



# **The European Nitrogen Assessment**

## **Sources, Effects and Policy Perspectives**

**Mark A. Sutton<sup>1</sup>**

**Clare M. Howard<sup>1</sup>**

**Jan Willem Erisman<sup>2</sup>**

**Gilles Billen<sup>3</sup>**

**Albert Bleeker<sup>2</sup>**

**Peringe Grennfelt<sup>4</sup>**

**Hans van Grinsven<sup>5</sup>**

**Bruna Grizzetti<sup>6</sup>**

<sup>1</sup> NERC Centre for Ecology and Hydrology (UK)

<sup>2</sup> Energy Research Centre of the Netherlands (NL)

<sup>3</sup> CNRS and University of Paris VI (F)

<sup>4</sup> Swedish Environmental Research Institute (S)

<sup>5</sup> Netherlands Environmental Assessment Agency (NL)

<sup>6</sup> European Commission Joint Research Centre (I)

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# The European Nitrogen Assessment

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## Sources, Effects and Policy Perspectives

A century ago, when the world depended on fossil nitrogen and manure recycling, there was insufficient reactive nitrogen to feed the growing human population. With the invention of the Haber–Bosch process, humans found a way to make cheap reactive nitrogen from the almost inexhaustable supply of atmospheric di-nitrogen. What humans did not anticipate was that the massive increase in reactive nitrogen supply, exacerbated by fossil fuel burning, would lead to a web of new environmental problems cutting across all global-change challenges.

*The European Nitrogen Assessment* presents the first full, continental-scale assessment of reactive nitrogen in the environment and sets the problem in context by providing a multidisciplinary introduction to the key processes in the nitrogen cycle. Issues of up-scaling from field, farm and city to national and continental scales are addressed in detail with emphasis on opportunities for better management at local to global levels. A comprehensive series of maps showing nitrogen pools and fluxes across Europe also highlight the location of the major threats and allow a comparison of national budgets for the first time. Five key societal threats posed by reactive nitrogen are assessed, providing a framework for a set of policies that can be used for joined-up management of the nitrogen cycle in Europe. This includes the first cost–benefit analysis for different reactive nitrogen forms and consideration of future scenarios.

Incorporating a handy technical synopsis and summary for policy makers, this land-mark volume is an essential reference for academic researchers across a wide range of disciplines, as well as for stakeholders and policy makers in Europe and beyond. It is also a valuable tool in helping communicate the key environmental issues and future challenges to the wider public.

**Mark Sutton** is an environmental physicist investigating human alteration of the nitrogen cycle, with specific attention to ammonia. He is coordinator of the major integrated project 'NitroEurope', a 5-year effort, bringing together 64 research institutes to ask how nitrogen is affecting the European greenhouse gas balance. Dr Sutton is vice-chair of the 'Nitrogen in Europe' (NinE) programme of the European Science Foundation, the Director of the European Centre of the International Nitrogen Initiative (INI) and co-chair of the Task Force on Reactive Nitrogen of the UN-ECE Convention on Long-range Transboundary Air Pollution.

**Clare Howard** is currently engaged in a postdoctoral fellowship in knowledge transfer, with an emphasis on research networks which focus on nitrogen. Dr Howard is project coordinator for the European Nitrogen Assessment and for the Task Force on Reactive Nitrogen, which sits beneath the Working Group on Strategies and Review of the Convention on Long Range Transboundary Air Pollution. Her research interests involve the modelling of biogeochemical cycles of nitrogen and carbon and assessing uncertainty in model systems.

**Jan Willem Erisman** heads the Biomass, Coal and Environmental Research Unit of the Energy Research Centre of the Netherlands (ECN) and is a professor in Integrated Nitrogen studies at Vrije Universiteit, Amsterdam. His research focuses on atmosphere–biosphere exchange of gases and aerosols related to acidification and eutrophication and climate change. He was instrumental in establishing the International Nitrogen Initiative, the Nanjing Declaration on Nitrogen Management, the EU 6th Framework research program NitroEurope and for chairing the European Science Foundation project NinE and the EU COST Action 729.

**Gilles Billen** is research director of the Centre National de la Recherche Scientifique (CNRS) at the University Pierre and Marie Curie (Paris) where his research covers many aspects of biogeochemistry, with an emphasis on the nitrogen, phosphorus and silica cycles. His main expertise is on the assessment and modelling of the ecological functioning of hydrosystems, including marine, estuarine and freshwater environments. From 1997 to 2007, he was the Director of the PIREN-Seine programme, a large interdisciplinary research programme on the Seine river watershed.

**Albert Bleeker** works as a senior scientist at the Energy Research Centre of the Netherlands, in the department of Air Quality and Climate Change. He has almost 20 years of experience in the field of nitrogen, where his main expertise is on the atmospheric emission, transport and deposition of nitrogen at various spatial scales, as well as studies on the effect of nitrogen in the natural environment. Currently, he is the Nitrogen in Europe (NinE) Programme Co-ordinator and a member of the COST 729 Management Committee.

**Peringe Grennfelt** has a background in atmospheric chemistry. His research includes regional air pollution problems in Europe, in particular acidification, nitrogen deposition and tropospheric ozone. He has coordinated several national and international research programmes including the EU project Network for the support of European Policies on Air Pollution (NEPAP). He is presently leading the Mistra Climate Policy Research Programme (Clipore) and the Swedish Clean Air Research Programme (SCARP).

**Hans van Grinsven** works at the Netherlands Environmental Assessment Agency where he conducts research and coordinates projects related to agriculture and environment, focusing on nitrogen and phosphorus, and sustainable food production. Dr van Grinsven was responsible for evaluations of national implementation of the EU Nitrates Directive and was also closely involved in the evaluations of the implementation of the EU Water framework Directive and EU NEC directive.

**Bruna Grizzetti** is a researcher in the field of large scale modelling of nutrient and water transfer. She works on modelling nutrient pressures on water at European scale in support to the implementation of environmental European policies, such as the Water Framework Directive, Nitrates Directive and the Marine Strategy. Since 2007, Dr Grizzetti has been a member of the Coordination Team of the European Nitrogen Assessment process, supported through the European Science Foundation.



Ministry of Infrastructure and the  
Environment



The European Nitrogen Assessment has been prepared through coordinated action led by the Nitrogen in Europe (NinE) Research Networking Programme of the European Science Foundation, the NitroEurope Integrated Project supported by European Commission's 6th Framework Programme and the COST Action 729. The Assessment is a contribution to the work of the Task Force on Reactive Nitrogen (TFRN), led by the UK and the Netherlands, in support of the long-term goals of the UN-ECE Convention on Long-range Transboundary Air Pollution (CLRTAP). In parallel, the Assessment represents a European contribution to the work of the International Nitrogen Initiative (INI), a joint project of the International Geosphere Biosphere Programme (IGBP) and the Scientific Committee on Problems of the Environment (SCOPE), providing evidence to underpin many United Nations and other multi-lateral agreements. The actual assessment work has been carried out by 200 experts from 21 countries and 89 organizations which kindly provided support for this work.

The ENA has been conducted as a scientifically independent process. The views and conclusions expressed are those of the authors, and do not necessarily reflect policies of the contributing organizations.

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## Sources, Effects and Policy Perspectives

Edited by

**Mark A. Sutton**

NERC Centre for Ecology and Hydrology

**Clare M. Howard**

NERC Centre for Ecology and Hydrology and University of Edinburgh

**Jan Willem Erisman**

Energy Research Centre of the Netherlands

**Gilles Billen**

CNRS and University of Paris VI

**Albert Bleeker**

Energy Research Centre of the Netherlands

**Peringe Grennfelt**

Swedish Environmental Research Institute (IVL)

**Hans van Grinsven**

PBL Netherlands Environmental Assessment Agency

**Bruna Grizzetti**

European Commission Joint Research Centre



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# Contributors

---

**John van Aardenne**

European Commission Joint Research Center  
Institute for Environment and Sustainability  
via Enrico Fermi 2749  
21027 Ispra (VA)  
Italy

**Wenche Aas**

NILU, Norwegian Institute for Air Research  
PB 100  
2027 Kjeller  
Norway

**Beat Achermann**

Federal Office for the Environment  
Air Pollution Control and NIR Division  
Air Quality Management Section  
CH-3003 Bern  
Switzerland

**Rob Alkemade**

Netherlands Environmental Assessment Agency  
P.O. Box 303  
3720 AH  
The Netherlands

**Per Ambus**

Risø DTU National Laboratory for Sustainable Energy,  
Technical University of Denmark  
Biosystems Division  
Frederiksborgvej 399  
4000 Roskilde  
Denmark

**Michael Ashmore**

University of York  
Environment Department  
Heslington  
YO10 5DD  
United Kingdom

**Juergen Augustin**

Leibniz-Centre for Agricultural Landscape Research (ZALF)  
Eberswalder Strasse 84  
Muencheberg

D-15374

Germany

**Alex Baker**

School of Environmental Sciences  
University of East Anglia  
Norwich  
NR4 7TJ  
United Kingdom

**Hermann W. Bange**

IFM-GEOMAR, Leibniz-Institut für Meereswissenschaften  
Düsternbrooker Weg 20  
Kiel  
D-24226  
Germany

**Sabine Barles**

Université Paris Est – LATTS,  
Institut Français d'Urbanisme  
4 rue Alfred Nobel – Cité Descartes  
Champs-sur-Marne  
77420  
France

**Sébastien Barot**

IRD-Bioemco,  
Bioemco ENS  
46 rue d'Ulm  
75230 Paris Cedex 05  
France

**Jerzy Bartnicki**

Norwegian Meteorological Institute  
P.O. Box 43  
Oslo  
NO-0313  
Norway

**Claus Beier**

Risø DTU, National Laboratory for Sustainable  
Energy  
Ecosystems Research Programme  
P.O. Box 358  
4000 Roskilde  
Denmark

**Salim Belyazid**

Belyazid Consulting and Communication AB,  
Österportsgatan 5a  
21128 Malmö  
Sweden

**Leon J. L. van den Berg**

Radboud University Nijmegen  
Heyendaalseweg 135  
6525 AJ Nijmegen  
The Netherlands

**Peter Bergamaschi**

European Commission Joint Research Centre  
Institute for Environment via Enrico Fermi 2749 and  
Sustainability  
21027 290 Ispra (VA)  
Italy

**Haldis Berge**

Norwegian Meteorological Institute  
PO 43 Blindern  
0313 Oslo  
Norway

**Arthur Beusen**

Netherlands Environmental Assessment Agency  
P.O. Box 303  
3720 AH Bilthoven  
The Netherlands

**Gilles Billen**

University Pierre & Marie Curie  
4 place Jussieu  
75005 Paris  
France

**Albert Bleeker**

Energy Research Centre of the Netherlands  
P.O. Box 1  
1755 ZG Petten  
The Netherlands

**Jaap Bloem**

Alterra Wageningen University and Research Centre  
Soil Science Centre  
P.O. Box 47  
6700 Wageningen  
The Netherlands

**Roland Bobbink**

B-Ware Research Centre  
Radboud University  
P.O. Box 9010  
9500 GL Nijmegen  
The Netherlands

**Pascal Boeckx**

Ghent University  
Faculty of Bioscience Engineering

Coupure 653

9000 Gent

Belgium

**Fayçal Bouraoui**

European Commission Joint Research Centre  
via Enrico Fermi 2749  
21027 Ispra (VA)  
Italy

**Lex Bouwman**

Netherlands Environmental Assessment Agency  
P.O. Box 303  
3720 AH Bilthoven  
The Netherlands

**Nils-Axel Braathen**

OECD  
2 rue André-Pascal  
F-75775 Paris Cedex 16  
France

**Cristina Branquinho**

Universidade de Lisboa, Faculdade de Ciências  
Centro de Biologia Ambiental,  
Campo Grande, Bloco C2, 5º Piso, sala 37  
1749-016 Lisboa  
Portugal

**Frank Brentrop**

Yara International,  
Centre for Plant Nutrition and Environmental Research  
Hanninghof 35  
48249 Duelmen  
Germany

**Lutz Breuer**

Institute for Landscape Ecology and Resources Management  
Research Centre for BioSystems, Land Use and Nutrition  
Heinrich-Buff-Ring 26  
35392 Giessen  
Germany

**Corjan Brink**

Netherlands Environmental Assessment Agency  
P.O. Box 303  
3720 AH Bilthoven  
The Netherlands

**Roy Brouwer**

VU University Amsterdam  
Institute for Environmental Studies  
De Boelelaan 1085  
1081 HV Amsterdam  
Netherlands

**Michaela Budňáková**

Ministry of Agriculture of the Czech Republic  
Těšnov 17  
117 05 Praha 1  
Czech Republic

**Keith R. Bull**

Centre for Ecology and Hydrology  
Lancaster Environment Centre  
Library Avenue  
Lancaster  
LA1 4AP  
United Kingdom

**Klaus Butterbach-Bahl**

Karlsruhe Institute of Technology  
Institute for Meteorology and Climate Research  
Atmospheric Environmental Research  
Kreuzteckbahnstrasse 19  
82467 Garmisch-Partenkirchen  
Germany

**Andrea Butturini**

University of Barcelona  
Department of Ecology  
Faculty of Biology  
avd. Diagonal 645  
8028 Barcelona  
Spain

**John Neil Cape**

Centre for Ecology and Hydrology  
Bush Estate  
Penicuik  
EH26 0QB  
United Kingdom

**Ana C. Cardoso**

European Commission Joint Research Centre  
Institute for Environment and Sustainability  
via Enrico Fermi 2749  
21027 Ispra (VA)  
Italy

**Pierre Cellier**

INRA,  
UMR EGC  
78850 Thiverval-Grignon  
France

**Pavel Čermák**

Central Institute for Supervising and Testing in Agriculture  
Hroznová Street 2  
656 06 Brno  
Czech Republic

**Daniel J. Conley**

Lund University  
Department of Earth and Ecosystem Sciences  
Sölvegatan 12  
223 62 Lund  
Sweden

**Sarah E. Cornell**

University of Bristol  
QUEST, School of Earth Sciences

Queens Road  
Bristol  
BS8 1RJ  
United Kingdom

**Chris J. Curtis**

University College London  
Environmental Change Research Centre  
Gower Street  
London  
WC1E 6BT  
United Kingdom

**Cornelis Cuvelier**

European Commission Joint Research Centre  
P.O. Box 410  
21020 Ispra (VA)  
Italy

**Tommy Dalgaard**

Aarhus University  
Department of Agroecology and Environment  
P.O. Box 50  
8830 Tjele  
Denmark

**Michael Dannenmann**

University of Freiburg  
Institute of Forest Botany and Tree Physiology  
Georges Köhler Allee 53/54  
79110 Freiburg  
Germany

**Frank Dentener**

European Commission Joint Research Centre  
via Enrico Fermi 2749  
21027 Ispra (VA)  
Italy

**Barbara Deutsch**

Stockholm University  
Department of Applied Environmental Science  
Svanthe Arrheniusväg 8  
11418 Stockholm  
Sweden

**Roald Dickens**

Department for the Environment Food and Rural Affairs  
17 Smith Square  
London  
SW1P 3JR  
United Kingdom

**Nancy B. Dise**

Manchester Metropolitan University  
Department of Environmental and Geographical Sciences  
John Dalton East Building, Chester Street  
Manchester  
M1 5GD  
United Kingdom

**Ulrike M. Doering**

European Commission Joint Research Centre  
Institute for Environment and Sustainability  
P.O. Box 290  
21020 Ispra (Va)  
Italy

**Anthony Dore**

Centre for Ecology and Hydrology  
Bush Estate  
Penicuik  
EH26 9HF  
United Kingdom

**Ulrike Dragosits**

Centre for Ecology and Hydrology  
Bush Estate  
Penicuik  
EH26 0QB  
United Kingdom

**Jean-Louis Drouet**

INRA  
UMR INRA/AgroParisTech Environment and  
Arable Crops  
78850 Thiverval-Grignon  
France

**Patrick Durand**

INRA  
UMR 1069 SAS  
35000 Rennes  
France

**Sylvia Duretz**

INRA  
UMR EGC  
78850 Thiverval-Grignon  
France

**Anja Engel**

Alfred Wegener Institute for Polar and  
Marine Research  
Am Handelshafen 12  
27515 Bremerhaven  
Germany

**Jan Willem Erisman**

Energy Research Centre of the Netherlands  
P.O. Box 1  
1755 ZG Petten  
the Netherlands

**Ipek Erzi**

TUBITAK Marmara Research Centre  
Environment Institute  
P.O. Box 21  
41470 Gebze Kocaeli  
Turkey

**Hilde Fagerli**

Norwegian Meteorological Institute  
P.O. Box 43  
0313 Blindern  
Norway

**David Fernald**

Department for Environment, Food and Rural Affairs  
Kingspool, Peasholme Green  
York  
YO1 2PX  
United Kingdom

**Chris R. Flechard**

Soils, Agro-hydro systems and Spatialization  
65 rue de St-Brieuc  
35042 Rennes  
France

**David Fowler**

Centre for Ecology and Hydrology  
Bush Estate  
Penicuik  
EH26 0QB  
United Kingdom

**James Galloway**

University of Virginia  
P.O. Box 400772  
Charlottesville  
VA 22901  
United States of America

**Raja S. Ganeshram**

University of Edinburgh  
School of GeoSciences  
Grant Institute  
West Mains Road  
Edinburgh  
EH16 5NW  
United Kingdom

**Josette Garnier**

UMR Sisyphe UPMC & CNRS, ,  
4 place Jussieu  
75005 Paris  
France

**Markus Geupel**

Federal Environment Agency, Germany  
Wörlitzer Platz 1  
6844 Dessau  
Germany

**Ing-Marie Gren**

Swedish University of Agricultural Sciences  
Department of Economics  
750 07 Uppsala  
Sweden

**Peringe Grennfelt**

IVL Swedish Environmental Research Institute Ltd  
 Aschebergsgatan 44  
 P.O. Box 5302  
 400 14 Gothenburg  
 Sweden

**Hans van Grinsven**

Netherlands Environmental Assessment Agency  
 P.O. Box 303  
 3720 AH Bilthoven  
 The Netherlands

**Bruna Grizzetti**

European Commission Joint Research Centre  
 via Enrico Fermi 2749  
 21027 Ispra (VA)  
 Italy

**Per Gundersen**

University of Copenhagen  
 Forest and Landscape Denmark  
 Rolighedsvej 23  
 1958 Frederiksberg  
 Denmark

**Steen Gyldenkærne**

Afdeling for Systemanalyse  
 Danmarks Miljøundersøgelser  
 Frederiksborgvej 399  
 4000 Roskilde  
 Denmark

**Roy M. Harrison**

University of Birmingham  
 School of Geography, Earth and Environmental Sci.  
 Edgbaston  
 Birmingham  
 B15 2TT  
 United Kingdom

**Anna-Stiina Heiskanen**

Finnish Environment Institute  
 P.O. Box 140  
 251 Helsinki  
 Finland

**Josef Hejzlar**

Institute of Hydrobiology  
 Biology Centre AS CR  
 Na Sadkach 7  
 370 05 Ceske Budejovice  
 Czech Republic

**Ole Hertel**

University of Aarhus  
 National Environmental Research Institute  
 P.O. Box 358  
 4000 Roskilde  
 Denmark

**Jean-Paul Hettelingh**

National Institute for Public Health and the Environment  
 Coordination Centre for Effects  
 P.O. Box 1  
 3720 BA Bilthoven  
 The Netherlands

**Kevin Hicks**

University of York  
 Stockholm Environment Institute  
 Grimston House  
 Heslington  
 YO10 5DD  
 United Kingdom

**Peter Higgins**

University of Edinburgh  
 Holyrood Road  
 Edinburgh  
 EH8 8AQ  
 United Kingdom

**Klaas W. van Der Hoek**

National Institute for Public Health and the Environment  
 P.O. Box 1  
 3720 BA Bilthoven  
 The Netherlands

**Robert Hoft**

Convention on Biological Diversity  
 413, Saint Jacques Street, suite 800  
 Montreal  
 QC H2Y 1N9  
 Canada

**Mike Holland**

University of Reading  
 EMRC  
 Whitchurch Hill  
 Reading  
 RG8 7PW  
 United Kingdom

**Clare M. Howard**

Centre for Ecology and Hydrology  
 Bush Estate  
 Penicuik  
 EH23 4RB  
 United Kingdom

**Robert W. Howarth**

Cornell University  
 Department of Ecology and Evolutionary Biology  
 Corson Hall  
 Ithaca  
 NY 14853  
 United States of America

**Christoph Humborg**

Stockholm University

Department of Applied Environmental Science  
Svanthe Arrheniusväg 8  
10691 Stockholm  
Sweden

**Nicholas J. Hutchings**

University of Aarhus  
Research Centre Foulum  
8830 Tjele  
Denmark

**Andreas Ibrom**

Risø National Laboratory for Sustainable Energy  
Frederiksborgvej 399  
4000 Roskilde  
Denmark

**Hans van Jaarsveld**

Netherlands Environmental Assessment Agency  
P.O. Box 303  
3720 AH Bilthoven  
The Netherlands

**Brian H. Jacobsen**

University of Copenhagen  
Institute of Food and Resource Economics  
Rolighedsvej 25  
1958 Frederiksberg  
Denmark

**Steve Jarvis**

*The European Journal of Soil Science*  
Centre for Rural Policy Research  
University of Exeter  
Amory Building, Rennes Drive  
Exeter  
EX4 4RJ  
United Kingdom

**Michael E. Jenkin**

Atmospheric Chemistry Services  
Okehampton  
EX20 1FB  
United Kingdom

**Lars Stoumann Jensen**

University of Copenhagen  
Faculty of Life Sciences  
Department of Agriculture and Ecology  
Thorvaldsensvej 40  
1871 Frederiksberg C  
Denmark

**Timothy Jickells**

University of East Anglia  
School of Environmental Sciences  
Norwich  
NR4 7TJ  
United Kingdom

**Penny Johnes**

University of Reading  
Aquatic Environments Research Centre  
Whiteknights Reading  
RG6 6DW  
United Kingdom

**Age W. Jongbloed**

Wageningen UR Livestock Research  
Edelhertweg 15  
8219 PH Lelystad  
The Netherlands

**Åsa Jonsson**

IVL Swedish Environmental Research Institute  
P.O. Box 5302  
400 14 Göteborg  
Sweden

**Øyvind Kaste**

Norwegian Institute for Water Research  
Jon Lilletuns vei 3  
4879 Grimstad  
Norway

**Ralf Kiese**

Karlsruhe Institute for Technology  
Institute for meteorology and Climate Research  
Atmospheric Environmental Research  
Kreuzackbahnstrasse 19  
82467 Garmisch-Partenkirchen  
Germany

**Barbara Kitzler**

Federal Research and Training Centre for Forests,  
Natural Hazard and Landscape  
Seckendorff-Gudent-Weg 8  
1130 Vienna  
Austria

**Jeroen de Klein**

Wageningen University and Research Centre  
Aquatic Ecology and Water Quality Management Group  
P.O. Box 47  
6700 AA Wageningen  
The Netherlands

**Zbigniew Klimont**

International Institute for Applied Systems Analysis  
Schlossplatz 1  
2361 Laxenburg  
Austria

**Pirkko Kortelainen**

Finnish Environment Institute (SYKE)  
P.O. Box 140  
00251 Helsinki  
Finland

**Marina Kousoulidou**

Aristotle University of Thessaloniki  
 Department of Mechanical Engineering  
 Laboratory of Applied Thermodynamics  
 54124 Thessaloniki  
 Greece

**Natalia Kozlova**

North-West Research Institute of Agricultural  
 Engineering and Electrification  
 (SZNIIMESH)  
 P.O. Tiarlevo, Filtrovskoje shosse, 3  
 196625 Saint-Petersburg-Pavlovsk  
 Russian Federation

**Michael Kreuzer**

ETH Zurich  
 Institute of Plant, Animal and Agroecosystem  
 Science  
 Universitätstrasse 2  
 8092 Zurich  
 Switzerland

**Johannes Kros**

Alterra, Wageningen University and Research  
 Centre  
 P.O. Box 47  
 6700 AA Wageningen  
 The Netherlands

**Markku Kulmala**

University of Helsinki  
 Department of Physics  
 P.O. Box 64  
 14 Helsinki  
 Finland

**Joachim Lammel**

Yara International  
 Centre for Plant Nutrition and Environmental  
 Research  
 Hanninghof 35  
 48249 Duelmen  
 Germany

**Christiane Lancelot**

Université Libre de Bruxelles  
 Ecologie des Systèmes Aquatiques ESA,  
 CP 221  
 Boulevard du Triomphe  
 1050 Bruxelles  
 Belgium

**Patrick Lavelle**

CIAT  
 Km 17, Recta Cali-Palmira  
 Apartado Aéreo  
 6713 Cali  
 Colombia

**Anne-Christine Le Gall**

INERIS  
 Economics and Decision for the Environment, Chronic Risks  
 Division  
 Parc Technologique Alata, BP2  
 60550 Verneuil en Halatte  
 France

**Allison Leach**

University of Virginia  
 P.O. Box 400123  
 Charlottesville  
 VA 22904  
 United States of America

**Adrian Leip**

European Commission Joint Research Centre  
 Institute for Environment and Sustainability  
 via E Ferminrico 2749  
 21027 Ispra (VA)  
 Italy

**Ahti Lepistö**

Finnish Environment Institute (SYKE)  
 P.O. Box 140  
 251 Helsinki  
 Finland

**Jan Peter Lesschen**

Wageningen University and Research Centre  
 Alterra  
 P.O. Box 47  
 6700 AA Wageningen  
 The Netherlands

**Roos Loeb**

B-ware Research Centre  
 P.O. Box 6558  
 6503 GB Nijmegen  
 The Netherlands

**Benjamin Loubet**

INRA, INA PG  
 UMR Environm & Grandes Cultures  
 78850 Thiverval-Grignon  
 France

**Rob Maas**

Netherlands Environmental Assessment Agency  
 P.O. Box 303  
 3720 AH Bilthoven  
 The Netherlands

**Stephen C. Maberly**

Centre for Ecology and Hydrology  
 Lancaster Environment Centre  
 Library Avenue  
 Lancaster  
 LA1 4AP  
 United Kingdom

**Luc Maene**

International Fertilizer Industry Association  
28 rue Marbeuf  
75008 Paris  
France

**Jakob Magid**

Copenhagen University  
Department of Agriculture and Ecology  
Thorvaldsensvej 40  
1873 Copenhagen  
Denmark

**Abigail McQuatters-Gollop**

Sir Alister Hardy Foundation for Ocean Science  
Citadel Hill  
Plymouth  
PL1 2PB  
United Kingdom

**Philippe Merot**

INRA  
65 rue de Saint-Brieuc, CS84215,  
35042 Rennes  
France

**Jack J. Middelburg**

Utrecht University  
Faculty of Geosciences  
Budapestlaan 4  
3584 CD Utrecht  
The Netherlands

**Jana Moldanová**

IVL Swedish Environmental Research  
Institute Ltd  
Box 5303  
400 14 Göteborg  
Sweden

**Suvi Monni**

European Commission Joint Research Centre  
Institute for Environment and Sustainability  
via Enrico Fermi 2749  
21027 Ispra (VA)  
Italy

**Dominic Moran**

Scottish Agricultural College  
King's Buildings  
Edinburgh  
EH9 6GU  
United Kingdom

**John Munthe**

IVL Swedish Environmental Research Institute  
P.O. Box 5302  
400 14 Gothenburg  
Sweden

**Gabriela B. Nardoto**

Universidade de Brasília  
Faculdade UnB Planaltina  
Área Universitária 1  
Vila Nossa Senhora de Fátima, Planaltina  
73.340-710 Brasília  
Brazil

**Eiko Nemitz**

Centre for Ecology and Hydrology  
Bush Estate  
Penicuik  
EH26 0QB  
United Kingdom

**Rostislav Neveceral**

Czech Hydrometeorological Institute  
Na Sabatce 17  
14000 Praha  
Czech Republic

**Nikolaos P. Nikolaidis**

Technical University of Crete  
Department of Environmental Engineering  
University Campus  
73100 Chania  
Greece

**Oene Oenema**

Wageningen University and Research Centre  
Alterra  
P.O. Box 47  
6700 AA Wageningen  
The Netherlands

**Jorgen E. Olesen**

Aarhus University  
Department of Agroecology and Environment  
Blichers Alle 20  
8830 Tjele  
Denmark

**Mark van Oorschot**

Netherlands Environmental Assessment  
Agency  
P.O. Box 303  
3720 AH Bilthoven  
The Netherlands

**Lorenzo Orlandini**

European Commission – DG AGRI  
Rue de la Loi 130-05/20  
1000 Brussels  
Belgium

**Christian Pallière**

Fertilizers Europe  
Avenue E. Van Nieuwenhuyse 6  
1160 Brussels  
Belgium

**Gilles Pinay**

University of Birmingham  
School of Geography  
Birmingham  
B15 2TT  
United Kingdom

**Hanne Damgaard Poulsen**

Aarhus University  
Department of Animal Health and Bioscience  
P.O. Box 50  
8830 Tjele  
Denmark

**David Powlson**

Rothamsted Research  
Harpenden  
AL5 2JQ  
United Kingdom

**Michel Prud'homme**

International Fertilizer Industry Association  
28 rue Marbeuf  
75008 Paris  
France

**Ari Rabl**

ARMINES/Ecoles des Mines de Paris  
6 av. Faidherbe  
91440 Bures sur Yvette  
France

**David S. Reay**

University of Edinburgh  
School of Geosciences  
CECS, High School Yards  
Edinburgh  
EH8 9XP  
United Kingdom

**Robert M. Rees**

Scottish Agricultural College  
West Mains Road  
Edinburgh  
EH9 3JG  
United Kingdom

**Gert Jan Reinds**

Wageningen University and Research Centre  
Alterra  
P.O. Box 47  
6700 AA Wageningen  
The Netherlands

**Stefan Reis**

Centre for Ecology and Hydrology  
Bush Estate  
Penicuik  
EH26 0QB  
United Kingdom

**Hannes Isaak Reuter**

Gisxperts gbr  
Eichenweg 42  
06849 Dessau  
Germany

**Michael O. Rivett**

University of Birmingham  
Water Sciences Group  
Birmingham  
B15 2TT  
United Kingdom

**Trudy G. A. Rood**

Netherlands Environmental Assessment Agency  
P.O. Box 303  
3721 AH Bilthoven  
The Netherlands

**Joost Salomez**

Flemish Government  
K. Albert II-laan 20  
1000 Brussels  
Belgium

**Benjamin Sanchez Gimeno**

CIEMAT  
Avda. Complutense 22  
28040 Madrid  
Spain

**Alberto Sanz-Cobena**

Technical University of Madrid  
Av/ Complutense s/n, Ciudad Universitaria  
28040 Madrid  
Spain

**Martijn Schaap**

TNO Built Environment and Geosciences  
P.O. Box 80015  
3508 TA Utrecht  
The Netherlands

**Doris Schiedek**

National Environmental Research Institute  
Frederiksborgvej 399  
4000 Roskilde  
Denmark

**Jan K. Schjoerring**

University of Copenhagen  
Department of Agriculture and Ecology  
Thorvaldsensvej 40  
1871 Frederiksberg C  
Denmark

**Uwe A. Schneider**

KlimaCampus, Hamburg University  
Research Unit Sustainability and Global Change  
Bundesstrasse 55

20146 Hamburg  
Germany

**Valiyaveetil Shamsudheen Semeena**

Norwegian Meteorological Institute  
P. O. Box 43  
0313 Blindern  
Norway

**Günther Seufert**

European Commission Joint Research Centre  
Institute for Environment and Sustainability  
P.O. Box 050  
21027 Ispra (VA)  
Italy

**Jan Siemens**

University of Bonn  
Institute of Crop Science and Resource Conservation –  
Soil Sciences  
Nussallee 13  
53115 Bonn  
Germany

**Marie Silvestre**

CNRS – FR3020 FIRE  
4 place Jussieu  
75005 Paris  
France

**David Simpson**

Norwegian Meteorological Institute  
EMEP MSC-W  
P.O. Box 43  
0313 Blindern  
Norway

**Ute Skiba**

Centre for Ecology and Hydrology  
Bush Estate  
Penicuik  
EH26 0QB  
United Kingdom

**Carsten Ambelas Skjøth**

Aarhus University  
P.O. Box 358  
4000 Roskilde  
Denmark

**Caroline Slomp**

Utrecht University  
Department of Earth Sciences  
Budapestlaan 4,  
3584 CD Utrecht  
The Netherlands

**Erik Smedberg**

Stockholm University  
Baltic Nest Institute

Stockholm Resilience Centre  
10691 Stockholm  
Sweden

**Keith A. Smith**

University of Edinburgh  
Institute of Atmospheric and Environmental Science  
West Mains Road  
Edinburgh  
EH9 3JN  
United Kingdom

**Lise Lotte Sørensen**

Risø National Laboratory for Sustainable Energy  
P.O. Box 49  
4000 Roskilde  
Denmark

**Till Spranger**

Federal Ministry for the Environment, Nature  
Conservation and Nuclear Safety  
Stresemannstrasse 128–130  
10117 Berlin  
Germany

**Carly J. Stevens**

The Open University  
Department of Life Sciences  
Walton Hall  
Milton Keynes  
MK7 6AA  
United Kingdom

**Mark A. Sutton**

Centre for Ecology and Hydrology  
Bush Estate  
Penicuik  
EH26 0QB  
United Kingdom

**Anastasia Svirejeva-Hopkins**

Potsdam Institute for Climate Impact Research  
Telegrafenberg A31  
14473 Potsdam  
Germany

**Mette Termansen**

University of Aarhus  
Department of Policy Analysis  
Frederiksborgvej 399  
4000 Roskilde  
Denmark

**Mark Theobald**

Technical University of Madrid/Centre for Ecology  
and Hydrology  
Department of Agricultural Chemistry and Analysis  
Ciudad Universitaria, s/n  
28040 Madrid  
Spain

**Vincent Thieu**

UMR 7619 Sisyphe CNRS/UPMC  
4 place Jussieu  
75005 Paris  
France

**Philippe Thunis**

European Commission Joint Research  
Centre  
Institute for Environment and  
Sustainability  
via Enrico Fermi 2749  
21020 Ispra (VA)  
Italy

**Chris Tompkins**

Independent consultant  
United Kingdom

**Robert Upstill-Goddard**

Newcastle University  
School of Marine Science and Technology  
Ridley Building  
Newcastle-upon-Tyne  
NE47 9BL  
United Kingdom

**Laura Valli**

CRPA  
Corso Garibaldi 42  
42100 Reggio Emilia  
Italy

**Robert Vautard**

LSCE/IPSL laboratoire CEA/CNRS/VSQ  
Orme des Merisiers  
91191 Gif/Yvette Cedex  
France

**Gerard L. Velthof**

Wageningen University and Research Centre  
Alterra  
P.O. Box 47  
6700 AA Wageningen  
The Netherlands

**Timo Vesala**

University of Helsinki  
Department of Physics  
P.O. Box 48  
14 Helsinki  
Finland

**Valérie Viaud**

INRA,  
UMR 1069 SAS  
65 rue de Saint-Brieuc  
35000 Rennes  
France

**Massimo Vieno**

University of Edinburgh  
School of Geosciences  
The King's Buildings  
Edinburgh  
EH9 3JN  
United Kingdom

**Maren Voss**

Leibniz-Institute of Baltic Sea Research Warnemuende  
Seestrasse 15  
18119 Rostock  
Germany

**Wim de Vries**

Alterra, Wageningen University and Research Centre  
Centre Soil,  
Droevendaalsesteeg 4, Wageningen  
6708 PB  
The Netherlands

**Jim Webb**

AEA Energy and Environment  
Gemini Building, Harwell Business Centre  
Didcot  
OX11 0QR  
United Kingdom

**Henk J. Westhoek**

Netherlands Environmental Assessment Agency  
P.O. Box 303  
3720 AH Bilthoven  
The Netherlands

**Jaap Willems**

Netherlands Environmental Assessment Agency  
P.O. Box 303  
3720 AH Bilthoven  
The Netherlands

**Wilfried Winiwarter**

International Institute for Applied Systems Analysis  
Schlossplatz 1  
2361 Laxenburg  
Austria

**Peter Witzke**

EuroCARE GmbH  
Nussallee 21  
53115 Bonn  
Germany

**Richard F. Wright**

Norwegian Institute for Water Research  
Gaustadalleen 21  
349 Oslo  
Norway

**Sönke Zaehle**

Max Planck Institute for Biogeochemistry

Biogeochemical Systems Department  
Hans-Knöll-Strasse 10  
07745 Jena  
Germany

**Sophie Zechmeister-Boltenstern**  
Federal Research and Training Centre for Forests  
Natural Hazards and Landscape  
Seckendorff Gudent Weg 8

1131 Vienna  
Austria

**John F. Zevenbergen**  
TNO Defence, Security and Safety  
Lange Kleiweg 137  
2288 GJ Rijswijk  
The Netherlands

# Foreword

Addressing the grand challenges of society depends fundamentally on firm scientific evidence. Today, Europe faces several of these challenges, as outlined in the Europe 2020 strategy adopted by the Commission on 3 March 2010, including climate change, energy and food security, health and an ageing population. Research and innovation are crucial to address these challenges effectively. For that reason, the Commission launched the 'Innovation Union' flagship initiative, with the aim to re-focus research and development as well as innovation policy on these grand societal challenges.

In this framework we very much welcome the European Nitrogen Assessment. It is fair to say that nitrogen will be a new story for many people. Yet we can here clearly identify a case of science at its best: innovative thinking that enables the development of connections from evidence-based policies to evidence-tested decisions.

The Assessment highlights how human production of reactive nitrogen has literally changed the world. Since the invention of the Haber-Bosch process a century ago, humans have been able to double the world's circulation of nitrogen compounds, resulting in nitrogen fertilizers sustaining around 3 billion people, almost half of the world population. It is therefore obvious that nitrogen is essential, not only to meeting the challenge for food security, but, with the increasing importance of biofuels, also for energy security.

Yet with this achievement, originating from European innovation a century ago, has also come an inheritance of environmental effects that cuts across all global ecosystems. As the Assessment reveals, excess reactive nitrogen contributes to climate change; it adversely affects water, air and soil quality, and is putting unsustainable pressure on ecosystems and biodiversity in Europe. Moreover, the surplus of nitrogen compounds leaking into air and water may lead to a substantial health risk for vulnerable human populations.

The Assessment highlights how nitrogen is related to each of the great challenges that European society faces, and the need to develop joined up approaches to address them. In this respect the European Nitrogen Assessment is an important step, building scientific and institutional bridges and sharing different perspectives. It is rewarding to see different environmental disciplines being brought together, and scientists proactively seeking to engage European industry, policy makers and the public.

These significant commitments also emphasize the importance of critical mass in the European Research Area. The Assessment is a key output from a large amount of ongoing research in Europe and elsewhere, but in particular from the NitroEurope Integrated Project supported by the European Commission's 6th Framework Programme and the Nitrogen in Europe (NinE) Research Networking Programme of the European Science Foundation. With the involvement of Action 729 of the COST Programme, the necessary expertise has been gathered to drive the Assessment.

The message of 200 leading European experts from different disciplines and perspectives is surely that we need to take steps forward. Only by joining forces to face the societal challenges will European research provide the scientific basis and the evidence needed for solutions. If European innovation has handed us down a nitrogen inheritance, threatening the environment as a price for a solution to nourish the growing world population, it is only right that European science should lead the way in responding to the challenge.

*Robert-Jan Smits*  
Director General for Research,  
European Commission  
*Professor Marja Makarow*  
Chief Executive,  
European Science Foundation