Future policy options to reduce the adverse impacts of nitrogen deposition on Natura 2000 sites. – Topic 5

Background Document for the 'Nitrogen Deposition and Natura 2000: Science & practice in determining environmental impacts' Workshop at the Bedford Hotel and Conference Centre, Brussels, 18th – 20th May, 2009

Authors: Mark A. Sutton[1], Albert Bleeker[2], Ulrike Dragosits[1], Kevin Hicks[3], William J. Bealey[1] and Stephen Hallsworth[1]

[1] Centre for Ecology and Hydrology (CEH), Edinburgh Research Station, UK.
[2] Energy research Centre of the Netherlands (ECN), Petten, NL.
[3] Stockholm Environment Institute (SEI), York, UK.

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1. Introduction

Atmospheric nitrogen deposition represents a major anthropogenic threat to the 'Natura 2000' network and to the conservation status of habitats and species listed under the Habitats Directive. The Natura 2000 network has a central place in European conservation legislation, affording sites the highest degree of protection of any nature conservation areas under European law. Many of these habitats are naturally adapted to limited nitrogen supply, so that additional inputs can cause substantial changes in biogeochemistry and species composition. The importance of nitrogen as a key threat has been recognized through 'nitrogen deposition' being listed as one of the long-term indicators under the Convention on Biological Diversity, and, related to this, in the SEBI 2010 process of the European Environment Agency (Streamlining European Biodiversity Indicators for 2010; EEA, 2007).

In this background document, we briefly review the challenge of protecting the Natura 2000 network from nitrogen deposition, arguing that there is a need for further policy development, as well as improvement in the enforcement procedures. We then explore a range of possible policy options that could help address the concerns identified. It should be noted that the Habitats Directive uses the Natura 2000 network as part of its overall ambition to maintain and improve conservation status, including the occurrence of species outside of Natura 2000 sites. Here we deliberately focus on Natura 2000, as the flagship network with the highest degree of protection for conservation sites in the European Union. While not losing this focus, the present discussion should be seen in the context of these wider objectives.

The purpose of this document is to stimulate discussion for the COST 729 workshop. It is hoped that the ideas presented here will encourage additional suggestions. Together, these options can then be refined to provide a shortlist of approaches that merit in-depth investigation for future policy development and enforcement.

2. The nitrogen deposition threat and the need for further policy development to protect the Natura 2000 network.

The Natura 2000 network comprises all Special Areas of Conservation (SACs) and Special Protection Areas (SPAs), as designated under the Habitats Directive (92/43/EEC) and the Birds Directive (79/409/EEC), with the Habitats Directive also including updated provisions for the management of SPAs. In aiming to provide the highest degree of conservation protection, a precautionary approach is specified, as illustrated by Article 6.3 of the Habitats Directive:

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 …, 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.

For this purpose, a 'plan or project' seems to be intended to mean considered any activity which might potentially have an adverse effect on the integrity of one or more SACs. Apart from exceptions outlined in Article 6.4 (in the case of no alternatives and of overriding public interest, the Habitats Directive thus, in principle, guarantees a high level of protection, particularly as it explicitly notes that multiple activities should also be assessed in regard of their combined effect on the sites.

Given this precautionary approach, it is therefore of interest to note that many SACs and SPAs remain under the threat of anthropogenic nitrogen deposition. For example, Figure 1A shows the estimated location of critical load exceedance for nutrient nitrogen across Europe. This is the amount by which estimated total nitrogen deposition is larger than the 'critical load', the estimated amount of deposition below which effects do not occur according to present knowledge. Critical load exceedance is the indicator used by the SEBI 2010 activity, for which values have been established using extensive analysis of field observations, experiments and models (e.g., Achermann and Bobbink, 2003; ICP Modelling and Mapping, 2004). Similarly, critical levels are used for NH_3 and NO_x, which are the air concentrations above which effects do occur according to present knowledge (ICP Modelling and Mapping, 2004; Sutton et al., 2009b). Wherever exceedance of either a critical load or critical level occurs, adverse impacts of nitrogen on Natura 2000 site integrity may be expected. Figure 1A refers to 2010, assuming that the existing commitments under the UNECE Gothenburg Protocol (UNECE, 1999) and the EU National Emissions Ceilings Directive (2001/81/EC) to reduce emissions of nitrogen oxides (NO_x) and ammonia (NH_3) are met. From an international perspective, there is therefore a long way to go until adverse effects of nitrogen deposition on the Natura 2000 network can be avoided.

It is important to consider spatial scale when assessing the overall threat of nitrogen deposition to sensitive habitats. Thus Figure 2B shows the estimated pattern of critical loads exceedance for two example habitat types in the UK, based on national models. These maps illustrate the variation in sensitivity between habitat types (through differing values of critical loads) and the fact that the rates of nitrogen deposition are also dependent on land cover type (nitrogen deposition is largest to rough forest vegetation). While Figure 2B shows the regional patterns using 1 km estimates of critical loads and 5 km resolution estimates of nitrogen deposition, it still does not reveal the full extent of spatial variation. Reactive nitrogen emissions can occur in the rural environment, leading to gradients in atmospheric concentrations and deposition downwind of major roads (for NO_x and NH_3, Cape et al. 2004), and downwind of livestock farms (for NH_3, e.g. Dragosits et al. 2002 and other organic nitrogen compounds). Figure 1C illustrates the pattern of modelled critical load exceedance that may occur in a single 5 km grid-square in an agricultural landscape. Major gradients of nitrogen deposition occur with distance from ammonia sources, including manure spreading, grazing, farm buildings and manure stores. These spatial patterns are extremely important and can help guide the search for nitrogen mitigation policies. In particular, they highlight two extremes to the nitrogen deposition problem:

- **Long range transport**, leading to well dispersed increases in N deposition, which only vary as a result of topographic effects on wet deposition, and on dry deposition of secondary gases (e.g., nitric acid) and secondary particulate matter.
- **Short range transport**, leading to locally enhanced increases in N deposition, which are extremely spatially variable, mainly as a result of gradients in air concentrations away from sources and ecosystem dependent rates of gaseous dry deposition (especially ammonia and to a lesser extent nitrogen oxides).

Rather different strategies are needed to combat these two extremes, though both are important in contributing to the nitrogen threat to Natura 2000 sites.

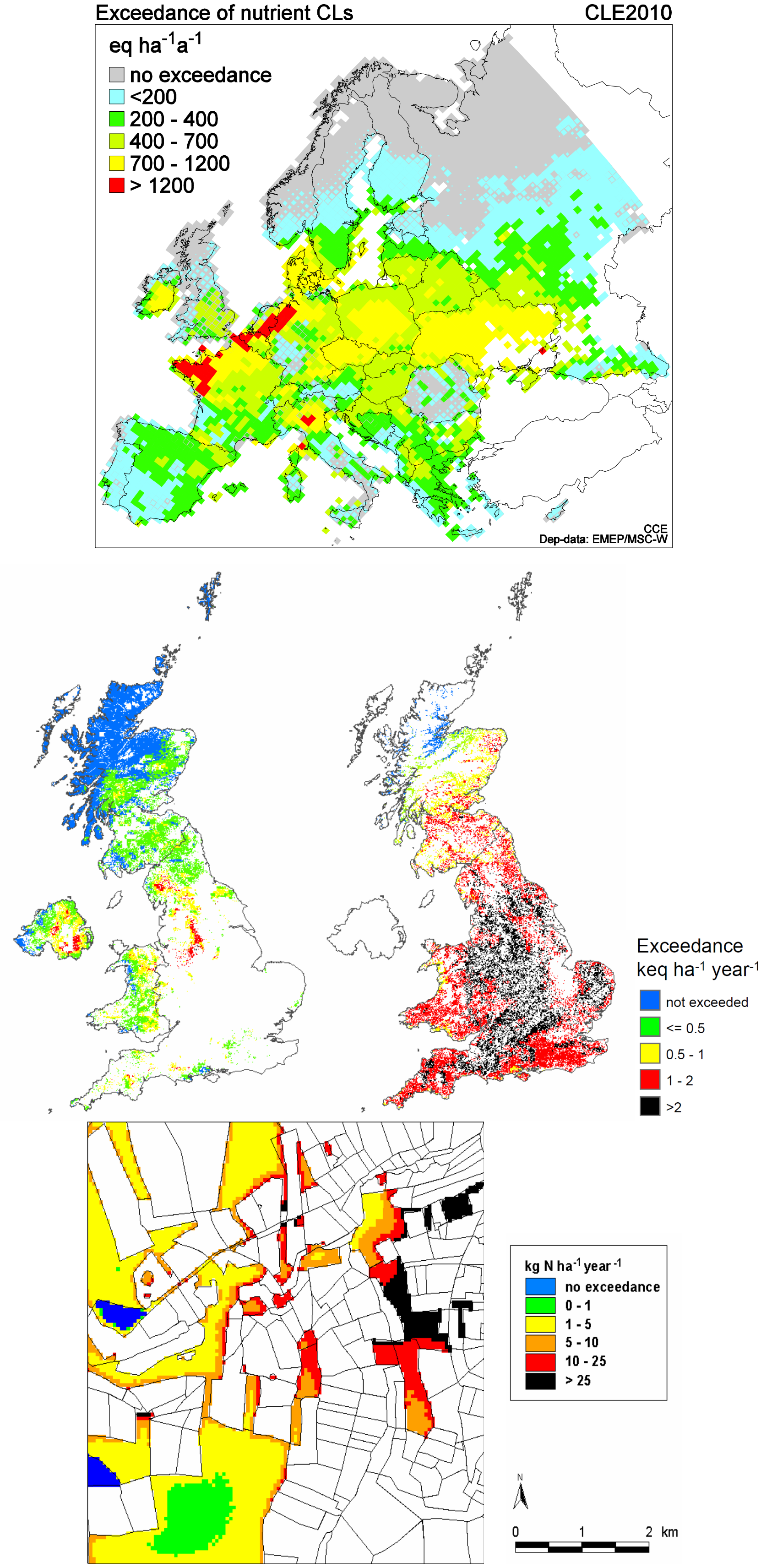

Figure 1: Patterns of exceedance of the nutrient nitrogen critical load at different spatial scales: A. Estimated exceedance across Europe in 2010 at 50 km resolution in response to total ammonia and nitrogen oxides emissions (Hettelingh et al., CCE 2008); B. Estimated exceedance across the UK at 1 km - 5 km resolution for two contrasting habitats: dwarf shrub heath (left) and managed broadleaf woodland (right) (for 2002-2004) (J. Hall, CEH); C. Estimated exceedance across a landscape in central England at 50 m resolution in response to only dry deposition of ammonia (agricultural fields are shown in white; Dragosits et al. 2002).

Of course, critical loads and levels exceedances only provide an indicator of the threat to sites. Nevertheless, in the case of empirical critical loads, the values have been derived from a combination of experiments and field observations where effects are seen in practice (e.g., Bobbink and Achermann, 2003). The result is that these maps give a good indication of the areas in Europe and the extent of spatial variability of where Natura 2000 sites can be considered under threat from nitrogen deposition.

Where a SAC or SPA is located in an area with exceedance of a critical load or level, it is therefore anticipated that adverse impacts on site integrity will follow. This may include both damage and loss of nitrogen sensitive species communities, coupled with invasion by nitrogen loving species of lower conservation value. Examples of such changes include the loss of sensitive shrubs and wild flowers from heathlands and woodlands and their replacement by grasses (e.g., Pitcairn et al., 2002), loss of sensitive forbs from grasslands (Stevens et al., 2004) or the loss of sensitive lichens growing on trees trunks and their replacement by a few nitrogen loving species (van Herk, 1999; Wolseley et al., 2006; Sutton et al., 2009b).

Lichens are particularly sensitive to air pollution, and major changes can occur at low concentrations of ammonia. An extreme example of change is illustrated in Figure 2, which compares the trunk of a birch tree under clean conditions (0.4 $\mu g\ m^{-3}$ NH_3, Whim Bog, southern Scotland), with another tree growing on an SAC about 60 m downwind of a small poultry farm (15 $\mu g\ m^{-3}$ NH_3, Moninea Bog, Northern Ireland). In the latter case, the typical lichen community has been completely replaced by a thick green slime of free living algae. Such changes in species composition are replicated for many different plant groups, and can be accompanied by subsequent changes in associated animal communities.

The contrast between the high degree of protection afforded to Natura 2000 sites and the actual degree of critical load exceedances and current impacts might be considered as rather surprising. Over a decade after its adoption, it seems that the commitment to protect the Natura 2000 network has still to be met. There are a number of reasons for why nitrogen deposition is still a significant threat to Natura 2000 sites, and these apply on both on local and regional scales. For example:

- Article 6 (3) of the Habitats Directive can only meet its purpose where an appropriate assessment of a plan or project is carried out. However, in practice it requires other regulatory requirements to trigger such assessments when these are not located on a Natura 2000 site. Polluting activities that do not require any formal assessment therefore potentially constitute a loop-hole for protection of the Natura 2000 network (cf. Frost, 2004), i.e. plans and projects which are unregulated.
- Although required by the Directive, it is often difficult to consider all polluting activities in combination. Even when the polluting emissions in an area are known, it can be a major modelling challenge to consider all together. In addition, it is a point of debate whether the requirement is to consider a particular regulated source in combination with all other sources, or only to all other *regulated* sources.
- Nitrogen deposition results from both local and long-range sources. For example, deposition to remote tundra ecosystems is the result of long-range transport from Europe-wide nitrogen emissions. Such transboundary fluxes can only be reduced by international agreement, such as the NECD and the Gothenburg Protocol.

Presently, the goal of avoiding critical load exceedance over the whole Natura 2000 network therefore remains a long-term aspiration, even if the Habitats Directive implies an existing indirect legal commitment to reduce nitrogen deposition to the sustainable levels that would be necessary to achieve favourable conservation status.

Figure 2: Effects of atmospheric ammonia on the epiphyte community of a birch tree trunk. Left: A rich diversity of lichens and mosses is seen on this tree typical of the north and west of the British Isles (Whim Bog, SSSI, Scotland, 0.4 µg m^{-3} NH_3). Right: The lichen and moss community has been replaced on this trunk by a thick slime of free living algae (Moninea Bog, SAC, Northern Ireland, 15 µg m^{-3} NH_3 Sutton et al., 2009a). The first adverse effects can be detected above 1 µg m^{-3} (Cape et al., 2009; Sutton et al., 2009b).

In this context, there is an obvious need to investigate the future policy options that could strengthen the protection of the Natura 2000 network from nitrogen deposition. In the next section we first review the role of existing policies in supporting the implementation of the Habitats Directive as regards the threat of nitrogen deposition. In the subsequent sections we then explore several future options that could be developed, making the distinction between policies designed to protect from long-range transported air pollution and from those designed to protect from nearby air pollution sources. In practice, both elements are needed, with the priority depending on the location of individual Natura 2000 sites.

3. The role of existing legislation in protecting Natura 2000 sites from the impacts of atmospheric nitrogen deposition.

There are a large number of policy instruments that potentially interact with Natura 2000. In order to keep the focus, we here restrict the discussion to the main linkages. We consider the current status of each of the measures, and the potential for further development of each. The status of ongoing revisions is mentioned as far as it is known to the authors.

National Emissions Ceilings Directive (NECD, 2001/81/EC) and the UNECE Gothenburg Protocol.

The NECD provides for the EU implementation of the Gothenburg Protocol, with the focus on reducing transboundary impacts of air pollution. These instruments provide for national emissions ceilings of NO_x and NH_3 to reduce both acidification and eutrophication in sensitive ecosystems at the European scale. As the Gothenburg Protocol covers the UNECE, which has a much larger area than the EU, it has the advantage of also reducing reactive nitrogen import into the EU (and exports from the EU), as well as the transboundary fluxes between the EU member states.

In addition to the national emissions ceilings, annexes in these instruments specify technologies that should be used to reduce both NO_x and NH_3 emissions, including various combustion and engine standards for NO_x, and a selection of mandatory measures to reduce ammonia emissions from agriculture. It should be noted that these texts represent the first time that Europe has set limits on ammonia emissions, and as such the ammonia ceilings are easily achievable for most countries. Both the Gothenburg Protocol and the NECD are being considered for future revision and the possible adoption of more ambitious targets (i.e., national ceilings) and requirements to adopt low emission technologies.

Although it is recognized in both instruments that the prime focus is on reducing transboundary transport and deposition, in practice it is difficult to separate deposition of local and transboundary origin. In general, a country reducing its emissions will be one of the largest beneficiaries of this action. On the other hand, the NECD and Gothenburg Protocol are not specifically designed to target the *local* reduction of emissions and environmental impacts. Thus, in meeting a national emission ceiling, it is still possible that source activities continue immediately adjacent to, and cause large local impacts on Natura 2000 sites.

Integrated Pollution Prevention and Control (IPPC, 96/61/EC and 2008/1/EC)

The EU Directive on Integrated Pollution Prevention and Control (IPPC) provides a contrasting emphasis to the NECD and Gothenburg Protocol. Rather, IPPC outlines a regulatory regime for an extensive list of specified industrial activities. Individual sources, described as ‘installations’ must obtain a permit to operate, based on the operation of Best Available Techniques (BAT) to reduce emissions.

The Directive is integrated to the extent that a wide range of emitted pollutants are specified, as well as noise, odour and losses to water. Many industrial activities are specified, which provides a means to reduce NO_x emissions. The main challenge in relation to nitrogen emissions has been the inclusion of agricultural emissions into such an ‘industrial’ regulatory regime for the first time. For this purpose, pig and poultry farms over certain size thresholds must operate according to BAT, which have been defined in extensive BAT Reference documentation (BREF, 2003). Currently, the thresholds are set at installations with more than 40000 bird places for poultry, more than 2000 fattening pigs or more than 750 sows.

As part of recent review of the IPPC directive, discussions have focused on possible lowering of these thresholds and inclusion of large cattle farms in the directive. For example, the body-mass and nitrogen excretion rates between poultry types are very different, and it could be justified to have a more diverse set of thresholds, e.g. with lower thresholds for large birds like turkeys and higher thresholds for small birds like pullets. These differences are illustrated in Figure 3, which shows the estimated annual total nitrogen excretion for farm installations according to different animal numbers, as well as estimated rates of total ammonia emission. In this graph, bars are also shown for farm level values of N excretion and ammonia emission for cattle farms according to different size classes. For all three of the farm size thresholds indicated, overall N and ammonia emission is at least as large as the amounts for the existing IPPC thresholds. It may be noted that the ammonia values for cattle in Figure 3 are relatively smaller than those for overall nitrogen. This is because this graph is calculated for UK conditions, where it is assumed that cattle spend roughly half of the year outdoors, where ammonia emissions are much smaller than for housed livestock (which contribute to emissions through housing, manure storage and manure spreading).

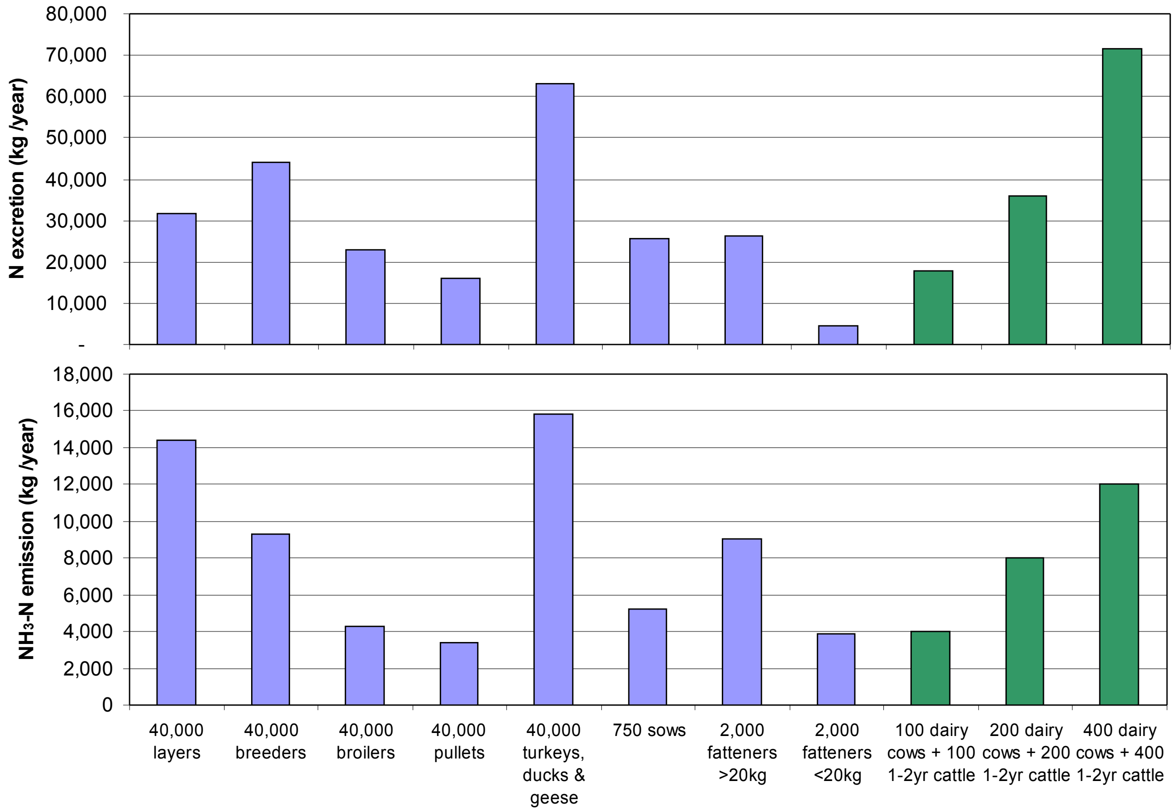

Figure 3: Comparison of overall nitrogen excretion rates and ammonia emissions for farm installations of different sizes according to numbers of different animals. The blue bars indicate current thresholds under IPPC, while the green bars indicate notional thresholds for cattle farms.

For the livestock sector, a particularly strong emphasis was given to the consideration of ammonia emissions in the definition of BAT (BREF, 2003). In addition to requiring practices in animal houses, which have been clearly specified, BAT was also defined for the land spreading of pig and poultry slurries and solid manures. For example, the Technical Working Group (TWG) agreed that default use of a 'splash plate' spreader system (the reference method) did *not* constitute BAT (BREF 2003). However, the TWG was unable to reach consensus on fully defining what BAT *would be* for these systems. For example, low emissions spreading techniques listed as Category 1 (well suited methods) by the UNECE (2001), such as band spreading and slurry injection, were not specified as being BAT, possibly because at that time (discussions up to 2002) countries had limited experience of these methods. Most focus was placed on discussion about the maximum time before applied manure should be incorporated for arable land.

In addition, the debate continues on the extent to which manures generated by IPPC regulated farms are considered in different Member States as regulated through their entire life cycle. It seems that the potential remains for manures generated on IPPC regulated farms to be passed to other landowners, where BAT measures would not be required. For example, this could include uncontrolled manure spreading to land (and the associated peak ammonia emissions) immediately adjacent to sensitive SAC habitats.

The debate on whether to extend IPPC to cattle appears to have focused on agreeing an acceptable number of permits across Europe, from which a farm size limit could be defined. This process led to a rather large farm size threshold for discussion (e.g., ~600 cattle). The result was that this would only address a small percentage of the cattle farms in Europe, and it has therefore been argued that such an approach would not be worth the benefits. Although it is not clear whether these discussions have now ended, there are further points that should be considered. Firstly, cattle are the main source of ammonia emissions in Europe. Thus, even if only 10% of the European cattle herd were included in IPPC, the emissions regulated would be of the same order as that from pigs or poultry. Secondly, the

IPPC regime introduces a regulatory framework, requiring review and assessment in relation to other environmental issues. This means that where there is an application for an IPPC permit for a farm located near to an SAC or SPA, it must be assessed in relation to the provisions of the Habitats Directive (Article 6.3). IPPC thus provides an important mechanism to ensure that the objectives of the Habitats Directive are met. At present, it seems that cattle farms often operate without a requirement for environmental impact assessment. Inclusion of the largest cattle farms would therefore ensure that such assessment could be made, supporting the Habitats Directive.

Environmental Impact Assessment Directive (97/11/EC)

The Environmental Impact Assessment Directive specifies conditions where environmental assessments of new plans and projects should be made, linking to planning policies in different Member States. The EIA Directive includes a list of project categories that are subject to assessment (specified in the Directive Annex I), including oil refineries, power stations, motorways or express roads, widening of dual carriage ways of more than 10 km continuous length, waste disposal installations and quarries, open cast mining and peat extraction of over 150 hectares. It can be seen that many of these are relevant to ensure the assessment of NO_x emissions from combustion sources. The directive also includes thresholds for agriculture, 85000 places for broilers, 60000 places for hens, 3000 places for production pigs (over 30 kg) and 900 places for sows. It is curious that the categories for animals broadly follow the IPPC directive, but with higher thresholds. Since assessment would already be required for IPPC installations, the intention of these higher thresholds is not clear.

The Directive also specifies a second list of activities (Annex II), for which assessments are required on a case-by-case basis according to thresholds to be set by Member States under the guidance of listed selection criteria (Annex III). The list includes many other small industries relevant for NO_x emissions. For ammonia, the list includes waste treatment plants, sludge deposition sites, projects for the restructuring of rural land holdings and intensive livestock installations (where not included in Annex I). The selection criteria for Member States to identify projects requiring assessment (Annex III) includes the characteristics of the project in regard to pollution, cumulative effect with other projects and the environmental sensitivity of areas likely to be affected, including areas classified as protected under Member States' legislation (including the Habitats Directive; SPAs are specifically mentioned).

In principle, therefore, provisions are available in the EIA Directive requiring the assessment of effects of most projects causing NO_x and NH_3 emissions on SACs and SPAs. However, work is needed to evaluate the interpretation given to Annex II categories by Member States. In practice, it appears that many agricultural activities are not assessed in regard of their impact on Natura 2000 sites. In the UK this links to the idea that agricultural activities are in general not classed as 'development'. A more-clear enforcement of the requirement to conduct environmental impact assessments for Annex II listed agricultural activities could provide a lighter touch approach than the extension of the detailed regulatory regime of IPPC to include more farms. However, as Annex II allows Member States to set their own criteria, there remains the danger that many activities impacting on Natura 2000 sites would continue to operate without assessment.

Strategic Environmental Impact Assessment (SEA) Directive (2001/42/EC)

The focus on the SEA Directive is the specification of environmental assessment for large scale plans and programmes. A list of conditions apply that require an EIA under this directive, including the requirement to inform other Member States of possible transboundary impacts of proposed plans or programmes.

Most importantly, the SEA Directive specifies that assessment should be made in relation to regional plans. Under Article 3, paragraph 2 is written: "*Subject to paragraph 3, an environmental assessment shall be carried out for all plans and programmes, (a) which are prepared for agriculture, forestry, fisheries, energy, industry, transport, waste management, water management, telecommunications, tourism, town and country planning or land use and which set the framework for future development consent of projects listed in Annexes I and II to Directive 85/337/EEC,…*" Here it should be noted that the Annexes to Directive 85/337/EEC specify an extremely long list of categories including (under Annex II): *"1. Agriculture (a) Projects for the restructuring of rural land holdings,… (e) Poultry-rearing installations (f) Pig-rearing installations."* Cattle and arable farming activities are not specified, and no size thresholds are stated.

This directive therefore has the potential to review the impacts of nitrogen emissions more widely, including both NO_x emissions from roads and NH_3 emissions from agriculture. For example, where a regional plan specifies an area as being targeted for agricultural activities rather than urban or other development, then it could be argued that this choice should be assessed in relation to the protection of the Natura 2000 network. Such assessments are urgently needed, especially since the N deposition threat to many SACs and SPAs will result from the cumulative effect of many farms (inc. small farms) from the surrounding region.

Other national legislation

It would be a large task to summarize all the other national legislation that exists which is relevant to support implementation of the Habitats Directive. Nevertheless, it would be useful to list examples during the workshop, in order to develop a fuller understanding of the variation between Member States.

In particular, as has been highlighted in the sections above, there appears to be a major loophole regarding the regulation and impact of ammonia emissions from agriculture on Natura 2000 sites. For example, under UK legislation, many agricultural activities are not considered part of 'development' legislation for the purposes of local planning policies. This may mean that a new animal house might be built or stocked without requiring planning permission, thereby avoiding assessment under the terms of the Habitats Directive.

Only in certain instances would such developments be assessed. For example, in the UK one public planning enquiry considered the siting of an agricultural dwelling in an area designated as 'green belt'. In such an area, only 'agricultural dwellings' would be allowed (pending the requirement obtain planning permission). However, to be accepted as an agricultural dwelling, the applicant had to demonstrate a viable agricultural business (in this case a poultry farm). In fact, the farming activity itself required no permission (it was below the IPPC threshold), even though the site was immediately adjacent to a sensitive heathland SAC. The inspector noted that there might be a loophole in the legislation, i.e. were it possible to conduct the farm business without an associated dwelling. However, he concluded that such a possible loophole did not apply in this instance, since the dwelling and the farm needed to be considered together, and thereby tested in relation to Article 6(3) of the Habitats Directive. Considering, in particular, the short distance to the SAC (around 10 m), the proposal was refused (Frost, 2004). This example highlights that there will be many other instances of agricultural activities that go untested in relation to the Habitats Directive.

4. Future options for protection of Natura 2000 sites from long -range transported nitrogen deposition

Here we consider the potential for other approaches that could reduce the nitrogen deposition impacts to Natura 2000 sites, firstly from long-range transported N deposition and secondly (in the following section), from locally transported deposition in source regions. We give particular attention to the role of agricultural sources, as the issue of most concern.

4.1. Revision of the Gothenburg Protocol and NECD

Both instruments are currently undergoing development work in preparation for their potential revision. The establishment of new, more ambitious national ceilings would result in an overall reduction in nitrogen deposition from both nitrogen oxides and ammonia emissions. It is worth comparing the progress already made in reducing the emissions of pollutants regulated under the Gothenburg Protocol. Figure 4 distinguishes between countries in the EU and other Parties in the UN-

ECE area. For the EU, the baseline reductions are largest for SO_2 (72% reduction) and NO_x (53% reduction), and smallest for ammonia (7% reduction). The gap between Baseline and the Maximum Reduction specified by measures included in the RAINS model (MRR) is also largest for ammonia, highlighting that the current commitments for this pollutant are the lightest of the different pollutants considered.

Figure 4 shows that there is considerable potential for further reduction of ammonia emissions under revision of the Gothenburg Protocol, which would result a substantial decrease in the threat to sensitive Natura 2000 sites. At present the degree of ambition, both in terms of the national ceilings and in the technical requirements, remains a topic for future discussion among the Parties to the Convention.

In addition to the benefits for the Natura 2000 network and Europe's natural environment as a whole, there would be substantial co-benefits from further reduction of nitrogen emissions under the Gothenburg Protocol. Both nitrogen oxides and ammonia contribute to particulate matter formation, which leads to significant life shortening across Europe, through respiratory and other illnesses. In the case of agriculture, nitrogen lost from the farming system as ammonia represents a waste of fertilizer N inputs. Given the high costs of fertilizer nitrogen, their sensitivity to oil price changes, and the energy consumed in nitrogen fertilizer production (2% of world energy consumption), saving nitrogen in the system has the potential to save farmers money, make them less at risk to fertilizer price changes, and reduce energy consumption. Many other co-benefits can be expected. For low emission manure spreading this can include: increased agronomic flexibility, more accurate delivery of manure to crops, more accurate avoidance of spreading adjacent to surfaces to be avoided (near water courses, near SACs etc) and a reduction in odour emissions (see discussion by Webb et al. 2009).

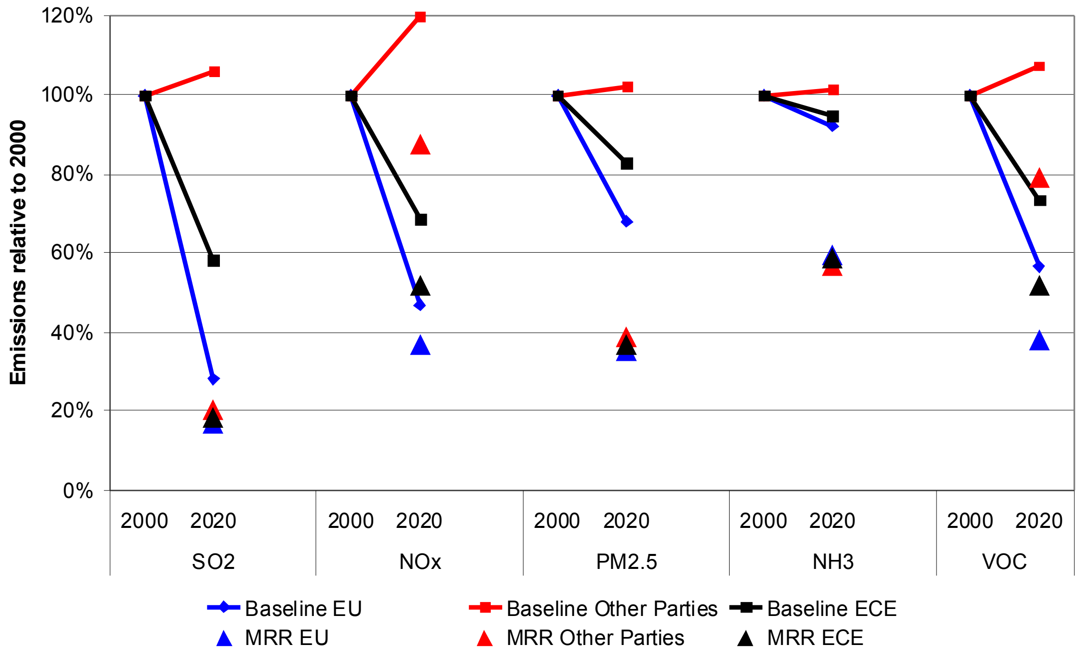

Figure 4: Comparison of baseline projections in emissions between 2000 and 2020 with the maximum rains reduction (MRR), which relates to full implementation of measures currently considered within the RAINS model. The distinction is made between countries of the EU (i.e. linked to NECD projections) and other parties to the UN-ECE Convention on Long Range Transboundary Air Pollution. The Gothenburg Protocol did not include explicit commitments for particulate matter (PM2.5), but it is currently proposed to include this in the protocol revision (Amman, 2009, pers. Comm..).

4.2. Interactions between other community legislation and Natura 2000

The targets of the Gothenburg Protocol and the NECD are set using a modelling optimization approach that aims to minimize environmental effects, including those on ecosystems as specified using Europe-wide maps of critical loads, such as that illustrated in Figure 1. By contrast, the legislative commitments of these instruments are set as the combination of required technologies (e.g., Gothenburg Protocol annexes) and the national emissions ceilings. There is currently no legal commitment in these instruments that is directly related to an ecosystem protection target.

As a large scale 'plan', it might be argued that the even revision of the NECD should be assessed under the SEA Directive, meaning that the implications of revision must be assessed explicitly in relation to the possible threat to the Natura 2000 network. Potentially this could lead to a circular position where only a revision that was sufficiently ambitious to protect the Natura 2000 network fully could be adopted, but that this would be, at the same time, too ambitious to be acceptable by Member States.

More constructively, such interactions should be considered in relation to directives considering other objectives. For example, it is understood that new European animal welfare legislation will require a change in animal housing, leading to a phasing out of the traditional 'tied stalls' for housing of cattle. This will require a change to more open animal houses allowing free animal movement, which is its core objective. However, it is also expected that this change will increase ammonia emissions, leading to an exacerbated threat to the Natura 2000 network. Presumably, through the requirements of the SEA directive, the impact on Natura 2000 should to be assessed. Subject to the conclusions of any such review, it might therefore be expected that any move from tied stall to open barn would be accompanied by the requirement to adopt techniques to ensure that overall ammonia emissions from each farm did not increase.

4.3. Development of an effects oriented goal for nitrogen exposure to Natura 2000 sites

In order to better protect the Natura 2000 network, there is a need for the legal commitments to be set directly in relation to environmental goals. Thus the NECD achieves a general reduction in emissions, but it does not relate closely to the commitment to protect the Natura 2000 network. For this purpose, critical loads (as already used by SEBI 2010) and critical levels could be used to set a *nitrogen target for Natura 2000 protection* across Europe and for each Member State. Such a target could be expressed as:

"*A long term goal to ensure that 95% of Natura 2000 designated sites do not exceed critical loads or levels for reactive nitrogen compounds by 2030*".

The details would need debate, including the 95% number and the target year, but the principle should be clear. It may be noted that this goal is phrased as the % *number of designated sites*, rather than the % area of the overall Natura 2000 network. This is important, since it could be argued that each SAC or SPA designation is of equal value to society. For example, a large SAC may occur in a very remote area, where there is no shortage of land, while a small SAC may occur as a priority for protection in a landscape under high human pressure. In a analysis for the UK presented by Hallsworth et al. (2009, poster this meeting), it is shown that there is a tendency for small SACs to occur in the most polluted areas. Finally, loss of integrity over any part of an SAC may be considered as a threat to the integrity of the whole. For this reason, Hallsworth et al. (2009) calculated the % number of SACs where the critical level was exceeded over some part of the each SAC (Designation Weighted Index, DWI). They compared this with the total area of SACs exceeded in the country (Area Weighted Index, AWI). Using ammonia critical levels of 1 $\mu g\ m^{-3}$ (ecosystems with relevant epiphytes) and 2 $\mu g\ m^{-3}$ (precautionary value for higher plants on Natura 2000 sites), they concluded that 11% and 1% of the area of the UK Natura 2000 network (AWI) exceed the critical levels, respectively. By contrast, 59% and 24% of Natura 2000 sites (DWI) exceed the same critical levels (Hallsworth et al., 2009). The AWI approach did not provide an appropriately precautionary measure because of: a) the anti-correlation between NH_3 concentrations and area of each SAC and b) the failure to consider variation in NH_3 concentrations across SACs. These last points can be seen clearly in Figure 5.

4.4. Co-benefits of planting trees and other low-nitrogen biomass

A rather different regional scale approach to reduce impacts of reactive nitrogen deposition and concentrations on Natura 2000 sites is through the application of land use policies. For example, such policies are already discussed in relation to carbon sequestration under the Kyoto Protocol, i.e. allowing credit for increasing carbon sinks in planted forests (Article 3.3).

In the context of carbon sequestration, it has recently been discussed whether a certain amount of N deposition would be beneficial in increasing forest C uptake rates (Hogberg, 2007; Magnani et al., 2007, de Vries et al., 2008, Sutton et al. 2008). Of course it must be recognized that such potential benefits must be balanced against increases in nitrous oxide emissions and impacts on biodiversity, water quality etc. (De Schrijver et al., 2008).

In the present discussion, however, the point of interest is that increasing forest area will lead to a decrease in atmospheric nitrogen concentrations and deposition to other receptor ecosystems. The reason for this is that forest land (and other unfertilized tall biomass crops) scavenges nitrogen compounds (especially ammonia, nitric acid and particulate matter) through dry deposition more effectively than short, fertilized agricultural land. A larger area of woodland therefore results in faster removal of these compounds from the atmosphere to these surfaces, resulting in less being available for deposition elsewhere. Policies of extending forest area based on this principle therefore have the potential for substantial co-benefit between carbon and nitrogen impacts. The idea of urban forest plantations has also been considered in relation to its benefits for human health, through reducing particulate matter concentrations (McDonald et al., 2007).

Theobald et al. (2004) examined scenarios of forest planting in the UK, showing that these had potential to give significant reductions in ammonia deposition to existing forests and to other semi natural land, such as heathlands. However, they pointed out that the location of the forest plantings is important in this context, as these should be made in the areas with highest nitrogen emissions and deposition. Planting a forest in a remote area with very low nitrogen deposition would lead to little benefit. Such policies should also be considered in relation to their local implications, for example in the establishment of buffer-zones (Section 5.2).

It should be examined whether this link between carbon and nitrogen policies could be made at a European scale. For example, it should be considered whether the benefits of Article 3.3. forests under the Kyoto protocol could also be considered as 'nitrogen emission credits' under the terms of a revised NECD.

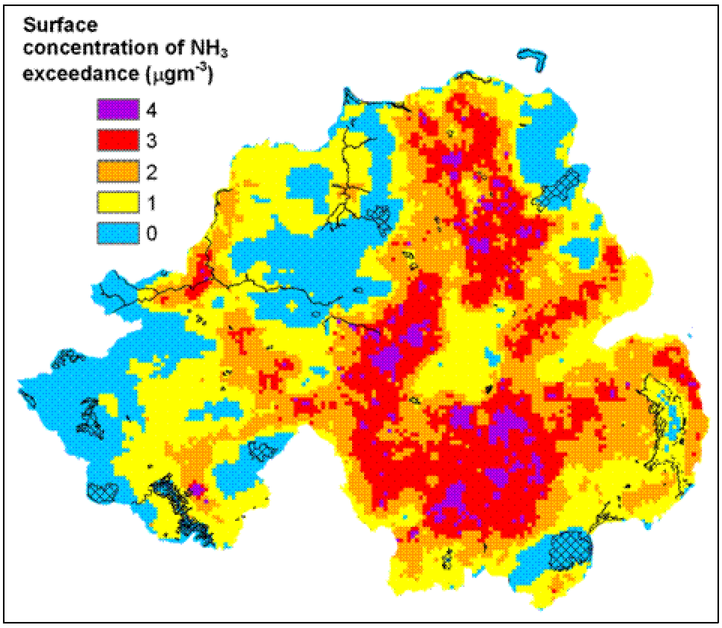

Figure 5: Spatial pattern of NH_3 concentration and the location of Special Areas of Conservation (SACs) in Northern Ireland (1 km resolution FRAME model estimates calibrated against UK measurement network).

Although many of the largest SACs do not exceed the lowest critical level (1 μg m^{-3}), substantial exceedance is seen for the smaller sites. 22% and 5% of the area of SACs in Northern Ireland exceed the 1 and 2 μg m^{-3} critical levels, respectively (Area Weighted Index, AWI), however, 74% and 42% of the SACs exceed the same critical levels over part of their domain (at 1 km^2 resolution, Designation Weighted Index, DWI). The DWI is considered the legally correct approach under the terms of the Habitats Directive (Hallsworth et al., 2009a,b). Moninea Bog is located ~2 km from the SW border (1-2 μg m^{-3}, area ~1 km^2).

4.5. Patterns of societal behaviour

It should briefly be noted that the directives discussed focus mainly on technical changes, whereas the overall burden of nitrogen emissions is a result of a much wider set of societal choices. For example, the choices of individual European citizens determine their energy consumption (NO_x emissions through electricity generation), their annual vehicle mileage and (NO_x emissions from transport) and their consumption of animal products (NH_3 emissions from livestock agriculture). A great deal of effort is currently placed on educating the public in their energy and transport choices, particularly to reduce carbon footprints. In parallel, much more thinking needs to be done to consider how to optimize European dietary choices for both human health and the environmental consequences. Such societal chances have a huge potential to influence European scale emissions of reactive nitrogen, thereby affecting the transboundary transport and deposition of nitrogen to Natura 2000 sites.

5. Future options for protection of Natura 2000 sites from short-range transported nitrogen concentrations and deposition

While the above policy interactions have the potential to affect transboundary fluxes, they do not directly address the problems of short range transport to Natura 2000 sites in source areas, with these often being the sites under the most extreme threat. Options for further development include strengthening the links with cross-compliance in agriculture, spatial planning including buffer zones and the application of air concentration objectives and local air quality management for ecosystems.

5.1. Strengthening the cross-compliance links for Natura 2000

One of the principles of European agricultural financial support (i.e., the single farm payment system) is that the payments are made to farmers under the principle of cross compliance. This includes two requirements:

a) *statutory management regime*: that farmers are in full compliance with existing legislation relating to their farm and the environment. For example, farmers need to comply with the Nitrate Directive, the Habitats Directive and any other relevant legislation. This requirement applies equally across the European Union.
b) that farmers maintain land in *good agricultural and environmental condition*, primarily relating to the condition of the farmland itself, but also with implications for off-site losses, e.g. avoidance of manure spreading adjacent to water courses. This requirement is delegated for each Member State to define.

The implication of cross-compliance is that, in principle, any farmer in receipt of a single farm payment should already have demonstrated that they have no adverse impact on Natura 2000 sites. In practice, it should be asked to what extent such links are currently made between different Member States. The impression is that, at present, this link is not adequately treated and that further guidance needs to be developed on: a) general rules for avoiding impacts on Natura 2000 sites through N concentrations and deposition, b) specification of suitable impact assessment approaches, including cost-effective methods applicable for small farms.

It is worth to note that, even under the previous system of agricultural area support payments, the principle of cross-compliance already applied. However, in practice the linkages seem to have been rarely enforced. This highlights the challenges involved in developing these linkages for the future.

5.2. Spatial planning, including buffer zones

Spatial planning has a significant role to play in reducing the impacts of nitrogen deposition and concentrations on the Natura 2000 network. In landscapes with large N emissions (source areas), the amount of N deposited to a sensitive site is very closely linked to the distance from major nearby emissions. This is for example, clearly shown for Northern Ireland (Figure 5), where the patterns of ammonia concentration (modelled at 1 km resolution) closely match to the mapped ammonia emissions.

In the Netherlands, policies were already established some years ago whereby manure from areas with high ammonia emissions was transported to areas with low emissions. Naturally, this resulted in an increase in ammonia concentrations in the cleaner areas, which caused some debate as to the benefits of the policy (see, Bleeker and Erisman, 1998). However, if the priority is to protect those areas most under threat and the other areas were established as a) less under threat and b) of lower priority for nature conservation, then the policy remains logical. If such policies should be considered more widely, a clear agreement on the relative priorities would need to be established from the outset. This poses a challenge for the wider objectives of the Habitats Directive, which seeks to maintain conservation status of habitats and species across Europe as a whole, including sites not designated as Natura 2000.

Local spatial planning policies, including the use of buffer zones have the potential to be much less controversial, and are already established for other effects, such as the use of buffer zones adjacent to water courses. In the case of nitrogen emissions to air, such buffer zones could be appropriate both for nitrogen oxides emissions from roads and for ammonia emissions from agriculture. Three aspects to such buffer zones should be considered:

a) increasing the distance from the source, allowing greater dispersion before the air reaches the sensitive area, such as an SAC,
b) increasing the dispersion between source and receptor, such as by planting tall rough vegetation, further diluting the pollutant before it reaches the sensitive area,
c) encouraging deposition between the source and receptor, such as provided by planting tall vegetation as a buffer zone.

In practice, the first two benefits are expected to be most important for narrow buffer zones of a few 10s of metres. For the third benefit, planting a single row of trees would have a trivial effect in removing ammonia from the atmosphere, for which purpose wide tree belts of >100 m would be required (see Theobald et al., 2004, Loubet et al., 2009). As dry deposition rates for NO_x are very small, only the first two benefits would apply for this pollutant. Enhanced nitrogen deposition adjacent to major roads is due to both NO_x and NH_3 (Cape et al., 2004), due to catalytic converters increasing NH_3 emissions compared with cars without converters. Hence broad woodland plantings adjacent to roads could achieve all three benefits.

Dragosits et al. (2006) considered the potential for tree plantings to reduce nitrogen deposition to a landscape in the UK. For example, they showed how tree plantings both adjacent to farm sources and to the nature reserve sinks could lead to significant reductions in deposition (Figure 6). They also investigated the potential of other buffer zones, for example, the avoidance of manure spreading and urea application up to 100 m, 300 m and 500 m from the nature reserves. These scenarios led to smaller benefits, mainly because in their model scenario, overall emissions were dominated by farm point sources (including a large poultry farm). Such buffer zones would, however, have significantly reduced peak ammonia concentrations on the nature reserves immediately after manure spreading.

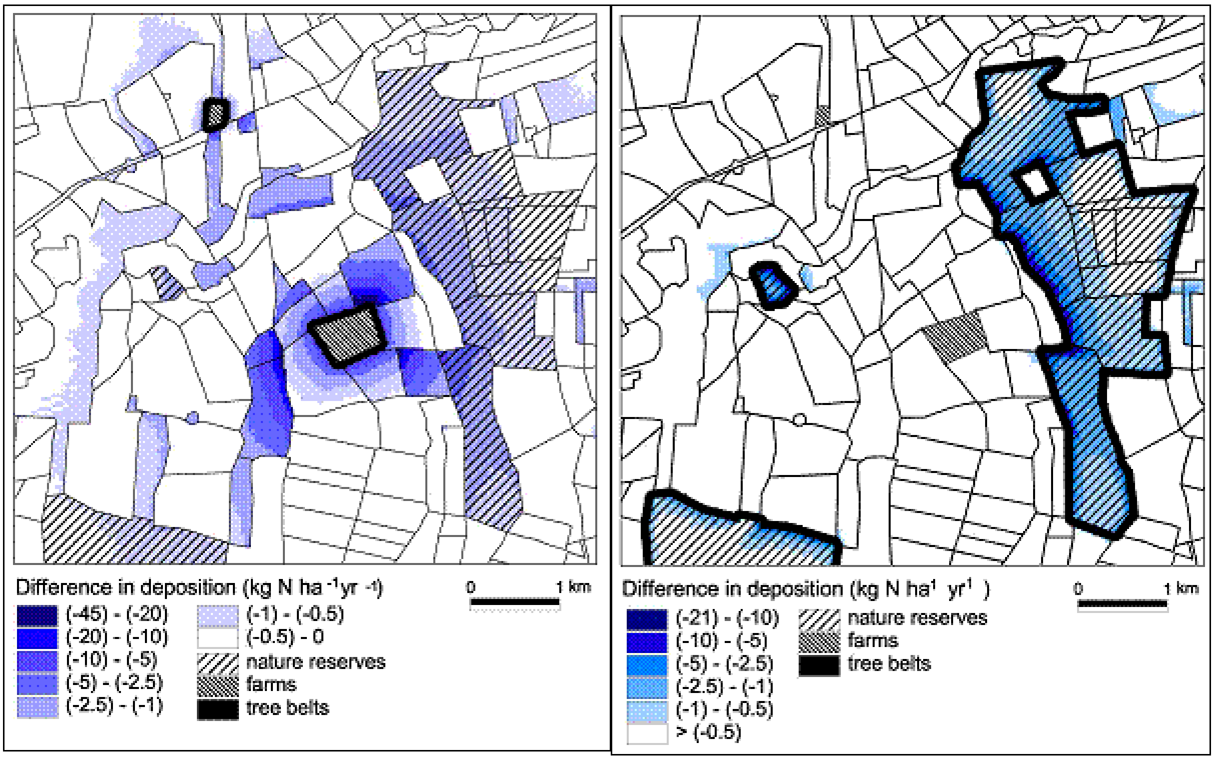

Figure 6: Landscape-level scenarios illustrating the effect of woodland buffer zones on atmospheric nitrogen deposition to three nature reserve areas. On the left, the scenario consisted of adding a 50 m wide buffer of trees planted around two farms (a small beef farm, and a large poultry farm). On the right, the scenario represented the adding of a 50 m wide buffer of trees around each of the nature areas. The maps show the reduction in N deposition compared with the base run. Both scenarios demonstrate significant benefits (Dragosits et al., 2006).

The same authors addressed the effect of location of the major point source. The scenarios shown in Figure 7 indicate that there are significant benefits, even if the farm is located 1 km further away from the reserve, to the west in this example. At a distance of 3 km, the farm makes a relatively minor contribution to deposition at this the nature reserve site, as shown by comparison of the scenario with the farm removed.

The use of buffer zones therefore has a high potential for further policy development to protect Natura 2000 sites from nitrogen deposition in source areas. In particular, the approach has the advantage that rather simple distance rules could be set for the avoidance of different sources, e.g., farm buildings or of manure spreading activities. For example, rules might be established that up to 300 m from a sensitive SAC (effectively at least 1 field distance), slurry and urea were not spread to agricultural land (or not unless a high abatement efficiency technique was applied, such as immediate ploughing in).

5.3. Air concentrations objectives and local air quality management for ecosystems.

Under the Air Quality Directive (2008/50/EC), ambient air standards have been set for NO_x (expressed as NO_2), SO_2, O_3 and particulate matter, with the prime focus on protecting human health from air pollutant exposure in the urban and industrial environments. However, the directive also includes critical levels for SO_2, NO_x and O_3 set for the protection of vegetation.

A major tool that was widely used in previous air quality directives, and has been continued in the AQD is the establishment of objective concentrations linked to local Air Quality Plans, or local air quality management (LAQM). There is a requirement for local authorities to regularly review and assess air quality in their area against the standards and objectives prescribed in regulations.

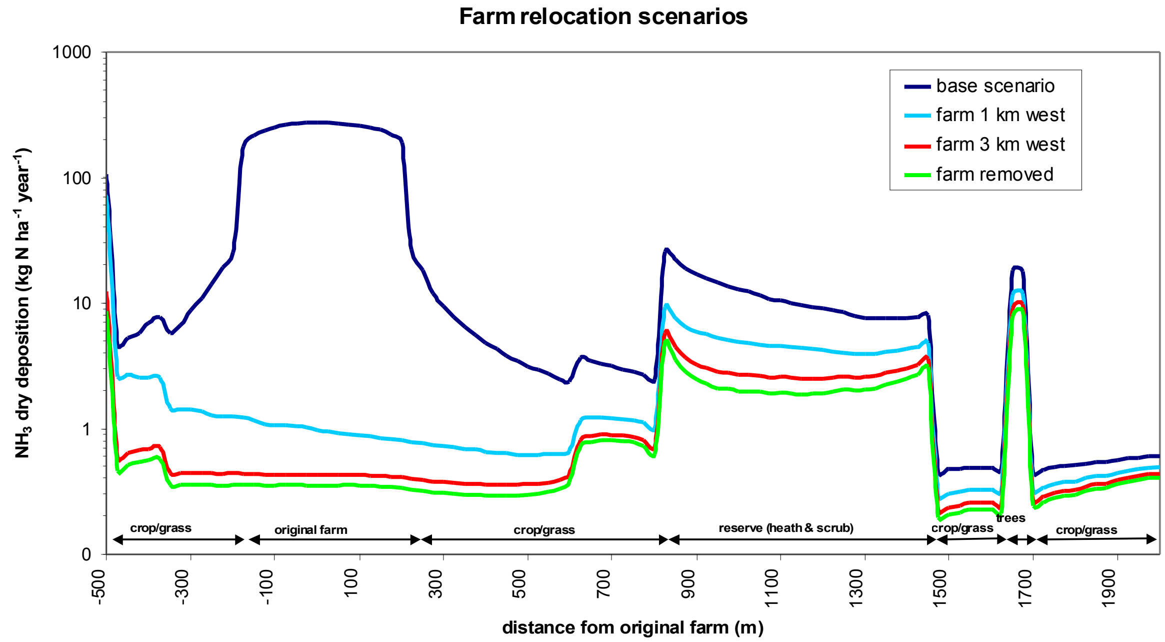

Figure 7: Modelled transect of atmospheric nitrogen deposition due to ammonia assuming a base situation and three scenarios related to the location of a major point-source livestock farm (Dragosits et al., 2006). The reserve area could be considered as an SAC or SPA.

When these objectives are not being achieved, or are not likely to be achieved within the relevant period an Air Quality Management Area (AQMA) must be designated. Once this area has been designated the local authority must develop a remedial Action Plan to improve air quality in that area. The local authority should define the boundaries of the AQMA, communicate the implications to the local community and statutory consultees and coordinate with neighbouring authorities regarding possible adjacent AQMAs.

Given the existing commitment under the Habitats Directive, such an approach would be applicable for the protection against ecological effects on Natura 2000 sites. For this purpose, existing critical levels for NO_x (ICP Modelling & Mapping 2004) and NH_3 (UNECE, 2007; Sutton et al., 2009) could be used as the starting point for defining objective concentrations.

The actual values set for this purpose would presumably depend on the balance of ecological risk versus costs, as negotiated between the Member States. For the purpose of ecosystem protection, the main focus could be in relation to annual mean concentrations, based on monthly sampling (also ensuring that certain peak monthly concentrations are not exceeded). Since daily fluctuations in NO_2 and NH_3 are not considered important from an ecosystem perspective, this would reduce the costs of the measurements required, because passive sampling methods could be used (where shown to be reliable).

The following approach might be taken:

a) Establish NO_x and NH_3 concentration objectives that apply in air over the surface of Natura 2000 sites (e.g., measured at 1-2 m above ground). The main focus should be on annual values, but monthly averaged maxima should also apply.
b) National modelling is used to assess whether the NO_2 or NH_3 objectives are exceeded over all or part of the domain of a Natura 2000 site.
c) Local screening models are applied to identify the locations on the Natura 2000 site that are most at risk of exceeding the NO_2 or NH_3 objectives.
d) Atmospheric monitoring is conducted at the locations identified in c) for at least one year (using monthly sampling with robust passive sampling methods).
e) If the objective concentrations are not exceeded, no action needs to be taken. If the objectives are exceeded, then a local management plan should be established that specifies a course of action by which they would be reduced.

Such an approach would necessarily need to be backed up by a clear set of legislative and voluntary tools to achieve the concentration objective values, and thereby reduce the impacts to Natura 2000 sites. The potential to link this to the existing Articles 6.1 and 6.2 of the Habitats directive should also be considered.

6. Conclusions

This review has identified that atmospheric nitrogen deposition and the associated concentrations of reactive nitrogen represent a significant threat to the Natura 2000 network. The evidence is that the application of existing policies is not currently adequate to protect these flagship sites for the protection of Europe's biodiversity. Many sites exceed critical levels and loads, with consequent adverse ecological effects.

It is concluded that the nature of the nitrogen deposition problem for biodiversity can be distinguished into: a) reducing long-range transboundary air pollution and b) reducing short-range pollution impacts in source areas. While policies addressing the first, e.g. NECD, will have some benefits for the second, they are not specifically targeted for this purpose, with the result that many local impacts can still be expected. To reduce the impacts on Natura 2000 sites in source areas requires a specific set of policies designed for this purpose.

In comparing NO_x and NH_3 emissions, it is clear that there is a much greater regulatory control over the NO_x emissions. This is reflected in a significant reduction in baseline estimates of European NO_x emissions over 2000-2020. By contrast, there has been hardly any reduction in NH_3 emissions, which mainly arise from agriculture. This difference is reflected in the current degree of attention to reducing NH_3 emissions in existing policies. Although requirements are included in both the NEC and IPPC Directives, these represent the first such agreements, and consequently the current ambition levels are rather modest.

In regard of the impacts on Natura 2000 sites, the existing commitments of the Habitats Directive should afford a high level of protection. In practice, this intended degree of protection is not achieved, in particular, because many sources of NH_3 continue with little regulation.

At the regional scale, there is potential for more effective protection of the Natura 2000 network through revision of the NEC and the IPPC Directives. In addition, there is substantial scope for revision or more rigorous enforcement of the Environmental Impact Assessment (EIA) and Strategic Environmental Assessment (SEA) Directives. For example, extending the provisions of the EIA Directive to include other farms could provide a light touch approach for these farms that would avoid the full regulatory regime of IPPC. Secondly, under the SEA Directive, the implications of regional plans on ammonia emissions need to be tested in relation to the terms of the Habitats Directive. Similarly, the effect of other proposed legislation (e.g., animal welfare legislation causing increased NH_3 emissions) needs to be tested in relation to the Habitats Directive.

New approaches that should be investigated include an effects-oriented goal for N effects on Natura 2000, the linking of carbon sequestration and nitrogen deposition benefits in forest planting policies (linking Kyoto Article 3.3 and NECD revision) and approaches that help foster reduced nitrogen consumption by European citizens. Approaches that include the assessment of ecosystems services, such as carbon sequestration, could highlight important positive and negative effects of nitrogen deposition on Natura 2000 sites that could provide an added incentive for actions to protect sites.

Much more effort needs to be given to managing the local impacts of nitrogen deposition and concentrations on Natura 2000 sites in source areas. This could include strengthening the enforcement of existing cross-compliance links between single-farm payments and impacts on Natura 2000 sites, coupled with the development local spatial planning measures, including guidance on buffer zones for atmospheric N deposition. Finally, substantial focus has been given to developing local air quality management under the EU Air Quality Directive, linked to human health protection. Currently, no such system is in place for ecosystem protection. A combination of establishing objective concentrations for NO_x and NH_3, together with a system of local air quality management for ecosystem protection would provide a suitable approach. By integrating ecosystem-level air quality management with some of the options mentioned above, a more rigorous approach could be developed that matches to the existing commitments under the Habitats Directive.

7. Key questions for discussion

1) Have Natura 2000 sites been assessed for the risk of N deposition in your country?
2) Are sufficient policies in place to protect Natura 2000 sites, and if so are they being adequately implemented and enforced?
3) Do you see a need for further policy development in this area?
4) To what extent do you agree that the procedures needed to protect from NO_x emissions are largely in place?
5) Do you agree that the challenges to protect Natura 2000 sites from nitrogen deposition and concentrations are greatest for the impacts of agricultural ammonia emissions?
6) To what extent do you think that existing legislation could be enforced more effectively to protect the Natura 2000 network?
7) How important do you rate the usefulness of high level goals, e.g., "*A long term goal to ensure that 95% of Natura 2000 designated sites do not exceed critical loads or levels for reactive nitrogen compounds by 2030*", as compared with the application local level policies?
8) What are the other possible approaches that have not been discussed in this document?
9) If you were to develop a package of measures to protect Natura 2000 sites from nitrogen deposition, what would you consider to be the most suitable elements?
10) How might such a package be expected to differ when viewed from different viewpoints (scientific, administrative, policy, political, industry, conservation etc.)?
11) How should such a package be considered in relation to wider objectives of the Habitats Directive to maintain Europe wide conservation status, including areas outside the territory designated as Natura 2000 sites?
12) Would an assessment of ecosystem services provided by Natura 2000 sites be a help or a hindrance to policy development for their protection?

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