PROJECT INFORMATION

Project title: **IM**pact of **NI**trogen nutrition on the production of European **FOR**ests (**IMNIFOR**)

Project ID: 108

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PROJECT DESCRIPTION

1. Scientific rationale

Forest ecosystems account for 40% of the continental carbon (C) stock and act as net C sinks at the global scale (Pan et al. 2011). The durability of the forest C sink is questioned. On the one hand, more frequent extreme climatic events (heatwaves and drought) are likely to reduce forest productivity and threaten the viability of forest stands (Anderegg et al., 2013; Allen et al, 2015). On the other hand, the enhancement of productivity under elevated CO_2 may be compromised by progressive nutrient limitation, as observed in temperate forests where nitrogen (N) limitation is frequent (Elser et al., 2007).

Considering the widespread nutrient limitation of forest productivity, it is clear that precise estimations of the current and future C sequestration capacity of forests cannot be made without incorporating representations of the C sink-limiting nutrient cycles in Terrestrial Ecosytem Models (TEMs) (Norby et al., 2010).

To date, most of the TEMs used in the C and water cycling community still do not simulate the influence of nutrient limitation on forest productivity. Only a handful incorporate coarse representations of the N and P cycles (Wang et al. 2010; Goll et al. 2012; Yang et al. 2013) and are thus potentially able to evaluate their feedback on forests C balance. The choice of the N and P cycles is dictated by the identification of these nutrients as primary current or near-future limiters of the production of forest ecosystems worldwide.

2. Objectives of the project

The general objective of the **IMNIFOR** project is to evaluate the impact of the processes related to the nitrogen cycle in determining the production (i.e. biomass growth) and resource (light, water, nutrient)-use efficiencies of European forests.

To this aim, we will use the CASTANEA process-based model of forest ecosystem functioning. CASTANEA (Dufrêne et al., 2005; Delpierre et al., 2012; Guillemot et al., 2014, in press) has initially been designed for simulating the growth and C and water exchanges of even-aged forest stands at scales of hours to decades. Its first published version was developed for *Fagus sylvatica* (Dufrêne et al., 2005). CASTANEA has since then been successfully adapted to the main European forest tree species (namely *Quercus robur/petraea*, *Quercus ilex*, *Picea abies* and *Pinus sylvestris*). Evaluations of the model against flux and growth data proved its very good ability to simulate the hourly to decadal variations of C fluxes and wood growth from the stand scale (Delpierre et al., 2012), to

regional scales (e.g. over the French National Forest Inventory data, Guillemot et al., in press). The latest version of the model incorporates a forest management module, providing CASTANEA the capacity to bridge the gap between ecophysiological and forestry models (Guillemot et al., 2014). More recently, a representation of the nitrogen cycle has been incorporated into the model (Delpierre et al., unpublished). Its main features consist in the representations of (i) nitrogen mineralization, nitrification and denitrification (Penillard, 2014; Geoffroy, 2014), (ii) transfers of N mineral forms (ammonium and nitrate) into the rhizosphere and their absorption by the root surface (Leadley et al., 1997; Delpierre & Leadley, unpublished), (iii) seasonal allocation of the absorbed N to plant organs, including its limiting effect on organ growth (Delpierre, unpublished).
The resulting coupled carbon-water-nitrogen version of the CASTANEA model first needs to be parameterized and validated against independent observations. This is one objective of the **IMNIFOR** project.

We will then use a sensitivity analysis (SA) framework (Delpierre et al., 2012) in order to:

- to disentangle the influence of CO_2 fertilization, climate, N deposition and forest management on the recent productivity of European forests,

- evaluate the impact of the processes related to the nitrogen cycle in determining the production (i.e. biomass growth).

The SA framework uses model runs conducted alternatively with / without considering the influence of a given factor (e.g. CO_2 fertilization, climate variability) or process representation (e.g. diffusion of nutrients across the rhizosphere). The simulations obtained under these "constrained" conditions are then used to reconstruct the original time series (simulated under "unconstrained" conditions, i.e. all sources of variability being considered in the model run). This allows estimating the share of each factor in determining the variability of the process / flux of interest (e.g. wood production here).

3. What will the ICP data be used for?
The ICP data will be used for parameterizing the N modules on 4 European tree species (*Quercus robur/petraea*, *Fagus sylvatica*, *Picea abies* and *Pinus sylvestris*), and evaluating the coupled model on an independent dataset (i.e. using half of the data for parameterization, half for evaluation). Considering the large climate gradient spanned by the ICP network, the nature of the monitored variables (composition of the soil solution and leaf nutrient concentration, as regards the N data; LAI, stand growth and soil water as regards the C and water cycles) and the considered tree species, we envision the ICP dataset as very informative for our purpose.

References (bold = papers coordinated by N. Delpierre's group)

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