EFFECTS OF ACIDIC DEPOSITION ON WATER QUALITY AND FOREST HEALTH IN GEORGIA

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ıstract. Biogeochemical studies at the Panola Mountain search Watershed near Atlanta, Ga., and in the Coastal ıin Province of Georgia have provided an assessment of ne of the potential effects of acid deposition on eamwater quality and forest health in Georgia. Historically, :id rain" has not been considered a potentially serious ›blem in the southeastern United States; however, recent dies have raised questions about the sensitivity of forest 1 aquatic resources to chronic pollutant loading. Intensive eamwater-quality monitoring during storms has shown that sodic acidification presently is occurring and likely will :ome substantially more severe in future decades. Acidic ›osition at current rates does not appear to have direct verse effects on forest health, but does contribute to the :onic loss of nutrient cations.

INTRODUCTION

This paper briefly reviews several recent studies related to effects of acidic deposition on water quality and forest ılth in Georgia. Acidic deposition refers to both wet ›osition of sulfuric and nitric acids in precipitation and dry ›osition of oxides of sulfur and nitrogen. Oxides of sulfur 1 nitrogen generally are derived from the products of fossil 1 combustion and they are the precursors of sulfuric and :ic acids in precipitation. Most of the studies were ıducted at the Panola Mountain Research Watershed ИRW), near Atlanta, where the U.S. Geological Survey SGS) has been investigating biogeochemical processes ıted to the influences of the atmospheric deposition of fur, a non-point source pollutant, on terrestrial ecosystems 1 aquatic resources since 1985. One study was conducted the Coastal Plain of Georgia. One common element in ny of these studies involves the depletion of soil calcium ich is accelerated by acidic deposition. This process and potential consequences of long-term calcium depletion 1 be discussed in a later section.

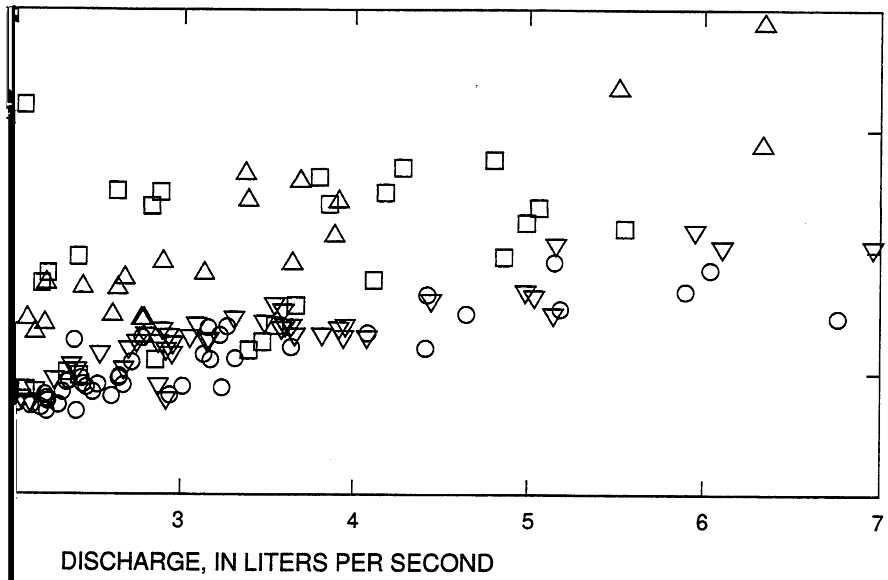
Historically, "acid rain" has not been considered a entially serious problem in the southeastern United States ause pollutant loadings were relatively low and forest ls, although naturally acidic and generally low in fertility, re thought to have a large potential for sulfate adsorption. ıtheastern forest ecosystems also are typically nitrogen ited, so nitrate saturation and subsequent leaching has not n an important issue. Therefore, the potential to protect against the accelerated leaching of base cations caused by mobile anions (sulfate and nitrate) was thought to be sufficient to ensure long-term protection against acidification. Research over the last decade has begun to question many of these assumptions, because the capacity of the system to buffer against chronic sulfur loading along critical flow paths is small enough that adverse forest and aquatic effects likely are to emerge sooner than previously thought.

The southern hardwood and loblolly pine mixed forest at PMRW is representative of the dominant forest types of the Southern Plains ecoregion. Tree ring analyses indicate an average tree age for these canopy dominant trees of 60 to 80 years. Soils predominantly are Ultisols developed in residuum and colluvium intergrading to Inceptisols or Entisols developed in colluvium, fluvial sediments, or highly eroded landscape positions.

Investigations of the potential role of acidic deposition in the pattern of southern pine beetle infestation in the northwestern Coastal Plain Province were conducted in collaboration with forest entomologists at the Georgia Forestry Commission (Huntington, 1996). These investigations included measurements of acidic deposition, ambient air quality, soil properties, and surface water quality in areas of high and low beetle infestation. The forest in this study area was predominantly loblolly pine. Soils in this study area are derived from marine sedimentary Cretaceous sand and loamy parent materials. The predominant soil order is Ultisols that are highly weathered, low in cation exchange capacity, organic matter, and base saturation. Ultisols in this study area tend to have a sandy surface horizon of variable thickness overlying a clay-rich horizon.

ATMOSPHERIC ACIDIC DEPOSITION AT THE PANOLA MOUNTAIN RESEARCH WATERSHED AND IN THE NORTHWESTERN COASTAL PLAIN

Dry deposition sulfur fluxes, dominated by sulfur dioxide, are estimated to range from 33 to 50 percent of total atmospheric sulfur deposition at PMRW (Peters, 1989; Meyers *et al.*, 1991; Cappellato and Peters, 1995). Shanley and Peters (1993) have shown that, in spite of high sulfate retention capacity of Ultisol soils at PMRW, during storms streamwater alkalinity approaches zero because of the routing of runoff through acidified surface soil horizons and dilution of more alkaline waters associated with deeper flowpaths. These



centrations as a function of discharge at flows less than or equal to 7 liters per second Panola Mountain Research Watershed.

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At the Fernow Experimental Forest in West Virginia, streamwater calcium concentrations increased in response to increased atmospheric deposition of nitrate and subsequent accelerated soil cation leaching (Edwards and Helvey, 1991). At the Hubbard Brook Experimental Forest in New Hampshire, acidification is thought to have first elevated calcium concentrations in streamwater during a period of soil depletion; and subsequently, concentrations have declined (Likens et al., 1996). Some studies also have reported soil acidification, including declines in calcium contents of the forest floor and surface mineral soil, which are thought to be a result of both vegetation uptake and acid-induced cation leaching (Likens *et al.*, 1996; Richter *et al.*, 1994; Wilson and Grigal, 1995; Ronse *et al.*, 1988; Billet *et al.*, 1990; Bjørnstad, 1991; Johnson *et al.*, 1991; Kuylenstierna and Chadwick, 1991).

Element mass-budget calculations at PMRW and at other intensively studied forest sites in eastern United States (Table 1) indicate that the rate of calcium depletion by vegetation uptake and soil leaching is several times greater than the rate of calcium input in atmospheric wet deposition (Johnson and Todd, 1990; Huntington, 1996b). Weathering of non-exchangeable mineral calcium can be an important process that replenishes calcium lost by leaching and vegetation uptake, but at many sites these pools are relatively small and weathering rates may be too slow to compensate for losses.

Highly weathered Ultisol soils of the southeastern United States frequently are largely depleted of non-exchangeable mineral calcium within the rooting zone (Daniels and Hammer, 1992) so that weathering resupply probably is quite small in these ecosystems. Total elemental analysis of the non-exchangeable fraction of soil, saprolite, and partially weathered rock collected at PMRW indicates that these materials are highly calcium depleted. Soil calcium stores in the soil

ɔgrams per hectare per year) from selected forest
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D= not determined]

	Walker Branch, TN Oak-Hickory	Calhoun Forest, S.C. Loblolly Pine	Panola Mountain, Ga., Oak-Hickory-Pine	Cockaponset State Forest, CT., Oak, Hickory, Maple, Birch
	140	245	2,200	276
	1,800	ND	2,200	3,410
	8	7.5	10	6.6
	5.4	2.8	1.4	2
	1	10.2	2.7	ND

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