Characterizing the Extent and Impacts of Beaver Engineering in the ABoVE Domain

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Background

Beavers are Colonizing Alaskan Tundra

- Proliferation of shrubs and absence of bedfast ice as climate warms opens new habitat for beavers in Alaskan tundra
- Beaver populations are also rebounding from reduced trapping pressure over the last century
- Indigenous observations and remote sensing imagery indicate absence of beavers in Alaskan tundra in the mid-twentieth century
- Over the past several decades beavers have begun colonizing Alaskan tundra, with the number of beaver ponds doubling between ~2003 and ~2017

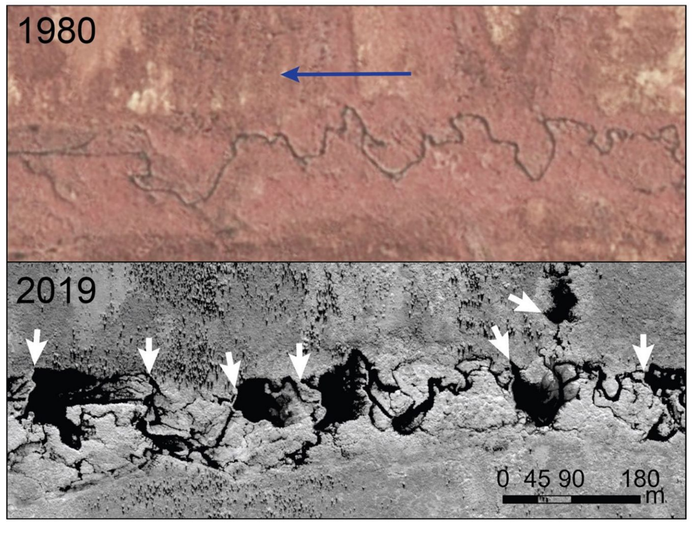
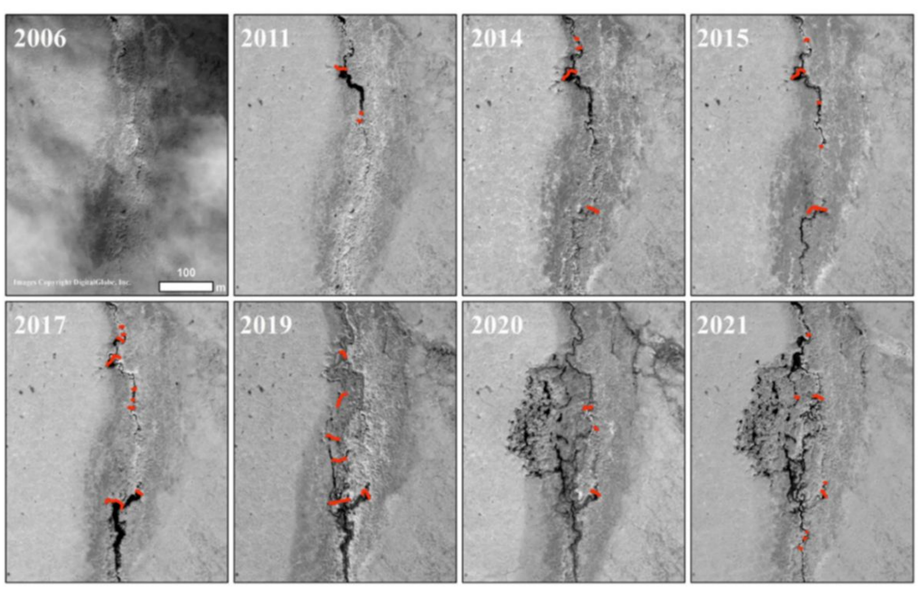


Figure 1 Beaver dams (white arrows) and ponds formed since 1980 along a stream on the Seward Peninsula. Blue arrow indicates flow direction. Top image is a color infrared aerial photo and bottom is a Worldview satellite image (© 2022 Maxar Inc.).

Tape, K. D., Clark, J. A., Jones, B. M., Kantner, S., Gaglioti, B. V., Grosse, G., & Nitze, I. (2022). Expanding beaver pond distribution in Arctic Alaska, 1949 to 2019. *Scientific Reports*, *12*(1), Article 1. https://doi.org/10.1038/s41598-022-09330-6

Beaver Activity Uniquely Impacts Permafrost Landscapes & People

- In all landscapes, beaver ponds alter biological and physical characteristics of aquatic and adjacent terrestrial ecosystems
- In areas underlain by permafrost, beaver pond impacts on ground thermal regimes initiate permafrost thaw that can result in dam failure
- *Dam failure leads to widespread permafrost thaw,* especially in areas of ice-rich permafrost where thermofluvial erosion, thermal erosion, and thermokarst may combine to cause rapid and dramatic landscape changes
- *The impact of beaver induced changes in water chemistry, and aquatic and terrestrial environments on subsistence resources for local communities is unknown*
- *The climatic consequences of beaver disturbance remains unquantified*



Jones, B. M., Tape, K. D., Clark, J. A., Bondurant, A. C., Ward Jones, M. K., Gaglioti, B. V., Elder, C. D., Witharana, C., & Miller, C. E. (2021). Multi-Dimensional Remote Sensing Analysis Documents Beaver-Induced Permafrost Degradation, Seward Peninsula, Alaska. *Remote Sensing*, *13*(23), Article 23. https://doi.org/10.3390/rs13234863

Figure 2 Permafrost thaw following beaver dam failure and flooding along Swan Creek on the Seward Peninsula, AK. Red lines indicate beaver dam locations.

Project Overview

What is the distribution of beaver ponds in the ABoVE study domain?

- Using high-resolution airborne and satellite optical imagery we are testing the hypothesis that there are between 500 and 5000 beaver ponds within the extent of ABoVE flightlines.
- Additionally, we hypothesize that ~80% of of these ponds occur in boreal forest, and the majority of them have formed since 1999.

How do beaver ponds alter riparian vegetation communities?

- Using AVIRIS imaging spectroscopy we are testing the hypothesis that beaver engineering causes shifts in riparian vegetation that are characterized by increased functional and spectral diversity.

How do beaver ponds affect ground deformation and water turbidity?

- Using Interferometric Synthetic Aperture Radar (InSAR) we are testing the hypothesis that multi-year subsidence adjacent to beaver ponds is greater than in control reaches that are not affected by beavers.
- We use NIR/R reflectance ratio from AVIRIS-NG imaging spectroscopy as a turbidity proxy to test the hypothesis that beaver engineering increases downstream turbidity.

Do beaver ponds enhance methane emissions?

- We are using methane (CH_4) hotspot data from AVIRIS-NG to test the hypothesis that beaver engineering increases CH_4 hotspot occurrence relative control reaches unaffected by beavers.
- Using field observations of CH_4 fluxes we will quantify differences in CH_4 emissions between beaver ponds and non-beaver ponds.

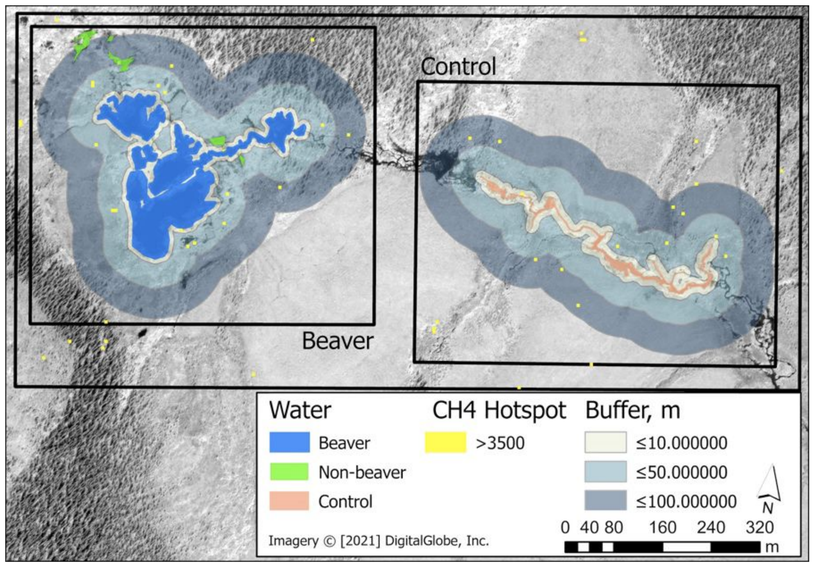


Figure 3 AVIRIS-NG detected CH_4 hotspots in a beaver-engineered and a control site. Methane data from Elder et al. 2020 (CH_4 hotspot threshold 3500 ppm m). There are 3x more hotspots in the beaver engineered 10-50m buffer than the control site 10-50m buffer.

Clark JA, Tape KD, Baskaran Latha, Elder C,Miller C, Miner K, O'Donnell JA, Jones BM, In review. "Do beaver ponds increase methane emissions along Arctic tundra streams

Elder, C. D., Thompson, D. R., Thorpe, A. K., Hanke, P., Walter Anthony, K. M., & Miller, C. E. (2020). Airborne Mapping Reveals Emergent Power Law of Arctic Methane Emissions. *Geophysical Research Letters*, *47*(3), e2019GL085707. https://doi.org/10.1029/2019GL085707

How does the magnitude and extent of beaver engineering disturbance compare with other regional disturbance such as wildfire?

- By synthesizing the results outlined above, we will identify relationships between vegetation change, ground subsidence, CH_4 emissions and water quality associated with beaver engineering.
- Combining information on the impacts (i.e. on subsidence, vegetation, CH_4, & turbidity), and the spatial and temporal extent of beaver disturbance provides context for comparison with other regionally important disturbances.
- Coordination with the **Arctic Beaver Observation Network** will provide observational data and co-produced knowledge that can inform interpretation of remote sensing data and help to extrapolate our results beyond the ABoVE study domain

Arctic Beaver Observation Network

https://commons.wikimedia.org/wiki/File:American_Beaver.jpg