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# Tree tissue nitrogen concentration in boreal and temperate forests - Controls and implications for the vegetation carbon cycle

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The rate at which forests take up atmospheric $CO_2$ is critical because of their potential to mitigate climate change and their value for wood production. The allocation of carbon fixed through photosynthesis into biomass can be quantified through the tree carbon (C) use efficiency (CUE), which is determined by gross primary production (GPP) and plant respiration (Ra) via the relation CUE=(GPP-Ra)/GPP. The effect of future climate on CUE is unclear due to the highly uncertain response of plant respiration to the expected increases in temperature and possible changes in tissue nitrogen (N) concentrations that also affect GPP and Ra.

Within the project *"Improving tree carbon use efficiency for climate-adapted more productive forests" (iCUE-Forest)*, we aim to develop novel data-driven estimates of plant respiration, net primary production (NPP=GPP-Ra) and tree CUE covering the northern hemisphere boreal and temperate forests. These will be based on recent satellite-driven maps of tree living biomass, databases of N concentration measurements in tree compartments (leaves, branches, stems, roots) and the relationships between respiration rates and tissue N concentrations and temperature. Such estimates will enable the detection of spatial relationships between CUE and environmental conditions and facilitate the parameterization of dynamic global vegetation models to predict the change in CUE in response to future climate and forest management.

Here we compile an unprecedented database of N concentration measurements in tree stems, branches and roots covering all common boreal and temperate tree genera together with data available mainly for leaves from databases like TRY. We apply this database to test different hypotheses on the controls of tree tissue N concentration and allocation. We find that the variation in tree tissue N concentrations of boreal and temperate trees is controlled by their leaf type (broadleaf deciduous, needleleaf deciduous, needleleaf evergreen), growth rate (fast- vs. slow-growing), tree age/size and climate conditions. These relationships have important implications on the coupling of the C and N cycles in the vegetation, since tissue N concentrations determine photosynthesis, growth and plant respiration. Thus, by altering tissue N concentrations, changes in the distribution of tree species, in tree age/size or in climate, induced by climate change, forest management or disturbances, can affect the C sequestration potential of boreal and temperate forests.

Subsequently, we combine the derived tree-level relationships between tissue N concentrations and underlying drivers, tree species distribution maps, and estimates of tree compartment biomass based on satellite remote sensing products. In this way, we derive novel estimates of the spatial distribution of N content in northern boreal and temperate forests that will in turn be used to assess CUE variations.