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

Melissa Chipman[1], Philip Higuera[1,2], Jennifer Allen[3], T. Scott Rupp[4]. Feng Sheng Hu[1]

[1]Department of Plant Biology, University of Illinois, Urbana, IL 61801 [2]Department of Earth Sciences, Montana State University [3]Regional Fire Ecologist, National Park Service, Fairbanks, AK [4]University of Alaska, Fairbanks, AK

1. Background and Rationale

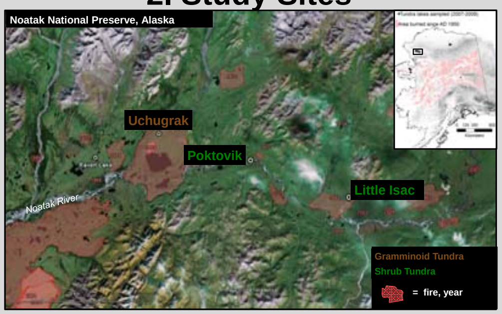
Record-setting tundra burning in 2007 (Fig. 1.1) and paleo evidence of frequent tundra fires in the past (*1*) suggest tundra ecosystems can burn more frequently than is evident in the observational record. Land managers and global change scientists lack critical information on the controls of tundra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

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)

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

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

2. Study Sites



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

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

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*).

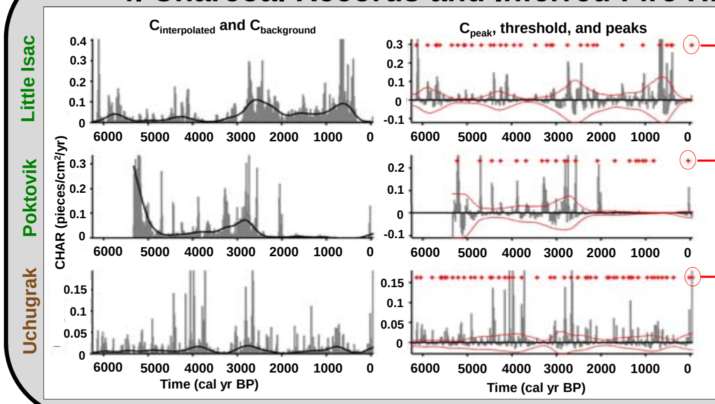
References

(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.

4. Charcoal Records and Inferred Fire History



Peak: AD 1981-1993
Known fire: AD 1984

Peak: AD 1916 -1931, before historical record

Peak: AD 1979-1986
Known fire: AD 1977

Charcoal records resolve known tundra fires.

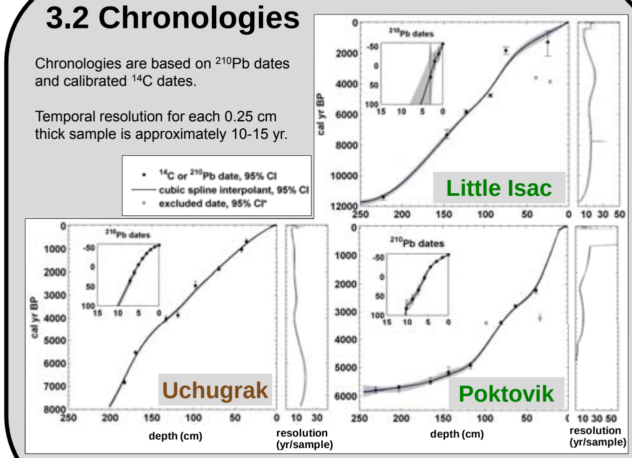
CONCLUSIONS

1. **Sediment charcoal records can faithfully resolve known tundra fires.**
2. **Tundra ecosystems can sustain short fire return intervals (< 100 yr) and have burned more frequently in the past than during the observational record.**
3. **Tundra fire regimes show different fire histories, likely due to interactions between climate and vegetation change. Ongoing work focuses on these possibilities.**

3.2 Chronologies

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.



Author Contact Info

Melissa Chipman: mfarmer@life.uiuc.edu
Phil Higuera: philip.higuera@montana.edu
Jennifer Allen: Jennifer_Allen@nps.gov
Scott Rupp: ffsr@uaf.edu
Feng Sheng Hu: fshu@life.uiuc.edu

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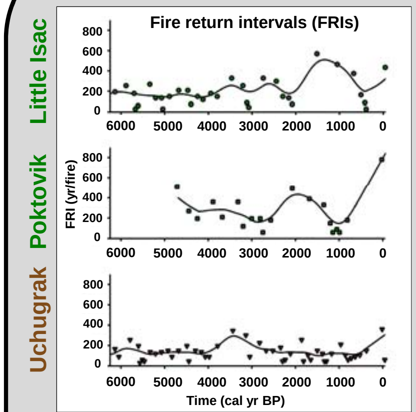
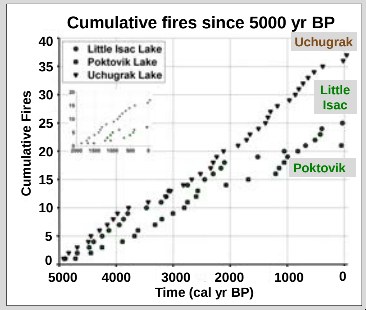
5. Temporal Patterns

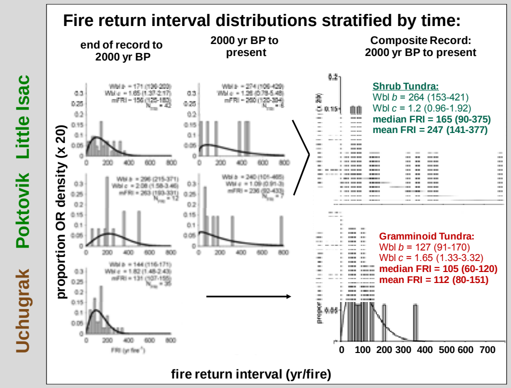


- Fire return intervals (FRIs) at all sites show an increasing trend over the last 500 years.
- **Shrub tundra** sites experienced longer FRIs in the past relative to the **gramminoid tundra,** particularly over the past 2000 years.

- 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 from the **gramminoid tundra** site.



6. How often can tundra burn?



All sites indicate that tundra can sustain short (< 100 yr) return intervals. Shrub sites burned less than gramminoid sites over the past 2000 years. Differences in fuel abundance likely explain this pattern. The role of climate and vegetation in past changes is the current focus of our work.

Gramminoid mFRI < Shrub mFRI