

Shenandoah National Park

The Shenandoah Watershed Study (SWAS) was initiated in 1979 as a cooperative research program of Shenandoah National Park and the Department of Environmental Sciences at the University of Virginia. The objective of SWAS, in broad terms, is to understand the processes that govern biogeochemical cycles in forested watersheds. More specifically, the primary research emphasis has been determined by the need to assess watershed response to the deposition of atmospheric acid.

The principal investigators of SWAS are Dr. Jack Cosby, ecosystem modeler; Dr. Jim Galloway, aquatic chemist; Dr. George Hornberger, hydrologist; Dr. Hank Shugart, forest ecologist; and Dr. John Sigmon, forest meteorologist.

From both a scientific and a resource management perspective, the SWAS has been informative. Of principal importance, SWAS research has identified a combination of watershed sensitivity and elevated acid deposition which results in a poor prognosis for large areas of Shenandoah NP.

The concentration of sulfate in precipitation, for example, provides a measure of the anthropogenic component of acid deposition. Compared with remote areas of the world, the current loading of atmospheric sulfate to this part of the Blue Ridge Mountains is conservatively estimated to be about ten times preindustrial levels. This amounts to about 25 lbs. of wet deposited sulfate per acre per year in Shenandoah NP—one of the highest acid deposition levels received by any of the national parks.

This elevated acid influx is made critical by the lack of buffering capacity associated with many of the soils and streams in the area. Approximately one third of the Shenandoah NP watersheds have been identified as susceptible to acidification. Streams draining these watersheds have alkalinity values less than 100 ueq/L (or about 5.0 mg/L), well below commonly cited sensitivity criteria. Our current prediction is that these streams will be subject to significant reductions in pH and alkalinity over

the next few decades—with coincident loss of indigenous eastern brook trout populations.

SWAS has taken a threefold approach to understanding controls on both aquatic and terrestrial response to elevated acid deposition. The first approach treats watersheds as units by measuring their inputs (atmospheric deposition) and outputs (stream discharge) to determine the net effect of the watershed processes. This information is then used to formulate explanatory hypotheses. The second approach uses laboratory and field experiments to test the hypotheses formulated from the results of the input-output studies. The third approach applies the previous results to create models that predict watershed response and impacts.

The information needed to establish input-output budgets, both in terms of net loadings and temporal variation, has been provided by monitoring the quantity and chemistry of precipitation and stream discharge at the White Oak Run and Deep Run watersheds over the past 6 years. These watersheds, located in the Park's southern section, are underlain by relatively inert quartzites, sandstones, and phyllitic shales. A third watershed, the North Fork of Dry Run, which is associated with granitic bedrock in the Park's central section, has recently been adopted into the routine monitoring program.

Field and laboratory studies associated with SWAS have ranged in scale from park-wide surveys of stream chemistry to laboratory studies of soil properties. Major research areas addressed by individual projects over the previous 6 years have included: the control of stream chemistry by watershed characteristics such as bedrock, soil type, and vegetation; the acid neutralization and sulfate retention properties of watershed soils; the mobility of aluminum in soil and streamwater; and the hydrologic controls of the study area.

Currently the SWAS effort is expanding to include establishment of monitored terrestrial sites for integrated soil and vegetation studies. This work, in the North Fork Dry Run area, is coordinated with construction of above-canopy towers to facilitate intensive study of elemental exchange between the atmosphere and the forest system. Three aluminum towers, placed on an elevational gradient within the watershed, have been equipped with sampling systems and micrometeorological instrumentation designed to measure elemental fluxes in solution, gaseous, and solid particulate phases.

An overall integrating factor for SWAS has been the development of MAGIC, a computer model which is a process-oriented, intermediate-complexity model of watershed acidification. This model, which incorporates our present understanding of the most important controls on watershed response, can be applied to explain current watershed stream chemistry, and to predict future changes in streamwater chemistry

under a range of future acid deposition scenarios.

The bleak prediction that one third of Shenandoah NP streams will suffer acidification over the next few decades is based on the assumption of no change from current acid deposition levels. The MAGIC model indicates that substantial reductions in acid deposition will be required to reverse this trend. Even an immediate 50 percent reduction, for example, may be insufficient to achieve more than a delay in the acidification process. Acid deposition levels would still be elevated compared to preindustrial background levels.

Because of the significance of these predictions, refinement of the MAGIC model has assumed principal importance to the SWAS effort. A second generation of SWAS research within Shenandoah NP focuses on the need to reduce uncertainties in model structure and parameter specification. In addition, the application of the model to watersheds and regions in other areas of the country is being evaluated.

More information concerning SWAS research can be obtained by writing the Shenandoah Watershed Study, Clark Hall, Department of Environmental Sciences, University of Virginia, Charlottesville, VA 22903, or by calling (804) 924-0603.

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