

Response to Reviewer #2

This study tries to establish a quasi-equilibrium (QE) analytical framework, introduced by Comins & McMurtrie (1993), for evaluating model assumptions on carbon-nitrogen interaction in influencing ecosystem responses to elevated CO₂. Overall, this paper is extremely valuable for understanding a variety of assumptions in influencing model outputs of carbon and nitrogen coupling.

Responses: We thank the reviewer for this positive feedback on our manuscript.

I particularly like your examples on page 23 to make a point that “the QE framework can highlight where additional complexity is not valuable.”

Responses: Thank you. This is indeed one of the key points that we would like readers to pay attentions to.

Here are a few suggestions to improve your manuscript:

First, the authors may consider improve the readability of your paper so that your message can go more miles. It is quite competent of the authors to work out all those equations in section 3. But those equations will hinder delivering your message as not all the ecologists or even modelers will go over those equations when they read your paper.

Responses: Indeed, this is a problem that details in Section 3 may prevent a smooth read of the manuscript. As we suggested in our response to Reviewer #1, we will move some equation derivations into an Appendix (not supplementary materials) to both comply with the journal requirement of keeping all essential elements in the main body of text, as well as improve readability of our manuscript. We hope that this will sufficiently address the issue.

In addition, would it be possible to convert Table 1 to a graph so that readers can quickly get your message? To me, Table 1 is probably the most important part of your manuscript. Even though I am familiar with the subject, it still takes me a while to go over the table. Converting it to a figure may help deliver your message faster. Moreover, the abstract I don't think deliver the message well, especially the second half.

Responses: We will revise the abstract to make it more impactful. Table 1 is a summary of the literature which have adopted the quasi-equilibrium framework in the past. We presented some detailed introduction and discussion of this pool of literature in our Literature Review section (Section 2), and provided a graphic example in Supplementary Figure 1. Given the diverse set of model assumptions evaluated in the past pool of literature, as presented in Table 1, it is not easy to plot one figure to sufficiently synthesize all information. However, the general aim of including Table 1 and the Literature Review section was to demonstrate the usefulness of the quasi-equilibrium framework; they are not the key novel results that this manuscript adds into the literature.

Table 3 summarizes how different model assumptions affected plant production response to eCO₂ at various time steps, which we believe are the “novel” results that this study brings. The graphic interpretations of the effect of each individual model assumption have been provided in Figures 4-6, and the table is a synthesis and numerical display of these results. We think that the combination of the Table and individual Figures is the most appropriate way of presenting our analyses. A stand-alone summary figure based on Table 3 appears very noisy, and makes it difficult for readers

to capture the detailed dynamics that each assessment brings. All our codes, including the quasi-equilibrium framework and the plots, are publically accessible. Therefore, one can potentially explore how alternative plotting schemes compare using this code repository.

Second, the work by Comins & McMurtrie (1993) is great. But, during the same period in 1990s, Dr. Edward Rastetter has developed the Multiple Element Limitation (MEL) model of carbon-nitrogen interactions. He published a few papers to illustrate similar principles on carbon-nitrogen interactions as revealed by G'DAY. In fact, Ed Rastetter also lumped all those assumptions (or processes) into three categories as in the first three items of your Table 1. MEL further shows the time scales at which each of the three categories of processes plays. In other words, MEL not only gives information about the equilibrium responses but also offers information about C/N interaction to influence transient dynamics. I think the authors at least should acknowledge Ed's work in your manuscript.

Responses: Thank you for this insightful comment. We will revise our text wherever appropriate to incorporate this insightful comment and valuable literature.

Third, it is fine that the G'DAY model offers an analytical framework to evaluate model assumptions on carbon and nitrogen interactions. However, the impacts (or sensitivity) of those assumptions evaluated by the framework depend on the ranges of the variables you changed. For example, your analysis shows that wood N:C flexibility is very important for modeling carbon and nitrogen interactions. What ranges of wood N:C did those studies change? Do those ranges realistically match observations? Lots of data are available to evaluate those ranges. In fact, several studies have evaluated the ranges of changes of those variables (e.g., Liang et al. 2016). Bringing observations into your study may require the authors to do additional work but will improve quality of your study. At least the authors should add discussion on observed vs. modeled ranges of changes.

Responses: Thank you again for this insightful comment. We will revise our manuscript accordingly. However, it is still our major purpose to demonstrate how one can analytically interpret consequence of a model assumption without running a model, rather than having readers to focus on how close one can match some theoretical model behaviors with a range of observations. Therefore, while we believe it is important to bridge observations with modeling, the inclusion of such an analysis may make this already heavily condensed paper more complicated. On the other hand, we will add a paragraph acknowledging this important issue in our discussion.

Forth, if the authors want to popularize the QE framework to be used by the broad community, they may develop a simpler scheme for others to use. The extensive list of those equations may make it very difficult for others to use.

Responses: Agree. We will revise our baseline model description section (i.e. section 3.1) in combination of comments made by Reviewer #1 to improve the readability of the baseline QE framework.

Reference: Junyi Liang, Xuan Qi, Lara Souza, and Yiqi Luo. 2016. Processes regulating progressive nitrogen limitation under elevated carbon dioxide: a meta-analysis. *Biogeosciences*, 13, 2689-2699.

Responses: This is a useful reference and we will add it wherever appropriate.