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Trading space for time: Assessment of tree habitat shifts under climate change using bioclimatic envelopes

Katharina Enigl[1,2], Matthias Schlögl[1,3], and Christoph Matulla[1]

[1]Climate Impact Team, Department for Climate Research, Zentralanstalt für Meteorologie und Geodynamik, Vienna, Austria
[2]Department of Meteorology and Geophysics, University of Vienna, Vienna, Austria
[3]Institute of Mountain Risk Engineering, University of Natural Resources and Life Sciences, Vienna, Austria

Climate change constitutes a main driver of altering population dynamics of spruce bark beetles (*Ips typographus*) all over Europe. Their swarming activity as well as development rate are strongly dependent on temperature and the availability of brood trees. Especially over the last years, the latter has substantially increased due to major drought events which led to a widespread weakening of spruce stands. Since both higher temperatures and longer drought periods are to be expected in Central Europe in the decades ahead, foresters face the challenges of maintaining sustainable forest management and safeguarding future yields. One approach used to foster decision support in silviculture relies on the identification of possible alternative tree species suitable for adapting to expected future climate conditions in threatened regions.

In this study, we focus on the forest district of Horn, a region in Austria's north east that is beneficially influenced by the mesoclimate of the Pannonian basin. This fertile yet dry area has been severely affected by mass propagations of *Ips typographus* due to extensive droughts since 2017, and consequently has suffered from substantial forest damage in recent years. The urgent need for action was realized and has expedited the search for more robust alternative species to ensure sustainable silviculture in the area.

The determination of suitable tree species is based on the identification of regions whose climatic conditions in the recent past are similar to those that are to be expected in the forest district of Horn in the future. To characterize these conditions, we consider 19 bioclimatic variables that are derived from monthly temperature and rainfall values. Using downscaled CMIP6 projections with a spatial resolution of 2.5 minutes, we determine future conditions in Horn throughout the 21st century. By employing 20-year periods from 2021 to 2100 for the scenarios SSP1-26, SSP2-45, SSP3-70 and SSP5-85, and comparing them to worldwide past climate conditions, we obtain corresponding bioclimatic regions for four future time slices until the end of the century. The Euclidian distance is applied as measure of similarity, effectively yielding similarity maps on a continuous scale. In order to account for the spatial variability within the forest district, this procedure is performed for the colder northwest and the warmer southeast of the area, individually seeking similar bioclimatic regions for each of these two subregions. Results point to Eastern Europe as well as the Po Valley in northern Italy as areas exhibiting the highest similarity

to the future climate in this North-Eastern part of Austria.