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.

2. Study Sites

4. Charcoal Records

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

5. How often can tundra burn?

All sites indicate that tundra can sustain short (< 100 yr) return intervals, in sub sites burned less than 10 yr since the past 2000 yrs. Differences in fuel quantity and quality likely explain this pattern. The impact of climate change on fire regimes is discussed below.

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.

3.1 Methods

Macroscopic charcoal (> 150 μm) 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 from the lake. We used a moving window approach to identify peaks exceeding the threshold. The moving window is 20 yr wide and moves in 5 yr intervals. 

4.2 Chronologies

Funding provided by the Joint Fire Science Program with in-kind contributions from the National Park Service.

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We thank Denali National Park fire personnel for field assistance and Tine Young and Jennifer Schwartz for lab assistance.

Raven Lake Pollen

References


3. Methods

Macroscopic charcoal (> 150 μm) 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 (FRI, 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 ¹⁴C dates and calibrated ¹⁳C dates. Temporal resolution for each 2.5 cm thick sample is approximately 10-15 yr.

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6. Temporal patterns, climate, and vegetation

The role of vegetation likely depends on climatic conditions.

1. Prior to ca 2000 yr BP, fire frequencies (the slope of line) are similar between sites
2. After ca 2000 yr BP, fire frequencies decrease at shrub tundra sites and become significantly different (lower) than the graminoid tundra sites.
3. 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
4. The combination of climate, vegetation, and fire history suggests that shrubs were more flammable in the past, under drier climatic conditions. 

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