

# Changes in soil organic carbon in response to climate manipulation under *Cassiope tetragona* in Zackenberg, Greenland

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## INTRODUCTION

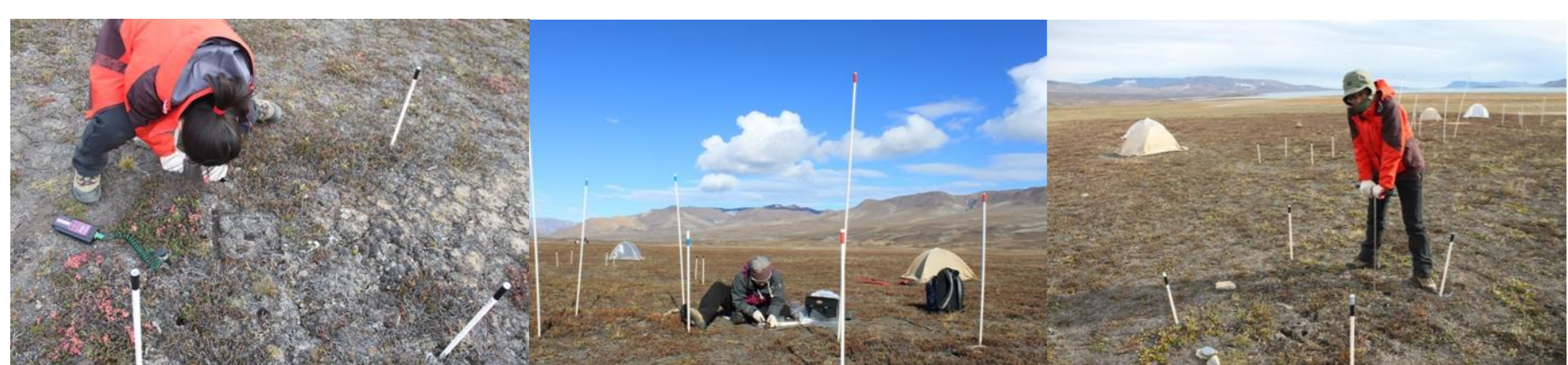
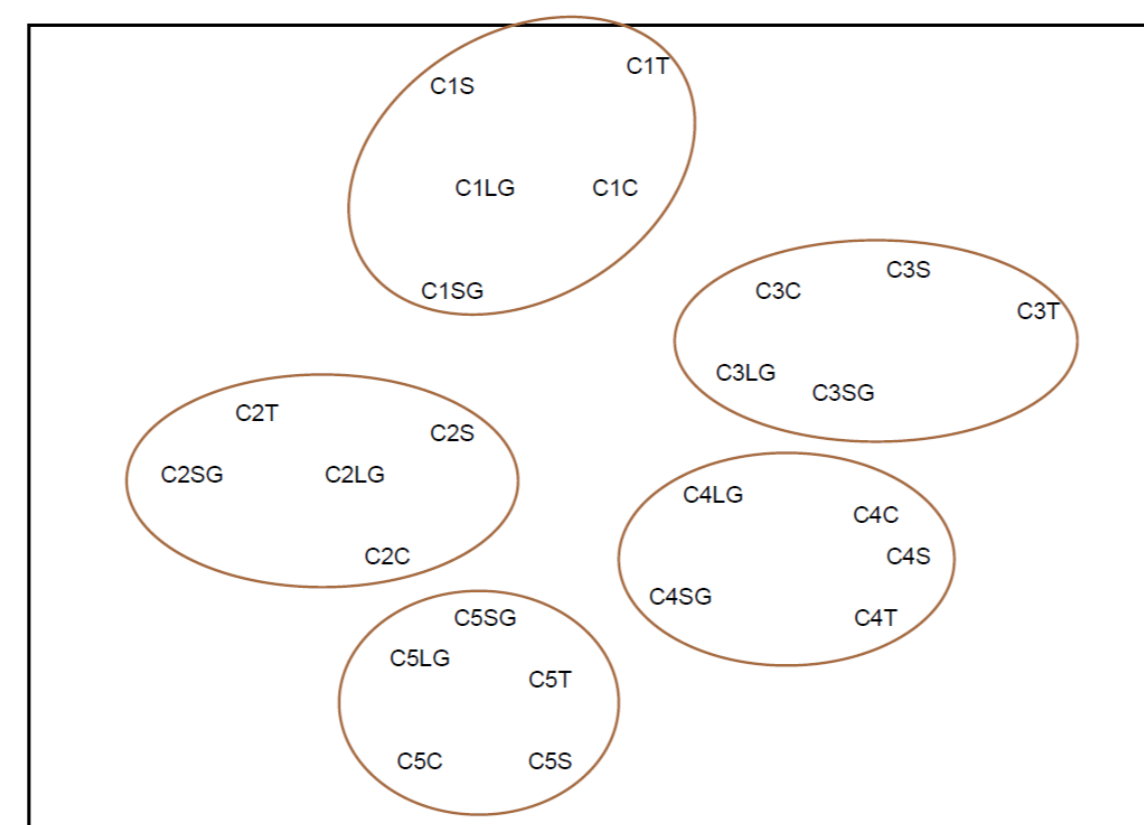
It is projected that climate change will be more pronounced in the Arctic than further south. Climate change will affect soil organic carbon (SOC) pools which are directly related to carbon dioxide fluxes. Thus, it is crucial to understand how soil will respond to climate change in the Arctic where large amount of SOC is accumulated in many ecosystem types due to low temperature reducing decomposition. In this study, we aimed to understand the characteristics of SOC and the effects of climate manipulation on SOC under two high arctic heaths. We hypothesized that change in temperature and in growing season length would affect microbial activities and thus the amount and chemical composition of SOC.

## MATERIALS & METHODS

- Study site:** Zackenberg, Greenland (74°28'N, 20° 33'W)
- Average temperature:** -20, 6.3, and -9.0 °C in January, July, and whole year, respectively
- Soil type:** Typic Psammoturbels (Elbering et al., 2008)
- Vegetation type:** Dry heath dominated by *Cassiope tetragona*
- Climate manipulation plots:** established in 2004 by Prof. Michelsen and coworkers (Klitgaard et al., 2006) one control (C) and four treatments plots: warming with plastic tents (T), shading from sack-cloth (S), short growing by addition of snow (SG), and long growing by removal of snow (LG) plots.
- Field measurement:** Soil temperature, litter layer thickness, and thawing depth
- Soil sampling:** Litter layer (D0), 0-5 (D1), 5-10, (D2) and 10-15 (D3) cm with 5 cm diam. cores
- Soil physical and chemical analyses:** soil moisture content, bulk density, soil texture, soil organic carbon (SOC) and total nitrogen content (TN), density fractionation (sodium polytungstate, 1.55 g cm<sup>-3</sup>) which separates SOC as free light fraction (FLF), occluded light fraction (OLF), and heavy fraction (HF), and <sup>13</sup>C Nuclear Magnetic Resonance spectroscopy
- Statistical analysis:** one-way ANOVA and post-hoc with Tukey's test (p < 0.1)



Completely randomized block design  
Five blocks and five treatments



## RESULTS

### 1. Field measurement

	Mean (SE)				
	C	T	S	SG	LG
Thawing depth (cm)	72 (5)	71 (4)	78 (3)	69 (4)	72 (4) <sup>ns</sup>
Litter layer thickness (cm)	1.2 (0.2)	0.9 (0.2)	0.9 (0.1)	1.0 (0.2)	1.3 (0.3) <sup>ns</sup>
Soil temperature (°C)	6.7 (0.5) <sup>b</sup>	8.2 (0.7) <sup>a</sup>	6.7 (0.4) <sup>b</sup>	6.9 (0.5) <sup>b</sup>	7.0 (0.7) <sup>b</sup>

### 2. Bulk density (g cm<sup>-3</sup>)

	Mean (SE)				
	C	T	S	SG	LG
0-5 cm depth	1.06 (0.07)	1.07 (0.03)	1.01 (0.10)	0.97 (0.07)	0.98 (0.04) <sup>ns</sup>
5-10 cm depth	1.39 (0.07)	1.43 (0.04)	1.41 (0.04)	1.38 (0.05)	1.34 (0.04) <sup>ns</sup>

### 3. Soil moisture content (%)

	Mean (SE)				
	C	T	S	SG	LG
Litter layer	44.8 (9.7)	56.5 (17.8)	74.3 (5.9)	40.4 (11.7)	54.1 (13.3) <sup>ns</sup>
0-5 cm depth	32.7 (4.7)	35.4 (7.8)	52.0 (11.3)	38.1 (8.1)	48.5 (6.3) <sup>ns</sup>
5-10 cm depth	18.5 (2.9)	17.2 (1.5)	21.3 (2.6)	14.0 (0.9)	21.8 (4.6) <sup>ns</sup>
10-15 cm depth	17.1 (2.4)	16.8 (4.3)	16.1 (2.5)	18.3 (3.8)	25.7 (5.2) <sup>ns</sup>

### 4. Soil texture (%)

	Mean (SE)				
	C	T	S	SG	LG
<b>Sand</b>					
0-5 cm depth	62.1 (10.0)	61.8 (8.6)	59.5 (11.9)	62.6 (4.4)	61.6 (9.1) <sup>ns</sup>
5-10 cm depth	64.2 (7.0)	73.0 (10.3)	73.3 (4.6)	76.8 (7.3)	70.4 (9.9) <sup>ns</sup>
10-15 cm depth	65.4 (10.4)	74.7 (12.6)	72.4 (4.6)	69.0 (5.3)	72.8 (8.5) <sup>ns</sup>
<b>Silt</b>					
0-5 cm depth	26.9 (9.2)	26.8 (8.2)	28.6 (10.2)	25.7 (5.1)	26.9 (6.9) <sup>ns</sup>
5-10 cm depth	24.1 (6.7)	17.4 (7.9)	17.7 (4.0)	14.9 (5.8)	20.0 (7.5) <sup>ns</sup>
10-15 cm depth	23.6 (8.3)	16.5 (10.2)	17.7 (4.1)	22.4 (4.0)	18.5 (7.4) <sup>ns</sup>
<b>Clay</b>					
0-5 cm depth	11.0 (1.0)	11.4 (1.4)	12.0 (2.5)	11.7 (2.8)	11.5 (2.4) <sup>ns</sup>
5-10 cm depth	11.7 (1.4)	9.6 (2.6)	9.1 (1.3)	8.3 (2.2)	9.6 (3.3) <sup>ns</sup>
10-15 cm depth	11.0 (2.7)	8.8 (3.2)	10.0 (1.5)	8.6 (1.7)	8.7 (1.6) <sup>ns</sup>

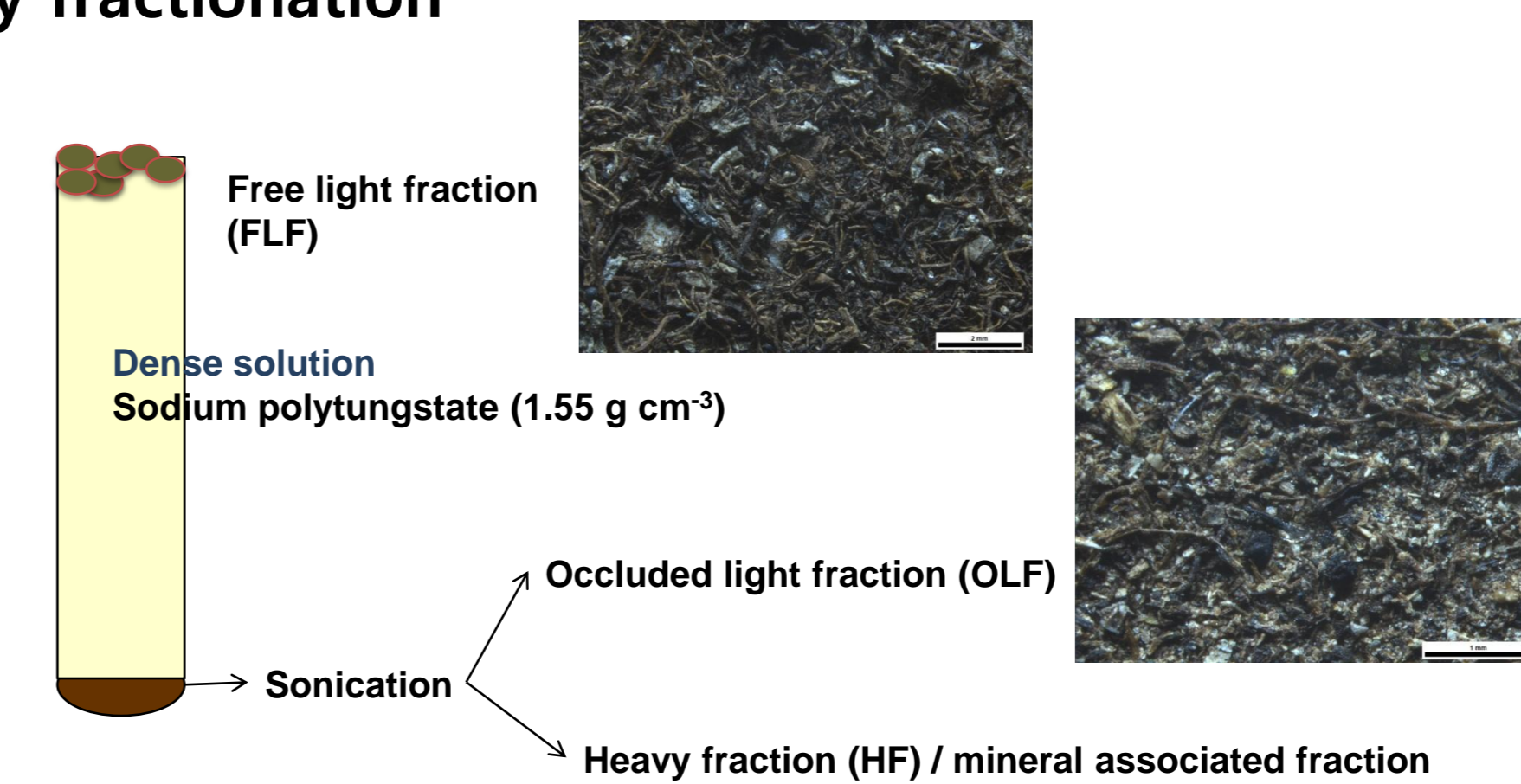
## SUMMARY

- Soil temperature in the T treatment was 1 °C higher than the other treatments.
- Most physical and chemical properties in soil were not significantly different among treatments despite a fairly long period of climate manipulation.
- Although SOC and TN contents were not different among treatments, the amount of LF was lower in T and SG treatments than that in control.
- <sup>13</sup>C NMR showed that in the T treatment, the ratios of the O/N-alkyl C (labile) and that of the alkyl C (recalcitrant) groups were relatively lower and higher than the others, respectively.
- Warming did not alter the amount of SOC, however, it could cause the change in SOC quality by decreasing a labile portion of SOC

### 4. Soil organic carbon and total nitrogen concentration

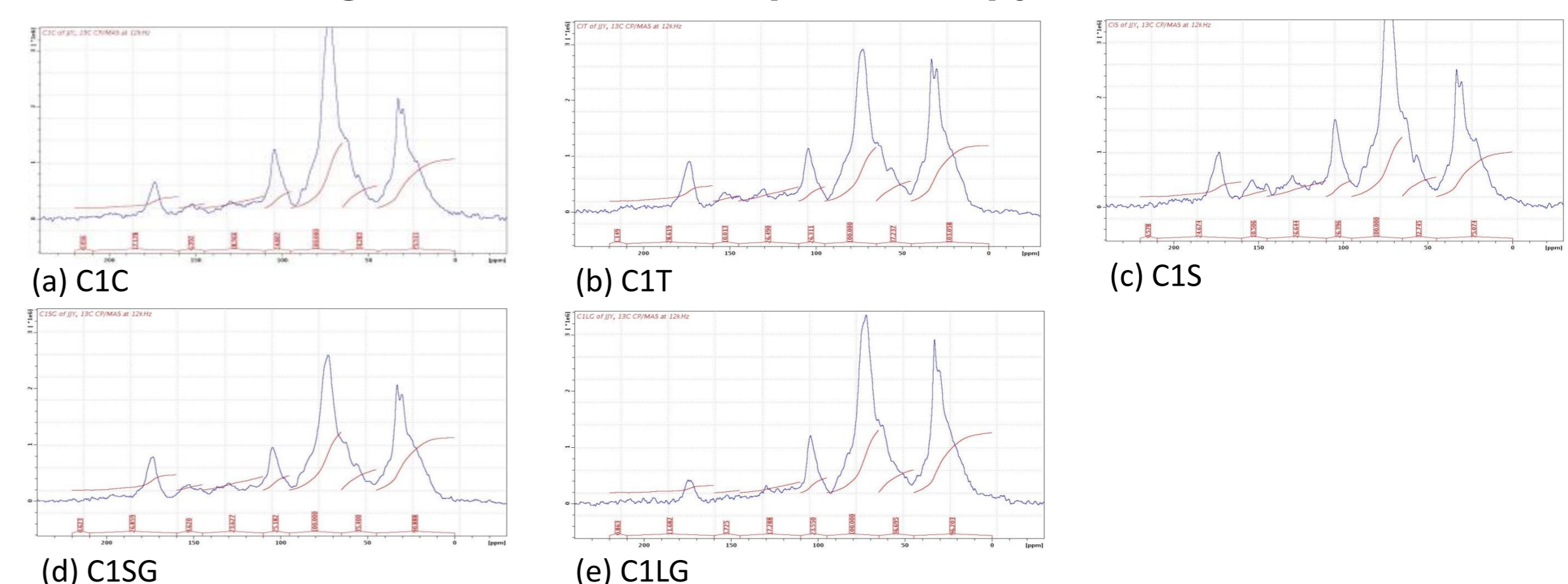
	Mean (SE)				
	C	T	S	SG	LG
<b>SOC (%)</b>					
Litter layer	15.4 (1.16)	14.8 (1.84)	13.5 (1.52)	13.5 (1.58)	15.0 (1.81) <sup>ns</sup>
0-5 cm depth	4.25 (0.47)	3.52 (0.44)	4.64 (0.63)	3.74 (0.44)	5.25 (0.71) <sup>ns</sup>
5-10 cm depth	3.31 (0.34)	2.11 (0.40)	2.48 (0.43)	2.39 (0.34)	2.46 (0.36) <sup>ns</sup>
10-15 cm depth	2.93 (0.39)	1.84 (0.40)	2.26 (0.68)	2.49 (0.34)	2.11 (0.11) <sup>ns</sup>
<b>TN (%)</b>					
Litter layer	0.66 (0.06)	0.71 (0.07)	0.67 (0.08)	0.65 (0.04)	0.68 (0.06) <sup>ns</sup>
0-5 cm depth	0.27 (0.03)	0.22 (0.03)	0.3 (0.04)	0.25 (0.03)	0.35 (0.06) <sup>ns</sup>
5-10 cm depth	0.22 (0.02)	0.14 (0.03)	0.16 (0.03)	0.17 (0.03)	0.17 (0.02) <sup>ns</sup>
10-15 cm depth	0.19 (0.03)	0.12 (0.03)	0.15 (0.05)	0.17 (0.03)	0.13 (0.004) <sup>ns</sup>
<b>C/N ratio</b>					
Litter layer	23.6 (1.0)	20.8 (0.8)	20.8 (2.4)	20.5 (1.3)	21.7 (1.0) <sup>ns</sup>
0-5 cm depth	15.8 (0.7)	16.2 (1.0)	15.6 (0.2)	15.3 (0.7)	15.3 (0.4) <sup>ns</sup>
5-10 cm depth	15.1 (0.7)	15.4 (0.6)	15.9 (0.5)	14.4 (0.7)	14.7 (0.2) <sup>ns</sup>
10-15 cm depth	15.5 (0.5)	16.3 (0.8)	16.2 (0.9)	15.1 (0.6)	15.8 (0.6) <sup>ns</sup>

### 5. Density fractionation



	Mean (SE)				
	C	T	S	SG	LG
<b>FLF (%)</b>					
0-5 cm depth	2.65 (0.27) <sup>a</sup>	1.93 (0.23) <sup>b</sup>	2.91 (0.68) <sup>ab</sup>	2.15 (0.19) <sup>b</sup>	2.43 (0.20) <sup>ab</sup>
5-10 cm depth	1.28 (0.26)	1.10 (0.15)	1.02 (0.11)	0.92 (0.11)	1.08 (0.19) <sup>ns</sup>
10-15 cm depth	1.14 (0.16)	0.88 (0.19)	0.87 (0.17)	1.12 (0.13)	1.06 (0.12) <sup>ns</sup>
<b>OLF (%)</b>					
0-5 cm depth	0.86 (0.05)	0.79 (0.15)	1.29 (0.43)	1.02 (0.13)	1.07 (0.08) <sup>ns</sup>
5-10 cm depth	0.52 (0.16)	0.49 (0.15)	0.55 (0.12)	0.50 (0.09)	0.51 (0.09) <sup>ns</sup>
10-15 cm depth	0.43 (0.08)	0.34 (0.1)	0.40 (0.08)	0.56 (0.11)	0.51 (0.08) <sup>ns</sup>
<b>LF (%)</b>					
0-5 cm depth	2.65 (0.27)	1.93 (0.23)	2.91 (0.68)	2.15 (0.19)	2.43 (0.20) <sup>ns</sup>
5-10 cm depth	1.28 (0.26)	1.1 (0.15)	1.02 (0.11)	0.92 (0.11)	1.08 (0.19) <sup>ns</sup>
10-15 cm depth	1.14 (0.16)	0.88 (0.19)	0.87 (0.17)	1.12 (0.13)	1.06 (0.12) <sup>ns</sup>
<b>HF (%)</b>					
0-5 cm depth	96.2 (0.4)	96.3 (0.4)	95.9 (0.8)	96.5 (0.4)	96.1 (0.8) <sup>ns</sup>
5-10 cm depth	97.6 (0.2) <sup>c</sup>	97.7 (0.3) <sup>bc</sup>	98.1 (0.2) <sup>abc</sup>	98.4 (0.1) <sup>ab</sup>	98.8 (0.5) <sup>a</sup>
10-15 cm depth	97.8 (0.2)	98 (0.2)	98.8 (0.6)	98.2 (0.2)	98.3 (0.2) <sup>ns</sup>

### 6. <sup>13</sup>C Nuclear Magnetic Resonance spectroscopy



Treatment	Chemical shift (ppm)	0-45 (alkyl-C)	45-110 (O/N alkyl-C)	110-160 (aromatic C)	160-210 (carboxyl C)
C1C		27.3	57.5	9.0	6.2
C1T		31.1	49.3	11.0	8.6
C1S		25.4	53.8	12.5	8.3
C1SG		29.2	51.5	10.7	8.6
C1LG		33.3	55.4	7.3	4.0

## ACKNOWLEDGEMENTS

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