森林生態系の窒素循環に及ぼす土壌凍結の影響

The effect of soil freezing on N cycling: comparison of two headwater subcatchments with different vegetation and snowpack conditions in the northern Hokkaido.

Sheila F. Christopher[1, 2], Hideaki Shibata[1], Megumi Ozawa[1], Yasunori Nakagawa[1] and Myron J. Mitchell[3]

Climate change models predict that the snowpacks of temperate forests will develop later and be shallower resulting in a higher propensity for soil freezing. In the northern most island of Japan, Hokkaido, snowpack depth decreases from west to east. This snowpack depth gradient provided a unique opportunity to test the effects of variable snowpack and soil freezing on N biogeochemistry. The Shibecha Northern Catchment in Shibecha Experimental Forest, eastern Hokkaido had deciduous trees and a mean annual snowpack of 0.7 m while the M3 catchment in Uryu Experimental Forest, western Hokkaido had mixed deciduous and coniferous tree species and a mean annual snowpack of 2.0 m. We conducted a field study (October 2004–April 2005) to determine if differences in Shibecha and Uryu soil extractable N, N mineralization, and nitrification were controlled by the variability in soil freezing during winter or tree species composition that affected the quality of the forest floor. The mixed deciduous and coniferous trees forming the Uryu forest floor had a higher C:N ratio (25.0 vs. 22.4 at Shibecha), higher lignin:N ratio (15 vs. 8.8), and higher lignin concentrations (0.28 vs. 0.18 g lignin g^{-1}). These differences in forest floor quality contributed to higher net N mineralization and nitrification in Shibecha compared to Uryu. In Shibecha, soil remained frozen for the entire study. For Uryu, except for an early period with cold temperatures and no snow, the soil generally remained unfrozen. As a result of the early winter cold period and soil freezing, extractable soil NH_4^+ did not change but NO_3^- increased. Reciprocal 0–5 cm mineral soil transplants made between Shibecha and Uryu and incubated during winter at 0, 5, and 30 cm suggested that soil freezing resulted in greater net N mineralization yet lower nitrification regardless of the soil origin. The effect of soil freezing should be considered when evaluating differences in N dynamics between temperate ecosystems having a propensity for soil freezing.

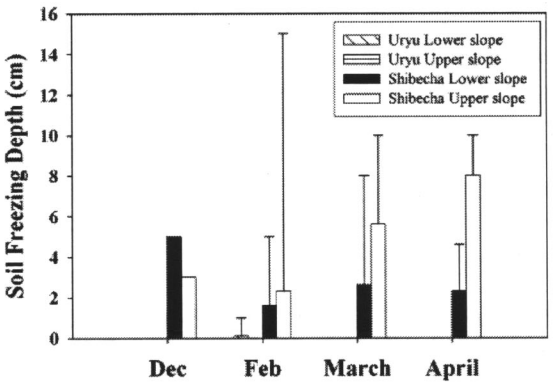

Fig. 1 Soil freezing at the lower and upper slope of Uryu and Shibecha. Values are means with bars showing the range (N=5).

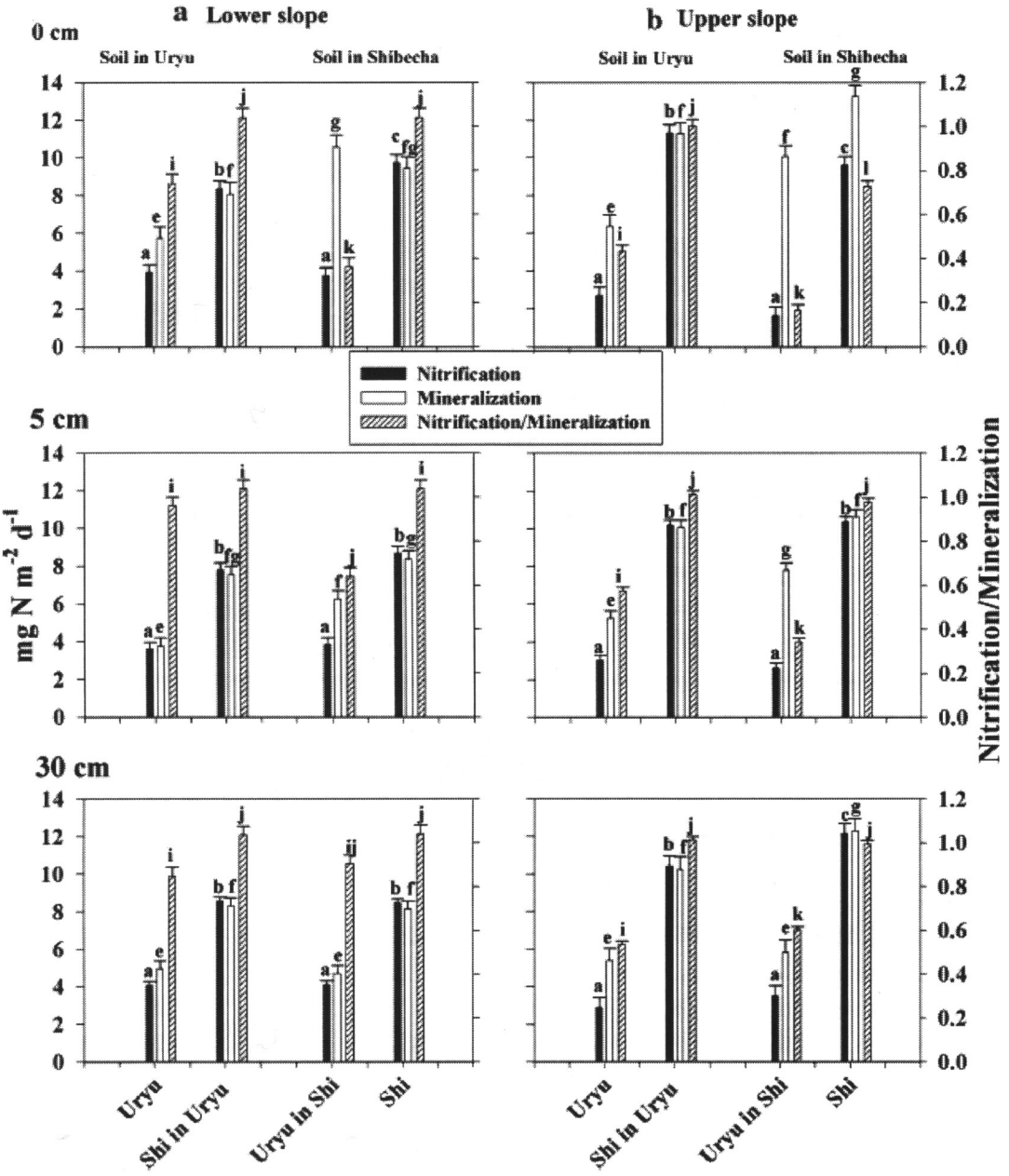

Fig.2 Mean net nitrification and N mineralization and nitrification/mineralization (+SE of the group means) in the lower slopes (a) and upper slopes (b) of Uryu and Shibecha at 0, 5 and 30 cm. Letters that differ among catchment burial sites (Uryu, Shibecha in Uryu, Uryu in Shibecha and Shibecha) indicate significant differences at the 0.05 levels.

Christopher, S.F., Shibata, H., Ozawa, M., Nakagawa, Y. and Mitchell, M.J. (2008) The effect of soil freezing on N cycling: Comparison of two headwater subcatchments with different vegetation and snowpack conditions in the northern Hokkaido Island of Japan. Biogeochemistry 88(1): 15-30.