Tundra fire regimes in the Noatak National Preserve, northwestern Alaska, since 6000 yr BP

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1. Background and Rationale

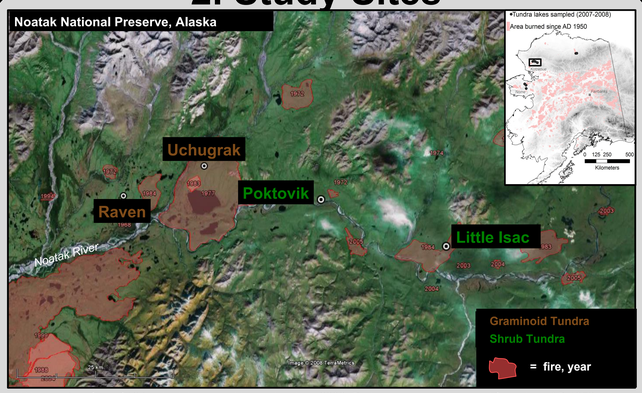
Record-setting tundra burning in 2007 (Fig. 1.1) and paleo evidence of frequent tundra fires in the past (*1*) suggest tundra ecosystems can burn more frequently than is evident in the observational record. Land managers and global change scientists lack critical information on the controls of tundra fire regimes and their potential response to ongoing and predicted climate warming (*2*).

Using macroscopic charcoal from lake-sediment cores we are characterizing the 6000-yr fire history in shrub-dominated and herb-dominated (graminoid) tundra in three regions across Alaska**.**

Here we present the first long-term, high-resolution records of tundra fire history from four lakes in the Noatak National Preserve, a region encompassing some of the most flammable tundra in Alaska.

Fig. 1.1 The Anaktuvuk River fire burned 256,000 acres in late summer 2007, making it the largest documented fire north of the Brooks Range and the largest fire of the Alaskan fire season. Warm, dry weather, similar to predicted changes for the next century, promoted the fire. Was this event unprecedented in the recent past? (BLM photo).

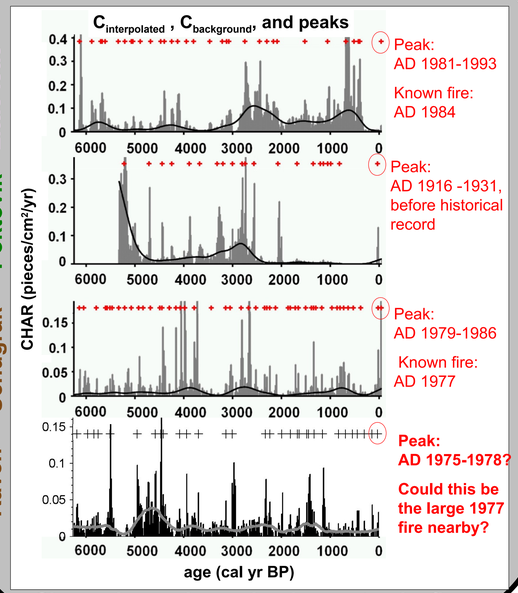
2. Study Sites



We report on four of 10 tundra lakes cored in Alaska since 2006. Red polygons are observed fires since AD 1950.

"**Graminoid Tundra**" lakes are dominated by tussock and non-tussock sedge while "**Shrub Tundra**" lakes are dominated by birch, alder, and willow shrubs. Neither category is exclusively "shrub" or "graminoid".

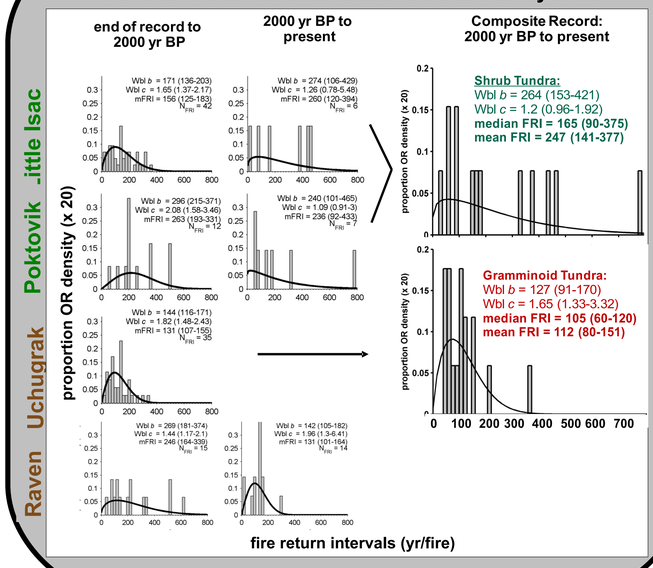
4. Charcoal Records



Charcoal records resolve known tundra fires.

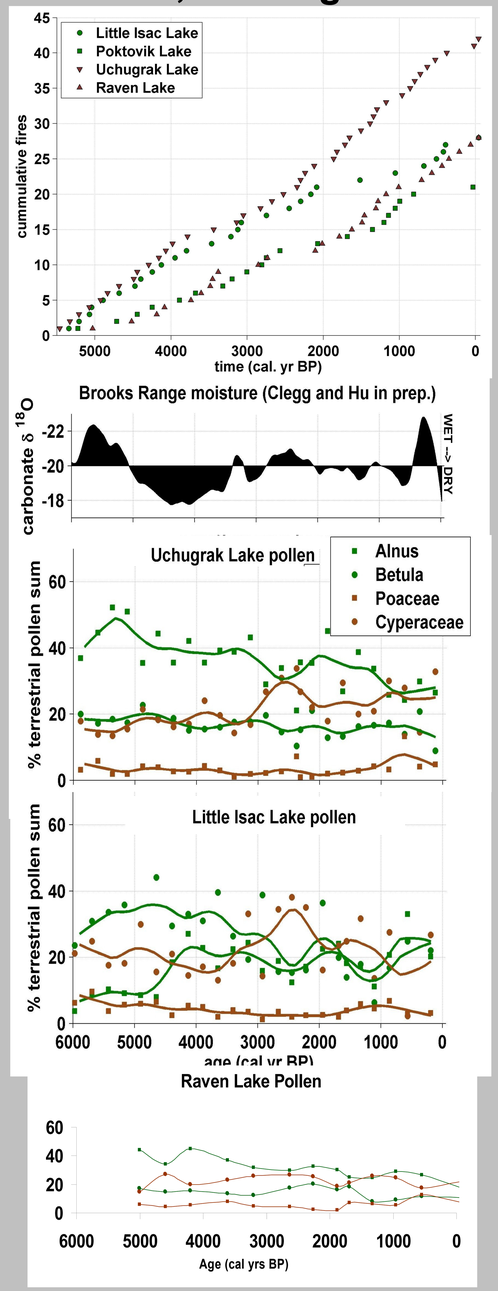
5. How often can tundra burn?

Fire-return interval distributions stratified by time:



All sites indicate that tundra can sustain short (< 100 yr) return intervals. **Shrub** sites burned less than **graminoid** sites over the past 2000 years. Differences in fuel quality and quantity likely explain this pattern. The impact of climate change on fire regimes is discussed below.

6. Temporal patterns, climate, and vegetation



CONCLUSIONS

1. **Sediment charcoal records can faithfully resolve known tundra fires.**
1. **Tundra ecosystems can sustain short fire return intervals (< 100 yr) and have burned more frequently in the past than during the observational record.**
3. **Fire frequencies differ between fuel types (graminoid vs. shrub-tundra).**
4. **Tundra fire regimes have varied over time, with the impact of fuels likely dependent on climate.**

- Prior to ca 2000 yr BP, fire frequencies (the slope of line) are similar between sites
- After ca 2000 yr BP, fire frequencies decrease at **shrub tundra** sites and become significantly different (lower) than the **graminoid tundra** site.
- Similar fire frequencies prior to 2000 yr BP coincide with (1) low effective moisture (i.e. "dry") in the central Brooks Range (2) greater shrubs abundance at Uchugrak and Little Isac lakes .
- The combination of climate, vegetation, and fire history suggests that shrubs were more flammable in the past, under drier climatic conditions.

The role of vegetation likely depends on climatic conditions

3.1 Methods

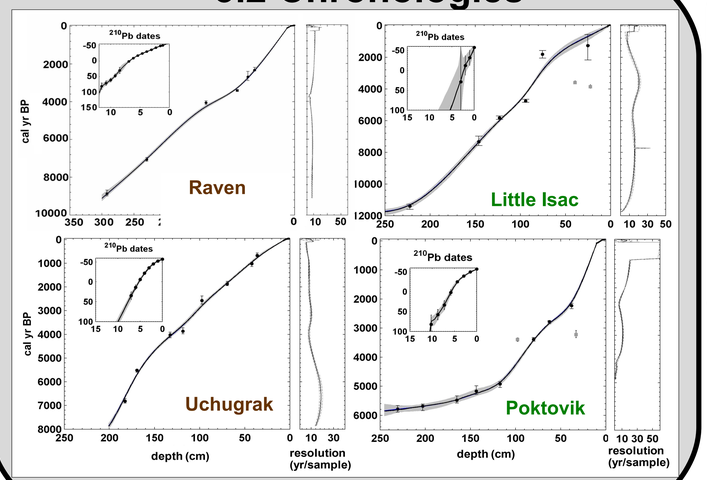
Macroscopic charcoal (> 180µm) was quantified at continuous ≈10-25 yr intervals, and radiocarbon dates from plant macrofossils provide chronologies and estimates of charcoal accumulation rates (CHAR).

Low-frequency trends in CHAR were removed from each record, and a uniform threshold criteria was applied to separate fire-related variations in CHAR from statistical noise (*3*). Peaks exceeding this threshold are interpreted as past fires within 0.5-1 km of each lake and are used to calculate fire return intervals (FRIs, yr fire^{-1}). FRI distributions are summarized with Weibull models and statistically compared to detect differences between lakes and within different periods in the past (*3*).

Pollen was counted and identified for 3 of the 4 lakes. The % of total terrestrial pollen for specific species is presented.

Chronologies are based on ^{210}Pb dates and calibrated ^{14}C dates. Temporal resolution for each 0.25 cm thick sample is approximately 10-15 yr.

3.2 Chronologies



References

(1) Higuera, P. E., L. B. Brubaker, P. M. Anderson, T. A. Brown, A. T. Kennedy, and F. S. Hu. 2008. Frequent Fires in Ancient Shrub Tundra: Implications of Paleorecords for Arctic Environmental Change. PLoS ONE 3:e0001744.

(2) ACIA. 2004. Impacts of a Warming Arctic: Arctic Climate Impact Assessment. Cambridge University Press, Cambridge.

(3) Higuera, P. E., L. B. Brubaker, P. M. Anderson, F. S. Hu, and T. A. Brown. in press. Vegetation mediated the impacts of postglacial climate change on fire regimes in the southcentral Brooks Range, Alaska. Ecology.

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