Publication

Sulphate, nitrogen and base cation budgets at 21 forested catchments in Canada, the United States and Europe

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To assess the concern over declining base cation levels in forest soils caused by acid deposition, input-output budgets (1990s average) for sulphate (SO4), inorganic nitrogen (NO3-N; NH4-N), calcium (Ca), magnesium (Mg) and potassium (K) were synthesised for 21 forested catchments from 17 regions in Canada, the United States and Europe. Trend analysis was conducted on monthly ion concentrations in deposition and runoff when more than 9 years of data were available (14 regions, 17 sites). Annual average SO4 deposition during the 1990s ranged between 7.3 and 28.4 kg ha(-1) per year, and inorganic nitrogen (N) deposition was between 2.8 and 13.8 kg ha(-1) per year, of which 41-67% was nitrate (NO3-N). Over the period of record, SO4 concentration in deposition decreased in 13/14 (13 out of 14 total) regions and SO4 in runoff decreased at 14/17 catchments. In contrast, NO3-N concentrations in deposition decreased in only 1/14 regions, while NH4-N concentration patterns varied; increasing at 3/14 regions and decreasing at 2/14 regions. Nitrate concentrations in runoff decreased at 4/17 catchments and increased at only 1 site, whereas runoff levels of NH4-N increased at 5/17 catchments. Decreasing trends in deposition were also recorded for Ca, Mg, and K at many of the catchments and on an equivalent basis, accounted for up to 131% (median 22%) of the decrease in acid anion deposition. Base cation concentrations in streams generally declined over time, with significant decreases in Ca, Mg and K occurring at 8, 9 and 7 of 17 sites respectively, which accounted for up to 133% (median 48%) of the decrease in acid anion concentration. Sulphate export exceeded input at 18/21 catchments, likely due to dry deposition and/or internal sources. The majority of N in deposition (31-100%; median 94%) was retained in the catchments, although there was a tendency for greater NO3-N leaching at sites receiving higher (>7 kg ha(-1) per year) bulk inorganic N deposition. Mass balance calculations show that export of Ca and Mg in runoff exceeds input at all 21 catchments, but K export only exceeds input at 16/21 sites. Estimates of base cation weathering were available for 18 sites. When included in the mass balance calculation, Ca, Mg and K exports exceeded inputs at 14, 10 and 2 sites respectively. Annual Ca and Mg losses represent appreciable proportions of the current exchangeable soil Ca and Mg pools, although losses at some of the sites likely occur from weathering reactions beneath the rooting zone and there is considerable uncertainty associated with mineral weathering estimates. Critical loads for sulphur (S) and N, using a critical base cation to aluminium ratio of 10 in soil solution, are currently exceeded at 7 of the 18 sites with base cation weathering estimates. Despite reductions in SO4 and H+ deposition, mass

balance estimates indicate that acid deposition continues to acidify soils in many regions with losses of Ca and Mg of primary concern.

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