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Effects of bark beetle disturbance on soil nutrient retention and lake chemistry in glacial catchment

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Forest ecosystems worldwide are subjected to human-induced stressors, including eutrophication and acidification, and to natural disturbances (e.g. insect infestation, windstorms, fires). The occurrence of the later is expected to increase due to the ongoing climate change. These multi-stressor forcings modify ecosystem biogeochemistry, including the retention of limiting nutrients, with implications for terrestrial and aquatic biodiversity. Here we present whole ecosystem nutrient (N, Ca, Mg, K) mass balances in the forested catchment of Plešné Lake, CZ, which has undergone transient changes linked to the recovery from anthropogenic acidification and to the forest disturbances caused by severe infestations by the bark beetle (Ips typographus). Measured fluxes and storage of nutrients in the lake-catchment ecosystem were used to constrain the process-oriented biogeochemical model MAGIC (Model of Acidification of Groundwater In Catchments). Simulated lake water chemistry and changes in soil nutrient pools fitted observed data and revealed that i) the ecosystem N retention declined, thus nitrate leaching increased for 10 years following the bark beetle disturbance, with transient adverse effects on the acid-base status of lake water, ii) the kinetics of nutrient mineralisation from decaying biomass coupled with nutrient immobilisation in regrowing vegetation constrained the magnitude and duration of ecosystem losses of N, Ca and Mg, iii) the excess of mineralised base cations from decomposing biomass replenished the soil cation exchange matrix, which led to increased soil base saturation, and iv) the improvement of the catchment soil acid-base status led to an increase of lake water pH and acid neutralising capacity. Forested ecosystems underlain by nutrient-poor soils and bedrock are prone to human-induced damages caused by acidification and eutrophication, and any natural disturbance may further lead to nutrient imbalances. We demonstrated that in this natural forest ecosystem protected from human intervention, disturbances together with natural post-disturbance vegetation recovery have temporally positive effects on the nutrient stores in the soil.