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Plant nutrient acquisition strategies in tundra species: at which soil depth do species take up their nitrogen?

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The Arctic is warming at unprecedented rates. Increased thawing of permafrost releases nutrients locked up in the previously frozen soils layers, which may initiate shifts in vegetation composition. The direction in which the vegetation shifts will co-determine whether Arctic warming is mitigated or accelerated, making understanding successional trajectories urgent. One of the key factors influencing the competitive relationships between plant species is their access to nutrients, in particularly nitrogen (N).

We assessed the depth at which plant species took up N by performing a 15N tracer study, injecting 15(NH4)2SO4 at three depths (5, 15, 20 cm) into the soil in arctic tundra in north-eastern Siberia in July. In addition we explored plant nutrient acquisition strategy by analyzing natural abundances of 15N in leaves.

We found that vascular plants took up 15N at all injection depths, irrespective of species, but also that species showed a clear preference for specific soil layers that coincided with their functional group (graminoids, dwarf shrubs, cryptogams). Graminoids took up most 15N at 20 cm depth nearest to the thaw front, with grasses showing a more pronounced preference than sedges. Dwarf shrubs took up most 15N at 5 cm depth, with deciduous shrubs displaying more preference than evergreens. Cryptogams did not take up any of the supplied 15N . The natural 15N abundances confirmed the pattern of nutrient acquisition from deeper soil layers in graminoids and from shallow soil layers in both deciduous and evergreen dwarf shrubs.

Our results prove that graminoids and shrubs differ in their N uptake strategies, with graminoids profiting from nutrients released at the thaw front, whereas shrubs forage in the upper soil layers. The above implies that graminoids, grasses in particular, will have a competitive advantage over shrubs as the thaw front proceeds and/or superficial soil layers dry out. Our results suggest that the vertical distribution of nutrients over the soil will play an important role in vegetation succession as permafrost thaw progresses.