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Climate change at upper treeline: How do trees on the edge react to increasing temperatures?

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Treeline ecotones are thought to be particularly sensitive to climate warming, and an alteration of their growth conditions may have important implications for the ecosystem services they supply in mountain regions.

We use a novel approach to quantify effects of a changing climate on tree growth, using case studies in the European Alps. We compiled tree-ring data from almost 600 trees of four species at treeline in three climate regions of Switzerland. Temperature loggers installed along transects provided data for a precise interpolation of temperatures experienced by the sampled trees. To assess the influence of temperature on annual growth, we used linear mixed-effects models, allowing us to quantify effect sizes and to account for between-tree growth variability. After removing biological growth trends, we isolated temporal trends of ring-width indices. Furthermore, we fitted non-linear regression models to radial growth rates of individual years with temperature and tree age as predicting covariates for a fine-scale investigation of the temperature dependency of tree growth.

For all species, climate-growth linear mixed-effects models indicated strong positive responses of ring-width indices to temperature in early summer and previous year's autumn, featuring considerable between-tree variability. All species showed positive ring-width index trends at treeline but different interactions with elevation: Larix decidua exhibited a declining ring-width index trend with decreasing elevation, whereas Picea abies, Pinus cembra and Pinus mugo showed increasing and/or stable trends. Not only reflected our findings the effects of ameliorated growth conditions, they might have also revealed suspected negative and positive feedbacks of climate change on growth, and increased the knowledge about the functional form and parameterization of the temperature dependency of tree growth.