Role of Atmospheric Nitrogen Deposition in Forests of New York

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Part 1: Quantifying Atmospheric Nitrogen Deposition

- Human activities have approximately doubled the rate of reactive nitrogen (N) inputs to terrestrial ecosystems.
- In the northeastern USA, this enhanced supply of N has been linked to many environmental concerns such as eutrophication, violations of drinking water standards, and forest health decline.
- The primary source of new N to New York state's largely forested watersheds derives from atmospheric inputs, and New York experiences some of the highest rates of atmospheric N deposition in the nation (Figure 1).
- ***The objectives of this study*** are to quantify rates of atmospheric N deposition to NY watersheds, and to fingerprint the sources of N that are being delivered to landscapes (in deposition) and to surface waters.

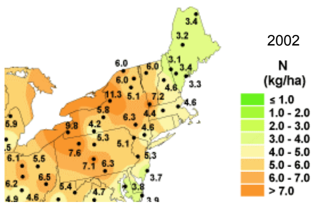

Figure 1. Atmospheric N deposition in the northeastern U.S. (Boyer, EW; Data from National Atmospheric Deposition Program - National Trends Network, 2002).

National Atmospheric Deposition Program National Trends Network (NADP-NTN): Wet deposition monitoring, designed to determine geographical patterns & long-term trends in precipitation chemistry. 9 active sites in NY; most since ~ 1980.

Atmospheric Integrated Research Monitoring Network (AIRMoN): Wet deposition monitoring, designed to determine daily and storm-event trends. 1 site in NY since 1992.

Clean Air Status and Trends Network (CASTNET): provides dry deposition & ground-level ozone monitoring data. 2+ active sites in NY since ~ 1990.

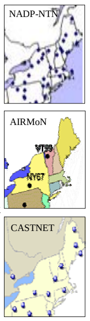

Figure 2. National Atmospheric Deposition Monitoring Networks (Boyer, EW)

Figure 3. National atmospheric deposition monitoring network at Connecticut Hill, NY (Boyer, EW)

Part 1: Study Approach

- We are using several sources of N deposition data to quantify rates of atmospheric N deposition in New York: (1) Data from established national monitoring networks throughout New York state - National Atmospheric Deposition Program (NADP), Clean Air Status and Trends Network, and the Atmospheric Integrated Research Monitoring Network (Figures 2, 3, & 4) and (2) Data from our project's passive air samplers (Figure 5) to collect dry (particulate and gaseous) N deposition in forested, agricultural, and urban settings.
- N concentration measurements using passive samplers will be converted to deposition flux data and results will be compared to measurements at the national network at Connecticut Hill, New York.
- Isotopes of Nitrate-N ($\delta^{18}O$, $\delta^{15}N$) will be used to evaluate whether sources of N (e.g., atmospheric N, fertilizer, and sewage sources) can be determined by the isotopic composition of N.
- Stream water N concentrations are also being measured to determine the quantity of N reaching the stream and isotopic analyses will be applied to distinguish among sources of N.

Figure 5. Passive dry N deposition collectors at Connecticut Hill, NY (Elliott, EM)

Part 2: The Fate of Nitrogen in Woody Biomass

- Approximately 25% of N deposited from the atmosphere is exported to rivers, and the fate of the remaining 75% is only beginning to be characterized (Boyer et al. 2002; Figure 6).
- N in harvested and living woody biomass can explain some of the export and storage of N in large watersheds (Goodale et al. 2002).
- ***The objectives of this study*** are to estimate the amount of N stored in harvested and living woody biomass across New York watersheds (Figure 7) and calculate export and import of N in harvested trees.
- Watersheds within the state of New York present a significant opportunity for studying the fate of atmospheric N because of their extensive forest coverage and the presence of the New York City (NYC) watershed, the largest surface water supply system in the nation.

Part 2: Study Approach

- Atmospheric deposition is estimated from our passive sampler N concentration measurements and from the national monitoring network in New York.
- Forest volume, age-class structure, composition, annual net growth, mortality, and harvest was accessed via the USDA's Forest Inventory & Analysis (FIA) 1993 and 2003 (soon available) county-level data at http://www.fs.fed.us/ne/fia/. This data (e.g., Figure 8) will be converted to watershed-level estimates using Geographic Information Systems (GIS).
- Estimates of N concentrations will be assigned to key tree species within each watershed according to estimated literature values (Goodale et al. 2002).
- Two sinks of N in harvested woody biomass will be calculated through several stages of forest growth and recovery:
  1. Net change of N in standing stock = *N in net growth (Figure 8) – N in harvest* (after Goodale et al. 2002)
  2. Net N harvest export = *N in harvested wood + N in imported wood – N in wood consumed within watershed – N in logging debris.*

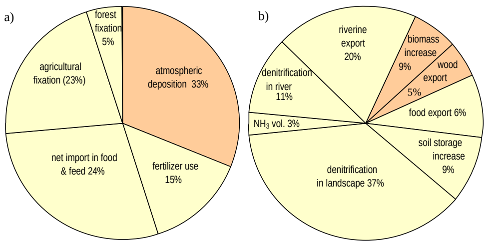

Figure 6: Sources (A) and sinks (B) of N in the environment in the northeastern USA (after van Breeman, 2002)

Figure 7: New York's watersheds (8-digit Hydrologic Unit Codes)

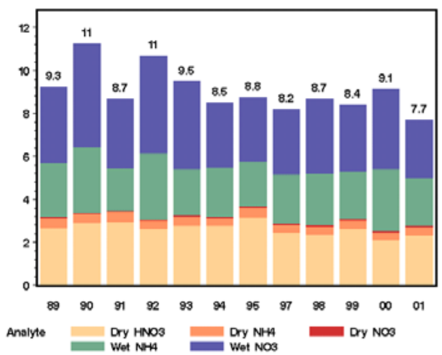

Figure 4. Composition of N deposition at Connecticut Hill (Boyer, EW; Data from Clean Air Status & Trends Network monitoring station at Connecticut Hill, NY)

Impact of Research:

- Data determining the amount and sources of atmospheric nitrogen deposition is essential for managing its effects on the extensively forested watersheds and water quality within New York state.
- Focusing research on the amount, sources, and a potential sink of atmospheric N deposition within New York is imperative for several reasons: (1) the high amount of N deposition New York receives relative to other parts of the nation, (2) the connectivity of many New York watersheds to issues involving over-enrichment of N in coastal and lacustrine waterways, and (3) the presence of the New York City watershed, the nation's largest water storage and supply system.
- Estimates of the fate of atmospheric N in harvested and woody biomass will provide critical data concerning the fate of the approximately 75% of new atmospheric N in forested systems that does not reach the stream.

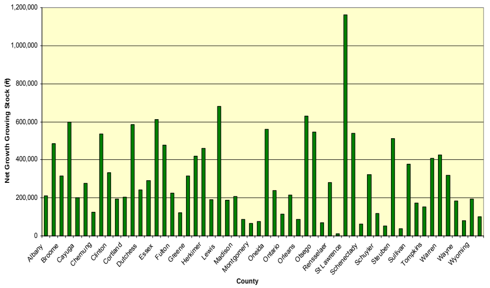

Figure 8. Example of FIA data to be converted to watershed-level estimates of N in harvested & living wood

Literature Cited:

Boyer EW, Goodale C, Jaworski JA, and Howarth RH. 2002. Anthropogenic sources and relationships to riverine nitrogen export in the Northeastern U.S.A. *Biogeochemistry* 57/58:137-169.

Goodale CL, Lajtha K, Nadelhoffer KJ, Boyer EW, and Jaworski JA. 2002. Forest nitrogen sinks in large eastern U.S. watersheds: estimates from forest inventory and an ecosystem model. *Biogeochemistry* 57/58:239-266.

Van Breeman N, Boyer EW, Goodale CL, Jaworski JA, Paustian K, Sietzinger SP, Lajtha K, Mayer B, Vandam D, Howarth RH, Nadelhoffer KJ, Eve M, and Billen G. 2002. Where did all the nitrogen go? Fate of nitrogen inputs to large watersheds in the Northeastern U.S.A. *Biogeochemistry* 57/58:267-293.

Acknowledgements: EPA's GRO grant provides the graduate research funding for this project, and the New York State Energy Research and Development Authority provides support for N concentration & isotopic measurement & analyses. Partial support to begin this project was provided by the National Science Foundation's (NSF) Graduate Teaching Fellows in K-12 Education Project and the New York City Watershed Agricultural Council.