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LETTER TO THE EDITOR

Tackling climate change—the contribution of scientific knowledge in forestry

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Climate change is one of the major challenges forestry is facing in the twenty-first century and beyond. Forests, as long-living ecosystems that cover large areas of the landmass of the world, will be particularly affected by the projected climate change. Major issues with respect to climate change related to forests and forestry are shifts in the distribution range of the most important tree species, an increase of extreme climate events resulting in a different regime of biotic and abiotic disturbances, changes in the productivity of forest ecosystems, and, more generally, a change in the goods and services forests are able to provide to society. This may affect biodiversity as well as the ability of forests to sequester carbon and to emit greenhouse gas. Furthermore, the potential loss of productive species due to the expected increase in temperature and decrease of precipitation, as projected for larger areas in Europe, may lead to strong economic losses that can affect forest owners as well as the whole timber industry (Hanewinkel et al. 2013).

In order to tackle the multiple problems that forest management is facing, sound adaptation strategies are needed. They include the choice and spatial organisation of species as well as genetically adapted provenances and management strategies that prepare forests to deal with increasing drought, pests and diseases and abiotic hazards such as fire and storm.

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Apart from adaptation, forestry has to ensure that the ability of forests to mitigate climate change by forming a stable sink for carbon and limiting the emission of greenhouse gas is maintained. This is a task that often requires activities on a political level as well as an outreach to forest owners and stakeholders.

Within this framework, the international conference "Tackling Climate Change—the contribution of forest scientific knowledge" took place in May 2012 in Tours, France. It delivered the background for this special issue of "Annals of Forest Science." The conference was organized by the coordinators of a number of climate-related research projects and COST actions funded under the seventh framework program of the European Union (ECHOES, MOTIVE, BACCARA, TRANZFOR, ForEAdapt, REINFFORCE) under the lead of the COST action FP 703 ECHOES (chaired by J.L. Peyron). Over 300 participants discussed in plenary and parallel session scientific papers, of which a selection is presented here. The contributions of this issue cover a range of the most important topics related to climate change.

The question of changing species under climate change is an important topic. Hernández et al. (2014) show that species like European beech and Scots pine may even enlarge their ranges in mountain areas and move upwards. Bolte et al. (2014) point out that understory dynamics can play a key role for forest succession from spruce- to beech-dominated forests. The potential economic effects of species changes and how to deal with them are analysed by Brunette et al. (2014). They present an option value approach to support the decision when to change a tree species and they point at the necessity to integrate species like Douglas fir (*Pseudotsuga menziesii*) in further considerations about tree species under climate change. Meason and Mason (2014) emphasize the necessity to deploy alternative tree species under climate change. They show, based on two case studies in two different continents,

that the new species can outperform "traditional" species under changing climate conditions.

Robinet et al. (2014) deal with the problem of insect pests extending their ranges under climate change. They demonstrate that pests like the pine processionary moth can be a serious threat to forests and that their spread, although limited by dispersal capability, can be accelerated by human activities.

The change of net primary productivity for different tree species in Europe under climate change is investigated by Reyer et al. (2014). They show that, beside a regional effect with a general increase in the north and a decrease in the south, the persistence of CO_2 effects is a crucial factor.

Closely linked to productivity is the future role forests can play in mitigating climate change when their capacity for carbon sequestration is affected. Sievänen et al. (2014) assess the impact of roundwood and fuelwood removals and climate change (CC) on the changes in carbon stock of Finnish forests and hypothesize that it is likely that forest land in Finland acts as a carbon sink in the future. Sjølie et al. (2014) analyse the impacts of the Kyoto Protocol on boreal forest climate change mitigation. According to their results, the Kyoto protocol increases the Norwegian forest sector's climate mitigation compared to no climate policy, but less in the long run than a carbon policy with no cap on forest carbon credits. In a simulated reforestation program in a densely populated locality in central Mexico aiming to analyse indirect land-use change, or leakage, Dyer and Nijnik (2014) investigate the implications of carbon forestry for local livelihoods and leakage and show that potential leakage is lowest in remote and poorly integrated localities, where declining wages foster local food production while discouraging consumption.

With increasing uncertainty of managing forests under climate change, it is important to know how decision makers come to decisions in a complex environment. Yousefpour et al. (2014) apply a Bayesian updating approach therefore and show that this approach can be useful for the analysis of adaptive forest decision-making, in particular for irreversible or costly decisions of long-term impact. Garcia-Gonzalo et al. (2014) show how a decision support system to manage Eucalypt plantations under climate change should be designed.

The role of extreme events is an important topic when analysing climate change impacts. Rasztovits et al. (2014) want to know whether the incorporation of extreme drought events improves modelling of beech persistence at its distribution limit. They reveal that the increasing frequency and severity of extremes could play an important role in limiting species distribution in the future. According to the study of Lawrence and Marzano (2014), understanding private forest owners and managers, and their attitudes to uncertainty and change, is essential for the success of climate change adaptation policies.

Besides these "classical" scientific papers, this special issue encompasses three opinion papers, a category of contributions, in which mainly policy-relevant topics are presented to the readers in a concise and understandable way. Here, Leturcq (2014) discusses the question of whether wood preservation (carbon sequestration) or wood burning (fossil–fuel substitution) is better for mitigating climate change, while Spathelf et al. (2014) present the expert views of local observers on the general issue of climate change impacts in European forests. Sample et al. (2014) show how a US strategy for forest management adaptation to climate change may be used as framework for decision-making.

Looking at the very broad range of topics that are tackled in this special issue of "Annals of Forest Science," we can yet see that some important scientific questions related to climate change impacts to forests will persist as major challenges in the nearer future. Besides the question of the choice of tree species and the change of productivity linked to changing climatic conditions, it will be important to know whether our forests will be able to conserve their ability to sequester carbon and thus contribute to mitigation. The question of how to design adaptation strategies under increasing uncertainty and the impact of extreme events and biotic and abiotic disturbances will be as well a topic as the proper implementation of policy instruments to preserve the ecosystem goods and services of the forests. This special issue of "Annals of Forest Science" aims only at being an initial step to tackle these important research endeavours.

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Marc Hanewinkel and Jean-Luc Peyron

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