



Tree species drive soil fertility change during the 43 years after plantation - A dual approach (soil sampling and input-output mass balance) study of the Breuil-Chenue common garden experiment (Burgundy, France)

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TREE SPECIES DRIVE SOIL FERTILITY CHANGE DURING THE 43 YEARS AFTER PLANTATION – A DUAL APPROACH (SOIL SAMPLING AND INPUT-OUTPUT MASS BALANCE) STUDY OF THE BREUILCHENUE COMMON GARDEN EXPERIMENT (BURGUNDY, FRANCE)

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A forest ecosystems are generally developed on acidic and nutrient poor soils. In some numerous areas, elevated acid atmospheric deposition (sulphuric and nitric acids) drastically accelerated soil and surface water acidification during the XXth century leading, in many cases, to degraded soil fertility and forest decline. In addition to this context, tree species selection and/or substitution by forest management (to increase biomass production and/or adapt forests to a changing climate and its consequences) may have an important effect on the biogeochemical functioning of soils and ecosystems. Generally, acidification increase under conifers due to: higher atmospheric deposition rates, higher nitrate leaching fluxes, lower soil pH, higher aluminium concentrations in soil solutions and reduced organic matter mineralization rates. In such a context, the sustainability of the fertility of forest soils is at risk and a major concern for the forestry communities. It is therefore essential to understand the biogeochemical functioning of forest ecosystems and deconvolve environmental drivers from tree species effect drivers of forest soil fertility change over time. Using a very unique dataset acquired over the 20 years of monitoring of the common garden experiment (6 monospecific plots planted in 1976: Norway spruce, Douglas fir, Nordmann fir, Beech, Oak and Laricio pine) at the Breuil-Chenue site in Burgundy, France, the objectives of this study were (i) to quantify the change in plant-available nutrient pools over time (soil resampling and “input-output” mass balance approach) and (ii) determine the drivers (derived from the tree species effect) of soil fertility change.

The soils in the different monospecific plots were sampled in 2001 and in 2019. The comparison of these two sampling dates showed an on-going soil acidification at this site and a marked tree species effect on soil chemical properties and their change over time. Three groups of species were identified: i) Nordmann fir/Norway spruce for which acidolysis and chelation was likely to be the dominant process, resulting in the most pronounced pH decrease in the topsoil, ii) Douglas fir/Laricio pine where soil acidification was most likely caused by elevated nitrification rates, iii) and oak/beech where soil acidification was the least intense compared to all other species. For certain nutrients and species, both the soil resampling and nutrient mass balance approaches were in agreement for instance on the depletion of K exchangeable pools in the beech stand : - 4 kg.ha-1.yr-1 and - 6 kg.ha-1.yr-1 respectively. In other cases, there were strong discrepancies between approaches: in the Douglas fir stand, exchangeable Ca depletion was predicted by mass balance (- 1.5 kg.ha-1.yr-1) whereas soil resampling showed an increase exchangeable Ca pools (+ 3 kg.ha-1.yr-1).

These results show that tree species exert a very strong influence over soil processes and thus over how chemical properties change over time. However our current models and understanding of nutrient biogeochemical cycling are yet incomplete: different fluxes in the ecosystem may be poorly estimated and/or trees may access nutrient sources that are not currently or properly taken into account.