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Decomposition patterns across the tundra biome: Litter substrate explains more than environment

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Hot things rot

The tundra is a huge global store of carbon. It holds about half of the worlds soil carbon[1], and almost twice as much carbon as is currently in the atmosphere[2]. However, the tundra is also warming twice as fast as the rest of the planet[3], lifting limits to decomposition and potentially releasing large amounts of stored carbon to the atmosphere[4].

Despite the importance of the tundra biome, our understanding of what controls decomposition is surprisingly uncertain. We know that temperature, moisture and substrate quality all affect how quickly material breaks down[5], but not their relative importance or the precise nature of relationships[6]. We also lack consistent field data from the tundra[7], perhaps because it is huge, cold, remote, and full of mosquitoes.

Why Tea?

The quality of what goes in the ground - the litter substrate - greatly affects how quickly it rots[5]. One of the big challenges in a decomposition experiment of this scale is therefore making sure that the same material is buried everywhere, whether in the Canadian Arctic or the mountains of Australia.

Our solution was to use tea bags.

Tea bags replicate the traditional litter bag: dried plant material inside a plastic mesh[8]. They are uniform, transportable and cheap (so I didn't have to spend half my PhD making them). We used two types of tea - rooibos and green - with very different nutrient contents, that represent differences among tundra species.

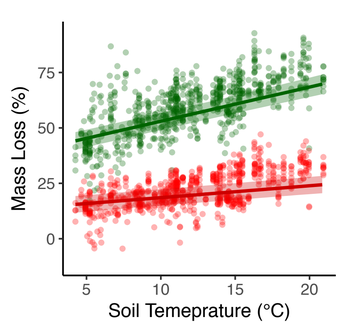
Five Thousand tea bags

In this study we established a decomposition experiment across the entire tundra biome to test the drivers of decomposition. Using tea as a common litter substrate[8], we created the largest database of decomposition in the tundra to date, with approximately 5,000 data points covering over 300 sites.

We quantified the relationships between tea decomposition (mass loss) and air temperature, soil temperature and soil moisture to better understand how climate change might alter decomposition.

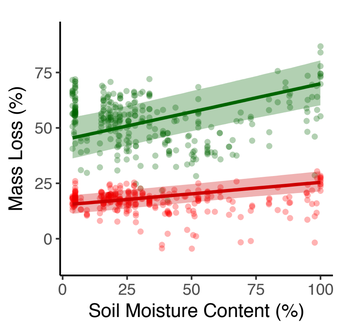
We also tested the importance of environmental variables compared to litter quality - in this case tea type. This helps us to understand how changing vegetation communities in a warmer tundra might alter decomposition in the future.

Key Findings



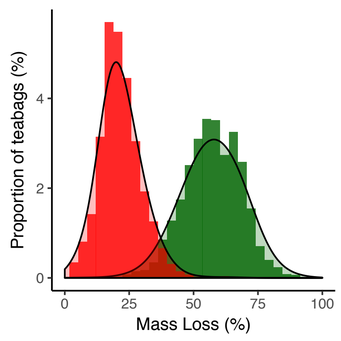
Decomposition increases with soil temperature

We found a strong linear relationship between decomposition and soil temperature across the entire tundra. That means that warming will increase decomposition and carbon loss in the tundra, but in a predictable way.



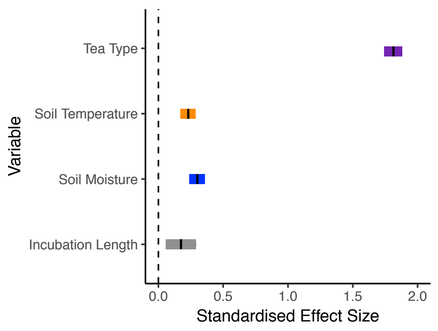
Decomposition increases with soil moisture

We found that decomposition increases with soil moisture content even when soils are almost saturated. That means decomposition will increase most in wetter areas, but could remain low in dry areas, even if they warm up.



It's what rots that matters (not where it rots)

The greatest single predictor of decomposition rate was litter quality (tea type). That means that changes to plant communities, such an increase in shrubs, could have much larger impacts on decomposition than warming.



Moisture and vegetation change alters decomposition more than warming

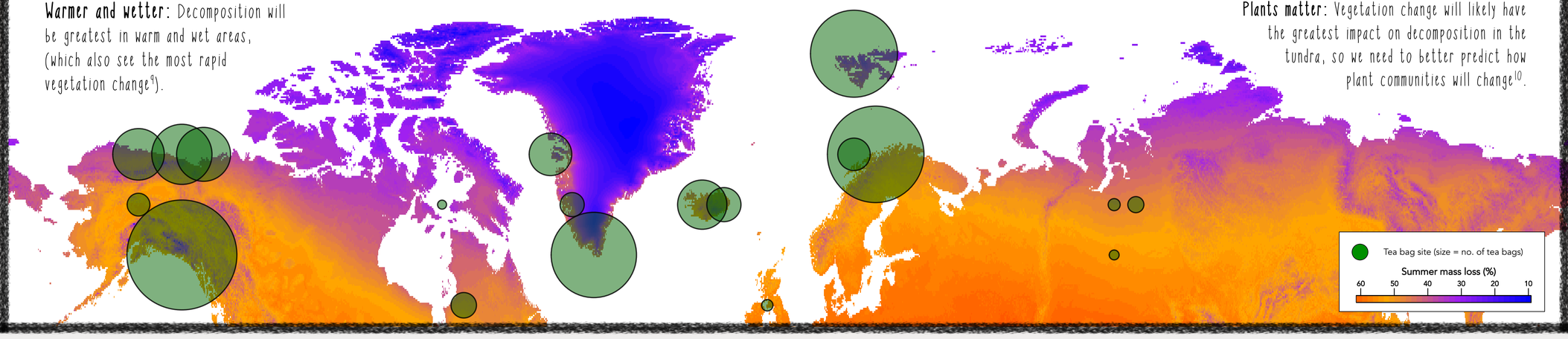
Soil moisture and litter quality had a stronger effect on decomposition than temperature, suggesting that the indirect effects of climate change change could have the most profound impacts on decomposition in the tundra.

So what?

Our results can be used to map decomposition across the tundra biome, to understand how quickly decomposition could change, and to predict carbon loss and nutrient cycling in a warmer future.

Warmer and wetter: Decomposition will be greatest in warm and wet areas, (which also see the most rapid vegetation change[9]).

Plants matter: Vegetation change will likely have the greatest impact on decomposition in the tundra, so we need to better predict how plant communities will change[10].



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