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Ecosystem C and N cycle interactions – diverse model representations and divergent model predictions versus collective empirical constraints

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Representations of interactions between the C and N cycles in terrestrial ecosystems are now implemented in a majority of state-of-the-art Dynamic Global Vegetation Models (C-N models). Standard models for simulating the response of individual processes to changes in N availability have not yet emerged and widely used models have not been tested against the full diversity of empirical data. Large remaining model structural uncertainty has important implications for projections and hindcasts of the land C uptake.

Here, we summarise the current state of global land C balance simulations by comparing C-N models to C-only models; summarise data from field surveys and experiments to elucidate the role of soil N in controlling photosynthesis and its acclimation, stoichiometry, allocation, and growth; and demonstrate how optimality principles can guide the representation of acclimation and allocation for simulating ecosystem responses to experimental treatments of CO2 and soil N – consistent with observations. Promising model results are achieved by assuming that the atmospheric environment, including CO2, is the principal driver for photosynthetic capacities and leaf N following optimality theory of photosynthetic acclimation (Prentice et al., 2014). In turn, the functional balance hypothesis (Bloom et al., 1985) yields accurate predictions for how soil N

availability and CO2 influence allocation and growth in different tissues.

Our results show how confronting new theoretical approaches to simulating ecosystem C-N interactions against the collective constraints from diverse types of observations can guide model development and potentially reduce the large uncertainty in global carbon cycle projections.

References

Bloom, Arnold J, F Stuart Chapin, and Harold A Mooney. “Resource Limitation in Plants--An Economic Analogy” Annual Review of Ecology and Systematics, 16, no. 1 (1985): 363–92. https://doi.org/10.1146/annurev.es.16.110185.002051.

Prentice, I. Colin, Ning Dong, Sean M. Gleason, Vincent Maire, and Ian J. Wright. “Balancing the Costs of Carbon Gain and Water Transport: Testing a New Theoretical Framework for Plant Functional Ecology.” Ecology Letters 17, 1 (2014): 82–91. https://doi.org/10.1111/ele.12211.