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Herbivore-induced "deshrubification" alters the biogeochemistry of subarctic riparian ecosystems

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In the European subarctic, river valleys and other moist zones are dominated by tall shrub tundra, dominated by willows. Although climate warming is generally hypothesized to result in an expansion of this shrub zone, intensive reindeer husbandry in Finnmark (Northern Fennoscandia) during the last three decades seems to have resulted in a “deshrubification”: riparian tall willow dominated shrub zones evolved to open meadows, dominated by grasses. These changes in land cover may have major biogeochemical consequences for both the terrestrial and aquatic environment. We investigated the relation between this “deshrubification” and the biogeochemical cycling of silicon (Si), nitrogen (N) and phosphorous (P), essential nutrients for aquatic primary production. This study was conducted along a climatic gradient from the moist and warm southwest towards the drier and colder northeast of Finnmark.

Along the contrast of Finnmarks typical reindeer husbandry system, with intensively grazed summer pastures and extensively grazed spring/autumn pastures, we quantified the difference in vegetation composition and the associated differences in terrestrial pools of Si, N, P and soil organic carbon. Intensive reindeer grazing consistently excludes the presence of willow shrubs in the studied riparian zone and the transition from willow dominated tall shrub tundra towards open meadows dominated by grasses is associated with a clear silicification of the vegetation: all dominating grasses in the open meadow-state show 10 to 30 times higher Si concentrations compared to the dominating willow and forb species of the tall shrub vegetation, but also original tall shrub species show increased Si-concentrations under the intensive grazing regime. Silicon is a known defence component against herbivory, especially in grasses. Opposite, a transition to more N- and P-poor species occurs under intensive reindeer grazing: the continuum between tall willow dominated shrubs and open meadows is also a continuum between low and high Si:N- and Si:P-ratios in the vegetation, affecting both the size, reactivity and availability of the soil Si, N and P pools, as well as the export of these nutrients towards deeper soil layers and finally towards the river system. This has potentially large implications for the aquatic phytoplankton community, especially in adjacent estuarine and coastal systems, where low Si availability in relation to N and P can cause a transition from diatom dominance to non-diatom dominance, altering food-webs structure and carbon sequestration potential.