Lab 5 – Multi-level models

Ecological data are often collected at multiple scales or levels of organization in nested designs. “Group” is a catchall term for the upper level in many different types of nested hierarchies. Groups could logically be composed of populations, locations, species, treatments, life stages, and individual studies, or really, any sensible category. We have measurements within groups on individual organisms, plots, species, time periods, and so on. We may also have measurements on the groups themselves that is covariates that apply at the upper level of organization or spatial scale or the category that contains the measurements. Multilevel models represent the way that a quantity of interest responds to the combined influence of observations taken at the group level and within the group.

Nitrous oxide, a greenhouse gas roughly 300 times more potent than carbon dioxide in forcing atmospheric warming, is emitted when synthetic nitrogenous fertilizers are added to soils. Qian and colleagues (2010) conducted a Bayesian meta-analysis of such additions ($gN \cdot ha^{-1} \cdot d^{-1}$) using data from a study conducted by Carey (2007), who reviewed 164 relevant studies. Studies occurred at different locations, forming a group-level hierarchy. Soil carbon content ($g \cdot$ organic $C \cdot g^{-1}$ soil dry matter) was measured as a group-level covariate and is assumed to be measured without error. Observations of N_2O emission is also assumed to be measured without error and were paired with measurements of fertilizer addition ($kgN \cdot ha^{-1}$). The effect of different types of fertilizer was also studied.

You tasks are to build model from low to high complexity for N_2O emission using Carey’s (2007) data. For each model, you will need to build DAG first and then write the code. Test the convergence and get some outputs (95% credible intervals).

Pooled model

Your first task is to write a simple, “pooled” model where you gloss over differences in sites and fertilizer types.

Intercepts for each site

You will implement the model that allows intercept to vary by site, where each intercept is drawn from a common distribution.

Intercepts vary with carbon level in site soils and slopes vary with fertilizer type

Modify your model to include a covariate at the site level, soil carbon content and allow slopes to vary with fertilizer type

Slope *and* intercepts vary by site

Modify your model to allow *both* slopes and intercepts to vary by site

References

1. Carey, K. 2007. Modeling N_2O emission from agricultural soils using a multilevel linear regression. (Doctoral dissertation, Duke University).

2. Qian, S. S., Cuffney, T. F., Alameddine, I., McMahon, G., & Reckhow, K. H. 2010. On the application of multilevel modeling in environmental and ecological studies. Ecology, 91(2), 355-361.