Time for Tea: Nutrient Affect on Tea Decomposition After Three-Month Incubation in Northern Hardwood Forest Soil

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INTRODUCTION

The decomposition of organic matter is vital to nutrient cycling in ecosystems. We are participating in a research study using a standardized methodology for global measurement of decomposition rates in a range of climates, soil types, and treatment studies (Didion, 2016). As part of the project, the bioassay of Lipton's fast-decomposing green (*Camellia sinensis)* and slow-decomposing rooibos (*Aspalathus linearis)* tea were installed from 405 sites and retrieved after 3 months, 1, 2, and 3 years (Didion, 2016).

The nutrients available in litter and soil influence the rate of decomposition (Berg & Matzner, 1997). Our study investigates how decomposition is altered by nitrogen, phosphorus, and calcium additions. We expect green tea to decompose faster than rooibos tea. We hypothesized that nutrient treatments will delay the rate of decomposition after three months of incubation.

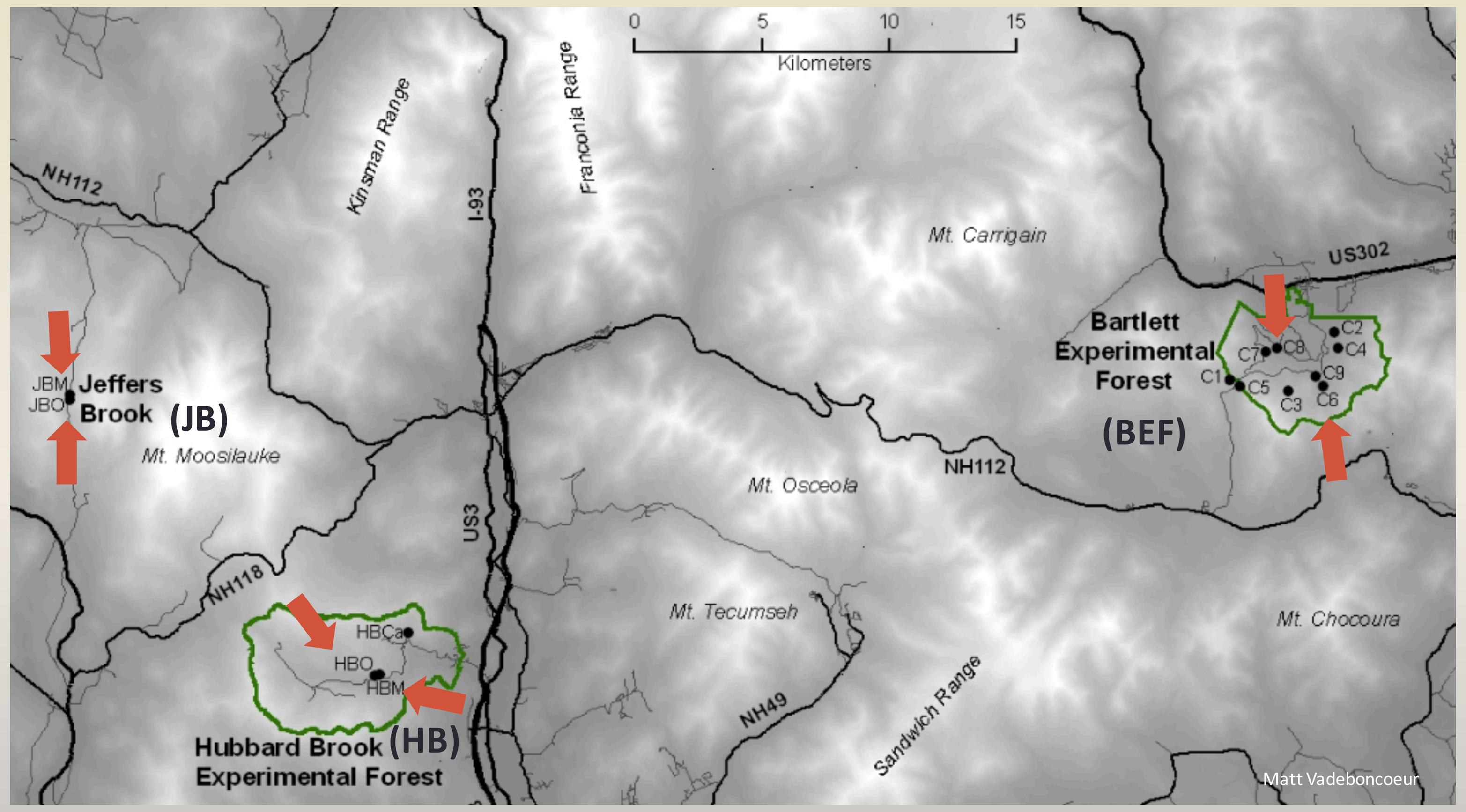


Figure 1. Location of sites. Arrows point to stands where teabags were installed.

METHODS

Site description

- This study was within the Multiple Element Limitation in Northern Hardwood Ecosystem (MELNHE) Project.
- We used a mid-age and old-age stand in Bartlett (BEF), Hubbard Brook (HB), and Jeffers Brook (JB) experimental sites located in the White Mountains of NH (Fig. 1).
- Within the stands, five plots were fertilized with N (NH_4NO_3), P (NaH_2PO_4), N+P, Ca ($CaSiO_3$), or left untreated.

Teabag Incubation Procedure

- A total of 240 nylon bags containing rooibos and green tea with 0.25mm mesh were dried at 60ºC (Fig. 2).
- On August 2nd and 3rd 2016, four teabags were buried at the bottom of the soil's Oa layer right above the mineral layer (~3 - 13 cm deep) on each side of the square plots (Figs. 4a & 4c).
- Three months later, the teabags were extracted and frozen (fig. 3). Once dried at 60ºC and cleaned, 221 teabags were weighed (Fig. 4b). Bags with visible holes were excluded from the analysis.

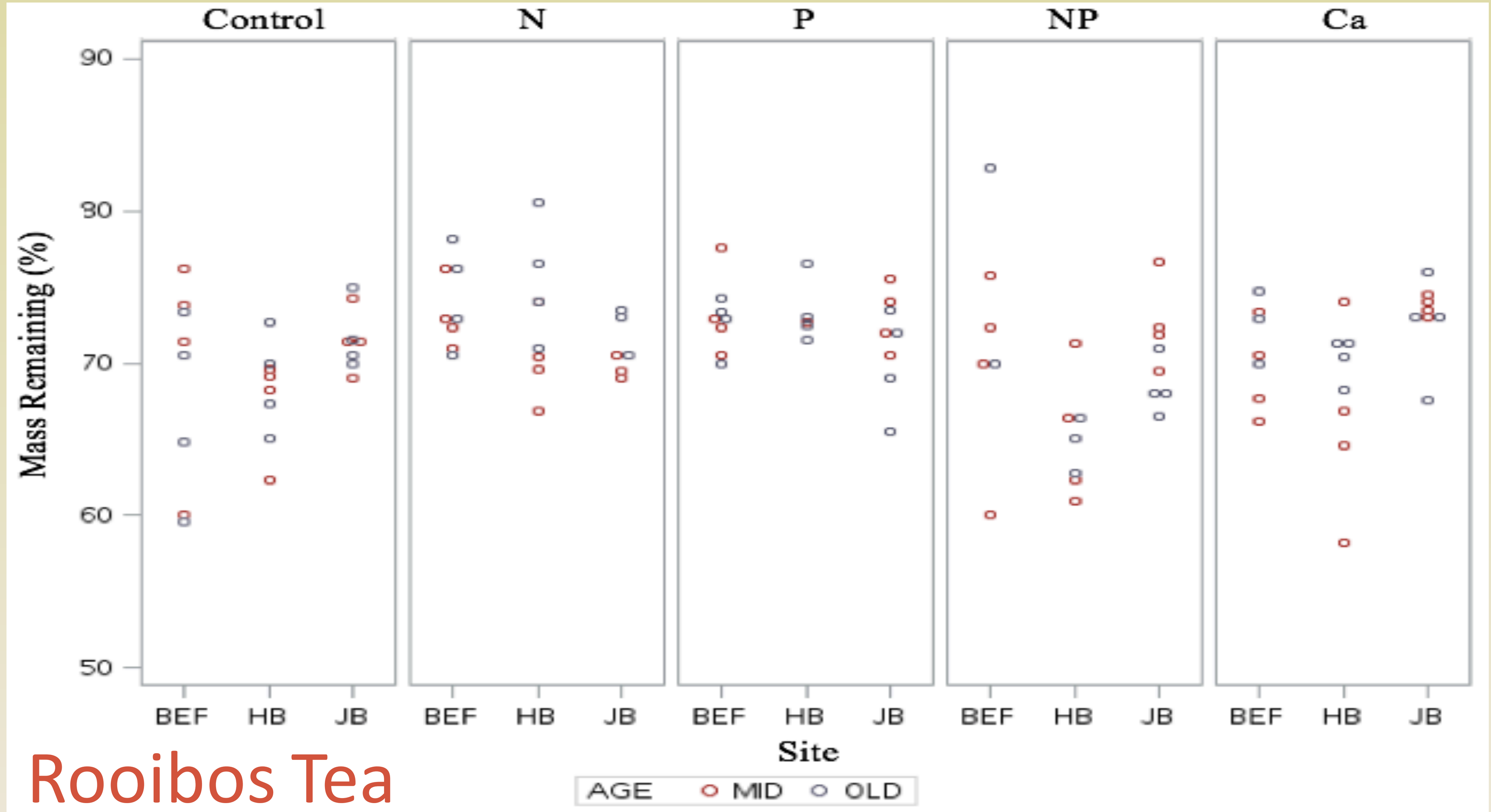
Analysis

- The initial and final masses were used to determine the percentage of mass remaining.

$$\frac{\text{final mass}}{\text{initial mass}} \times 100 = \text{mass remaining (\%)}$$

- Percent decomposition was averaged in each plot. We used a randomized complete block design analysis of variance (ANOVA) with stands as replication. We used an interaction among treatment and sliced between the type of tea to test for a difference of decomposition among treatments. A 2 x 2 factorial was used to test for the effect of N and P. We tested for a difference among sites and between stand age by nesting age within stands. (SAS version 3.6)

RESULTS

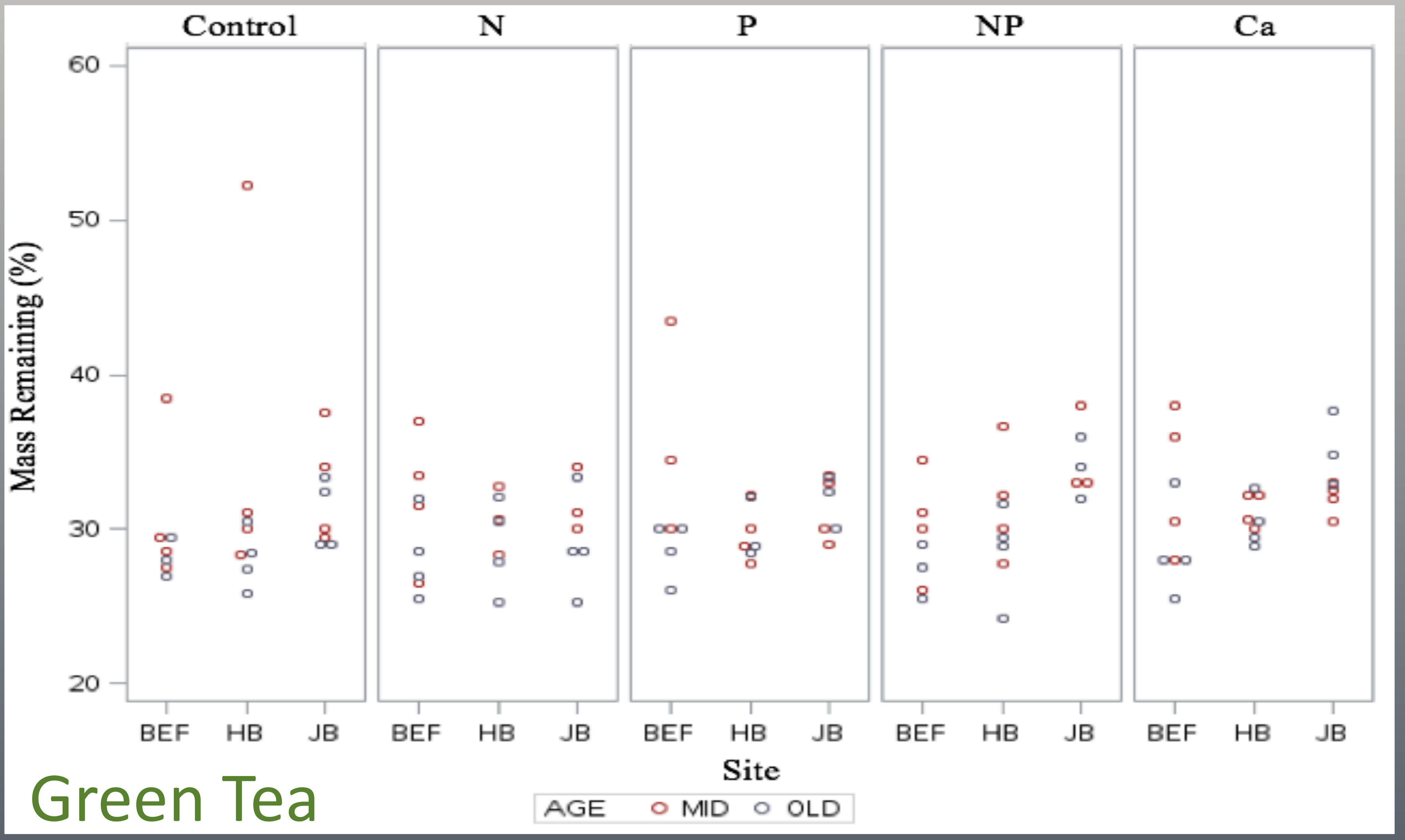


The percentage of the original mass remaining of rooibos tea after 3 months of incubation (n=111).

The average mass of rooibos tea remaining was 71%. The ANOVA we used to test for an interaction of treatment sliced by tea type showed that there was a weak difference of mass between control and N teabags ($p = 0.11$). In the 2 x 2 factorial, teabags treated with N (average = 73%) and/or P (73%) delayed decomposition when compared to the control (70%) ($p = 0.06$). Rooibos tea decomposed faster in Hubbard Brook (69%) compared to Bartlett (average = 72%) or Jeffers Brook (72%) ($p = 0.10$). Stand age did not significantly influence decomposition ($p = 0.16$).

Figure 2 (left): image of the nylon mesh teabags made by Lipton.

Figure 3 (right): image of incubated teabags prior to removal.



The percentage of the original mass remaining of green tea bags after 3 months of incubation (n=110).

The amount of decomposition between rooibos and green tea was significantly different ($p < .0001$). The average mass of green tea remaining was 31%. Teabags from old stands (average = 30%) decomposed faster compared to teabags in mid-age stands (32%) ($p = 0.03$). The average mass remaining of teabags in Jeffers Brook (32%) vary to Bartlett (30%) and Hubbard Brook (30%), but was not significant ($p = 0.13$). Treatments did not significantly alter decomposition ($p = 0.87$).

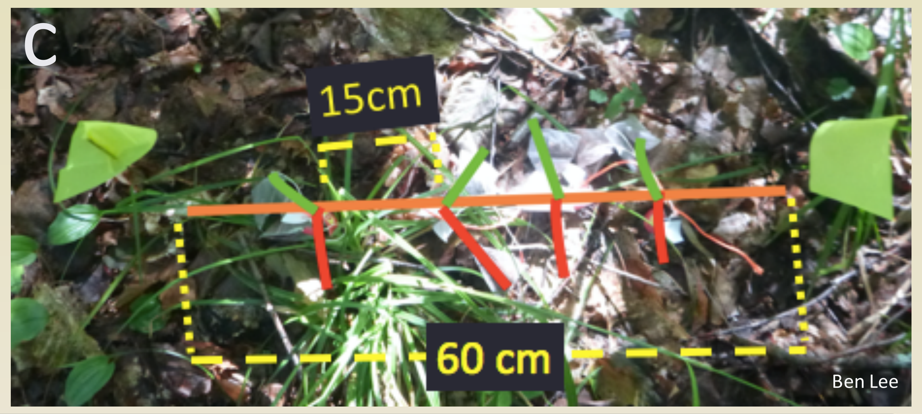


Figure 4a: Teabag installation.

4b: Rooibos and green tea on scale.

4c: Teabag field layout. Green tea positioned on top of orange string and rooibos on bottom.

DISCUSSION

- Rooibos and green tea are different species. Organic matter decomposition rates vary among species due to lignin to N ratios (Melillo *et al.*, 1982). High lignin to low N ratios decompose faster than the inverse (Melillo *et al*., 1982).
- A delay in decomposition in N and P treated plots could be related to nutrient limitation of decomposers. Decomposition is limited by N at low N:P ratios and P at high N:P ratios (Güsewell & Gessner, 2009).
- The rapid decomposition of green tea in our old stands may be caused by the lack of available high-quality substrate (Bauhus *et al.,* 1997), so decomposers prefer leafy tea.
- Site variation may be due to temperature differences. At higher temperatures, microbial activity is increased which increases decomposition of soil organic matter (Wang *et al*., 2016). Hubbard Brook is the warmest site and the rooibos tea incubated there decomposed the fastest.

CONCLUSION

- Because of the rapid mass loss after 3 months, green tea will likely be too far decomposed to show a treatment effect of decomposition. We expect Rooibos tea will have a stronger treatment effect as decomposition progresses.
- This study represents a sliver of the information being gathered on a global scale. By advancing our knowledge of decomposition rates around the world, we will have a greater understanding of factors controlling nutrient cycling on a global scale.

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REFERENCES

Bauhus, J., Paré, D., & Coˆté, L. 1998. Effects of tree species, stand age and soil type on soil microbial biomass and its activity in a southern boreal forest. *Soil Biology and Biochemistry, 30*(8-9), 1077-1089.

Berg, B., & Matzner, E. 1997. Effect of N deposition on decomposition of plant litter and soil organic matter in forest systems. *Environmental Reviews, 5*(1), 1-25.

Didion, M., Repo, A., Liski, J., Forsius, M., Bierbaumer, M., & Djukic, I. 2016. Towards Harmonizing Leaf Litter Decomposition Studies Using Standard Tea Bags—A Field Study and Model Application. *Forests, 7*(8), 167.

Güsewell, S., & Gessner, M. O. 2009. N : P ratios influence litter decomposition and colonization by fungi and bacteria in microcosms. *Functional Ecology, 23*(1), 211-219.

Melillo, J. M., Aber, J. D., & Muratore, J. F. 1982. Nitrogen and Lignin Control of Hardwood Leaf Litter Decomposition Dynamics. *Ecology, 63*(3), 621-626.

Wang, J., Xiong, Z., & Kuzyakov, Y. 2015. Biochar stability in soil: meta-analysis of decomposition and priming effects. *GCB Bioenergy, 8*(3), 512-523.