Virginia Trout Stream Sensitivity Study 2010 Survey:
Evidence for Recovery From Acidification

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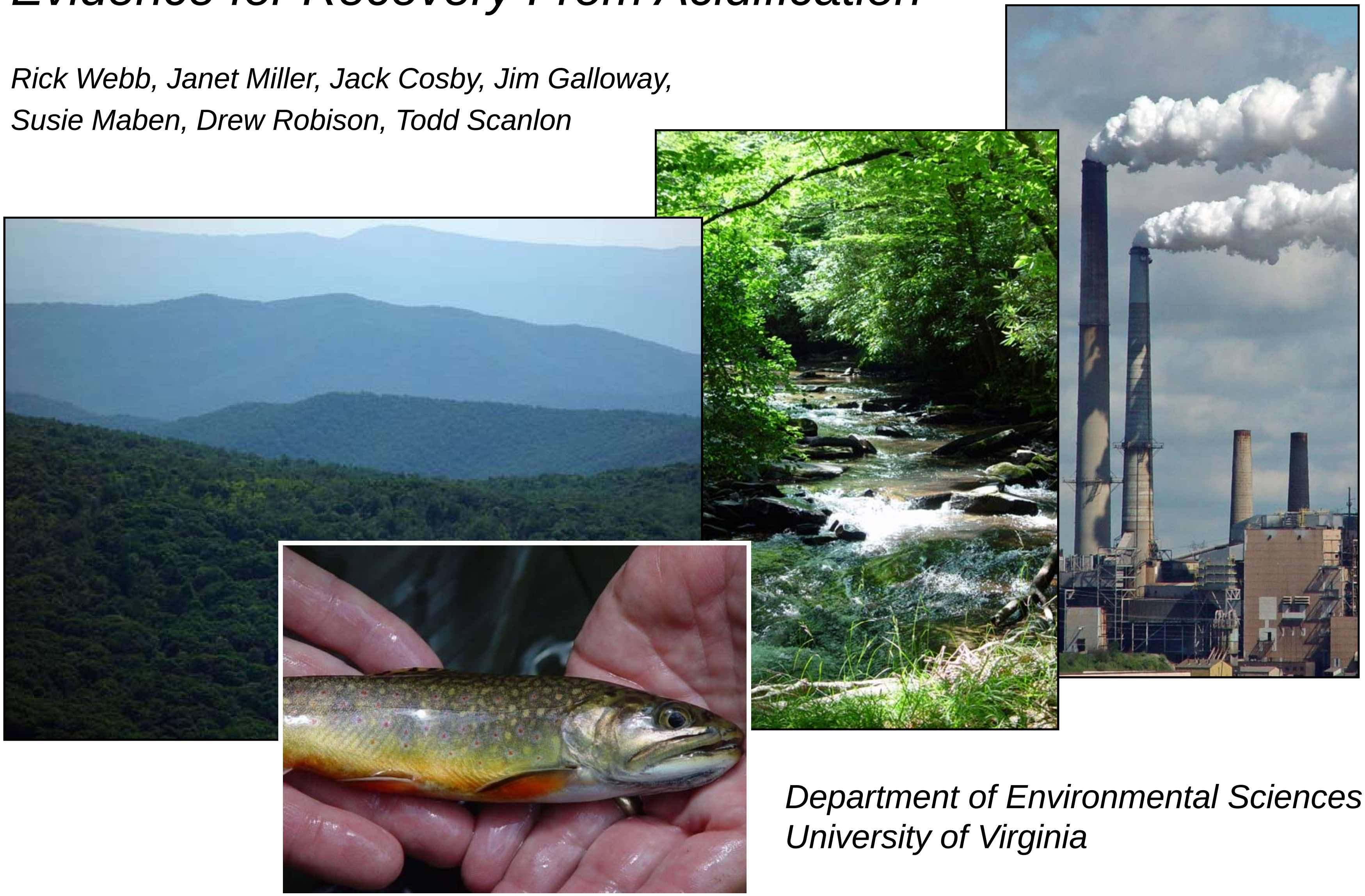

Department of Environmental Sciences
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Acknowledgement

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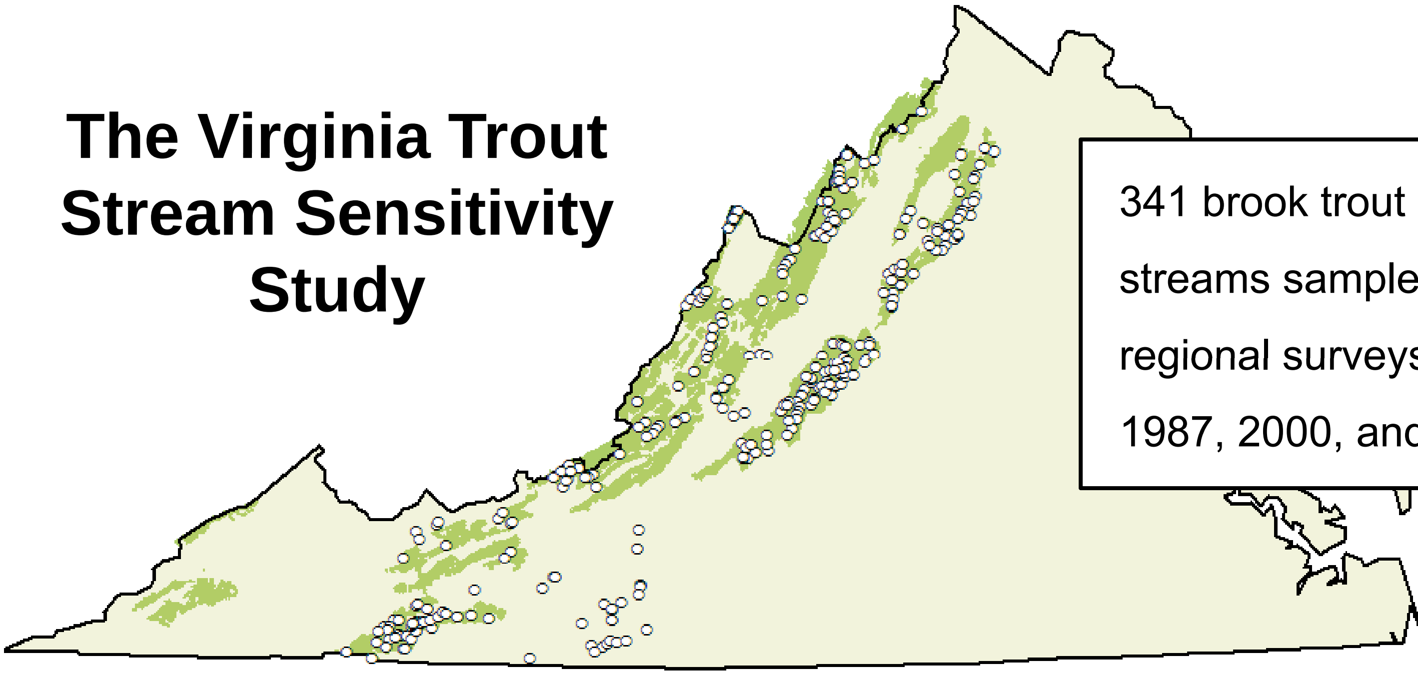
U.S. Environmental Protection Agency Clean Air Markets Division

Presentation Outline

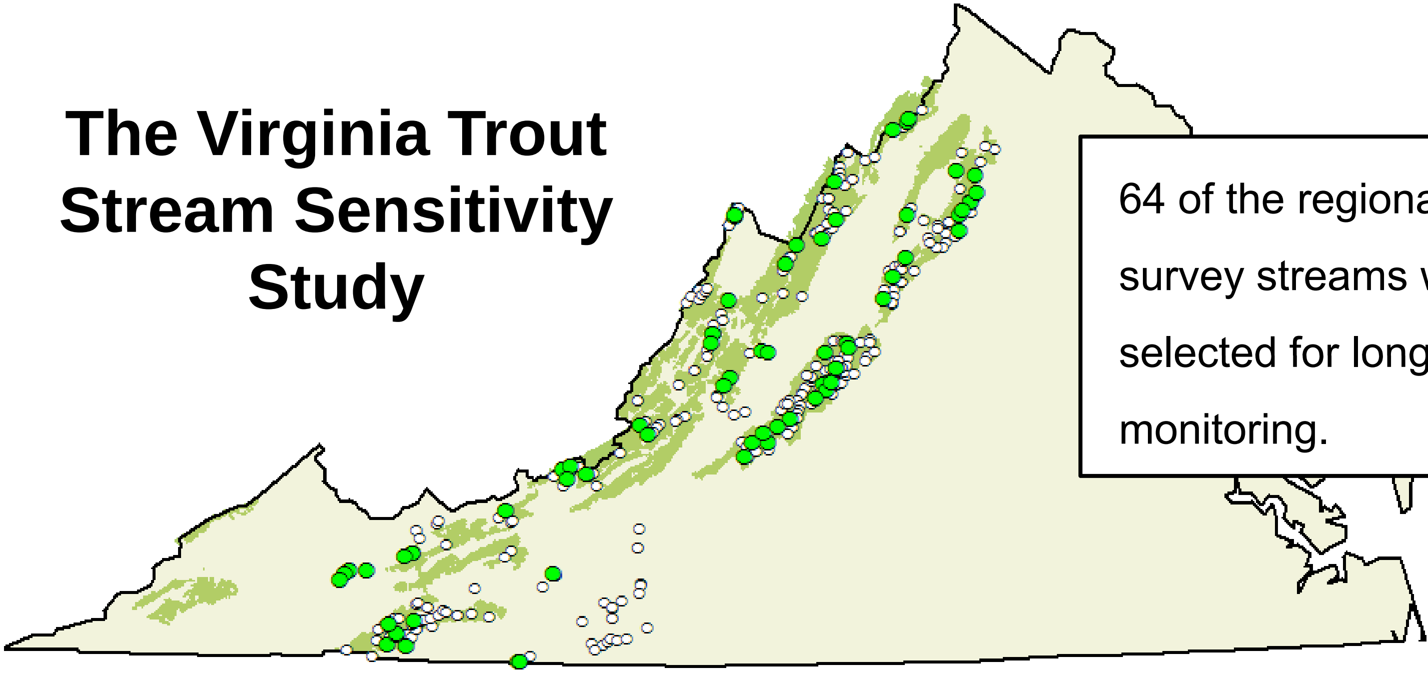
- Program Description
- Initial Observations
- Forecasts/Projections
- Current Observations
- Consistency with Expectations?
- Summary

The Virginia Trout Stream Sensitivity Study



341 brook trout streams sampled in 3 regional surveys: 1987, 2000, and 2010

The Virginia Trout Stream Sensitivity Study

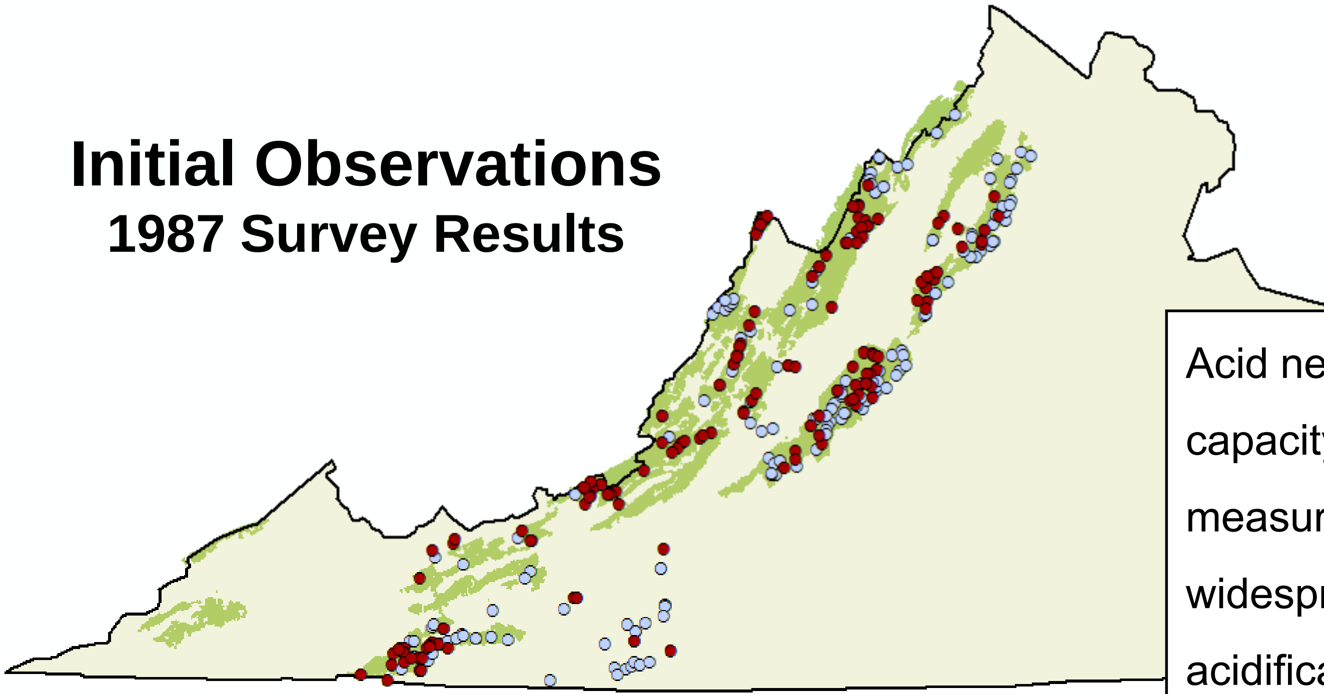


64 of the regional survey streams were selected for long-term monitoring.

Streams sites were selected to represent relatively pristine conditions and regional bedrock distribution. Most of the sites are on public lands.

Initial Observations

1987 Survey Results



Acid neutralizing capacity (ANC) measurements indicated widespread sensitivity to acidification.

- **Indeterminate, marginal, or chronically acidic**: ANC < 50 µeq/L
- **Not acidic**: ANC ≥ 50 µeq/L

ANC values for 45% of the sites eventually sampled in all 3 surveys were in the critical range in 1987.

Forecasts and Projections

Current, reconstructed past, and projected future status of brook trout streams in Virginia (Bulger et al., 2000)

Southern Appalachian Mountain Initiative (Sullivan et al., 2002)

Shenandoah Assessment (Cosby et al., 2006)

Model forecasts: significant stream recovery will not occur by 2040 despite projected sulfur emission reductions.

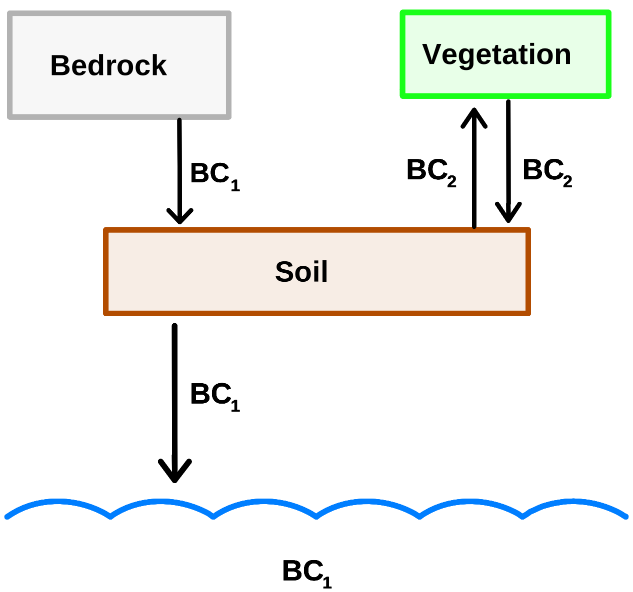
Critical loads analysis: for some streams recovery is unobtainable by 2040 regardless of sulfur emission reductions.

Limited stream recovery: a result of base-cation depletion in soils exposed to decades of acidic deposition.

Delayed stream recovery: a result of sulfur retention in watershed soils.

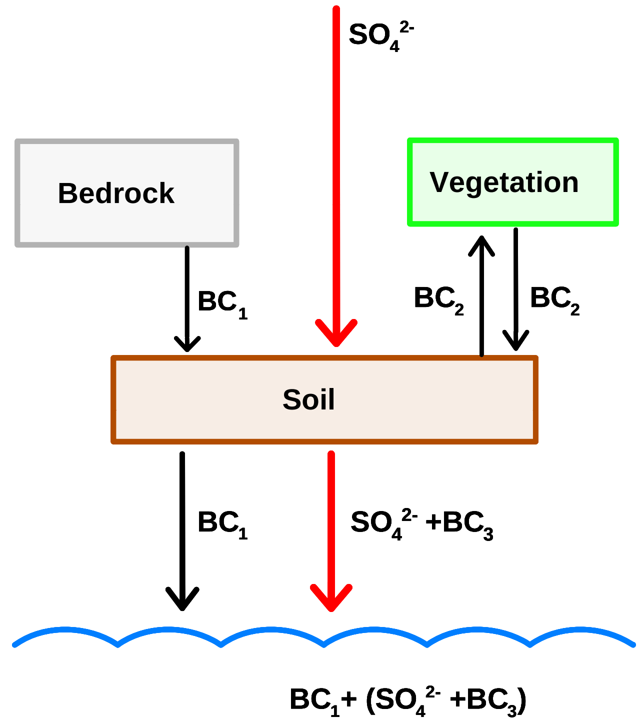
Base-Cation Depletion in Watershed Soils

Pre-Industrial Period



Base-cation supply in soil is stable.

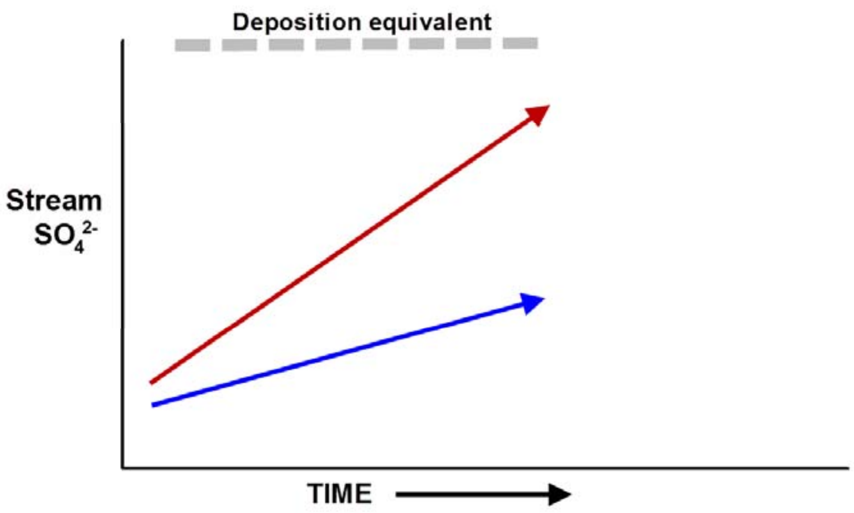
Post-Industrial Period



Base-cation supply in soil is depleted.

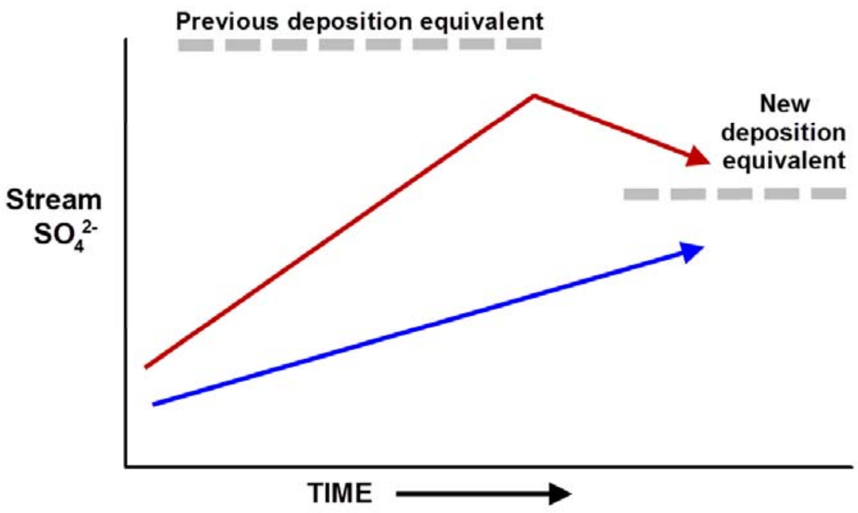
Effect of Sulfur Retention in Watershed Soils

Before emission reductions



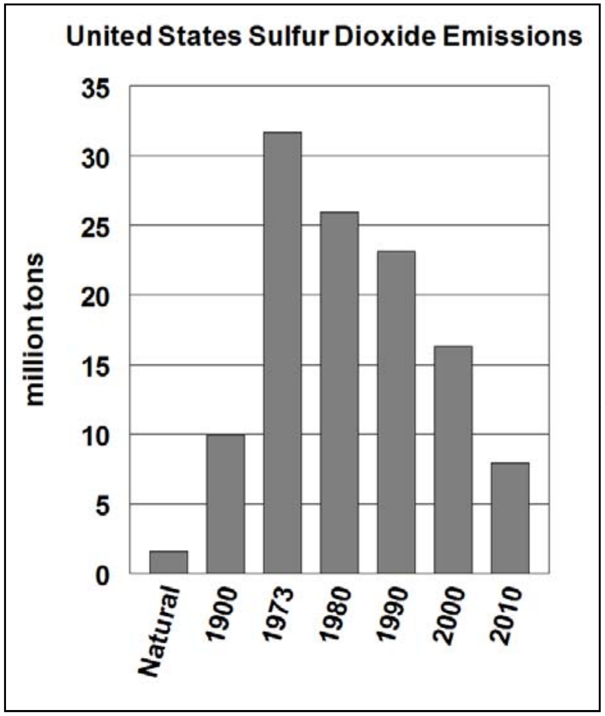
Stream concentrations increase as soils accumulate sulfur.

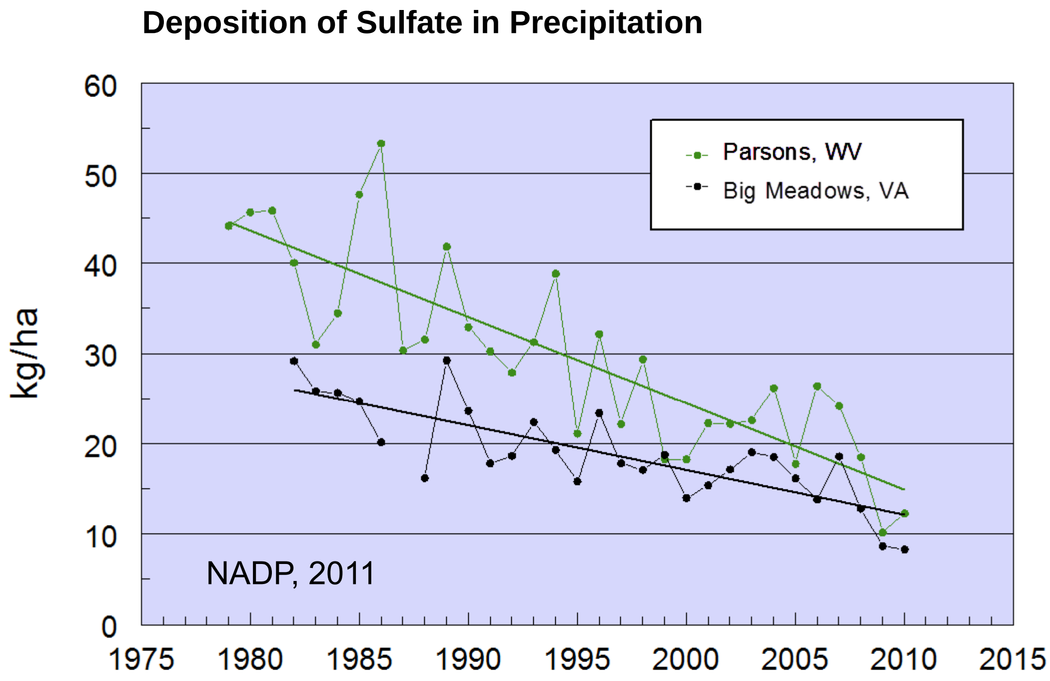
After emission reductions



Stream concentrations increase or decrease depending on relative deposition equivalent.

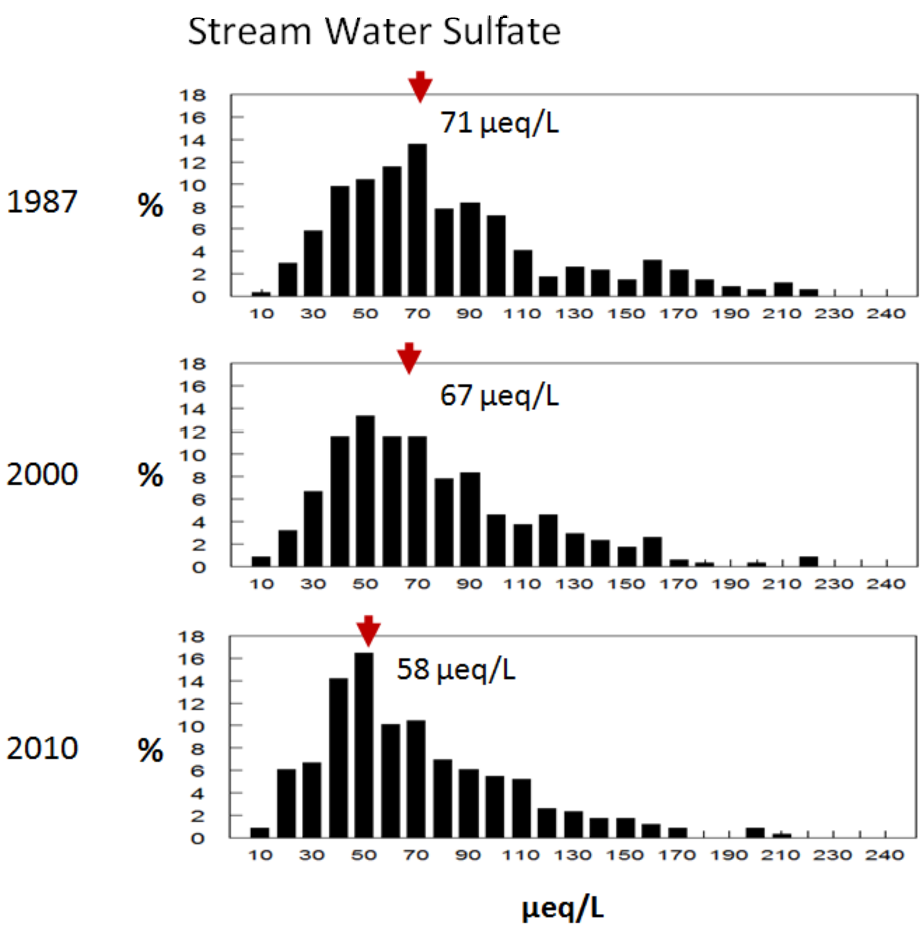
Large Reductions in Sulfur Emissions and Deposition Have Been Achieved



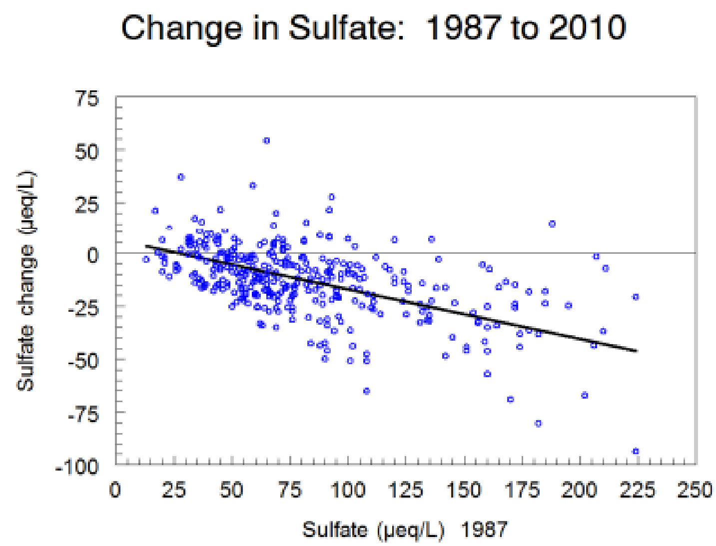


Most of the recent decline can be attributed to implementation of the Clean Air Act Amendments of 1990. Emissions from electric generating units in 2010 were about 30% below the required emissions cap.

Change in Stream Sulfate Concentrations

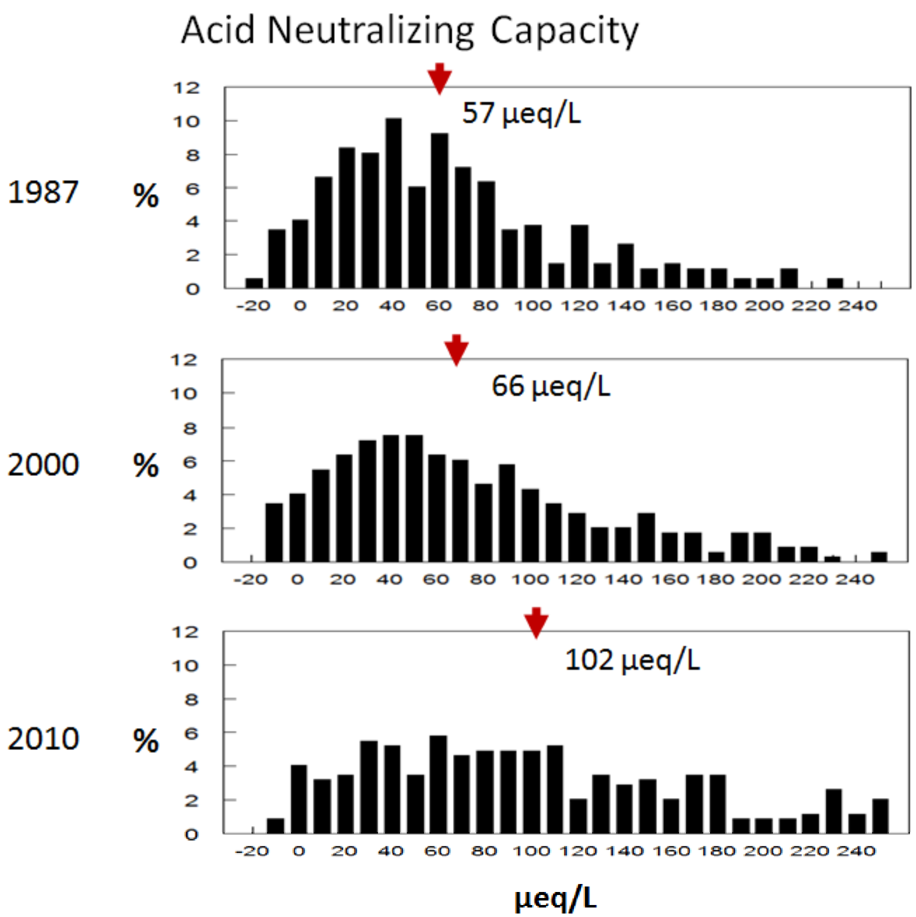


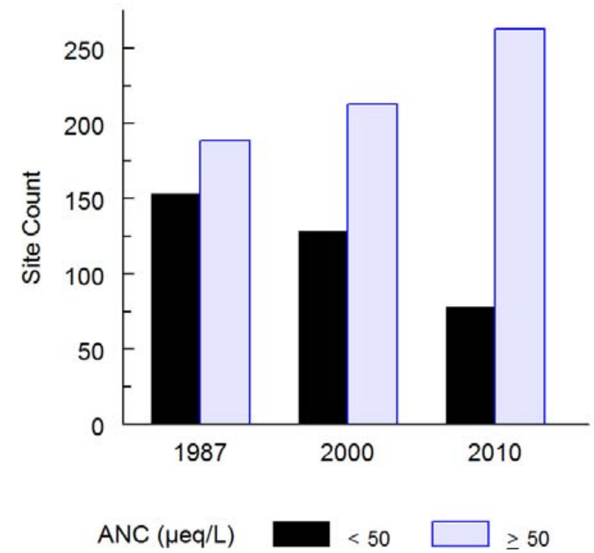
The median sulfate concentration decreased 18% (13 µeq/L) between the 1987 and 2010 surveys.



Consistent with expectations, sulfate concentrations decreased most in streams with the highest initial (1987) concentrations.

Change in Stream Acid Neutralizing Capacity





Between the first and third surveys the percentage of streams with ANC < 50 µeq/L decreased from 45% to 23%.

The median stream ANC value increased 44% (45 µeq/L) between the 1987 and 2010 surveys.

An Inconsistency:
the decrease in sulfate concentrations is insufficient to account for the increase in acid neutralizing capacity

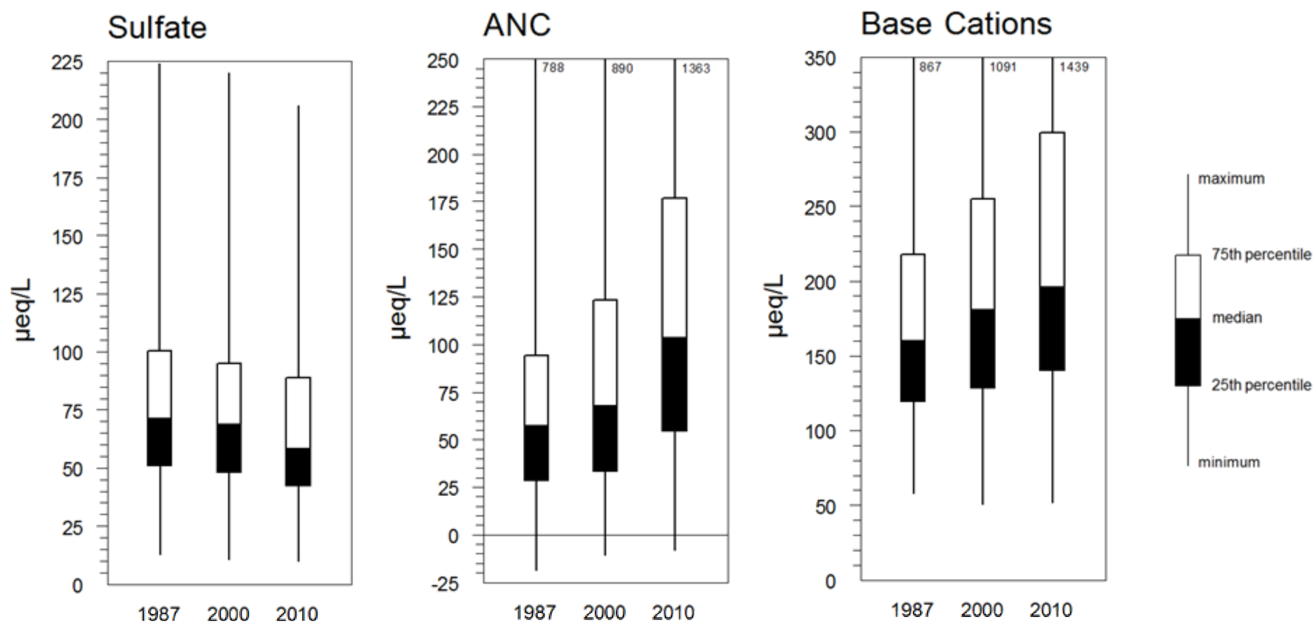
ANC = Base Cations – Acid Anions

$+45\ \mu eq/L = \Delta(\text{Base Cations}) - (-13\ \mu eq/L)$

The decrease in median sulfate accounts for less than 1/3 of the increase in ANC.

Much of the Increase in ANC is Associated With Increasing Base Cations

Range and interquartile distributions for sites sampled in the three surveys.



Medians of differences in concentrations for samples collected at the same site in each of the three surveys.

	1987-2010 Entire Record	1987-2000 First Interval	2000-2010 Second Interval
Sulfate (µeq/L)	-11.9	-5.4	-5.8
ANC (µeq/L)	+40.6	+10.2	+27.8
Sum of base cations (µeq/L)	+32.57	+13.5	+13.9

- all medians of differences significant at p <0.001

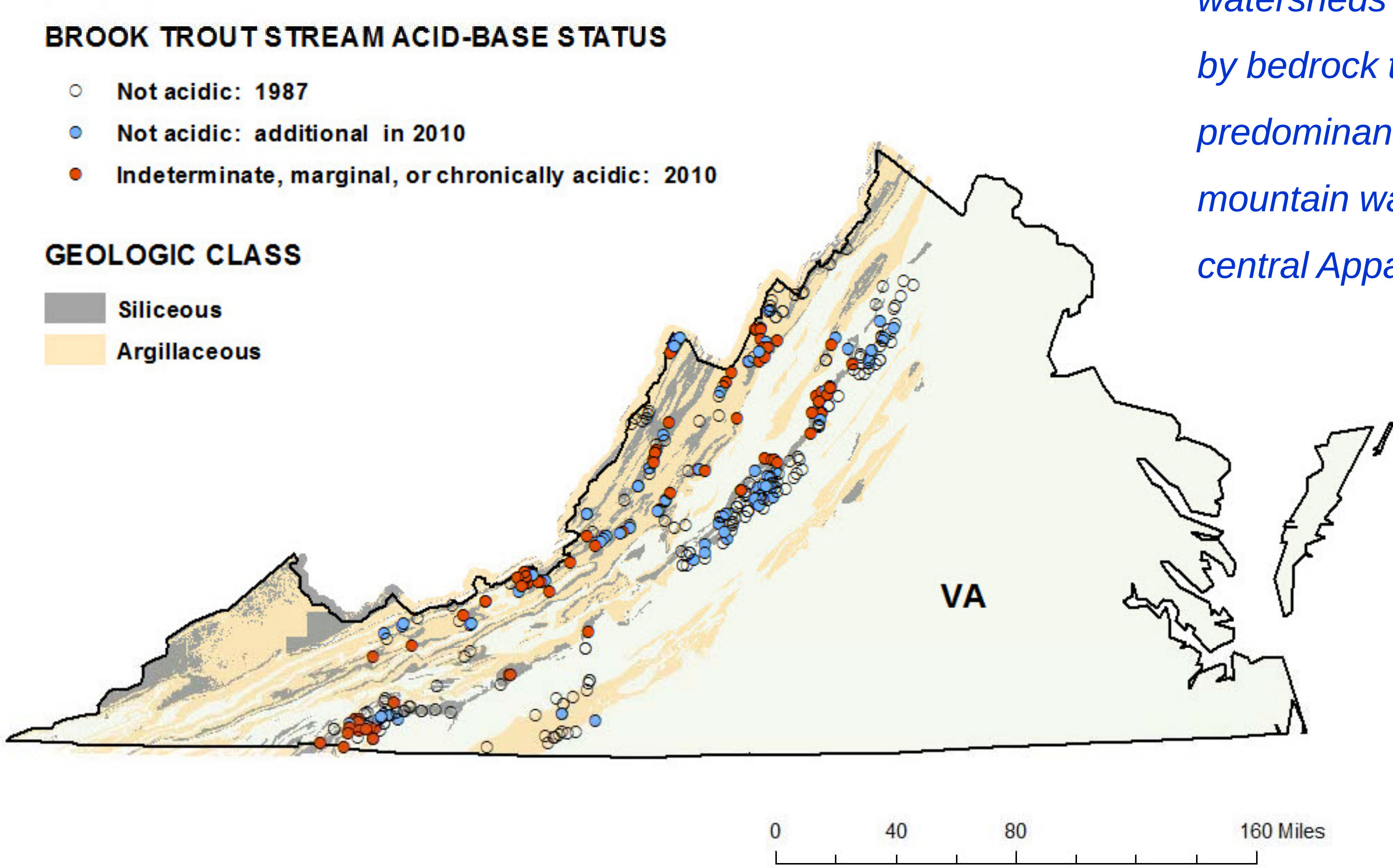
Possible Explanations for the Unexpected Increase in Base Cations

- Differences in stream discharge between the three survey windows.
- Redistribution of base cations due to the gypsy moth infestation.
- A change in the mobility of organic anions.
- Increased soil temperature and increased carbonic acid weathering.

A Key Observation

– a large class of streams show minimal improvement

Most of the remaining streams with ANC ≤ 50 µeq/L drain watersheds that are underlain by bedrock types that are predominant in the forested mountain watersheds of the central Appalachian region.



Summary of Observations

- Sulfate concentrations declined in most streams between the 1987 and 2010 surveys – though not as much as reductions in emissions and deposition.

- Stream ANC increased in most streams – partly due to decreased sulfate, but in larger part due to increased base cations.

- The increase in base cation concentrations is unexpected and not well understood. It may be unsustainable.

- A large subset of streams associated with base-poor bedrock has not shown substantial improvement.

More Information and Access to Data

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