Assessment of Nitrogen and Acidic Deposition Impacts to Terrestrial and Aquatic Ecosystems of the Tug Hill

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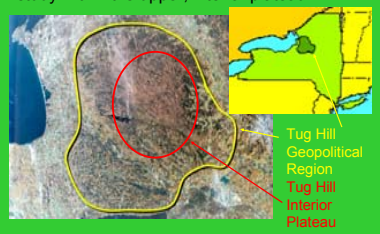
INTRODUCTION

The Tug Hill

encompasses ~291,000 ha and is the third largest, intact forested landscape in New York (Figure 1). The region ranges in elevation from 75-640 m and is positioned at the western extent of the "Adirondack Highland Section" of the "Adirondack – New England Mixed Forest – Coniferous Forest Province." The Tug Hill contains 6400 km of streams, supports world-class fisheries, serves as a drinking water supply for several municipalities and sustains an $80-million wood products and paper manufacturing industry.

Figure 1. The Tug Hill Region and extent of study within the upper, interior plateau.



Atmospheric N and acid deposition

fluxes to the Tug Hill are consistently among the highest in the eastern United States. Compared to other regions of New York that are impacted by atmospheric deposition, the Tug Hill receives the highest long-term (1980-2002) average annual deposition rates for NH_4^+, NO_3^-, total inorganic N, SO_4^{2-}, and H^+ (Table 1). Therefore, great potential exists for the Tug Hill to display symptoms of N saturation and acidification.

Table 1. Average (1980-2002) wet deposition rates (kg/ha/yr) of solutes in major forested regions of New York (NADP, 2004).

			Inorganic		
	NH_4^+	NO_3^-	N	SO_4^{2-}	H^+
Tug Hill	4.6	27.3	9.7	31.8	0.6
Adirondacks	2.1	14.6	5.9	18.2	0.4
Catskills	2.5	18.1	6.0	23.8	0.6
Chautauqua	3.5	19.8	7.2	27.8	0.5

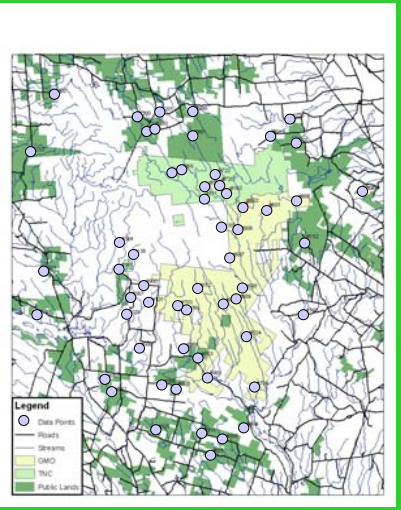
Our objective

was to conduct the first assessment of Tug Hill surface waters and forests with respect to N saturation and acidification through a two-year synoptic survey of surface water quality, soil chemistry, and foliar tissue chemistry.

METHODS

We established 57 study sites throughout the interior Tug Hill plateau (Figure 2). Each site consisted of a randomly selected 1st-order stream and adjacent upland forests. Surface water samples were collected during snowmelt periods in 2005-2007, and during summer baseflow periods in 2005-2006. Adjacent to each stream sample location, we sampled forest floor and upper mineral soils, and foliar tissue of dominant tree species. Samples were analyzed for indicators of N-saturation and acidification.

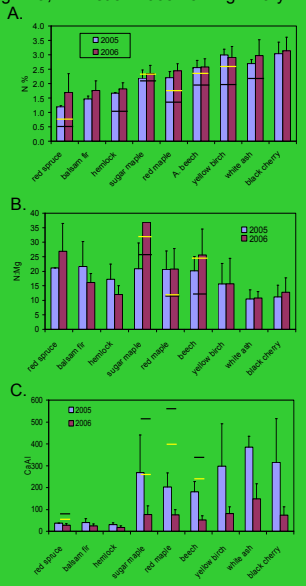
Figure 2. Study site locations within the Tug Hill interior plateau. Study sites were established on NY State Forests, Wildlife Management Units, Forest Preserves, and private industrial and non-industrial woodlands.



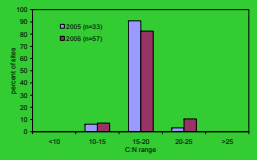
RESULTS and DISCUSSION

Indicators of N saturation

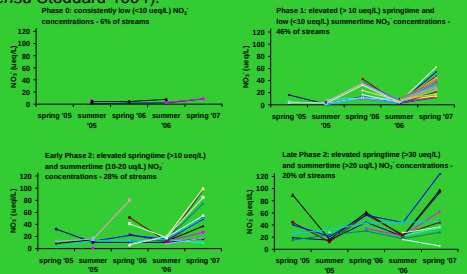
Foliar chemistry of Tug Hill canopy-dominant trees reflect conditions of high N input. Tug Hill foliar N content was consistently higher than that reported from experimental forests receiving high N-addition treatments in New England (Panel A). Similarly, foliar N:Mg ratios were higher (Panel B) and Ca:Al ratios (Panel C) were lower in the Tug Hill samples compared to the N-addition sites in New England. The superimposed bars in the following graphs represent average values reported from northern hardwood forests in ME, NH and MA for untreated observations and control plots (black bars) and high N addition plots (yellow bars). Data are from Aber et al. 1995, Bear Brook, ME, 56 kgN/ha/yr * 4 yrs; Bolster et al. 1996; Magill et al. 1997, Harvard Forest, MA, 50 kgN/ha/yr * 6 yrs; Fahey et al. 1998, NH, 167 kgN/ha; Elvir et al. 2005 25.2 kgN/ha/yr * 15 yrs.



More than 90% of the Tug Hill forest floor samples had C:N ratios <20, and all samples exhibited C:N ratios <25. Previous studies have demonstrated the onset of elevated nitrification rates when soils reach C:N <22 (Ollinger et al. 2002; Aber et al. 2003).

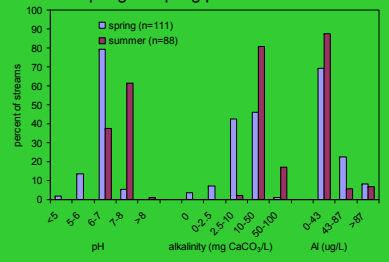


Ninety-four percent of sampled Tug Hill streams exhibited seasonal high nitrate concentrations during spring snowmelt. Twenty percent of the streams sampled displayed high (>20 ueq/L) nitrate concentrations during summer baseflow periods, reflecting the potential onset of Phase 2 N-saturation conditions (*sensu* Stoddard 1994).



Indicators of acidification

Tug Hill surface waters remain generally well buffered to acidic deposition. Approximately ~10-12% of streams were acidified or considered susceptible to acidification (<2.5 mg $CaCO_3$/L, Driscoll et al. 2001) during spring snowmelt, and none were susceptible or acidified during baseflow conditions. Aluminum concentrations surpassed thresholds for chronic toxicity (87 µg/L, Gostomski 1990) in ~5-10% of streams during both summer and spring sampling periods.



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