The response of European tree species to drought: a meta-analysis

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Introduction

While there is a high uncertainty regarding the influence of climate change on precipitation patterns in Europe, most future climate scenarios concur on an increasing potential for prolonged and more intense summer droughts in the Mediterranean area as well as the Southern parts of the Alps. Some of these tendencies may already be seen today (Fig. 1). However, besides many other site-relevant factors, depending on which tree species are actually affected by these summer droughts, its effect on forestry may indeed be very different. For example, hydrostable tree species are closing their stomata to restrict the loss of water at a much earlier stage of drought than hydrolabile species.

Regarding the tree species' physiological reaction to summer droughts, a lot of traits on different levels of scale may be of interest for comparisons among them: Stomatal and cuticular conductance, transpiration, water potential, osmotic potential, the percentage loss of cavitation, hydraulic conductivity, and sap flux density. Within the presented StartClim project, the aim is to determine these physiological traits for all silviculturally relevant European tree species and to compare the tree species with regard to these findings.

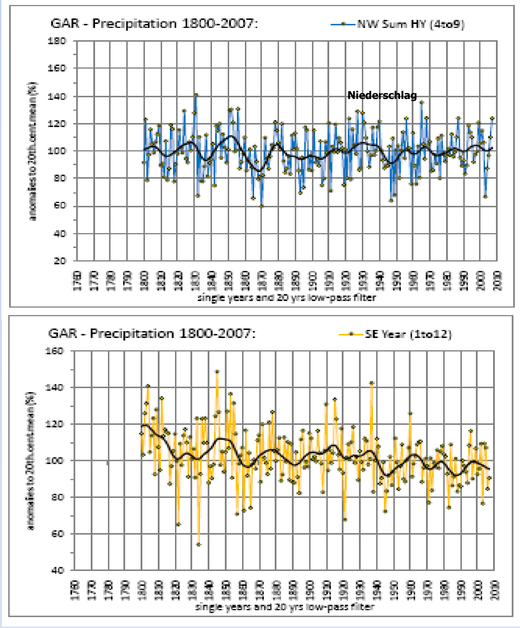

Fig. 1: Annual average in precipitation in the North-West (NW) and the South-East (SE) of the European Alps from 1800 to 2007. While the NW does not show a particular trend, the SE shows a downward trend in precipitation.

Methods

To compare all 120 silviculturally relevant European tree species regarding their physiological reaction to summer droughts, a literature search is conducted (ISI Web of Knowledge) in order to collect all available studies regarding this topic. Only literature of species growing and measured in Europe is taken into account. The resulting publications are screened and parameters at organ (e.g. leaf or shoot), individual (i.e. tree) and ecosystem scale are transferred to a data base, including relevant additional information, such as the geographical location, the soil properties, the trees' age, and the methods of measurement.

On the thereby compiled data a meta-analysis is conducted by means of descriptive and explorative statistics including a cluster analysis of the tree species.

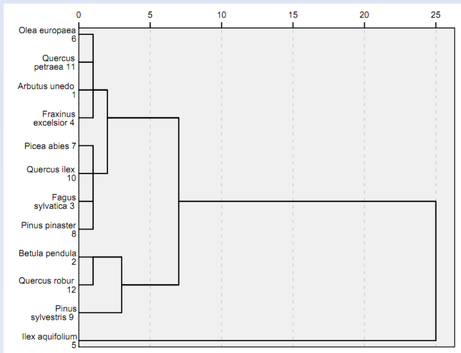

Fig. 2: Hierarchical Dendrogram with average linkage (among groups) using standardized values of maximum stomatal conductance and maximum leaf transpiration deducted from a literature search.

Preliminary Results

The literature search in the ISI Web of Knowledge yielded more than 1800 potentially relevant papers regarding various water relations of the European tree species we were looking for. Although not yet completely screened, it can be estimated that about 225 papers are actually usable for the database, resulting in about 380 data points. The species that European scientists looked at the most were *Fagus sylvatica, Olea europaea, Picea abies, Pinus pinaster, Pinus sylvestris, Quercus ilex, Quercus petraea,* and *Quercus robur*. Many other species are neglected in the literature.

Apart from measurements of pre-dawn and midday water potentials of stem and leave, the most frequent parameter found in the literature is the maximum stomatal conductance with about 135 data points. A first try to classify the species using maximum stomatal conductance and maximum leave transpiration can be seen in Fig. 2.

Preliminary Discussion

Even before actually finishing the screening of the literature, one can conclude that considering we were searching for data on 120 European tree species and that most of the literature contained only one or two of the many relevant parameters we were looking for, the resulting data pool is quite sparse. With so many additional factors influencing the searched-for parameters, like age, geography, different methods in measurement, different cultivars etc., it would actually be surprising to be able to find a consistent way to distinguish among the European tree species with such a small data basis.

However, in many cases, it seems that although the literature itself may not include usable data, the scientists conducting the work could have actually measured usable data, but only published non-usable data (e.g. cumulative or relative parameters) with respect to making a meta-analysis. To gain a good tool to analyze the differences in the water relations of European (or Earth´s) tree species by means of a meta-analysis, a comprehensive data base with shared data among the scientists is called for, as, for example, it has already been realized for Eddy Covariance data in the Fluxnet.