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Biogeochemical cycling in Subarctic birch forests: above- and belowground variation along natural environmental gradients across scales

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Studies along elevational gradients have been widely applied to study the effects of temperature on ecosystem processes. However, such studies are usually performed along one transect, which poses potential problems about inference at the landscape scale, for instance due to variability in aspect and slope which trickles down to variation in solar insulation and primary productivity, particularly at high latitudes with low solar angles.
We estimated a range of key above- and belowground biogeochemical fluxes along 9 elevation gradients with three sites along each in the mountain birch forests of Subarctic Sweden. The design allows us to compare the regional variation in key bioclimatic driver variables and biogeochemical responses with the local variation in the same variables along individual elevational transects. Potential abiotic driver variables were soil temperature, soil moisture, solar insulation, elevation and mineral soil texture, while biotic drivers were represented by plant and soil chemical compositions (carbon, (C), nutrient and secondary metabolites), plant productivity and soil fungal and bacterial biomass and growth. The primary aboveground response variable was insect herbivory rate, which was translated into C, nitrogen (N) and phosphorous (P) fluxes through background insect herbivory and litter. The primary belowground response variable was soil respiration. For data exploration, we used bias corrected and accelerated bootstrapped (999 resamples) partial least square regression models to estimate coefficients and 95% confidence intervals of our predictor variables (coefficient [lower, upper CI limit]).
Preliminary results suggested increasing insect herbivory rates with elevation along individual transects (0.64 [0.48, 0.96]), while variation with elevation (-0.33 [-0.78, -0.06]) and temperature (0.22 [0.10, 0.70]) at the regional scale was much weaker. Soil respiration rates also showed a weak decrease with elevation (-0.20 [-0.54, -0.00]) and increase with temperature (0.26 [0.07, 0.45]) across the entire regional dataset, but showed no systematic variation with elevation along individual transects (0.15 [-0.06, 0.41]). However, while the soil C:N and fungal:bacterial biomass ratios did not show significant predictor power, fungal:bacterial growth ratios was strongly negatively correlated with soil respiration (-0.56 [-0.70, -0.40]).
Our results adds complexity to modelling ecosystem responses to climatic change at the landscape scale; first, certain aboveground parameters show marked and important systematic variation with elevation/temperature at the local scale, while not at the regional and vice versa; second, although temperature is a relatively good predictor of belowground microbial activity, estimates of microbial growth, but not biomass, has much more predictive power, hence should be considered as a separate predictor of soil respiration. We provide important steps towards understanding the complex nature of the above-belowground interactions driving biogeochemical cycling in the mountain birch forests.