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Upscaling biogeochemical processes from plot to catchment to country (or, why small catchments might not be such bad places to work after all)

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Much research carried out at small spatial scales is used to infer larger-scale processes, and to inform national and international scale policy development. In the UK, results from plot-scale experiments, small catchment monitoring and periodic larger surveys have been used as the basis for large-catchment and national-scale modelling of the effects of atmospheric pollutant deposition on (sensitive, semi-natural) terrestrial and aquatic ecosystems, utilising a range of methods for upscaling. Model outputs contribute to policy development under the UNECE Convention on Long-Range Transboundary Air Pollution (CLRTAP). Testing of model outputs against a range of spatial and temporal observations illustrates the severe difficulty of predicting present-day conditions at the fine (soil plot) scale, due to small-scale lateral and vertical heterogeneity in soil chemistry and hydrology. At the small catchment scale, however, both process-based and statistical models are better able to reproduce observed spatial variations, reflecting the role of the catchment as an effective aggregator of lateral and vertical variation within the landscape, and the comparable resolution of the spatial datasets used for model parameterisation.

For many key biogeochemical variables, including concentrations of nitrate and sulphate, dissolved organic carbon (DOC) and acid neutralising capacity (ANC), monitoring data from both plots and catchments show remarkably consistent temporal patterns across large spatial scales, and in some cases among catchments with quite dis-

similar soil and land-use characteristics. This uniformity of behaviour suggests that many underlying drivers of temporal biogeochemical change are, to a considerable extent, consistent across the landscape, and therefore that large-scale prediction of biogeochemical change is achievable. Existing models used within the CLRTAP framework are largely effective in reproducing observed sulphate and ANC trends, but currently less effective in predicting change in nitrate and DOC due to the omission of key climatic drivers, and feedbacks between acidity change and organic matter cycling.

It is concluded that, while challenges undoubtedly exist in upscaling biogeochemical understanding to a policy-relevant landscape scale, existing programmes that combine process understanding from plot-scale experimentation, temporal information from catchment-scale monitoring, and spatial information from large scale surveys, provide an effective conceptual framework for this process. Development and maintenance of sufficiently extensive catchment monitoring programmes, and effective integration of data from different spatial scales, represent key challenges.