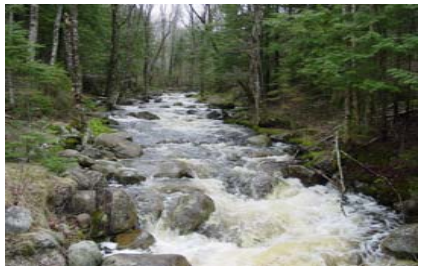
Assessment of Acid Rain Effects On Streams in the Western Adirondack Region of New York, USA



1. Problem

Despite 30 years of research, the extent of acid rain effects on streams and soils of the Adirondack region of New York has not been well assessed, despite the probability that this is the most affected region in the country. To better characterize the status of streams and soils, a large-scale survey has been conducted in the Oswegatchie and Black River watersheds of the western Adirondack region.

2. Sampling Approach

1. All streams not substantially influenced by upstream impounded waters (< 25% of drainage area upstream of a lake or pond) were identified within the 4,000 km^2 Oswegatchie-Black drainage basin. Of these, 565 were determined to be accessible (< 1 hour hike), and 200 of these were randomly selected for sampling.

2. Stream water was collected for chemical analysis twice during summer low flow, twice during spring snowmelt, and once during fall high flow. The 5 surveys were completed in 3 to 4 days to minimize effects of flow variations. Buck Creek, theonly gaged stream in the study region of approproiate size, provided flow data during sampling.

3. Twelve streams sampled multiple times in 1980-1985 were resampled to evaluate long-term differences in pH and acid neutralizing capacity by Gran titration (ANC_G).

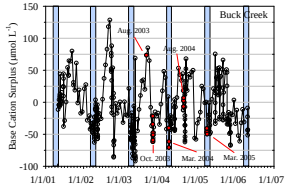
4. Soil samples were collected in 11 watersheds of varying stream chemistry to determine if high flow stream chemistry could be used to infer soil base status.

5. Macroinvertebrate communities were assessed in 36 streams selected to cover a range in stream chemistry.

6. Periphytic diatom samples were collected at all stream sites during four of five surveys.

3. Stream Survey Results

a. Buck Creek data were used to put sampling conditions during the 5 surveys into the context of variability over a 5-year period. Red circles indicate the values for base cation surplus on the days that survey sampling was conducted. ***The March 2004 survey was the most acidic of the 5 surveys, but not the most acidic conditions during 2001-06. The August 2003 survey fell among the least acidic dates in 2001-2006.***



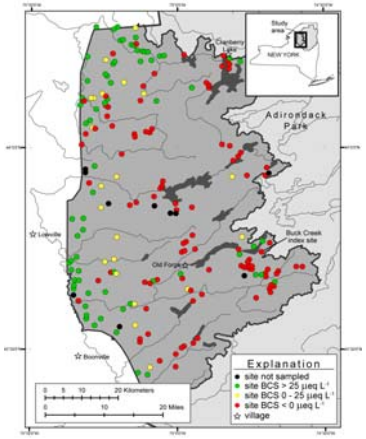
b. Acidification was assessed with the newly developed base-cation surplus (BCS) and acid-neutralizing capacity by Gran titration (ANC_G). ***In the March 2004 survey, 56% of streams were acidified based on the criterion of BCS < 0, whereas 29% were acidified based on an ANC_G value < 0 (EPA's definition of acidification).***

c. Buck Creek monitoring shows that during worst conditions, BCS values are likely to be about 25 µeq L^{-1} lower than those measured in the March 2004 survey. ***The 66% of streams with BCS values below 25 in the March 2004 survey are likely to be prone to episodic acidification.***

d. The BCS allows natural organic acidity to be distinguished from acidity derived from acid rain. ***With this approach, 81% of the acidity in stream water in the March 2004 survey was attributable to acid rain.***

Survey Date	Aug. 25-29 2003	Oct. 27-30 2003	Mar. 29-31 2004	Aug. 16-18 2004	Mar. 29 -Apr. 1 2005
Number of streams sampled	129	196	188	195	190
Range in flow during the survey (L sec^{-1})	4.7–5.5	188-988	216-346	20-37	116-265
Percentage of year with less flow	5-6	90-99.8	90-95	24-38	84-93
Number of streams with BCS < 0 µeq L^{-1}	15	106	105	57	70
Number of streams with BCS < 25 µeq L^{-1}	25	123	124	68	100
Number of streams with ANC_G < 0 µeq L^{-1}	6	49	55	29	36
Number of streams with ANC_G < 50 µeq L^{-1}	26	130	133	74	118
Number of streams with Ali > 2.0 (µmol L^{-1})	14	88	78	49	64
Number of streams with pH < 6.0	26	126	121	79	103
Mean SO_4^{2-} + NO_3^- (percent of total anions)	77	66	81	62	80
Mean $RCOO^-$ (percent of total anions)	20	29	16	34	17

e. Locations are shown for the 200 streams sampled one or more times in the 5 surveys. Colored circles represent sites sampled in the March 2004 survey. ***The acidity of streams tends to increase from west to east, with some exceptions likely due to widely scattered calcareous till.***



F. Similar numbers of streams were chronically and episodically acidified based on August 2004 (base flow) and March 2004 (high flow) surveys. ***Had the August 2003 survey been used for base flow, the relative fraction of episodically acidified streams would have been higher.***

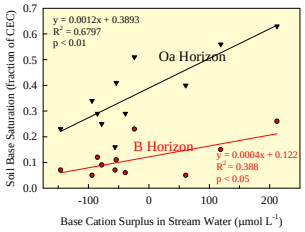
Acidification Class	Number of Streams
Chronically acidified	67
Episodically acidified	57
Non acidified	65
Total	189

4. Comparison Between pH and ANC_G in 1980-85 and 2003-05

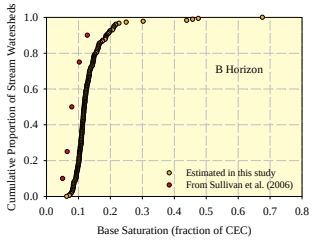
	pH (pH units yr^{-1})		ANC_G (µeq L^{-1} yr^{-1})	
Stream	Range in 2003-05	Increase since the 1980s	Range in 2003-05	Increase since the 1980's
Bald Mt. Bk.	5.10 – 7.29	1.1	2.6 – 107.0	1.7
Black Bear Mt. Brook	5.29 – 7.52	0.35	9.9 – 177.3	--
Bradley Bk.	4.47 – 5.60	0.19	-27.9 – 17.3	0.62
Buck Cr.	4.80 – 6.97	--	-6.7 – 68.9	--
Cellar Bk.	4.45 – 5.72	0.16	-42.3 – 21.9	0.52
Eagle Cr.	5.48 – 7.80	0.13	27.4 – 300.4	--
Independence R.	5.35 – 7.37	0.72	10.3 – 130.8	--
Otter Cr.	6.40 – 7.52	0.45	37.8 – 201.3	--
Seventh L. Inlet	4.93 – 7.13	--	-0.21 – 91.5	--
Silver Run – downstream	4.63 – 6.97	0.29	-12.0 – 71.3	0.48
Silver Run – upstream	5.33 – 7.51	ns	11.9 – 174.3	--
Wheeler Cr.	4.46 – 6.13	ns	-27.6 – 33.8	--
Average increase for all streams	na	0.29	na	13.1

a. No decreases in pH or ANC were observed. Although pH increased in 8 of 12 streams, ANC increased in only 4 of 12 streams. ***The average annual rate of increase over 23 years was 0.012 for pH and 0.57 µeq L^{-1} for ANC. This degree of chemical recovery probably resulted in little or no biological recovery in stream ecosystems.***

5. Soil-Stream Water Relations

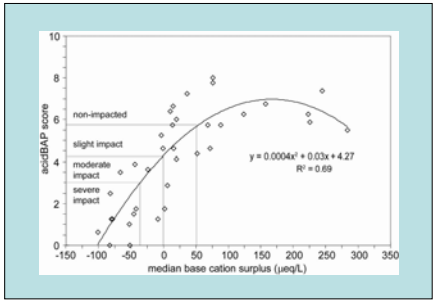


a. The base cation surplus in stream water was more strongly related to base saturation of the Oa horizon than the B horizon. ***This result suggests that neutralization of stream water is being controlled by the Oa horizon because the B horizon is Ca depleted.***



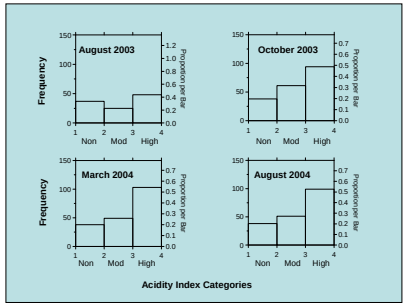
b. The relation between the base cation surplus in stream water and soil base saturation was used to estimate base saturation in 188 WASS watersheds. ***In over 90% of the watersheds, base saturation was estimated to be less than 20%, the level below which Al dominates exchange chemistry.***

6. Macroinvertebrate Results



a. The strong relation between the BCS and acidBAP (R^2 = 0.69) supports its use as a gauge of biologic impacts associated with various degrees of stream acidification. ***Data from the March 05 survey (the median of the 5 surveys based on the BCS) indicates that macroinvertebrate communities were slightly to severely impacted in 53% of the streams, and moderately to severely impacted in 37% of the streams.***

7. Diatom Results



a. The ACI, an index based on the acid tolerance of the species found to be present, was strongly related to stream chemistry. Results were grouped into three categories of impact based on ACI values. ***In the four surveys, 44% to 54% of the streams were severely impacted, and in three of the four surveys, appoximately 80% of the streams were moderately to severly impacted.***

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