Reconstructing fire regimes in tundra ecosystems to inform a management-oriented ecosystem model

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Joint Fire Science Program

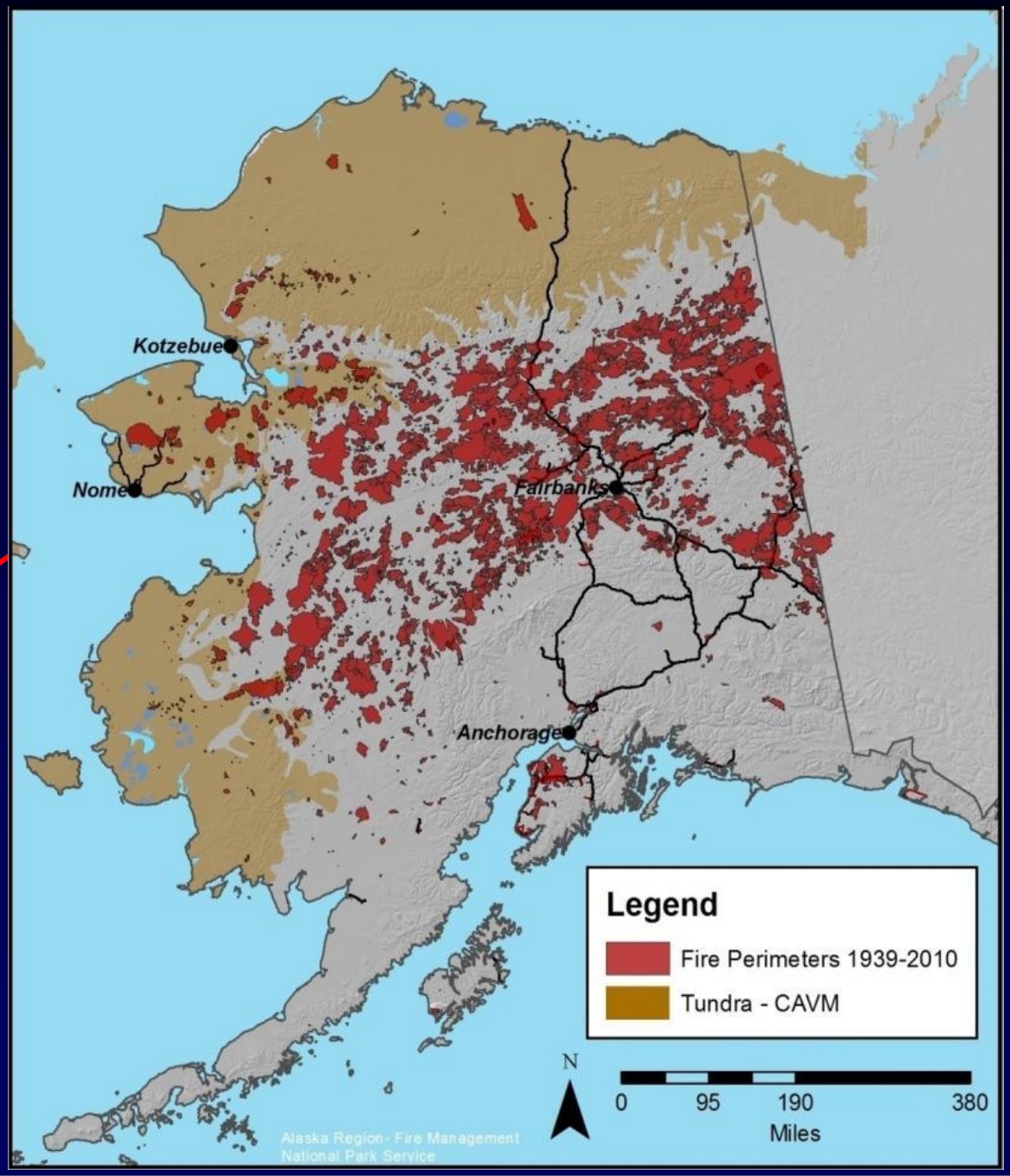
NATIONAL PARK SERVICE

ILLINOIS
UNIVERSITY OF ILLINOIS AT URBANA-CHAMPAIGN

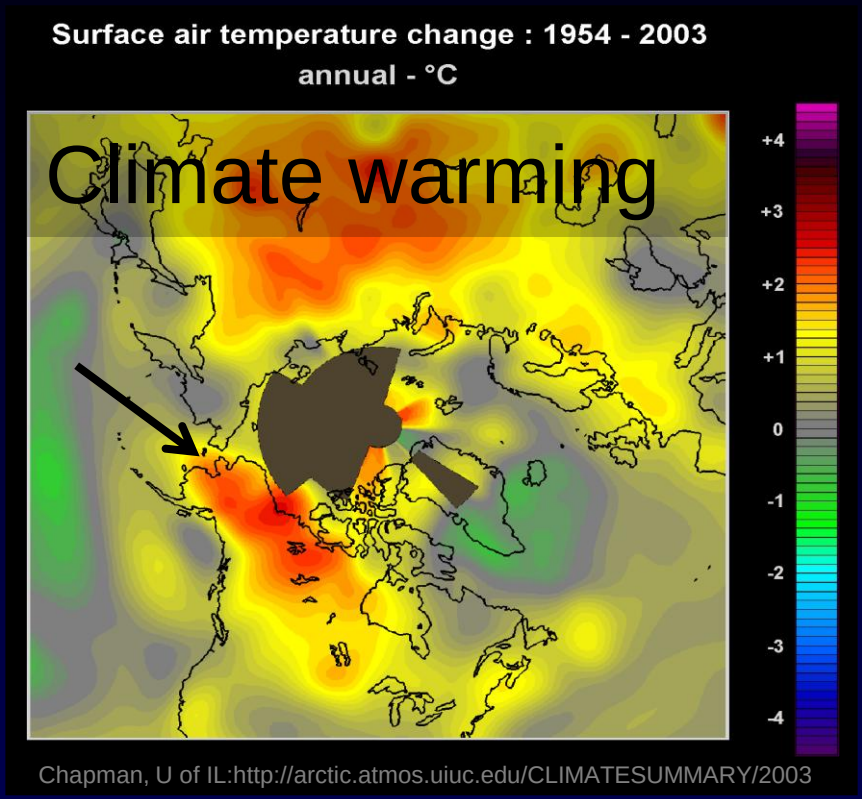
Alaska Fire

- >57 million acres burned since 1940
- 5.4 million acres of tundra fire
- Majority of research on boreal fires

Anaktuvuk River Fire 2007. 256,764 acres
Photo: Dale Woitas, AFS, BLM



Background



Chapman, U of IL:http://arctic.atmos.uiuc.edu/CLIMATESUMMARY/2003

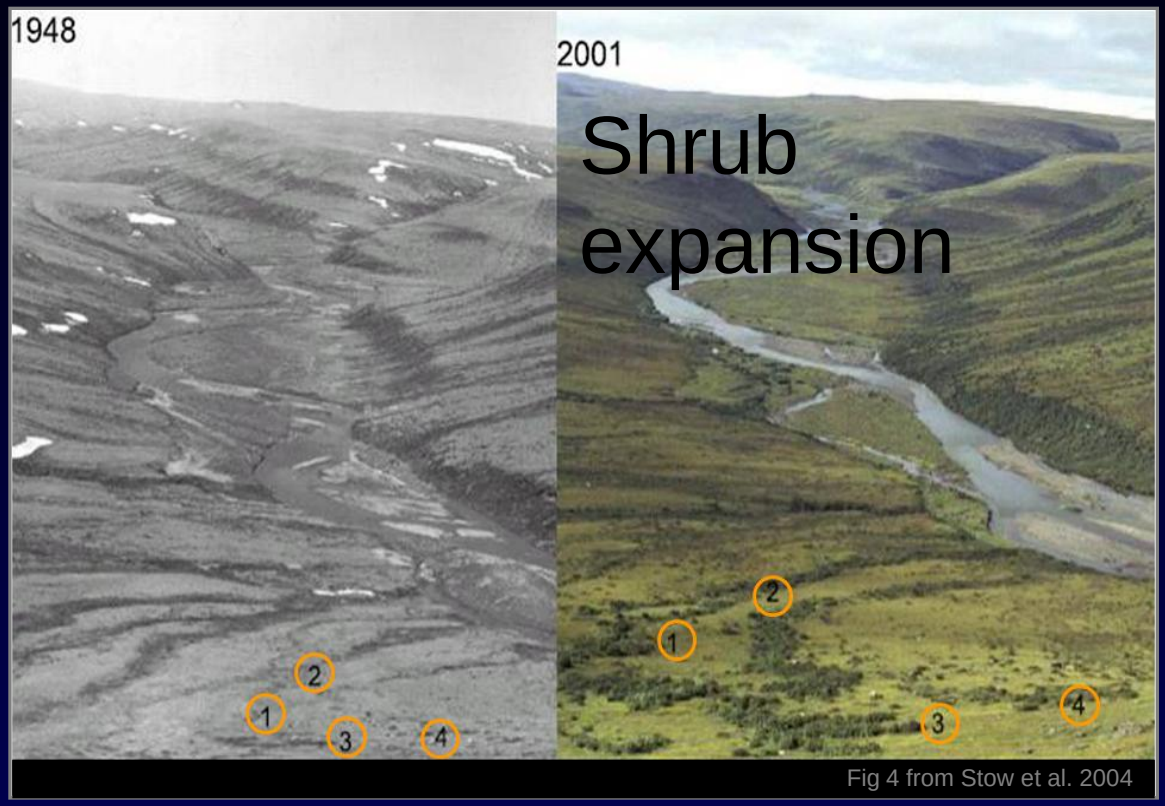
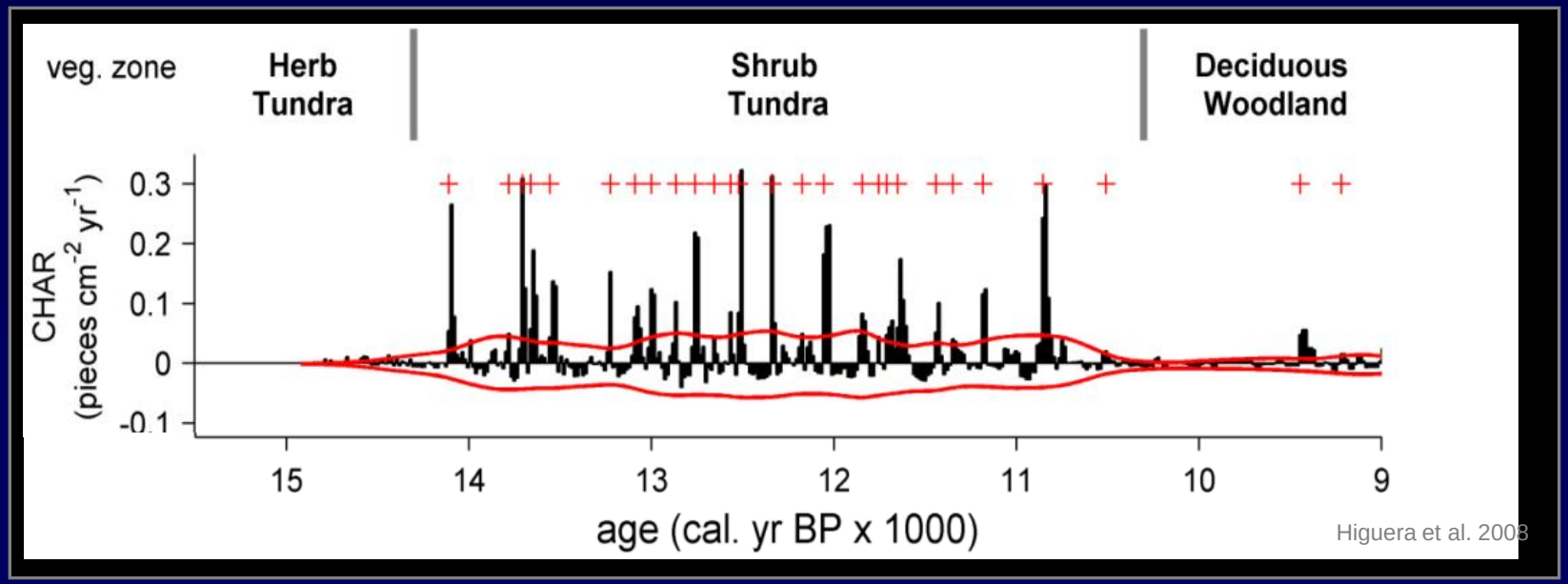


Fig 4 from Stow et al. 2004



Higuera et al. 2008

Objectives

- Quantify fire-return intervals in tundra ecosystems in Noatak and Seward Peninsula for the past 6,000 yrs
- Examine relationships between fire, vegetation, and climate
- Inform ecosystem model (ALFRESCO) to assess fire in tundra under future climate / vegetation scenarios

Reconstructing the past

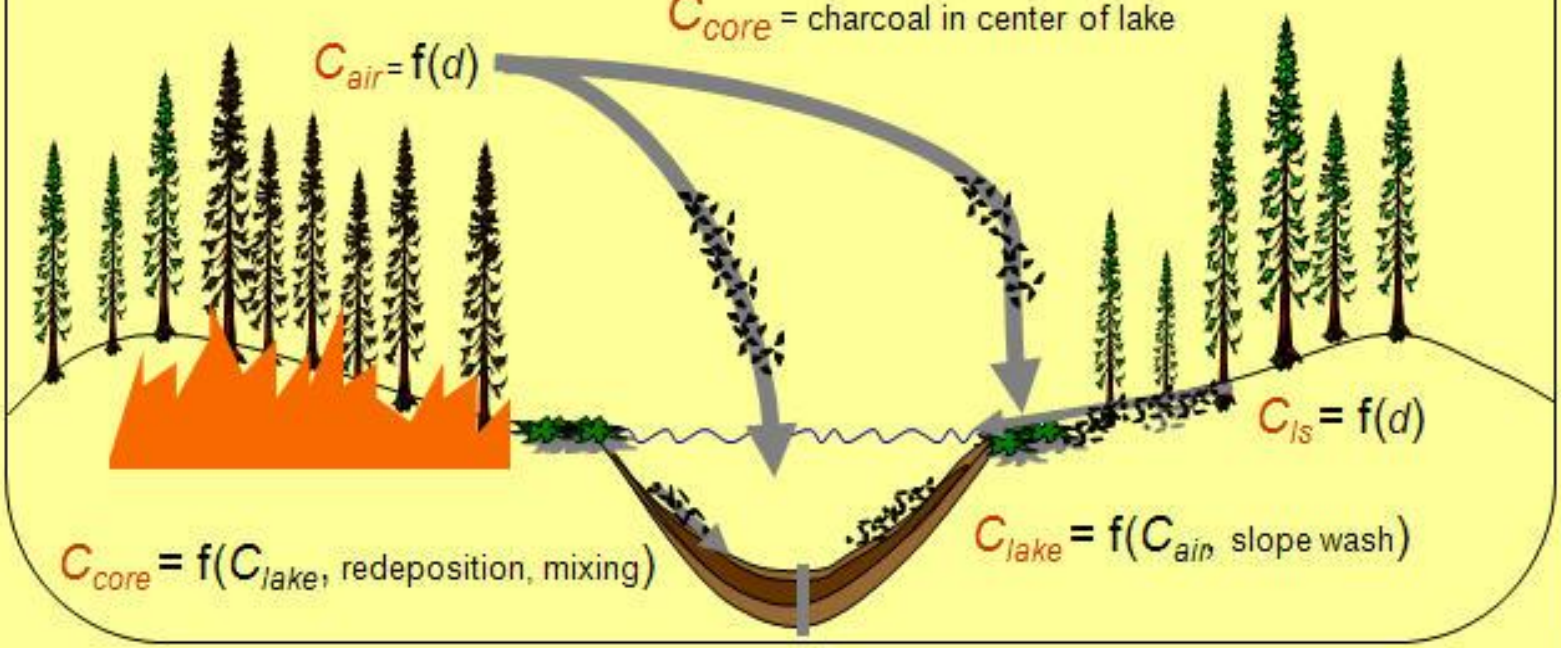
Charcoal Deposition and Fire History

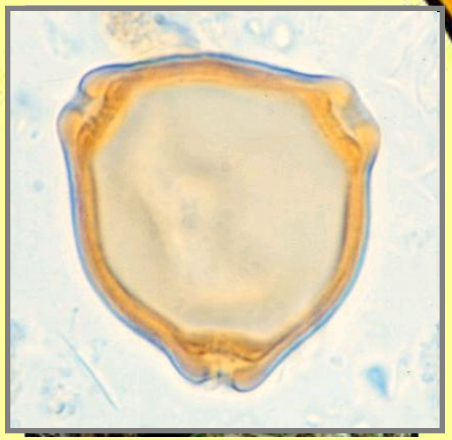
C_{air} = airborne fallout of charcoal

C_{ls} = charcoal on landscape surface

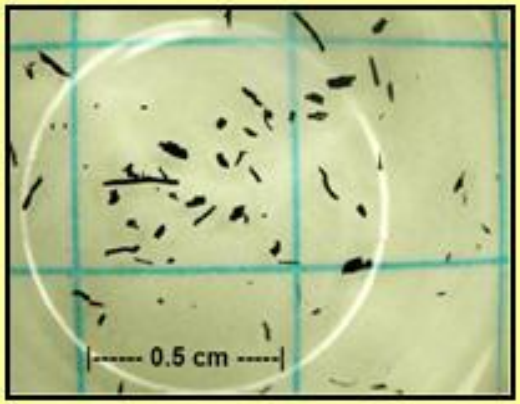
C_{lake} = charcoal on lake surface

C_{core} = charcoal in center of lake

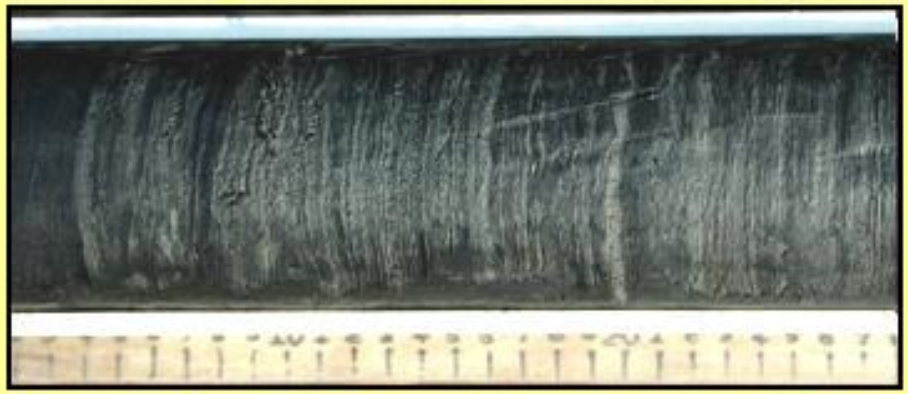




Pollen Identification – to determine vegetation composition at sites



Macroscopic charcoal

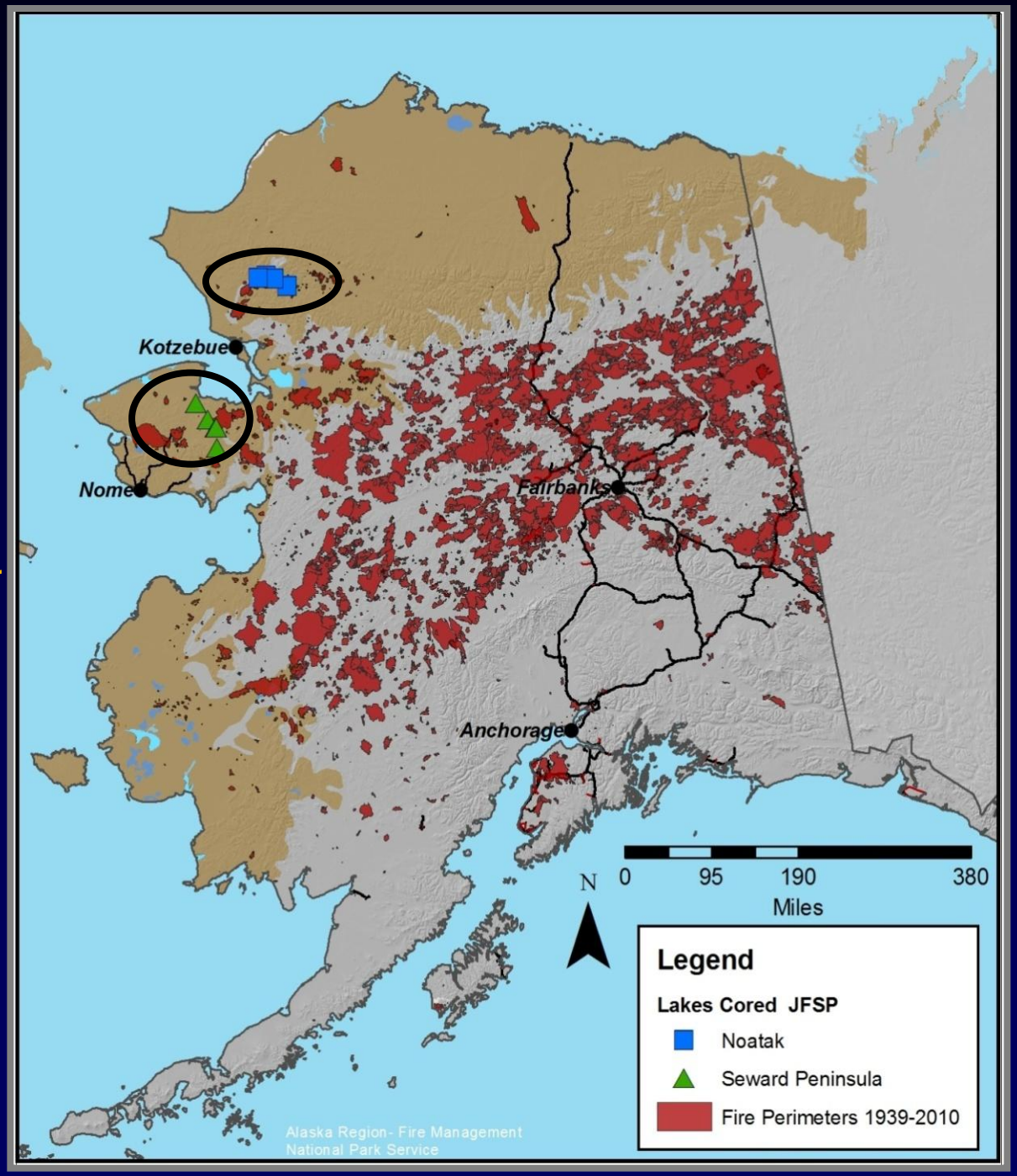


All cores were sliced at 0.25 cm resolution, and age models were developed using radiocarbon dates from terrestrial macrofossils.

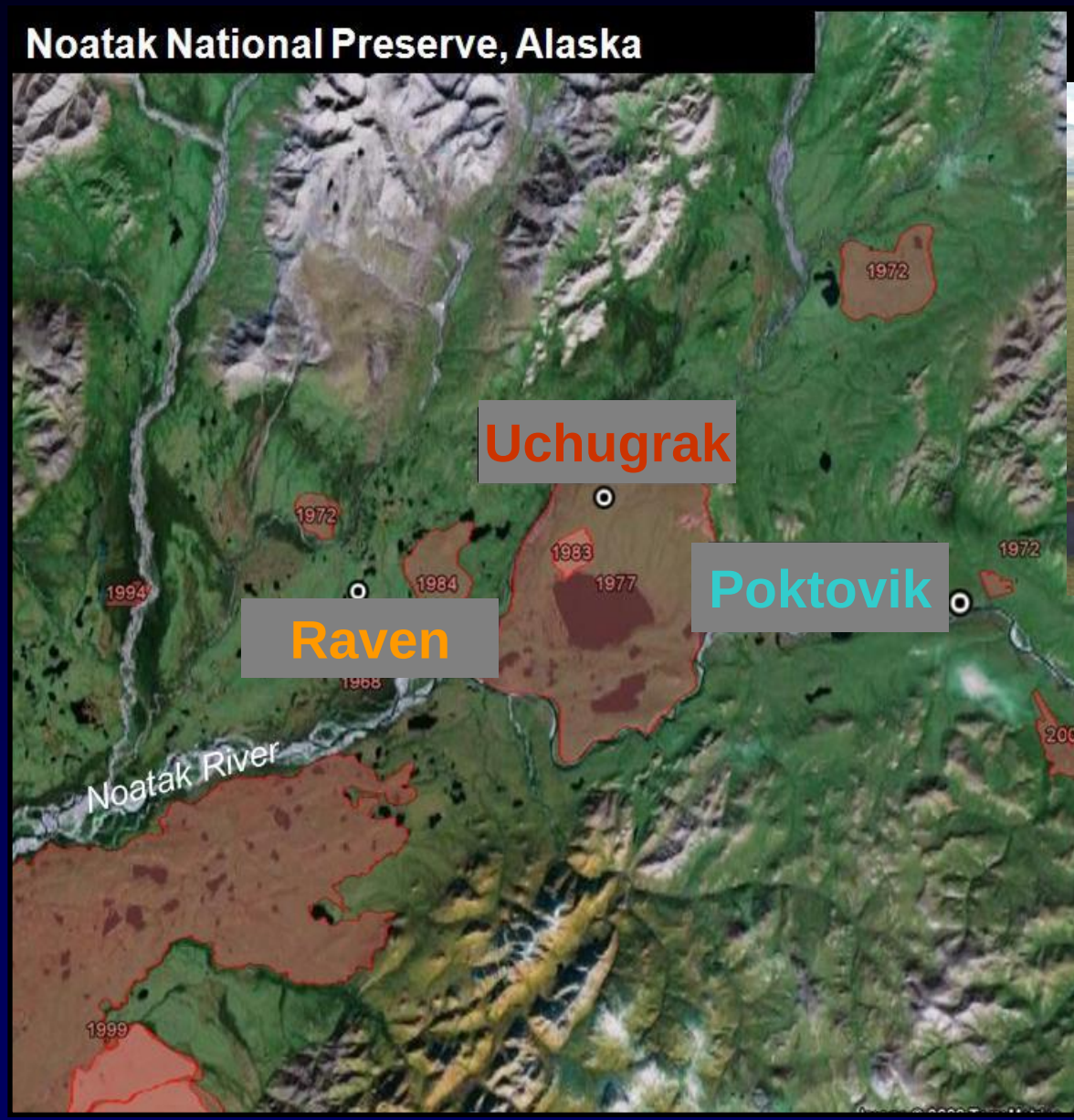
Newly-acquired sediment core

Study Areas

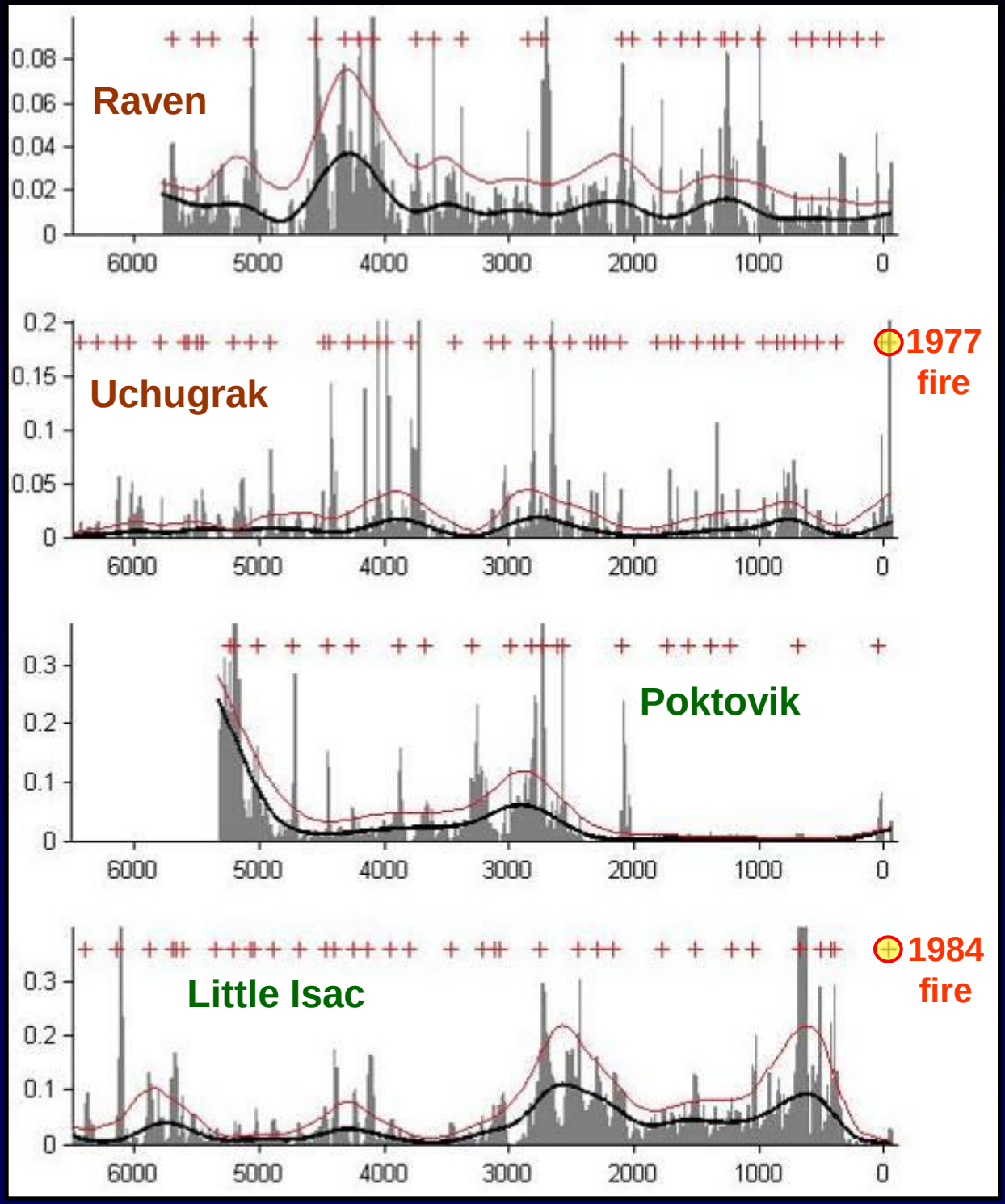
- NW Alaska Tundra Areas:
  - Noatak River
  - Seward Peninsula



Study Area: Noatak

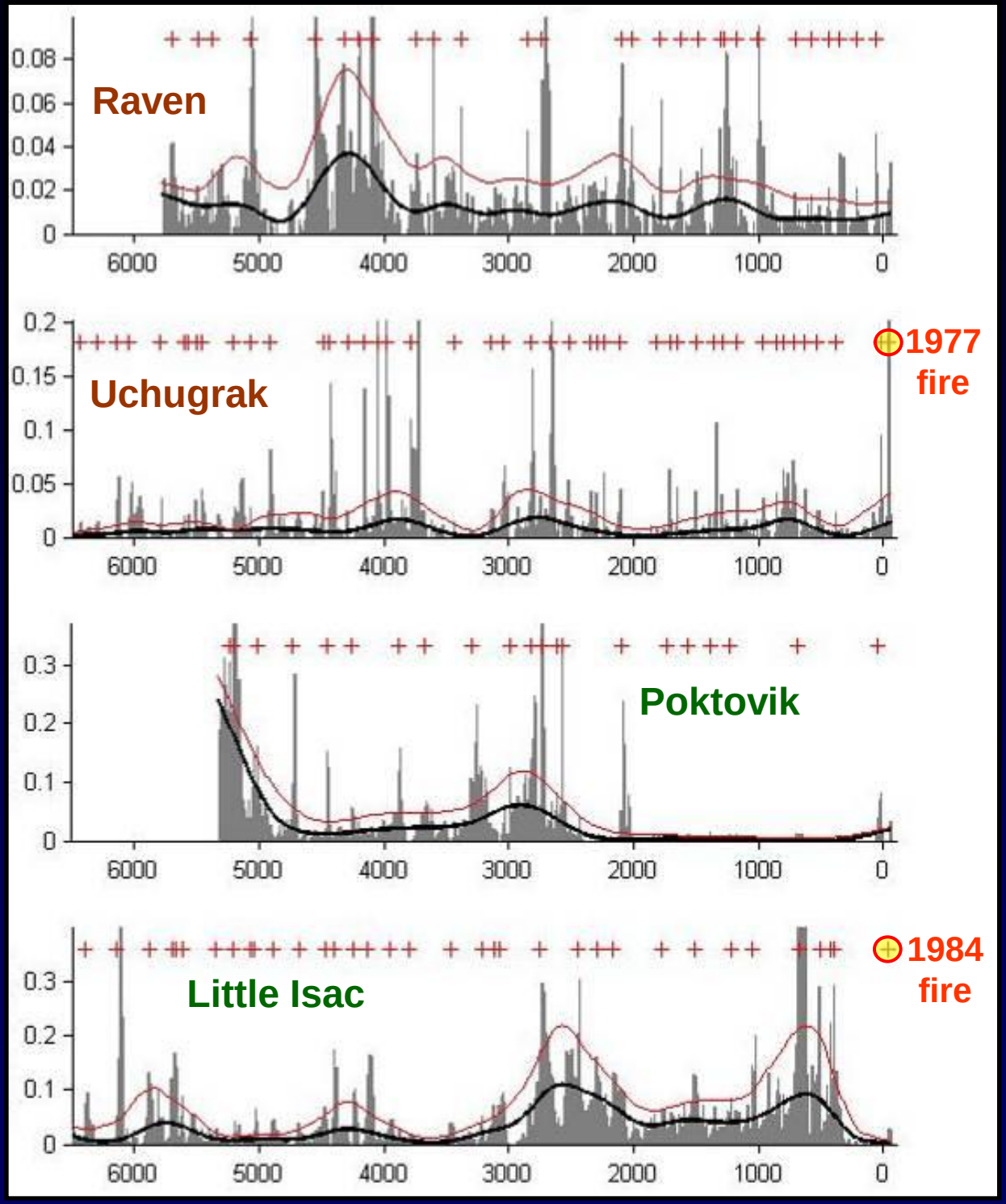


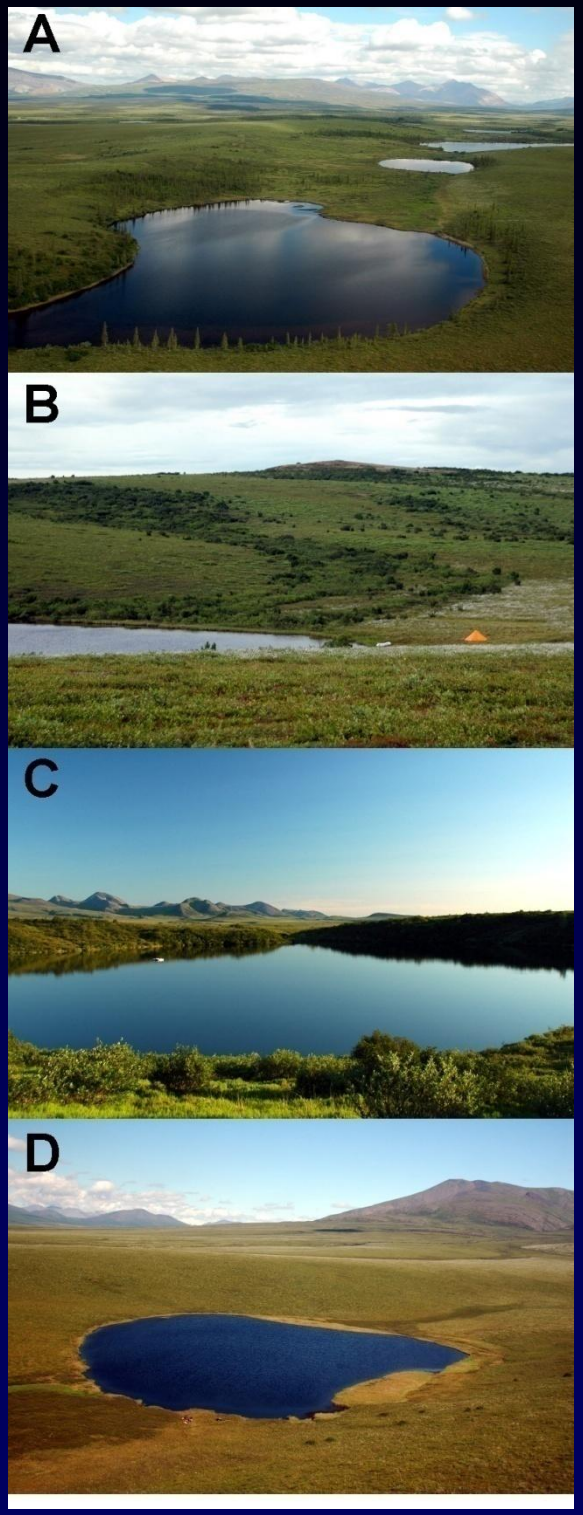
Peak Identification

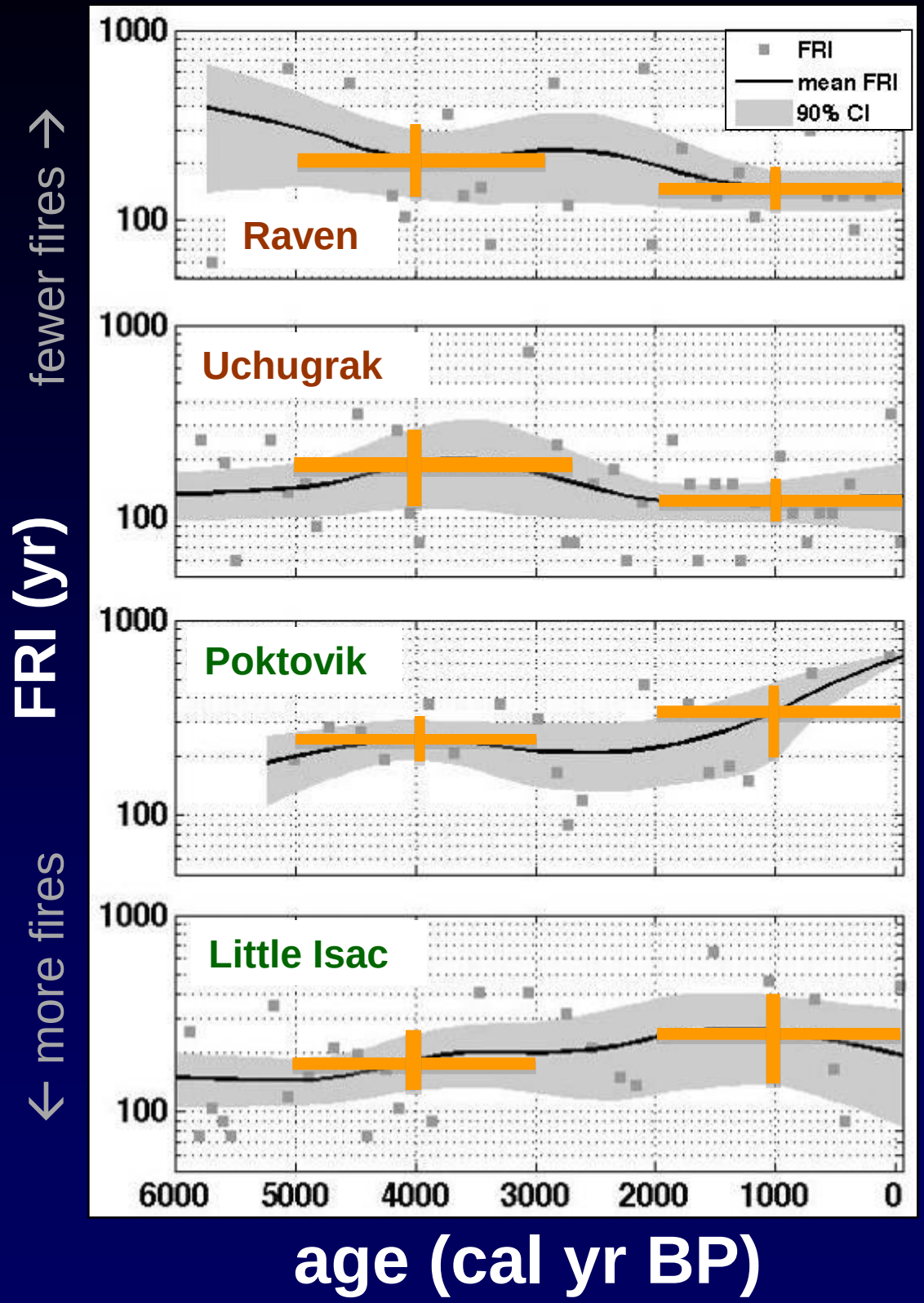


1. Tundra burns

- Records appropriate for peak identification
- Recent large fires detected


Raven
Uchugrak
1977 fire
Poktovik
Little Isac
1984 fire
CHAR (# cm-2 yr-1)
age (cal. yr BP)
6000
5000
4000
3000
2000
1000
0


A
B
C
D



2. FRIs vary through time

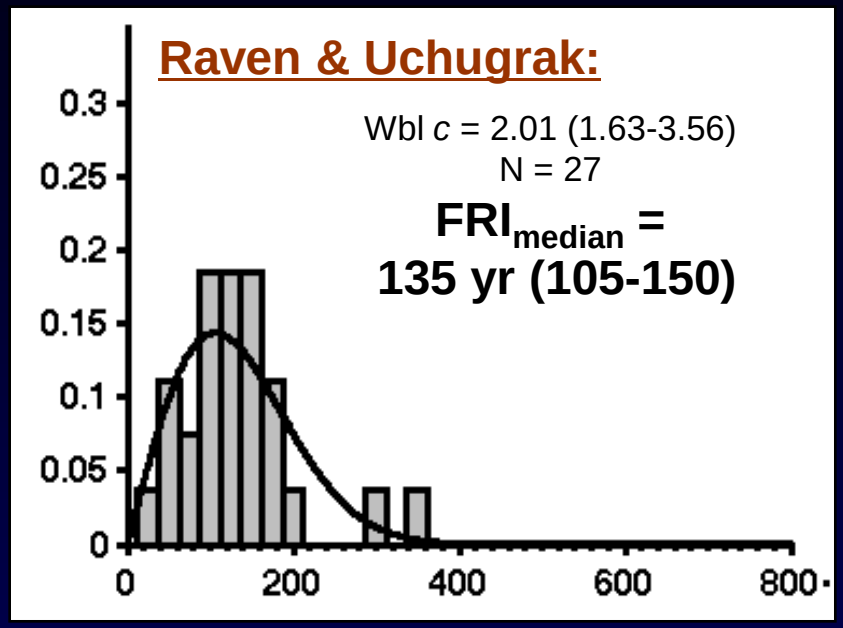
- At individual sites
- Between sites

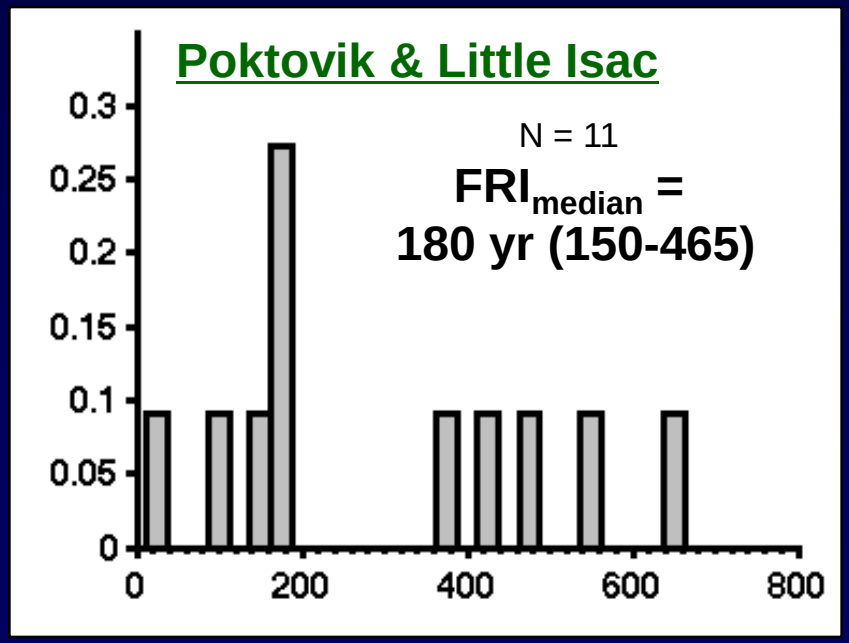
Fire return intervals ranged from 30-720 yrs over the past 6000 yrs

site	4000 yr BP	1000 yr BP
RA	210	140
UC	195	130
PI	250	340
LI	180	260

Fire return intervals since 2000 yr BP

3. Location matters

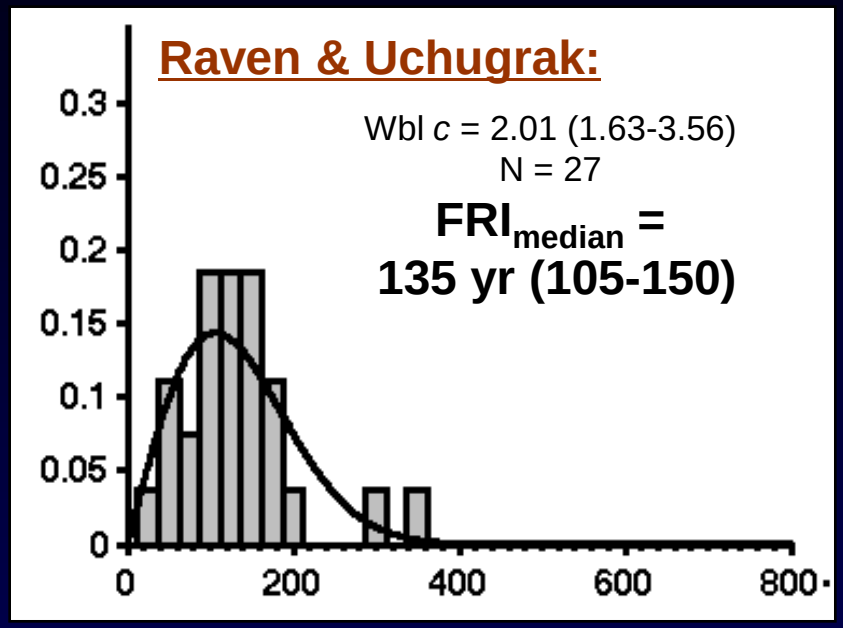


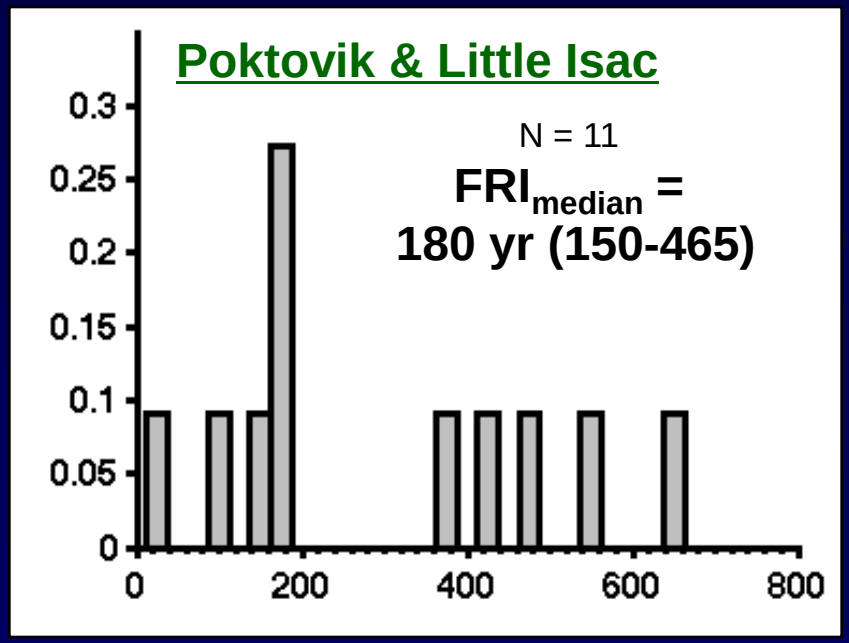


density OR proportion (x25)

FRI (yr)

Fire return intervals since 2000 yr BP



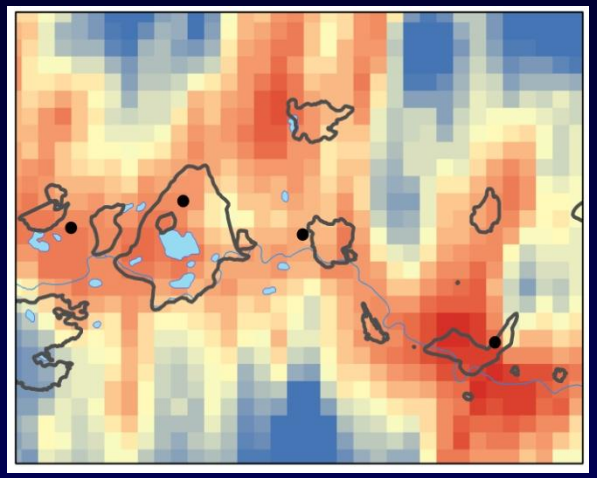


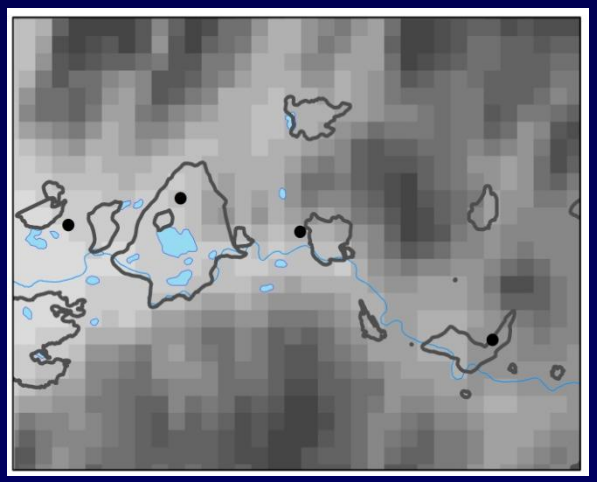
density OR proportion (x25)

FRI (yr)

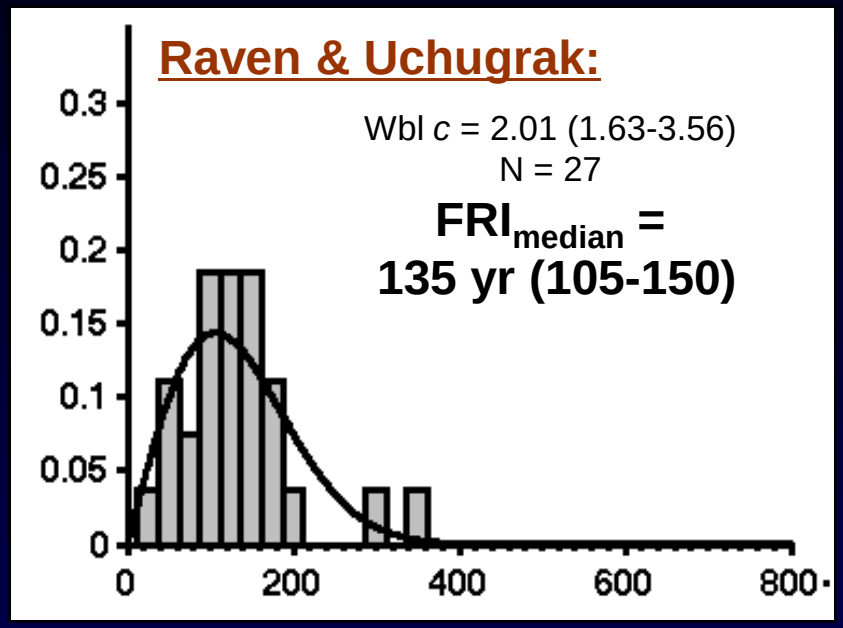
3. Location matters:

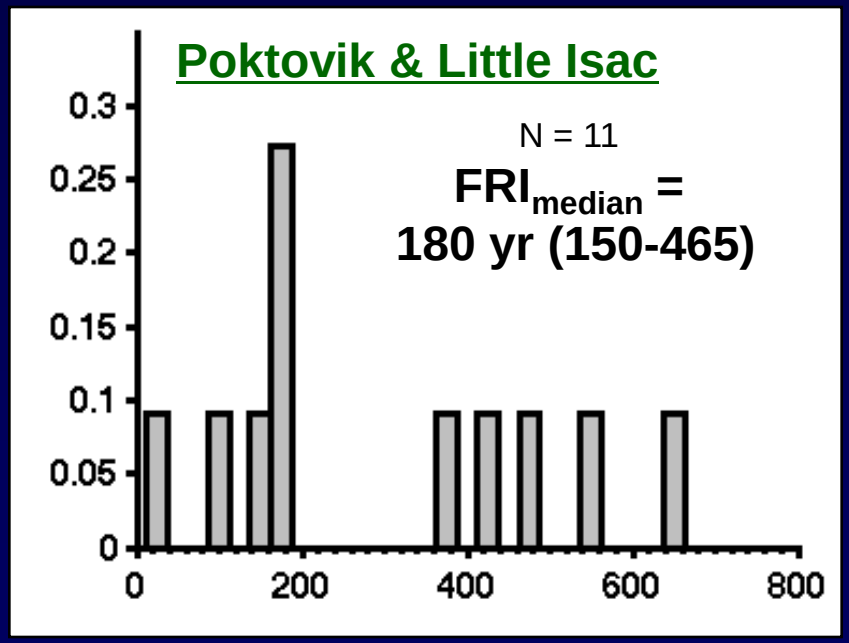
- climate





Fire return intervals since 2000 yr BP



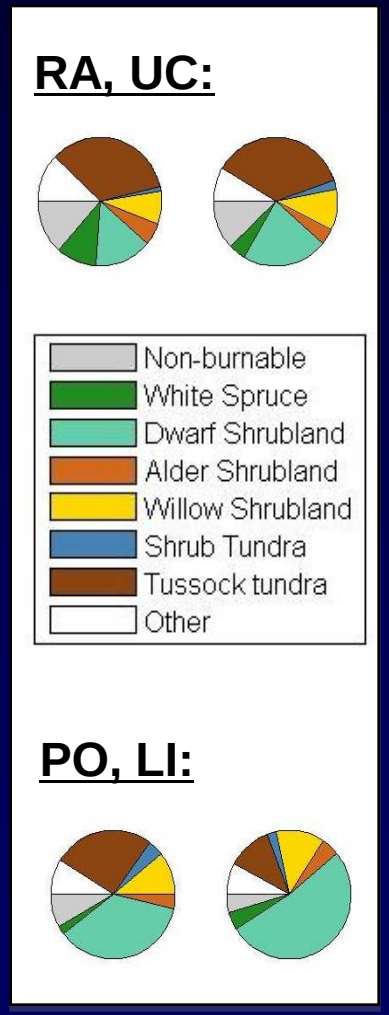


density OR proportion (x25)

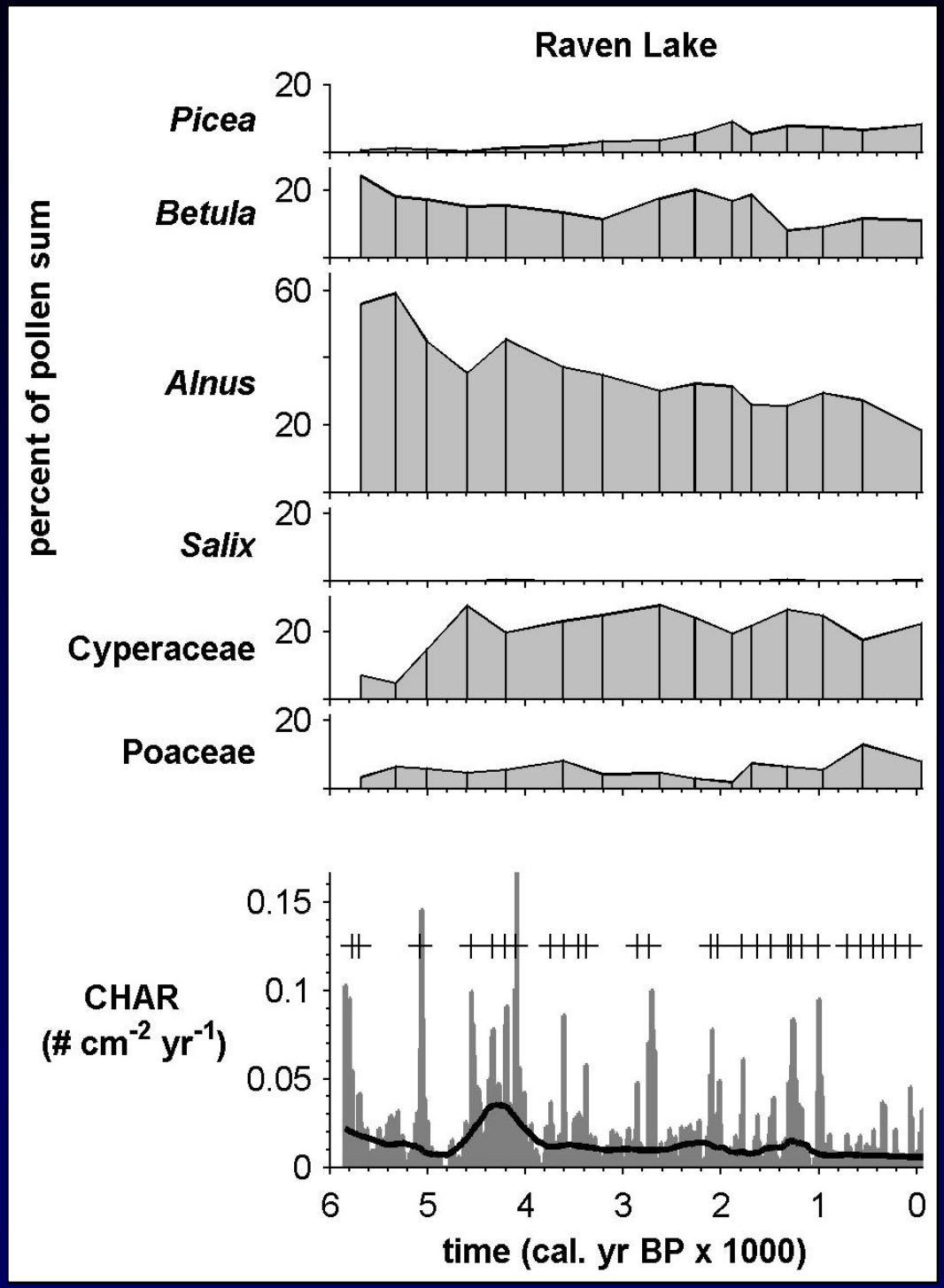
FRI (yr)

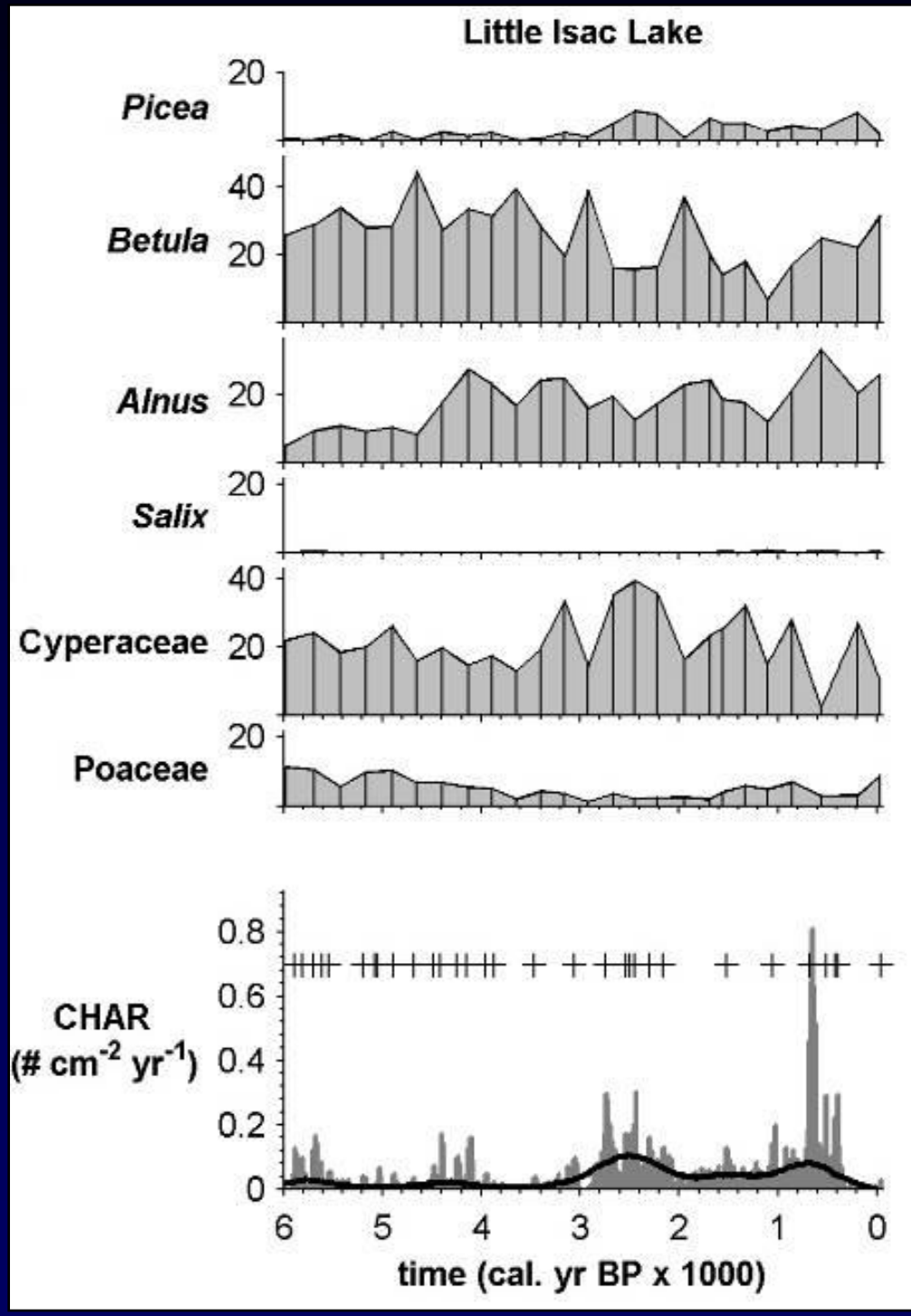
3. Location matters:

- climate + vegetation

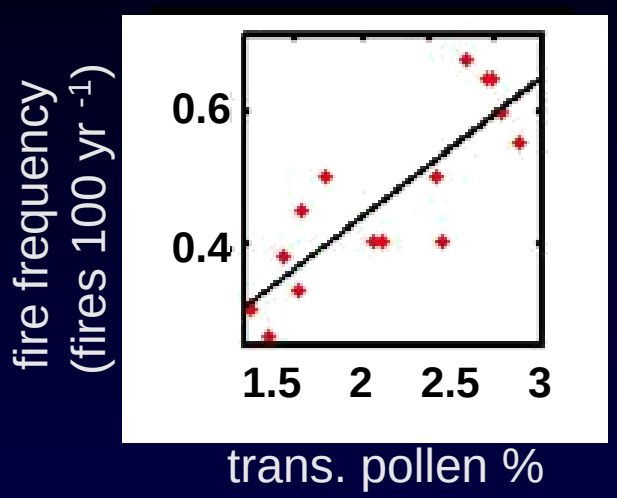


Holocene vegetation change





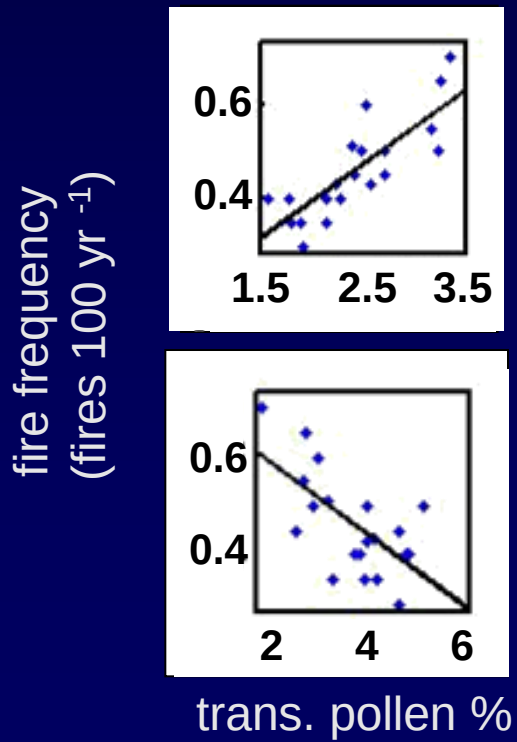
Fire-Vegetation Relationships



***Picea* (Spruce)**

$r^2_{adj} = 0.65$

$p = 0.019$



***Poaceae* (Grass)**

$r^2_{adj} = 0.64$

$p = 0.009$

Alder

$r^2_{adj} = 0.37$

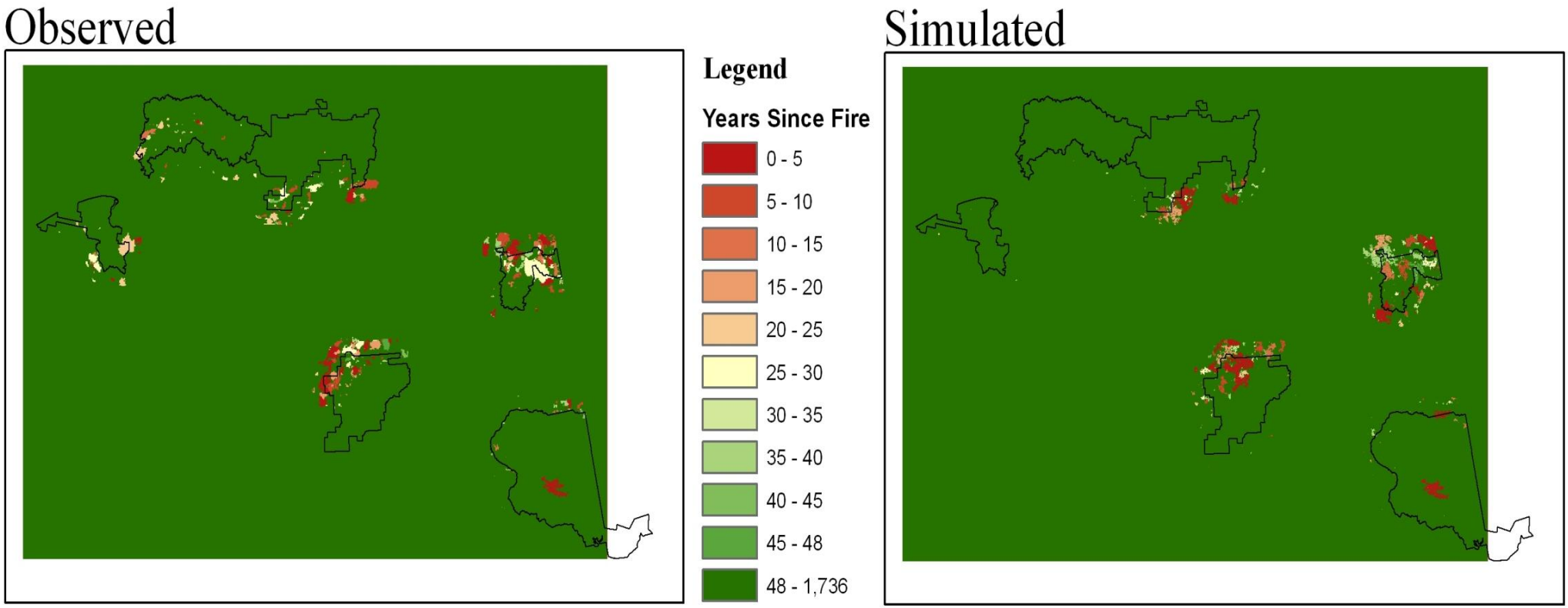
$p = 0.01$

Noatak Tundra Fire Regimes

- Fire return intervals ranged from 30-720 yrs over the past 6000 yrs
- Past 2000 yrs
  - FRI 140 yrs down-valley sites
  - FRI 295 yrs up-valley sites
- Fire frequencies varied through time as a result of climate, vegetation and local factors

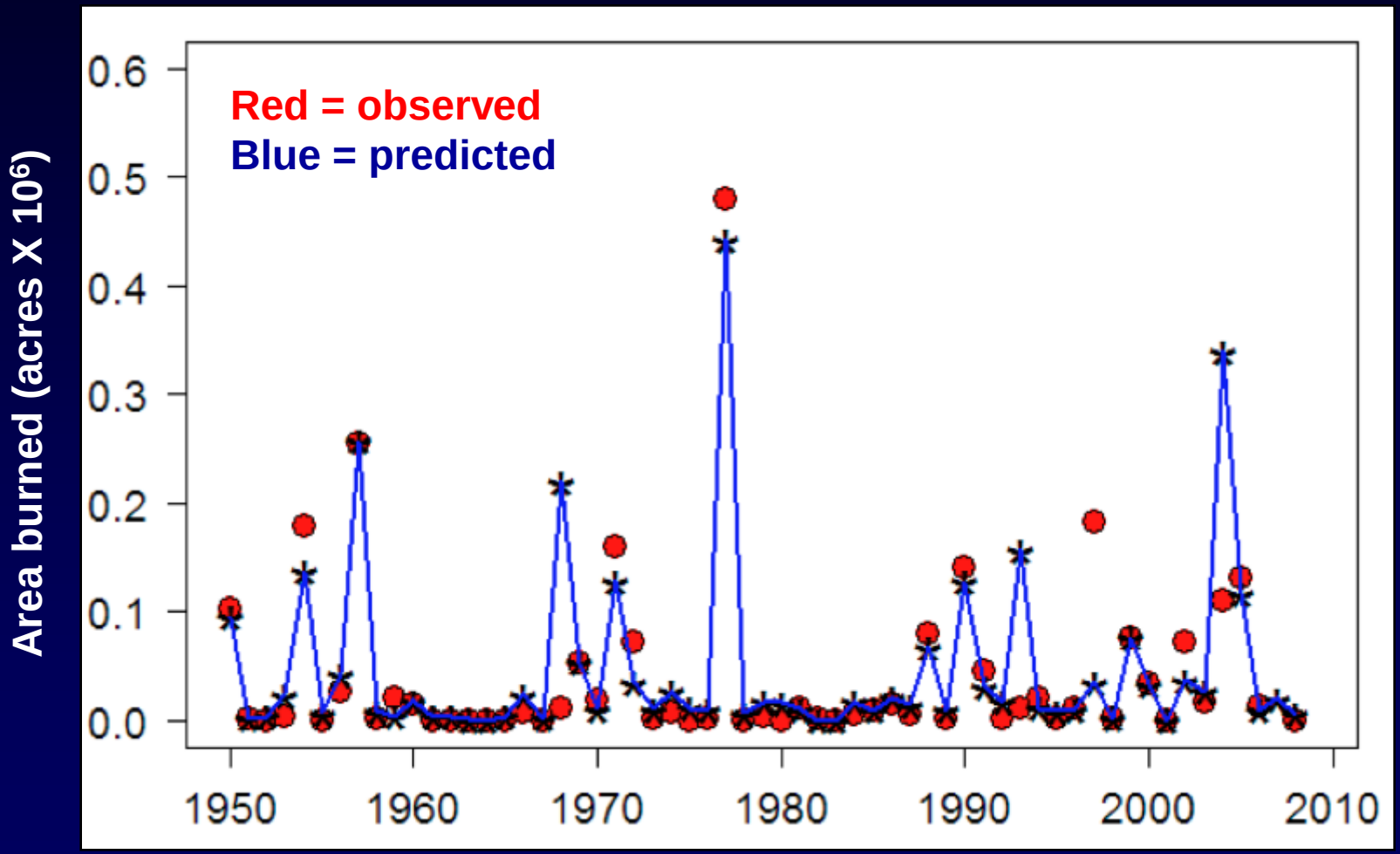
Using data to inform future climate-fire models

- Boreal ALFRESCO
  - Tundra fire return intervals
  - Climate drivers to fire extent



Modern Tundra Fires

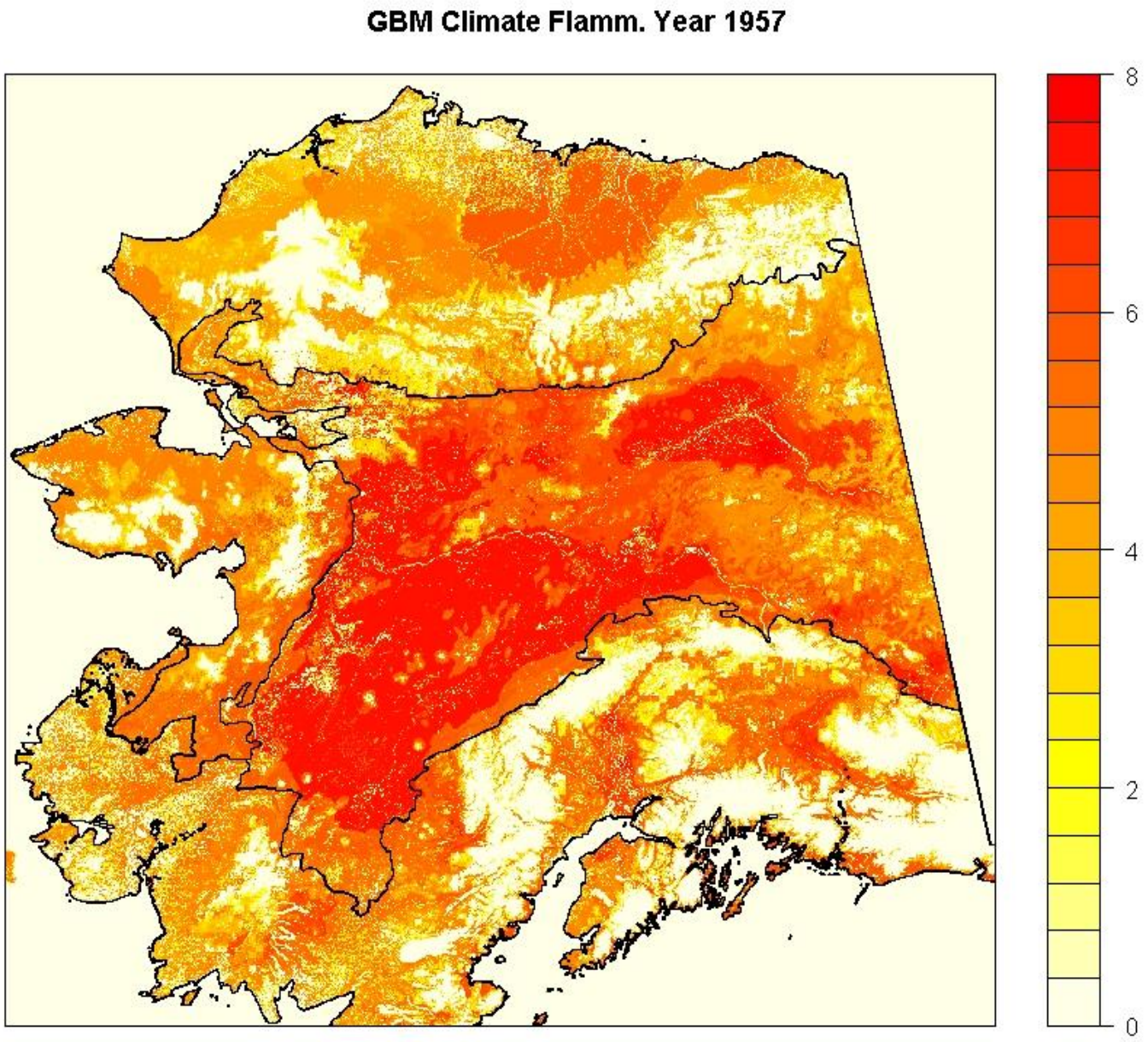
- **Inter-annual variability explained by August temperature and precipitation (fire weather)**



Model Variables: Mean Aug. Temp
Jan, June and July Precipitation

Paul Duffy, unpublished data.

Models used to improve Boreal ALFRESCO



Summary

1. Long term average FRIs for tundra are statistically similar to Alaskan boreal forests
2. Fire frequencies varied through time, determined by climate, vegetation, and *local factors*
3. Information gained from this study will improve future climate/fire models for tundra

Acknowledgements and Questions

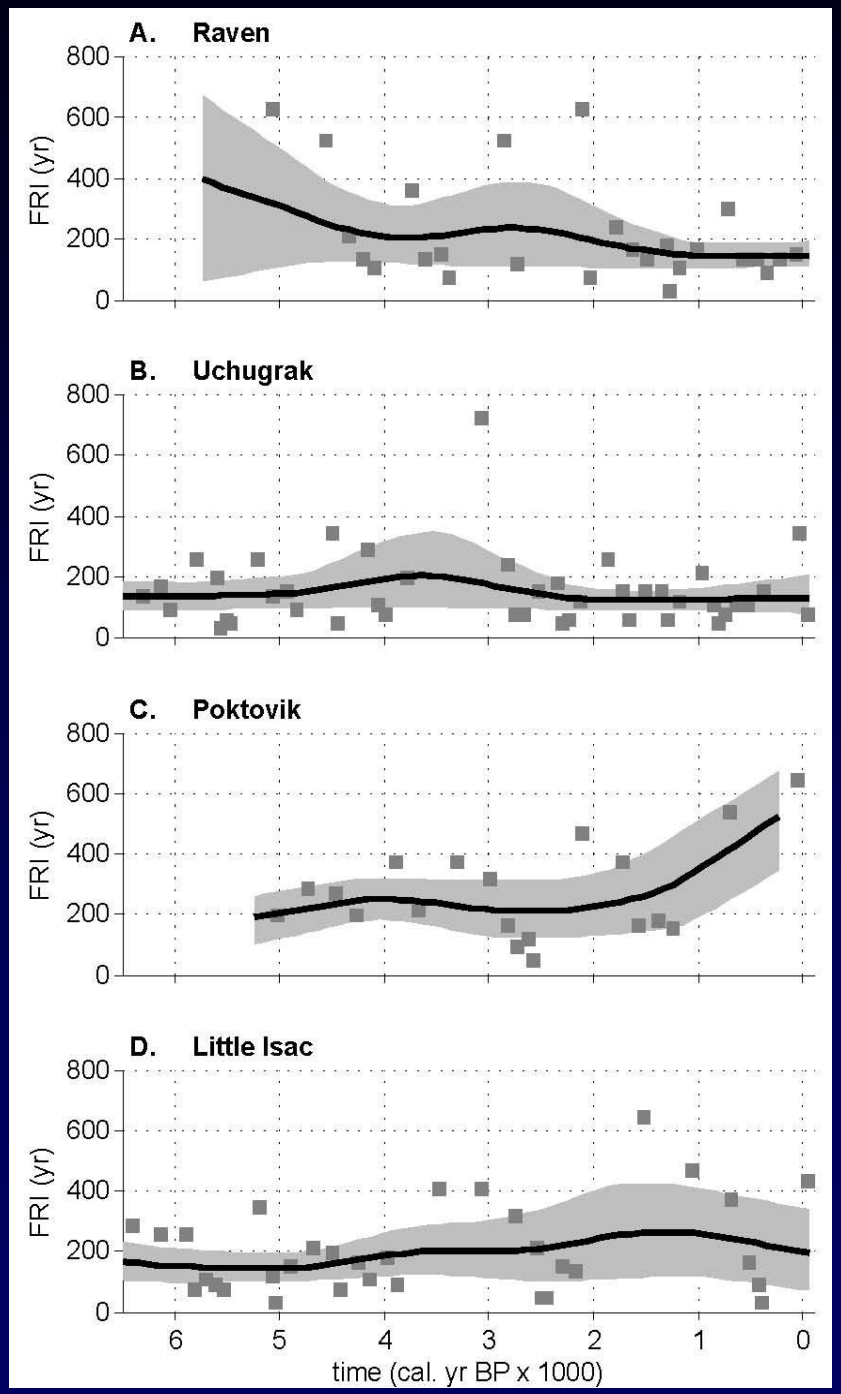
Funding: Joint Fire Science Program and the National Park Service.

Field Assistance: Denali National Park fire personnel

Lab Assistance: Triet Vuong and Jennifer Schwarz

Poktovik Lake, 11:30 pm, June 19th

Tundra Fire Return Intervals



Past 2,000 Years

Lake	Mean FRI	Median FRI	Range
Raven	151	135	30-300
Uchugrak	135	113	45-345
Poktovik	291	180	135-630
Little Isac	313	360	30-645

Past 6,500 Years

Lake	Mean FRI	Median FRI	Range
Raven	204	135	30-630
Uchugrak	146	120	30-645
Poktovik	246	195	30-630
Little Isac	197	158	30-645