

Nitrogen and the Environment



Although nitrogen plays a vital role in global food security, it is also a growing source of environmental stress through water and air pollution. RTI International’s state-of-the-art environmental engineering research labs and our staff of more than 200 environmental scientists and engineers, environmental economists, microbiologists, ecologists, and statisticians provide the venue and capabilities to produce groundbreaking solutions to global nitrogen challenges.

Overview

The National Academy of Engineering (NAE) selected “Managing the Nitrogen Cycle” as a Grand Challenge that awaits engineering solutions to address human concerns of “sustainability, health, vulnerability, and joy of living.” Increasing demands for food production have led to large-scale commercial production of nitrogen-based fertilizers, but over-application of these fertilizers generates nutrient runoff to sensitive surface waters. Additionally, growing populations around the world generate more nitrogen-laden wastewaters, and increasing combustion of fossil fuels for electricity and transportation emits more nitrogen air pollutants.

Many of the NAE’s Nitrogen Grand Challenge goals are consistent with RTI’s mission to improve the human condition. Our research and technical services range from helping livestock producers with more efficient utilization of nitrogen-rich manure to developing lower nitrogen-emitting coal combustion technologies. In addition, RTI supported the Environmental Protection Agency (EPA)’s 2006 non-CO₂ greenhouse gas mitigation report and the 2013 report. Our nitrogen-related experience in regulatory development and support

includes atmospheric dispersion and deposition modeling of ammonia and nitrogen oxides, as well as ecological risk and environmental impact assessments of nitrogen pollution on aquatic and terrestrial ecosystems.

RTI’s Nitrogen-Relevant Experience Spans Air, Water, and Terrestrial Research

Precursors of Ozone and PM_{2.5} and Greenhouse Gases

- *Ammonia Air Pollution Control Technology*— Evaluated the relative performance of technologies for concentrated animal feeding operations.
- *National Air Emission Monitoring Study (NAEMS)*— Provided statistical analysis of livestock monitoring data to develop emission models for pollution reduction.
- *Regional Haze Strategic Planning*— Supported the nine-state Central Regional Air Planning Association (CENRAP) to assess ammonia emissions and develop monitoring strategies.
- *PM_{2.5} Speciation*— As national contracted laboratory, performed speciation analyses of U.S. EPA’s PM_{2.5} monitoring network.

- *Clean Energy Research*—Performing advanced gasification and syngas cleaning gasification research, focusing on cleanup of contaminants and developing catalytic and membrane processes for the conversion of coal and biomass to substitute natural gas, hydrogen, fuels/chemicals, and electricity.
- *AgSTAR*—Supported EPA's promotion of anaerobic digestion to livestock producers to capture and use greenhouse gases with outreach literature development for the farming community.
- *Ammonia Emissions and Dispersion Modeling*—Compared traditional and emerging livestock waste management technologies' ammonium $PM_{2.5}$ emissions and valuing human health benefits from emissions reduction.
- *N_2O Mitigation*—Evaluating the impacts of CO_2 mitigation strategies on N_2O emissions.

Water Pollution

- *CLEANEAST™*—Under 4-year EPA Office of Water cooperative agreement, provided no-cost nutrient management planning services to over 400 livestock and poultry operations in the eastern United States.
- *State Nutrient Reduction Strategies Workshop Agricultural Component*—Provided technical and logistical support for Upper Mississippi River Basin workshop to develop Nutrient Reduction Plans for agriculture.
- *Highway Runoff Screening Tool*—Model development to estimate nitrogen and phosphorus loadings to watersheds and evaluate nutrient Total Maximum Daily Load (TMDL) scenarios.



Aquatic and Terrestrial Ecosystems

- *Interactive Impacts of Climate Change and Nitrogen Deposition on Ecosystems*—For EPA Office of Research and Development, integrated atmospheric monitoring and predictive models, soils data, plant community composition, and dynamic modeling across ecological areas, time frames, and deposition and climate change scenarios.
- *Ecological Risk Assessment*—Supporting EPA's Secondary National Ambient Air Quality Standards (NAAQS) review for NO_x and SO_x by performing risk and exposure assessments for aquatic and terrestrial acidification and nutrient over-enrichment.
- *Integrated Science Assessment*—Supporting EPA's NO_x - SO_x Secondary NAAQS 5-year review of literature about the state of science related to acidification and eutrophication impacts to aquatic and terrestrial ecosystems from NO_x and SO_x deposition.
- *2010 Acid Rain Report to Congress*—For EPA Clean Air Markets Division, compiled NO_x and SO_2 emissions and deposition data and assessing recovery rates of acid-sensitive ecosystems.

Economic and Policy Analysis

- *Chesapeake Bay Restoration Optimization Framework*—For EPA's Office of Research and Development, developed and demonstrated a 6-state Chesapeake Bay watershed optimization framework to identify cost-effective alternative nitrogen, phosphorus, and sedimentation reduction practices and land uses. Estimated ecosystem service co-benefits associated with alternative practices and land uses.
- *Nutrient Credit Trading for the Chesapeake Bay*—For the Chesapeake Bay Commission, projected the potential annual cost savings from including nutrient credit trading as a strategy for achieving the Chesapeake Bay TMDL for nitrogen and phosphorus.
- *Technical Support for Nutrients, Sediment and Related Environmental Credits Protocols*—For EPA's Office of Water, provided strategic insights on the design of measurement, reporting, and verification protocols for environmental credits.
- *Valuation of Reductions in Lake Eutrophication*—With a grant from EPA, designed and implemented a combined stated preference and recreation behavior survey of households in the southeastern United States and analyzed data to estimate values for improving nutrient-related water quality in the region's lakes.



- *Costs and Burden Sharing for Controlling Nutrient Pollution in South Florida*—For the Everglades Foundation, addressed several questions regarding control of nutrient loads to South Florida waters, including how large are the costs of existing controls, how do costs and nutrient reductions vary across sectors, and who bears the burden of the nutrient control costs?
- *Climate Policies Costs and Impacts Analysis*—Contributing research to the development and application of the Forest and Agricultural Sector Optimization Model with Greenhouse Gases (FASOMGHG) and integration of FASOMGHG with other key models, including the Integrated Planning Model (IPM) and the ADAGE model.

RTI Experts and Select Professional Service

- *Mary Barber, PhD*—Senior Environmental Scientist. Fellow, American Association for the Advancement of Science. Certified Senior Ecologist, and past Director, Ecological Society of America's Sustainable Biosphere and Scientific Programs
- *Robert Beach, PhD*—Senior Research Economist and RTI Fellow, Agricultural Resource and Energy Economics and Policy Program. IPCC ARS WGIII, invited member of U.S. government review team, Chapters 5, 6, and 11.
- *Marion Deerhake, MSPH*—Senior Research Environmental Scientist. Heinz Center Nitrogen Deposition Advisory Committee, North Carolina Environmental Management Commission (Chair, Air Quality Committee)
- *Jennifer Phelan, PhD*—Research Ecologist. Chairperson, National Atmospheric Deposition Program—Critical Loads of Atmospheric Deposition (CLAD) Science Committee
- *George Van Houtven, PhD*—Senior Research Economist and Director, RTI Ecosystem Services Program. Member, Everglades Phosphorus Grand Challenge Advisory Committee

Recent Peer-Reviewed Publications and Presentations

- Beach, R. H., Cai, Y., Thomson, A. M., Zhang, X., Jones, R., McCarl, B. A., et al. (in press). Climate change impacts on US agriculture and forestry: Benefits of global climate stabilization. *Environmental Research Letters*. doi:10.1088/1748-9326/10/9/095004
- Ragnauth, S., Creason, J., Alsalam, J., Ohrel, S., Petrusa, J. E., & Beach, R. H. (in press). Global mitigation of non-CO2 greenhouse gases: Marginal abatement costs curves and abatement potential through 2030. *Journal of Integrative Environmental Sciences*. doi:doi:10.1080/1943815X.2015.1110182
- Phelan, J., Belyazid, S., Jones, P., Cajka, J., Buckley, J., and Clark, C. 2016. Assessing the Effects of Climate Change and Air Pollution on Soil Properties and Plant Diversity in Sugar Maple-Beech-Yellow Birch Hardwood Forests in the Northeastern United States: Model Simulations from 1900-2100. *Water, Air, & Soil Pollution*, 227, 84.
- Van Houtven, G., Mansfield, C., Phaneuf, D. J., von Haefen, R., Milstead, B., Kenney, M. A., & Reckhow, K. H. (2014). Combining expert elicitation and stated preference methods to value ecosystem services from improved lake water quality. *Ecological Economics*, 99, 40–52.
- Birur, D. K., Beach, R. H., Loomis, R. J., Chipley, P. S., Gallaher, M. P., & Dayton, D. (2013). Externalities of transportation fuels: Assessing trade-offs between petroleum and alternatives (RTI Press Publication No. OP-0013-1307). *RTI Press*, 1–50. www.rti.org/pubs/op-0013-1107-birur.pdf
- Brinson, M. Rheinhardt, R., Ferrell, R., Duncan, B., Hobbs, L., McNaught, D. Phelan, J., and Rader, D. (2013). A rapid watershed assessment approach for assessing the condition of small, coastal watersheds: Protocol and case study. *Ocean and Coastal Management*, 71, 238–255.
- Wainger, L., Van Houtven, G.L., Loomis, R.J., Messer, J., Beach, R.H., & Deerhake, M.E. (2013). Tradeoffs among ecosystem services, performance certainty, and cost-efficiency in the implementation of the Chesapeake Bay TMDL. *Agricultural and Resource Economics Review*. 42(1), 38–66.
- Greaver, T.L., Sullivan, T.J., Herrick, J.D., Barber, M.C., Baron, J.S., Cosby, B.J., Deerhake, M.E., Dennis, R.L., Dubois, J.B., Goodale, C.L., Herlihy, A.T., Lawrence, G.B., Liu, L., Lynch, J.A., & Novak, K.J. (2012). Ecological effects from nitrogen and sulfur air pollution in the United States: what do we know?" *Frontiers in Ecology and the Environment*. doi: 10.1890/110049.

Rea, A.W., Davis, C., Evans, D.A., Heninger, B.T., & Van Houtven, G.L. (2012). Using ecosystem services to inform decisions on U.S. air quality standards. *Environmental Science and Technology*, 46(12), 6481–6488.

Phelan, J.N., Sinha, P., Van Houtven, G.L., Deerhake, M.E., Waite, R., Rea, A., & Tennant, G. (2012). Impacts of nitrogen and sulfur deposition on the growth of red spruce and sugar maple in the United States. In *Moving from Status to Trends: Forest Inventory and Analysis (FIA) Symposium*, pp. 367–370.

Beach, R.H., Zhang, Y., & McCarl, B. (2012). Modeling bioenergy, land use, and GHG emissions with FASOMGHG: Model overview and analysis of storage cost implications. *Climate Change Economics*, 03(03), 1250012-1–1250012-34. doi:10.1142/S2010007812500121.

Example Nitrogen-Related Government Reports Supported by RTI

Chesapeake Bay Commission. 2012. *Nutrient Credit Trading for the Chesapeake Bay: An Economic Study*. www.chesbay.us/nutrienttrading.htm



U.S. Environmental Protection Agency, Office of Research and Development. 2011. *An Optimization Approach to Evaluate the Role of Ecosystem Services in Chesapeake Bay Restoration Strategies*. www.epa.gov/sites/production/files/2014-03/documents/chesapeake-bay-pilot-report.pdf

U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards. 2009. *Risk and Exposure Assessment for Review of the Secondary National Ambient Air Quality Standards for Oxides of Nitrogen and Oxides of Sulfur—Main Content—Final Report*. www.epa.gov/ttn/naaqs/standards/no2so2sec/cr_rea.html

More Information

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