Virginia Trout Stream Sensitivity Study

2010 Survey

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TOPICS

- Background on the VTSSS program
- VTSSS 2010 survey results
- Regional context
- Additional analysis

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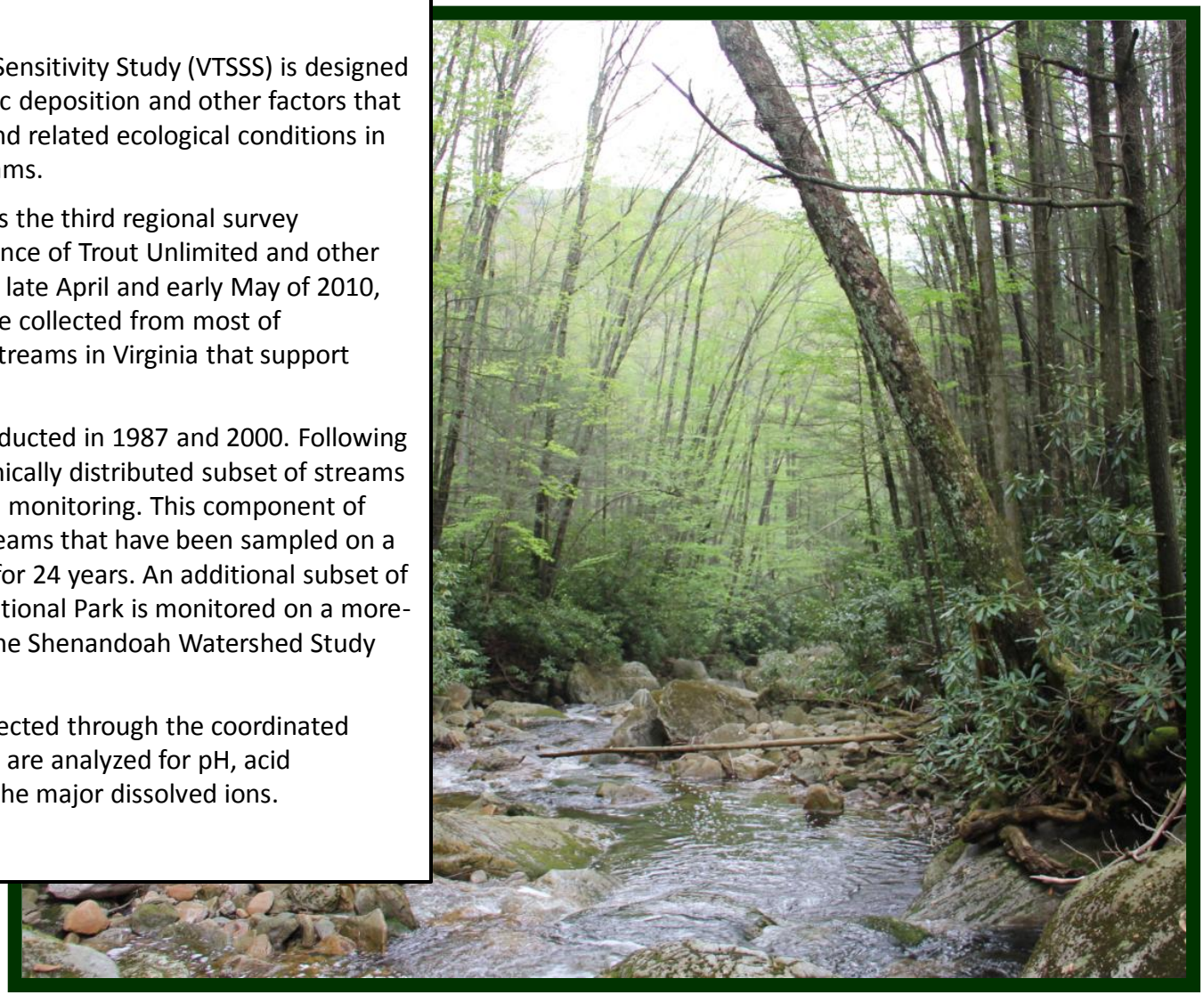
VTSSS program overview

The Virginia Trout Stream Sensitivity Study (VTSSS) is designed to track the effects of acidic deposition and other factors that determine water quality and related ecological conditions in Virginia's native trout streams.

The VTSSS 2010 survey was the third regional survey conducted with the assistance of Trout Unlimited and other volunteer organizations. In late April and early May of 2010, stream water samples were collected from most of the mountain headwater streams in Virginia that support reproducing brook trout.

Previous surveys were conducted in 1987 and 2000. Following the first survey, a geographically distributed subset of streams was selected for long-term monitoring. This component of VTSSS now includes 66 streams that have been sampled on a seasonal (quarterly) basis for 24 years. An additional subset of streams in Shenandoah National Park is monitored on a more-intensive basis as part of the Shenandoah Watershed Study (SWAS) program.

Stream water samples collected through the coordinated VTSSS and SWAS programs are analyzed for pH, acid neutralizing capacity, and the major dissolved ions.



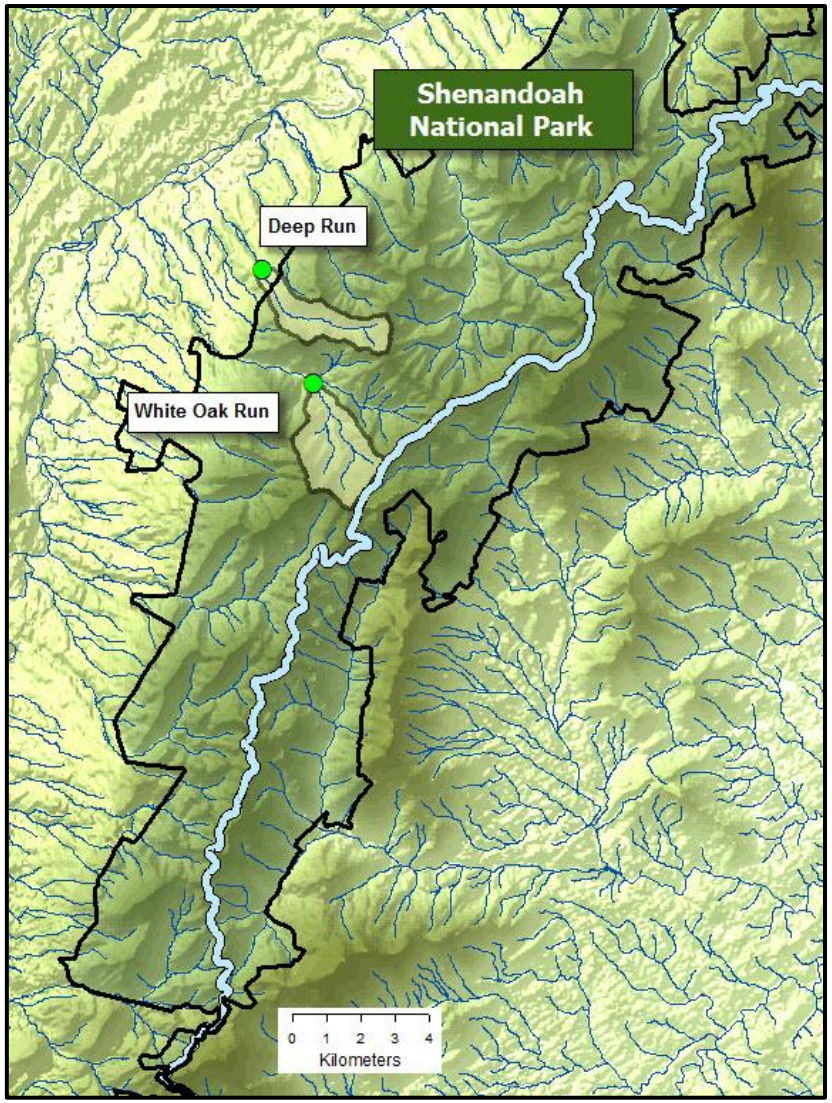
The Shenandoah Watershed Study

. . . earlier evidence for stream acidification

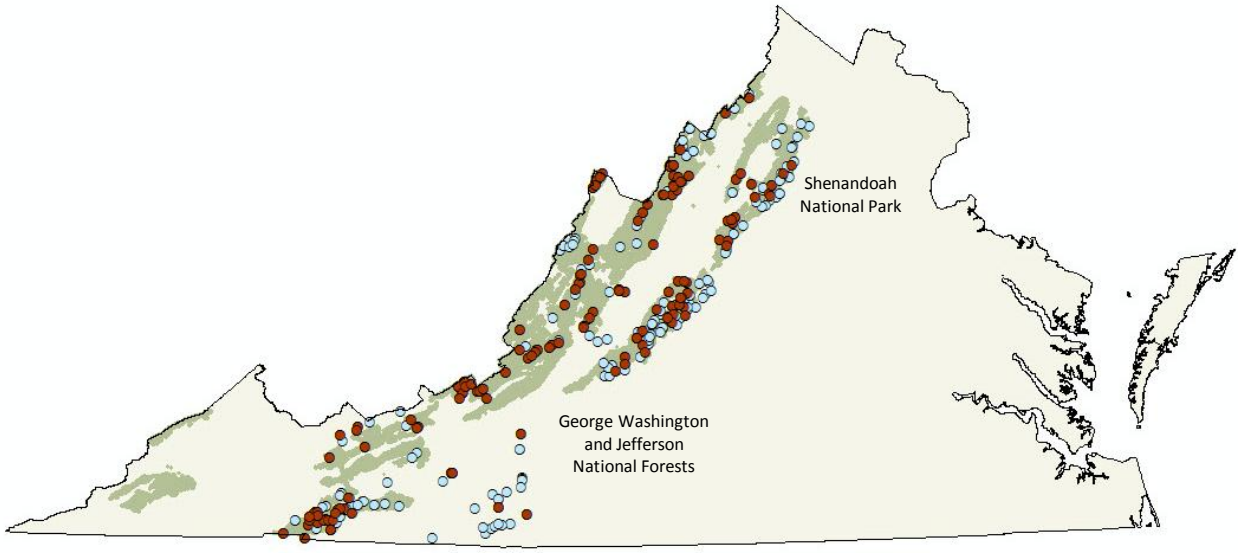
Research on stream acidification in the Virginia mountains was conducted by the Shenandoah Watershed Study (SWAS) beginning in 1979, with monitoring on two streams, White Oak Run and Deep Run, in the southern part of the Shenandoah National Park.

Increasing sulfate and decreasing acid neutralizing capacity concentrations were observed in both streams in the 1980s —indicating acidification due to acidic atmospheric deposition.

The VTSSS program extended this research to streams in the broader mountain region.



The Virginia Trout Stream Sensitivity Study



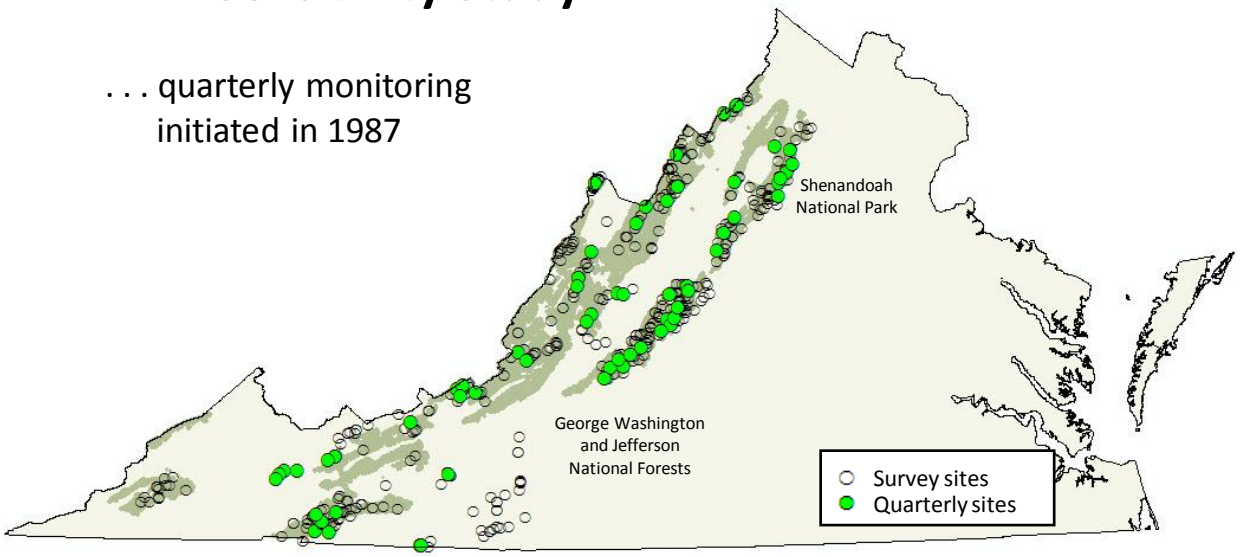
The first VTSSS survey of native brook trout streams throughout western Virginia was conducted in the spring of 1987. Stream water samples were collected at 379 sites in 34 counties. The results indicated widespread sensitivity to acidification.

- **Not acidic**: reproducing populations of brook trout expected where habitat suitable
- **Indeterminate, marginal, or chronically acidic**: extremely sensitive to acidification, sub-lethal and/or lethal effects on brook trout possible or probable

Approximately 50% of the streams surveyed in 1987 were identified as substantially impaired by acidification based on acid neutralizing capacity (ANC) values of less than 50 µeq/L.

The Virginia Trout Stream Sensitivity Study

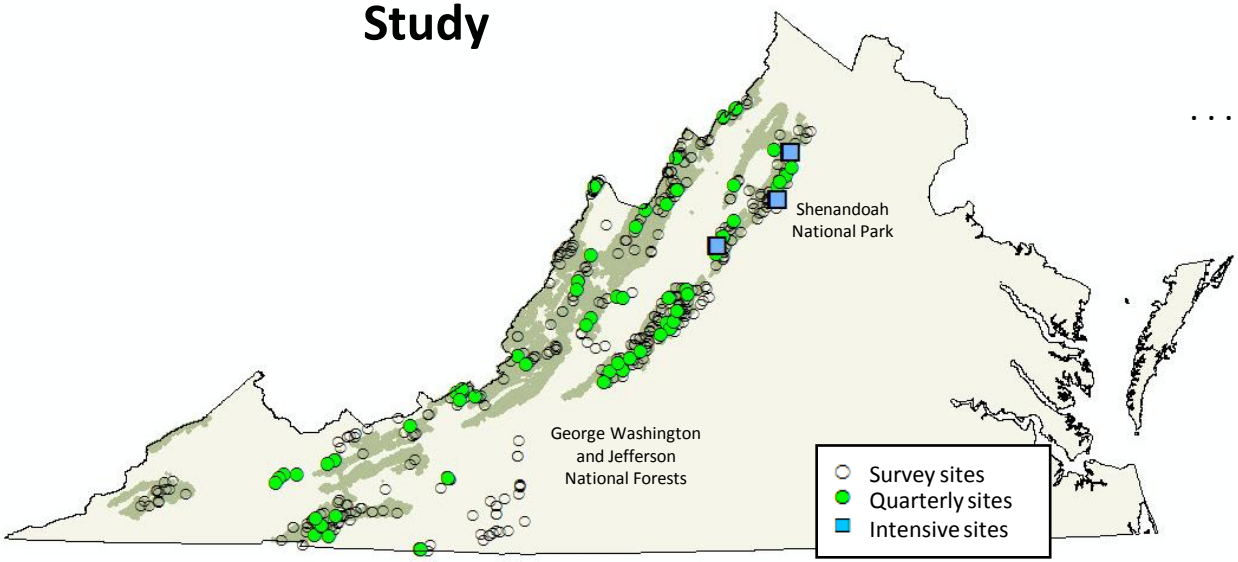
. . . quarterly monitoring initiated in 1987



A subset (n = 66) of the 1987 survey streams was selected for long-term quarterly monitoring. Most of these streams are in National Park, National Forest, or Virginia Wildlife Management Areas.

Quarterly long-term monitoring sites were selected to represent relatively pristine conditions and regional bedrock distribution.

The Shenandoah Watershed Study

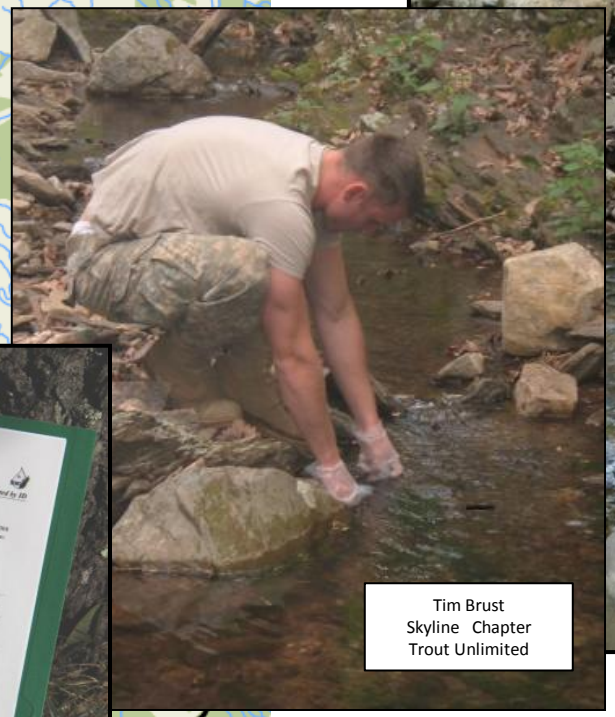


. . . monitoring initiated in 1979

Intensive stream monitoring continues in Shenandoah National Park. Data collection on three streams includes weekly sampling, automated high-flow sampling, and continuous flow gauging.

VTSSS 2010 Survey

- 384 streams sampled in 34 counties
- 18 Trout Unlimited chapter coordinators
- 165 volunteer sample collectors



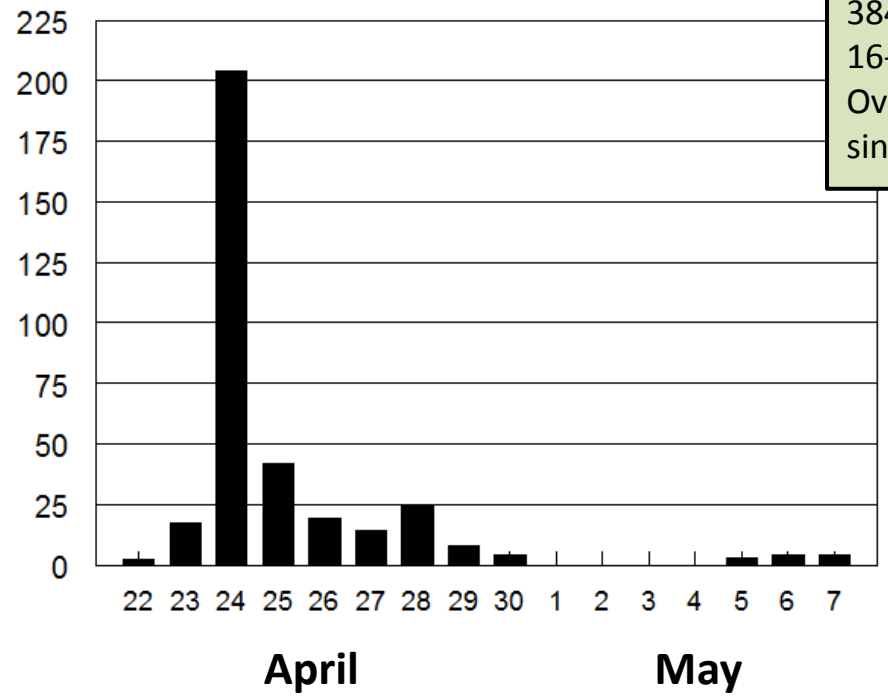
Tim Brust
Skyline Chapter
Trout Unlimited

Stan Ikonen
Winchester Chapter
Trout Unlimited

Sample collection and documentation followed protocols published on the VTSSS 2010 website.

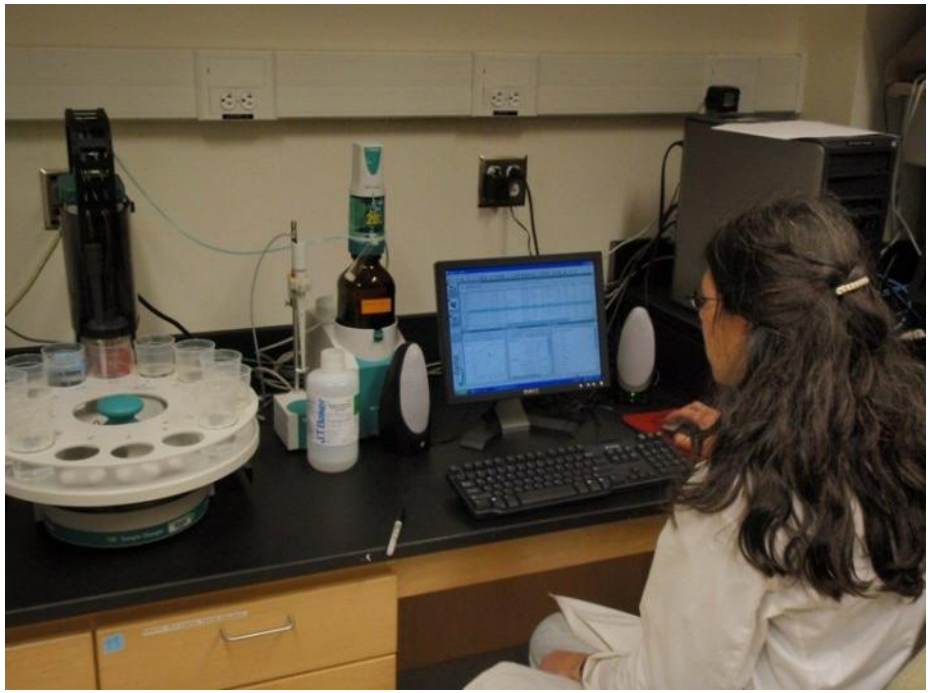
http://swas.evsc.virginia.edu\VTSSS-2010\Survey.html

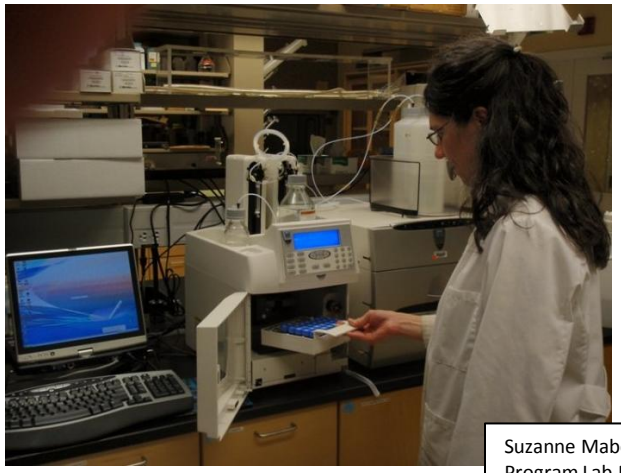
The Sample Collection Window



384 samples were collected during a 16-day period in the spring of 2010. Over 200 samples were collected on a single day.

Sample analysis





Suzanne Maben, VTSSS Program Lab Manager

The samples were delivered to the project lab at the UVA Department of Environmental Sciences in Charlottesville. Sample analyses included the major acid-base constituents in Virginia's mountain stream water.

Acid-neutralizing capacity (ANC)
pH

Conductance

Sulfate
Nitrate
Chloride

Ions mainly derived from atmospheric deposition.

Calcium
Magnesium
Sodium
Potassium

Ions mainly derived from watershed soil and rock.

Survey results

The VTSSS 2010 survey data provide evidence for partial recovery from stream acidification.

Relative to previous surveys:

- acid neutralizing capacity (ANC) in stream waters increased
- sulfate concentrations in stream waters decreased

Recovery is indicated by increasing ANC and decreasing sulfate concentrations. The following slides provide more information concerning these changes.

Acid neutralizing capacity (ANC)

ANC indicates the balance between dissolved acids and bases in surface water. ANC provides a measure of the acid-buffering capacity of surface water and determines pH. Variation in ANC among brook trout streams in Virginia is due to differences in watershed bedrock composition and differences in historic exposure to acidic atmospheric deposition.

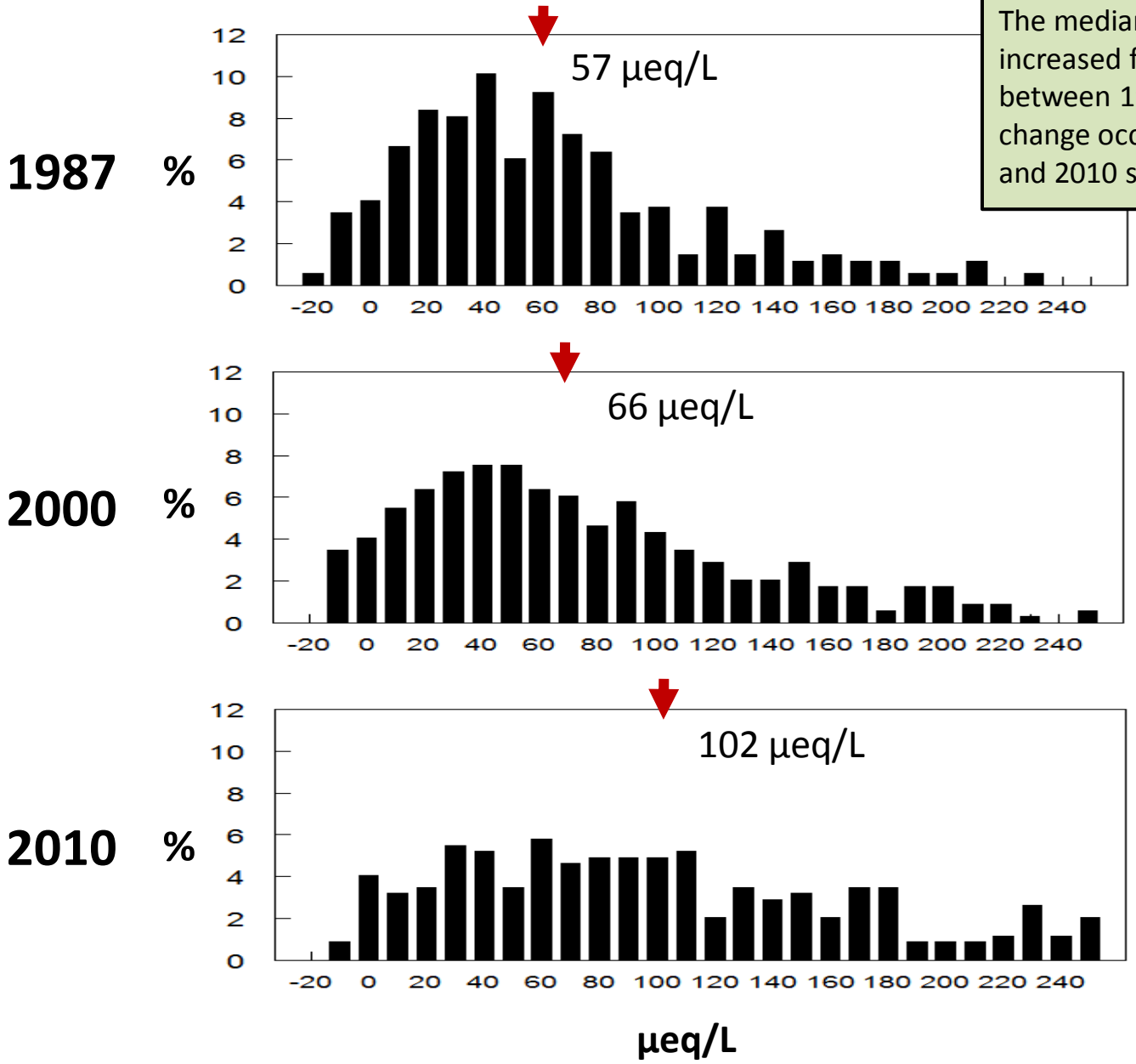
*ANC response categories have been determined for brook trout in Virginia.**

Response Category	ANC Class	ANC Range µeq/L	Brook Trout Response
Suitable	Not acidic	>50	Reproducing brook trout populations expected where habitat suitable
Indeterminate	Indeterminate	20-50	Extremely sensitive to acidification; brook trout response variable
Marginal	Episodically acidic	0-20	Sub-lethal and/or lethal effects on brook trout possible
Unsuitable	Chronically acidic	<0	Lethal effects on brook trout probable

Note: ANC range based on volume-weighted annual mean.

* Bulger, Cosby, and Webb (1998). Acid Rain: Current and Projected Status of Fish Communities in the Southeastern U.S. in the Context of Continued Acidic Deposition

Acid Neutralizing Capacity

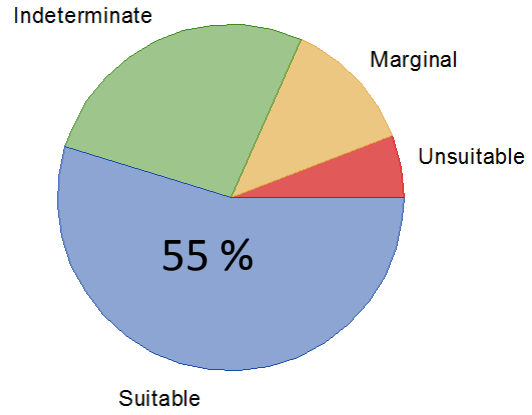


The median stream water ANC increased from 57 to 102 µeq/L between 1987 and 2010. Most of the change occurred between the 2000 and 2010 surveys.

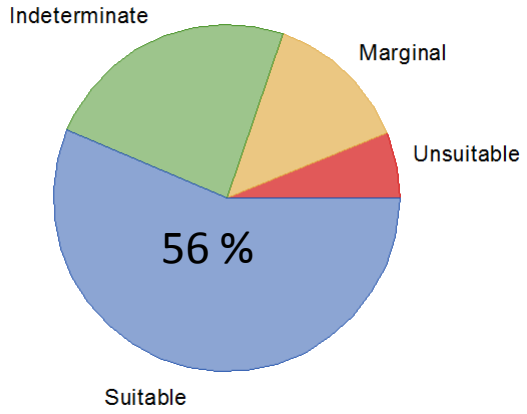
Note: comparisons are among stream sites that were sampled in all three surveys (n = 345).

ANC change in relation to brook trout response categories

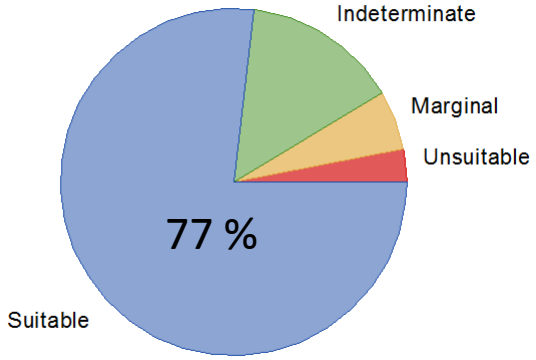
1987



2000



2010

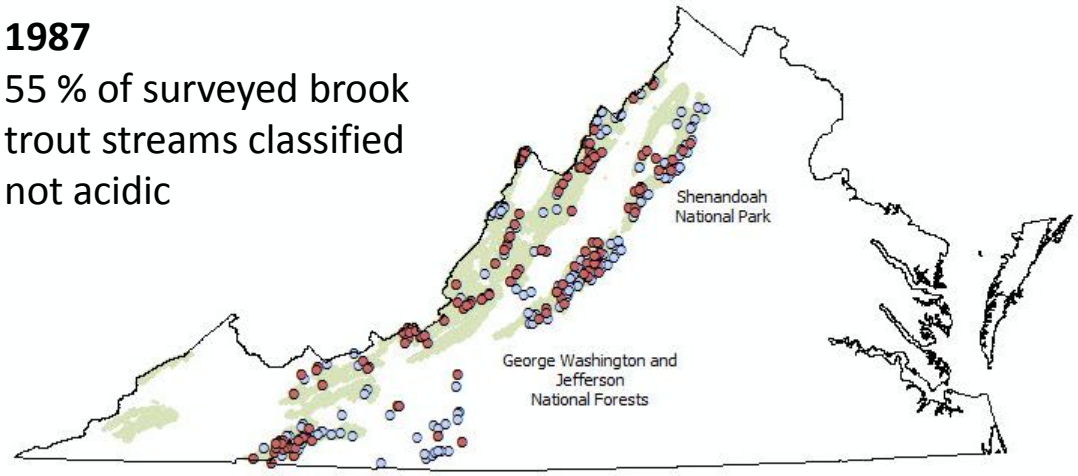


The percentage of survey streams in the suitable category (ANC $\geq$ 50 µeq/L) increased from 55-56% in 1987 and 2000 to 77% in 2010.

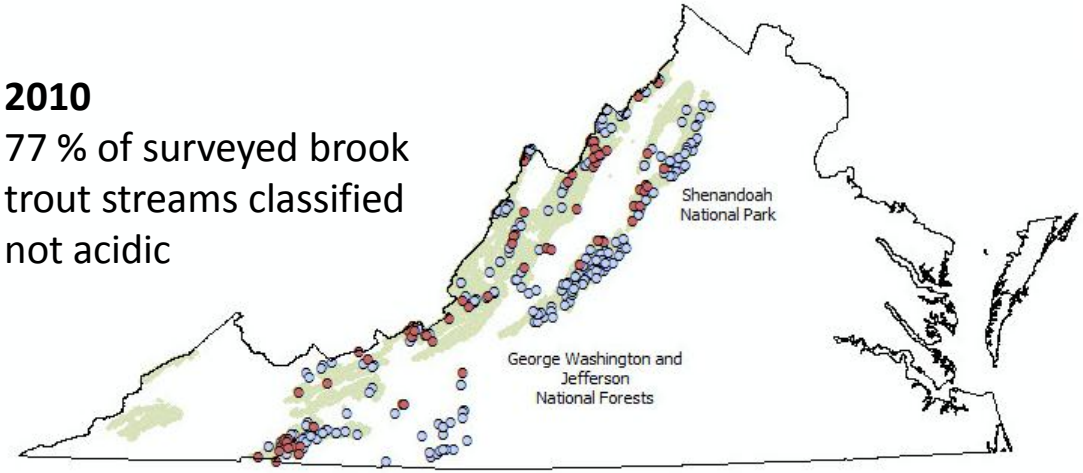
The geography of ANC improvement

ANC improvement between the 1987 and 2010 surveys was most pronounced in northern and central Blue Ridge Mountain streams.

1987
55 % of surveyed brook trout streams classified not acidic



2010
77 % of surveyed brook trout streams classified not acidic



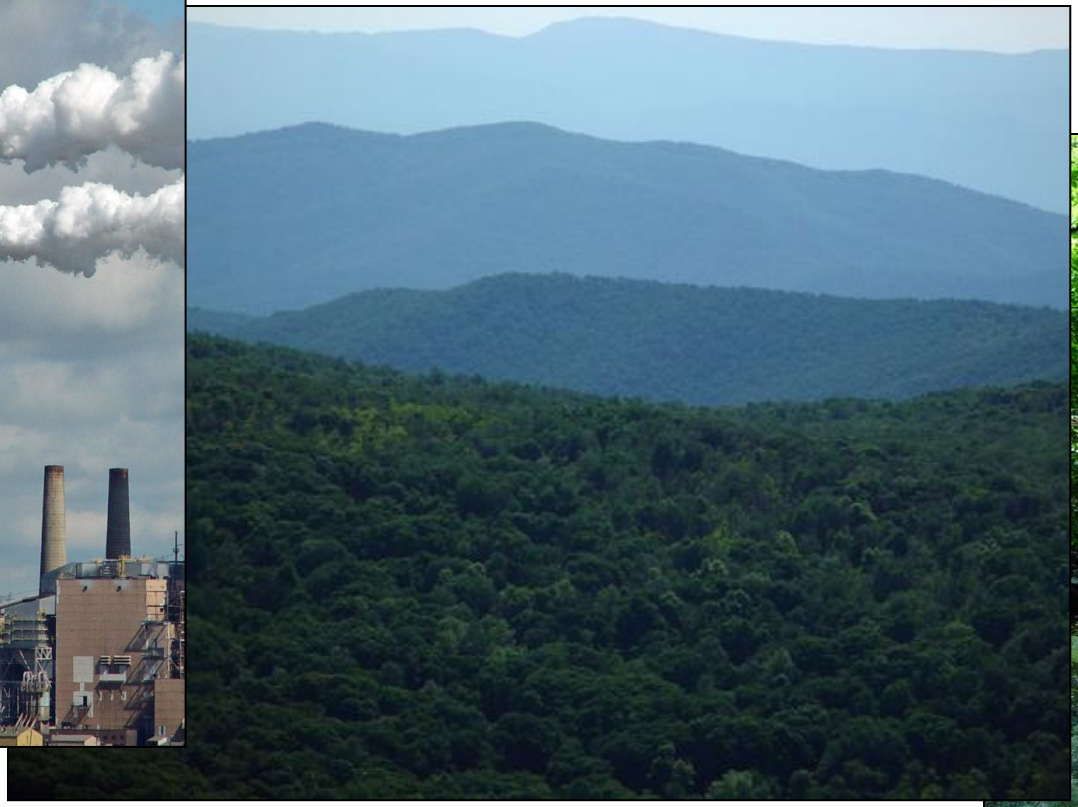
- **Not acidic**: reproducing populations of brook trout expected where habitat suitable
- **Indeterminate, marginal, or chronically acidic**: extremely sensitive to acidification, sub-lethal and/or lethal effects on brook trout possible or probable

Sulfate

Stream water acidification due to atmospheric deposition in western Virginia is driven by sulfur derived mainly from coal-burning electricity generation facilities to the west of Virginia.

Although both sulfur and nitrogen compounds contribute to the acidity of atmospheric deposition in western Virginia, nitrogen is a nutrient in watersheds and generally does not contribute to stream acidification.

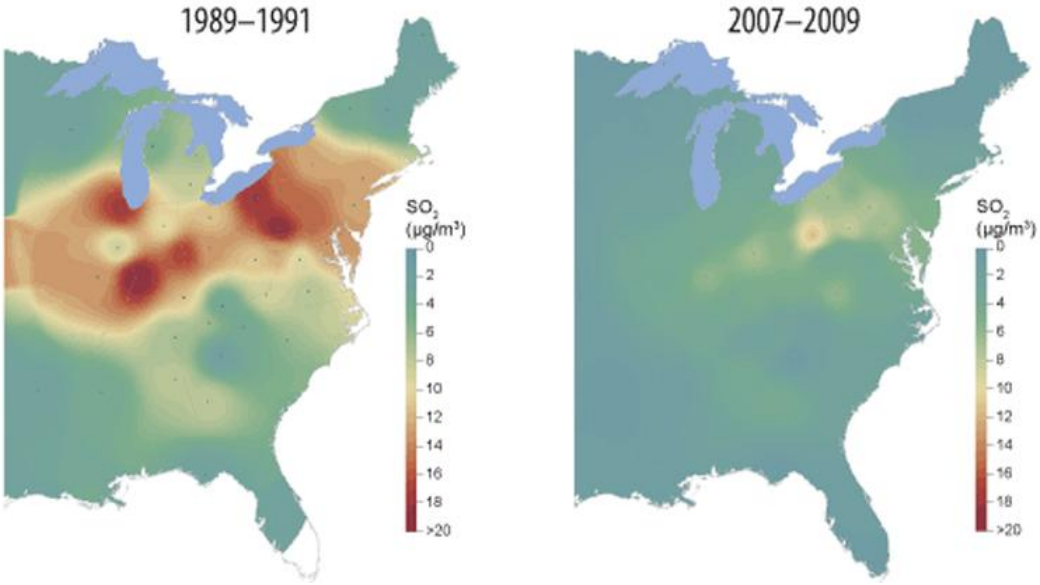
Sulfur, emitted as sulfur dioxide by coal-burning power plants, is measured in stream water as sulfate.



The Acid Rain Program

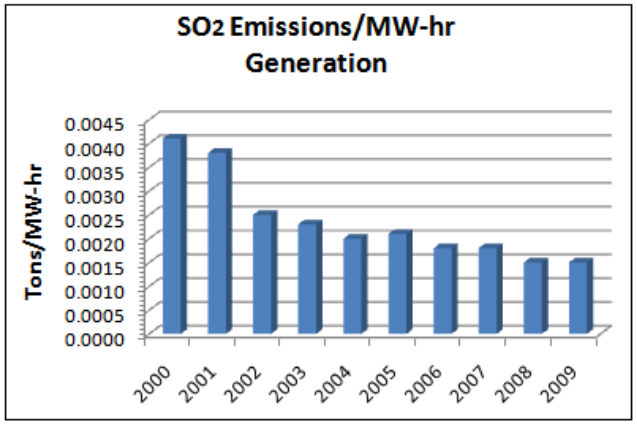
The Clean Air Act Amendments of 1990 established a phased approach to reducing sulfur dioxide emissions, resulting in reduced sulfur concentrations in the atmosphere, in deposition, and in surface waters.

Between 1990 and 2009 sulfur dioxide emissions from coal-fired power plants declined by 64%.



Change in annual ambient mean sulfur dioxide concentrations: comparison between 3-year means

Source: www.epa.gov/airmarkets/progress/ARP09_3.html

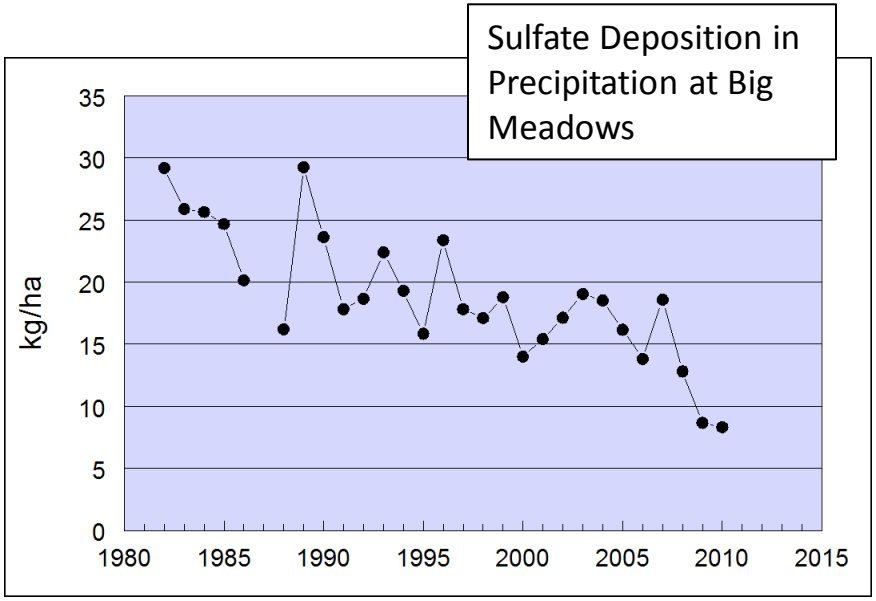


Improvements close to home: Sulfur emissions declined at Dominion power plants during the period, 2000–2007, while generation increased by more than 50%. Approximately 95% of sulfur dioxide is now removed from emissions at the regional utility's largest coal-fired plant, Mount Storm (shown in slide 15), which is upwind of western Virginia and Shenandoah National Park.

Source: www.dom.com/about/environment/report/index.jsp

The Acid Rain Program

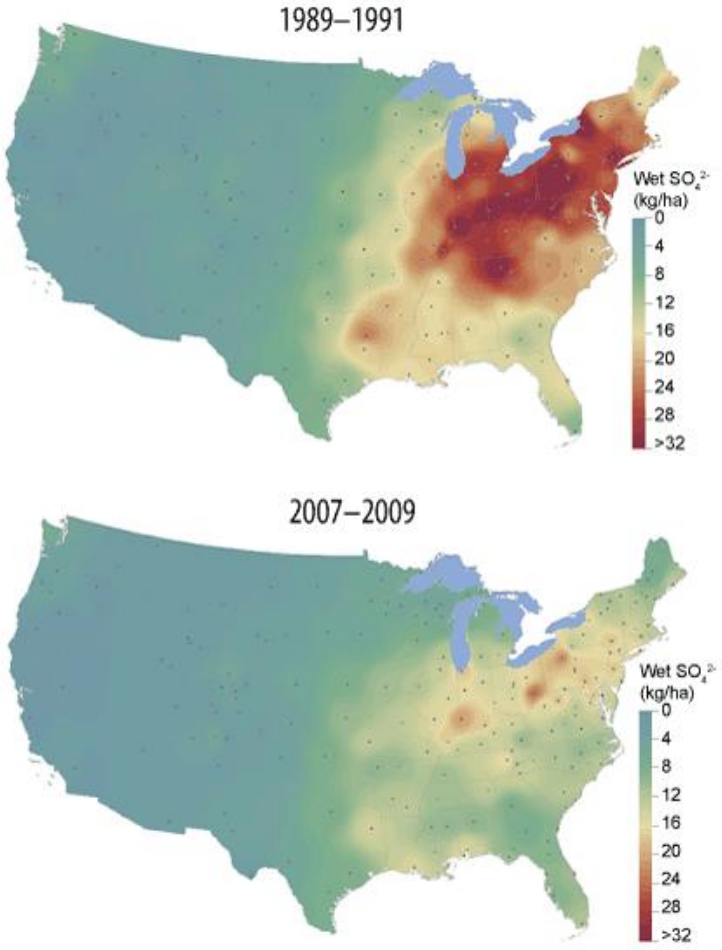
The reduction in emissions from coal-fired power plants has resulted in reduced sulfur deposition to Virginia's mountain watersheds and throughout the eastern U.S.



Sulfur deposition in precipitation at Big Meadows in Shenandoah National Park has decreased by about two-thirds from maximum levels observed in the 1980s.

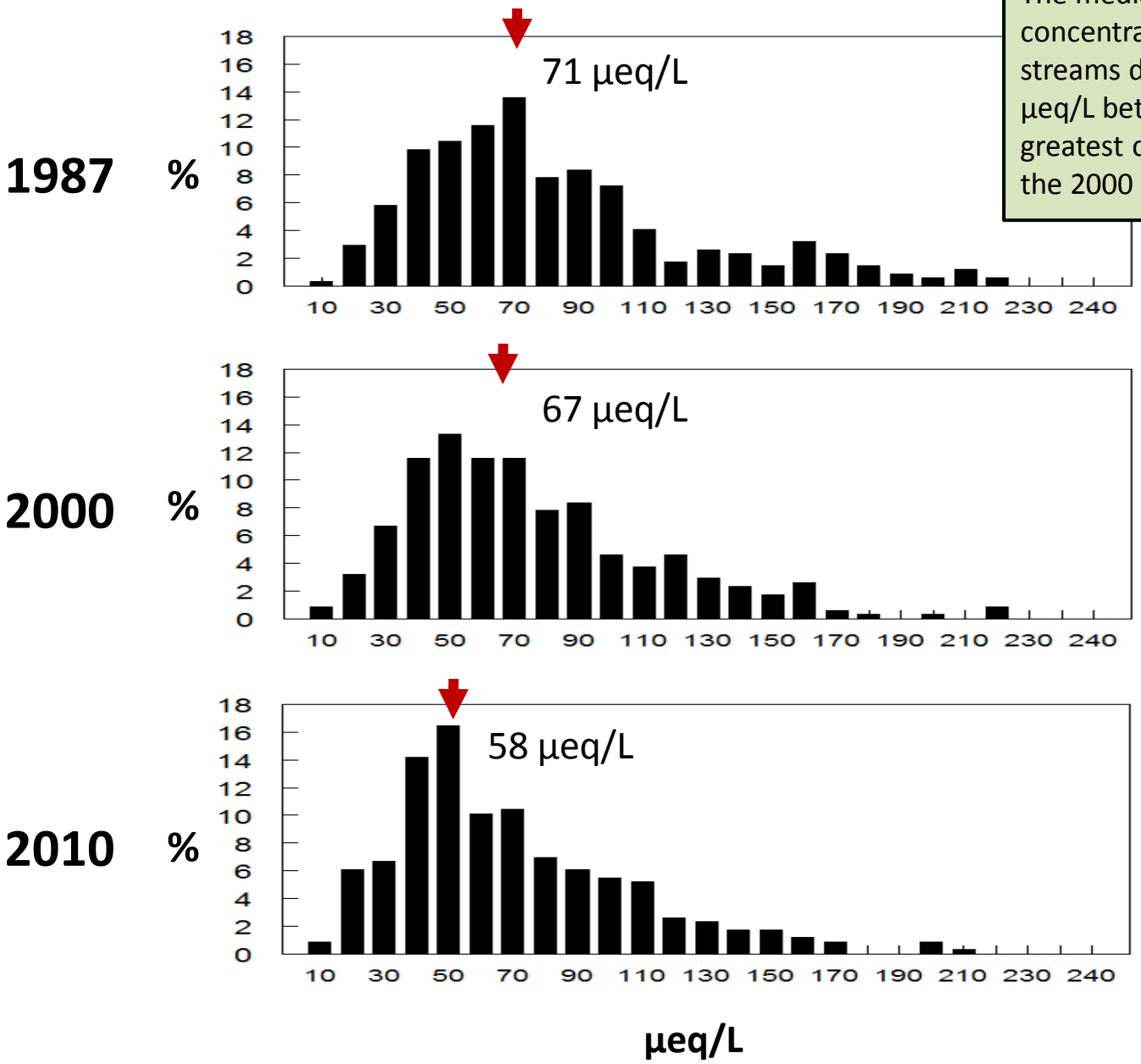
Source: nadp.sws.uiuc.edu/

Change in regional deposition of sulfate in precipitation: comparison between 3-year means



Source: nadp.sws.uiuc.edu/

Stream Water Sulfate



The median stream water sulfate concentration in VTSSS survey streams decreased from 71 to 58 µeq/L between 1987 and 2010. The greatest change occurred between the 2000 and 2010 surveys.

Note: comparisons are among stream sites that were sampled in all three surveys (n = 345).

Context for interpretation of VTSSS 2010 results

The VTSSS 2010 survey data provide evidence for recovery from acidification when compared with data from the 1987 and 2000 surveys.

However, information provided by the VTSSS quarterly monitoring data are somewhat less encouraging.

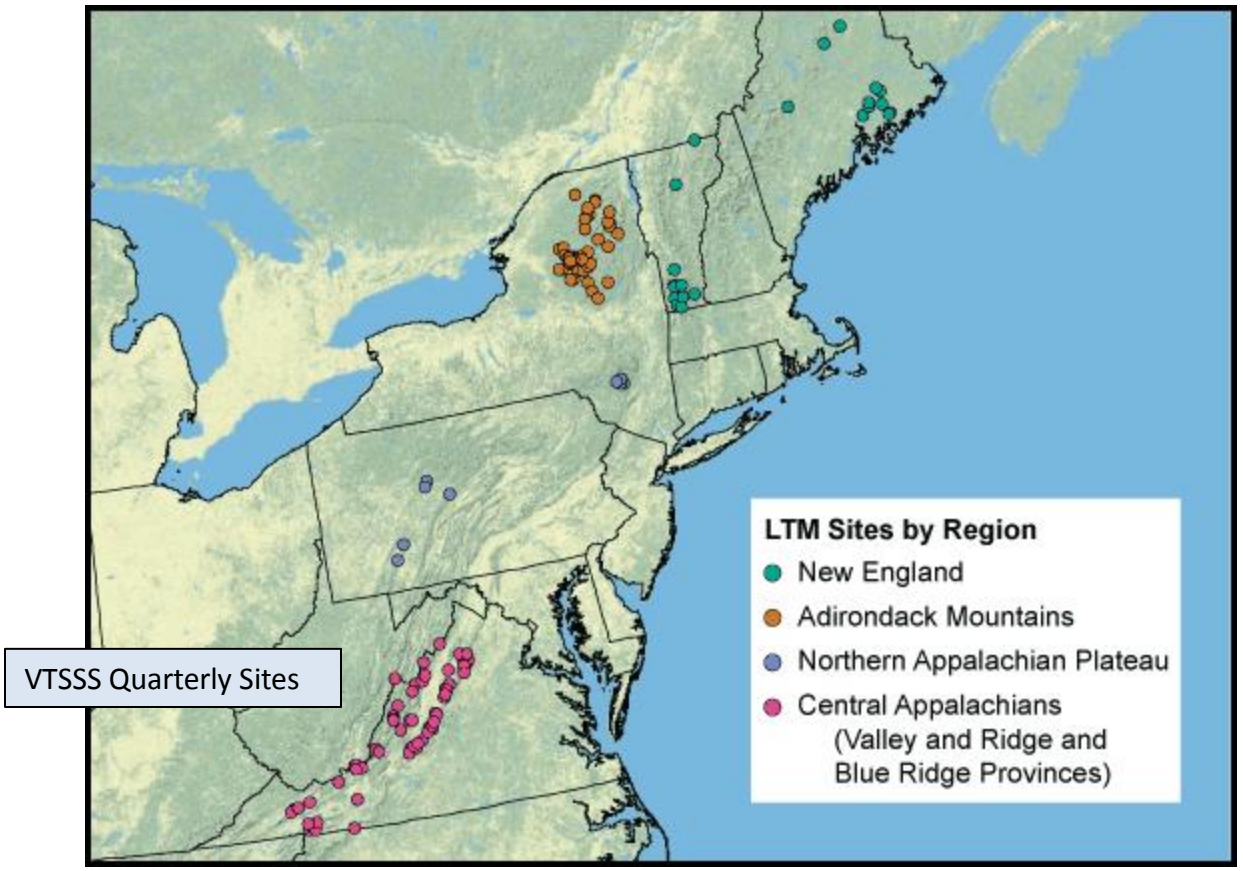
Between 1990 and 2008:

- *ANC increased in some VTSSS quarterly sample streams, but decreased in others.*
- *In contrast with surface waters in other eastern U.S. regions affected by acidic deposition, sulfate concentrations in many VTSSS quarterly sample streams increased.*

As described in following slides, these observations are based on a multiregional analysis of surface water response to reductions in acid-forming emissions.

Regional context

The VTSSS quarterly stream monitoring sites are part of the EPA Long-Term Monitoring (LTM) program established to track the environmental results of air pollution reductions achieved through the Clean Air Act.



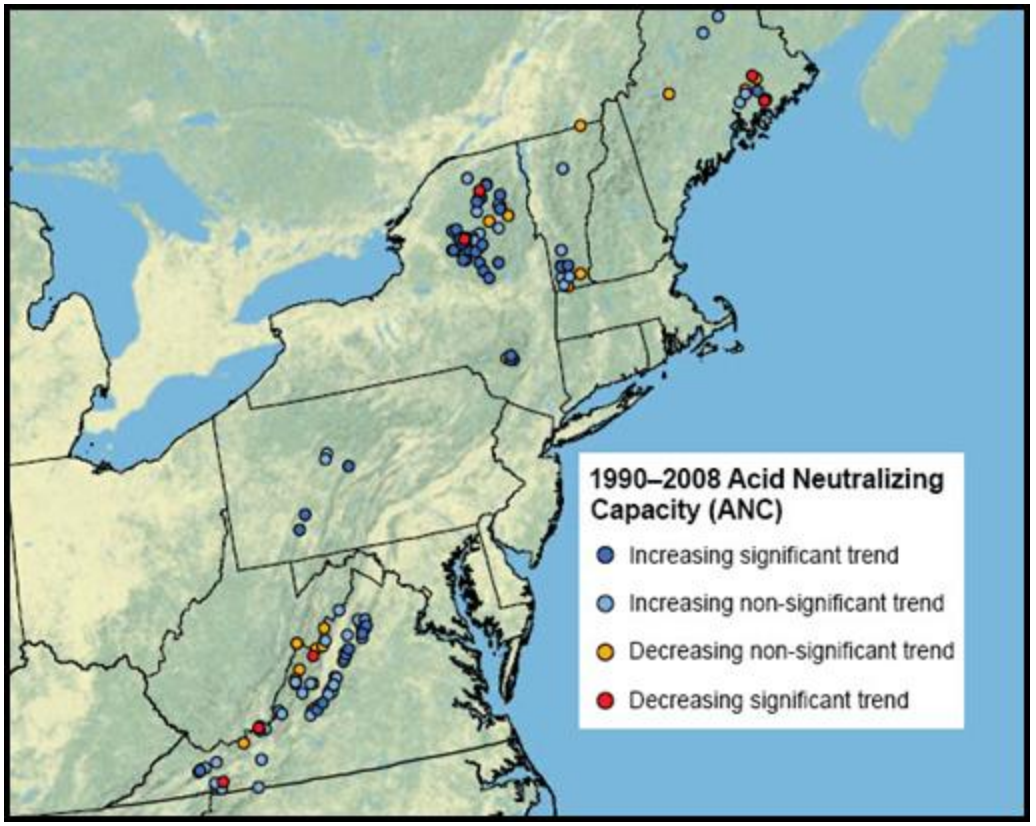
Adirondack Mountains	5	lakes in NY
Catskills/N. Appalachian Plateau	9	streams in NY and PA
New England	26	lakes in ME and VT
Central Appalachians	66	streams in VA

Source: www.epa.gov/airmarkets/progress/ARP09_3.html

Acid neutralizing capacity

ANC increased in some VTSSS study streams and decreased in others between 1990 and 2008.

The percentage of sites with ANC improvement was less than in the Adirondack Mountains or the Catskills/Northern Appalachian regions.



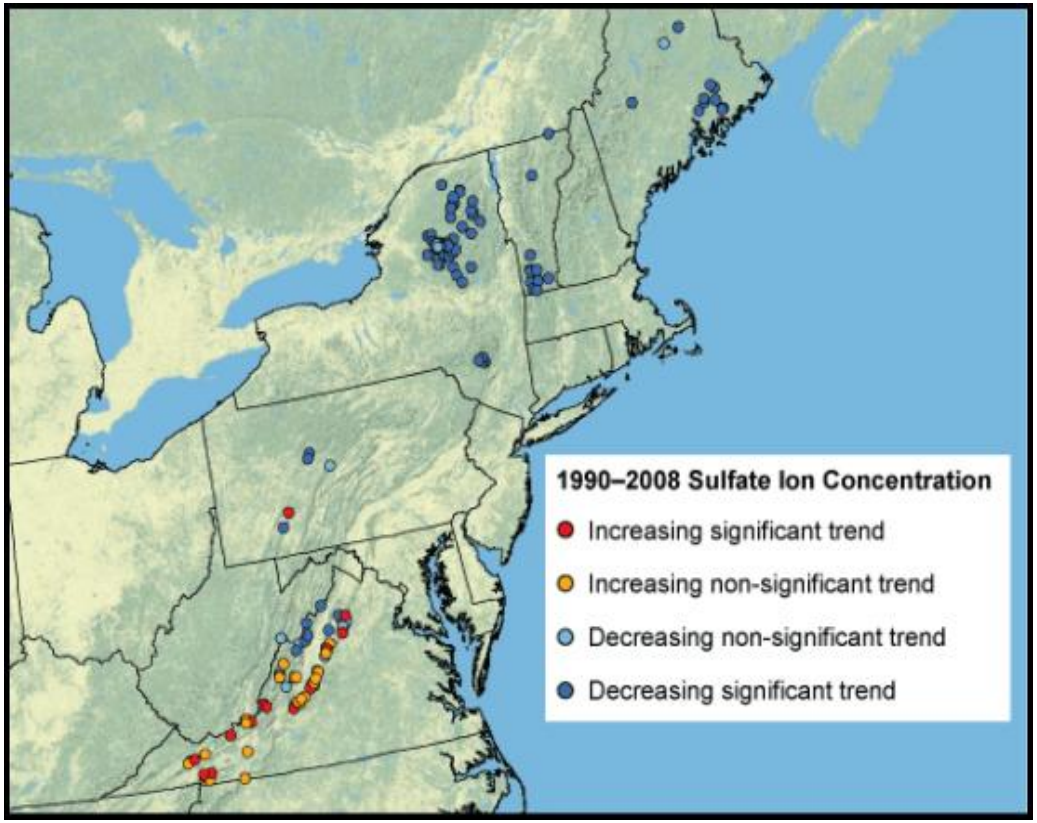
	N	% of sites with improving ANC trend
Adirondack Mountains	50	58 %
Catskills/N. Appalachian	9	56 %
New England	26	12 %
Central Appalachians	66	12 %

Source: www.epa.gov/airmarkets/progress/ARP09_3.html

Sulfate

Sulfate concentrations in many western Virginia streams increased between 1990 and 2008. Sulfate concentrations in northeastern surface waters decreased during the same period.

This regional difference in response to reduced sulfur emissions is attributed to differences in soil properties. Soils in the southeastern U.S. accumulate sulfate, resulting in a delayed response to changes in sulfur deposition to watersheds.

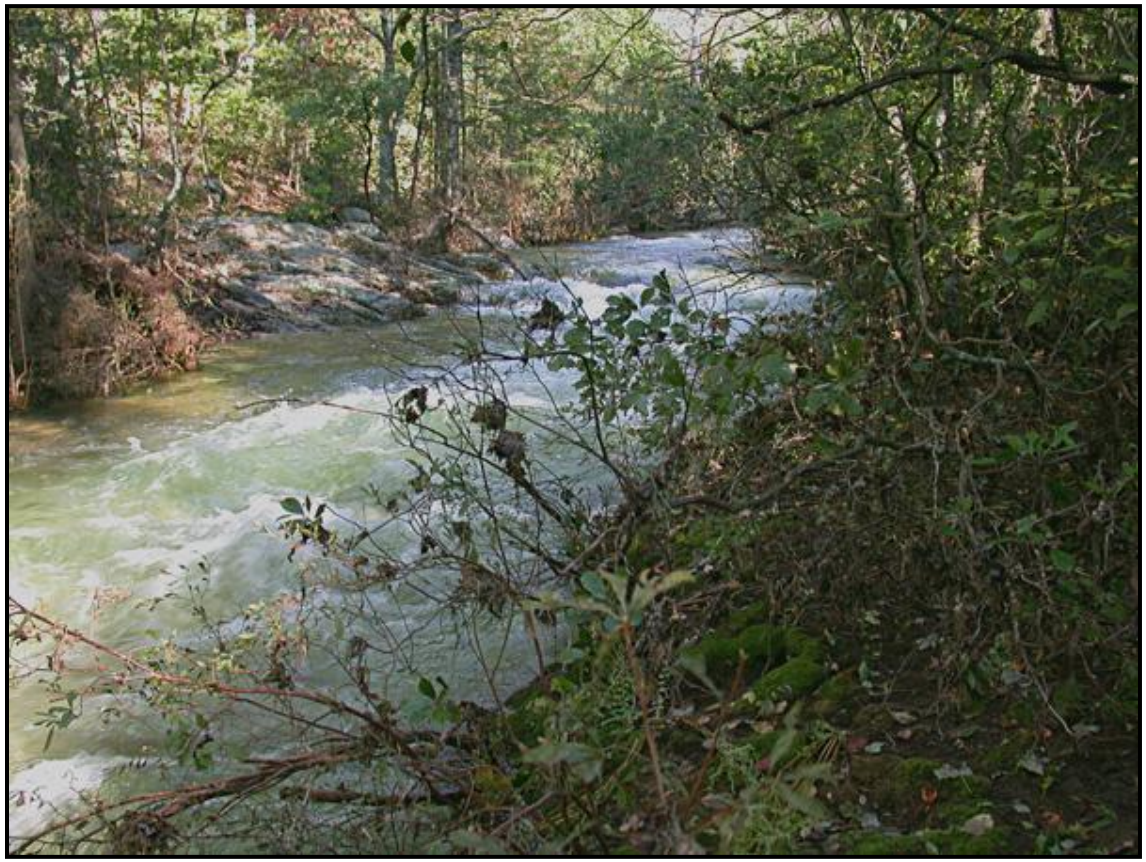


	N	% of sites with improving sulfate trend
Adirondack Mountains	50	90%
Catskills/N. Appalachian	9	78%
New England	26	96%
Central Appalachians	66	12%

Source: www.epa.gov/airmarkets/progress/ARP09_3.html

Observations

- The VTSSS 2010 survey data provide evidence for partial recovery from acidification in Virginia brook trout streams.
- Most of the recovery has occurred since 2000.
- Analysis of VTSSS quarterly monitoring data indicates that acidification is continuing is some Virginia brook trout streams.
- Recovery from surface water acidification in western Virginia is generally less than in other eastern U.S. areas affected by acidic deposition.



Additional analysis of survey results

Chemical changes in Virginia's brook trout streams: An analysis of statewide surveys 1987-2010

- *MS Thesis by Janet Miller, Department of Environmental Sciences, University of Virginia*

Topics include:

- Evidence for stream recovery from acidification.
- Change in acid-base constituents in stream waters.
- Analysis of spatial, geographic, and geologic characteristics to identify factors responsible for variation in stream recovery from acidification.

http://swas.evsc.virginia.edu/VTSSS-2010/Miller_Thesis_2011.pdf

Acknowledgements

The VTSSS program is conducted with support provided by:

- *The Virginia Council of Trout Unlimited, affiliated chapters, and volunteer sample collectors*
- *The U.S. Environmental Protection Agency*
- *The National Park Service*
- *The USDA Forest Service*
- *The Virginia Department of Game and Inland Fisheries*
- *Students, staff, and faculty in the Department of Environmental Sciences at the University of Virginia*

And thanks especially to:

- *Marcia Woolman, Virginia Council of Trout Unlimited, for VTSSS 2010 volunteer coordination*
- *Janet Miller, Department of Environmental Sciences, UVA, for VTSSS 2010 data analysis*