

National Science Foundation Research Coordination Network: Reactive Nitrogen in the Biosphere

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Objectives:

The objective of the RCN on reactive nitrogen (Nr) is to facilitate a community of researchers from a wide range of disciplines to exchange information and knowledge about Nr in the environment, thus fostering the creative science and synthesis needed to search for well-informed and integrative mitigation strategies. A parallel objective is to promote the communication of this science and synthesis to a broad audience of scientists and nonscientists.

Major activities since inception of the Reactive N RCN:

July, 2011 – Workshop on climate-nitrogen interactions, held at the Powell Center, Ft. Collins, CO. The main products were a technical report submitted to the National Climate Assessment (NCA) and publications of each of the seven chapters of that report in a special issue of *Biogeochemistry* (see list below). The technical report and the peer-reviewed papers were cited widely in the biogeochemistry chapter of the NCA.

Papers and reports emanating from the 2011 workshop:

National Climate Assessment Technical Report:

Suddick, E.C., and E.A. Davidson. 2012. The Role of Nitrogen in Climate Change and the Impacts of Nitrogen-Climate Interactions on Terrestrial and Aquatic Ecosystems, Agriculture, and Human Health in the United States: A Technical Report Submitted to the US National Climate Assessment. North American Nitrogen Center of the International Nitrogen Initiative (NANC-INI). Woods Hole Research Center, Falmouth, MA. [Suddick & Davidson 2012](#)

Biogeochemistry peer-reviewed papers (<http://link.springer.com/journal/10533/114/1/page/1>):

Suddick, E.C., P. Whitney, A.R. Townsend, E.A. Davidson (2012). The role of nitrogen in climate change and the impacts of nitrogen-climate interactions in the United States: Foreword to Thematic Issue. *Biogeochemistry*. DOI 10.1007/s10533-012-9795-z

Houlton, B.Z., E. Boyer, A. Finzi, J. Galloway, A. Leach, D. Liptzin, J. Melillo, T.S. Rosenstock, D. Sobota, A.R. Townsend (2012). Intentional vs. unintentional nitrogen use in the United States: Trends, efficiency, and implications. *Biogeochemistry*. DOI 10.1007/s10533-012-9801-5

Pinder, R.W., W.H. Schlesinger, G.B. Bonan, N.D. Bettez, T.L. Greaver, W.R. Wieder, E.A. Davidson (2012). Impacts of human alteration of the nitrogen cycle in the US on radiative forcing. *Biogeochemistry*, DOI: 10.1007/s10533-012-9787-z.

Robertson, G.P., T.W. Bruulsema, R. Gehl, D. Kanter, D. Mauzerall, A. Rotz, C. Williams (2012). Climate-nitrogen interactions in agriculture. *Biogeochemistry*. DOI 10.1007/s10533-012-9802-4

- Baron, J.S., E.K. Hall, B.T. Nolan, J.C. Finlay, E.S. Bernhardt, J.A. Harrison, F. Chan, E.W. Boyer (2012) The Interactive Effects of Human-Derived Nitrogen Loading and Climate Change on Aquatic Ecosystems of the United States. *Biogeochemistry*. DOI 10.1007/s10533-012-9788-y
- Porter, E., W.D. Bowman, C.M. Clark, J.E. Compton, L.H. Pardo, J. Soong (2012). Nitrogen, climate and biodiversity. *Biogeochemistry*. DOI 10.1007/s10533-012-9803-3
- Peel, J., R. Haeuber, V. Garcia, L. Neas, A.G. Russell (2012). Implications of nitrogen-climate interactions for ambient air pollution and human health. *Biogeochemistry*. DOI 10.1007/s10533-012-9782-4

November, 2012 – Workshop on human health impacts of excess nitrogen in air and water, held in Bethesda, MD. This workshop included water and air quality experts from environmental sciences, epidemiologists, and human physiology researchers.

August, 2013 – Conference entitled “Improving Nitrogen Use Efficiency in Crop and Livestock Production Systems: Existing Technical, Economic, and Social Impediments and Future Opportunities,” cosponsored by the Soil Science Society of America (SSSA), American Geophysical Union (AGU), International Plant Nutrition Institute (IPNI), and The Fertilizer Institute (TFI), was held in Kansas City.

Peer-reviewed papers in the *Journal of Environmental Quality* emanating from the 2013 Kansas City conference, many of which are available as open access:

[Journal of Environmental Quality Special Issue](#)

- David, M.B., C.G. Flint, L.E. Gentry, M.K. Dolan, G.F. Czapar, R.A. Cooke and T. Lavaire (2015). Navigating the Socio-Bio-Geo-Chemistry and Engineering of Nitrogen Management in Two Illinois Tile-Drained Watersheds. *Journal of Environmental Quality*. DOI: 10.2134/jeq2014.01.0036
- Davidson, E.A., E.C. Suddick, C.W. Rice, and L.S. Prokopy. 2015. More food, low pollution (Mo Fo Lo Po): A grand challenge for the 21st century. *Journal of Environmental Quality* 44:305–311.
- Fabián G. Fernández, Richard E. Terry and Eric G. Coronel (2014). Nitrous Oxide Emissions from Anhydrous Ammonia, Urea, and Polymer-Coated Urea in Illinois Cornfields. *Journal of Environmental Quality*. DOI: doi:10.2134/jeq2013.12.0496
- Ferguson, R.B. 2015. Groundwater Quality and Nitrogen Use Efficiency in Nebraska’s Central Platte River Valley. *Journal of Environmental Quality*. DOI: 10.2134/jeq2014.02.0085
- Fernández, F.G., R.E. Terry, and E.G. Coronel. 2015. Nitrous oxide emissions from anhydrous ammonia, urea, and polymer-coated urea in Illinois cornfields. *J. Environ. Qual.* doi:10.2134/jeq2013.12.0496.
- Jarecki, M.K., J.L. Hatfield and W. Barbour (2015). Modeled Nitrous Oxide Emissions from Corn Fields in Iowa Based on County Level Data. *Journal of Environmental Quality*. DOI: 10.2134/jeq2014.03.0100
- Kanter, D.R. X. Zhang and D.L. Mauzerall (2015). Reducing Nitrogen Pollution while Decreasing Farmers’ Costs and Increasing Fertilizer Industry Profits. *Journal of Environmental Quality*. DOI: 10.2134/jeq2014.04.0173
- Lacey C. and S. Armstrong (2015). The Efficacy of Winter Cover Crops to Stabilize Soil Inorganic Nitrogen after Fall-Applied Anhydrous Ammonia. *Journal of Environmental Quality*. DOI: doi:10.2134/jeq2013.12.0529
- McCrackin, M.L., J.A. Harrison and J.E. Compton (2015). Future Riverine Nitrogen Export to Coastal Regions in the United States: Prospects for Improving Water Quality. *Journal of Environmental Quality*. DOI: 10.2134/jeq2014.02.0081
- Osmond, D.L., K. Hoag, A.E. Luloff, D.W. Meals and K. Neas. Farmers’ Use of Nutrient Management: Lessons from Watershed Case Studies (2015). *Farmers’ Journal of Environmental Quality*. DOI: 10.2134/jeq2014.02.0091
- Perez, M. 2015. Regulating farmer nutrient management: A three-state case study on the Delmarva Peninsula. *J. Environ. Qual.* 44: 402–414. doi:10.2134/jeq2014.07.0304
- Powell, M. and C. Rotz. 2015. Measures of nitrogen use efficiency and nitrogen loss from dairy production systems. *J. Environ. Qual.* 44: 336–344. doi:10.2134/jeq2014.07.0299

- Soares, J., H. Cantarella, V.P. Vargas, J.B. Carmo, A.A. Martins, R.M. Sousa, C.A. Andrade (2015). Enhanced-Efficiency Fertilizers in N₂O Emissions from Urea Applied to Sugarcane. *Journal of Environmental Quality*. DOI: 10.2134/jeq2014.02.0096
- van Grinsven, H.J.M., L. Bouwman, K.G. Cassman, H.M. van Es, M.L. McCrackin, A.H.W. Beusen (2015). Losses of ammonia and nitrate from agriculture and their effect on nitrogen recovery in the European Union and the United States between 1900 and 2050. *Journal of Environmental Quality*. DOI: 10.2134/jeq2014
- Weber, C. and L. McCann (2015). Adoption of Nitrogen-Efficient Technologies by U.S. Corn Farmers. *Journal of Environmental Quality*. DOI: 10.2134/jeq2014.02.0089
- Zhang, X., D. Mauzerall, E.A. Davidson, D. Kanter, R. Cai (2015). The economic and environmental consequences of implementing nitrogen-efficient technologies and management practices in agriculture. *Journal of Environmental Quality*. DOI: 10.2134/jeq2014.03.0129

A consensus statement from the conference was developed and posted:

[Consensus Statement](#)

A third product of the KC conference is a brochure for policy makers and the public, which is available on line at: [NUE Brochure](#)

In March 2014, the PI collaborated with colleagues from the SSSA, TFI, and the World Resources Institute (WRI) to brief policy makers about the conference and the consensus statement. We met with the following groups:

1. USDA
2. EPA
3. Staff of House and Senate agriculture committees
4. The Farm Bureau
5. NGOs convened by WRI

February, 2015: A workshop on “Air Quality and Ecosystem Services” was hosted by the US Park Service Santa Monica National Recreation Area, Thousand Oaks CA. The rationale and purpose of the workshop were as follows:

- Air pollution has negative effects on the environment and the organisms within the environment. The critical load concept has been used to help characterize the levels of pollution, particularly nitrogen deposition, that initiate damage to a variety of natural resources.
- Environmental policy and management decisions must often consider how changes to the environment, including those induced by excess air pollution, affect human welfare. The concept of ecosystem services is now being used to describe the benefits provided by nature and valued by people.
- The purpose of this workshop is to use our current understanding of critical loads of nitrogen to describe the impacts of air pollution and nitrogen deposition on specific ecosystem services.

A final technical report for this workshop was published by the National Park Service:

Blett, TF, Bell, MD, Clark CM, Bingham, D, Phelan, J., Nahlik, A., Landers, D., Irvine, I., and A. Heard. 2016. Air Quality and Ecosystem Services Workshop Report: Santa Monica Mountains National Recreation Area, Thousand Oaks, CA- February 24-26, 2015. Natural Resource Report NSP/NRSS/ARD/NRR/2016/1107. National Park Service. Fort Collins, Colorado.

[AQES Workshop Final Report Part 1](#)

[AQES Workshop Final Report Part 2](#)

Four manuscripts are now in review at *Ecosphere*.

January 2016: A World Café session entitled “Managing Nutrients, Water, and Energy for Producing More Food with Low Pollution (MoFoLoPo); What Would Success Look Like?” was held in Washington DC at the 16th National Conference of the National Council on Science and the Environment (NCSE).

Growing more food while conserving water and air resources has been called a “wicked problem” because the interactions among sectors and stakeholders are complex, and there are many stakeholders who stand to win and lose from evolving environmental, economic, energy, and food security policies. The objective of this World Café session was to explore what success for this wicked problem would look like from the varying perspectives of several stakeholders, including farmers, crop advisors, industry representatives, and researchers.

A summary of the workshop was published by Baron (2016). [Baron 2016](#)

Baron, J.S. 2016. Managing nutrients, water, and energy for producing more food with low pollution (MoFoLoPo); What would success look like? *Environmental Development*, 18:52–53.

A white paper was also produced prior to the workshop and published with open access in the *Journal of Environmental Studies Science* [Nutrients in the Nexus](#)

Davidson, E.A., R.L. Nifong, R.B. Ferguson, C. Palm, D.L. Osmond, and JS. Baron. 2016. Nutrients in the nexus. *Journal of Environmental Studies Science*, DOI 10.1007/s13412-016-0364-y.

October 2016: A Workshop to Develop a Nooksack Basin Nitrogen Assessment and Management Program was held October 24-26, 2016, at Western Washington University, Bellingham WA. The goal was to kick start a demonstration project in Bellingham Bay and the Nooksack watershed as part of the International Nitrogen Management System. This watershed includes both British Columbia and Washington state and includes agricultural and municipal inputs and long-range transport deposition of N, with resultant pollution problems, including the estuary itself. A manuscript is currently being written by a group of workshop participants for submission to the *Journal of Soil and Water Conservation* and a poster will be presented at the Soil and Water Conservation Society’s upcoming annual meeting. A grant proposal is also being developed by workshop participants to fund a project going forward.

Other book chapters and peer-reviewed publications from the RCN project:

Davidson, E.A., M. B. David, J. N. Galloway, C. L. Goodale, R. Haeuber, J. A. Harrison, R. W. Howarth, D. B. Jaynes, R. R. Lowrance, B. T. Nolan, J. L. Peel, R. W. Pinder, E. Porter, C. S. Snyder, A. R. Townsend, and M. H. Ward. 2012. Excess nitrogen in the U.S. environment: trends, risks, and solutions. *Issues in Ecology*, Report Number 15, Ecological Society of America.

[Davidson et al. 2012](#)

Davidson, E.A., D. Kanter, E.C. Suddick and P. Syntharalingham. 2013. Chapter 3: N₂O: Sources, Inventories, Projections. In J. Alcamo, S.A. Leonard, A.R. Ravishankara, and M. A. Sutton (eds.). *Drawing Down N₂O to Protect Climate and the Ozone Layer*. A UNEP Synthesis Report. United Nations Environment. Programme (UNEP), Nairobi, Kenya, ISBN: 978-92-807-3358-7 DEW/1748/NA

[Davidson et al. 2013](#)

Davidson, E.A. J.N. Galloway; N. Millar, A.M. Leach. 2014a. N-related greenhouse gases in North America: Innovations for a sustainable future. *Current Opinion in Environmental Sustainability*, 9–10:1–8.

[Davidson et al. 2014](#)

Davidson EA and D Kanter. 2014b. Inventories and scenarios of nitrous oxide emissions. *Environmental Research Letters* 9, doi:10.1088/1748-9326/9/10/105012. Davidson & Kanter 2014

