

Base Cations In Northern Red Oak Trees, Soils, and Surface Waters of Shenandoah National Park, VA

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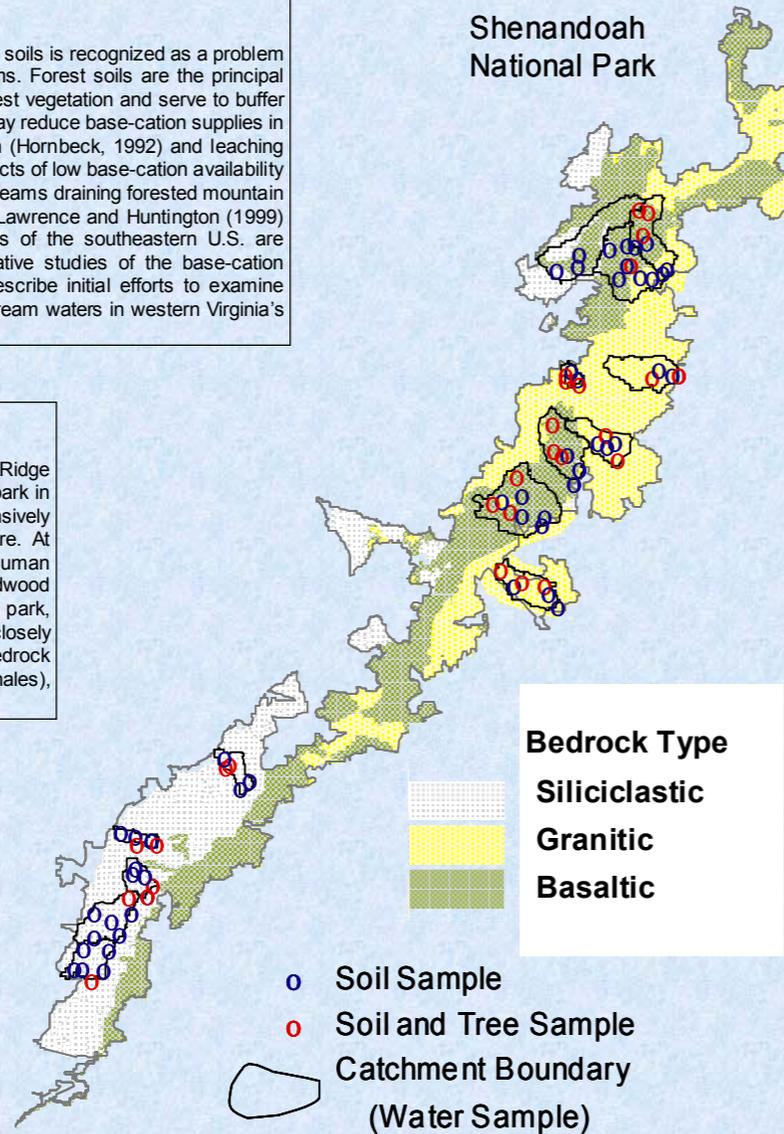
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Introduction

Depletion of exchangeable base cations (especially calcium) in soils is recognized as a problem with significant implications for the health of forest ecosystems. Forest soils are the principal source of base cations that serve as essential nutrients for forest vegetation and serve to buffer the effects of acidic deposition in surface water. Factors that may reduce base-cation supplies in forest soils include uptake associated with forest regeneration (Hornbeck, 1992) and leaching associated with acidic deposition (Likens et al., 1996). The effects of low base-cation availability have been well quantified with respect to the acidification of streams draining forested mountain watersheds in western Virginia (Webb et al., 1989). Although Lawrence and Huntington (1999) estimate that calcium supplies in forest soils in many areas of the southeastern U.S. are presently insufficient to support forest regeneration, quantitative studies of the base-cation status in forests of western Virginia are limited. Here we describe initial efforts to examine linkages between the base status of forest soils, trees, and stream waters in western Virginia's Shenandoah National Park.

Study Sites

The Shenandoah National Park is located in the Blue Ridge Mountains in western Virginia. Prior to establishment of the park in the late 1920s, the forest in the park area was intensively harvested and much of the land was cleared for agriculture. At present, most of the park is protected from direct human disturbance and occupied by a regenerating mixed hardwood forest of about 70-years age. Ecosystem variability in the park, including forest-cover type and fish species distributions, is closely associated with the distribution of the park's three major bedrock types. These include siliciclastic rocks (sandstones and shales), granitic rocks, and basaltic rocks (see map).



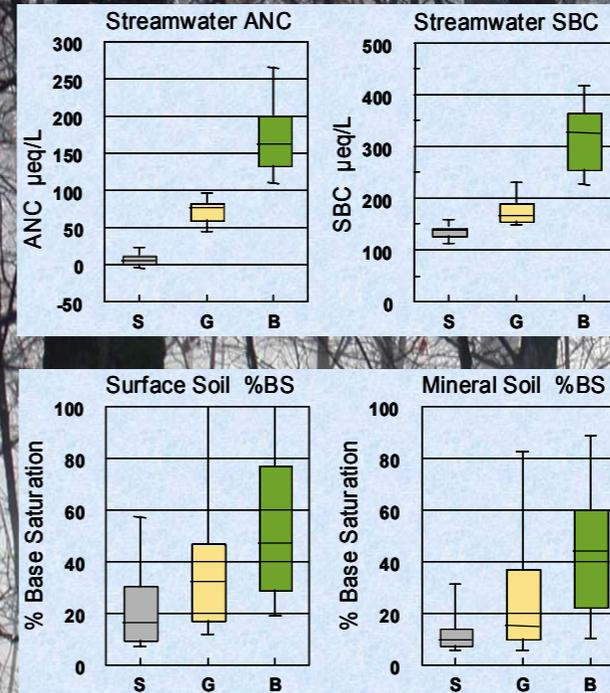
Analyses

The current distributions of base cations in streamwater, soils and trees of SNP was summarized using box and whisker diagrams. The base cation data were stratified according to the bedrock lithology in the park (see map at left). Patterns in base cation availability across the landscape can be examined by comparing the distributions within each bedrock class.

Streamwater Samples - Quarterly streamwater samples were taken from 14 catchments in SNP over the period 1988-1999 (see map). The 12 spring samples for each catchment were used in this analysis (spring concentrations are the nearest to volume weighted annual average in gauged catchments with weekly sampling in the park). The bedrock type with greatest areal extent in each catchment determined the bedrock classification for the catchment (most catchments were > 90% of a single bedrock type).

Soil Samples - Seventy-nine soil pits were sampled throughout SNP in 2000 (see map). The pits were all located within the 14 monitored catchments in the park. Each pit was assigned to the bedrock class based on which it occurred. Duplicate pits were sampled at some locations and the average values used here.

Wood Samples - Northern red oak trees were sampled with a tree corer in 2000 at 28 sites where soils were sampled (see map). Cores were obtained from the bole wood of three trees at each site. The cores were subdivided into ten-year increments and each increment analyzed for base cations. The results presented here are for the increment from 1980 to 1990. This is the most recent sample of wood tissue that does not contain active sapwood.



Box and Whisker Plots

The box and whisker plots here display the following percentiles:

5%, 25% 50%, 75% and 95%.

The bedrock classes are abbreviated as:
 Siliciclastic - S, Granitic - G, Basaltic - B.

Number of Samples

Streamwater analyses:

Siliciclastic - 60, Granitic - 48, Basaltic - 60.

Soil analyses:

Siliciclastic - 28, Granitic - 26, Basaltic - 25.

Wood analyses:

Siliciclastic - 23, Granitic - 30, Basaltic - 27.



Results and Conclusions

There is a clear pattern of decreasing base cation availability in the forest ecosystems of SNP. Areas underlain by basaltic bedrock have a greater capacity for export of base cations in streamwater, have higher soils base saturations, and have higher bole wood content of the important nutrient cations Ca and Mg. Granitic areas are intermediate, and siliciclastic areas have the lowest base cation availability. The base cation patterns relative to bedrock lithology are similar for surface waters, soils, and bole wood of red oak trees. In particular, patterns of Ca and Mg in bole wood correspond with base cation availability in soils and base cation export in streams. This has not been demonstrated previously for southeastern forests. The siliciclastic landscape units have significantly lower availability of base cations in all components of the ecosystem. Because the reservoir of base cations are relatively low, this landscape unit is especially sensitive to loss of base cations. The implications of base cation loss for forest health and suitability of aquatic habitat are of particular concern for these areas.

References

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Acknowledgments

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