Assessing the impact of N deposition on surface water N concentrations: up-scaling from the plot to hillslope

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BACKGROUND

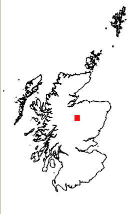
High altitude montane ecosystems in Scotland are very sensitive to changes in anthropogenic deposition (nitrogen and sulphur) and climate change. Soils beneath montane vegetation are generally nutrient poor. Recent evidence suggests that montane ecosystems are demonstrating a response to enhanced atmospheric nitrogen deposition. A Geographic Information System (GIS) was used to determine landscape classes based on the association of topographic features with dominant soil and vegetation assemblages.

AIMS

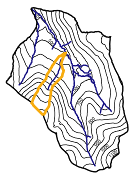
To a) quantify the concentration of N species through a soil profile and between landscape classes along a hill slope transect, and

b) develop an up-scaling procedure within a GIS to allow prediction of surface water nitrate concentrations at the hill slope scale.

SITE



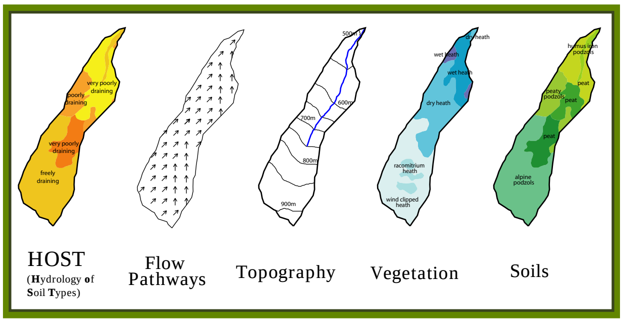
The Allt a' Mharcaidh catchment is underlain by biotite-granite of Lower Old Red Sandstone age, overlain by drift deposits including till, moraine, and organic material. At the highest altitudes Raccomitrium Heath predominates, giving way to Nardus Stricta (snow bed communities), with dry heath on the steeper slopes and wet heath at lower altitudes, and a small area of naturally regenerating Scots Pine near the outflow.



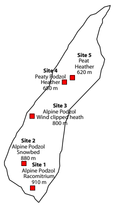
One subcatchment was selected - around 0.5 km^2 in size, it drains the north east slope of Geal-charn (920m) to the junction of the main Mharcaidh stream at 490m.

Monitoring in the sub-catchment began in October 2004.

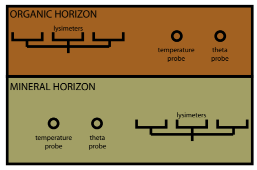
SPATIAL DATASETS



EXPERIMENTAL DESIGN

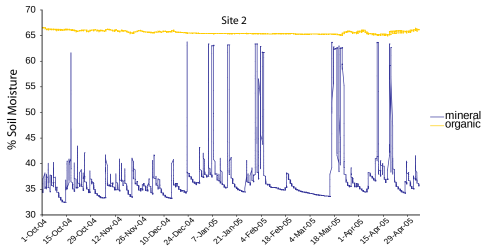


- 5 sites represent major soil and landcover combinations
- At each site, 4 replicate soil pits were instrumented with tensionless (tray) lysimeters in the organic and mineral horizons, with minimum disruption of the above-ground vegetation. Soil water, precipitation and run-off are collected for analysis every 2 weeks during spring and autumn, and monthly in summer and winter.
- Data loggers have been installed at each site, with each pit having sensors which record soil temperature and soil moisture every minute. 2 of the sites also have rain and interception gauges.
- An undisturbed core was taken from each soil horizon at each site at the time of establishment. These were used to determine the unsaturated hydraulic conductivity of the soils in the laboratory using an evaporation method.



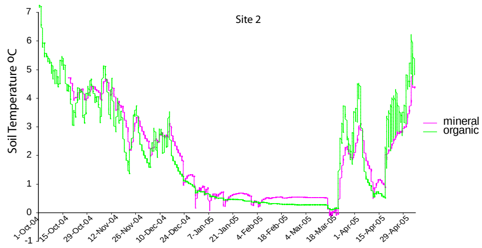
RESULTS

Figure 1



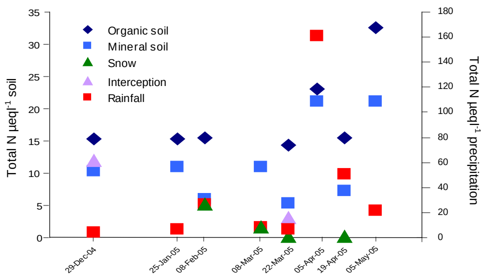
The moisture content of the (upper) organic horizon has remained fairly stable over the winter months. In the more freely draining (lower) mineral layer, a different pattern of wetting/drying can be seen - peaks in Figure 1 indicate responses to rainfall events or snowmelt.

Figure 2



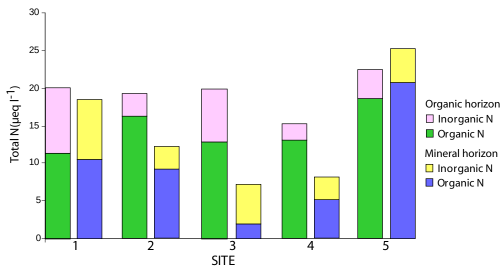
Soil temperature began to fall over the autumn and winter months, reaching a low in the middle of March. The temperature difference between the top and bottom sites - around 2^{o}C (min and max) reflects an altitudinal gradient of around 300m. Biological transformations of nitrogen are influenced by soil temperature.

Figure 3



Soil water total N concentrations are generally in the region of 5-20 ueql^{-1}, with higher concentrations in the organic horizons than the mineral. Total N in rain/snow and occult deposition is much higher, around 10 times in some cases, while levels of 0-5 ueql^{-1} are commonly found at the spring.

Figure 4



Total N concentrations for the organic horizons are similar across the sites, varying only in the proportion of organic to inorganic N. Those sites with thin, freely draining, nutrient poor mineral soils (particularly site 3) are much lower.

FUTURE WORK

- Calculate hydrochemical budgets and N fluxes for the sub-catchment and catchment
- Carry out time series statistical analysis of the soil temperature and moisture data in order to identify trends, seasonal effects effects, and cyclic variations in data. Further, to attempt to link soil water chemistry data to soil temperature/moisture, and to investigate spatial/temporal effects.
- Determine N uptake and cycling rates for selected plant communities
- Conduct a further survey of the hillslope (grid based/stratified random sampling) to gather more data with which to perform upscaling. Easily measured soil properties such as moisture and carbon content will be used for point based spatial interpolation (eg kriging) across the hillslope.
- Explore ways of classifying the hillslope using a grid based approach and a data mining technique such as cluster analysis to group the cells into a number of landscape units according to their 'similarity' to one another. Different clustering algorithms - tree (hierarchical), block (two-way joining), k-means - will be tested.

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