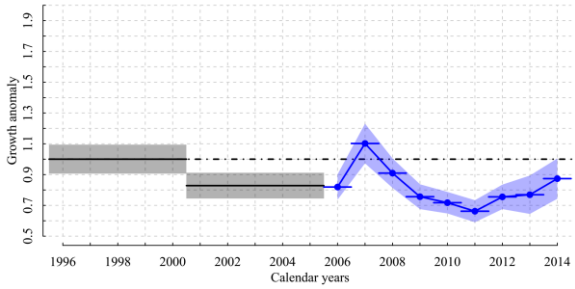
GRECOFORCC



Assessing the GRowth of main European COniferous FORests under a warmer ClimatiC regime

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Context — The attested warmer climatic regime experienced over the recent years raises question as regards how sustainable forest growth will be in the future, and whether a diversity of responses among tree species exist that would inform of their suitability for the function of forest production. With this respect, fast-growing coniferous species are a major support to forestry activities in Europe and deserve attention. Because some naturally grow in colder mountain or Nordic contexts and have been introduced in warmer areas in hills and plains, occupy more southern areas in Europe where water constraints may increase, or are largely distributed across contrasted climatic contexts, their response is likely not uniform.

Objectives — The present project is based on collaboration between the French (IGN) and Austrian (BFW) national forest inventories and associated research teams. The objectives are 1) to investigate the recent growth trends and anomalies of major European coniferous tree species, present in oceanic, continental and mountain contexts in Europe, and representative of contrasted climatic niches, and 2) study their relationships with climatic factors to infer their possible behavior over the longer run. A salient original feature of the project is to describe forest growth in large forest domains at an annual resolution, permitted by recent progresses in both French and Austrian NFI programs.

Approach — The project is split in two 12/6-month sessions with French/Austrian NFI respectively. The species under study include Norway spruce, silver fir, Scots pine and European larch that will be studied in both countries, and pine species (Corsican, Aleppo and maritime pines) and Douglas fir, further investigated in French contexts. These species are inquired in regional natural and afforestation ranges, in pure and even-aged stands taken as reference communities in which an accurate filtering of environment-driven growth signals is performed by developing statistical growth models. Increment cores collected in the field on ½ dominant trees per plot were studied. The annual temporal resolution privileged in the study allows build annual growth chronologies of stand growth in regional domains, and will provide an unprecedented view of forest growth in a recent warmer regime (past 25 years). EOBS European climate databases will be used to infer the growth response of these tree species over wide climatic gradients and infer their growth response to climatic factors, with a view to extrapolate their future qualitative growth behavior.

Key results —

- To date, temporal growth signals have been estimated for France over all 8 tree species considered in 13 regional domains selected 1) to be representative of the French forest resources, 2) to explore species' behaviour in contrasted contexts (mountain and plain ranges) and compare species across same contexts. A total >14,000 increment cores at 1,30m height were used. In order to achieve temporal significance, growth chronologies have been estimated over two temporal periods, namely 2006-2014 (annual resolution) and 1996-2014 using 5- and 10-years increments (1996-2000/2001-2005, and 2006-2014). Statistical tree growth models used to isolate temporal growth anomalies include the effects of stand density, homogeneity and pureness, tree size, social rank and competition pressure, and soil nutrition and mean climate, and account for 25-40% of the total growth variations

- A systematic analysis of chronologies elaborated with 1-to-5 annual rings (to which case a same ring is measured 5 successive times by the NFI) shows a progressive flattening of the growth chronologies, suggesting that NFI measurements in the field at $1/10^{th}$ cm resolution require the implementation of a statistical interdating and ring positioning correction process

- A regression analysis of climatic chronologies over 1980 – 2015 for the regions under study reveal no trend in precipitation, and strong increases in temperatures. The highest magnitude in climate warming is observed for spring maximum temperatures, with increases by 0.5 to 1.0°C over 10 years. Western plains are less prone to climate warming than Eastern areas and mountain ranges

- Growth chronologies show: that tree species exhibit contrasted growth behaviors with respect to the magnitude of temporal auto-correlation, ranging from smooth temporal variations (Douglas and Corsican pine in Northern plains) to high-frequency growth deviations (Norway spruce and silver fir in the Vosges mountain, Aleppo pine in the Mediterranean), irrespective of the geophysical context. Depending on this pattern, 2006-2014 allows or not detecting a significant trend in growth: while Douglas fir (-40%), Corsican (-30%) and Scots (-30%) pine in Northern plains, as well as Douglas fir (-20%) and Norway spruce (-20%) in the Central mountain range show growth decreases, Maritime/Aleppo pines in the Northern plains/ Mediterranean show growth increases (+40%/+50%) suggesting that Southern species set across more latitudinal ranges have made profit from the recent environmental context. No clear signal is highlighted for European larch, silver fir and Norway spruce

- Over the longer period 1996-2014: i) negative trends are confirmed for Douglas fir (-20%) and Scots pine (-10%) in both the Northern plains and Central mountain range, ii) positive trends are confirmed in maritime pine in Northern plains (+40%) and Aleppo pine in the Mediterranean (+30%), iii) no signal (flat chronologies) is identified in European larch in the Alps, Silver fir in the Vosges mountain and Corsican pine. Further model developments are required for Silver fir and Norway spruce in the Central mountain range.

Main conclusions including key points of discussion — In general, tree species over the periods 2006-2014 and 1996-2014 show no dramatic deviation in the face of a recent climate warming of unprecedented magnitude. In many tree species, absent or moderate decreases therefore suggest a significant resistance of tree species growth in this context. Exceptions concern maritime pine in Northern plains and Aleppo pine in the Mediterranean, two species originating from Mediterranean native ranges. The latter finding is in agreement with Charru et al. (2017).

Future perspectives — A similar inference has to be conducted over Austrian forests. Climatic models of annual growth chronologies at plot level will allow elucidate what is the contribution of climate drivers, and which ones, in these temporal changes.

Valorization —

Publications

Bontemps J-D, Charru M, Ols C, Seynave I, Hervé J-C, Bertrand R (2017) NFI-based investigations of recent changes in forest growth in Western europe – Variations across tree species, geographical scale & climatic context, IUFRO 125th anniversary, division #4, 18 September 2017, Freiburg-im-Breisgau, Germany.

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Media

Sciences et Avenir (2017) La forêt française étend son emprise, dossier rédigé par Loïc Chauveau (journaliste) et conçu avec l'IGN Nancy et J-D Bontemps, encadré sur les impacts du changement climatique, mai 2017, 5pp.

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