ABSTRACT. Data are presented for surveys of (1) 344 native brook trout streams in the mountains of western Virginia (80% of all such streams in Virginia), (2) 47 streams draining the Shenandoah National Park in west-central Virginia, and (3) 63 headwater streams in the southwestern portion of the Shenandoah National Park. Based on analyses of these survey data and of six years of data from two intensively monitored catchments in the park, we concluded that the mountain streams of Virginia are at considerable risk to damage from acidic deposition. In the largest of the stream surveys, 93% of the streams have ANC concentrations $< 200$ µeq L$^{-1}$, 49% of the streams have ANC concentrations $< 50$ µeq L$^{-1}$; and 10% of the streams are currently acidic ($\text{ANC} \leq 0$). Sulfate is the major anion in most streams with low ANC. All catchments surveyed are retaining a significant proportion of atmospherically deposited sulfur; median sulfate retention for all streams surveyed is approximately 60%. Bedrock geology appears to exert the strongest control on the variability of ANC in the streams within the region. Streams in the Valley and Ridge province have lower ANC and higher sulfate concentrations than streams in the Blue Ridge province. The potential for damage to fish populations is large, and at least one instance of decline in fish and invertebrate populations has been reported in the region.

Introduction

Large areas of the southeast, particularly the Appalachian Mountains from Virginia to Georgia, receive acidic deposition at rates equal to or greater than those in the northeast (Chapter 5, Eilers and Selle, this volume). The physical characteristics of catchments in the southeastern United States are different from those in the northeastern United States. Surface waters in the mountains of the southeast are generally limited to low-order or headwater streams; natural lakes are rare. Snow accumulation is hydrologically much less important than it is in more northern climes. The bedrock geology of the southeastern United States is more variable than that of the northeast, including shales and metabasalts as well as granites and quartzites. Soils are typically thin and rocky (usually ultisols or inceptisols). The surficial deposits of the southeast are geologically much older than those of the northeast, since the southeast is below the limit of recent glaciations. Both soils and parent rock in the southeast are highly weathered.

Previous studies (e.g., Galloway and Cowling 1978, Hendrey et al. 1980, Arnold et al. 1985, Kaufmann et al. 1988) have suggested that streams in large areas of the southeast are vulnerable to...
acidification. The Appalachian Mountains have been identified on national maps as potentially sensitive to acidic deposition (Galloway and Cowling 1978, Omernik and Powers 1983). The Shenandoah National Park in Virginia is located in the Appalachian Mountain chain. Several areas in the park have been designated as wilderness areas and, as such, offer an ideal setting for controlled studies of the effects of acidic deposition on streamwater quality. Other large areas in the Appalachian Mountains of western and southwestern Virginia are included in the National Forest system and offer limited control to facilitate studies of the effects of acidic deposition. This chapter presents a summary and synthesis of several studies of the streams of western Virginia and the Shenandoah National Park.

Virginia Trout Stream Sensitivity Survey (VTSSS)

Approximately 450 streams supporting native populations of eastern brook trout (Salvelinus fontinalis) have been identified in an area of western Virginia roughly 100 by 500 km (Mohn and Bugas 1979). In April and May 1987, a synoptic survey of 349 of these streams was conducted as part of the Virginia Trout Stream Sensitivity Survey (Webb et al. 1989). This sample represents approximately 80% of the total number of identified streams with naturally reproducing trout populations in the state. Exclusion of the nonsampled streams was based primarily on watershed disturbance criteria, access difficulty, and watershed size. A small number of streams were excluded due to the presence of carbonate bedrock. Data from 344 of the sampled streams were used in this study.

Shenandoah National Park Synoptic Survey, Phase I (SNP)

The Shenandoah National Park straddles a 100-km segment of the Blue Ridge mountains in northcentral Virginia. Approximately 675 km² are included within the Shenandoah National Park Synoptic Survey, Phase I (SNP-I) boundaries. Fifty-six watersheds representing approximately 70% of the area of the SNP-I were sampled six times each (approximately every other month) from August 1981 through June 1982 (Lynch and Dise 1985). The areas of the sampled watersheds varied from 0.4 to 25 km². Streams were selected for sampling based on (1) presence of one of the major geological formations in the area, (2) accessibility, (3) negligible human impact within the catchment, and (4) fishing or recreational value. The flow-weighted annual average data from 47 of the sampled streams were used in this study.

Shenandoah National Park Synoptic Survey, Phase II (SWSNP)

Since data from the SNP-I indicated that catchments in the southwestern portion of the park had the lowest ANC values, researchers conducted a more detailed survey of the catchments draining that portion of the park (Webb 1988). Ten of the larger catchments of the Phase I survey of the southwestern part of the park were divided into headwater subcatchments with drainage areas from 25 to 180 ha. Sixty-three of these headwater drainages were sampled during the 30-day period from May 10 to June 9, 1985. Data from that survey, the Southwest Shenandoah National Park Synoptic Survey, Phase II (SWSNP), are used in this study.

Shenandoah Watershed Intensively Studied Sites, White Oak Run and Deep Run

Two small watersheds, White Oak Run and Deep Run, in the southwestern portion of Shenandoah National Park, were selected for intensive monitoring. Weekly sampling of precipitation and streamwater chemistry has been carried out at both sites since November 1979 (Ryan et al. 1989, Shaffer and Galloway 1982). Precipitation volume and stream discharge have been continuously monitored throughout the study. Data for the complete calendar years 1980 through 1985 are used in this study.

Regional Characteristics

Climatic, Topographic, and Hydrologic Characteristics

This case study focuses on headwater streams in the mountainous region of western Virginia (Figure 10.1). This area, about 100 by 500 km in size,