Beaver engineering impacts on Arctic riparian vegetation

V. Sebastian Zavoico[1,2], Ken Tape[2], Chip Miller[3], Simon Zwieback[2], Philip Townsend[4], Kyle Kovach[4], Mike Loranty[5], Emily Graham[2]

1. Department of Biology & Wildlife, UAF; 2. Geophysical Institute, UAF; 3. NASA Jet Propulsion Laboratory; 4. Forest and Wildlife Ecology Department, University of Wisconsin-Madison; 5. Geography Department, Colgate University

Introduction

Beavers (*Castor canadensis*) have expanded their ranges far beyond treeline in recent decades[1], and their impact in the Arctic is largely unknown. While beavers forage on vegetation, their engineering often promotes plant diversity[2] and nutrient uptake[3]. This may especially be the case in the Arctic, where flooding from dams thaws permafrost[4] up to 60m[5] away and thus allows greater rooting depth in a deeper active layer.

Figure 1. Map of the study area. Red polygons denote beaver ponds, yellow polygons denote control streams, and dotted rectangles show 2019 AVIRIS-NG flightlines from the region.

Methods

We identified beaver ponds and control areas unimpacted by beaver engineering across low order streams using high-resolution imagery (e.g. WV-03, GEO1; Maxar) from 2019. To understand how beavers impact riparian vegetation, we summarized various Plant Functional Traits (PFT) derived from 2019 AVIRIS-NG imagery in 10m increments away from water's edge - up to 60m. We compared beaver ponds to control areas for each buffer and PFT using multiple linear regressions (MLRs) that accounted for elevation and heatload (derived from slope and aspect):

```
PFT ~ site + elevation + heatload
```

We then compared *site* coefficient values & p-values between buffers for each PFT.

Objective: *Characterize the* ***impacts of beaver engineering on the productivity and diversity on Arctic riparian vegetation*** *using plant functional traits (PFTs)*

Hypothesis: *Beaver engineering* ***increases plant productivity and diversity*** *up to 60m away from pond edges*

Results

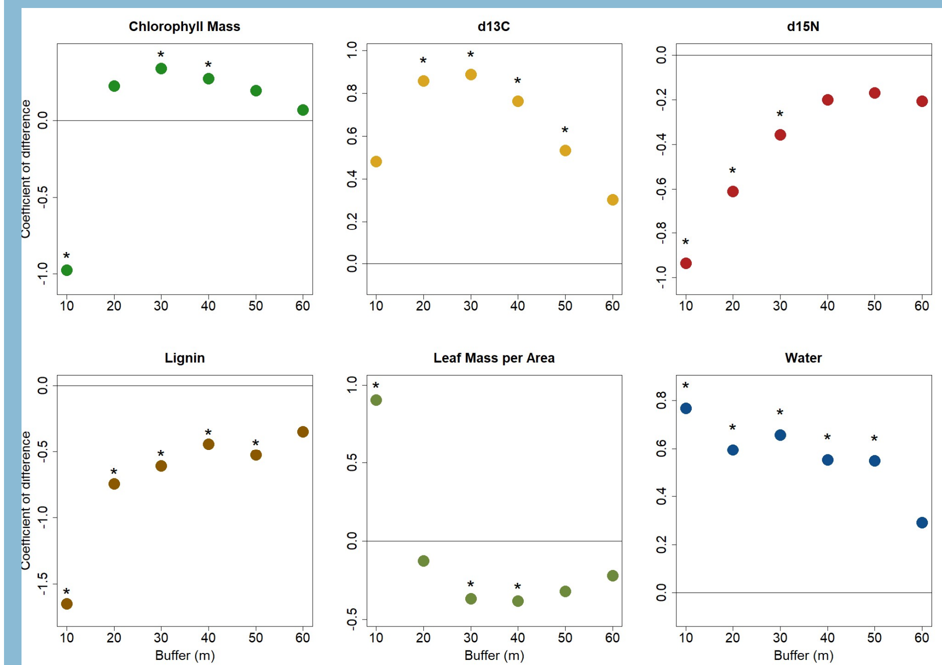
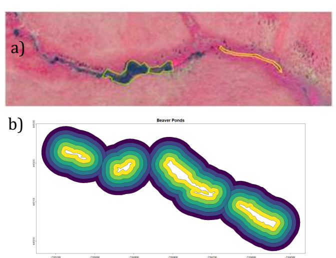


Figure 2. Differences in PFTs between ponds (n=26) and controls (n=35) in reference to the edge of waterbodies. Each dot represents the coefficient of difference between ponds and controls from the MLR for the given PFT and buffer. Asterisks above a dot denote whether the coefficient was statistically significant ($p<0.05$). These are preliminary results.



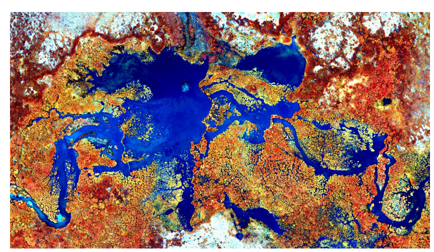


Figure 3 (L). a) Example of beaver pond and control polygons in false color high-res imagery (Maxar, GEO1) and b) 10m buffers surrounding beaver ponds used in the analysis
Figure 4 (R). Tundra beaver pond complex in false color drone imagery (PC: Ben Jones)

PFT	Site	Elevation	Heatload
Carbon	-	-	-
Carotenoids	-	-	* (-)
Chlorophyll Mass	* (+/-)	-	-
δ13C	* (+)	-	-
δ15N	* (-)	* (-)	-
Lignin	* (-)	-	-
Leaf Mass per Area	* (+/-)	-	-
Nitrogen	-	* (-)	-
Sugar	-	-	*(-)
Water	* (+)	-	-

Tab 1: Results from MLRs, where *'s denote if there was at least one significant coefficient for the PFT, and symbols denote the relationship direction. +'s indicate ponds had higher PFT values than controls, and vice versa for –'s.

Results & Conclusions

1. Beaver engineering impacts various components of ecosystem function in riparian areas in the Arctic, and impacts are confined to areas within 40m of ponds.

2. Multiple PFTs exhibited higher differences between ponds and controls within 10m of waterbodies, indicating substantial effects from lateral flooding.

3. At intermediate distances (20-40m), areas around ponds exhibited *higher* water use efficiency (δ13C) and leaf mass (Chl), but *lower* nutrient uptake (δ15N), leaf mass per area (LMA), and leaf structure and defense (Lignin).

4. No changes were detected in photosynthetic activity (C, N, Sugar).

Main takeaway: Results may reflect a changing plant community around ponds to one better adapted to wet soils, but no different in productivity. Ponds are likely still storing C[6] and N[7], which may result in higher nutrient uptake after dam abandonment.

Literature cited

1. **Tape et al. 2022** *Scientific Reports*. 2. **Stringer and Gaywood 2016** *Mammal Review*. 3. **Wohl 2021** *ERL*. 4. **Glass et al. *in review*** *Ecosphere*. 5. **Clark et al. 2023** *ERL*. 6. **Levine and Meyer 2019** *Scientific Reports*. 7. **Naiman and Melillo 1984** *Oecologia*.