Working Group 5
Nitrogen – integrated environmental policies

JW. Erisman, T. Spranger (chairs), MA. Sutton (rapporteur), C. Akselsson, S. Amin-Hanjani, HV. Anderson, H. ApSimon, S. Belyazid, H. Fagerli, H. Harmens, M. Havlikova, J.P. Hettelingh, K. Hicks, L. Horvath, N. Hutchings, M. Maasikmets, M. Maione, S. Reis, C. Stenby

1. Why focus on nitrogen?

The Working Group highlighted the importance of nitrogen to many environmental effects. In some cases nitrogen emission is the key driver of effects (e.g. terrestrial and coastal eutrophication, nitrous oxide emissions), while in many other situations nitrogen represents a key contributor exacerbating a wider problem. In this way, the central role of nitrogen can appear hidden, even though it actually underpins many transboundary pollution problems.

In this context, the group noted that there is no current international Convention or other agreement that addresses all the interlinked effects of nitrogen. By contrast, there is currently a very apparent split, where different aspects of the nitrogen cycle are considered separately in different regulatory frameworks. The group noted that this separation currently led to several antagonisms between different nitrogen priorities and conventions. At the same time, many of the known and potential synergies are currently missed by the existing approach to dealing with the problems of excess nitrogen.

The group recognized that nitrogen is also a multi-source problem, including emissions from a wide range of combustion, transport, and other sources. However, the importance of agricultural activities was particularly highlighted, including the spatial interaction between agricultural and natural areas.

2. An integrated approach to address the Nitrogen Issue

With this background, the group agreed that an approach needs to be established to address the nitrogen issue in an holistic way. A framework was agreed that is driven primarily by the need to deal with the different environmental effects, and consists of the following elements:
1. Quantifying the **effects** (on humans, ecosystems, other societal values)
2. Identification or development, and use of appropriate **indicators** for the different effects
3. Identification or development of methods to quantify **nitrogen budgets/balances**
4. Relating the above to overall spatial and temporal **emissions** from various sources.

In particular, the group noted that the use of regional nitrogen budgets (including e.g. assessment of nitrogen surpluses in agricultural systems) was a new element for the CLRTAP, while elements of the others are already in place, but need to be further developed in relation to a holistic nitrogen approach.

3. The relevant N effects, priorities and where are they currently being addressed.

The working group reviewed the wide range of effects of excess nitrogen. Tables 1-3 summarize the different environmental effects, the currently used indicators, and whether there are current limit values set, either within the UNECE or EU areas. The tables then identify the main links to the cascade of nitrogen in the environment, the relevance and link to N of the effect/pollutant, and where the effect is currently dealt with under existing agreements. In addition, the group noted that some issues are more relevant than others in relation to societal importance and the connection to the nitrogen cascade. The categorization on a scale of 1 (highest relevance) to 5 (unimportant) provides a first review relevant to the prioritization for future mitigation activity. In particular, the group noted that some less important issues in most cases will automatically be addressed when the priorities are considered and therefore not need to be addressed elsewhere.

Table 1: Summary of the effects of excess nitrogen on humans in relation to currently used indicators, the existence of current limit values and the link to the nitrogen cascade. The relevance and link to N provide a prioritization for future international action to mitigate the effects of excess nitrogen. The last column summarizes existing links to international regulations and conventions.

Direct effects on humans	*Indicators*	*Limit?*	*Link to N cascade*	*Relevance and link to N*	*Link to political body/conv.*
Respiratory disease in people caused by exposure to high concentrations of:					
-- ozone	SOMO35	Y	NOx emission	3	CLRTAP; EU CAFÉ
-- other photochemical oxidants	Org. NO_3, PAN conc (atm)	N	NO_x emissions	5	indirectly CLRTAP et al
-- fine particulate aerosol	PM_{10}, $PM_{2.5}$ conc (atm)	Y	NO_x, NH_3 em	1	CLRTAP; EU CAFE
-- direct toxicity of NO_2	NO_2 conc (atm)	Y	NOx	2	WHO ; CLRTAP; EU CAFE
Nitrate contamination of drinking water	NO_3 conc (aq.)	Y	NO3 leaching	2	EU EFD, NitrateD
Increase allergenic pollen production, and several parasitic and infectious human diseases	-	N		5	None?
Blooms of toxic algae and decreased swimability of in-shore water bodies	Chlorophyl a NO_3 (&P) conc (aq)	N	Run-off, Ndep	1	OSPAR; HELCOM; Barcelona Conv.

Relevance and link to Nitrogen incorporates societal priority and N contribution: 1) highest relevance, 2) high relevance, 3) significant relevance, 4) some relevance, 5) unimportant.

Table 2: Summary of the effects of excess nitrogen on ecosystems in relation to currently used indicators, the existence of current limit values and the link to the nitrogen cascade. The relevance and link to N provide a prioritization for future international action to mitigate the effects of excess nitrogen. The last column summarizes existing links to international regulations and conventions.

Direct effects on ecosystems					
Ozone damage to crops, forests, and natural ecosystems	AFstY (O_3 flux), AOT40	Y	NO_x em	2	CLRTAP; EU CAFE
Acidification effects on terrestrial ecosystems, ground waters, and aquatic ecosystems	Critical loads	Y	Ndep	2	CLRTAP; EU CAFE, WFD
Eutrophication of freshwaters, lakes (incl. Biodiversity)	BOD, NO_3 conc (aq) Critical loads	Y N	Run-off, Ndep	3	WFD
Eutrophication of coastal ecosystems inducing hypoxia (incl. Biodiversity)	BOD, NO_3 conc (aq) Critical loads	Y N	Run-off, Ndep	1	OSPAR; HELCOM; Barcelona Conv
Nitrogen saturation of soils (incl. effects on GHG balance)	Critical loads	Y	Ndep	1	CLRTAP; EU CAFE
Biodiversity impacts on terrestrial ecosystems (incl. Pests and diseases)	Critical loads, critical levels (NH_3, NO_x)	Y	Ndep	1	CLRTAP; EU CAFE ; CBD

Relevance and link to Nitrogen incorporates societal priority and N contribution: 1) highest relevance, 2) high relevance, 3) significant relevance, 4) some relevance, 5) unimportant.

Table 3: Summary of the effects of excess N on other societal values in relation to currently used indicators, the existence of current limit values and the link to the nitrogen cascade. The relevance and link to N provide a prioritization for future international action to mitigate the effects of excess nitrogen. The last column summarizes existing links to international regulations and conventions.

Effects on other societal values					
Odor problems associated with animal agriculture	(NH_3 conc (atm))	N	same sources as NH_3 emission	5	-
Effects on monuments and engineering materials	Acidity in prec., prec./T O_3, PM	Y	NO_x, NH_3	3	CLRTAP
Regional hazes that decrease visibility at scenic vistas and airports	$PM_{2.5}$ conc (atm)	N	NO_x, NH_3	4 (EU)	-
Depletion of stratospheric ozone	NO_x, N_2O conc/flux (atm)	N	NO_x, N_2O	3	Montreal Protocol
Global climate warming induced by excess nitrogen	N_2O, CH_4, CO_2 conc/flux (atm)	N	N_2O (dir, indir), CH_4, CO_2	1	UNFCCC
Regional climate cooling induced by aerosol	$PM_{2.5}$ conc (atm)	N	NO_x, NH_3	1	(UNFCCC)

Relevance and link to Nitrogen incorporates societal priority and N contribution: 1) highest relevance, 2) high relevance, 3) significant relevance, 4) some relevance, 5) unimportant.

6. Nitrogen and the LRTAP Convention

The particular challenge of excess nitrogen is its role in multiple environmental effects through many different nitrogen forms. In considering these, the group noted, firstly, that most are mediated through the atmosphere. Secondly, it was noted that most have substantial transboundary interactions. With this basis, it was agreed that the Convention on Long-range Transboundary Air Pollution was the most relevant place to develop a holistic approach to the international nitrogen problem.

In forming this conclusion, the group recognized the impressive record of the CLRTAP in dealing with multi-pollutant, multi-effect problems. This is clearly illustrated by the Gothenburg Protocol, which includes effects of SO_2, NO_x and NH_3 emissions on acidification, eutrophication and ground level ozone. This Convention thus has the experience and many of the tools needed to develop a full multi-issue nitrogen approach. Secondly, it is recognized that the nitrogen problem is primarily regional in nature, with linkages to local and global scales. The major regional differences are already recognized by the International Nitrogen Initiative (INI), which has focused its work through 5 regional centers (Europe, N. America, S. America, Asia/Australasia and Africa). Hence activity within the UNECE domain is highly relevant to the main scale of the problem.

In relation to the current scope of the LRTAP Convention, the main areas that need to be increased are attention to nitrate leaching and nitrous oxide emissions, as well as further attention to quantifying nitrogen balances. Currently, the Convention already addresses (under the Working Group on Effects) nitrate leaching from natural ecosystems, but overall nitrate leaching needs to be addressed including agricultural areas and transboundary nitrate transport. Under the Agriculture and Nature Panel of the Task Force of Emission Inventories (in the Emission Inventory Guidebook, joint with CORINAIR), some attention is already given to the estimation of nitrous oxide emissions and this needs to be further developed through linkage with the Intergovernmental Panel on Climate Change. In addition, the aim of protecting biodiversity would benefit from increased cooperation with the UN Convention on Biodiversity and programs to implement it in Europe.

7. Development of short term goals and implementation (<5 yr)

The group considered it helpful to separate the short term goals for developing an integrated nitrogen approach from the more ambitious longer term goals.

Key short term goals were noted as:

- The development of appropriate tools for more integrated analysis of nitrogen fluxes and impacts. The group noted that such tools are already being developed, including the MITERRA-Europe model (as used for the European Commission in linking ammonia, nitrate and nitrous oxide emissions from agriculture), the GAINS model (existing for multi-pollutant use in the Convention and currently under development to include nitrate leaching and nitrous oxide emissions) and the INTEGRATOR model (being developed under the NitroEurope IP and including N and C including greenhouse gases, nitrate leaching).

- In parallel, the group noted that there were also tools (e.g. dynamic models, critical loads) being further developed for assessment of the environmental effects, including biodiversity and climate interactions.
- The group also noted the importance of developing tools which address the problem of scale and nitrogen. The short term focus should be on developing zooming approaches (dealing with the issues of hot spots and variability) on sub-regional scale, which provide a better quantification of the problems and help focus abatement policies.
- A monitoring strategy suited to the nitrogen framework needs to be developed. In particular, it is noted that this should go further than air monitoring (as e.g. under EMEP). Such a strategy needs to take a more integrated approach including more comprehensive monitoring of the effects (incl. Biomonitoring, which is partly in place via ICPs) and the monitoring of calculated nitrogen balances (e.g. N surplus).
- The group recognized that there was a major challenge to encourage better dissemination of the nitrogen problem, including simplification to foster stakeholder involvement. This should encourage involvement of both industrial stakeholders and those interested in the environmental effects.
- Lastly, it was recommended to explore the possibilities to of including a more holistic/integrated approach in the Revision of the Gothenburg Protocol.

In all the roles of nitrogen (including both the beneficial aspects for food production and the adverse effects), there is a need for much better understanding of the contribution of nitrogen to effects. This can be illustrated by the effects of nitrogen on biodiversity. Both the UNECE assessment (e.g. through critical loads exceedance and the ICPs) and other scientific studies show that there are widespread impacts of nitrogen on biodiversity. By contrast, existing monitoring activities (e.g. monitoring condition of European Natura 2000 sites and other natural areas), are not sufficiently aware of these impacts, so that their monitoring methods are not appropriately designed to quantify the adverse effects of excess nitrogen.

8 Long-term Goals (>5 yr)

Key long term goals highlighted by the group were:

- Highlighting the problem of scale, the group highlighted the need to utilize the results of local zooming approaches to identify the implications for the regional UNECE scale assessment. In particular, the need was identified to develop integrated N approaches to generalize the implications of scale at the regional level, including the development of appropriate tools.
- The group highlighted the importance of basing negotiated targets (and compliance monitoring) as close as possible to the target environmental effects. The rationale is that there is a need to maximize the use of flexible solutions, which can often be hard to quantify as e.g. national emissions ceilings. In particular, the Convention needs to engage constructively with the agri-food chain, including the utilization of “soft measures”, such as fertilizer and other agricultural best management practices. An example of such a closer linkage of targets to effects is provided by the Water Framework

Directive, which has placed the meeting and monitoring of "good ecological status" (GES) as a central objective.

- Lastly, a more integrated monitoring strategy as described above needs to be established and implemented.

9. Institutional/organizational considerations

It is recommended that the Convention on LRTAP should take the lead on developing an integrated approach towards sustainable nitrogen management. Elements of recommended future activity should include proposed objectives:

- To develop and provide a holistic framework for integrated nitrogen management
- To enhance integration and synergies between the existing bodies of the Convention relevant to the nitrogen framework
- To draw from and link to other Conventions, for example by establishing a working group under the Convention or an inter-convention working group. The other UN conventions of particular relevance include:
    - The UNECE Helsinki Convention on the Protection and Use of Transboundary Watercourses and International Lakes (Water Convention).
    - The UNECE Espoo Convention on Environmental Impact Assessment in a Transboundary Context (TEIA Convention)
    - The UN Framework Convention on Climate Change (UNFCCC)
    - The UN Convention on Biological Diversity (CBD)
- To explore the possibilities of an Integrated Nitrogen Protocol, potentially jointly with other UN(ECE) Conventions.
- To establish a stronger link with agricultural stakeholders (UN Food and Agriculture Organization FAO; European Commission Directorate General on Agriculture, DG Agri; International Fertilizer Association, IFA etc …)
- To utilize the knowledge, concepts, etc. developed within ongoing activities, including the International Nitrogen Initiative (INI), the NitroEurope Integrated Project (NEU) and the Atmospheric Composition Change Network of Excellence (ACCENT) of the European Commission Framework 6 program, the COST 729 Action and the European Science Foundation research framework program Nitrogen in Europe: current problems and future solutions (NinE).