Erect Shrubs Modulate the Carbon Distribution in Soils of the Prostrated Tundra in the Qarlikturvik Valley, Bylot Island, Nunavut

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Increasing growth of erect shrubs species, like *Salix richardsonii*, have been well documented in Arctic tundra. This shrubification of the North causes profound changes in water, energy and nutrient feedbacks between the biosphere, geosphere and atmosphere (Myers-Smith et al 2011). However, few studies have yet to examine the impact of these changes on the carbon (C) cycle in soils. Our objective is to quantify the balance and distribution of organic carbon in soils associated with the colonisation of *S. richardsonii* at the northern limit of its distribution. For doing so, we compared colonised with uncolonized zones crossed with hydrologically active vs inactive zones.

We rely on the "soil bank mechanism" framework (Fontaine et al 2011) to make our soil C balance predictions. It is now established that fresh energy-rich C (e.g. plant litter) stimulates microbial populations and decomposition of soil humified organic matter (SOM). This phenomena called Priming Effect (PE) is modulated by the concentration of nutrients in the soil solution. At low soil fertility, PE may lead to an overall soil C loss, as micro-organisms enhance the decomposition of nutrient-rich SOM to satisfy their nutrition. In our study, we assume that the shrubification will increase fresh energy-rich input but at the same time decrease soil nutrient fertility. We also assume that the activity of hydrology may replenish soil fertility, leading to the following 4 cases scenario (Table 1):

Table 1: Scenarii for the impact of *S. richardsonii* on soil organic C.

|		Soil fertility	
		High	**Low**
Fresh biomass input	**High**	Sequestration (Invaded–fertile)	Release (Invaded–fertile)
	Low	Stable (Virgin–fertile)	Stable (Virgin–fertile)

Figure 1. Location of the study site.

Along two alluvial fans in the valley, we established in 2016 five treatments, split between 30 patches that included three sediment input levels (None, Low, High); two *S. richardsonii* colonization levels (In, Out) and three repetitions. In a given 70 x 70 cm patch, a soil core (diameter 6 cm) was sampled until the permafrost was reached (maximum depth of 12-15 cm). Three layers were visually defined corresponding to the horizon O, A1, A2. Soils were kept fresh (4°C) before laboratory analyses. Cores were sieved at 2 mm and 50 g were set aside for characterizing usual soil properties. The remaining soil were wet sieved with three additional mesh sizes: 1 mm, 250 μm and 63 μm to separate four SOM compartments (roots, coarse and fine particulate organic matter and recalcitrant organic matter; hereafter named Root, POMg, POMf and ROM, respectively). C-N analyses were conducted with a mass-spectrometer for each soil compartment (300 samples). Soil C stock (g m^{-3}) were calculated accounting for bulk density and core volume. Finally, in each patch, a 20 cm * 20 cm area were defined to sample root and shoot plant biomass. Data analyses were performed with the R software (R Development Core Team 2017).

Our design distinctively crossed three levels of soil pH, considered here as three levels of soil fertility, with two levels of plant living biomass, considered here as two levels of fresh energy input into the soil (Figure 2A-B). These first results confirmed that our framework can be used to understand the C storage variation with the presence of *S. richardsonii*. We also assumed that soil C storage likely occurs in soil humified organic matter compartments, where soil decomposition have already processed the most labile forms of carbon. Figures 2C-D show that smaller is the organic matter compartment, significantly lower is its C/N ratio and higher is its 13C composition. This likely indicates that the carbon molecule was relatively more used (by respiration) in comparison with the one of nitrogen (by absorption). In this process, soil 12C has been preferentially respired. Altogether, these two results suggest that the smallest soil organic matter compartment are the ones where soil C would be likely stored in the long-term. Finally, figure E shows that there is no impact of shrubification on soil C when all soil compartments and all horizons were considered. However, when smallest OM compartments were considered, shrubification had a net positive impact on soil C storage, but only when there was enough soil nutrients. This results were significant in H1 layer at 0.001 p-value level, while only a tendency was found for H0. This result may be explained by the strong microbial activity of H0 layer,

where most roots were present and microbes could have continuously decomposed the most recalcitrant OM compartment with the constant input of fresh OM. In contrast in H1 layer, roots and fresh OM were less present, likely favoring the C sequestration.
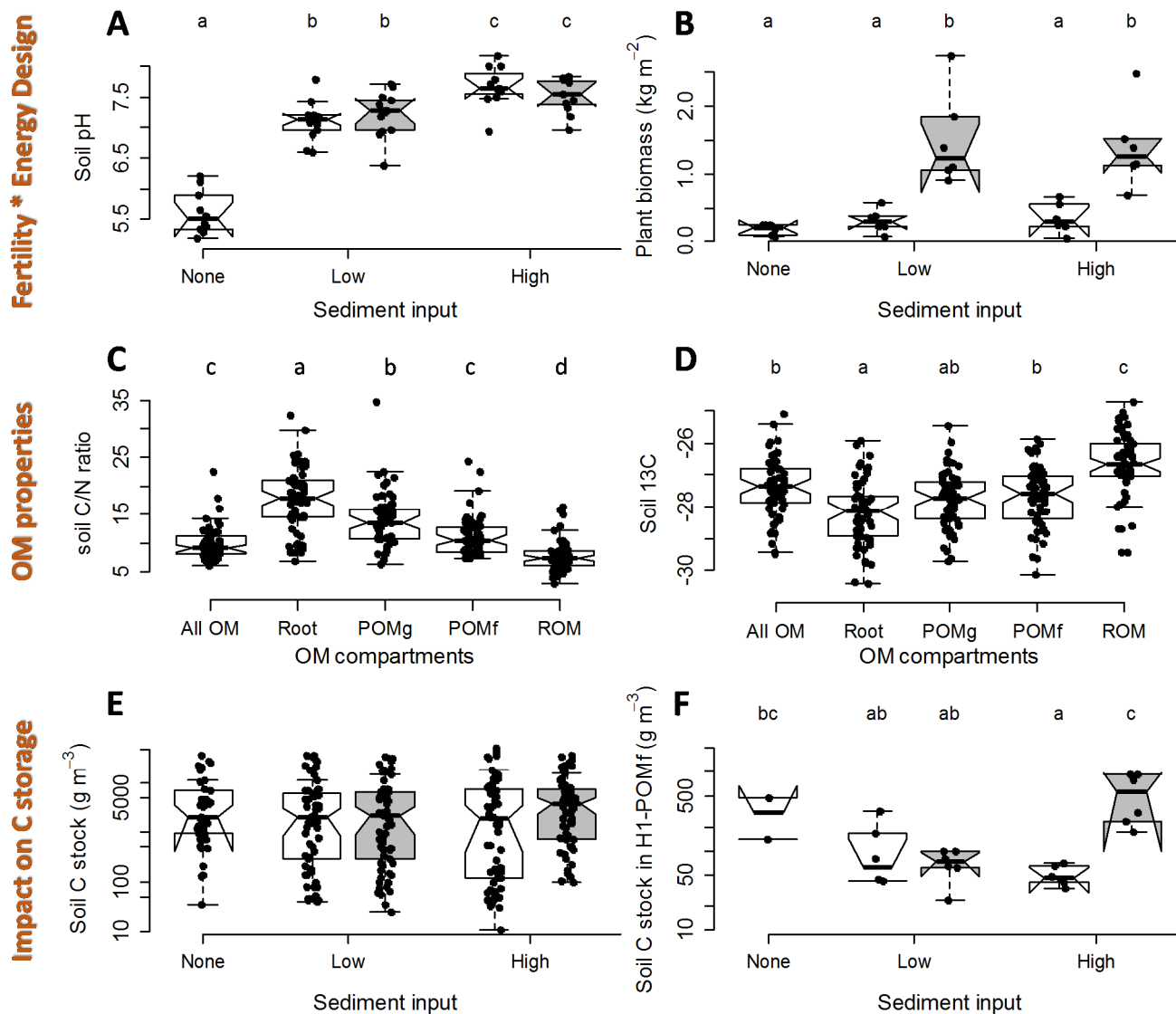
Figure 2. Effect of the shrubification and three sediment input levels on soil functioning. Figure A presents soil pH measured in water. Figure B presents plant biomass (shoot and root) measured n 20*20 cm area. Figures C and D present C/N ratio and 13C composition in the different soil organic matter compartments separated by wet sieving. Figures E and F presents the impact of the shrubification on the C storage, considering all OM compartments and only in the POMf – Horizon 1 OM, respectively. Letters indicate significant differences between treatments using a MANOVA procedure and a post-hoc Tukey test at 0.05 P-level.

Overall, our preliminary results indicate that the soil bank mechanism framework may be applied to understand the differences in soil C balance from our treatments. In conclusion, we encourage further studies to focus on soil C sequestration in arctic tundra in regards to the habitat fertility.

References

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