

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 ($\text{gN} \cdot \text{ha}^{-1} \cdot \text{d}^{-1}$) 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 ($\text{g} \cdot \text{organic C} \cdot \text{g}^{-1}$ 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 ($\text{kgN} \cdot \text{ha}^{-1}$). The effect of different types of fertilizer was also studied.

Your tasks are to build models 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.

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.