



## Species- and region-specific climate sensitivities of European tree provenances across a continental gradient

Jernej Jevšenak<sup>1</sup>, Luka Krajnc<sup>2</sup>, and the OptForests\*

<sup>1</sup>Slovenian Forestry Institute, Department for Forest and Landscape Planning and Monitoring, Ljubljana, Slovenia (jernej.jevsenak@gozdis.si)

<sup>2</sup>Slovenian Forestry Institute, Department of Forest Yield and Silviculture, Ljubljana, Slovenia (jernej.jevsenak@gozdis.si)

\*A full list of authors appears at the end of the abstract

Climate change is profoundly altering forest ecosystems worldwide by affecting tree growth, mortality and regeneration through rising temperatures, shifting precipitation regimes and more frequent extreme events. Provenance trials provide a powerful framework to assess how tree populations from different climatic origins perform under changing environmental conditions. Here, we analysed tree-ring data from 25 common gardens and 176 provenances spanning a broad gradient from the Mediterranean to Scandinavia. These trials encompassed four climatic clusters (Northern, Central, Southwestern and High elevation) and six widespread European tree species (*Quercus robur*, *Quercus petraea*, *Picea abies*, *Pinus sylvestris*, *Pinus pinaster* and *Larix decidua*). More than 5,500 increment cores were collected and measured using standard dendrochronological methods. Provenances were classified as originating from climates that were warmer or colder, drier or wetter, or locally similar relative to conditions at the trial sites. For each trial and provenance class, we quantified radial growth patterns, climate–growth relationships and resilience components (resistance, recovery, resilience) to past warming and drying events. Our results indicate strongly species- and region-specific responses. The clearest patterns emerged for *Quercus robur* from the Northern cluster, where provenances originating from warmer regions showed enhanced heat vulnerability and reduced radial growth, indicating a smaller thermal safety margin under additional warming, whereas provenances from cooler regions responded more positively to increased spring temperatures. In contrast, the opposite pattern emerged for *Larix decidua* and *Pinus pinaster* from the Southwestern cluster, where provenances from warmer origins exhibited higher heat tolerance than those from cooler parts of the native range. Overall, our findings demonstrate that provenance choice can substantially modify tree growth and resilience to extreme weather events, and that these effects are strongly region- and species-specific.

**OptForests:** Patrick Fonti, Christian Rellstab, Alexandru Alin, Samuel Aspalter, Mariya Belovarska, Egbert Beuker, Benjamin Brachi, Maria Regina Chambel, Jose Maria Climent Maldonado, Irena Fundova, Polona Hafner, Carina Heiling, Jon Kehlet Hansen, Paolo Iovieno, Jiri Korecky, Harri Mäkinen, Maurizio Marchi, Georgeta Mihai, Luc Pâques, Silvio Schueler, Arne Steffenrem, Jan

Stejskal, Emanuel Stoica