Conference Volume	6th Symposium for Research in Protected Areas 2 to 3 November 2017, Salzburg	pages 465 - 466

Water availability as a key factor of forest dynamics in protected areas – long-term perspectives inferred from tree rings

Walter Oberhuber

Keywords

dendroclimatology, dry inner Alpine valley, riparian forest, Scots pine, tree mortality, water table

Summary

Drought is known to have a large influence on forest health and to be one of the most important factors triggering both temporary declines and the mortality of susceptible species in temperate forests (e.g. ALLEN et al. 2010; ANDEREGG et al. 2015). Tree mortality and forest die-off events are expected to increase as a result of further global warming and increasing drought stress (ALLEN et al. 2015). Tree ring analysis gives a long-term perspective of tree growth and stand dynamics, and allows determination of environmental stresses (e.g. SCHWEINGRUBER 1996). The focus of this study was to evaluate the impact of drought stress on long-term growth trend and stability of two contrasting forests located within protected areas in the inner Alpine dry valley of the Inn River (Tyrol, Austria): a xeric Scots pine forest (Tschirgant-Bergsturz) and a grey alder dominated riparian forest (Mieminger and Rietzer Innauen). Selected stands are within c. 15 km in linear distance. The study area has a relatively continental climate with mean annual precipitation and temperature of 716 mm and 7.3 °C (long-term mean during 1911-2013). To accomplish our goals dendroclimatological techniques were applied (e.g. HUGHES et al. 2011).

On a postglacial rock-slide area (Tschirgant-Bergsturz) situated in the montane belt (c. 750 m asl; cf. PRAGER et al. 2008) we found that radial growth of Scots pine (*Pinus sylvestris* L.) growing on shallow, stony soils responds extremely sensitive to water availability during spring (April to May) and wood formation already peaks in May prior to occurrence of more favorable environmental conditions, i.e. increase in precipitation in summer (GRUBER et al. 2010, SWIDRAK et al. 2013, OBERHUBER et al. 2014). Evaluation of long tree ring series (>150 yr) revealed a stepwise growth decline of trees predisposed to die, which indicates that the effects of drought stress accumulated slowly until tree death occurred (OBERHUBER 2001). The long-term nature of the individual mortality process illustrates that *P. sylvestris* can sustain growth at very low rates for decades and emphasizes the role of accumulated stress or slow-acting processes (e.g. competition) in tree mortality (SCHUSTER & OBERHUBER 2013, CAILLERET et al. 2017). Accordingly, moderate growth reduction and only sporadically found tree death of *P. sylvestris* in response to the extraordinary 2003 heat-wave can be related to (i) spring precipitation as the primary growth limiting climate variable, (ii) biological preconditioning in previous years and (iii) substantial lag effects associated with drought impacts (PICHLER & OBERHUBER 2007). Although results of this study provide evidence that drought-prone forest ecosystems dominated by *P. sylvestris* show a high resilience against short-term climatic stresses, xeric sites within dry inner Alpine valleys might gradually become treeless or be replaced by more drought tolerant tree species like *Quercus* spp. as a result of climate change (cf. RIGLING et al. 2013).

P. sylvestris also dominates along riversides on free-draining gravel beds, which are only occasionally subject to flooding. The dominance of *P. sylvestris* at these sites is thought to be caused by high tolerance of water table fluctuations alternating with soil drought during the growing period (POLACEK et al. 2006). For this reason *P. sylvestris* is able to invade the riparian forest of the special nature protection area Mieminger and Rietzer Innauen (c. 635 m asl). Stands, currently dominated by grey alder (*Alnus incana* Moench.) grow on rarely flooded alluvial terraces (flooding occurs about once every 10 years; cf. GATTERMAYR & STECK 2006), and are exposed to extreme seasonal fluctuations of the water table (>2 m). We evaluated the impact of fluctuations of the water table and of climate factors (precipitation, temperature) on year-to-year variability of tree growth and long-term basal area increment of dominant tree species (ASTER 2015, DEMAR 2015, RASS 2017). Statistically significant correlations between water availability and annual increments of grey alder indicated that tree growth is severely constrained by water supply in spring and summer leading to reduced stand height, lower basal area increment, pronounced top-killing and crown-thinning at some sites. Results also revealed that drought stress during the growing season caused only temporary growth reductions and no distinct decrease in long-term trend of basal area increment was detected. However, owing to mean tree age >50 yr of some stands, tree mortality (most likely drought triggered) will increase in the future. Whether *P. sylvestris* can subsequently spread in developing gaps of the riparian forest will depend on the duration and frequency of extreme weather events, i.e. drought, heat-waves and flooding.

Acknowledgements

Studies were funded by the Austrian Science Fund (FWF), P22280-B16 “Conifer radial stem growth in response to drought” and P25643-B16 “Carbon allocation and growth of Scots pine” and Amt der Tiroler Landesregierung, Tiroler Naturschutzfonds.

References

ALLEN, C.D., A.K. MACALADY, H. CHENCHOUNI et al. 2010. A global overview of drought and heat-induced tree mortality reveals emerging climate change risks for forests. Forest Ecology and Management 259:660–684.

ALLEN, C.D., D.D. BRESHEARS, N.G. MCDOWELL. 2015. On underestimation of global vulnerability to tree mortality and forest die-off from hotter drought in the Anthropocene. Ecosphere 6, art129.

ANDEREGG, W.R.L., J.A. HICKE, R.A. FISHER et al. 2015. Tree mortality from drought, insects, and their interactions in a changing climate. New Phytologist 208:674–683.

ASTER, I. 2015. Einfluss von Umweltfaktoren auf das Wachstum eines Grauerlenwaldes (*Alnetum incanae*) im Sonderschutzgebiet Mieminger und Rietzer Innauen (Tirol). Master thesis, University of Innsbruck. 92 pages.

CAILLERET, M., S. JANSEN, E.M.R. ROBERT et al. 2017. A synthesis of radial growth patterns preceding tree mortality. Global Change Biology 23:1675–1690.

DEMAR, F. 2015. Einfluss von Umweltfaktoren auf Wachstum und Entwicklung einer Weichholzau im Sonderschutzgebiet Mieminger und Rietzer Innauen (Tirol). Master thesis, University of Innsbruck. 85 pages.

GATTERMAYR, W. & J. STECK. 2006. Innsbruck und das Hochwasser. Abt. Wasserwirtschaft, Amt der Tiroler Landesregierung, Innsbruck.

GRUBER, A., S. STROBL, B. VEIT, W. OBERHUBER. 2010. Impact of drought on the temporal dynamics of wood formation in *Pinus sylvestris*. Tree Physiol 30:490–501.

HUGHES, M.K., T.W. SWETNAM, H.F. DIAZ (eds). 2011. Dendroclimatology. Progress and prospects. Springer Verlag.

OBERHUBER, W. 2001. The role of climate in the mortality of Scots pine (*Pinus sylvestris* L.) exposed to soil dryness. Dendrochronologia 19:45–55.

OBERHUBER, W, A. GRUBER, W KOFLER, I SWIDRAK. 2014. Radial stem growth in response to microclimate and soil moisture in a drought-prone mixed coniferous forest at an inner Alpine site. Eur J For Res 133:467-479.

PICHLER, P. & W. OBERHUBER. 2007. Radial growth response of coniferous forest trees in an inner Alpine environment to heat-wave in 2003. Forest Ecology and Management 242:688–699.

POLACEK, D., W. KOFLER, W. OBERHUBER. 2006. Radial growth of *Pinus sylvestris* growing on alluvial terraces is sensitive to water-level fluctuations. New Phytologist 169:299–308.

PRAGER, C., C. ZANGERL, G. PATZELT, R. BRANDNER. 2008. Age distribution of fossil landslides in the Tyrol (Austria) and its surrounding areas. Natural Hazards and Earth System Science 8:377–407.

RASS, S. 2017. Dendroökologische Untersuchung des Einflusses von Umweltfaktoren auf das Wachstum der Grauerle (*Alnus incana*) in den Mieminger und Rietzer Innauen. Master thesis, University of Innsbruck, 84 pages.

RIGLING, A., C. BIGLER, B. EILMANN et al. 2013. Driving factors of a vegetation shift from Scots pine to pubescent oak in dry Alpine forests. Global Change Biology 19:229-240.

SCHUSTER, R. & W. OBERHUBER. 2013. Drought sensitivity of three co-occurring conifers within a dry inner Alpine environment. Trees 27:61–69.

SCHWEINGRUBER, F.H. 1996. Tree rings and environment. Dendroecology. WSL, Verlag Haupt, Bern.

SWIDRAK, I., R. SCHUSTER, W. OBERHUBER. 2013. Comparing growth phenology of co-occurring deciduous and evergreen conifers exposed to drought. Flora 208:609–617.

Contact

Walter Oberhuber
walter.oberhuber@uibk.ac.at
University of Innsbruck
Institute of Botany
Sternwartestrasse 15
6020 Innsbruck
Austria
phone: +43(0)512-507-51048