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Climate change and tree responses in Central European forests

T. Wohlgemuth¹

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Research on climate change effects concerns most ecosystems and species worldwide. There is strong evidence that forests in all parts of the world are affected by changing temperatures and aggravating drought situations (Allen et al. 2010). Marked range shifts of tree species are projected as a consequence of extensive and large climatic changes (Hanewinkel et al. 2013). In this frame, the International Conference on “Climate Change and Tree Responses in Central Europe” held in September 2013 in Zurich, Switzerland, invited research contributions with a special geographical focus on the countries Austria, Czech Republic, France, Germany, Hungary, Italy, Poland, Slovakia, Slovenia, and Switzerland. More than 250 participants attended the conference, and a total of 120 oral papers were presented in the frame of 13 thematic sessions (Table 1). The conference was organized by the Swiss Federal Institute for Forest, Snow and Landscape Research WSL and the Swiss Federal Institute of Technology Zurich ETH (Wohlgemuth and Priewasser 2013). The event aimed at bringing together researchers from different disciplines and with

expertise on experiments, long-term survey, and modeling (Table 1).

In this special issue, five contributions are offered and represent the variety of aspects related to climate change effects.

As one effect of climate change, extreme events such as European winter storms may become more frequent or at least more disastrous (Seidl et al. 2014). In this context, Pasztor et al. (2015) used empirical models (generalized linear mixed models) to quantify wind damage in mountain forests of four regions of the Austrian Alps (28,800 ha in total). The probability of wind damage in these forests was best explained by the factors timber stock volume, stand age, elevation, previous disturbances, wind gust speed, and frozen state of soil. Wind damage can be mitigated by decreasing the proportion of Norway spruce (*Picea abies*), limiting stand age, and reducing timber stock.

Climate warming will result in more frequent drought episodes (IPCC 2013) and hence, drought as a limiting factor will affect species in all life stages. In this respect, Moser et al. (2015) studied the root architecture of Scots pine (*Pinus sylvestris*) seedlings as well as the colonization rate of root tips by ectomycorrhizal fungi under experimental drought in a common garden experiment. While ectomycorrhizal colonization did not increase under “dry” conditions compared to “wet” or “seasonally variable” (Mediterranean) moisture conditions, root architecture clearly adapted to dry conditions by an increased root/shoot ratio under dry conditions. Plasticity in root architecture is supposed to be an important mechanism for drought resistance of *P. sylvestris* during early seedling establishment.

Global warming during the last century or during the last decades has been shown to cause species range shifts in alpine plants (e.g., Walther et al. 2005) or in forest species (e.g., Lenoir et al. 2008). The paper of Küchler et al. (2015) tested

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•Key message The special issue reports on the successful ClimTree 2013 conference held in Zurich (Switzerland) and gives view on the diversity of both current and projected climate change impacts in forest structures, communities, or individual species of Central Europe.

✉ T. Wohlgemuth
thomas.wohlgemuth@wsl.ch

¹ WSL Swiss Federal Institute for Forest, Snow and Landscape Research, Zürcherstrasse 111, 8903 Birmensdorf, Zurich, Switzerland

Table 1 Thematic sessions held at the ClimTree 2013 conference

	Sessions
1	Disturbance ecology and management in a changing world
2	Responses of tree roots (including mycorrhizas) to climate change
3	Sensitivity and resilience of mixed forests to climate change
4	Phenology and climate change
5	Impacts of drought on tree growth and vulnerability
6	Drought-induced tree mortality—patterns, processes and mechanisms
7	Frontiers in dendroclimatology and dendroecology
8	Impact of climate change on demographic changes and species ranges
9	Adaptability of tree species to climate change (phenotypic plasticity, genotypic variation)
10	Adapted forest management
11	Challenges in forest biodiversity conservation under climate change
12	Tree vulnerability to pests in relation to climate change
13	Biotic responses of trees and understory vegetation to contemporary climate change

forest herbaceous species, shrubs, and trees for possible upward shifts due to recent climate warming in Swiss forests by using two balanced samples of revisited relevé plots with survey intervals of 15 and 60 years, respectively. Since 1950, vascular plant species in the herbaceous forest layer (herbs and tree regeneration) have significantly shifted upslope by 10 m per decade. A similar signal was absent in shrub and tree layers. At lower elevations, species in the shrub/tree layer even shifted downslope, which cannot be explained by climate change effects. Climate change impacts on tree species composition in Swiss forests are weak if compared to factors arising from forest management and land use change.

Species distribution models comprise several techniques referring to species occurrences as baseline data and are most often used to project species range shifts under various climate change scenarios (e.g., Elith et al. 2006). Two applications are presented in this special issue. By means of ensemble distribution models, Vacchiano and Motta (2015) projected the presence of Scots pine (*P. sylvestris*) and downy oak (*Quercus pubescens*) in the Aosta valley (Italian Alps) using factors such as climate (scenarios for 2080), topography, soil, competition, natural disturbances, and land use. For all scenarios, *Q. pubescens* cover increased. In warming scenarios, *P. sylvestris* experienced an upward displacement that might be mitigated by intensified land use. As an interesting result, the authors question the hypothesis that extreme dry spells trigger shifts in species composition.

In the second application, Gottschalk and Reiners (2015) projected bird species distribution and abundance for Germany by combining scenarios for both climate change and forest conversion (coniferous forests replaced by deciduous forest). While for climate-change-only scenarios, a majority of the 25 modelled bird species not only lost partly considerable percentages of suitable habitats but also shrank in population size.

Additional forest conversion amplified (15 species) or weakened (10 species) the predicted climate driven gains and losses of species' population size.

In the session wrap-ups during the conference, important fields of further investigations were highlighted, e.g., the multi-scale nature of disturbance regimes, the relevance of roots, and root/shoot ratios as indicator of environmental change, the role of biodiversity in tree species mixtures, impacts of phenological change due to climate warming on tree fitness, the definition of thresholds for tree mortality, the cause of drought-induced mortality in tree species, the growing market of dendroclimatology and dendroecology due to increasing global data networks, the capacity of trees to withstand a warmer/drier climate that exceeds values currently observed, a definition of the most important factors/processes that will change forests due to climate change, the combination of climate change and land use effects in modelling, the incorporation of climate change effects on host quality (trees) and natural enemies of pests in available climatic models, the distinction of important global change drivers behind responses of plants in the forest vegetation, and the provision of simplified syntheses of scientific results for managers.

Birmensdorf (CH), February 2015
Thomas Wohlgemuth

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