Geophysical Research Abstracts
Vol. 19, EGU2017-2292, 2017
EGU General Assembly 2017

Role of genetics in adapting forests under climate change: lessons learned from common garden experiments in central Europe

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Adaptive management aiming at reducing vulnerability and enhancing the resilience of forested ecosystems is a key to preserving the potential of forests to provide multiple ecosystem services under climate change. Planting alternative or non native tree species adapted to future conditions and also utilizing the genetic variation within tree species has also been suggested as an important adaptive management strategy under climate change. Therefore, knowledge on suitable provenances/populations is a key issue. Provenance trial experiments, where several populations of a species are planted in a particular climate or throughout an appropriate climatic gradient offers a great opportunity to understand adaptive genetic variation within a tree species. These trials were primarily established, for identifying populations with desired growth and fitness characteristics. Due to the increasing interest in climate change, such trials were revisited to understand the relation between growth performance and climate and to recommend suitable populations for future conditions.
Here we present the lessons learned from provenance trials of Norway spruce and Douglas -fir in central Europe. With data from provenance trials planted across a wide range of environmental conditions in central Europe we developed multivariate models, Universal Response Functions (URFs). The URFs predict growth performance as a function of climate of planting locations (i.e. environmental factors) and provenance/ population origin (i.e. genetic factors). The flexibility of the URFs as a decision making tool is remarkable. The model can be used as to identify suitable planting material for a give site, and vice versa and also as a species distribution model (SDM) with integrated genetic variation.
Under current and climate change scenarios, the URFs were applied to predict populations with higher growth performance in central Europe and also as species distribution models for Douglas-fir (Pseudotsuga menziesii [Mirbel] Franco) and Norway spruce (Picea abies (L.) Karst).
For both Douglas-fir and Norway spruce wide variation in growth performance were detected. Populations of Douglas-fir identified by the URFs to be optimum for central Europe current climate and climate change scenarios originate from western Cascades and coastal areas of British Columbia, Washington and Oregon. The current seed stands of Douglas-fir in North America, providing planting materials for Central Europe under the legal framework of the Organization for Economic Cooperation and Development (OECD) were found to be suitable for under future conditions. In case of Norway spruce provenances originating from warm and drier regions of south east Europe were found to be suitable for central Europe under future conditions.
Even though calibrated with data from Central Europe, when applied as SDMs, the URFs predicted the observed occurrence of Douglas-fir in its native range in North America with reasonable accuracy compared to contemporary SDMs developed in North America. For both Douglas-fir and Norway spruce significant variation in habitat suitability was found depending on the planted population or seed source indicating the role of intraspecific variation in buffering effects of climate change.