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Modelling of plant-soil carbon, nitrogen and phosphorus cycling in semi-natural terrestrial ecosystems

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In recent centuries pools and fluxes of C, N and P in natural and semi-natural UK ecosystems have been transformed by atmospheric pollution leading to: acidification; eutrophication of surface waters; loss of biodiversity; and increased greenhouse gas emissions. In addition, climate change now threatens to perturb these systems further. Understanding in this field is vital in determining the consequences of artificial nutrient enrichment and land use and climate change, and mitigating against their effects.

The N14CP model has been recently developed to assess the temporal responses of soil C, N and P pools to nutrient enrichment in semi-natural ecosystems, and explore the connections between these nutrients. It is a dynamic, mechanistic model, driven by: climate; CO_2, N (fixation and pollutant deposition), and P (weathering and atmospheric deposition) inputs; and plant cover type. It explicitly links C, N, and P in both plants and soils, using plant element stoichiometry as the primary constraint. Net primary production, and plant/soil element pools, are calculated over time, and output fluxes of dissolved organic and inorganic, and gaseous, forms of C, N, and P produced. Radiocarbon data are used to constrain Soil Organic Matter (SOM) turnover. The SOM is represented as three pools, undergoing first-order decomposition reactions with turn-over rates ranging from 2 to 1000 years.

The N14CP modelling methodology is discussed and its calibration and verification using observations from 200 northern European sites presented. Whilst the primary period of interest with respect to nutrient enrichment is from the industrial revolution onwards, plant-soil C, N and P are simulated at these sites for a period spanning from the start of the Holocene (to provide a spin-up period) to the present day. Clearly, during this time span land cover and usage will have changed at these sites, and histories of these changes are used as an input to the model. The influence of these land cover and management histories in determining current C N and P pools is also explored.