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Investigating Nitrous Oxide Fluxes along a Harvested Red Spruce Forest Chronosequence

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Forest harvesting can alter soil physical, chemical and biological functioning, shifting the fluxes of greenhouse gases to the atmosphere on the scale of months to decades. Clearcut harvesting is a standard management practice in many temperate forest regions, yet our current understanding of how this alters the balance of production and consumption of nitrous oxide (N_2O) in these soils is poorly understood and quantified. This study investigates soil N_2O fluxes across a clearcut harvest red spruce forest chronosequence in eastern Canada with six post-harvest sites (stand ages 0 - 83 years) and one uncut control old growth (125+ yrs) forest site. Nitrous oxide surface fluxes along with soil temperature and moisture were measured biweekly through the growing season, and supplemented with laboratory based experiments designed to understand the controls of moisture, temperature and N-status upon harvested soil cores (1 year). Over the chronosequence, soils acted as a net sink during the 0 - 0.5 year period immediately following harvesting (-0.84 $\pm$ 0.80 μg N_2O-N/m^2/hr), followed by a net source in stands aged 0.5 - 5 years (3.27 $\pm$ 1.50 μg N_2O-N/m^2/hr), with fluxes declining to background control forest levels (0.17 $\pm$ 0.45 μg N_2O-N/m^2/hr) within 20 years. Overall, high spatial and temporal variability in field fluxes were documented, with negative fluxes observed at all stands and comprising approximately 46% of the measured fluxes. Additionally, no significant correlations were observed between N_2O fluxes and soil temperature and moisture in the field data. Post harvest fluxes measured in controlled laboratory experiments pointed to N availability as the major control upon flux magnitudes. Nitrogen amendments resulted in positive soil fluxes that increased with elevated temperature and under optimal moisture conditions. Under N-limiting conditions (no N amendments) however, enhanced sink activity was observed at elevated temperatures.