Seasonal Variation in Nitrogen Retention Processes in a Coupled Terrestrial-Aquatic Ecosystem: a Tracer Experiment

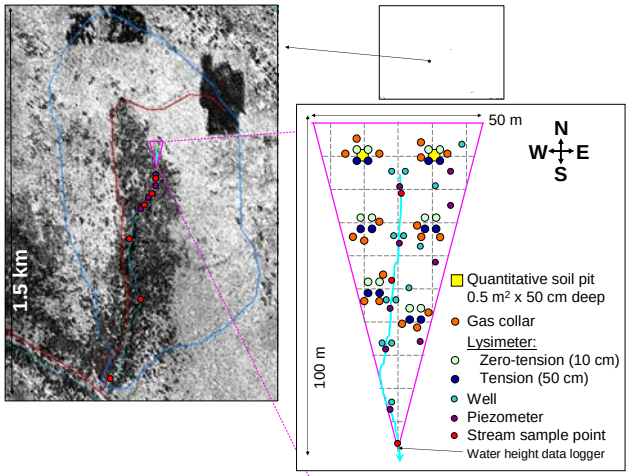
Abstract: A variety of ecosystem processes affect the retention and loss of N from forests, and these processes are likely to vary seasonally (e.g., Table 1). This project follows the fate of NO_3^- entering in Upper Susquehanna forests through a field study of coupled terrestrial and aquatic N retention processes. Tracer doses of ^{15}N-NO_3^- were applied in late April (post snowmelt, pre-leafout), late July (mid growing-season), and late October (end of leaffall) to allow comparison of N retention processes across seasons. The fate of these additions is being followed as losses of N gases, assimilation into upland forest ecosystem pools (roots, foliage, wood, soil), down through the soil profile, through the near-stream zone, and into and down the stream reach. The experiment integrates terrestrial and aquatic perspectives and will assess the relative contribution of watershed subsystems in N retention.

Background:

- Forests cover over two-thirds of the Susquehanna Basin.
- These forests receive considerable quantities of N deposition, of which more than half is as NO_3^--N.
- Small forested catchments in this region appear to retain or denitrify about 95% of atmospheric N inputs.
- Seasonal patterns of stream NO_3^- concentration exhibit summer peaks, fall minima, and moderate values during the dormant season, suggesting marked seasonal variation in controls on N export (Table 1).
- Understanding ***where*** and ***when*** N is retained or lost is crucial to understanding if or when that pool might saturate.
- Past ^{15}N tracer studies have followed either the long-term fate of ^{15}N in terrestrial ecosystems or the short-term cycling of ^{15}N in streams. We are merging strengths of both approaches.

Table 1: Hypothesized seasonal variation in N retention processes in a deciduous forest catchment.

Retention Process	Spring (pre-leafout)	Summer (mid-growing)	Autumn (leaffall)
Plant uptake	**Large**; by fine roots prior to leaf-out.	**Med.**; maintaining photosynthesis	**Small**; resorbing and dropping litter N instead
Soil microbial Immobilization	**Small**; soils cool, wet; 6 mo. without large C inputs.	**Large**; new root C inputs and warm temperatures	**Very large**; responding to large C input from leaves
Denitrification (soils)	**Large**; soils seasonally N rich and wet.	**Small**; soils drier and N poor	**Small/Med.**; soils wetter; C-rich, but N-limited
In-stream uptake	**Med.**; high light and N may allow autotrophic uptake.	**Low**; light- C- and often N-limited	**High**; fueled by fresh leaf material



Methods:

- A 0.25 ha triangular plot surrounding the headwaters of Pine Brook, Schuyler County, NY (Fig. 1) was established in summer 2006.
- The site was instrumented with 6 sets of 3 gas collars (n = 18), 6 pairs of zero-tension lysimeters (10 cm depth), 6 pairs of tension lysimeters (50 cm depth), and 13 near-stream wells (Fig. 1B).
- Background C, N, and ^{15}N pools were characterized in 2006, and will be resampled in summer 2008, including:
  - Two quantitative soil pits and five 50 cm soil pits
  - 54 surface soil cores (10 cm deep, 6 cm diameter);
  - All roots (coarse and fine) retained for ^{15}N analysis;
  - All trees > 10 cm dbh tagged and measured;
  - Dominant trees (n = 22) were cored (2/tree) for ^{15}N analysis;
  - Foliage collected from 18 trees by slingshot for ^{15}N analysis; and
  - Litterfall collected in 2006 and 2007 with 25 litter baskets (0.24 m^2).
- On three dates (April 30, July 31, and Oct. 30, 2007), 70.2 g ^{15}N/ha was applied to the plot along with 1.5 mm of water (4.6 mg ^{15}N/L or 309 μmol/L KNO_3) and 309 μmol/L KBr.
- Surface litter (Oi), soils (to 10 cm), fine roots, ^{15}N gases (N_2O, N_2), and all solutions (lysimeter, well, stream) were collected the day before and 1, 2, 7, 30, and 90 days post ^{15}N application and following select rainfall events.
- Stream water was also sampled at 3 locations (stream head, plot base, and 100 m downstream) with ISCO automated water samplers.

Results:

- Sample processing and analyses are still underway.
- Preliminary results from the April addition indicate that most of the 70 g/ha of added ^{15}N was immediately retained in the litter (32 ± 2 g/ha ^{15}N) and the mineral soil (33 ± 2 g/ha ^{15}N) (Fig. 2).
- However, discernable quantities of bromide and ^{15}N moved down through soil water (Fig. 2) and out in the stream (Fig. 3).