Using Regional Stream and Soil Surveys to Study the Effects of Acid Deposition on the Catskill Mountains

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Objectives of the Study

1. Assess the acidification status of streams and soils.
2. To test the concept that stream chemistry can be used to identify soil-calcium depletion.

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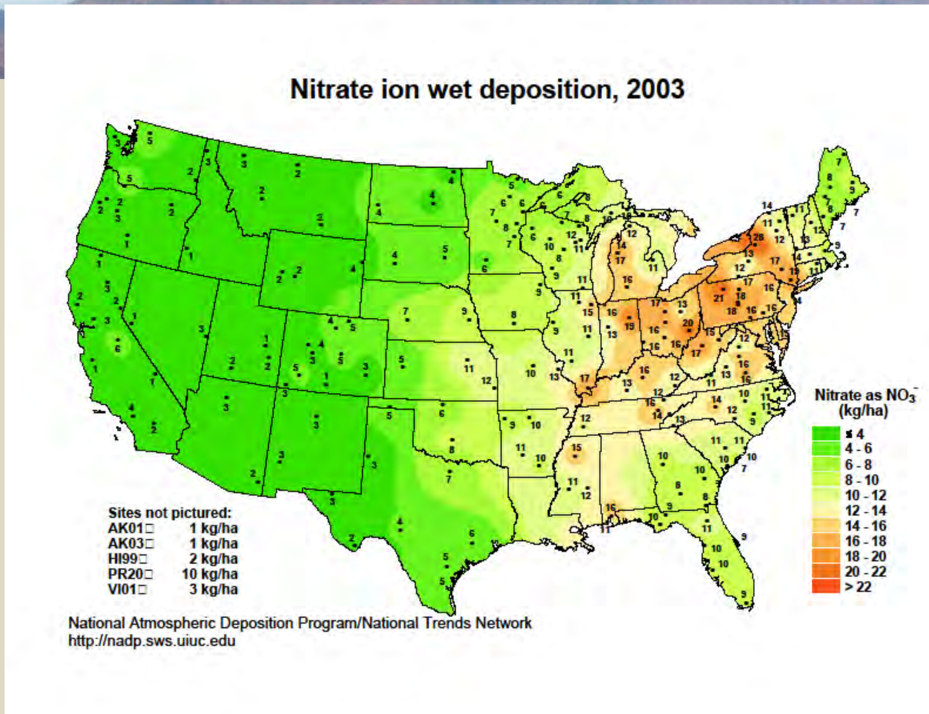
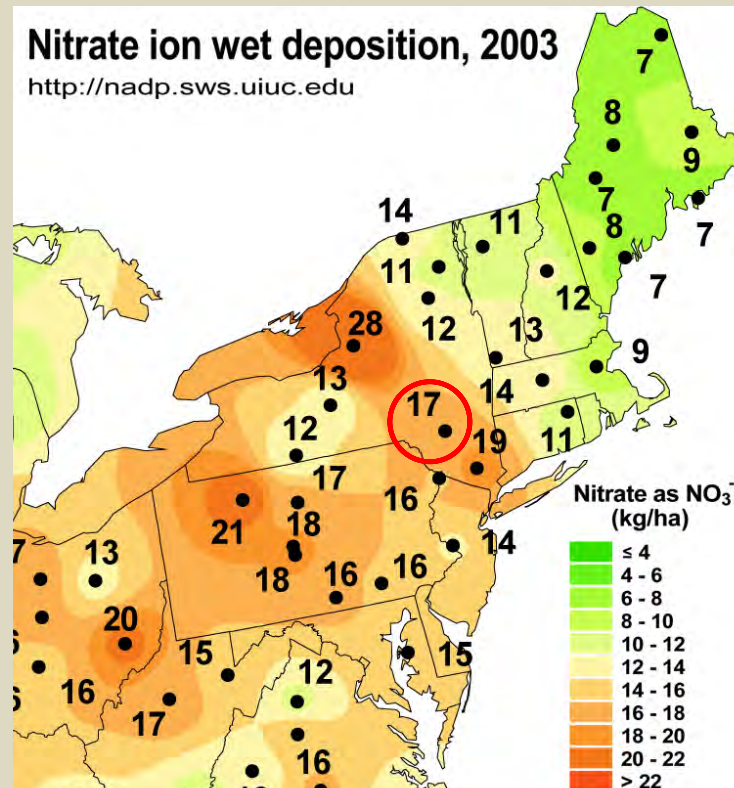
The Background



- Historically elevated deposition rates in the Catskills
- Catskill soils poorly buffered and naturally acidic



Why do we care?

- Brook Trout
- Sugar Maple, Red Spruce
- Overall ecosystem health

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The Background

- Acidic deposition levels have declined by as much as 50% in the Northeastern United States since 1990
- But recovery of acidified surface waters has lagged
- Delayed recovery has been attributed to depletion of available calcium
- Generally, where there is little or no stream acidification, soils are considered to be well buffered

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Previous Studies

- Lawrence (2002) 16% of stream reaches as chronically acidified and 66% of stream reaches as episodically acidified in the Neversink.

- 7% of streams acidified during baseflow in only other Catskill-wide stream survey previously conducted in 1986 (Murdoch and Barnes, 1996)

- Lack of acidification attributed to carbonates in glacial till and in bedrock, declining northwest to southeast (Murdoch and Barnes, 1996)

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Data Leveraged From:

- CEMRI (Collaborative Environmental Monitoring and Research Initiative) formed in 1998 by USFS, USGS, and NPS (Murdoch et al, 2008)
- EPA Long Term Monitoring (intensive stream sampling, 15+ years of record)
- USGS Upper Node-Lower Node Stream Water Quality (intensive stream sampling, 10 years of record) (McHale and Siemion, 2010)
- Forest Service, Forest Inventory and Analysis (soils collection)
- NYSERDA (Rich Hallet and others' ecosystem sensitivity tool) (soils collection) (Hallet et al, 2011)
- Current study developed as result of this work

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Methods

- Soil samples from more than 200 locations from 2000 to 2006
  - O horizon and upper 10cm B horizon

- Stream water samples from more than 180 locations
  - 1st order streams in forested basins
  - Spring high flow 2000-2006
  - Fall moderate flow 2000, 2002, 2006

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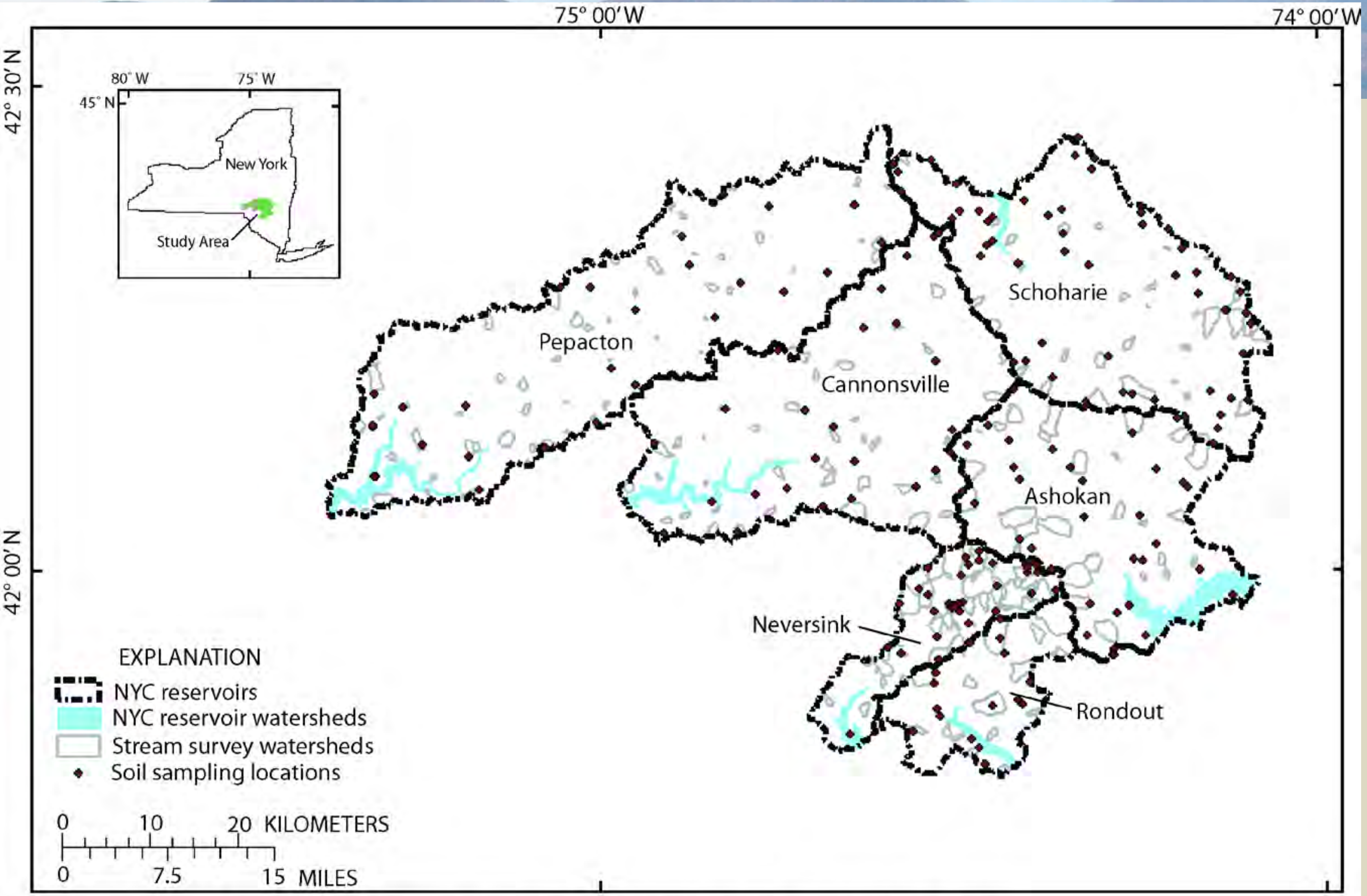
Study Area



Base from U.S. Geological Survey 1:24,000 digital raster graphics, North American Datum 1983, Universal Transverse Mercator Projection, Zone 18.

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Determining Stream Acidification Status

- Base Cation Surplus (BCS)…takes into account the role of strong organic acids (Lawrence and others, 2007)
  - BCS < 0 considered acidified
  - 0 < BCS < 60 considered prone to acidification
  - BCS > 60 considered not acidified
- ANC < 0
- $Al_{im} > 2\ \mu mol\ L^{-1}$


B. Baldigo Photo

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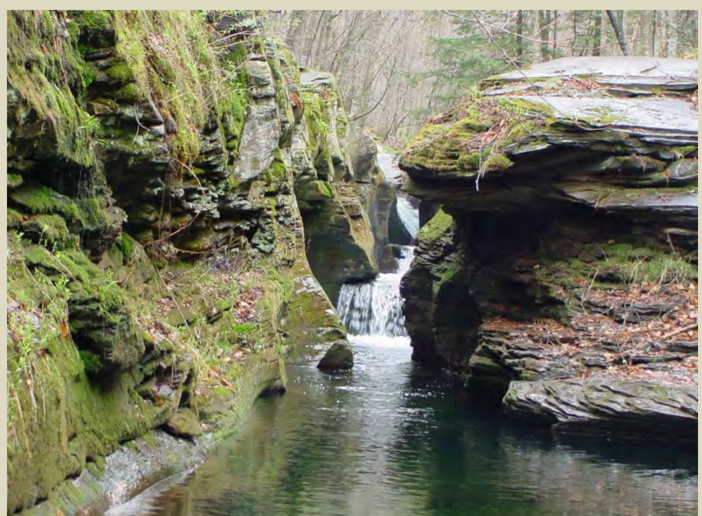
Prone to Acidification?

- Streams were considered prone to acidification because under extremely high flow conditions the BCS would be likely to drop below 0.
- The lowest BCS value measured during the study period at the intensively monitored streams was an average of 60 µeq L^{-1} (range of 31 to 94 µeq L^{-1}) lower than the mean BCS value calculated from the survey sample collected for that same stream.
- Therefore, streams with mean BCS values between 0 and 60 µeq L^{-1} were considered to be prone to acidification (Lawrence et al, 2008).



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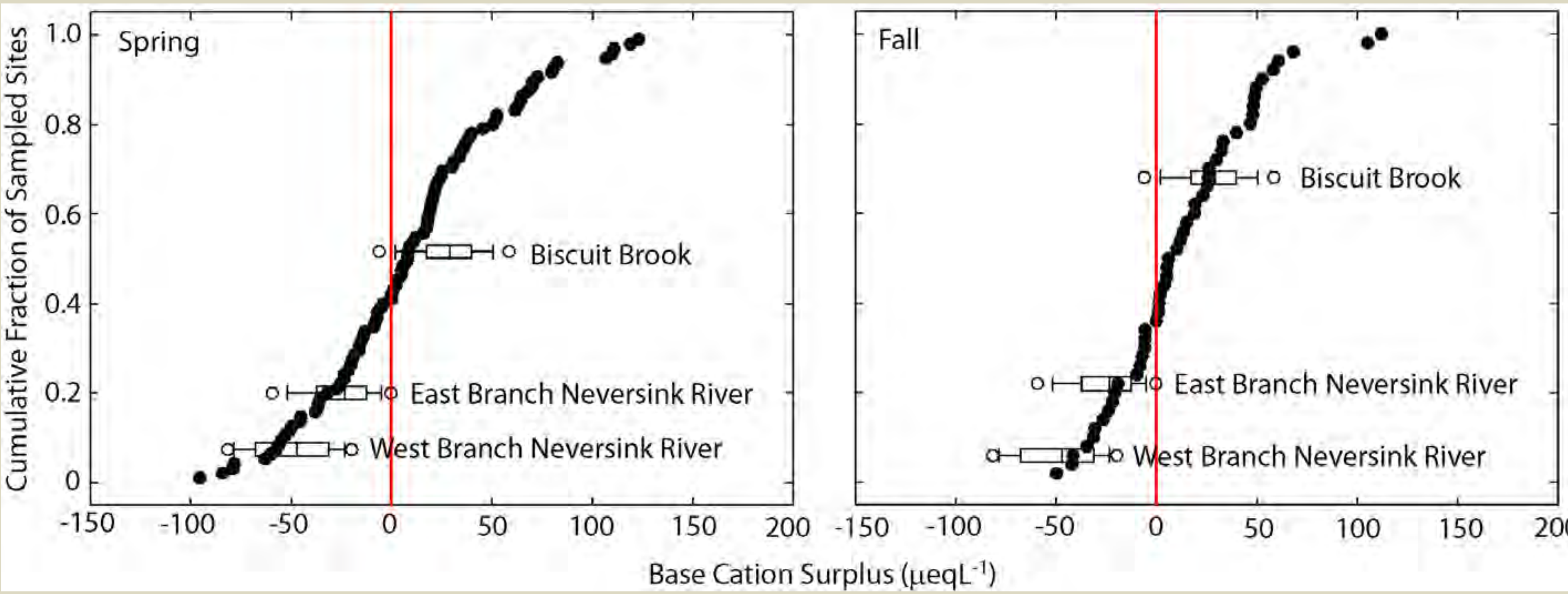
Results in Terms of Annual Variability

Neversink Basin



Spring high-flow, BCS in lower 10-35th percentile.

Fall moderate high-flow, BCS 50th percentile.

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Number of Impacted Streams in Each West-of-Hudson Reservoir Watershed

Watershed	BCS < 0 (Acidified)		0 <BCS < 60 (Prone to Acidification)		ANC < 0 µeq L^{-1}		Al_{im} > 2 µmol L^{-1}	
	Spring	Fall	Spring	Fall	Spring	Fall	Spring	Fall
Ashokan	1/38	0/28	6/38	5/28	0/38	0/28	0/38	0/28
Cannonsville	1/75	1/56	8/75	2/56	0/75	0/56	1/75	0/56
Neversink	38/95	18/50	78/95	46/50	35/95	13/50	48/95	20/50
Pepacton	0/41	0/42	3/41	1/42	0/41	0/42	1/41	1/42
Rondout	3/17	1/16	16/17	8/16	1/17	0/16	2/17	2/16
Schoharie	0/32	0/34	10/32	3/34	0/32	0/34	0/32	0/34

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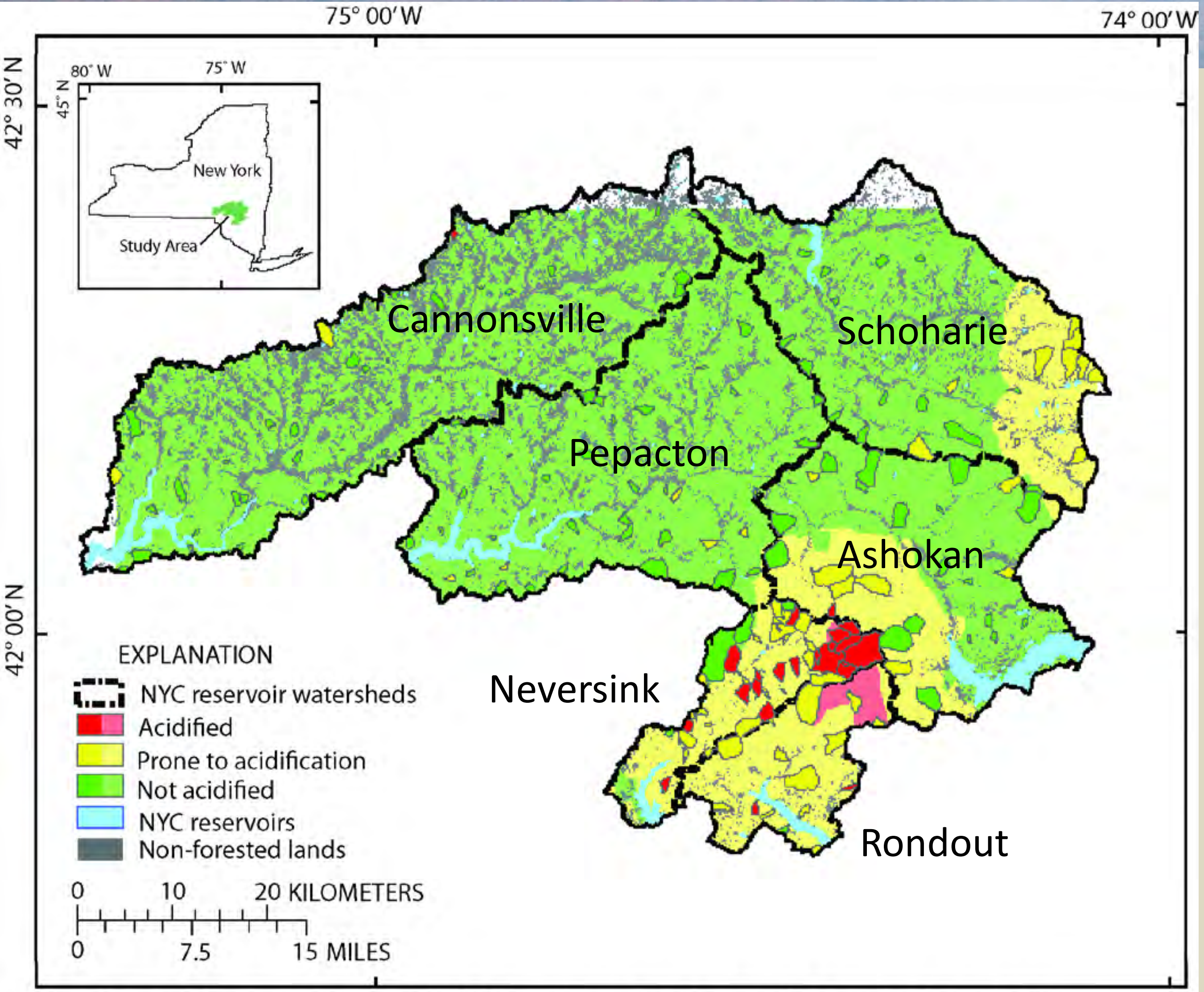
Stream Status During Spring High Flow



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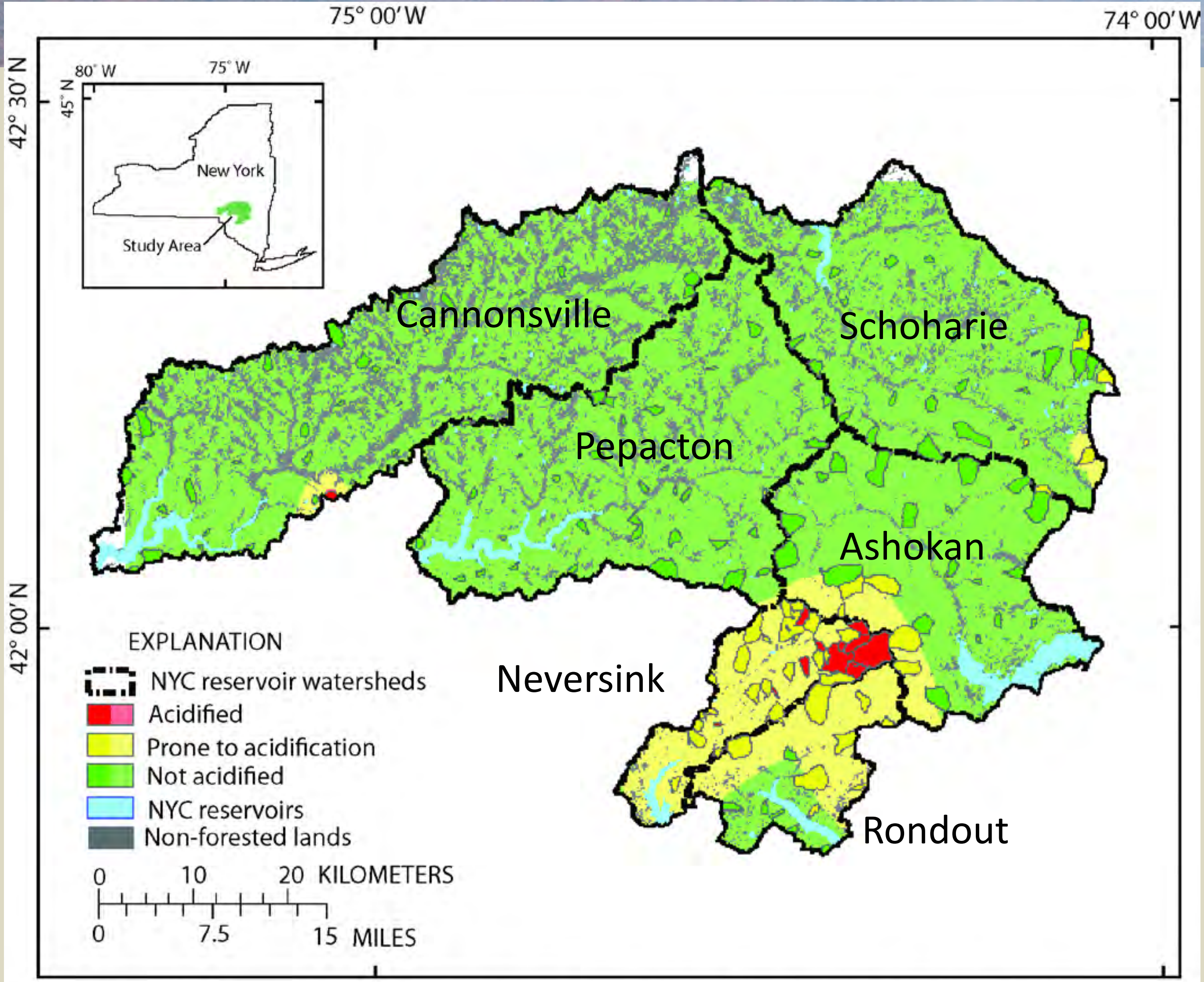
Stream Status During Fall Moderate-High Flow



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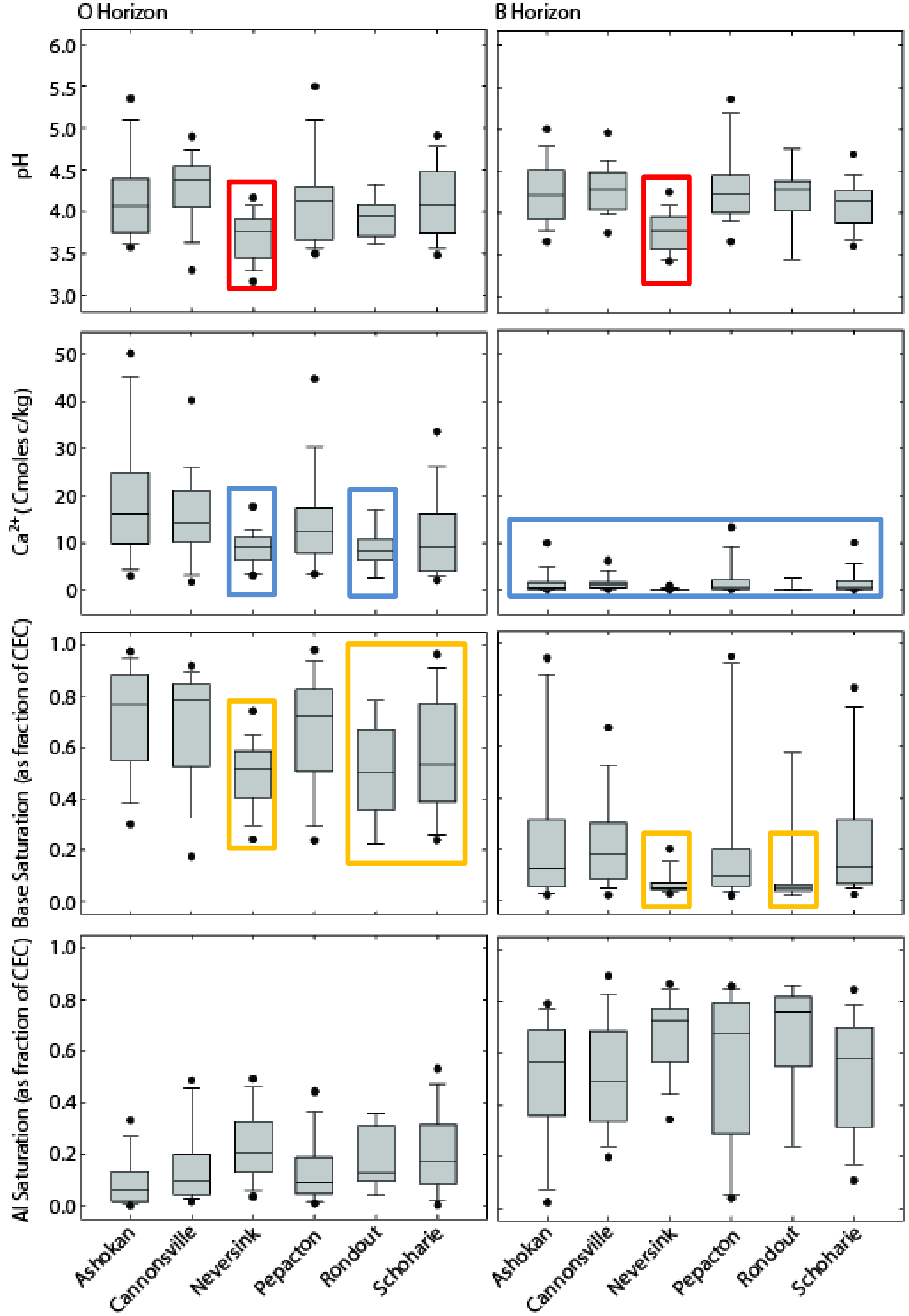
Soil Chemistry



- pH lower in Neversink in O and B hor.
- Calcium much lower in B horizon in all watersheds
- B horizon median base saturation below 20% threshold in all watersheds
- O horizon calcium and base saturation lower in Neversink, Rondout, and Schoharie
- Aluminum saturation much higher in B horizon in all watersheds

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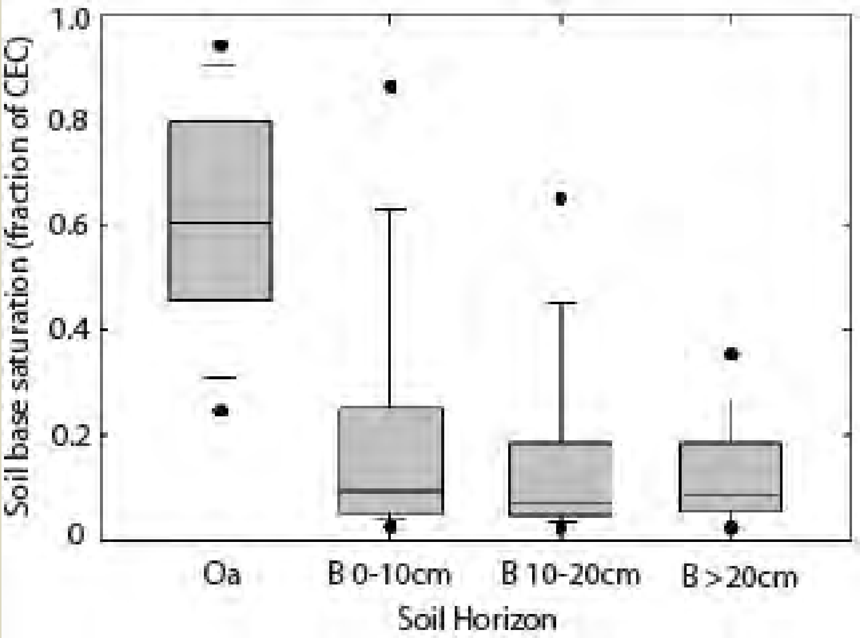
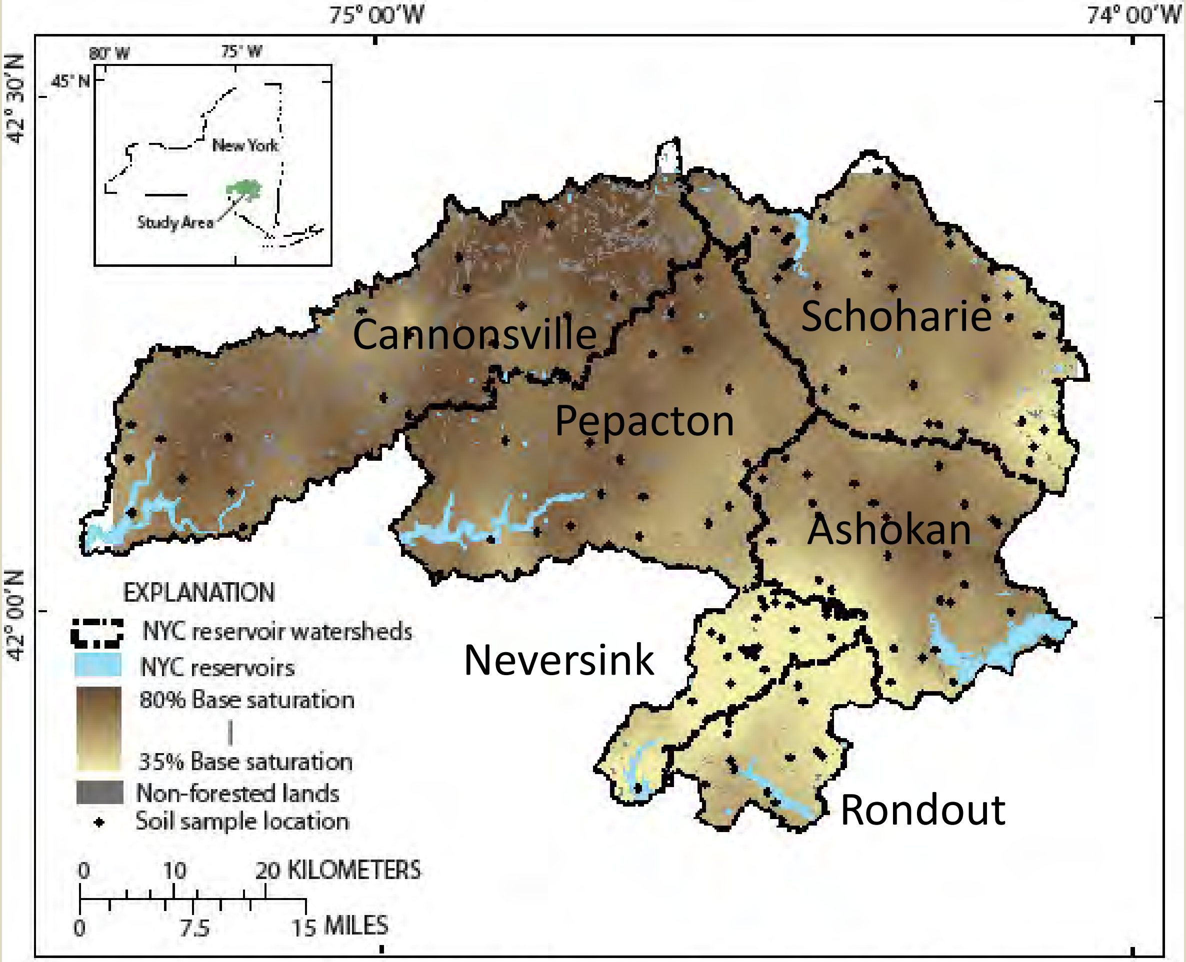
Soil Base Saturation in Deeper Pits



- Base cations leached to a depth of at least 30cm

Interpolated O-horizon Soil Base Saturation



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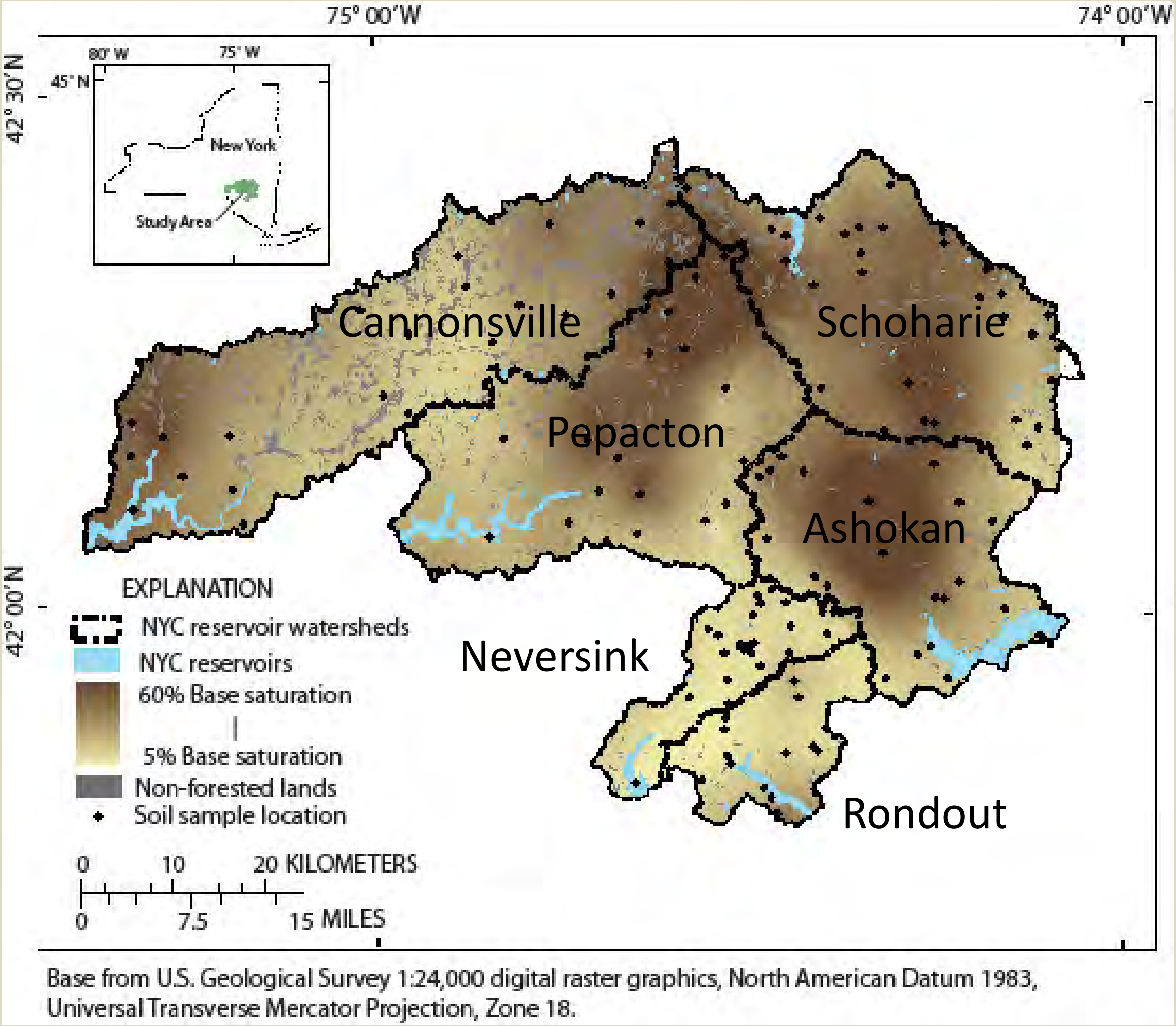
Interpolated B-horizon (0 to 10 cm) Soil Base Saturation



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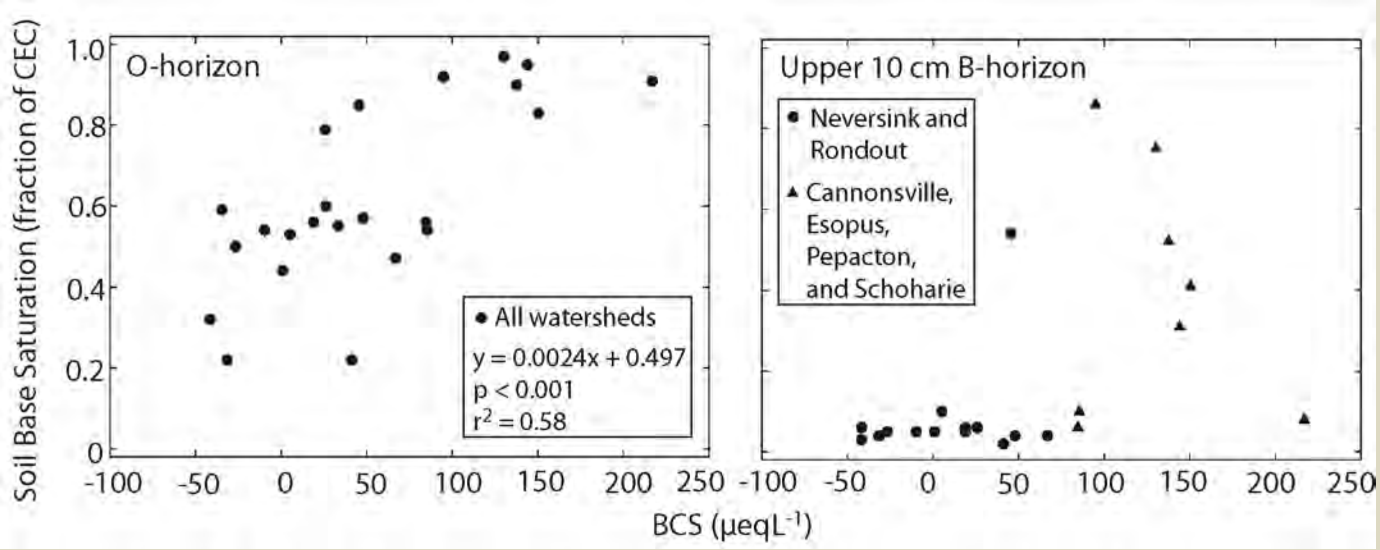
Relation of Stream Chemistry to Soil Chemistry

- BCS was strongly related to the base saturation of the O horizon ($p < 0.001$, $r^2 = 0.58$)
- BCS was not related to base saturation of the upper 10 cm of the B horizon ($p > 0.1$)



In Summary…The Specifics

- 40% of the streams sampled in the Neversink had Al_{im} concentrations greater than a threshold toxic to aquatic biota
- More than 80% of the streams sampled in the Neversink and Rondout, and 20-30% of the streams sampled in the Ashokan and Schoharie likely exceeded this threshold during the most acidic conditions

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In Summary…The Bigger Picture

- Stream survey results → large portion of the study area was assessed as not acidified
- Soil survey results → the B horizon has been severely impacted by acidic deposition across the entire study area
- Where streams were considered not acidified → O horizon is providing buffering
- Streams acidified or prone to acidification → the O horizon is no longer capable of buffering acidic deposition → mobilization of Al_{im}
- The use of stream surveys may not yield a true representation of the severity of the effects of acid deposition on mineral soils in the Catskills

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