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Editorial

Alpine and Polar Treelines in a Changing Environment

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Received: 23 February 2020; Accepted: 25 February 2020; Published: 26 February 2020

Concerns have been raised with respect to the state of high-altitude and high-latitude treelines, as they are anticipated to undergo considerable modifications due to global change, especially due to climate warming [1–4]. Given that high-elevation treelines are temperature-limited vegetation boundaries [5–8], they are considered to be sensitive to climate warming. As a consequence, in a future, warmer environment, an upward migration of treelines is expected because low air and root-zone temperatures constrain their regeneration and growth. Despite the ubiquity of climate warming, treeline advancement is not a worldwide phenomenon: While some treelines have been advancing rapidly, others have responded sluggishly or have remained stable [9]. This variation in responses is attributed to the potential interaction of a continuum of site-related factors, which may lead to the occurrence of locally conditioned temperature patterns. Furthermore, competition amongst species and below-ground resources has been suggested as an additional aspect to explain the variability of the movement of treelines. This Special Issue is dedicated to the discussion of treeline responses to changing environmental conditions in different areas of the globe. A short outline of the individual contributions will be presented in the following paragraphs.

Effects of climate change on conifers within the treeline ecotone of the Central Austrian Alps is reviewed by Wieser et al. [10]. They outline tree growth conditioned by elevation and possible effects of climate change on carbon gain and water relations, which are derived from space-for-time studies and manipulative experiments. In addition, based on long-term observational records, possible future tendencies of tree growth in a warmer environment are discussed. Oberhuber et al. [11] analyzed the growth trends of conifers along environmental transects in the Central European Alps and explain the missing adequate growth response to climate warming, competition for resources in increasingly denser stands at subalpine sites, and by frost desiccation injuries of evergreen tree species at the Krummholz-limit. Wieser et al. [12] investigated the effects of artificial topsoil drought on the water use of *Picea abies* and *Larix decidua* Mill. saplings at the treeline in the Austrian Alps. Their study revealed that a three-year water shortage in this layer of the ground did not considerably reduce water loss in both species investigated. Mayr et al. [13] investigated winter embolism and recovery in *Pinus mugo* L. and state that future changes in snow cover regimes may significantly affect embolism and refilling processes. With respect to *Pinus cembra* L. saplings, Oberhuber et al. [14] demonstrated that a weak apical control might serve as protection against severe climatic conditions above the treeline during the winter.

High resolution maps of climatological data are essential for modeling the potential impacts of climate change on forests. For the Swiss Alps, Zischg et al. [15] presented such maps of temperature, relative humidity, radiation, and "föhn" winds. Apart from altitude, these maps also take into account micro-relief, slope, and aspect. Chiang et al. [16] proposed that aside from temperature, potential changes in light quality and quantity also play an important role in the phenology and growth of woody plants in boreal and temperate climates.

González-Rodriguez et al. [17] assessed the photosynthetic performance of *Pinus canariensis* Chr. Sm. Ex DC in Buch in Tenerife, Canary Islands to cope with seasonal changes in environmental conditions, especially summer drought. They found that, at the treeline, *Pinus canariensis* displays a drought avoidance strategy due to a great plasticity in gas exchange, antioxidants, and pigments. Pakharkova et al. [18] demonstrated that *Pinus sibirica* Du Tour and *Abies sibirica* L. showed different patterns of photosynthetic pigments along an elevational gradient in the West Sayan ridge, Siberia. As the decline in photosynthetic pigments with increasing elevation was more pronounced in *Pinus sibirica* needles than in *Abies sibirica* needles, the authors conclude that under conditions of future climate warming, *Pinus sibirica* trees will have an advantage in colonizing zones above the present treeline. Shiryaev et al. [19] investigated the long-term influence of climate change on the spatiotemporal dynamics on mycobiota in the Polar Ural. Their results showed that the composition of the fungal community followed alterations in vegetation, which changed from a forest-tundra to a boreal forest in the past 60 years.

Yu et al. [20] investigated the microenvironmental effects on the physiological performance of *Betula ermanii* at and beyond the treeline on Changbai Mountain in Northeast China. Their results showed that mature trees at these levels did not differ substantially in their ecophysiological performance due to microclimatic amelioration at microsites above the treeline. Leaf and soil $\delta^{15}N$ patterns were studied along elevational gradients in tree- and shrublines in three different climatic zones in Wolong Nature Reserve in Southwest China by Wang et al. [21], who reported that $\delta^{15}N$ leaf and $\delta^{15}N$ soil values were higher in subtropical forests compared to dry and wet-temperate forests.

McGlone et al. [22] presented a study on the postglacial treeline history of Sub-Antarctic Campbell Island, south of New Zealand. Their results pointed out that the treeline position in the southern hemisphere is noticeably affected not only by temperature, but also by cloudiness and seasonality. As a consequence, they concluded that a continuous increase in warming may not necessarily cause an advancement of the treeline in oceanic regions. A dendroclimatic assessment of Ponderosa pine radial growth along elevational transects in Western Montana, USA was presented by Montpellier et al. [23]. Their research findings suggest that Ponderosa pine trees at lower elevations may be better adapted to withstand warm and dry periods, while trees at high elevations are better suited to cool and wet conditions.

Seedling regeneration is an important feature discussing treeline dynamics in a future, changing environment. Based on a worldwide survey, Johnson and Yeakley [24] showed that seedling regeneration varied with respect to climate zone and microsite. Their results suggest that due to climate change, seedling regeneration will mainly benefit in cold and wet locations. The review of Holtmeier and Broll [25] provides a literature overview of treeline research from its onset to the present. They detected a reiterative pattern: a moderate number of ideas that, at present, are considered novel, that originated several decades ago, and tend to confirm prior knowledge. Additionally, they also outline further research questions.

Finally, I would like to express my gratitude to all the authors for their timely, high-quality contributions providing insights into high-altitude and high-latitude treelines within the context of global change. Furthermore, I thank all the anonymous reviewers for maintaining the quality standard of the Special Issue. I also appreciate the fruitful co-operation with the MDPI *forests* team, especially A. Zhang, during all stages of the project.

Conflicts of Interest: The author declares no conflicts of interest.

References

1. Wieser, G.; Tausz, M. Trees at their upper limit: Treelife limitation at the Alpine Timberline. In *Plant Ecophysiology*; Springer: Berlin/Heidelberg, Germany, 2007; Volume 5.
2. Körner, C. *Alpine Treelines: Funtional Ecology of the Global High. Elevation Tree Limits*; Springer: Berlin/Heidelberg, Germany, 2012.

3. Holtmeier, F.-K.; Broll, G. Treeline advance—Driving processes and adverse factors. *Landsc. Online* **2007**, *1*, 1–33. [CrossRef]
4. Smith, W.K.; Germino, M.J.; Johnson, D.M.; Reinhardt, K. The altitude of alpine treeline: A bellwether of climate change. *Bot. Rev.* **2009**, *75*, 163–190. [CrossRef]
5. Körner, C. A re-assessment of high elevation tree line positions and their explanation. *Oecologia* **1998**, *115*, 445–459. [PubMed]
6. Esper, J.; Cook, E.R.; Schweingruber, F.H. Low-frequency signals in long tree-ring chronologies for reconstructing past temperature variability. *Science* **2002**, *295*, 2250–2253. [CrossRef] [PubMed]
7. Körner, C.; Paulsen, J. A world-wide study of high altitude treeline temperatures. *J. Biogeogr.* **2004**, *31*, 713–732. [CrossRef]
8. Rossi, S.; Deslauriers, A.; Gričar, J.; Seo, J.-W.; Rathgeber, C.B.K.; Anfodillo, T.; Morin, H.; Levanic, T.; Oven, P.; Jalkanen, R. Critical temperatures for xylogenesis in conifers of cold climates. *Glob. Ecol. Bioeogr.* **2008**, *17*, 696–707. [CrossRef]
9. Harsch, M.A.; Hulme, P.E.; Huntley, B. Are treelines advancing? A global meta-analysis of treeline response to climate warming. *Ecol. Lett.* **2009**, *12*, 1040–1049. [CrossRef]
10. Wieser, G.; Oberhuber, W.; Gruber, A. Effects of Climate Change at Treeline: Lessons from Space-for-Time Studies, Manipulative Experiments, and Long-Term Observational Records in the Central Austrian Alps. *Forests* **2019**, *10*, 508. [CrossRef]
11. Oberhuber, W.; Bendler, U.; Gamper, V.; Geier, J.; Hölzl, A.; Kofler, W.; Krismer, H.; Waldboth, B.; Wieser, G. Growth Trends of Coniferous Species along Elevational Transects in the Central European Alps Indicate Decreasing Sensitivity to Climate Warming. *Forests* **2020**, *11*, 132. [CrossRef]
12. Wieser, G.; Oberhuber, W.; Gruber, A.; Oberleitner, F.; Hasibeder, R.; Bahn, M. Artificial Top Soil Drought Hardly Affects Water Use of *Picea abies* and *Larix decidua* Saplings at the Treeline in the Austrian Alps. *Forests* **2019**, *10*, 777. [CrossRef]
13. Mayr, S.; Schmid, P.; Rosner, S. Winter Embolism and Recovery in the Conifer Shrub (*Pinus mugo* L.). *Forests* **2019**, *10*, 941. [CrossRef]
14. Oberhuber, W.; Geisler, T.; Bernich, F.; Wieser, G. Weak Apical Control of Swiss Stone Pine (*Pinus cembra* L.) May Serve as a Protection against Environmental Stress above Treeline in the Central European Alps. *Forests* **2019**, *10*, 744. [CrossRef]
15. Zischg, A.; Gubelmann, P.; Frehner, M.; Huber, B. High Resolution Maps of Climatological Parameters for Analyzing the Impacts of Climatic Changes on Swiss Forests. *Forests* **2019**, *10*, 617. [CrossRef]
16. Chiang, C.; Olsen, J.; Basler, D.; Bånkestad, D.; Hoch, G. Latitude and Weather Influences on Sun Light Quality and the Relationship to Tree Growth. *Forests* **2019**, *10*, 610. [CrossRef]
17. González-Rodriguez, Á.M.; Brito, P.; Lorenzo, J.; Jiménez, M. Photosynthetic Performance in *Pinus canariensis* at Semiarid Treeline: Phenotype Variability to Cope with Stressful Environment. *Forests* **2019**, *10*, 845. [CrossRef]
18. Pakharkova, N.; Borisova, I.; Sharafutdinov, R.; Gavrikov, V. Photosynthetic Pigments in Siberian Pine and Fir under Climate Warming and Shift of the Timberline. *Forests* **2020**, *11*, 63. [CrossRef]
19. Shiryaev, A.; Moiseev, P.; Peintner, U.; Devi, N.; Kukarskih, V.; Elsakov, V. Arctic Greening Caused by Warming Contributes to Compositional Changes of Mycobiota at the Polar Urals. *Forests* **2019**, *10*, 1112. [CrossRef]
20. Yu, D.; Wang, Q.; Wang, X.; Dai, L.; Li, M. Microsite Effects on Physiological Performance of *Betula ermanii* at and beyond an Alpine Treeline Site on Changbai Mountain in Northeast China. *Forests* **2019**, *10*, 400. [CrossRef]
21. Wang, X.; Jiang, Y.; Ren, H.; Yu, F.; Li, M. Leaf and Soil δ^{15}N Patterns Along Elevational Gradients at Both Treelines and Shrublines in Three Different Climate Zones. *Forests* **2019**, *10*, 557. [CrossRef]
22. McGlone, M.; Wilmshurst, J.; Richardson, S.; Turney, C.; Wood, J. Temperature, Wind, Cloud, and the Postglacial Tree Line History of Sub-Antarctic Campbell Island. *Forests* **2019**, *10*, 998. [CrossRef]
23. Montpellier, E.; Soulé, P.; Knapp, P.; Maxwell, J. Dendroclimatic Assessment of Ponderosa Pine Radial Growth along Elevational Transects in Western Montana, USA. *Forests* **2019**, *10*, 1094. [CrossRef]

24. Johnson, A.; Yeakley, J. Microsites and Climate Zones: Seedling Regeneration in the Alpine Treeline Ecotone Worldwide. *Forests* **2019**, *10*, 864. [CrossRef]
25. Holtmeier, F.; Broll, G. Treeline Research—From the Roots of the Past to Present Time. A Review. *Forests* **2020**, *11*, 38. [CrossRef]