Lichen bioindicators of nitrogen and sulfur deposition in dry forests of Utah and New Mexico, USA

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Abstract

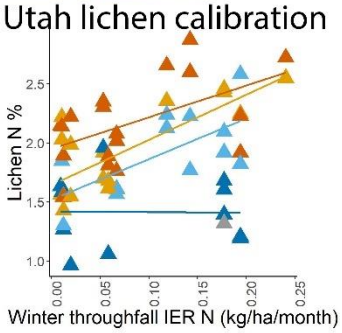
Anthropogenic nitrogen (N) and sulfur (S) deposition can negatively affect ecosystem functions and lichen biomonitors can be a cost-effective way to monitor air pollution exposure across the landscape. Interior dry forests of the southwestern United States face increasing development pressures; however, this region differs from others with well-developed biomonitoring programs in having drier climates and a greater fraction of deposition delivered in dry forms. We measured throughfall N and S deposition at 12 sites in Utah and 10 in New Mexico and co-located collection of 6 lichen species. N deposition ranged from 0.76 to 6.96 kg/ha/year and S deposition from 0.57 to 1.44 kg/ha/year with elevated levels near human development that were not predicted by commonly used simulation models. Throughfall N was 4.6 and 1.6 times higher in summer compared with fall-spring in Utah and New Mexico and S deposition was 3.9 and 1.8 times higher in summer. Lichen N and S concentrations ranged from 0.97 to 2.7% and

0.09 to 0.33%. Replicate samples within plots showed high variability in N and S concentrations with within-plot coefficients of variation for N ranging between 5 and 10% and for S between 7 and 15%. In Utah, N and S concentrations in lichen species were correlated with each other in most cases, with R^2 ranging from 0.52-0.85. N concentrations in *Melanelixia exasperatula* and *Melanohalea subolivacea* could be correlated with average annual throughfall N deposition in Utah (R^2 = 0.58 and 0.31). Those relationships were improved by focusing on deposition in fall-spring prior to lichen sampling in Utah (R^2 for *M. exasperatula, M. subolivacea,* and *X. montana* = 0.59, 0.42, and 0.28). In New Mexico, lichens exhibited greater coefficients of variability within plots than between plots and could not be correlated with throughfall N deposition. In neither study area was S correlated between lichens and throughfall deposition, which may be the result of low S deposition over a narrow deposition range or complex lichen assimilation of S. Lichen biomonitoring for N deposition in the region shows promise, but could potentially be improved by sampling more thalli to reduce within-plot variability, repeated lichen collection synchronized with throughfall changeouts to explore temporal variability, and washing lichen collections to distinguish N and S that has been incorporated by the thalli from dry deposition that may accumulate on lichen surfaces.

Deposition collectors with snow tubes

Lichen biomonitors

Utah lichen calibration



Temporal deposition