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

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The Virginia Trout Stream Sensitivity Study (VTSSS) is designed to track the effects of acidic deposition and other factors that determine the chemical properties of streams that drain the forested mountains of western Virginia and support reproducing populations of the native brook trout (*Salvelinus fontinalis*). The VTSSS 2010 survey was the third regional survey conducted with the assistance of resource management agencies, Trout Unlimited, and other volunteer organizations. Previous surveys were conducted in 1987 and 2000.

The 23-year period between the first and third VTSSS surveys spanned the enactment and implementation of the Clean Air Act Amendments of 1990, which mandated a substantial reduction in national emissions of acid-forming sulfur compounds from electric utilities. Between 1990 and 2009 sulfur dioxide emissions from coal-fired power plants declined by 64%, or from 15.7 to 5.7 million tons per year, resulting in reduced atmospheric acidic deposition to Virginia's mountain watersheds and throughout the eastern United States (USEPA 2010a). Analysis of stream water composition data obtained through the VTSSS surveys indicate that these reductions contributed to a partial recovery from the effects of acidic deposition (Miller 2011).

Figure 1 indicates the distribution of stream water acid neutralizing capacity (ANC), sulfate, and the sum of base cation concentrations for 341 sites sampled in each of the three surveys, excluding sites with limestone treatment or evident disturbance upstream. Between 1987 and 2010 the median of stream sulfate concentrations declined 18.1% (12.9 μeq/L), and the median of stream ANC concentrations increased 81.6% (46.5 μeq/L), consistent with recovery from stream water acidification caused by atmospheric acidic deposition. During the same period stream water base cation concentrations increased 22.3% (35.7 μeq/L). However, the expected and generally observed response to reduced sulfate mobility in watershed systems is a decrease in base cation concentrations in surface waters, which has the effect of limiting ANC increase (Galloway et al. 1983; Cosby et al. 2005; Stoddard et al. 1999). The opposite pattern, evident in this case, suggests

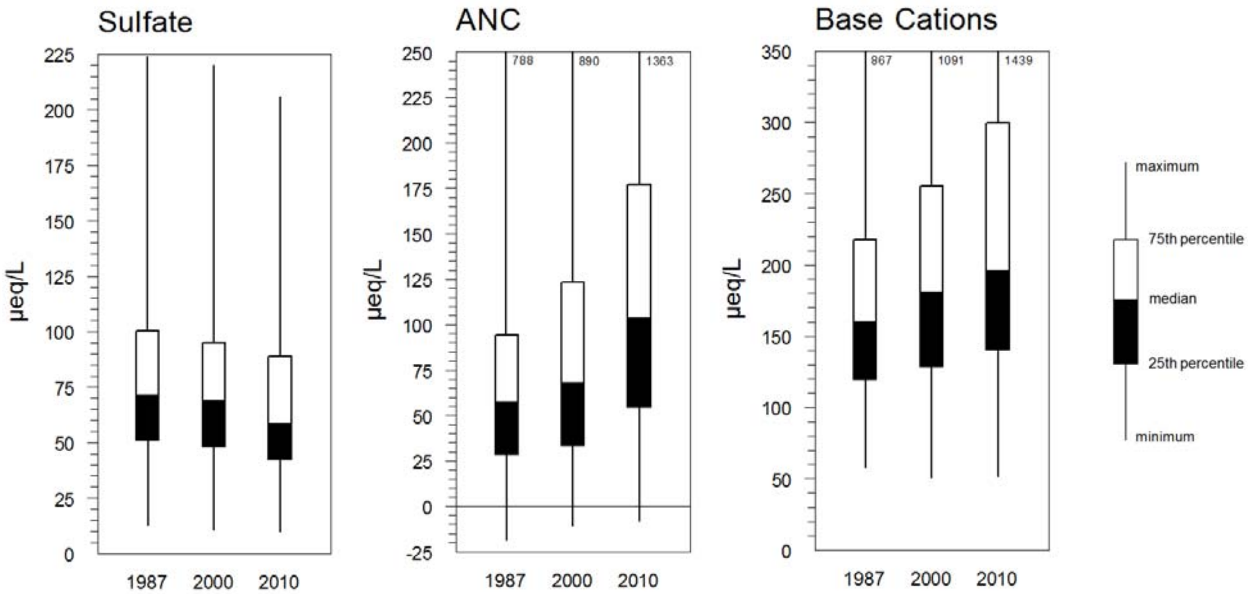

Figure 1 - Range and interquartile distribution for stream water concentrations of sulfate, ANC, and base cations for sites sampled in the three VTSSS surveys. Base cations include calcium ion, magnesium ion, potassium ion, and sodium ion.

that factors in addition to reduced acidic deposition are responsible for part of the recovery or increase in ANC observed between the surveys. Among the potential factors are differences in stream discharge between the three surveys, redistribution of base cations due to the gypsy moth infestation, changes in stream water concentrations of organic anions, and increased base cation mobilization due to an increase in soil temperature and carbonic acid weathering.

Table 1 lists the medians of the differences in stream water concentrations for ANC, sulfate, and the sum of base cations between samples collected at the same sites in each of the three surveys, including comparisons between samples collected in 1987 and 2010 (the entire record), 1987 and 2000 (the first interval), and 2000 and 2010 (the second interval). Most of the increase in ANC occurred in the second interval, with the 2010 data obtained after reductions in sulfur-dioxide emissions required under the Clean Air Act Amendments of 1990 were fully achieved. The changes in both sulfate and base cation concentrations were similar in both intervals.

Table 1 - Medians of differences in stream water concentrations for samples collected at the same sites in each of the three surveys.[1]

	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

[1] The Related-Samples Wilcoxon Signed Rank Test (SPSS 2011) was applied to test the medians of differences. Null hypothesis: the median of differences equals 0. All tests were significant at $p < 0.001$.

Figure 2 indicates the change between the three surveys in relation to the ANC value of 50 µeq/L, a value that is commonly referenced as an approximate threshold for biological response to acidification (Bulger et al. 2000; USEPA 2010b). In addition, modeling analysis indicates that the ANC of all streams in a subregion of the survey area (Shenandoah National Park), including streams that currently have much lower ANC, exceeded 50 µeq/L prior to the effects of acidic deposition (Sullivan et al. 2008). This is likely true for mountain streams throughout the larger survey area, given known relationships between watershed bedrock and the acid-base chemistry of stream water in the western Virginia mountain region. In 1987, the number of streams with ANC < 50 µeq/L was 153, or 44.9% of the total number of streams sampled in all three surveys. In 2010, the number of streams with ANC < 50 µeq/L

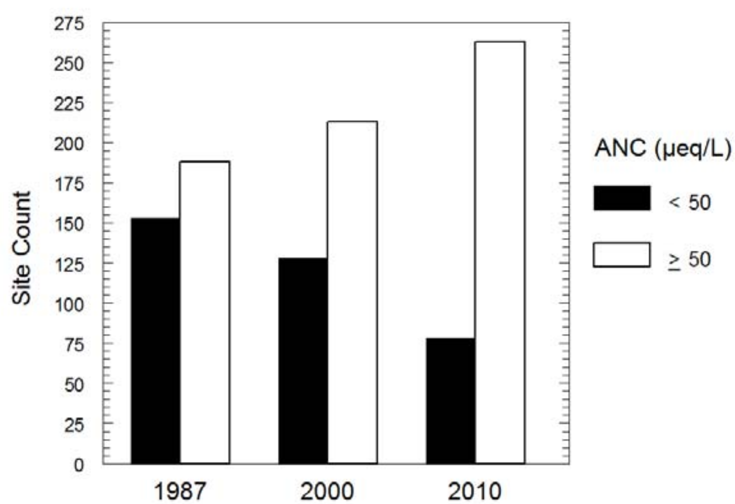

Figure 2 - Change between the three surveys in relation to the ANC criterion, 50 µeq/L.

decreased to 78, or 22.9% of the surveyed streams. Although this is a postive result, it is also apparent that recovery for a substantial subset of Virginia brook trout streams has not been sufficient to preclude biological impairment. Additionally, most (85%) of the streams with ANC < 50 μeq/L in 2010 drain watersheds that are predominantly (at least 90%) underlain by siliceous (quartzite and sandstone) or argillaceous (siltstone and shale) bedrock types. Given that these base-poor bedrock types are predominant in the forested mountain watersheds of the central Appalachian region, it can be assumed that many additional streams throughout the region are also exhibiting only limited recovery in response to the recent reductions in acidic deposition.

Citations

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