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Bioclimatology of beech (Fagus sylvatica L.) in the Eastern Alps: spatial and altitudinal climatic signals identified through a tree-ring network

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ABSTRACT

Aim. To identify the dominant spatial patterns of Fagus sylvatica radial growth in the Eastern Alps, and to understand their relationships to climate variation and bioclimatic gradients. Location Fourteen beech stands in the Eastern Alps, growing between 200 and 1500 m a.s.l. in Italy, Slovenia and Austria.

Methods. At each site, trees were sampled using increment borers or by taking discs from felled trees. Cores and discs were processed by measuring and crossdating ring width. Ring width series were standardized, averaged, and prewhitened to obtain site chronologies. Hierarchical Cluster Analysis (HCA) and Principal Components Analysis of prewhitened site chronologies were used to identify spatial and altitudinal growth patterns, related to the bioclimatic position of each stand. Bootstrap correlation and response functions were computed between monthly climatic variables and either principal component scores or composite chronologies from stands associated by HCA. The stability of dendroclimatic signals was analyzed by moving correlation functions (MCF).

Correlation analysis (teleconnections) based on a data base of 37 Italian and Slovenian beech tree-ring chronologies revealed the spatial extent of principal component scores.

Results. Sampled trees were 200–400 years old, representing the oldest beech trees that have been crossdated for the Alps to date. Maximum age was directly related to altitude and to the presence of historical forms of conservation. Treering parameters varied according to geographic patterns and the age of sampled trees. Stands were bioclimatically organized according to their location, and with reference to their elevation and distance from the Adriatic Sea. A direct response to winter temperature was found at all elevations. The altitudinal gradient ranged from low-elevation stands, characterized by a Mediterranean-type, late spring– summer drought signal, to mountain and high-elevation stands, characterized by a direct response to growing season temperature plus an inverse response to the previous year's July temperature. The mountain and high-elevation signal was evident in Austria, the Central Alps and Slovenia, while the low-elevation signal was confined to mountains adjacent to the Adriatic Sea. MCF revealed trends in the response to climatic factors affecting tree-ring formation in mountain and high-mountain stands linked to climatic warming.

Main conclusions. Dendroclimatic networks can be used for bioclimatic studies of tree populations. A biogeographical separation emerged between the Alps and the Apennines at the upper elevations, while different degrees of mediterraneity distinguished sites at lower elevations. This information will be useful in assessing any future climate-related bioclimatic shifts, especially for forests at ecotones and along altitudinal gradients.

Keywords

Alps, altitudinal gradient, bioclimatology, dendroclimatology, ecological gradient,ecotone, Fagus, old-growth forests, tree growth, tree-ring analysis.

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