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RESPONSE TO EDITOR

Tree growth and treeline responses to temperature: Different questions and concepts

In his letter to the editor, Körner (2021) commented on our recent assessment of climate impacts on tree growth at treeline (Camarero et al., 2021). We share some of his opinions such as the nonlinear responses of growth to temperature. We also agree that focusing on temperature-dependent processes such as growth can improve forecasts of treeline responses to climate. However, we disagree on his commentary suggesting that we concluded *treeline* will no longer be limited by low temperature and that this implies treeline and isotherms will diverge. For the sake of clarity, we must differentiate growth responses to temperature of treeline trees from treeline position responses to temperature. It must be noted that radial growth is just one component of treeline dynamics which consist of other processes, including establishment and mortality.

First, our study did not aim to predict shifts in treeline position, rather we aimed to model changes in growth of treeline trees as a function of temperature. Second, non-thermal, local factors can affect growth responses at treeline including, for instance, size and age structures, biotic interactions, soil conditions or precipitation regimes (Camarero et al., 2017; Fajardo & McIntire, 2012; Wang et al., 2016).

The explanatory power of growth variation based on temperature models did not evenly increase with elevation confirming threshold growth responses to temperature at treeline (Paulsen et al., 2000). According to Körner (2021), such variation would be explained by differential growth enhancement by climate warming shifting upwards or polewards. He suggests that once a threshold is surpassed, thermal effects diminish, and this would explain our findings because growth of 20th-century treeline trees will not be any more limited by low temperature since they will not form the "climatic treeline." We reconstructed growth of 20th-century treeline trees and projected their growth rates during the 21st century based on climate scenarios with different warming rates. Our forecasts involved treeline trees, and many recruited during the 19th century, but they should also apply to treeline trees recruited recently, for example, 50 years ago. If isotherms shift upslope or poleward due to climate warming, treeline trees will be exposed to more or less thermal constraints of growth depending on treeline shift rates. Some treelines could shift while others could show lagged or null responses to climate. Isotherms may move upslope, but treeline trees may not; our study focused on trees growing at the altitudinal or latitudinal limits of tree existence today regardless of where the treeline will be in the future.

Non-thermal factors such as soil moisture can also impact treeline dynamics by influencing regeneration, growth and mortality rates, thus making treeline shifts less dependent on temperature than expected (Batllori et al., 2009; McIntire et al., 2016; Sidgel et al., 2018). This would explain why many treelines are not shifting upward or poleward in response to climate warming (Harsch et al., 2009). Overall, we conclude that treeline trees showing a high growth limitation by cold temperatures during the 20th century could become less responsive to warmer conditions during the 21st century.

DATA AVAILABILITY STATEMENT

Not applicable.

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