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Impact of climate warming-induced increase in drought stress on successional dynamic of a coniferous forest within a dry inner Alpine environment

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Climate sensitivity of tree growth will effect the development of forest ecosystems under a warmer and drier climate by changing species composition and inducing shifts in forest distribution. We applied dendroclimatological techniques to determine impact of climate warming on radial stem growth of three native and widespread coniferous tree species of the central Austrian Alps (Norway spruce, Picea abies; European larch, Larix decidua; Scots pine, Pinus sylvestris), which grow intermixed at dry-mesic sites within a dry inner Alpine environment (750 m a.s.l., Tyrol, Austria). Time series of annual increments were developed from > 250 saplings and mature trees. Radial growth response to recent climate warming was explored by means of moving response functions (MRF) and evaluation of trends in basal area increment (BAI) for the period 1911 - 2009. Climate-growth relationships revealed significant differences among species in response to water availability. While precipitation in May – June favoured radial growth of spruce and larch, Scots pine growth mainly depended on April – May precipitation. Spruce growth was most sensitive to May – June temperature (inverse relationship). Although MRF coefficients indicated increasing drought sensitivity of all species, which is most likely related to intensified belowground competition for scarce water with increasing stand density and higher evapotranspiration rates due to climate warming, recent BAI trends strikingly differed among species. While BAI of larch was distinctly declining, spruce showed steadily increasing BAI and quite constant BAI was maintained in drought adapted Scots pine, although at lowest level of all species. Furthermore, more favourable growing conditions of spruce in recent decades are indicated by scattered natural regeneration and higher growth rates of younger trees during first decades of their lifespan. Because human interference and wildlife stock is negligible within the study area, results suggest a competitive advantage of shade-tolerant and shallow-rooted late successional spruce over early successional species, whereby the spruce‘s competitive strength is most likely related to synergistic effects of shade-tolerance and efficient uptake of small rainfall events by fine roots distributed primarily in upper soil layers. On the other hand, strikingly decreasing trend in BAI of larch is suggested to be due to negative influence of climate warming on tree water status. We conclude that climate warming-induced increase in drought sensitivity changed competitive strength of co-occurring conifers due to differences in inherent adaptive capacity at a drought-prone inner Alpine site.