Biogeosciences Discussions

Biogeosciences Discuss., referee comment RC2
https://doi.org/10.5194/bg-2021-169-RC2, 2021

Comment on bg-2021-169

Ch. Körner (Referee)

Referee comment on "Nitrogen restricts future sub-arctic treeline advance in an individual-based dynamic vegetation model" by Adrian Gustafson et al., Biogeosciences Discuss., https://doi.org/10.5194/bg-2021-169-RC2, 2021

Comment for the Authors

Gustafson et al. aim at modelling future treeline position in northern Sweden and the causes that control potential shifts. I am familiar with the associated theory and the region. Using environmental data and biological response functions, a digital vegetation model is applied (with the treeline forming species of this region, Betula pubescence ssp.).

Such a model has a predefined response hierarchy, that is, assumptions on both, the relative importance of drivers and the direction of causality. These assumptions, though absolutely central, are not mentioned upfront, but they become obvious as one reads the text. One of the key assumptions is that these trees are C limited and that photosynthesis, A f (T, PFD, CO2) drives growth. Starting with such assumptions, the inevitable outcome is that CO2 matters for growth, although it may not matter for treeline position, depending in other assumptions. Yet, in my view this is dressing the horse from the tail. It became obvious in recent decades that outside horticulture and agro-conditions, growth controls A via phloem downloading on demand for C, and this demand is set by meristem activity and other sinks. Not surprisingly manipulating C supply in the field neither rose growth or productivity in alpine vegetation, nor in treeline trees (there were transitory effects on young, isolated Larix individuals in exceptionally warm summers, that did not affect final biomass data, pine was never affected). None of these works are cited (the only reference to CO2 experiments is the differential response of two upper montane understorey shrubs).

I do respect the skills of the authors to parameterize and handle such a complex set of algorithms, but the underlaying rationale reflects our understanding of causalities in the 1980s. I am quite aware that starting with modelling growth rises other issues, but

several teams have no engaged (Simone Fatichi, Andrew Friend, several papers) and even the dendro-community is now moving forward in that direction (read e.g. Jan Tumajer et al. Frontiers in Plant Sciences 28 Jan 2021). They are still unable to handle resource supply as modulating factors.

With these concerns, the results of the modelling reflects the assumptions. If one assumes soil fertility matters for treeline trees and selects N to represent these nutrients, the outcome is that N matters. If soil fertility were controlling treeline position there should not be a global treeline isotherm and treeline should be at higher elevation on good soils and at lower elevations on poor soils, not what we see in the field (e.g soils developing on young glacial deposits versus treelines on geologically old, weathered, low latitude mountains. Experiments by Hoch (2013) revealed that there is no compensatory effect of nutrient addition to low temperature constraints of growth. There is also no direct link between tree vigor and treeline position. Trees at treelines in Bolivia and Tibet at close to 5000 m elevation hardly grow (minute tree ring width), because they are clearly moisture and thus, nutrient limited.

The fact that soil nutrition and vigor do not affect treeline elevation relative to temperature globally, in my view contradicts the conclusions drawn from this modelling attempt.

Here a few references on experimental works in this field:

Hoch G (2013) Reciprocal root-shoot cooling and soil fertilization effects on the seasonal growth of two treeline conifer species. Plant Ecology and Diversity 6: 21-30

http://dx.doi.org/10.1080/17550874.2011.643324

Körner C, Diemer M, Schäppi B, Niklaus P, Arnone J (1997) The responses of alpine grassland to four seasons of CO2 enrichment: a synthesis. Acta Oecologica 18:165-175

Inauen N, Körner C, Hiltbrunner E (2012) No growth stimulation by co2 enrichment in alpine glacier forefield plants. Glob Change Biol 18:985-999

Dawes MA, Hagedorn F, Handa IT, Streit K, Ekblad A, Rixen C, Körner C, Hättenschwiler S (2013) An alpine treeline in a carbon dioxide-rich world: synthesis of a nine-year free-air carbon dioxide enrichment study. Oecologia 171:623-637

Körner C (2015) Paradigm shift in plant growth control. Curr Opin Plant Biol 25:107-114

See the discussion of CO2-effects and treeline in

Körner C (2021) Alpine Plant Life (3rd ed.), Springer, Cham, also available online

See also:

Körner C (2021) The cold limit of trees. Trends in Ecol Evol, online

I hope these comments are useful for revisiting the rationales underpinned in this model. I read the other report in copernicus, thanks for providing it. It seems to address additional facets of treeline formation, but does not touch upon the more fundamental bias regarding the assumptions that drive the model output.

Christian Körner