

## ***Interactive comment on “Continuous and discontinuous variation in ecosystem carbon stocks with elevation across a treeline ecotone”*** **by J. D. M. Speed et al.**

**Anonymous Referee #3**

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Speed et al. present a clearly structured paper documenting changes in ecosystem carbon stocks with elevation across a treeline ecotone. The major findings of this paper are: (1) vegetation C stocks decrease with elevation until the treeline, after which the vegetation C stocks are constant, (2) organic soil C stocks increase with elevation across the all vegetation zones, (3) total ecosystem C stocks increase with elevation above the treeline but decrease with elevation below the forest line, such that there is a minimum between the forest line and treeline (Fig. 5), and (4) there was no effect of short-term grazing on elevational patterns in ecosystem C stocks. This manuscript is appropriate for the scope of the journal Biogeosciences.

General Comments:

C7993

The authors establish clear predictions and then test these using appropriate methods, statistical techniques and interpretation. The results are well presented and the findings and interpretation are interesting. The paper is well written and the figures appropriately formatted and clear for the most part (see technical corrections below). The references to the literature are appropriate. However, I agree with reviewer #2 that the focus on the treeline as being static with a decrease in vegetation C with elevation is somewhat trivial and does not highlight the greatest contributions of the study.

This study will contribute to our understanding of forest ecotone carbon storage, particularly under global change. In fact, relating the findings to global change and addressing the dynamic nature of this treeline ecotone is where the paper could be strengthened (see below). There are three issues that could be better addressed: (1) the paper could have a stronger focus on climate and climate change, (2) the dynamic nature of the treeline could be better incorporated into the interpretation of the data, and (3) the implications of reduced recruitment due to herbivory could be better discussed.

As Referee #2 discusses, the paper could have a stronger focus on the separate contributing effects of vegetation versus climate along the elevational gradient. And these findings could be put in the context of on-going climate change in the region in the discussion. Right now the links of the findings to climate are weak. What are the differences in climate along the elevational gradient? How do these differences relate to projected temperature changes in the region? How might ecosystem C stocks change with climate warming?

The ecosystem C stocks are put in the context of the vegetation gradient, but the dynamic nature of the treeline that is suggested by the age structure (Fig. 3b) is not adequately discussed. How will ecosystem C stocks change with an advancing treeline. The study may not be able to answer this question, but it could be better addressed in the discussion section of the paper. Perhaps some sort of modelling exercise could shed further light on this issue.

C7994

Though the authors do discuss herbivory, the implications of changing herbivory on treeline carbon storage is not as well fleshed out in the paper as it could be. The authors did not observe an effect of short-term grazing on the ecosystem C storage, however, they have previously found an impact of grazing on tree recruitment in this region. However, the impacts of grazing on future reduced recruitment could potentially be worked into a model estimate of the impact of grazing on future ecosystem C stocks.

As mentioned above, it would improve the paper if the difference in response rates between soil, vegetation and herbivory contributions to ecosystem C were explicitly addressed. Since both soil and vegetation C are driven by climate, how quickly would change occur to ecosystem C storage in this system with treeline advance? This dynamism also ties in with discussion of grazing, since the authors recognized already that the experiment may not have been running for long enough to have a meaningful impact on C stocks during this study. Perhaps it would be possible to gain further information from analysis of the grazing plots regarding response times in this system (as per review 1).

In order to address these issues, I would recommend the inclusion of three new paragraphs in the discussion and perhaps the addition of qualitative or quantitative modeled estimates of the influence of changing climate, treeline dynamics and herbivory in the region and the impacts of these changes on ecosystem C storage.

Specific Comments and Technical Corrections:

1. The term field-layer vegetation should be changed to ground vegetation or something similar as it is confusing. (And, the hyphenation should be used consistently if the term or a similar one is retained)
2. There are some minor phrasing issues that might benefit from a re-read e.g. p15437, line 2-5: 'biomass contribute', 'stock are' – singular or plural? P 15440, line 3 'soils were stored dark and cold' could be 'soils were stored in dark and cold conditions'.

C7995

3. P 15437 line 16: Should treeline advance and shrub expansion be considered an environmental 'challenge'?
4. P15448 line 26-27: Discussion between Hallinger et al (New Phytologist (2010) 186: 890–899), Buntgen & Schweingruber (New Phytologist (2010) 188: 646–651) and Hallinger & Wilmking (New Phytologist (2011) 189: 902–908) – could be useful for context on treeline advance and age structure.
5. The grey and black dots in the figures are very hard to distinguish and should be changed to be larger or different symbols so that they can be told apart from each other.
6. Figure A2 is very difficult to read. Perhaps it could be turned into a multi-panel figure of the different components of the ordination to improve the communication of the data/analysis.

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