Interactive comment on "Modelling the demand for new nitrogen fixation by terrestrial ecosystems" *by* Xu-Ri and I.Colin Prentice

Responses to Anonymous Referee #1

RC – Reviewer's Comments, *AC* – Authors' Comments.

AC: We greatly thank Anonymous Referee #1 for providing constructive comments, which are important for improving our manuscript. The comments were carefully evaluated. Based on the comments, we have revised the manuscript. The detailed responses to the comments are shown as below (reviewer's comments in black, authors' responses in blue).

RC: This is an interesting and, for the most part, well written paper. It addresses an important and timely question. The analysis is logical and informative. I recommend publication with minor revisions as specified below.

page 2 line2 5-7: It would be good to quantify this recycled N; It is on the order of 98% of the N requirement of NPP in arctic systems, maybe 95% in temperate systems, and I suspect less in tropical systems. On the other hand, disturbance can result in substantial losses that have to be re-accumulated before full recovery. This disturbance-driven loss probably drives most of the NNF. And indeed, outside of the tropics, symbiotic N fixation is usually restricted to early succession.

AC: The recycled N has been quantified to be ~ 1 PgN (Cleveland et al., 2013; Xu-Ri and Prentice, 2008), but according to this study, when considering N immobilization, the recycled N might be larger than 1 PgN , ranged 1.13-1.20 Pg N a^{-1}. (As shown in Page 6, section 3.4, line 29-31, or Figure 1). Yes, according to figure 7 in this study, In the temperate steppe and boreal forest more than 80% of required N are supported by the recycled N. In the tropical ecosystems, about 70% of the N requirement are supported by the recycled N. While in some extreme cold (arctic), arid and high altitude ecosystems (Tibetan Plateau), more than 50% of the required N were supported by the new N instead of recycled.

Cleveland, C. C., Houlton, B. Z., Smith, W. K., Marklein, A. R., Reed, S. C., Parton, W., Del Grosso, S. J., and Running, S. W.: Patterns of new versus recycled primary production in the terrestrial biosphere, Proceedings of the National Academy of Sciences, 110, 12733-12737, 2013.

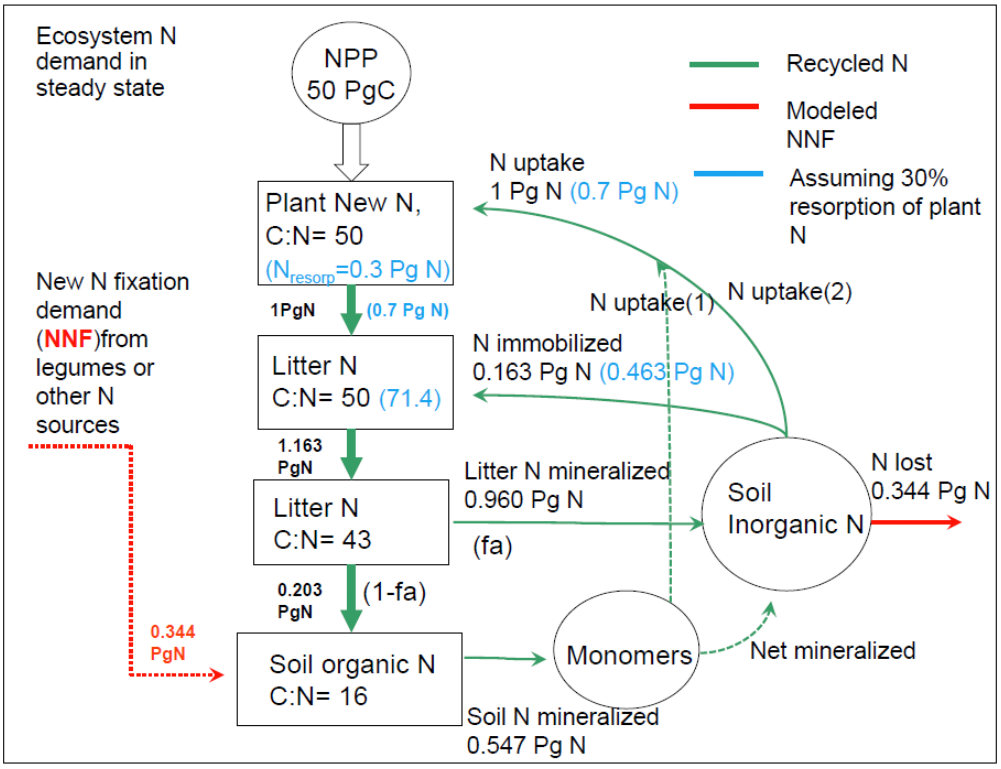
Xu-Ri, and Prentice, I. C.: Terrestrial nitrogen cycle simulation with a dynamic global vegetation model, Global Change Biology, 14, 1745-1764, 2008.

RC: page 3 lines 11-22; As I interpret this paragraph, the N demand is calculated based on soil N demand alone and does not include plant N demand. I agree that most of the N is in the soil (except perhaps in tropical systems), but you need to state explicitly that you are ignoring N demand associated with any increase in plant biomass or with changes in plant stoichiometry.

AC: As shown the explicit equation in Appendix S1, here we are considering the ecosystem N demand according to the mass balance, both of the plant and soil N demand have been considered. In the revised MS, this paragraph has been revised to be clearer.

RC: page 4 line 2: I don't think this is true; see Schimel and Bennett 2004 Ecology 85(3):591-602. But the immobilization of inorganic N by microbes is undeniable

AC: Yes, in this study, we did not considering the soluble organic forms of N that were taken up by plant, for example, monomers. However the ecosystem N demand might not be influenced by either monomer was considered or not. The mass balance figure might be changed as following when the monomers were considered.



RC: page 4 lines 13-14: I am confused by "vary systematically". Surely this ratio changes between bacteria versus fugus dominated decomposition communities.

AC: R_B (C:N ratio of the decomposer biomass) does not like R_{CR} vary systematically along gradients of organic matter and litter N:C and typically remains in the range of 5 to 15, with an assumed average value of 10 in (Manzoni *et al.*, 2008). While in this

study, as shown in Page 4 line 10-11, we analyzing the range of the R_B effect on NNF with R_B = 7.6 (low), 8.6 (intermediate) and 10 (high). The corresponding *e* values are 0.175 (low), 0.2 (intermediate) and 0.23 (high). The results can be seen in Page 6, section 3.2, line 5-7, NNF might varing from 290 to 340 Tg N a^{-1}, 340 to 410 Tg N a^{-1}, and 400 to 470 Tg N a^{-1} respectively (Fig. 3a).

RC: page 4 line 24: what is Rs? Not defined until pater on page 5 line 19

AC: Rs is soil C:N ratio, the interpretation has been added when it first appeared in the revised paper.

RC: page 5 lines 6-11: these results are interesting in that the NNF seems to vary inversely to the fraction of total N stocks in soil. If the analysis were based on plant N demand, it would suggest that the increased soil ability to meet demand precludes a NNF. However, the analysis is based on soil N demand. Like I said, interesting. Emphasize this point here and expand on it in the discussion.

AC: The NNF here is the ecosystems total N demand. Yes, it is very interesting that we found the NNF are inversely to correlated to the C:N ratio of soil organic matter. The more nitrogen stocks in soil and the more ecosystem NNF demand

"…If the analysis were based on plant N demand, it would suggest that the increased soil ability to meet demand precludes a NNF…", however if the analysis based on plant N demand, this might resulted very high C to N ratio for soil organic matter(might be closer to C to N ratio of litter, ~43), and the resulted high C to N ratio might not match the realistic values of around 13-16. So we listed out in this paper that ecosystem new N input need to maintain the C to N ratio of both plants and soils. .

RC:Throughout; it is difficult for the naive reader to follow all the symbols. A short word description rather than the symbol would make the manuscript easier to read e.g., like you do on page 5 line 19 for Rs (...ooh that's what Rs means) and line 20 for RL.

AC: R_L are C to N ratio of litter. In the revised MS, the more interpretation for R has been added to text.

RC:page 6 line 3: these numbers might be easier to interpret if they were expressed as C:N rather N:C ratios. Maybe provide both? These C:N rations are very woody. you might point this out and expand on it in the discussion...

AC: We are using the C:N ratio(R) throughout the paper, only using the N:C ratio(r) with the Manzoni's equation to define the critical C:N ratio.

NPP to NNF ratio are ranged between 110-150, while C to N ratio of plant production were ranged between 33-90 as shown in Table 2. This is mainly because parts of N required by NPP production are supplied by the recycled N.

RC: page 6 lines 6-11; Again I wonder about the role of disturbance in driving N losses from real ecosystems. Even the scattered effects of gap-phase dynamics would add up.

AC: Yes, the disturbed ecosystems, for example cropland, might need more new N to feed the losses.

RC: page 6 lines 20-23. I got confused here interpreting "litter" as litter fall or litter production. I'd clarify by changing the wording to "Mineralization from Litter and SOM".

AC: litter means the mass pool of the litter component. Around 52% of the new NNF are stored in SOC, 30% in litter and the remaining 28% in living plant.

RC: page 6 lines 23-25 again I am confused by the previous description of NNF based on soil demand and independent of plant demand. Yes I understand that N cycles and anything that goes into the soil will eventually be available to plants. It might just be the wording that has thrown me off. But if I am having trouble interpreting what you did, so will other readers.

AC: NNF here is the ecosystem N demand, contains N demand both from the plant and soil

RC: page 8 lines 1-8. I think your assessment of resorption versus immobilization in litter works if the vegetation biomass and soil organic mass remain constant, but as fertility increases, I would expect resorption to decline, vegetation biomass to increase and soil organic mass to increase. It is not clear to me that your analysis still holds under those conditions.

AC: I think there are two phases :(1) before NNF demand is satisfied and (2) after NNF were satisfied. During the first phase, with the increasing fertility, the vegetation and soil organic biomass increasing with fertility increase; while on the second phase, with the increasing fertility, vegetation and soil organic biomass will not increase anymore, and soil inorganic N might accumulated with the increasing NO_3^-, ecosystem N saturated.

RC: Copy editor issues Use of () in citations if the authors name is part of the sentence or not. e.g., page 3 lines5, 32 hanging "this" e.g., page 2 line 22 "but this is a small flux" v. "but this flux is small"
page 3 line 21 this acronym has already been defined on page 2 line 13.
page 3 lines 31-32; the first two sentences of this paragraph are empty and could be deleted by modifying the parenthetical in the next sentence to "described by Xu-Ri and Prentice (2008: see Fig. 1 and Appendix S1)"
page 8 line 26 and perhaps elsewhere: usage "due to" means "caused by" not

“because of”
page 9 line 29 “requires” to “require”

AC: All revised.