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Declining plant nitrogen supply and carbon accumulation in ageing primary boreal forest ecosystems

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Boreal forest soils are commonly characterized by a low plant nitrogen (N) supply. A high tree below-ground allocation of carbon (C) to roots and soil microorganisms in response to the shortage of N may lead to high microbial immobilisation of N, thus aggravating the N limitation. We studied the N supply at a Swedish boreal forest ecosystem chronosequence created by new land rising out of the sea due to iso-static rebound. The youngest soils develop with meadows by the coast, followed by a zone of dinitrogen fixing alder trees, and primary boreal conifer forest on ground up to 560 years old. With increasing ecosystem age, the proportion of microbial C out of the total soil C pool from the youngest to the oldest coniferous ecosystem was constant (c. 1-1.5%), whereas immobilised N (microbial N out of total soil N) increased and approached the levels commonly observed in similar boreal coniferous forests (c. 6-7 %), whereas gross N mineralization declined. Simultaneously, plant foliar N % decreased and the natural abundance of N-15 in the soil increased. More specifically, the difference in N-15 between plant foliage and soil increased, which is related to greater retention of N-15 relative to N-14 by ectomycorrhizal fungi as N is taken up from the soil and some N is transferred to the plant host. In the conifer forest, where these changes were greatest, we found increased fungal biomass in the F- and H-horizons of the mor-layer, in which ectomycorrhizal fungi are known to dominate (the uppermost horizon with litter and moss is dominated by saprotrophic fungi). Hence, we propose that the decreasing N supply to the plants and the subsequent decline in plant production in ageing boreal forests is linked to high tree belowground C allocation to C limited ectomycorrhizal fungi (and other soil microorganisms), a strong sink for available soil N. Data on organic matter C-14 suggested that the largest input of recently fixed plant C occurred in the younger coniferous forest ecosystems, whereas the soil C accumulation rate declined as N supply to the plants declined.