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Discussions

Interactive comment on "Nutrient limitation reduces land carbon uptake in simulations with a model of combined carbon, nitrogen and phosphorus cycling" *by* D. S. Goll et al.

Anonymous Referee #2

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This paper addresses an important issue – how will nutrients, particularly N and P, affect CO2 uptake and storage on land? Theory, experiments and observations have pointed out that N, P and NxP constrain plant growth globally, yet current C cycle projections have not adequately dealt with nutrient limitations. The authors thereby propose a stoichiometic framework that considers C, N and P cycles, simulated for the land biosphere with and without nutrient constraints. The authors suggest that nutrients will substantially constrain CO2 uptake, with the greatest effect observed for N and P limitation combined. However, I have several concerns about this conclusion in its present form.

Most importantly, the authors' framework assumes fixed C,N,P stoichiometry, without substitutions and in the absence of many known element cycle synergies. The authors' main assumption is that nutrients don't substitute or interact in positive ways – which stands in contrast to decades of work. For example, increased P leads to increased N fixation, and added N stimulates P cycling rates across many ecosystems (e.g., see Marklein and Houlton, New Phytologist, 2012), etc. The model's assumed "Liebig" limitation means that the effect of nutrients on CO2 uptake is necessarily maximized. And the authors need to be very clear about this point, throughout the manuscript, including the abstract: many major N xP interactions are not considered, as the models are largely uncoupled, and the results are going to approach maximal nutrient effects as such. I appreciate that it is difficult to build a model that considers important nutrient interactions; but in the absence of a model that including interactions and feedbacks among N and P availability, it is essential to qualify the results accordingly.

I'm also concerned about parameterization of plant N/P. The authors assume fixed stoichiometry for plant tissues and soil, yet N/P of plants vary widely within biomes, and within and across plant species and microbial functional groups. The authors make several statements in this regard – but I'm wondering if this could be done in a more rigorous way? For example, data in Townsend et al., Ecology, (2007) show that the N/P of tropical plants – the most important biome for terrestrial C exchange – varies considerably within and across plant species. I recommend that the authors consider plasticity in their model analysis via probability distribution (of N/P) and monte-carlo type simulations, to examine how much leverage plant stoichiometry has on CO2 uptake and storage. If done well, this would also add considerably to our understanding of plant traits and N/P adjustments in overall CO2 drawdown; and it would provide limits, something that this model is best equipped to do.

Finally, the model should be further validated by taking advantage of empirical data. One thing that comes to mind are data on C/N uptake ratios observed for several studies, for example Thomas et al., Nat Geo (2010). It would be interesting for the authors to calculate their modeled C uptake/N (or P) input to see how the model functions relative to empirical understanding. This would add depth to the discussion, and might help further the idea behind fixed C/N/P.

Other comments - The treatment of N fixation is way too simple, and needs to be further discussed. N fixation responds to many factors – NPP is only one – and clearly NPP can't predict many patterns of N fixation known to occur in nature (see Vitousek et al., Biogeochemistry, 2002; Houlton et al., Nature, 2008; Wang and Houlton, GRL, 2010). Please qualify the results as such.

- The paper reads well overall, but the introductions could benefit from further editing.

- The authors assume that rock weathering doesn't contribute substantial N into ecosystems; but it's worth mentioning that this assumption is undergoing revision (Morford et al., Nature, 2011).

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Interactive Comment