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Climate change impairs nitrogen cycling in European beech forests on marginal soil

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Beech forests on marginal calcareous soil are widely spread in Central Europe and provide – beside their economical values – important ecosystem services such as carbon storage, removal of reactive nitrogen from the biosphere and groundwater protection. The potential vulnerability of these ecosystems to reduced soil water availability in a changing climate has been associated with large-scale loss of ecological services and economical value. However, the mechanisms of climate change impacts on European beech forests are largely unknown and mainly ascertained to plant physiological limitations under drought. Recently, it has been proposed that reduced soil water availability may promote nitrogen (N) limitation of European beech due to impaired microbial N cycling in soil, but this hypothesis has not yet been tested. Here we present data on the influence of climate change on N transformation in the beech-soil interface. We show that nitrate (NO_3^-) is the dominant N source for beech natural regeneration. Reduced soil water content caused a persistent decline of ammonia oxidizing bacteria and therefore, a massive attenuation of gross nitrification and NO_3^- availability in the soil. Consequently, NO_3^- and total N uptake by beech seedlings were strongly reduced and impaired growth of beech seedlings was observed within two growing seasons. These findings support a dramatic decline by 78% of the distribution of beech forests on calcareous soils in Europe until 2080 predicted by statistical modelling. Therefore, the present results question the sustainability of European beech forests on marginal soils in the 21st century.