regulation	No present regulation, but the municipality has to make a specific assessment.	
Ammonia sensitive habitats outside SAC, covered by present regulation	Max. increment in deposition of 0.3-0.7 kg N $ha^{-1}yr^{-1}$ in bufferzone II No increment of emission in bufferzone I.	Max. total deposition 1.0 kg N $ha^{-1}yr^{-1}$.
Ammonia sensitive habitats and forests outside SAC, not covered by present regulation	No present regulation, but the municipality can make a specific assessment.	Max. increment in deposition of 1.0 kg N $ha^{-1}yr^{-1}$.

***Defined as (cumulative model): no. units > 15 Animal Unit (AU) within 200 m + no. units > 45 AU within 200-300 m + no. units > 75 AU within 300-500 m + no. units > 150 AU within 500-1000 m + no. units > 500 AU contributing with > 0.3 kg N/ha beyond 1000 m**

deposition in Denmark and in several decisions from the Environmental Board of Appeal it is emphasized that the local authorities have to ensure that environmental permits contain conditions for maximum N-emissions equivalent to the level if BAT was used.

The applicant can choose between different BAT systems approved by the Environmental Protection Agency (EPA) including techniques for both dairy, pig and poultry farms. Among the approved techniques are adding of sulphuric acid to the slurry, air scrubbers with sulphuric acid, drying of poultry manure, systems with frequent cleaning out, cooling of slurry etc. Presently more BAT techniques are awaiting approval (published at the EPA home page www.mst.dk/Virksomhed_og_myndighed/Landbrug/BAT-blade.htm).

3.3.4 New regulation of livestock farms (2011)

The Environmental Approval Act has recently been changed and now introduces a new concept for regulation of N-emissions in the neighbourhood of Natura 2000 sites. Instead of a threshold for the increment, a threshold is applied for the total contribution to nearby sensitive Natura 2000 habitats from each production unit.

The total allowable contribution from one livestock production unit is 0.7 kg N $ha^{-1}yr^{-1}$ if there are no other livestock farms within a certain distance of the applicant farm. If there is one other livestock farm within this distance, a total of 0.4 kg N $ha^{-1}yr^{-1}$ is allowed, and if there are two or more other livestock farms, a total of only 0.2 kg N $ha^{-1}yr^{-1}$ is allowed. This implies that existing emission may have to be reduced if the threshold requirements are not met today. But the regulation is only enforced if an existing farm unit applies for enlargement or change.

In the new regulation, the concept of buffer zones is abolished. The exclusion zone is proposed to be reduced from 300 m to 10 m. This implies that outside 10 m N-emissions are no longer capped and the establishment of new livestock farms is no longer prohibited, providing that the above requirements to total contribution are met. One reason for this altered regulation is the need for establishment of new cattle farms in order to comply with demands of extensive management of

Natura 2000 sites. Abolishment of the 1000 m buffer zone leads to future assessment of all projects regardless of distance to the Natura 2000 site.

In relation to Natura 2000 sites, the thresholds for total contributions are going to apply to all N-sensitive Annex I habitats, including forests, alkaline and oligotrophic fens, quaking bogs etc. Outside Natura 2000 sites a threshold of a total contribution of one kg N $ha^{-1}yr^{-1}$ is introduced as a substitution to the buffer zone regulation, but here it still only applies to the selected habitats mentioned above (see section 3.3.3.c). Additionally, a decree on a threshold of one kg N $ha^{-1}yr^{-1}$ increment to certain other sensitive habitats outside Natura 2000 has been passed.

Regarding the general N-emission reduction demands, the proposal implies an increase to 30 per cent by 2011, but by 2012 reduction demands should be replaced by standardised BAT conditions in all permits (cf. section 3.3.3.e).

3.3.5 Results and discussion

According to the present regulation in Denmark a ***significant contribution*** is interpreted as a contribution which can be expected to cause change in an ecosystem ***by itself*** in the long term. The threshold of 0.7 kg N $ha^{-1}yr^{-1}$ increment from a single source is based on the consideration, that it is unlikely that long term effects of a habitat from a contribution below this size can be proven. The National Environmental Research Institute has stated, that an increment of about 0.6 kg N $ha^{-1}yr^{-1}$ is found to be the best statistical estimate for the threshold under which the contribution calculated with the present models is statistically equal to zero, and where no effect can be demonstrated in 95 per cent of the cases. On the other hand, it cannot be rejected that an effect may occur on very sensitive habitats like Natura 2000 habitats, i.e. certain parameters of the ecosystem may be found to change after many years of exposure. But it is hard to imagine that even long-term effects from increments of about 0.1 kg N $ha^{-1}yr^{-1}$ can be proven (NERI, 2005).

When considering in-combination effects these are presently handled by considering ammonia contributions from other livestock farms situated near the applicant farm project. When one other farm is present, the allowable extra contribution is lowered to 0.4 kg N $ha^{-1}yr^{-1}$, and with two or more farms to 0.2 kg N $ha^{-1}yr^{-1}$. In this respect 0.2 kg N $ha^{-1}yr^{-1}$ can be viewed as a *de minimis* (trivial/inconsequential) contribution.

Impact assessment of sensitive Natura 2000 habitats and other regionally or locally important habitats normally include evaluation of *critical load exceedances*, typically by using the municipal mean background deposition.

Nevertheless, in an executive order it is emphasized, that municipalities must refuse a project if a case-by-case assessment brings doubt to whether the buffer zone conditions are in line with the obligation to provide good conservation status of a Natura 2000 habitat. No cases on this matter have yet been tried in the Environmental Board of Appeal, but municipal administration is subject to wide-ranging variation on this point.

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3.4 Assessing impacts of nitrogen emissions on Natura 2000 sites in Germany

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Abstract
- Nitrogen deposition has been recognized as a major threat to the conservation goals of Natura 2000 sites in Germany and has to be considered carefully within impact assessments.
- Critical loads have been accepted as an appropriate measure of sensitivity of protected Annex I habitats in respect to nitrogen deposition.
- No court decision and no expert convention has yet been made on how to treat project/plan contributions of nitrogen deposition where background deposition already equals or exceeds the critical loads. One approach that has been adopted in a number of cases advocates a value of 10 per cent of the critical loads (LUA Brandenburg, 2008), but is explicitly not intended to be used if conservation status is unfavourable due to nitrogen impacts.
- So far criteria are missing on how to classify conservation status with respect to nitrogen impacts.
- We propose an evaluation scheme that we think should be conservative enough to be accepted by the court under a variety of conditions as we experience them in our practice. In the case of background deposition exceeding critical loads it proposes thresholds for adverse effects on the integrity of Natura 2000 based on several criteria. In addition to the amount of project/plan contribution - in relation to critical loads – we consider the size of the area affected (based on an expert judgement, or guidance of acceptable area loss), and the site specific quality of the affected habitat.
- Another controversial issue has been the determination of background deposition, which frequently did not include dry deposition accurately. We shortly discuss the data provided by the UBA to overcome those problems.

3.4.1 Introduction
Nitrogen deposition is an important issue in Germany in the context of impact assessments under the Habitats Directive. Consultancies are involved in a number of impact assessments on Natura 2000 sites in Germany, mainly for traffic projects and we have also been entrusted with basic methodological work that is needed to provide evaluations conforming to the requirements stated

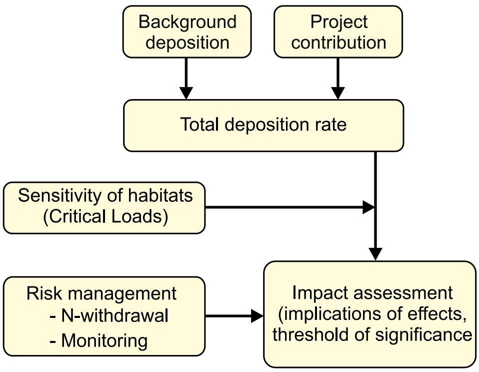

Figure 3.3: Scheme for the evaluation of effects caused by nitrogen deposition

by the courts. We are also watching very carefully the court decisions on this subject. Participation in this workshop allowed us to share the knowledge we had gained in this process with other European participants, and to widen our view on possible approaches as they can be found in the UK, Denmark and the Netherlands.

3.4.2 Aims and objectives

From this perspective we examine and provide knowledge on the following questions:

- How is nitrogen deposition considered within impact assessments under the Habitats Directive 6.3 in Germany?
- What are the controversial issues?
- How do we in practice try to resolve those issues?

A number of "key issues for discussion" as stated in the Bealey *et al.*, (this volume) proved to be an excellent guideline for answering those questions. They are restated below, followed by our remarks reflecting the situation in Germany.

3.4.3 Results and discussion

Impact assessments for Natura 2000 sites are conducted on a site specific basis, but the evaluation of effects caused by nitrogen deposition should essentially follow the scheme as depicted in Figure 3.3.

A quantitative estimate of nitrogen deposition is compared to the sensitivity of the habitat, usually expressed as critical loads. If adverse effects to the integrity of the site cannot be ruled out, the potential of mitigation and other measures will be explored. As stated by the court (Federal Administrative Court "Bundesverwaltungsgericht", judgement 17.01.07 – western motorway bypass of Halle), risk management is required to guarantee effectiveness of the measures and enduring absence of adverse effects.

How can background deposition be assessed reliably?

This question plays an important role in appropriate assessments. We do have good background values supplied by the UBA for the year 2004. They have a spatial resolution of one km² and are available online for nine different receptor types. So far, there are no prognostic values available, but work contracted by the UBA is in progress (research projects PAREST, MAPESI).

In the case of expansions more detailed background data is needed. Model calculations performed by B. Mohaupt-Jahr (UBA, pers. comm.) have shown for farms that it is appropriate to simply add locally dispersed contributions to the background data. The same holds true for roads.

What is a likely significant effect and how is it defined?
There are no general rules on how to handle a likely significant effect. As is stated in the Bealey *et al.*, this volume]); some federal states have adopted a regulatory proposal by the LAI (LAI, 2006) including a four kg N $ha^{-1}yr^{-1}$ threshold to screen for relevant installations. Since then, the threshold has been raised to five kg N $ha^{-1}yr^{-1}$, but at the same time a passage has been inserted restricting the scope of the paper: "it cannot be excluded, that further requirements might result e.g. from nature protection legislation". As far as assessments under the Habitats Directive are concerned, it has essentially been abandoned in favour of a 10 per cent rule: project contributions of less than 10 per cent of the critical loads may be considered as insignificant under certain conditions (see below). In our country the public dispute about assessing nitrogen deposition on SACs is often carried out in court. So if there are doubts if adverse effects on the integrity of the site cannot be ruled out, we have to assess the impacts of nitrogen deposition.

For significance, we consider effects that may in the long run compromise the ability of habitats as mentioned in the conservation objectives to stay at a favourable conservation status. As is stated by the European Commission, it would not be enough for a habitat to stay nominally in the same vegetation/habitat class, although there have been voices in favour of this interpretation.

What is a significant contribution from a project/plan in relation to either a habitats critical load or an emission target?
As long as a project's contribution does not lead to exceedance of critical loads, it is not considered to be significant in the sense of potentially exerting adverse effects on site integrity. If it does, its significance depends on the area affected. Indications on size have been given by court decisions: Thus exceedance of the critical load on 0.18 hectares of a *Molinia* meadow had been ruled as being significant in one court case. In the case of an Annex I - grassland, designated as priority Annex I habitat (*6120) with the characteristic species *Orchis morio*, even smaller areas were considered as potentially significant.

What if the background is already exceeded? How much more additional nitrogen is seen as having no adverse impact on the integrity of a site?
So far there has been - to our knowledge - no court decision for the case where critical loads are already exceeded by background deposition. The primary reason for this is that in the past background deposition had been determined without considering dry deposition, so background deposition was often underestimated. However, as described in Bealey *et al.*, (this volume) by Till Spranger and Dirk Bernotat, there is a proposal by the State Office for the Environment Brandenburg (LUA Brandenburg, 2008) which can be applied to those cases.

Relevant thresholds have been set by the LUA Brandenburg to 10 per cent of the CL, in analogy to the German air pollution abatement law, where air concentrations of 30µg/m³ NO_x are accepted and an irrelevance value of three µg/m³ is stated (B. Hanisch, LUA Brandenburg, pers. comm.). Cases where the site has an unfavourable conservation status of C or less, and N-deposition might be a likely cause for degradation, are explicitly exempt. For these cases no threshold is indicated.

Unfortunately the mapping scheme used in Germany for collecting data on the SACs (in case of the "Grunddatenerfassung" - basic data collection) was not designed to appropriately detect effects of eutrophication. The conservation status thus does not necessarily reflect impairments or degradations caused by excessive nitrogen input (see also Whitfield *et al.*, this volume). So in essence one might conclude that there are no habitats at all with an unfavourable conservation status caused by nitrogen deposition. From a technical or scientific point of view however, one has to consider already existing damage in many cases, e.g. by subtle species displacements, which are recognised as a great threat to biodiversity, but are rather hard to detect. Furthermore, major changes in the ground vegetation of forests for example might not lead to an unfavourable conservation status, if the trees meet the standards of the guidance - even if their vitality has decreased (thus raising the amount of dead wood which, under a structural view, may be considered as contributing to favourable conservation status). Forests often are self stabilizing systems, in that it takes external impacts to make changes visible, that literally have been lying in the dark (as we say in German). Such impacts may become more likely though, e.g. nitrogen enriched foliage boosting insect damage, or faster growth making droughts induced by climate change more hazardous to tree health.

The first thing one can do is to rule out the possibility of existing adverse impacts caused by nitrogen deposition. For example nutrient-poor species are not always in the focus of conservation objectives (e.g. in the case of nutrient rich alder and willow forests 91E0), or there might be evidence that current management maintains habitats in a favourable conservation status. However, there will be cases where this is not appropriate. Currently, there is no way of neglecting the need for an irrelevance threshold (*de minimis*), otherwise we would have to assess the impact of one project on sites tens or more kilometres away from the road. (Once such a threshold is identified, one could imagine it to be implied in some other criterion, e.g. distance).

Another aspect must be emphasized: in analogy to the national regulations concerning air pollution abatement, the LUA Brandenburg considers a single receptor point as being relevant in terms of affected size. In the case of roads this may lead to rather random assessments: if a single 10 per cent-receptor point is hit, there is a significant effect, otherwise not. The overall effects of additive nitrogen loads however are rather low in intensity (at least in the case of traffic-borne emissions), but they often cover a large area.

In this situation we have proposed a method to refine that of the LUA Brandenburg. It starts out with 3 per cent of the critical load, often equal to about 0.3 kg N $ha^{-1}yr^{-1}$. This we consider to be clearly smaller than the amount of uncertainty that we are dealing with in respect to modelled background deposition or critical loads, and also very low in comparison to background deposition and fluctuations in the environment. In the case of forests it is in most cases less than 1 per cent of present background deposition. In the case of grasslands, for example, the chances are that fertilizer applications somewhere in the environment mask any conceivable effect of small deposition increments. On the other hand, speaking of impact assessments for roads, it is an amount that can be found several hundred meters away from the road, so it does have a true cumulative potential, and if very sensitive biotopes are concerned, it might make sense to consider such a threshold seriously. It is also not inappropriate, as there are analogies in the history of national air pollution abatement concerning human health, which also has a 3 per cent irrelevance threshold. Accumulation effects e.g. in the case of heavy metals have similar, although stricter thresholds of 2 per cent in the context of environmental impact assessments (uvPVwV, 1995).

Another level we consider in our approach is five per cent as an intermediate value. In the case of our 10 kg N $ha^{-1}yr^{-1}$ critical load example this would mean 0.5 kg, which could be rounded in the case of the critical loads (Bobbink *et al.*, 2002) or the values the UBA database gives as background deposition. The upper level would be 10 per cent as proposed by the LUA Brandenburg (2008).

In our approach (FÖA, 2008) we have included two more criteria: the quality of the habitats concerned, in the sense of particular importance for the site and the size of the affected area.

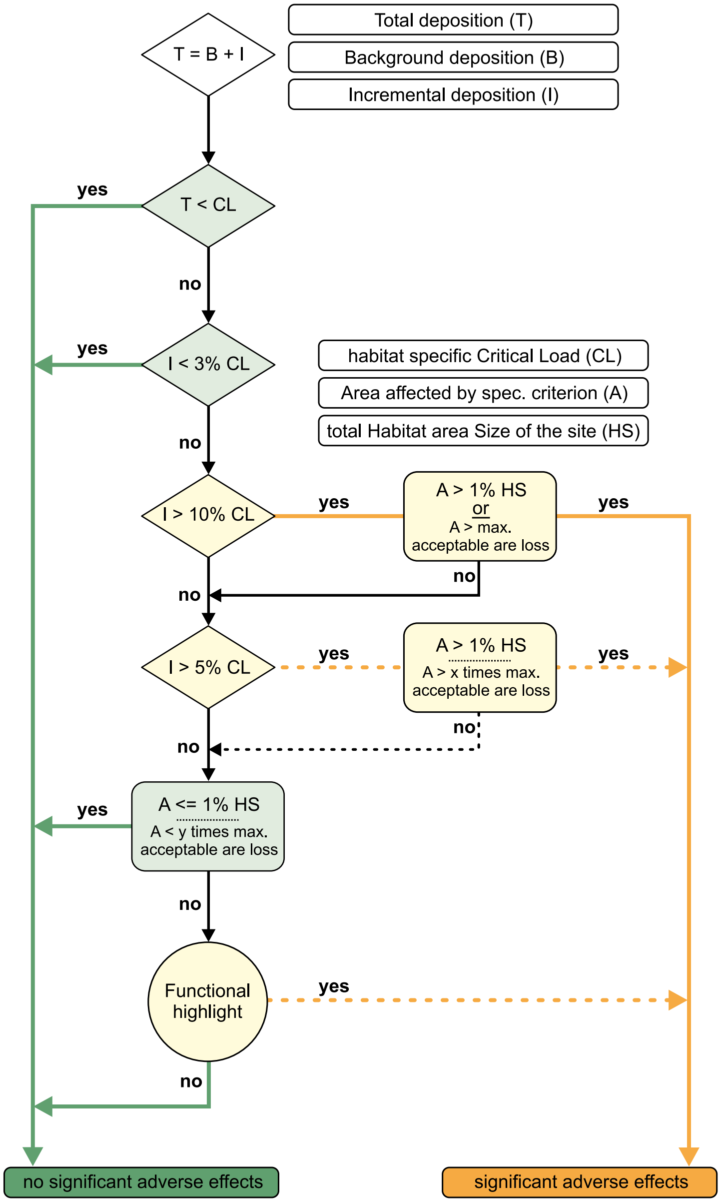

Figure 3.4: Proposed evaluation scheme in Germany

Both criteria can, in concept, also be found in the convention on acceptable area losses, as proposed by Lambrecht & Trautner (2007), see Bealey *et al*., this volume). For every German biotope covered by the Habitats Directive values of acceptable area losses have been determined. As a border criterion it was stated that the proportion of the habitat affected may be at most 1 per cent of the total area of the biotope within the protected site. (They gave supporting examples for 1 per cent being commonly considered as a minor proportion). They also recommended "qualitative-functional highlights", that should be considered regardless of their habitat type or affected size, with their function being of particular importance for the site (see Figure 3.4).

Although we think it might make sense to look at smaller intensities, we do not think that each small contribution has to be treated as a significant effect. As long as we do not overlook what is going on in the site concerned, i.e. in the case of small sites, the reasons for the 1 per cent proportion might support as well a spatial irrelevance threshold for small contributions below 10 per cent. If contributions are very small (less than 5 per cent of CL), it might be appropriate to consider effects dependant on the presence of functional highlights (otherwise the risk deems bearable). One thing, that is still unsatisfying about that approach however is significance being dependant on the size of the Natura 2000 site; particularly large sites may not be protected well enough by such a convention.

Another very appealing approach would be to extend the convention on partial function losses (Lambrecht & Trautner 2007, App. H). The rationale behind this is that the allowable affected area may be larger to a degree as the functions are only partially impaired. If one could tell, for example, what proportion of functions are impaired by an increment of one kg N $ha^{-1}yr^{-1}$, one could calculate the allowable affected area as

Allowable affected area = Allowable area of loss * (100 / per cent of functional loss)

However, as was stated on this workshop (Nancy Dise, pers. Comm), dose-effect relations are currently not in sight. As discussed above, detecting the degree of existing effects is already hard to achieve.

Of course one could say that the effects of nitrogen deposition can hardly be as dramatic as a total loss. However, given the present degree of remaining uncertainty we think it is appropriate to apply the spatial threshold of total loss to impacts of 10 per cent or more, and at the same time to consider the effects and spatial extent of minor impacts.

How should in-combination (multi-source) effects be handled? For example, can de minimis values be set for the consideration of individual project contributions where the cumulative effect of many projects is being considered?
As far as the Habitats Directive is concerned, we have to consider all cumulative effects that we find. Since there is no centralized permit system in Germany though, some kind of threshold of significance is implicitly, and probably in most cases, rather unconsciously applied.

Apart from plans and projects in the sense of the Habitats Directive, which to our understanding have to be considered as contributing to the impact in question, we also have to deal with effects exerted by existing installations. We know that the LUA Brandenburg advocates a site register of all sources of impact, but this would require rigid concerted efforts.

Where are the relevant gaps in this scientific knowledge?
Commissioned by the Federal Highway Research Institute (BASt) we have started a research project comprising of methodological and scientific work. One goal is to continue the work on the generally acceptable model as outlined above. Another goal is to differentiate critical loads within habitat classes where the Bern list only delivers general values for broad EUNIS classes. For example rather low critical loads are given for forest habitats in general. However, we are often confronted with Annex I habitat*91E0 forests, that are obviously quite eutrophic in nature. Accumulation effects are rather less likely due to undulations that certainly carry lots of nutrients with them, but should carry away project specific depositions. So the reasons

that led to critical loads for forest habitats might not apply to *91E0 forests. Similar problems arise in applying critical loads to water habitats.

Any 'higher resolution' (in terms of Annex I habitat types according to the Habitats Directive) of critical loads would be of great help. Of course we also would appreciate more guidance in the handling of ranges of critical loads. There are approaches to determine critical loads more specifically by using expert judgement (again by the LUA Brandenburg, 2007), as well as by modelling. The Dutch approach to systematically differentiate critical loads by a peer reviewed process (van Dobben & van Hinsberg, 2008) or in the UK by Bealey *et al*., (2007) may also be a model for further research on critical loads and its application in planning processes in Germany.

Are critical loads and levels fit for the purpose for site relevant assessments since they were originally developed for national risk assessments?
This is indeed a matter of controversy in Germany as well. There are approaches that say critical loads are not applicable in some cases or even in general. A discussion will be urgently needed in Germany to agree on accepted evaluation methods. Maybe a bundle of methods can be applied on a case by case basis. It would also be of great value if the scientific community could keep track of the discussion of the approaches that are used in impact assessments in practice.

From this point of view we had asked working group discussing theme:

- Under what circumstances are critical loads not appropriate to be applied as a measure for sensitivity of a habitat and hence as a measure for significance of possible effects?
- Under what circumstances can be stated, that present and past exceedances did not lead to an impairment of the habitat in question. Furthermore, under which circumstances may be concluded from the above, that critical loads do not have to be applied in an impact assessment (because there is no reason to believe that nitrogen-related damage will arise in the future)?

The answer, from a scientific point of view, was quite clear to both questions: critical loads are appropriate under most circumstances.

Another question might rather be subject to the formulation of appropriate conservation goals, but can still be quite obvious in the field. Therefore, would it make sense to switch to more realistic reference-states defining good conservation status achievable within reasonable time spans, and if background deposition were very high (e.g. two or more times the critical loads)? In cases, where favourable conservation status of a site obviously is not linked to compliance with critical loads, or conservation objectives do not depend on reaching values below the critical load, one could imagine higher critical loads to be reasonable as a measure of sensitivity.

What rules should be applied for new plans or projects where background critical loads and levels are already exceeded? How should de mimimis be defined and cumulative (in combination) effects be handled in this instance?
As stated above, so far we do not know of any German court decision for the case, that critical loads had been exceeded already by background deposition. In accordance with indications given by the courts we tend to think that high background levels give reason to precautionary assessments. As long as incremental deposition caused by projects is overall rather small (as is the case with highways) it is appropriate just to look at the increment (take the view of the project), as described above. In other words, to our knowledge it is common sense in Germany, that high background depositions do not prescribe neither refusal of plans nor general permission. Under a technical point of view we think it could make sense to switch to more realistic reference states, if the project doesn't change the overall situation. A prerequisite would be that conservation goals do not demand

low nutrition status. Of course such a different reference state would still have to be guaranteed in the long run. In less severe cases we think it is reasonable to assume that conditions below critical loads can be attained within the next decades, so the reference state of the conservation objective should be the best one can conceive of.

What are some of the mitigation / compensatory measures that can, or are being applied across the EU? For example, mitigation of the effects with the use of tree shelter-belts have been used to capture N pollutant species. Are there other experiences of such landscape level mitigation / compensatory practices?
In the course of our work we have collected evidence (by empirical on-site tests), that grazing can be a way to remove additional nitrogen out of calcareous grassland (6510) and prairie grassland (6240), under certain conditions also out of dry heaths (4030), but not out of rocky habitats as 8230.

We are also confident that selective cutting of non-habitat tree species (in our cases mostly conifers) may result in forest habitats that can serve as compensatory habitats of the same type as the one that may become affected, and often in quite a short time.

In the past so called deposition protective plantings (mainly shrubs or smaller trees) close to highways had been accepted as mitigation measures, but they have relevant effects only in immediate vicinity.

3.4.4 Conclusions

- Within the common staged approach to impact assessments, nitrogen deposition does play an important role in Germany. Critical loads are widely accepted to be fit for the purpose of site relevant assessments, but there are no central regulations yet on how to evaluate projects contributions.
- Background values can be obtained by the UBA, and are combined with local models of dispersion. Further research projects (PAREST, MAPESI) will improve the estimates made available by the UBA for regional predictions as they are required for impact assessments.
- At present it is common sense that exceedance of the critical loads regularly means an adverse effect on the integrity of the site, if there had been no exceedance before.
- The question, how to deal with project contributions in the widely spread cases of existing exceedance of critical loads is less clear. In our work we have proposed an evaluation scheme that comprises and extends the less general scheme of the LUA Brandenburg. So far there has been no public discussion yet, and no court decision, on which approach will be accepted in the long run. This work remains to be finished, presumably within a research project of the BASt that will be conducted in the next two years, and maybe with the help of further court decisions.[1]

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1 During preparation of this volume there have indeed been court decisions confirming the assumptions expressed in this paper (BVerwG 9 B 28.09 10.11.09; BVerwG 9 A 5.08 14.04.10, http://bverwg.de/media/archive/8138.pdf)

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3.5 The approach taken by UK statutory agencies to assess nitrogen deposition impacts on Natura 2000 sites from 'plans and projects'.

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Abstract

- In the UK, a risk based approach is used to assess the potential effects of atmospheric nitrogen deposition and concentrations on Natura 2000 sites arising from 'plans and projects', as required under Article 6(3) of the Habitats Directive.
- The assessment uses a staged approach and includes tests based on those in the Habitats Directive (Article 6(3) and 6(4)).
- Modelled pollutant concentration/deposition is compared with critical level(s) and critical load(s) allocated to each Natura 2000 site. Assessment thresholds are also applied, allowing a certain percentage of deposition above the critical load/concentration above the critical level
- Existing (background) pollutant concentration/deposition at the sites is also included in the assessment. A large number of Natura 2000 sites in the UK are predicted to be at risk from the harmful effects of atmospheric nitrogen (based on predicted critical load exceedance).
- The detailed assessment stage takes account of any additional site-specific information and considers the uncertainties within the assessment.
- As an example, the approach used for the assessment of the potential impacts of ammonia from (existing) intensive livestock units (pig/poultry farms) is described in more detail.

3.5.1 Introduction

This paper describes the approach applied in the UK, by the statutory environment agencies and conservation agencies, to assess potential impacts of reactive nitrogen concentration/deposition arising from 'plans and projects', as required under Article 6(3) of the Habitats Directive (92/43/EEC).

The Habitats Directive (Council Directive 92/43/EEC) has been transposed into UK legislation as The Conservation (Natural Habitats &c.) Regulations 1994 in England, Scotland and Wales, and as The Conservation (Natural Habitats &c.) Regulations (Northern Ireland) 1995 for Northern Ireland, all commonly referred to as the 'Habitats Regulations'. Since coming into force, there have been a number of amendments (e.g. 2004, 2007, 2010) to the Regulations that have been produced by the UK government both centrally and through the devolved institutions. The tests within the Habitats Regulations, in relation to 'plans and projects', closely mirror the tests in the Directive and require that permission can be granted only after it has been ascertained that the plan/project will have no adverse effect on the integrity of a Natura 2000 site; subject to certain provisions such as 'Overriding Public Interest'.

There are a large number of Natura 2000 sites in the UK, consisting of Special Areas of Conservation (SACs) and Special Protection Areas (SPAs). It is also Government policy to treat Ramsar sites (designated under the International Convention on Wetlands of International Importance) the same as SACs and SPAs with regards to the assessment of plans and projects. A large proportion of these sites are predicted to exceed their critical loads for nutrient nitrogen and/or acidity and are therefore considered to be at risk of significant harmful effects from air pollution

In accordance with the Pollution, Prevention and Control (England and Wales) Regulations 2000, Pollution Prevention and Control (Scotland) Regulations 2000 and Pollution Prevention and Control Regulations (Northern Ireland) 2003, industrial installations must apply to the relevant pollution regulator (Environment Agency/Scottish Environmental Protection Agency (SEPA)/ Northern Ireland Environment Agency (NIEA)) for a permit to operate. In England and Wales these regulations recently became part of the Environmental Permitting Regulations 2007 (amended in 2010). Some categories of installations may also be regulated by local authorities. The application for a permit requires an assessment under the Habitats Regulations (i.e. it is a 'plan or project') which is undertaken by the competent authority, in this case the relevant pollution regulator. A planning application, e.g. an application to the local authority to build a new installation, will also require an assessment, in the this case the local authority usually the competent authority. The nature conservation agencies (Natural England/Countryside Council for Wales/Scottish Natural Heritage) are statutory consultees in both legislative processes (planning and pollution control). In Northern Ireland, the NIEA also has responsibility for nature conservation.

3.5.2 General assessment approach

To assess the potential nitrogen deposition impacts from a plan or project under the Habitats Regulations, a standard risk assessment procedure is applied. The risk assessment is carried out in a number of stages, which mirror the tests in Habitats Directive:

- Stage 1 – "Relevance screening" (distance based);
- Stage 2 – "Likely significant effect" test (modelling of process contribution to critical level/ load);
- Stage 3 – Appropriate Assessment - "No adverse effect" test (modelling of process contribution to critical level/load);
- Stage 4 – Determination.

The precise detail varies with the type of industrial/agricultural installation in question but the four stages are generally applied as follows: First, a distance screen (in many cases 10km from a Natura 2000 site) is applied to filter out any plans/projects that by virtue of their nature or location could not conceivably have an effect on the interest features of a Natura 2000 site. If it is deemed that the plan/project is not 'relevant' to any Natura 2000 sites the subsequent stages are not required. The second stage is a coarse screening stage, intended to identify those proposed plans and projects that require further assessment (an 'appropriate assessment'). A likely significant effect in this context is any effect that may reasonably be predicted as a consequence of a plan or project that may affect the conservation objectives of the features for which the site was designated, but excluding trivial or inconsequential effects. Potential impacts on all interest features of the Natura 2000 sites, identified at Stage 1, need to be assessed. The plan or project is assessed for 'likely significant effect' either alone or in combination with other plans or projects, and in the context of the prevailing environmental conditions. Prevailing environmental conditions include background/ diffuse pollution contributions to the site and the residual effects of plans and projects that have been completed/implemented.

If a likely significant effect is determined, an appropriate assessment is made of the implications for the Natura 2000 site, in view of that site's conservation objectives (Stage 3). Its purpose is to ascertain whether or not the proposal will have 'no adverse effect on the integrity of the Natura 2000 site'. Atmospheric dispersion models (such as ADMS and AERMOD) are generally used to estimate the 'process contribution' (potential /NH_3 concentrations and nitrogen deposition resulting from the installation) at the given Natura 2000 site. This is compared with the relevant environmental benchmarks (critical levels and loads) to assess the potential impacts on the designated features making up a given Natura 2000 site. At this stage, further consideration is given to the modelling assumptions, location of designated features, sensitivity of the features, uncertainties within the assessment etc.

The UK regulatory and conservation agencies have developed a database of 'Site Relevant critical loads', whereby critical loads are assigned to each interest feature on each individual SAC and SPA, where possible (see Whitfield *et al*., 2010 in this volume, for more details). Information on 'background' (existing) nitrogen levels are usually derived from the UK Air Pollution Information System – www.apis.ac.uk (deposition at five km resolution, based on UK FRAME model; Singles *et al*., 1998) for each site.

If it cannot be concluded that there is no adverse effect on site integrity, having also taken into account any conditions, restrictions or mitigation measures that can be imposed on the plan/ project, a process of determining alternative solutions and whether there is a case for applying for 'Overriding Public Interest' (OPI) is followed. If OPI is agreed (which is a decision for the Secretary of State) then compensatory measures (habitat) would need to be secured.

3.5.3 Assessment of Impacts of Ammonia from IPPC Intensive Livestock Installations

Evidence from modelling and monitoring studies has shown that very high concentrations and deposition of ammonia can occur around intensive livestock units. These have been associated with harmful impacts on semi-natural habitats, such as direct effects on sensitive species and changes in the compositions of the vegetation (Sutton *et al*., 2009).

The Pollution Prevention and Control Regulations 2000[2], Pollution Prevention and Control (Scotland) Regulations 2000 and Pollution Prevention and Control Regulations (Northern Ireland) 2003, required, for the first time, intensive livestock units above a certain size to apply for a permit. This requirement is applied to new pig/poultry units and also retrospectively to those already in operation. Permit applications also require an assessment under the Habitats Regulations.

In 2007, the regulators (Environment Agency/SEPA/NIEA) received over 1,000 permit applications from pig and poultry installations the vast majority of which were already in operation. To undertake an assessment under the Habitats Regulations, a distance criterion of 10km was used at Stage 1, so that a livestock unit was considered 'relevant' to all Natura 2000 sites (or Ramsar sites) within a 10km radius of the unit. At Stage 2 (the 'likely significant effect' screening), modelling of predicted ammonia concentrations was undertaken using simple assessment tools (Environment Agency Ammonia Screening Tool or Simple Calculation of Ammonia Impact Limits (http://www.scail.ceh.ac.uk/). The emission was calculated from the number of animal places multiplied by a standard emission factor. 'No likely significant effect' was concluded if the predicted concentration at the Natura 2000 site (resulting from the livestock unit) was equal to or less than a threshold of four per cent[3] of the appropriate critical level. If greater than 4 per cent, the unit proceeded to Stage 3 for further assessment. The assessment was based on the then newly revised ammonia

2 The requirements have now been transposed into the Environmental Permitting Regulations 2007 in England and Wales.

3 These thresholds were determined by the environment agencies specifically for use in these circumstances (other numeric thresholds have been used with different installation types, pollutants, dispersion models etc).

critical levels for the protection of vegetation and ecosystems (one μg/m^3 for lichens and mosses or three μg/m^3 for higher plants Cape *et al*., 2009).

Stage 3, the Appropriate Assessment, involved a more detailed assessment including: more detailed modelling, consideration of other 'background' sources, assessment of the installation's contribution and the consideration of site specific factors. An advanced dispersion model was used to predict the ammonia concentrations at the Natura 2000 site resulting from the livestock unit. At this point, the 4 per cent threshold was re-applied. If the predicted concentration was still greater than this, the assessment moved on to consider other sources of ammonia. The 'background' concentration of ammonia at the Natura site in question was identified from the Air Pollution Information System (www.apis.ac.uk) and added to the contribution from the livestock unit (to give a 'predicted environmental concentration'). If this total was less than the critical level then no further assessment was required. If greater, then further consideration was given to the farm contribution. If the process contribution (alone or in combination with that from any other neighbouring livestock units) was less than 20 per cent of the appropriate critical level, a conclusion of no adverse effect on site integrity was reached. If the process contribution was greater than 20 per cent[2] then a review of the data was undertaken.

The emission data was reviewed and checked with the operator, where appropriate, to confirm it matched the general operation of the farm. The application of the critical level was reviewed to ensure that the more stringent of the two critical levels was only applied to sites where sensitive lower plants (lichens and bryophytes) are considered key to ecosystem integrity. The location of the sensitive features relative to the predicted pollution 'footprint' was also considered. Other site specific information, e.g. site survey data, other sources of nitrogen for 'wet' sites were also identified and taken into account.

At Stage 4, if it was not possible to conclude 'no adverse effect on site integrity' based on the detailed assessment outlined above, the appropriate permit conditions were identified. The operators in England and Wales were required to produce an 'Emission Reduction Plan' and to implement actions to reduce ammonia, within specified timescales. In Northern Ireland, operators were required to assess/review whether standard ammonia emission factors were appropriate for their installation, and to submit proposals for reducing the impacts of ammonia emissions on the designated habitat(s). NIEA have also carried out monitoring of ammonia levels in the vicinity of the installations and the designated sites to establish actual air ammonia concentrations. In Scotland, SEPA has been piloting the development of a nitrogen bio-monitoring process in the vicinity of a number of intensive agriculture installations. Natural England and the Countryside Council for Wales have undertaken a series of site surveys in England and Wales, in support of the risk assessments. These looked for evidence of effects, consistent with ammonia/nitrogen impacts, on the designated features but also for other signals indicting high nitrogen conditions. Surveys included some or all of the following: a visual assessment, detailed quadrats of species abundance and cover, tree macro-lichen study, measurement of tissue nitrogen in mosses and soil nitrogen. The results were considered in relation to the site's conservation objectives. Where impacts consistent with the effect of ammonia on the site's conservation features were not found (despite the livestock unit being in operation for a significant period of time), permit conditions to reduce ammonia emissions from the installations(s) have subsequently been removed.

3.5.4 Conclusions

- In the UK, the tests within the Habitats Regulations (in relation to 'plans and projects') closely mirror the tests in the Habitats Directive, and require that permission can be granted only after it has been ascertained that the plan/project will have no adverse effect on the integrity of a Natura 2000 site (subject to certain provisions).

- A four stage risk assessment is applied in the assessment of nitrogen emissions from industrial sources, which also reflects the tests within the Habitats Directive and Habitats Regulations.
- Critical loads (for nutrient nitrogen and acid deposition) and critical levels (for ammonia and oxides of nitrogen) are applied at the site scale.
- After some initial screening stages (aided by various tools), detailed dispersion modelling is used to assess potential ecological impacts by comparing the predicted process contribution from the plan or project to the (site-relevant) critical loads and levels. Existing pollution levels at the Natura site(s) are also considered and assessment thresholds are applied.
- Site surveys have been conducted in some instances in support of the risk assessments, e.g. to look for impacts consistent with the effects of ammonia at sites close to (existing) intensive livestock units.
- Permit conditions have been imposed on some installations in order to reduce nitrogen emissions and enable a conclusion of 'no adverse effect' under the Habitats Regulations to be reached.

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3.6 Moninea Bog - Case study of atmospheric ammonia impacts on a Special Area of Conservation

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Abstract
Moninea Bog is a lowland raised bog in Northern Ireland, designated as a Special Area of Conservation (SAC). The peatland flora typically supports many bog mosses, including the rare *Sphagnum pulchrum* and all three sundew species native to the British Isles. Farming activities take place around the bog, and questions were raised about the possible impact of ammonia emissions from a poultry farm directly to the north west. In response, following a site visit in January 2007, atmospheric ammonia was measured across the site, combined with measurements of nitrogen foliar bioindicators and the use of an atmospheric dispersion model. Taking the field observations, atmospheric measurements, modelling and bioindicators together, a clear picture emerged of a site under subsantial threat from atmospheric ammonia deposition. The combination of source- and receptor-oriented indicators coupled with a strong gradient in exposure 50-1000 m from the poultry farm provides for a robust approach to characterise these effects. This case-study graphically illustrates the nature of ammonia damage, showing how a short progamme of measurements and modelling can be used to support local decision making.

3.6.1 Background
Moninea Bog is a lowland raised bog in the west of Northern Ireland. The description of the Special Area of Conservation (SAC) notes that “*Moninea Bog is one of the best remaining examples of an active raised bog within the drumlin landscape that occurs across the southern counties of Northern Ireland. The peatland flora typically supports a high cover of bog-mosses, including the hummock-forming species* Sphagnum imbricatum *and* S. fuscum *and the nationally rare* S. pulchrum*. All three native British sundew species,* Drosera rotundifolia*,* D. anglica *and* D. intermedia*, are also present*” (JNCC, 2010).

The site became of interest from an air pollution perspective due the activities of a poultry farm directly to the north west of the bog. A number of units on the farm had been built and concern was raised that emissions of ammonia (NH_3) from the poultry farming activities might be causing adverse effects on the integrity of the SAC. The UK Centre for Ecology and Hydrology (CEH) therefore became involved to investigate whether there was evidence of ammonia damage, and, if so, whether this could be attributed to the poultry farming activities.

In planning such an assessment, we were able to draw on an extensive review of bioindicator methods for nitrogen deposition conducted by CEH with the support of the Joint Nature Conservation Committee (Sutton et al., 2004a and b’; Leith *et al*., 2005). In particular, that analysis had reviewed strategies for measurements in relation to what was termed the ‘biomonitoring chain’, the logical sequence of stages in biomonitoring from source to environmental effects (Sutton *et al*., 2005), as illustrated in Figure 3.5. The concept of the biomonitoring chain highlights how different monitoring methods may be selected to support a environmental assessment. Methods that are more ‘source oriented’ are naturally best for attributing their signal to particular emission sources, but typically give only indirect evidence of whether the biological environment is being adversely affected. By contrast, those that are ‘receptor oriented’ can have a much stronger link to the designated biological features of a nature conservation area, but typically have only an indirect connection to the pollution source, as other factors may also affect the designated features.

The biomonitoring chain envisages the range of possible stages for monitoring in the sequence from source to eventual biological effects. Thus a robust package of biomonitoring in any study can be envisaged as one that combines methods from several stages along the chain, including both source oriented, receptor oriented and intermediate methods (Sutton *et al*., 2005).

From a practical perpsective resources are typically limiting in any particular study, and it is therefore important to note that some stages in the biomonitoring chain are easier to determine than others. In Figure 3.5, stages that are typically easier to assess are shown as darker shaded elipses, and it can be noted that these are conveniently distributed along the chain from source to ultimate effect.

These principles were applied in the observations and monitoring activities undertaken at Moninea Bog. With the available resources for such a study, it was not feasible to measure deposition fluxes or growth responses. Therefore, the asssessment focused on the following elements from along the chain:

- Monitoring of atmospheric ammonia concentrations,
- Measurement of nitrogen accumulation in indicator plant species,
- Assessment of visible injury to plants or other signals of nitrogen damage,
- Consideration of the status of particular target species/interest features.

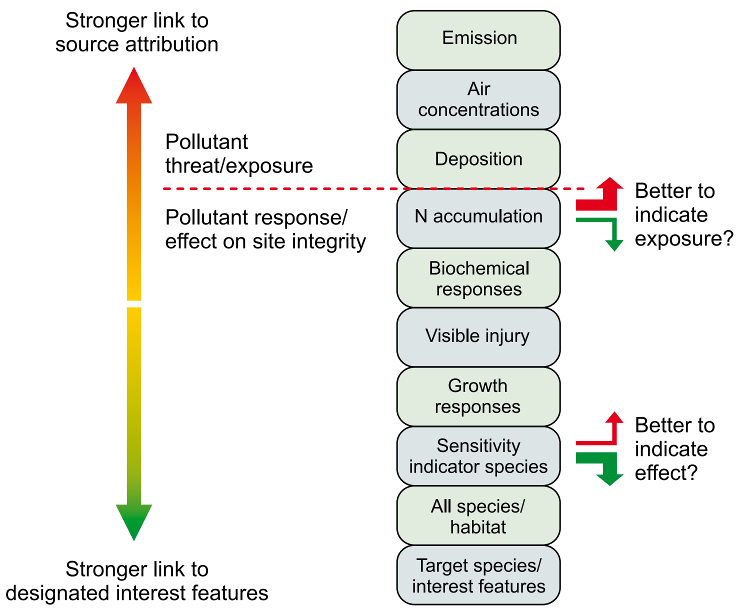

Figure 3.5. Overview of the "biomonitoring chain" showing how different indicator measurements may be ordered from pollutant source to ultimate pollutant impacts. Measurements closer to emission show a stronger link to source attribution, but weaker link to effects on designated interest features. Conversely, species-based measurements show a close link to the designated interest features, but a weak link to source attribution. A comprehensive robust programme of biomonitoring should therefore combine measurements distributed along the biomonitoring chain. Dark shaded elipses show the typical and most practicable approaches (Sutton *et al.*, 2005).

In implementing these observations and measurements, a transect was assessed with distance from the poultry farm, allowing quantification of the local profile from around 50 m to up to one km from the farm. In addition, in order to make a comparision with a clean reference site, observations and measurements were made approximately 40 km away at Loch Navar, where annual ammonia concentrations are typically 0.3-0.4 μg m^{-3} (recorded as part of the long-term UK ammonia monitoring network (Sutton *et al*., 2001; Tang *et al*., 2001).

Finally, based on livestock numbers for the poultry management systems (including the existence of an open lagoon), estimates of ammonia emissions rates from the poultry farm were calculated, and used with nearby meteorological data to model the local dispersion of ammonia from the poultry farm, allowing comparision between modelled and measured ammonia concentrations.

Put together, these elements cover a broad range of the stages illustrated in Figure 3.5, representing a suitable package to assess the extent of local ammonia impacts on Moninea Bog.

3.6.2 Methods

Visual assessment: A visual assessment of the Moninea Bog site was made during January 2007. This consisted of an initial walk across the site from a location furthest from the poultry farm to areas on the bog closest to the farm. Based on the initial observations, the return walk was used to record photographic observations of damage indicators and to label plant samples for chemical analysis. The location of photographs and plant samples was recorded using a global positioning system, with the locations shown in Figure 3.6.

Plant nitrogen accumulation: Collected plant samples were dried and measured in the laboratory for chemical analysis using two methods, total foliar nitrogen concentration and foliar ammonium concentration (Sutton *et al*., 2004a; van Dijk *et al*., 2005, 2009). The use of these two complementary methods has been shown to be useful as the foliar ammonium indicator typically shows a much larger signal compared with total nitrogen, reflecting an increased availability of ‘substrate nitrogen’ in the plant system under situations of high nitrogen deposition.

Atmospheric ammonia: The locations for monitoring ammonia were identified during the site visit and subsequently established for measurements from February 2007. Air concentrations were measured using high sensitivity passive samplers (‘ALPHA’ samplers, limit of detectcion ~0.02 μg m^{-3}), exposed in triplicate, with the calibration of these samplers based on long term intercomparison with active denuder sampling (Tang *et al*., 2001).

Atmospheric modelling: The ADMS model was applied by the Northern Ireland Environment Agency (NIEA). This was run using local meteorological data using monthly wind statistitics to calculate average monthly ammonia concentrations, for the same periods as the ammonia monitoring to allow full comparison. In comparing the model outputs with the field measurements, some uncertainty is associated with assigning a representative local background concentration for the model estimates. For this purpose, the cleanest measured concentration at the site (~1 km distant from the farm), was considered to provide an upper estimate, since this may still, to some extent, be influenced by the poultry farm.

Since the time of the measurements in 2007, additional surveying has assessed the influence of ammonia on lichen community composition (cf. van Herk, 1999; Wolseley *et al*., 2006), though this is not reported here.

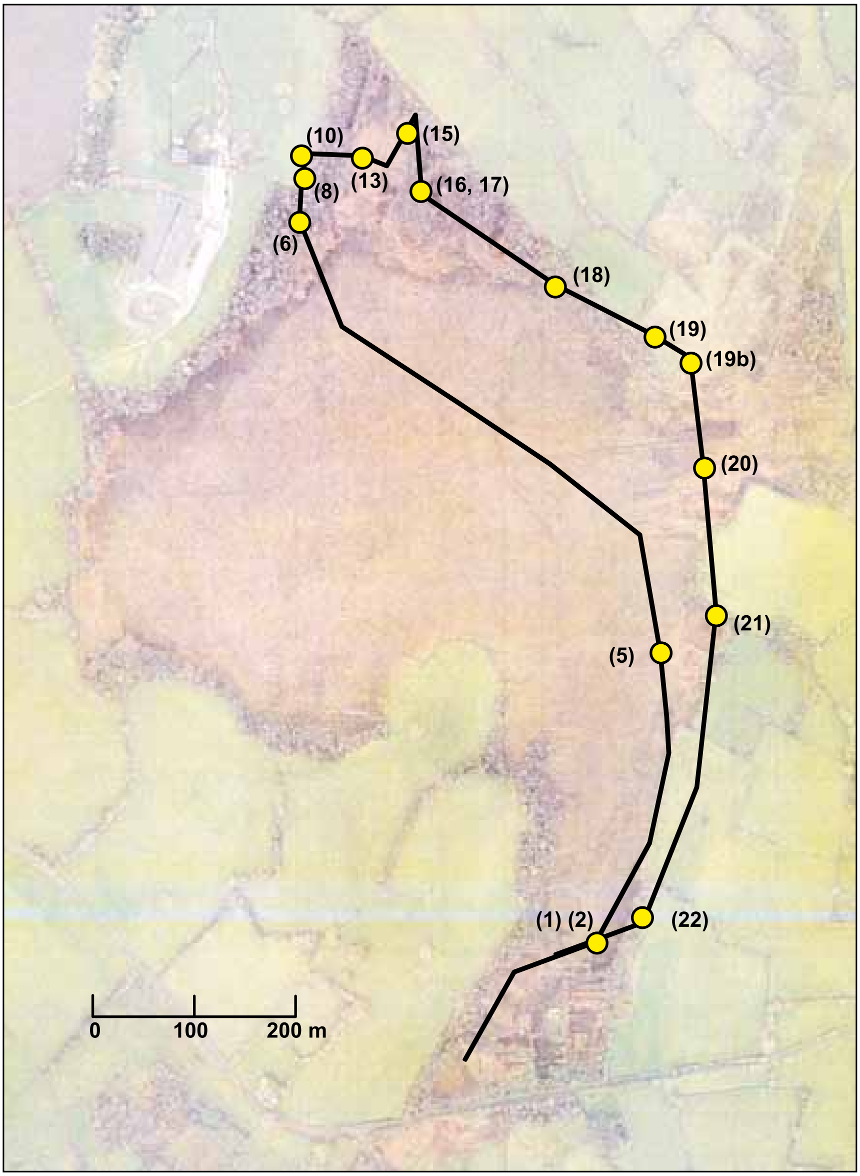

Figure 3.6: Map of Moninea Bog, showing the route of site visit, and numbered sampling/observation points. The poultry farm is located at the top left of the picture.

3.6.3 Results

Visual assessment

At the northern edge of Moninea Bog the mixed decidous (mainly birch) woodland showed signs of extreme ammonia damage when compared with typical birch woodland in clean locations of Northern Ireland and northern Britain. In regard of the woodland ground flora, several mosses were present, but only in very limited amounts. For example, such a woodland at a clean location would be expected to have a rich bryophyte flora with species such as *Rhytidiadelphus* spp present. At Moninea, a single small sample of *R. triquetrus* was observed at site 10, which was unusually green, suggesting a very high nitrogen level, (as also confirmed by a measured tissue nitrogen concentration of 4 per cent dry weight, see below).

For the trees, a number of gaps in the canopy were present. Although it was not possible to determine the cause of the tree decline from such a visual assessment, it was notable that bramble (*Rubus* spp), ivy (*Hedera helix*) and Holly (*Ilex aquilifolium*) were flourishing, which species appear (from observations elswhere) to be characteristic of eutrophic conditions and insensitive to high ammonia concentrations.

One of the most graphic features of the woodland was the lack of the ephiphyte flora on the birch trees characteristic of clean locations. By contrast, on several trees, a thick algal slime had built up on the tree trunks, indicating an extreme level of eutrophication. This is illustrated in Figure 3.7, which contrasts the lichen and moss flora of a birch tree trunk characteristic of the clean reference location at Lough Navar, with an example tree in the woodland at Moninea Bog around 130 m east of the poultry farm (around sites 11-15). The contrast between these two trunks illustrates one of the strongest possible contrasts between clean and eutrophicated conditions in such woodlands.

Other matching signs of ammonia damage were seen to the vegetation of the open area of Moninea Bog. The most dramatic effects were in visible injury to lichen species, such as *Cladonia uncialis* and *Cladonia portentosa*, and to the bog mosses *Sphagnum* spp, which are particularly important for the peat building function of such sites. By contrast, because the survey was made in the winter season (January) it was not possible to evaluate whether there was ammonia damage to the sundew (*Drosera* spp) occurring on the site.

As an approximate indication, it was estimated that up to 200 m downwind (near site 17) of the poultry farm, the *Cladonia* and *Sphagnum* spp were more than 90 per cent eradicated or injured. At 400 m distant from the farm (near site 19) these species were estimated to be around 50 per cent eradicated or injured. The least injury was in the far south of Moninea Bog, 800-1000 m distant from the poultry farm. Here there was probably <10-20 per cent injury attributable to ammonia, and many apparently healthy *Cladonia* and *Sphagnum* specimens were found. However, even this area of Moninea Bog did not show the consistent vigour and health of the bog species present near Lough Navar.

Examples of ammonia damage to *Cladonia* spp are shown in Figure 3.8. In the left hand photograph, a hummock of *Cladonia uncialis* shows the bleaching that is characteristic of ammonia damage, as shown from the Whim Bog ammonia field release experimental study in Scotland (Sheppard *et al*., 2009). This bleaching (often accompanied by a slight pink colour) indicates where the algal symbiont appears to have been killed, and can be compared with a light bluish-green colour at the top of the photo, where the lichen is still alive. Following such an impact on the lichen, the lichen hummock eventually falls apart, leaving what can look like the 'dead bones' of the former lichen (see right side of Figure 3.8), which eventually decay into the peat.

Figure 3.7: Contrast between the epiphyte flora of a birch tree trunk at a clean location in northern Britain (left, 0.4 μg m^{-3} NH_3) and in the woodland on Moninea Bog (right, ~10 μg m^{-3} NH_3). The natural epiphyte flora of this area has in this case been replaced by a thick slime of algae.

Figure 3.8: Example of progressive deterioration of two hummocks of *Cladonia lichen*, showing severe signs of characteristic ammonia damage, as recorded at Moninea Bog. Left: *Cladonia uncialis*, which is normally bluish (see at the top), is bleached over most of this specimen. Right: The eventual fate of this ammonia damage is illustrated by this specimen of *Cladonia portentosa*, where the lichen hummock falls apart, in this case becoming overgrown by a pleurocarpous moss.

Ammonia damage to the *Sphagnum* bog mosses appears to proceed in a different way, and was clearly illustrated on Moninea bog. In the first instance, the high ammonia concentrations appear to favour algal growth over the surface of the *Sphagnum* plant. The main factors driving this require further elucidation, but the may be related to a combination of increased nitrogen availability from the ammonia and an increased pH of the moss surface due to ammonia exposure. As the algal slime develops, it appears that this smothers the *Sphagnum*, limiting gas exchange and photosynthesis, leading to eventual loss of integrity and death of the plant. This sequence is illustrated in Figure 3.9, which compares three specimens of *Sphagnum imbricatum* from site 18. The apparently healthy hummock on the left (based on visual assessment), is compared with a sample in the middle that shows the glistening coating of a developing algal slime (middle). Finally, on the right, the structure of the *Sphagnum* starts falling apart, leading to eventual decay and loss of this important peatland building element of the bog flora.

It is important to note that ammonia damage was not the only concern noted at Moninea Bog. In particular, broken fencing had allowed cattle to access and graze the bog, leading to physical damage (trampling of plants), as well as direct nutrient inputs through dung and urine. It was therefore important in making the field observations to ensure that the effects of grazing damage were distinct from those due to ammonia. In this respect, it was found to be fortuitous that the areas of most extensive grazing damage were to the south and east of Moninea Bog, at sites most distant from the poultry farm. In particular, it was found that the grazing damage was rather extreme where it occurred, but highly localized to areas of less than a few square metres (trampling) or less than one square metre (excretion). Thus the areas distant to the farm showed a clear distinction with patches of severe grazing damage, with apparently undamaged lichen and moss specimens growing immediately adjacent. Thus although, the grazing damage was easily visible, it did not in this instance present an all pervasive threat to the integrity of the bog ecosystem. By contrast, where the damage characteristic of ammonia was worst (closest to the poultry farm), this was pervasive, leading to a widely spread level of damage, representing a more significant threat to the integrity of the site. Figure 3.10 illustrates the localized impact of grazing on the bog, showing *Lolium perenne* grass (from the seed of adjacent fields) growing over a dung patch on the bog.

Plant nitrogen accumulation

The outcome of the plant nitrogen measurements is summarized in Figure 3.11. This shows the total foliar N concentration and the foliar ammonium concentration with distance from the north west edge of the Special Area of Conservation (SAC) near the poultry farm, as compared with the clean reference location (a peat bog near Lough Navar). The lowest foliar nitrogen and ammonium values were found at the reference location (plotted at an indicative 10000 m on the x-axis) at about 0.5-1 per cent N of dry weight and 0.1-0.7 μg NH_4 per g fresh weight, with the next lowest values at the Moninea site most distant from the farm. Close to the farm, values increased up to 4 per cent N of dry weight and 45 μg NH_4 per g fresh weight (the *Rhytidiadelphus triquetrus* specimen noted previously and in *Eurhynchium praelongum*). The increase in values closer to the poultry farm demonstrates how an additional source of nitrogen (in this case local ammonia dispersion) is leading to an accumulation of nitrogen in the plants, which can be expected from previous studies to be associated with an increased risk of adverse effects on the plant communities. This indicator therefore is reflective of its position midway along the biomonitoring chain, with a link to both the emissions and the eventual effects on species composition.

For the *Sphagnum imbricatum* specimens collected at site 18 (Figure 3.10), the tissue nitrogen concentration was also compared with the visual assessment of integrity. This is illustrated in Figure 3.12, which suggests that adversely affected speciments were associated with higher foliar nitrogen concentrations. Although statistics are not feasible for such a comparison, this points to the potential for further examination of the relationship between sample health in response to nitrogen

Figure 3.9: Example of progressive damage in the bog moss *Sphagnum imbricatum*, as observed at Moninea Bog. An apparently healthy specimen (shown left) is comparaed with a specimen showing algal invasion over the leaves (middle). At the bottom, severe algal invation has lead to a complete loss of integrity of the specimen (All samples from site 18). *© Ian Leith*

Figure 3.10: Illustration of grazing damage to Moninea Bog, where a localized patch of *lolium perenne* has colonize a dung patch (site 4). Because of the localized nature of such damage, it was clearly distinguishable from the more pervasive effects characteristic of ammonia which were more severe closer to the poultry farm *© Mark Sutton*

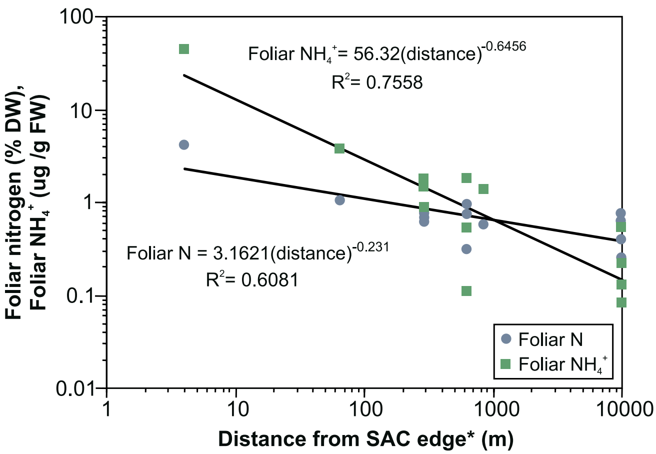

Figure 3.11: Foliar N (per cent dry weight) and foliar NH_4^+ -N (mg/g fresh weight) for moss and lichen species sampled on Moninea Bog. Distances are from a point 4 m north of Site 10. Samples from the clean reference location (Site 23) are plotted at an indicative 10000 m.

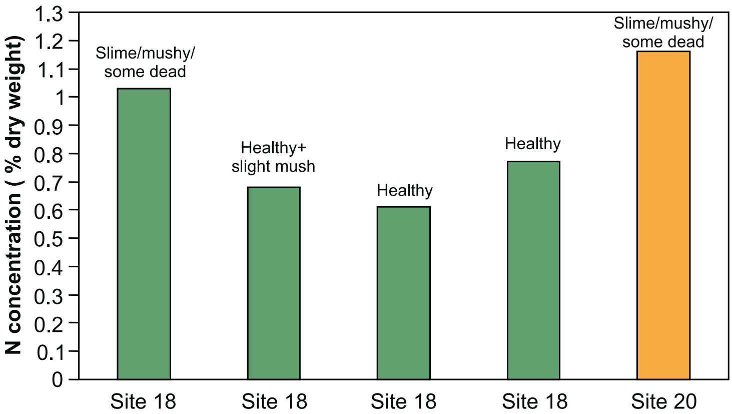

Figure 3.12: Comparison of foliar nitrogen contents of *Sphagnum imbricatum* specimens in different levels of condition from two sites on Moninea Bog (sites 18 and 20). There is an indication that damaged specimens (colonized with algae) have higher tissue N content.

deposition and the biodindicator value. For example, as samples become damaged, reduced growth rates may further augment the high nitrogen concentrations.

Atmospheric ammonia measurements and dispersion modelling

Example results from the monitoring of atmospheric ammonia concentrations are illustrated in Figure 3.13. By using triplicate measurements with the ALPHA samplers, robust estimates of ammonia concentration were provided, with coeficients of variation (standard deviation / mean) in the range 1 per cent to 4 per cent. For each of the three months illustrated (and for other subsequent months, not shown), the highest ammonia concentrations were recorded at the location closest to the poultry farm (14 to 34 μg m^{-3}), with the lowest concentrations at the site most distant to the farm (1-4 μg m^{-3}). These concentrations were substantially larger than those recorded at the clean reference site (Lough Navar) over the same period (0.2-0.4 μg m^{3}), indicating how even the most distant site was to some degree influenced by the poultry farm and other ammonia sources in the area, such as from adjacent fields grazed with cattle.

The local dispersion modelling conducted by NIEA was found to be fully consistent with the measured ammonia concentrations, as illustrated in the right side of Figure 3.13. The monthly variation could be partly explained due to differences in wind direction frequency between months. Apart from the model uncertainties for meteorology and ammonia emissions, an uncertainty of around one μg m^{-3} applies to the assumption of background ammonia concentration for the model, though this has negligible influence on the comparison for locations close to the farm. Since the atmospheric dispersion modelling is based on estimated ammonia emission rates from the poultry farm and meteorology for each month, the comparison with measurements can be considered as extremely encouraging, indicating that the spatial pattern in measured ammonia concentrations are fully consistent with dispersion away from the poultry farm as a major local ammonia source.

3.6.4 Discussion and Conclusions

This case study at Moninea Bog shows how a package of methods applied from across the 'biomonitoring chain' can provide a robust demonstration of an ammonia threat to a Special Area of Conservation. Such a short term assessment provides useful evidence to attribute changes to a particular driver. For example, two particular threats are noted here that appeared to be influencing

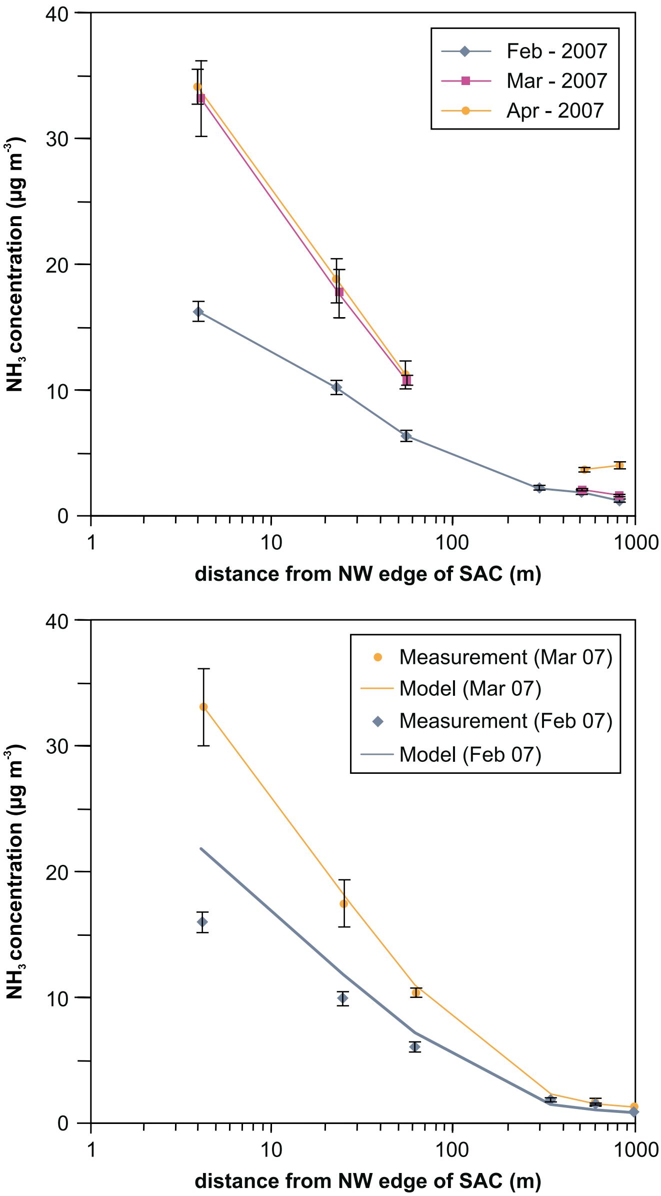

Figure 3.13: Atmospheric ammonia concentrations measured across Moninea Bog SAC for three months of 2007 (Measured at 1.5 m height above ground, showing +/-95 per cent confidence limits of the mean based on triplicate sampling). The graph on the right compares the measured concentrations with a simulation using the ADMS model for March 2007.

the integrity of Moninea Bog: grazing damage from cattle and the threat of ammonia deposition, especially from a nearby poultry farm.

Visual observations at the site allowed the grazing and ammonia threats to be clearly separated, which in this case was made easier by the fact that the worst grazing damage at the site was on locations most distant from the poultry farm. The grazing damage was found to be significant and easily identifiable (trampling, plants growing out of dung patches etc), but highly localized. By contrast, the ammonia damage was more pervasive, leading to wide scale damage, that was most extreme close to the farm, and which decreased with distance over the first km from the farm. This broader scale damage on the site can be attributed to ammonia from the poultry farm, because:

- the visible injury symptoms, both for mosses and lichens are characteristic of ammonia damage
- the visible injury increased closer to the farm (representing higher ammonia concentrations).
- the plant nitrogen and ammonium concentrations were increased over the same range, proportionately to the exposure of ammonia, and consistent with other studies downwind of ammonia sources,
- the measured ammonia concentrations were substantially increased near the farm, decreasing with distance away from it, and
- these measured ammonia concentrations could be replicated by the a dispersion model, using emission factors for poultry management based on the local stocking rates.

Altogether, the range of indicators used, together with the availability of a clear transect of decreasing threat with distance from the farm, provide for a robust assessment of the site that establishes the link from source attribution, through chemical nitrogen accumulation, to eventual loss of integrity of the designated features.

Such an assessment, where effects can be attributed to a source, can also support long term monitoring activities. For example, ongoing monitoring of Moninea Bog by NIEA showed a 50 per cent loss of sphagnum over a the period 2004-2007 for locations less than 400 m from the farm. On their own, such observations highlight a serious concern about a site, but can leave the questions of the causal threats unanswered. Using the approaches together, including the comparison with a clean refernece location, therefore provides a robust evidence-base on the cause and extent of concern, which can be used to inform local decision making.

The example of Moninea Bog provides a salulory less of how farming activities can have acute effects on the integrity of a Special Area of Conservation in the Natura 2000 network. The results are also consistent with the ammonia critical level (Cape *et al*., 2009; Sutton *et al*., 2009) of one μg m^{-3} for lichens bryophytes and habitats like peat bogs where these are essential to the ecosystem integrity. With concentrations, much larger than this at Moninea, it is not surprising that acute adverse effects were observed.

By contrast, the present assessment of Moninea Bog never set out to determine the extent to which the cleanest location the bog (to the south east, furthest from the farm) was under significant threat from ammonia. This becomes a harder question, given that the reference bog near Lough Navar was 40 km distant. However, based on a comparison of: a) visual assessment of *Cladonia* and *Sphagnum* spp between the two sites (with poorer condition on the same date for the cleanest location of Moninea), b) the difference in foliar nitrogen and ammonium concentrations (Figure 3.11), and c) the result that the concentration at around 850 m from the farm was in the range one to four μg m^{-3} (i.e., larger than the critical level), it seems most likely that even the cleanest location of Moninea was sufferering from chronic exposure to ammonia.

This case study illustrates an extreme case of ammonia exposure and damage to a Natura 2000 site. However, at the same time, it highlights the widespread nature of the ammonia threat to such ecosystems where lichens and bryophytes are essential to their integrity. As Hallsworth *et al.*, (2010, 2011) demonstrate, the ammonia critical level is exceeded across more than 93 per cent of England, 68 per cent of Wales, 26 per cent of Scotland and 85 per cent of Northern Ireland (1 km resolution estimates), showing how widespread adverse effects can be expected.

Acknowledgements

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