Nitrogen Deposition and Natura 2000: Science & practice in determining environmental impacts

Findings of a European Workshop linking scientists, environmental managers and policy makers.

18-20 May, 2009, Brussels

Summary for Policy Makers

Background and objectives

1. Atmospheric nitrogen deposition represents a major threat to European biodiversity. Nitrogen emissions to the atmosphere have increased substantially over the 20th century, mainly as ammonia from agriculture and nitrogen oxides from industry. Following atmospheric dispersion and chemical processing, these nitrogen forms are deposited across European landscapes, providing unplanned nitrogen inputs and adversely affecting many sensitive habitats.

2. The issue represents a serious challenge for the conservation of natural habitats and species under the Habitats Directive (92/43/EEC). Noting these problems, this workshop was organized to bring together scientists, environmental managers and policy makers to clarify our understanding of the key issues, to develop European best practices when conducting assessments and to recommend options for consideration in future strategies.

3. The Habitats Directive is a cornerstone of Europe's nature conservation policy. It promotes the maintenance of biodiversity and requires Member States to take measures to maintain or restore natural habitats at a favourable conservation status. The Directive establishes the Natura 2000 network with the aim to assure the long-term survival of Europe's most valuable and threatened species and habitats. These sites are afforded the highest degree of protection under European legislation: the provisions of the Directive require strict site protection measures and avoidance of deterioration. It introduces a precautionary approach to permitting "plans or projects" which may have a likely significant effect on a site.

4. Control of emissions to air of reactive nitrogen are regulated under several directives including the National Emissions Ceilings Directive (NECD, 2001/81/EC), the Large Combustion Plants Directive (LCPD, 2001/80/EC), the Air Quality Directive (AQD, 2008/50/EC) and the directive on Integrated Pollution Prevention and Control (IPPC, 96/61/EC). A range of other policies and legislation also influence emissions, such as the Nitrates Directive (91/676/EEC). However, the impacts of nitrogen deposition on the Natura 2000 network (and the habitat and species resource outside of the network), together with the associated impacts due to elevated concentrations of ammonia (NH_3) and nitrogen oxides (NO_X), are often not addressed adequately or systematically; this is despite the strong protection measures in place through the Habitats Directive.

5. The Habitats Directive does not directly address nitrogen impacts and until now there has been no common European approach for determining the impacts of nitrogen deposition on individual sites or on conservation status. At the same time, the scale of pollution exposure suggests that there are widespread threats to the Natura 2000 network and to conservation status more widely due to the concentrations and deposition of reactive nitrogen species.

6. Outline of the workshop
The specific aims of the workshop were as follows:

- to compare case studies of N impacts on Natura sites from across Europe,
- to compare national criteria for risk assessment between countries,
- to develop clear messages that could improve assessment approaches,
- to communicate the scale of the nitrogen threat to the Natura network,
- to review the role of cross-compliance on managing Natura sites,
- to link the science with decision making at local to European scales.

7. Together these aims contributed to the overall workshop goal: *to harmonize approaches for determining the impacts of atmospheric nitrogen deposition on Natura 2000 sites and review the future policy options.*

8. The workshop was structured into themes addressed by five Working Groups, supported in each case by a background document setting out the issues in detail and the challenges currently faced.

Theme 1: Comparison of impact assessment and decision making approaches to determine the **nitrogen deposition impacts associated with plans and projects** in the context of **Habitats Directive Article 6.3** obligations (see Bealey et al., 2010);

Theme 2: Comparison of approaches to assessing and reporting **nitrogen deposition impacts on conservation status (Habitats Directive Article 17)** and discussion of harmonising approaches for future reporting rounds (see Whitfield and Strachan, 2010);

Theme 3: **New science** on the effects of nitrogen deposition and concentrations on Natura 2000 sites, including bio-indicators, effects of nitrogen form (e.g. reduced nitrogen, NHx, versus oxidized nitrogen, NOy,), and the relationships between critical thresholds and biodiversity loss (Nordin et al., 2010);

Theme 4: **Approaches to modelling** local nitrogen deposition and concentrations in the regulatory context of Natura 2000 (Hertel et al., 2010);

Theme 5: **Options for future policy development** to manage and mitigate the impacts of nitrogen deposition effects on the Natura 2000 network (Sutton et al., 2010).

9. Overall, the workshop encouraged links to be developed between the scientific basis of nitrogen deposition effects, regulatory practice and policy application. A graphical summary of the different themes and their relationships is shown in Figure 1. As part of the assessment, nitrogen effects were related to both atmospheric nitrogen deposition and atmospheric concentrations of reactive nitrogen compounds, including the use of critical loads and critical levels as effects thresholds.

10. The workshop was attended by 73 delegates from 13 countries: Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Portugal, Spain, Sweden, the Netherlands and the UK. The delegates were scientists, conservation practitioners and policy makers, including representatives from the European Commission DG Environment, and various Government Departments.

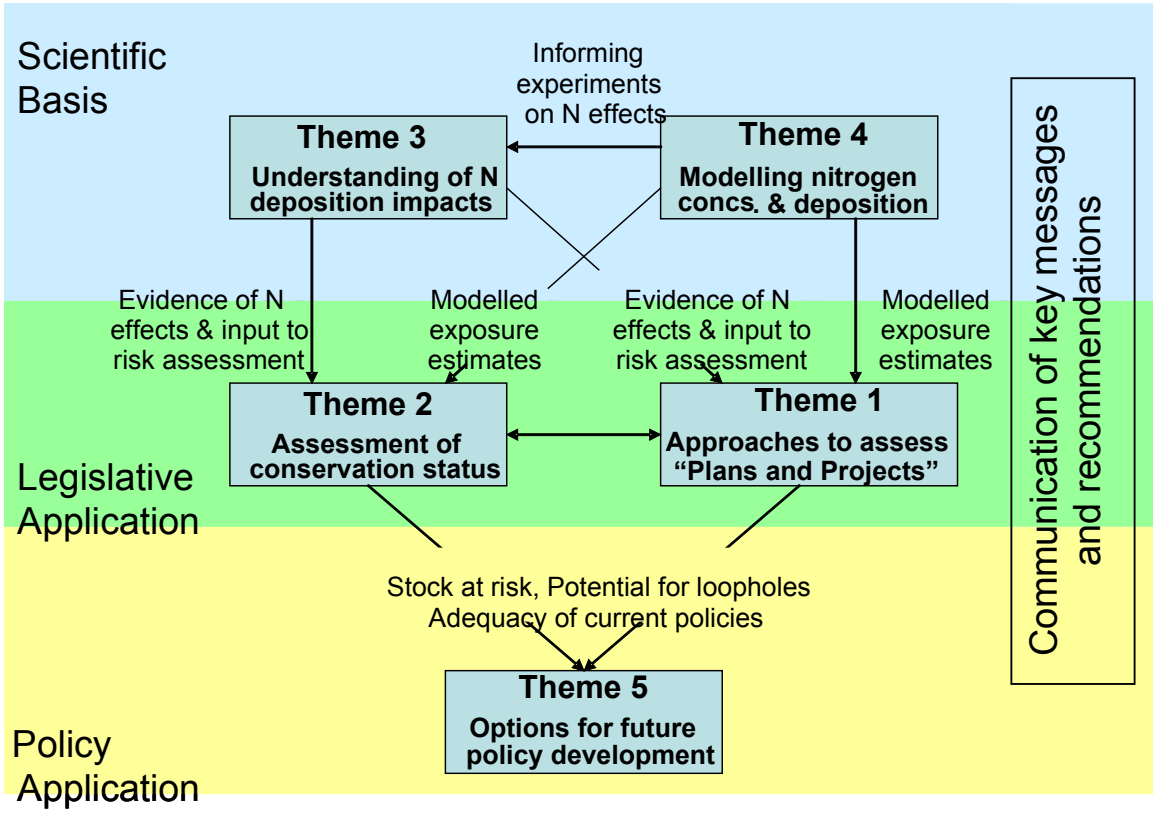

Figure 1: Summary of the workshop structure, highlighting the inter-linkages between the five main themes.

Conclusions and Recommendations of the Workshop

11. The workshop agreed that nitrogen deposition represents a major threat to European biodiversity, including sensitive habitats listed under the Habitats Directive. Many of Annex I habitats are naturally adapted to low nitrogen supply, so that fertilization with nitrogen compounds from the atmosphere alters the natural ecological balance. This results in the loss of the most sensitive species, which are often a priority for protection, and their replacement by invasive species that prefer high rates of nitrogen supply. In addition, the evidence also points to a net loss of overall numbers of species.

12. The workshop noted that both atmospheric nitrogen deposition and air concentrations of reactive nitrogen compounds were appropriate indicators of the scale of threat. The use of critical loads and critical levels, as effects thresholds for nitrogen deposition and air concentrations, respectively, have demonstrated their usefulness at the European and site scales.

13. The workshop agreed that in many cases across Europe, nitrogen deposition and concentrations substantially exceed the critical loads and levels. Examples were presented of predicted and actual habitat change, demonstrating that this is a major current threat, implying serious management challenges to work toward favourable conservation status and to prevent deterioration of Natura 2000 sites.

14. The working groups addressed the different components of science, environmental management and future policy development needs.

Theme 1. Comparison of impact assessment approaches in the context of Habitats Directive 6.3

15. The Habitats Directive requires that all 'plans and projects' which are likely to have a significant effect on a Natura 2000 site require an appropriate assessment of the implications for the site. Subject to certain exemptions, the plans or projects can only be approved where they are shown to have *no adverse effect* on any Natura 2000 site. However, at present, there is no common approach for evaluating the effects of nitrogen deposition and concentrations on these sites. The workshop therefore reviewed the practices in use across Member States. A key challenge was how to handle the situation where local background levels of deposition (or concentrations), resulting from existing activities, already lead to exposure in excess of critical thresholds. In this case, the question was raised of how to define an acceptable additional pollution burden, when in principle; any further exposure will give rise to an increasing risk, and magnitude of adverse impact.

16. The impact assessment and decision making approaches applied in the different Member States, for 'plans and projects' under Article 6(3) of the Habitats Directive, were found to be clearly influenced by national policy, national aspirations, and national court decisions. However, an examination of the different approaches identified a number of common components, which were used to develop a 'best practice framework' relevant across Europe.

17. 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).

18. 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.

19. 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.

20. 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.

21. 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.

Theme: 2. Assessing nitrogen impacts on conservation status

22. The Habitats Directive requires Member States to provide an assessment of conservation status of habitat and species listed in the Annexes of the Directive every six years. At the highest level, favourable conservation status is defined and there is a standardized approach as regards the

parameters to assess and descriptive statements of condition (e.g. favourable, unfavourable, unknown). Across Europe nitrogen deposition is increasingly recognised as a major issue for biodiversity. However, there is currently no standardisation as to how to consider nitrogen deposition impacts on conservation status. There is a high likelihood that the scale of nitrogen deposition effects on conservation status of habitats and species is not being accurately reported.

23. The workshop compared experience between countries as a basis to investigate what might be considered best practice in the assessment of conservation status. Different approaches to assessing whether nitrogen deposition is a 'pressure' on the 'structure and function' of habitats or a 'threat' to the 'future prospects' were considered. These include critical loads exceedance, field survey and bioindicators. Limitations to implementation were considered, including financial and expertise requirements.

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

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

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

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

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

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

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

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

biogeochemical based monitoring data in order identify whether nitrogen deposition is a 'pressure to current structure and function'.

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

Theme 3. New science on the effects of nitrogen deposition and concentrations on Natura 2000 sites

31. Actions to manage the Natura 2000 network and to assess conservation status must be based on a sound scientific understanding of how reactive nitrogen deposition causes impacts on sensitive habitats. The workshop reviewed the latest evidence:

- to provide a clear picture of the scale of threat from nitrogen deposition to the Natura 2000 network and to conservation status;
- to consider the relative effects of different nitrogen forms, including ammonia versus nitrogen oxides (especially as this relates to different polluting source sectors) and to dry versus wet deposition (as this relates to near source impacts versus long range transport);
- to evaluate the critical loads and levels approach, and consider the role of other approaches, including indicators from site level measurements to the European scale;
- to consider the potential to improve relationships between concentrations/dose and biodiversity loss, as well as the use of management practices to mitigate nitrogen impacts.

32. It was concluded that the latest science supports and strengthens the already established empirical Critical Loads, encouraging their use in environmental decision making.

33. The workshop concluded that there are no acceptable exceedances above a Critical Load or Critical Level. Discussions regarding "acceptable exceedances" are not a science issue and should be addressed at a policy level. In order to improve the situation, one should aim at reducing nitrogen deposition below the Critical Loads and Levels.

34. New data have strengthened the view that it is important to consider different nitrogen forms when evaluating effects of nitrogen deposition. It was concluded that evidence of responses for the different nitrogen forms is consistent across ecosystems and species. Moreover, because the effects from nitrogen deposition differ between different nitrogen forms (dry/wet deposition and oxidized/reduced nitrogen) it is important to evaluate their effects independently. Hence several types of Critical Loads/Levels for a particular habitat type are needed. The Critical Level for ammonia may, for example, be well below the Critical Load set for total nitrogen deposition. Hence it is important that both Critical Loads and Levels are used.

35. In the latest up-date of empirical Critical Loads (from 2003) there was a lack of data from Southern Europe. Since then new important data from this region have emerged, for example, during the workshop results from experiments and surveys conducted in Portugal and Spain were presented.

36. The workshop concluded that improved conditions following reduction in nitrogen deposition are only relevant when nitrogen deposition is reduced below the Critical Load/Level. Reduction of exceedance will only improve the situation in the sense that it reduces the risk of further worsening of the effects. Available information of the effects on recovery time following reductions below

Critical Loads/Levels is still largely lacking. Available data suggests that the rate of improvement will differ depending on type of function/species studied, and is often site specific.

37. It was concluded that management to reduce the impact of nitrogen deposition will only work in combination with reductions in nitrogen deposition and should not be seen as an alternative to reducing the nitrogen deposition. For semi-natural habitats, positive effects from reducing the nitrogen inputs will only be possible in combination with appropriate management.

38. The workshop agreed that there are important interactive effects between nitrogen deposition and climatic factors. A changing climate will also therefore influence the effects of nitrogen deposition. Currently, the knowledge of such interactive effects, and how they may change with a changing climate is, however, poorly understood. The climatic factors most important for interactive effects with nitrogen are also the most uncertain in climate change modelling (e.g. precipitation), making predictions of future interactions between nitrogen deposition and climate change difficult.

39. It is recommended that future research should prioritize the assessment of relative impacts of different nitrogen forms in relation to critical thresholds and dose response relationships, the relationships between nitrogen dose and site- and landscape-level management practices as a basis for minimizing adverse effects on ecosystem integrity, and quantification of the interactive effects of climate change and nitrogen deposition.

Theme 4. Approaches to modelling local nitrogen deposition and concentrations in the context of Natura 2000

40. Assessment of the threat of nitrogen to the Natura 2000 network is fundamentally dependent on the ability to model the pathway from emissions, though air chemistry to deposition. There are currently many atmospheric models available, and recent reviews (for ammonia) have considered these at both local and regional scales. The challenge of the present workshop was to address effectiveness of such models for assessment in relation to the protection of Natura 2000 sites, including the different nitrogen forms, and consideration of relative contributions from short range, mesoscale and transboundary (international) atmospheric transport.

41. Key questions included, how well we can simulate measured air concentrations for comparison to critical level estimates, and to what extent ecosystem specific dry deposition rates are treated in models. Specific examples were considered of where models have been applied in existing case studies to investigate the relative contribution of emissions from different sources to nitrogen deposition and concentrations experienced at Natura 2000 sites.

42. It was noted that modelling assessment approaches differ widely from country to country, both in terms of the type of models used and the level of detail considered. In particular, two types of assessment can be used (source-based or receptor-based) and the workshop recommended the type used should be clearly specified in all assessments.

43. The workshop concluded that the uncertainty in concentration predictions by models is much smaller than the uncertainty in the deposition predictions. This has the practical implication that, from the perspective of the atmospheric modelling, assessments based on air concentrations will have less uncertainty than those based on atmospheric deposition.

44. The workshop noted that the emissions from fertiliser (including both inorganic mineral fertilizers and organic manures) when applied to land is not usually modelled in current

assessments. This is a major gap in current practice, given the substantial contribution to nitrogen deposition at many Natura 2000 sites from the nearby land application of fertilizers to agricultural land.

45. The workshop concluded that estimation of dry deposition of nitrogen compounds remains highly uncertain. In particular, uncertainty analysis for dry deposition is needed but remains a difficult task.

46. The workshop recommended that validation datasets for both concentration and deposition need to be developed and compiled in a form that can be made readily available for the purpose of model verification.

47. The workshop recommended that further development and testing of nitrogen dry deposition parameterisations are needed as a means to reduce uncertainties in assessing total nitrogen inputs to Natura 2000 sites. In particular, further assessment of ammonia canopy compensation points is needed for different habitat types. Overall, much more field deposition data are needed for model verification.

48. The workshop recommended that the emissions of ammonia to the atmosphere following fertiliser application (including both organic manures and mineral fertilizer) should be included in future environmental assessments of the impact of current and future activities on Natura 2000 sites.

49. It was recommended that a harmonised approach to uncertainty analysis for the models needs to be developed to aid the regulatory assessment of nitrogen emission, dispersion and deposition to sensitive habitats.

Theme 5. Options for future policy development to manage and mitigate the impacts of nitrogen deposition effects on the Natura 2000 network

50. One of the motivations for the workshop was the perception that current practices to protect Natura 2000 from nitrogen deposition are far from optimal. While, in principle, the Habitats Directive affords the highest level of protection, much of the Natura network remains under threat. The workshop therefore reviewed the options for future policy development to better protect the Natura 2000 network. While the focus was on Natura 2000, the challenge was also viewed in the context of the wider aims of the Habitats Directive (inc. habitats/species outside of Natura 2000 sites) and other European biodiversity policy.

51. The workshop analyzed the current mechanisms by which the Habitats Directive affords protection to Natura 2000 sites, including the application of cross-compliance with other European Community legislation. It discussed the existence of potential loopholes, where certain polluting activities continue without formal review and assessment, including the relative roles of industrial, transport and agricultural emissions.

52. The workshop then reviewed a wide range of potential future options that could support Natura 2000 protection from nitrogen deposition, including: the strengthening of existing legislation, the application of spatial and land use-based policies, the role of ecosystem services, consideration of air quality objectives and local air quality management for the protection of Natura 2000 sites.

53. In regard of the current policies in place and their adequacy to protect the Natura 2000 sites from the threat of nitrogen deposition, the workshop concluded:

- that Natura 2000 sites are not routinely assessed for the risk of nitrogen deposition effects;
- that nitrogen deposition is a Europe-wide problem, but with very high spatial variability;
- that legislation at both regional and local scales is needed, including measures to deal with within-country long-range transport;
- that regional international agreements (NEC Directive and Gothenburg Protocol) should have a higher level of environmental ambition (especially for NHx) to help reach local targets;
- that the present policies and /or their enforcement are not sufficient;
- that there is currently insufficient linkage between biodiversity and air pollution assessment, including both the current policy development and the environmental politics of these issues.

54. The workshop concluded that there are currently extremely variable levels of ambition between European Member States:

- A lack of awareness of the nitrogen threat is the main problem in some Member States;
- Unsustainably high nitrogen deposition levels make policy development difficult in some countries (e.g., where regional future development may be refused because of adverse effects on the integrity of the Natura 2000 network, as required under the Habitats Directive, unless compensatory actions are agreed);
- Some Members States have advanced policies integrating several legislative instruments, which can provide lessons for other Members States.

55. The workshop recommended that increased emphasis be given to consider policies and procedures to distinguish the management of nitrogen oxides and ammonia:

- The procedures needed to protect sites from NO_x emissions are largely in place in many Member States. (While this can be considered as a success, it does not mean there is no need for further reduction in NO_x emissions)
- The challenges are much larger concerning agricultural ammonia emissions, which are regulated little across most Member States. In many cases, agricultural ammonia emissions are not assessed in relation to their impacts on the Natura 2000 network.
- Agricultural activities are also thought to emit many organic nitrogen compounds to the atmosphere. These have seldom been assessed and represent a potentially significant additional threat to the Natura 2000 network that requires further quantification.

56. It is recommended that several new approaches are explored in future policy development to complement existing approaches to managing the nitrogen deposition threat in relation to Natura 2000 and the wider objectives of the Habitats Directive:

- *Nitrogen Ceilings*: regional reactive nitrogen (Nr) ceiling, limited by the most sensitive nitrogen form/effect should be explored as a basis for further policy development. This approach could enable the optimization of nitrogen emissions in relation to the adverse impacts.
- *Provincial nitrogen reduction plans*: this could include a long-term plan to attain Critical Loads on a regional level including: (i) regional legislation; (ii) abatement techniques (BAT); (iii) autonomous development; (iv) trading permits, as considered already in the Netherlands. It should be noted that any trading permits should consider the spatial aspects of the ecological impacts.
- *Spatial Planning*: this may be operated at a landscape and regional levels. The approach optimizes the location of existing pollution sources to minimize the overall threats, exploiting where possible landscape structures to buffer impacts (including buffer zones and tree belts).

- *Further development of nitrogen indicators*: a number of indicators are available, but the policy message depends on their implementation. For example, it was shown that for ammonia critical level exceedance in the Natura 2000 network, the often cited Area Weighted Index (AWI), underestimates the scale of threat compared with a Designation Weighted Index (DWI).
- *Ecosystem Services concept*: This may provide a holistic framework for examining the links between air pollution effects on ecosystems and human well-being.

57. Of the suite of options considered, the workshop recommended the most suitable package of measures for future policy development to reduce the impacts of nitrogen deposition in relation to Natura 2000 and the Habitats Directive.

a. The following specific measures were recommended for further consideration:
- Negotiate more ambitious ammonia ceilings under NECD and Gothenburg Protocol.
- Improve ammonia coverage of IPPC, i.e. include manure spreading in IPPC revision, consider the current farm size thresholds and inclusion of cattle (note: such measures may not be appropriate for small farms). Potential for Environmental Impact Assessment (EIA) directive to cover this without full burden of IPPC approach.
- Include ammonia in Air Quality Directive.

b. The following general measures were recommended:
- Setting strict limits encourages abatement technology development.
- Strategic Environmental Assessment (SEA) has a role to play at high level planning for pollution.
- Include non-technical measures (societal behaviour).

c. Finally, it was recommended to consider establishing a high level goal as part of a package of actions. The following was proposed as a starting point for future discussions: "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 way forward

58. The outcomes of the Workshop will be used to inform future research, environmental practice and policy development in relation to the threat of nitrogen deposition on European habitats. The information presented here is being drafted in full for a book to be published during 2010, including full background papers and working group reports.

59. It was noted that there is currently no established framework for the harmonization of decision making approaches related to the threat of nitrogen deposition to the Natura 2000 network or on conservation status. Further effort is needed to consider how to develop such a framework in future.

60. The scientific outcomes, regulatory experience and policy options reported at the workshop will be considered for feeding into future plans at national, European and international scales. In particular, the messages will be fed into the Expert Group on Reporting under the Nature Directives, the UNECE Convention on Long Range Transboundary Air Pollution, through its subsidiary bodies (e.g. Working Group on Effects, Task Force on Reactive Nitrogen), and into work of the UN Convention on Biological Diversity on development of the nitrogen deposition indicator.

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