United Nations ECE/EB.AIR/WG.5/2012/3

Economic and Social Council

Distr.: General
28 June 2012

Original: English

Economic Commission for Europe

Executive Body for the Convention on Long-range Transboundary Air Pollution

Working Group on Strategies and Review

Fiftieth session
Geneva, 10–14 September 2012
Item 6 of the provisional agenda
Progress in the implementation of the 2012-2013 workplan

Reactive Nitrogen

Report by the co-Chairs of the Task Force on Reactive Nitrogen*

I. Introductory remarks

1. This report, prepared in cooperation with the secretariat to the Convention on Long-range Transboundary Air Pollution, describes the results of the seventh meeting of the Task Force on Reactive Nitrogen, in St Petersburg, Russian Federation, 28 February to 2 March 2012[1]. The report also summarizes the activities and outcomes of the workshop "Abating ammonia emissions in countries of Eastern Europe, the Caucasus and Central Asia and other countries of the UN Economic Commission for Europe (ECE) regions" and the workshop of the Network of Environmental Benefits and Economic Instruments (NEBEI).

A. Attendance

2. The meeting was attended by 67 participants from 16 countries, including those participating in the parallel meeting of NEBEI. Also present were representatives from the Working Group on Strategies and Review, the Task Force on Integrated Assessment

* This report is being issued without formal editing

[1] The background documents and presentations made during the meeting and the reports presented are available at: www.clrtap-tfrn.org. Reports on the recent work conducted through the expert panels of the Task Force are also available at respective webpages of the Expert Panel on Mitigation of Agricultural Nitrogen, the Expert Panel on Nitrogen Budgets, the Expert Panel on Nitrogen and Food and Expert Panel on Nitrogen and Climate.

Modelling, the EMEP[2] Centre for Integrated Assessment Modelling (CIAM) at the International Institute for Applied Systems Analysis (IIASA); and the Helsinki Commission on the Protection of the Marine Environment of the Baltic Sea Area.

B. Organisation of work

3. The Task Force was co-chaired by representatives from the Netherlands and the United Kingdom. It was hosted by the Russian Federation, with support from the United Kingdom Department for Environment Food and Rural Affairs, the Netherlands Environmental Protection Institute (RIVM), the Ministry of Economic Affairs, Agriculture and Innovation of the Netherlands, and the North-West Research Institute of Agricultural Engineering and Electrification (SZNIIMESH) of the Russian Academy of Agricultural Sciences.

4. The meeting was opened by a representative of the Russian Federation, Director of SZNIIMESH, who highlighted the continuing challenges to abate ammonia in the Russian Federation and commented that meetings such as seventh meeting of the Task Force on Reactive Nitrogen, specifically designed to comprise issues relevant for representatives from Eastern Europe, the Caucasus and Central Asia and were very beneficial for mutual understanding. A representative of the Ministry for the Environment of the Russian Federation welcomed the participants, pointing out that the information shared between the countries of Eastern Europe, the Caucasus and Central Asia and the rest of the UN Economic Commission for Europe (ECE) region during this meeting would helpful when working towards a harmonization of policy across the ECE region.

5. The meeting of the Task Force on Reactive Nitrogen was held in plenary, with simultaneous translation in English and Russian. The Task Force discussed the work of the expert panels and the outcome of two preceding workshops. Other topics discussed were perspectives from the nitrogen water pollution community, and the potential links between nitrogen mitigation and the transition of countries to a green economy.

II. Activities related to the Protocol to Abate Acidification, Eutrophication and Ground-level Ozone (Gothenburg Protocol)

6. The British co-Chair updated the Task Force on the information presented to the forty ninth meeting of the Working Group on Strategies and Review, September 2011, as detailed in the co-chairs' report (ECE/EB.AIR/WG.5/2011/16).

7. An updated version of the ammonia guidance document had been submitted to the forty ninth meeting of the Working Group on Strategies and Review, (Informal document No. 21). It was agreed that a new version of this document would be submitted to the thirtieth Session of the Executive Body in April, after incorporating comments from members of the Working Group on Strategies and Review and the Expert Panel on Mitigating Nitrogen.

8. The Co-Chair summarized the findings of the report "Ammonia reductions and costs implied by the three ambition levels proposed in the Draft Annex IX to the Gothenburg protocol", which had been presented to the thirtieth session of the Executive Body

[2] The Cooperative Programme for Monitoring and Evaluation of the Long-range Transmission of Air Pollutants in Europe.

(Informal document No. 5). This report contained projected costs for abating ammonia emissions by 2020, under the three ambition levels outlined in the draft Annex IX to the Gothenburg Protocol (ECE/EB.AIR/2012/11) by the Task Force on Reactive Nitrogen, plus a cost optimised scenario. All calculations were made using the updated Greenhouse Gas and Air Pollution Interactions and Synergies (GAINS) model. Participants were asked to consider the report, in particular the costs reported for their countries, and to discuss them with their expert colleagues, national focal points and relevant Ministers. It was emphasized that the costs for ammonia abatement according to the three scenarios were much smaller than previous estimates, representing additional costs of between 200-1000 million euro across the whole of the ECE region, depending on the ambition level.

A. Annex IX to the Gothenburg Protocol

9. It was noted that an informal document had been submitted by the European Commission to the thirtieth meeting of the Executive Body of the Convention as a proposal for amending Annex IX. As the document contained technical information which was not completely correct, the Task Force agreed that the co-chairs would send a response on these technical points to the European Commission.

B. Guidance document on ammonia abatement

10. The finalisation of the Guidance document on ammonia abatement was the main focus of the meeting of the Expert Panel on the Mitigation of Agricultural Nitrogen held in Saint Petersburg, Russian Federation, on 27 February 2012. The group of forty five experts worked on the document in three parallel groups, each focussing on different sections of the guidance document. The outcomes of the discussions were to be included in a new draft. The revised document had been submitted for translation into both French and Russian, for onward submission to the thirtieth meeting of the Executive Body as an informal document.

11. The Task Force took note of a recent paper published in the journal Biogeosciences which suggested the need to revise the magnitude of ammonia emission factors from slurry spreading.[3] The Expert Panel on Mitigating Agricultural Nitrogen noted the potential implications for inventory work, mitigation calculations and developing nitrogen budgets. However, the group concluded that further information should be obtained on the datasets used and that mechanistic models of ammonia loss could also be used to further inform the work, before any updates to emission factors should be made. Ongoing work in Switzerland would also be available in the future to inform the discussion.

C. Framework Code of Good Agricultural Practice

12. The Expert Panel on Mitigating Agricultural Nitrogen discussed the updating of the UNECE Framework Code of Good Agricultural Practice for Reducing Ammonia (EB.AIR/WG.5/2001/7). A questionnaire on the Framework Code had been circulated and returned to the co-chairs of the panel, along with several offers of support in the further development of the document. The Czech co-chair of the Expert Panel stressed that the document was useful for countries and well worth reading by all those involved in work relating to the Gothenburg Protocol and its Annex IX.

[3] Sintermann et al., 2011, 'Are ammonia emissions from field-applied slurry substantially over-estimated in European emission inventories?

III. Workshop "Abating ammonia emissions in the region of Eastern Europe, the Caucasus and Central Asia and other countries of the ECE in the context of the nitrogen cycle"

13. The workshop was held on the 29 February 2012, with simultaneous translation in Russian and English. There were forty seven participants from sixteen countries. The programme included many country case studies, as well as presentations from several participants from Eastern Europe, the Caucasus and Central Asia. A workshop resolution was presented and agreed by the Task Force on Reactive Nitrogen. The resolution included an agreement of the Task Force to establish an Expert Panel on Nitrogen in countries of Eastern Europe, the Caucasus and Central Asia. The agreed resolution (Annex A) is included here for information to the Working Group on Strategies and Review and the EECCA Co-ordinating Group.

14. The purpose of the proposed new Panel on Nitrogen in countries of Eastern Europe, the Caucasus and Central Asia would be to: a) recognise the unique systems of nitrogen management in these countries, and b) to promote cooperation among countries of Eastern Europe, the Caucasus and Central Asia and across the ECE region, including cooperation with the other expert panels of the Task Force. It was anticipated that the Expert Panel would provide an opportunity for greater working and sharing in this area, leading to greater involvement of the countries of Eastern Europe, the Caucasus and Central Asia and views in the Task Force as a whole, building on the links and success of the meetings surrounding TFRN-7.

IV. Nitrogen budgets

15. The co-chair of the Expert Panel on Nitrogen and Budgets provided a report on the work of the panel since the last Task Force meeting and presented the agenda for its meeting which immediately followed the meeting of the Task Force on 2 March 2012. He reported progress in several areas including the Guidance Document on Nitrogen Budgets which had been submitted to the forty ninth meeting of the Working Group on Strategies and Review (Informal document No. 20). The Expert Panel on Nitrogen and Budgets would discuss any further amendments to be made to this document at their meeting, and would prepare the updated document for the thirtieth Session of the Executive Body in April, to support its discussions on the updating of the Gothenburg Protocol.

16. The workshop "Dynamic Tool for Nitrogen Budgets" was held in Switzerland in August 2011. The current version of the tool was set up for Switzerland. Following further development, the panel expressed its wish to support other countries in the use of the tool adapted to their national situations.

17. The expert panel had been forging links with other international bodies such as the Organization of Economic Cooperation and Development (OECD) and EUROSTAT, to discuss issues such as the use of nitrogen as a high-level environmental indicator. To further advance with this work, the panel had been exploring the possibility of a Memorandum of understanding between EUROSTAT and the ECE. The Task Force agreed that this was a good way to encourage future collaboration.

18. National level nitrogen budgets, such as the one developed for Austria, had also been discussed at the following meeting of the Expert Panel, together with the development of farm level budgets. It had been proposed that a workshop in autumn 2012 may be organised to further advance with this work. The Expert Panel on Nitrogen Budgets would welcome experts on farm budgets to approach the panel regarding this work.

V. Food consumption and nitrogen pollution

19. On behalf of the Expert Panel on Nitrogen and Food, a representative of Italy presented the draft summary of the report "Nitrogen on the table: The influence of food choices on nitrogen emissions and the European environment". The report established the links between dietary choices and nitrogen cycle pollution, including the links between ammonia emissions and emissions of other nitrogen forms, such as nitrates and the greenhouse gas nitrous oxide. The analysis had been conducted by first developing footprints according to different food commodities, and then examining the potential impact of six scenarios of dietary choices on pollution levels for two land-use scenarios in each case. As this was the first attempt of such an analysis, the group had restricted its work to the area of the twenty seven European Union countries (EU-27).

20. It was agreed that the full report would be published as the "Special Report of the European Nitrogen Assessment" later in 2012. Nitrogen footprints of all countries in EU-27 were presented at the meeting and it was noted that in some countries current protein consumption per capita is double the protein requirements according to standards established by the World Health Organization (WHO). Beef production was shown to be more polluting than pig and poultry production. Switching to a diet with a 50per cent reduction in all animal products (including meat and dairy, to be replaced by plant products) had the greatest benefits of the scenarios considered in reducing nitrogen pollution, reducing ammonia emissions by 43 per cent, and nitrate leaching by 35 per cent. Based on the WHO recommendations, including those for saturated fats, it could be considered that there are also significant co-benefits for human health in avoiding over-consumption of animal products, as illustrated by the scenarios. It had also been agreed that it would be useful in future to widen the scope of such a study to the countries in Eastern Europe, the Caucasus and Central Asia, if resources permitted.

VI. Nitrogen and climate

21. The Co-chair of the Task Force from the United Kingdom provided a summary and update on the work of the Expert Panel on Nitrogen and Climate. An initial report (Informal Document No.9) had been submitted to the Executive Body of the Convention in December 2010. The workshop "Nitrogen and climate: Interactions of reactive nitrogen with climate change and opportunities for integrated management strategies" was held in Amsterdam in late October 2011, in collaboration with the Working Group II of the Intergovernmental Panel on Climate Change (IPCC). The report of this meeting, accessible at the Task Force website, highlights opportunities for the IPCC fifth Assessment Report to consider the role of nitrogen in climate change.

VII. NEBEI workshop

22. The chair of the Network of Environmental Benefits and Economic Instruments (NEBEI), reported on the workshop "Further quantification of the effects of air pollutants on ecosystems" held on the 29 February in Saint Petersburg, Russian Federation, adjoining the seventh meeting of the Task Force on Reactive Nitrogen. There were seventeen participants in the workshop, from ten countries. The workshop had greatly benefitted from simultaneous translation between Russian and English. The role of NEBEI in the Convention was outlined and a discussion of the use of economic instruments held, such as subsidies, taxes and investment. The group has already produced a guidance document and it was noted that it would be very useful if this were translated into Russian.

23. Cost-benefit analysis was also discussed during the workshop, in the context of three case studies, including one in relation to the Gothenburg Protocol. New developments in methods were discussed, and it was noted from one case study that sensitivity to pollution can be seen to vary by country. Overall it had been also agreed that there was an important need to think carefully about how the outcomes of such studies were communicated to policymakers, keeping in mind the necessary technical details as well as legibility. A full report of the meeting will be prepared separately by NEBEI.

VIII. European Nitrogen Assessment

24. The British co-chair updated the Task Force on recent activities regarding the European Nitrogen Assessment (ENA) which had been launched in April 2011. He highlighted the large number of presentations of the Assessment which had invited and been conducive to its dissemination, including at conferences organized by Fertilizers Europe, the European Commission, and the International Federation of Organic Agricultural Markets (IFOAM). He outlined the approach whereby future special reports of the ENA may be published through the Task Force, as a means to simplifying outreach and communication, when a) a report had been peer reviewed and b) there was a case for a public launch of the report in question. In this regard, the Task Force agreed that the forthcoming report of the Expert Panel on Nitrogen and Food: 'Nitrogen on the table: The influence of food choices on nitrogen emissions and the European environment' would be published as a 'Special Report' of the European Nitrogen Assessment.

25. The co-chair provided an update on the work of the Global Partnership on Nutrient Management (GPNM) established under the lead of the United Nations Environment Programme (UNEP), which had been preparing an overview on nutrient management with a global perspective, to complement other regional nitrogen assessments under development. This overview had been presented by the British co-chair of the Task Force to the third Intergovernmental Review (IGR-3) of the Global Programme for Action for the Protection of the Marine Environment from Land-based Sources (GPA). This work could in due course provide the foundation for establishing a global nitrogen or nutrient assessment to which the Task Force on Reactive Nitrogen would contribute. The co-chair highlighted that this was an important opportunity to further link the assessment of nitrogen and transboundary air pollution with the marine and land pollution communities, therefore further developing a more integrated approach to nitrogen management.

IX. Experience from other international conventions and processes

26. A representative of the Helsinki Commission (HELCOM) presented an overview of nitrogen pollution issues with regard to the Baltic Sea, the work of HELCOM and the Baltic Sea Action Plan (BSAP). The BSAP aimed at improvements by the year 2020, through a number of measures, including the interim nutrient reduction targets set for 2016. Regarding eutrophication, targets set had been defined by calculating maximum allowable inputs to the Baltic and then converting this to the required reduction from the sources. It was also noted that 25 per cent of the nitrogen inputs into the Baltic are from airborne pollution. To tackle this, HELCOM was working on several fronts, including addressing inputs from shipping and is keen to liaise closely with both the Convention on Long-Range Transboundary Air Pollution and the European Commission. Regarding agriculture, there was an annex to the Helsinki Convention which addresses emissions from agriculture. A project which currently supported this work was Balthazar", focused on developing risk

assessments of large agricultural systems in the Russian Federation. However, there was significant work to be done in mitigating agricultural emissions.

27. A representative of Apele Romaine, the Ministry of Water and Environmental Protection of Romani spoke about the European Union Water Framework Directive and how it was being implemented in Romania, along with the Nitrate Directive (1991). In Romania around 55 per cent of the country had been designated as a nitrate vulnerable zone. Many measures in agriculture which were beneficial to nitrate leaching reduction were also be beneficial to ammonia reduction and there was an opportunity for gains in this area if the communities could link up and identify synergies.

28. A presentation was given by a representative of the Russian Federation on the difficulties of modelling the nutrient load in the Gulf of Finland. He emphasized the need for an assessment of the role of mass exchange between the land surface and the atmosphere, in terms of loading and mass budget. Land heterogeneity and also human impact could cause complications.

29. The Task Force discussed the links between air and water pollution, in relation to potential reductions from agricultural practices. It was noted that there were significant synergies, but there could also be trade-offs, and both of these would have to be addressed. It was suggested that in order to improve the integration between these policy areas it would be very useful if the groups developing targets could actively interact with each other, and, if possible, define targets to be achieved on similar timescales, making the process far more tangible for those involved. The co-chair of the Task Force also commented that communication had been established between the Task Force and the secretariat of the ECE Water Convention, with regard to possible future cooperation concerning interations between transboundary nitrogen pollution in the atmosphere and in watercourses.

X. Nitrogen and the green economy

30. A representative of Denmark initiated a discussion on the green economy in relation to nitrogen emissions, by presenting current developments in the organisation of agriculture in Denmark, which were hoped to contribute to the green economy. He noted that there are potential problems with some of the changes suggested in Denmark, each of which needs to be addressed. One such difficulty could be lower yields, resulting from a strive towards organic agriculture. The nature of “green economy”, “green growth” and other terms were discussed, and their linkages with agriculture, sustainability and potentially with energy and industry. It was noted that while there were differing opinions with regard to the aims of activities with “green” objectives, pursuing “sustainable development” versus “growth” with minimal environmental impact, deciding on the ways and means to implement a chosen objective remained a matter of debate between countries. The Task Force agreed that the presentation and discussion were a useful preparation for future work and that the next activity would be the organization of a workshop to take these discussions further and to engage with a range of stakeholders, potentially in cooperation with the Task Force on Integrated Assessment Modelling.

XI. Future work

31. The Task Force reviewed the previous workplan and updated the tasks and priorities accordingly. The future work, set out below, had been split into core/ongoing work and new items (with new and/or longer-term activities highlighted in italics and key focus areas in bold):

(a) Continue the work on nitrogen emission abatement from agricultural sources, develop technical and scientific information on an integrated approach to mitigation of agricultural nitrogen emissions with particular reference to the revision of the Gothenburg Protocol and, in particular:

(i) **Finalize the update of the guidance document;**

(ii) Continue to liaise with the Centre for Integrated Assessment Modelling (CIAM) to examine the costs and benefits of ammonia emissions abatement measures;

(iii) ***Work on updating the ECE Framework Code on Good Agricultural Practice for Reducing Ammonia; inform the deliberations of the Working Group on Strategies and Review on revisions to annex IX to the Gothenburg Protocol; and take account of the relevant Best Available Techniques Reference Documents (BREFs);***

(iv) *Develop multi-pollutant approaches;*

(b) Continue providing technical information on making and using nitrogen budgets and estimating nitrogen emissions:

(i) At the national scale and for various system boundaries;

(ii) **Looking specifically at the farm scale;**

(c) Continue developing and providing technical and scientific information to support the revision of the Gothenburg Protocol in relation to the whole nitrogen cycle;

(d) Continue collecting and assessing information from the national focal points regarding their experiences, including any difficulties that they have in developing and implementing an integrated approach;

(e) Provide technical information on the effects of human diets on nitrogen use and emissions;

(f) **Liaise with countries in Eastern Europe, the Caucasus and Central Asia in the development of approaches for managing reactive nitrogen in industry and agriculture in order to:**

(i) Investigate the barriers to implementation of the Gothenburg Protocol;

(ii) Improve collaboration with the newly formed Coordinating Group for Eastern Europe, the Caucasus and Central Asia;

(g) Continue improving coordination of activities across and outside the Convention, and collaborate with subsidiary bodies under the Convention to complement the work of the subsidiary bodies of the Convention, in particular:

(i) Working with the International Cooperative Programme on Modelling and Mapping of Critical Loads and Levels and Air Pollution Effects, Risks and Trends, focusing on critical loads and dynamic modelling of nitrogen effects, including the development of indicators through the use of nitrogen budget approaches and links between nitrogen and climate, in cooperation with other bodies such as the OECD, EUROSTAT and UNEP;

(ii) With the Task Force on Emission Inventories and Projections, continue to ensure consistency between development of emission estimates and the estimation of efficiencies of agricultural emissions

abatement; **organise a joint workshop as soon as feasible on agricultural emissions and projections;**

(iii) With the Task Force on Integrated Assessment Modelling, participate in relevant meetings, in particular providing advice to avoid pollutant swapping, and on effects of human behaviour, including dietary choices; **organize a joint workshop on nitrogen emissions and the green economy;**

(h) Further disseminate the results from the European Nitrogen Assessment and consider the longer-term perspective in relation to the potential of linking air pollution, water pollution and other environmental threats;

(i) Consider the vision and future possibilities for integrating nitrogen management within the Convention and in relation to other ECE and international conventions; prepare an informal document on this topic;

(j) Hold the Task Force's eighth meeting, tentatively scheduled to be held in May 2013, and submit its report.

Annex A:

Workshop resolution

Abating ammonia emissions in the ECE region and the countries of Eastern Europe, the Caucasus and Central Asia in the context of the nitrogen cycle

29 February, 2012, Saint Petersburg, Russian Federation

Recognizing that the mandate of the ECE Task Force on Reactive Nitrogen under the umbrella of the Convention of Long-Range Transboundary Air Pollution is

(a) to provide technical information to be able to develop an integrated vision and approach to the abatement of reactive nitrogen (N_r) emissions and effects;

(b) to improve coordination on the development of integrated N_r policies; and

(c) to search for synergies between policies on air pollution and other policies,

Appreciating the hospitality of SZNIIMESH to host and co-organize the 7th meeting of the Task Force on Reactive Nitrogen in Saint Petersburg, which allowed the participation of numerous specialists from countries of Eastern Europe, the Caucasus and Central Asia, with the support of many other countries;

Recognizing that ammonia emission abatement is part of an integrated approach to the abatement of reactive nitrogen (N_r) emissions and their effects on acidification, eutrophication, climate change, and that it can contribute to the nutrient use efficiency (nitrogen) of both plants and animals at local, regional and global scales,

Recognizing that the agricultural sector in countries of Eastern Europe, the Caucasus and Central Asia is large and diverse, a one-day special workshop was organized to exchange information about options for ammonia emissions abatement of Eastern Europe, the Caucasus and Central Asia countries in the context of the nitrogen cycle as well as in countries of the ECE region,

Appreciating that 47 delegates attended the workshop from 16 different countries: Azerbaijan, Belarus, Canada, Czech Republic, Denmark, Germany, Ireland, Italy, Kazakhstan, Moldova, the Netherlands, Romania, Russian Federation, Switzerland, Ukraine, and United Kingdom.

The workshop participants resolved:

1. To endorse the research results, conclusions and proposals presented in the communications of the workshop participants.

2. To promote the enhancement of cooperation and exchange of information between eastern and western countries.

3. To propose to establish an Expert Panel on Nitrogen in countries of Eastern Europe, the Caucasus and Central Asia within the Task Force on Reactive Nitrogen to a) recognise the unique systems and nitrogen management in these countries and b) to promote cooperation among countries of Eastern Europe, the Caucasus and Central Asia and across the ECE region, including cooperation with the other expert panels of TFRN. The focus of

the panel should be (i) To increase awareness and knowledge on reactive nitrogen (Nr) emissions and (ii) To explore options for integrated nitrogen management to abate these emissions (iii) to update the agricultural emission factors in countries of Eastern Europe, the Caucasus and Central Asia and to compare them with the *European Monitoring and Evaluation Programme/European Environment Agency* (EMEP/EEA) Air pollutant emission inventory Guidebook within the Convention of Long-Range Transboundary Air Pollution.

4. To coordinate the activity of the Expert Panel on Nitrogen in countries of Eastern Europe, the Caucasus and Central Asia within the Task Force on Reactive Nitrogen with that of Coordinating Group of Eastern Europe, the Caucasus and Central Asia, through the following:

(a) Planning of joint events

(b) Collaborative efforts to search for financing and realization of joint projects

(c) Exchange of information and implementation of obtained achievements throughout the countries of the region

(d) Translation of the documents of the Expert Panel on Nitrogen in countries of Eastern Europe, the Caucasus and Central Asia into Russian and English language versions (where possible), to make them accessible to experts from a wide range of countries.

5. To request the organizers and participants to publish the papers and communications of the workshop in the proceedings, and to explore the possibilities for an English-Russian edition of the proceedings.

6. To prepare a number of papers on the problems of reactive nitrogen for publication in leading scientific journals in countries of Eastern Europe, the Caucasus and Central Asia.

7. To disseminate the workshop resolution to relevant and interested organizations in countries of Eastern Europe, the Caucasus and Central Asia and bodies of the Convention, specifically the members of the Working Group on Strategies and Review and the Eastern Europe, the Caucasus and Central Asia Coordinating Group.

8. For more information contact the organizers of the special workshop, or the co-chairs of the Task Force on Reactive Nitrogen (tfrn@ceh.ac.uk).