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Discussions

Interactive comment on "Long-term Carbon and Nitrogen Dynamics at SPRUCE Revealed through Stable Isotopes in Peat Profiles" *by* Erik A. Hobbie et al.

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Anonymous Referee #1 Received and published: 10 October 2016 Comment: In this paper, authors try to link the observed chemical properties in peat profiles (C, N, and their isotopic composition) with current and historical biogeochemical processes over the several thousand years of peat development. Using the multiple regression analysis, they conclude that the peat profiles were controlled by the Suess effect, vegetation, hydrology, and fractionation involving C-N chemical bongs. Their approach is interesting and the information can potentially help better understand biogeochemical processes associated with peatland development. My biggest concern is that the conclusions are drawn heavily from the results of multiple regression analysis. If I un-

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derstand the Appendix 1 correctly, it appears that 238 C1 data points were regressed for 43 parameters. If this is correct, then there may be an overfitting problem, and some of the significance found in the analysis may be misleading. Combining plots and soil depth by functional groups (e.g., “near-lagg plots” vs. “away-from-lagg plots”, “modern vs. old soil horizon”, or differences in REDOX status) can reduce the number of parameters significantly. Response: We consulted with a statistician at UNH about this issue and he recommended transforming depth into a continuous variable, which we have now done. To account for the obvious non-linearity of the isotopic responses to depth, he also recommended including the depth, the square of depth, and the cube of depth as separate parameters (that is, a cubic transformation). This reduced the depth to three terms. Plots remained as nominal variables, but we now used a stepwise approach, which parses the plots sequentially into two groups to account for maximum variability. This reduced the number of plot variables to three as well. The best-fit models based on minimum AICc values now had only 11 terms for ïĄď15N and 13 for ïĄď13C, which is a four-fold reduction. Of the parameters previously included in the regression analysis, vegetation cover (near trees or not) is no longer a significant factor for ïĄď15N and topography is no longer a significant factor for ïĄď15N, presumably because the information is now largely included in the continuous variable of depth. The methods, results, and discussion have been changed to reflect these changes in our statistical approach.

Comment: I found the earlier part of the paper to be somewhat difficult to follow. This was mainly because of the lack of site information, which was described later in the paper. I think that it would be more helpful to the readers, who are not familiar with this particular ecosystem, if important site characteristics were described earlier in the paper. These include: the relative location of upland and lagg; hydrology differences among upland, lagg, and bog; seasonal shifts in water table (if any). Response: The site information is now moved to earlier in the paper. Figure 2 now indicates the location of the lagg versus the bog. In addition, hydrologic information about the bog and two relevant references have been added to the first section of the Methods. We indicate that the water table can shift up to 30 cm on an annual basis and 140 cm over the course of a 50-year record.

Comment: Finally, I think that the authors need to tie their findings back to the conceptual model presented in Fig. 1. by highlighting the correspondence and discrepancy between their conceptual model and their data in the discussion. Response: We have now added several sentences to the concluding paragraph discussing where our conceptual model captured important features of bog C and N dynamics that influenced isotopic patterns and where our conceptual model appeared to be lacking.

Specific comments: Comment: Hummock vs. hollow is described as "topography" in some places and "microtopography" in other. I suggest using the same word throughout the paper. Given that the authors discuss upland effects in the discussion, it is a bit confusing in some places whether they mean hummock-hollow or upland-bog. Response: microtopography has been changed to topography. We feel that for the most part the distinction between uplands and peatland topography of hummocks and hollows is clear in the manuscript. We have added the words "adjacent" and "within peatlands" to the caption of Figure 1 to further clarify this distinction. "N flux from adjacent uplands influences productivity in the lagg region, and hummock and hollow topography within peatlands influences methanogenesis and methanotrophy."

Comment: I suggest that the authors clearly describe what was used as a reference (0 cm) soil depth. In some places, it is referenced to the hollow surface, and other places the water table. Response: The reference (0 cm) depth is now clearly identified as the hollow surface.

Comment: P.4, L.19 How did fine roots identified to species? I don't think the root C, N, and isotope data are not presented in the paper. Response: Fine roots were not identified to species but were identified to broad taxonomic categories of shrubs (dicots), sedges (monocots), and conifers. However, the spatial sampling of roots was not often enough to permit each of the 17 core locations to have corresponding root

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data, and so root data are only presented in the text, in the first paragraph of the results.

Comment: P. 6, L.11-12 For this statement, it would be nice to have C, N, and isotope information of roots and senesced leaves. Because roots are the major player for boreal soil C C2 (Clemmensen et al. 2013) and because nearly half of foliar N would be resorbed during senescence, it would make more sense to use C, N, and isotope values of roots and senesced leaves than the values of live leaves, if the data are available. Response: There is little or no 15N fractionation during resorption, so litter corresponds closely to foliar δ15N. We do give isotopes on roots, but it is not given at the species level. Litter data were not available.

Comment: P.6, L.23 "very low in %N and δ15N and high in C/N" – Showing the actual values here from the citation would be helpful. Response: The values have been added: "very low in %N (0.22%) and δ15N (-3.6‰ and high in C/N ($\sim$190)"

Comment: P.8, L.17-19 It sounds that the water table in this bog is very close to the surface. I am not sure whether the presence of trees can create a large enough gradient in water potential that would affect 13C fractionation of photosynthesis. I would assume water potential gradient to be greater between the hummock and hollow than between locations near trees and away from trees. Response: The reviewer may very well be correct. As we worked on the revisions, we found a paper where ïĄď13C in Sphagnum was compared against water table depth, with a negative correlation and a slope of 0.04‰ per cm (Loader et al. 2016). Based on our coefficient of -0.12‰ for the tree factor, a 6 cm difference in depth to water table between treed and untreed areas would explain the difference. (Loader, N., StreetâĂŘPerrott, F., Mauquoy, D., Roland, T., van Bellen, S., Daley, T., Davies, D., Hughes, P., Pancotto, V., and Young, G., 2016: Measurements of hydrogen, oxygen and carbon isotope variability in Sphagnum moss along a microâĂŘtopographical gradient in a southern Patagonian peatland. Journal of Quaternary Science, 31(4): 426-435.)

Comment: P.9, L.2-3 Please specify which N-loss pathways are discussed here; via

DON leaching or denitrification, or both? The authors mentioned earlier that DON lost from wooded upland was more 15N enriched. Is the term “sedge system” equivalent to the wooded upland? If denitirification losses were being concerned here, then higher rates in fens than bogs (P.9, L.11) could result in N lost from fens can be more 15N depleted than bogs. Response: The N losses actually are unspecified and the main point is that equivalent N losses should be higher in 15N from sedge systems than from non-sedge systems. We have added “via equivalent pathways (e.g., denitrification, DON)” to the sentence in question (given below) to make this clear. “As a consequence, N losses via equivalent pathways (e.g., denitrification, DON) from sedge systems will tend to be 15N-enriched relative to N losses from systems without sedges. “

Comment: Table 2. Please add the information for roots. Response: As indicated above, all the root data are given in the first paragraph of the results, so it was not necessary to add it to a table. We did not have species-specific root data.

Comment: Fig. 1. This conceptual model and the data presented in the paper do not match in some cases. I would like to see discussions that tie their results back to this conceptual model: what are the processes responsible for the discrepancies? Response: See response to the ‘Conceptual Model’ comment (3rd comment above).

Comment: Fig. 5-b. Could it be possible to add a rough sketch of study sites, overlaying the coefficient values on each plot? Adding the relative location of upland, bog, and lagg on the sketch would help. I went back and forth between Fig.5-b and Fig. 2, only to find that the layout of the coefficient values do not align with the plot layout (there are different number of rows, for example). Response: In the revised statistical analyses, we have less precise spatial information on how the plots differ isotopically, and therefore discuss it less. The revised Figure 2 now includes the boundary between the lagg and the bog.

Technical Comments Comment: P.2, L.10 “d13C of photosynthesis” – photosynthates? " Response: Changed to “plant photosynthate”

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Comment: P.2, L.26-27 Rephrase to explain what "topographic effects" are considered here. Response: The sentence in question stated: "Differential rates of net primary production and decomposition which vary by specific vegetation and water table could also contribute to topographic effects (Moore et al., 2007; Vitt et al., 2009)." We have deleted this sentence and removed the two references from the reference list.

Comment: P.3, L.35 "the location of future experimental plots" – future? Response: "future" has been removed.

Comment: P.6, L.24 "seven times" – how does this frequency compare with the frequency of Sphagnum? Response: This was buried wood. Changed to "seven times during laboratory examination of the 238 samples".

Comment: P.7, L.4 "breaking a C:N bond will discriminate against both 13C and 15N." – please add citations for this statement. Response: An early cite under experimental conditions has been added, Silfer et al. 1992 (Silfer, J. A., Engel, M. H., & Macko, S. A. (1992). Kinetic fractionation of stable carbon and nitrogen isotopes during peptide bond hydrolysis: experimental evidence and geochemical implications. Chemical Geology: Isotope Geoscience Section, 101(3-4), 211-221.)

Comment: Fig. 1. "methanotrophy and CO2 recapture by Sphagnum" – "recaptured". Response: This has been changed to "methanotrophy and subsequent CO2 recapture by Sphagnum". Using 'recaptured' as a verb would not be appropriate with the rest of the sentence.

Comment: Fig. 3. The C/N axis does not look like natural-logged values. Response: The legend was changed to reflect that C/N, rather than log C/N, is plotted.

Comment: Fig. 5. "plot locations are as given in Figure 1" – should be Figure 2. Response: Changed.

Comment: References Some citations in the text are not included in the reference list. Response: All text citations have now been checked against the reference list.

Comment: Literature cited in this comment: Clemmensen et al. (2013) Science, 339:1615 Interactive comment on Biogeosciences Discuss., doi:10.5194/bg-2016-261, 2016.

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