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Chemical properties of litter inputs and organic matter along the Canadian Boreal Forest Transect Case Study

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To improve prediction of climate change impacts on the carbon balance of boreal forests, we are investigating C stocks, fluxes and organic matter quality of jack pine (Pinus banksiana) and black spruce (Picea mariana) stands in northern Saskatchewan and Manitoba along the Boreal Forest Transect Case Study (BFTCS). Jack pine stands occupy well-drained sandy soils with thin forest floor, whereas poorly-drained black spruce stands have a thick moss-dominated forest floor. Carbon storage for jack pine and black spruce stands respectively was 3.0-5.5 kg m-2 and 5.2-8.2 kg m-2 in vegetation, and 0.20-0.85 kg m-2 and 0.12-0.40 kg m-2 in coarse woody debris. Forest floor C stock was much higher for black spruce (6.0-12.7 kg m-2) than for jack pine (0.6-0.82 kg m-2). Mineral soil C to 50 cm was also significantly higher for black spruce (3.3-12.5 kg m-2) than for jack pine sites (2.2-3.0 kg m-2). Black spruce forest floor properties indicate hindered decomposition and N cycling, with high C/N ratios, strongly stratified and depleted [U+F064]13C and [U+F064][U+F020]15N values, high tannins and phenolics, and 13C nuclear magnetic resonance (NMR) spectra typical of poorly decomposed plant material, especially roots and mosses. The thinner jack pine forest floor appears to be dominated by lichen, with charcoal in some samples. These contrasts are unlikely due to the small differences in aboveground litter inputs (110 vs 121 g m-2) for jack pine and black spruce respectively, 2000-2010 means) or litter quality. Development of colder, wetter and thicker black spruce forest floor is more likely associated with soil texture and drainage, further exacerbated by increasing sphagnum coverage and forest floor depth. This suggests that small environmental changes could trigger large C losses through enhanced forest floor decomposition. An investigation of mineral soil C stabilization in four jack pine sites showed that silt plus clay accounted for 15-43 % of 0-1 m C (1.5-2.8 kg m-2); silt held 0.9-3.3% of horizon mass and 13-31% of total C. Carbon-13 NMR of HF-treated silt fractions showed that alkyl and O-alkyl C dominated the A and B horizons, but C-horizon samples were higher in aromatic C, possibly of fire origin. HCl hydrolysis was used to to isolate older C, but most 14C dates were modern, with five samples from deeper horizons ranging from 141-5184 ybp. HCl residues were mainly alkyl and aromatic C. Especially for black spruce stands, soil C appears to be dominated by inputs from roots and moss, and stabilized mainly by environmental factors; soil C stored as thick forest floor is also vulnerable to loss by fire. Forest floor and mineral soil show evidence of pyrogenic C, but quantitative data are lacking to assess its role in long-term C sequestration. Considering the sensitivity of this region to climate change, further research should focus on understanding the processes controlling climate, vegetation and soil interactions throughout the lifecycle of jack pine and black spruce forests.