Geophysical Research Abstracts
Vol. 13, EGU2011-2290, 2011
EGU General Assembly 2011

Soil Nitrogen Dynamics within Profiles of a Harvested Temperate Forest Chronosequence

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Soil nitrogen (N) represents an important store of N in northern forested ecosystems. As a limiting nutrient in many soils, its availability has important consequences for soil carbon (C) sequestration, and associated global climate feedbacks. Many northern forests are subjected to routine forest harvesting, resulting in a landscape composed of a patchwork of forest fragments in various stages of recovery from harvesting, and little if any intact old growth forest without a history of this disturbance. Quantifying soil N pools, transfer rates amongst these pools, and factors that control pool sizes are important if we are to fully understand the interaction of N with other biogeochemical cycles (i.e. C) in such systems. Using a harvested temperate red spruce forest chronosequence representing <1 to >80 year old harvest sites, alongside a reference old growth (125+ year) site with no documented history of harvesting, we investigated changes in N pools and fluxes and a) quantified N storage within specific depth and age intervals across a managed chronosequence, b) quantified changes in physical fractions of soil N through depth and time, c) examined patterns in the stable isotopic composition of soil N through depth and time, and d), quantified gross soil N mineralization through depth and time. Our findings point to a large loss of the soil N pool, particularly within the subsoil (>20cm) and the organo-mineral fraction. A pulse of available mineralized N (as ammonium) was observed following harvesting (mean residence time (MRT) >6 days) but its MRT dropped to <1 day 80 years following harvesting, in contrast to the the 2-3 day MRT observed in the old growth forest. These findings are consistent with storage estimates that suggest this store of N does not re-accrue in a harvesting cycle. Profiles of δ15N within the mineral soils show strong enrichments through depth ($\sim$6 - 9 permil) that likely reflect qualitative changes in soil biological functions following harvesting. Overall, this study suggests long term losses in soil N stores and availability following harvesting that are not recovered over the timescales of typical harvest cycles in this temperate forest, a factor which may play an important role in determining soil C sequestration potentials in harvested soils.