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[1,5], Michael Urban[1], Benjamin F. Clegg[1]

[1]Dept. of Plant Biology, University of Illinois, Urbana, IL [2]Dept. of Earth Sciences, Montana State University, Bozeman, MT [3]Regional Fire Ecologist, National Park Service, Fairbanks, AK [4]Univerisity of Alaska, Fairbanks, AK [5]Dept. of Geology, University of Illinois, Urbana, IL

1. Background and Rationale

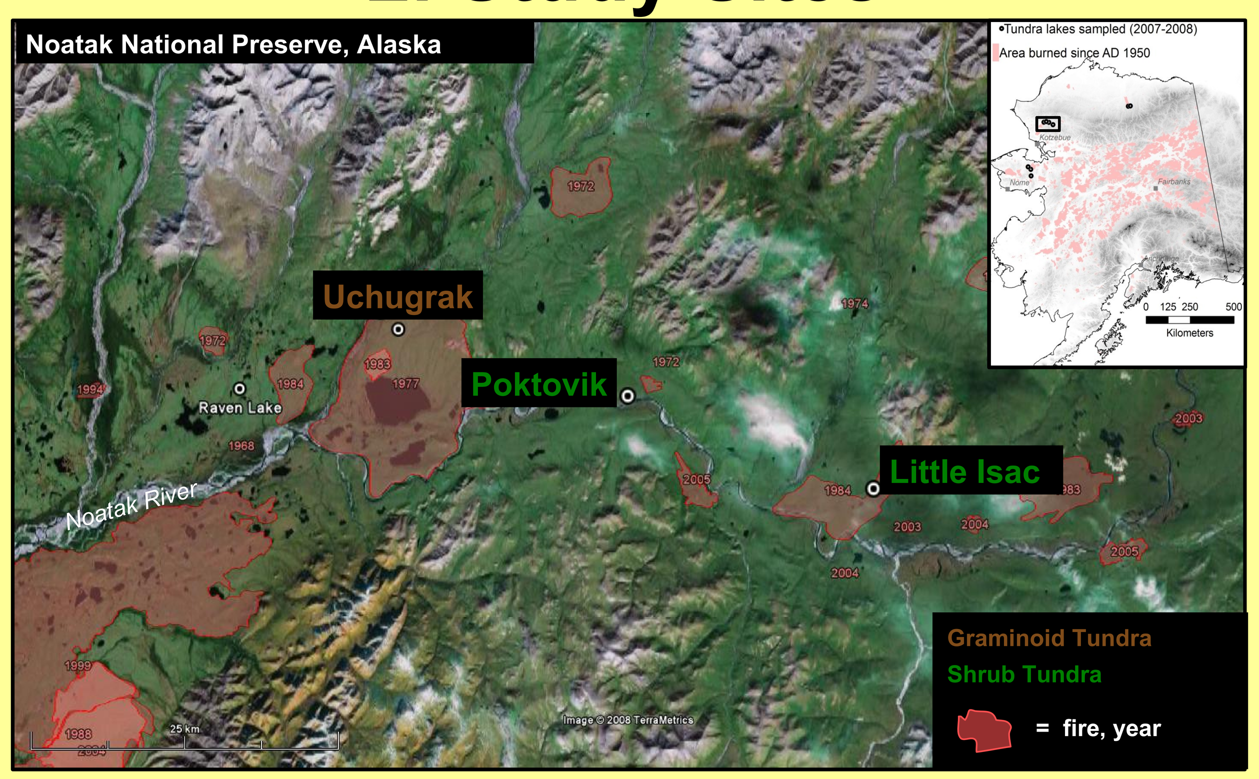
Record-setting tundra burning in 2007 (Fig. 1.1) and paleo evidence of frequent tundra fires in the past (*1*) suggest tundra ecosystems can burn more frequently than is evident in the observational record. Land managers and global change scientists lack critical information on the controls of tundra 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 (graminoid) 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.

Uchugrak Lake

Poktovik Lake

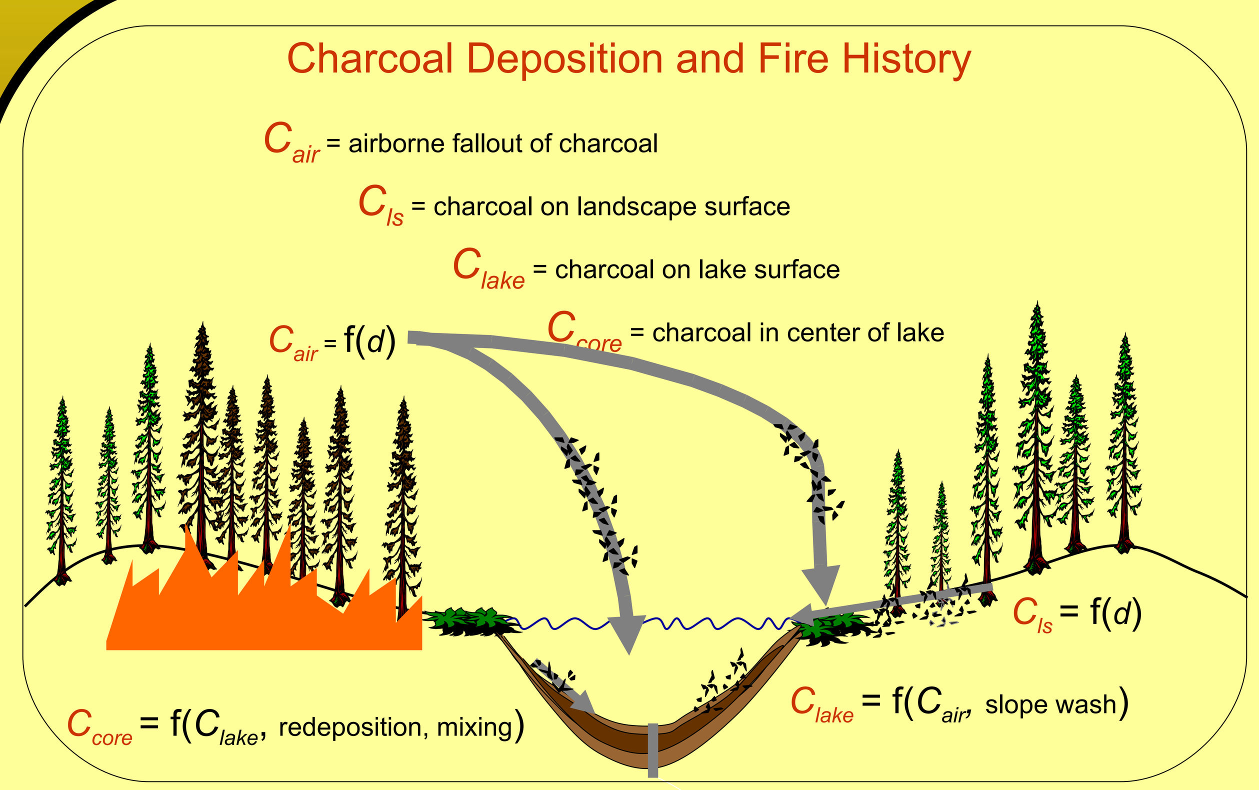
Little Isac Lake

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

3. Methods

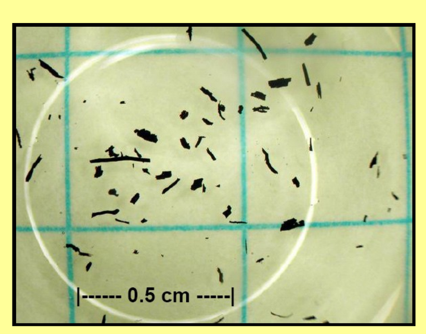
Macroscopic charcoal (> 180µm) was quantified at continuous ≈10-25 yr intervals, and radiocarbon dates from plant macrofossils provide chronologies and estimates of charcoal accumulation rates (CHAR).

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 modelled noise (*3*). Peaks exceeding this threshold are interpreted as past fires within ≈ 1 km of each lake and are used to calculate fire return intervals (FRIs, yr between fires). FRI-distributions are summarized with Weibull models and statistically compared to detect differences between sites and within different periods in the past (*3*).

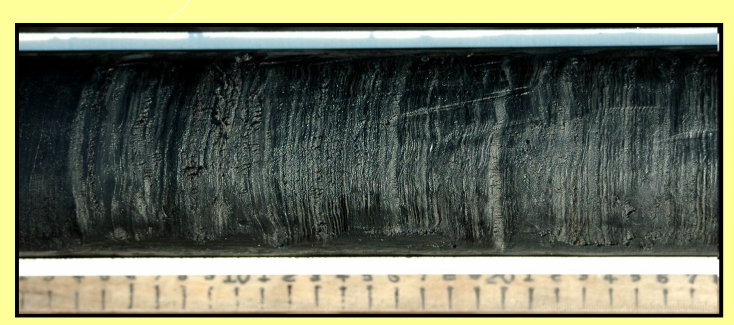


Burned tussock from 1977 fire

Newly-acquired sediment core



Macroscopic charcoal



All cores were sliced at 0.25 cm resolution, and age models were developed using radiocarbon dates from terrestrial macrofossils.

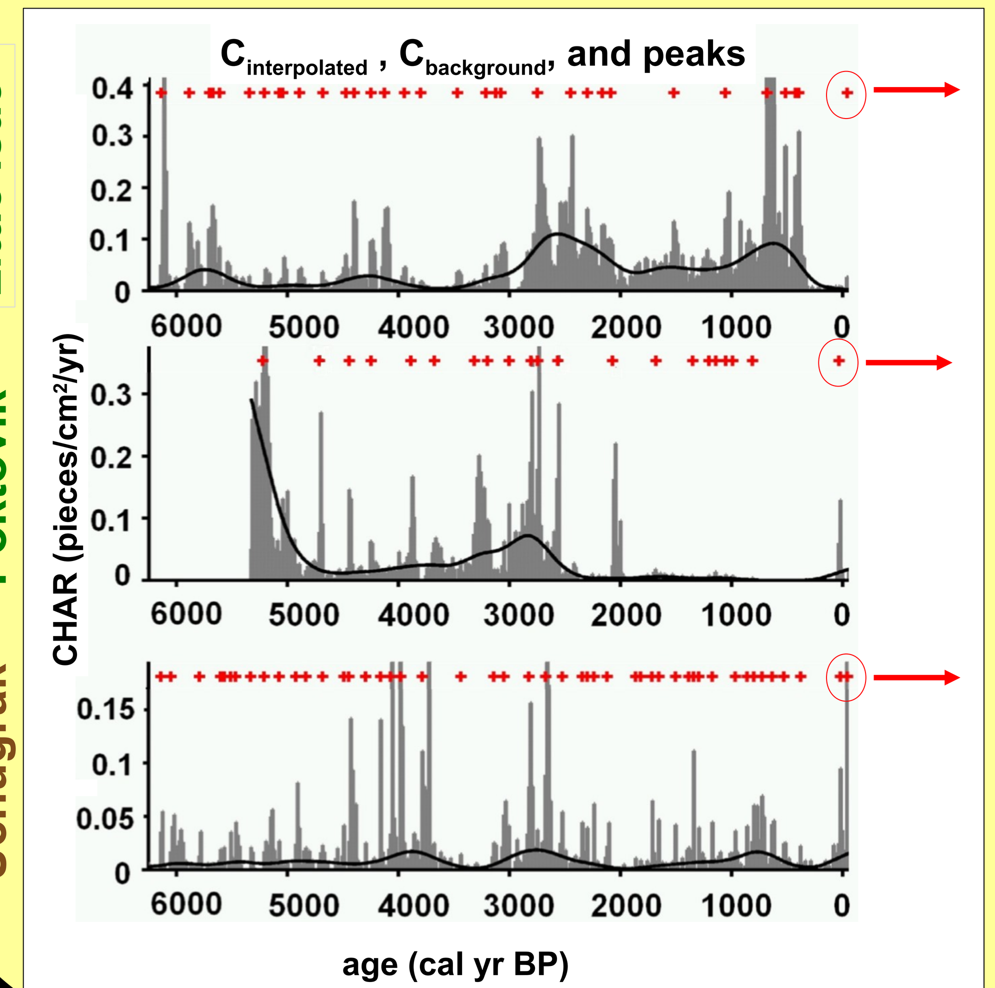
References

(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



Peak: AD 1981-1993

Known fire: AD 1984

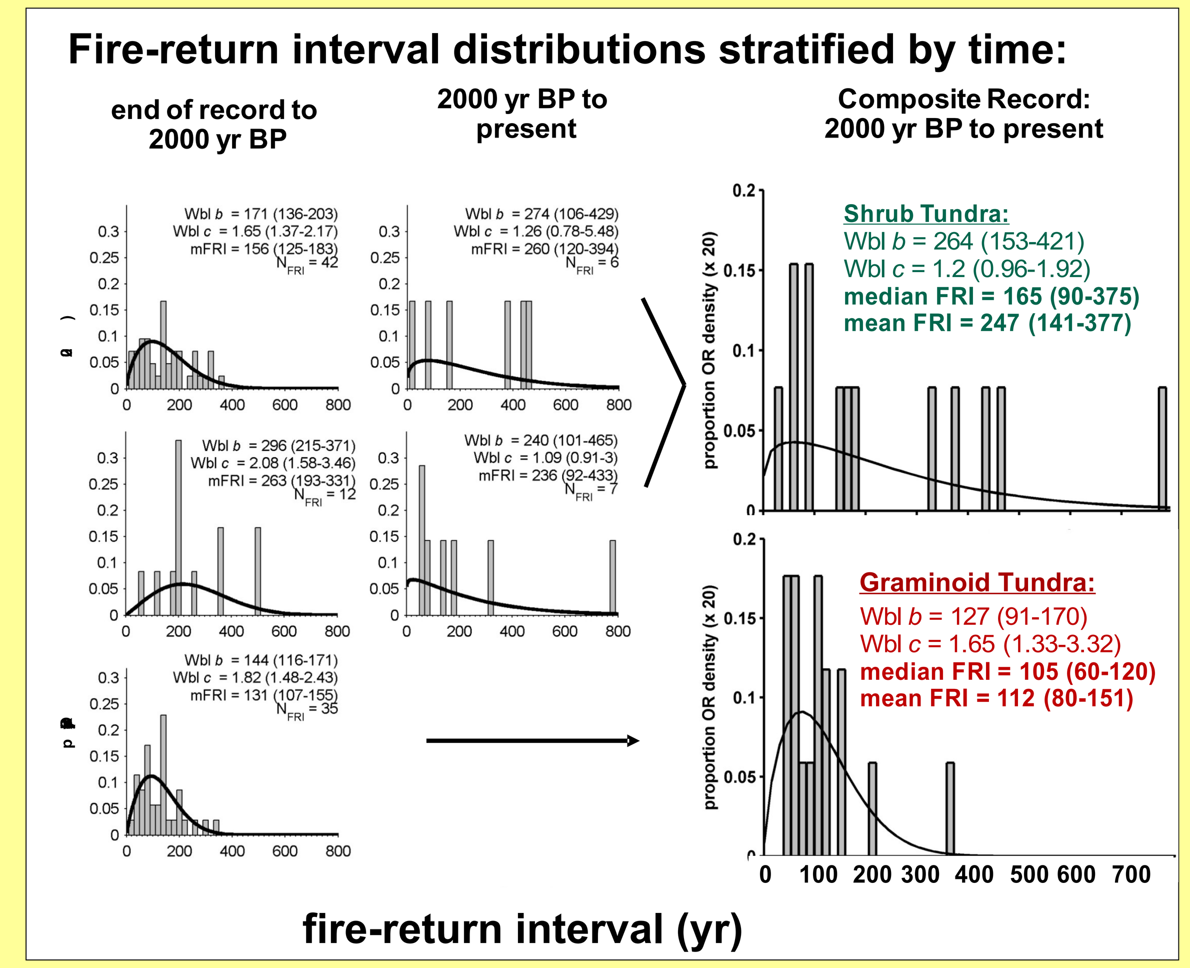
Peak: AD 1916 -1931, before historical record

Peak: AD 1979-1986

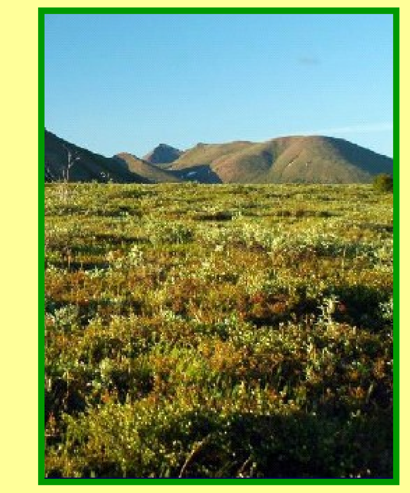
Known fire: AD 1977

Charcoal records resolve known tundra fires.

5. How often can tundra burn?



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.



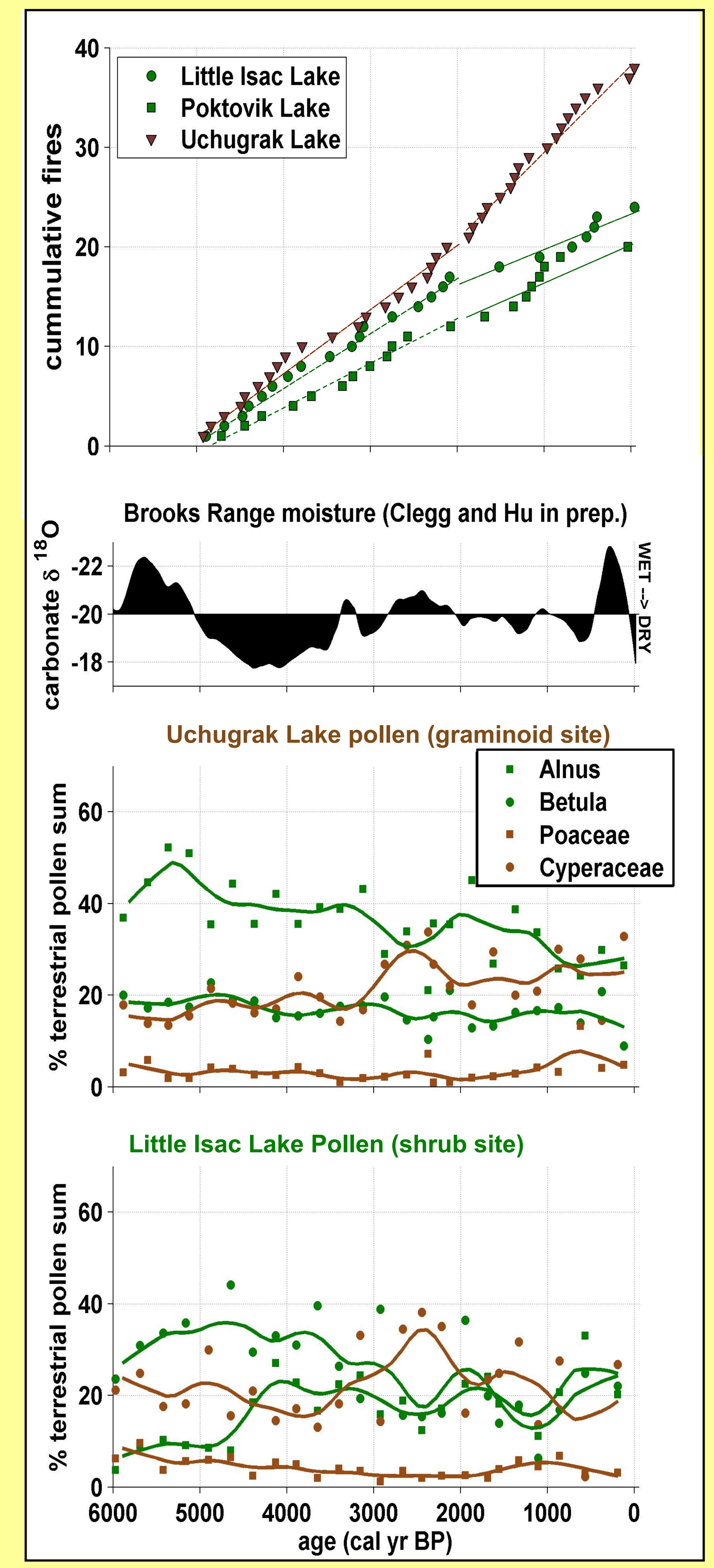
Graminoid FRI < Shrub FRI

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. 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.

6. Temporal patterns, vegetation, and 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 and .
- 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

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Author Contact Info

Melissa Chipman: mchipman@life.illinois.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

Michael Urban: urban1@uiuc.edu

Benjamin Clegg: bclegg@life.uiuc.edu