A brief history of wildfire: the past as a window to future

REM 244 Guest Lecture, 17 Jan., 2012

Philip Higuera
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University of Idaho
College of Natural Resources

"The farther backward you can look, the farther forward you are likely to see."
- Winston Churchill

High Country News

ECOLOGY

Salvage Harvesting Policies After Natural Disturbance

D. B. Lindenmayer,[1] D. R. Foster,[2] J. F. Franklin,[3] M. L. Hunter,[4] R. F. Noss,[5] F. A. Schmiegelow,[6] D. Perry[7]

Natural disturbances and the biologic legacies produced by them are oft poorly understood by policy-make and natural-resource managers. Recent larg scale natural disturbances include wildfir

news feature

Burning issues

Australia's cities impinge upon an ancient landscape shaped by fire. Carina Dennis talks to the researchers who are striving to protect lives and property, while retaining natural fire regimes

The Telegraph

Australian bushfires: Nearly 100 dead in deadliest ever blaze

Australia's worst ever bushfires have left at least 100 people d homeless as blazes continue to rage amid fears the death-toll

NEWS FEATURE

NATURE|Vol 461|3 September 2009

TUNDRA'S BURNING

Lightning and fires on the Arctic tundra seem to be on the rise. **Jane Qiu** meets the researchers learning from the scorched earth in Alaska.

Continued warming could transform Greater Yellowstone fire regimes by mid-21st century

Anthony L. Westerling[a,1], Monica G. Turner[b,1], Erica A. H. Smithwick[c], William H. Romme[d], and Michael G. Ryan[e]

News Focus

In a region already prone to water shortages, researchers now forecast that rising temperatures threaten the American West's hidden reservoir: mountain snow

As the West Goes Dry

Fire in the Earth System

David M. J. S. Bowman,[1*] Jennifer K. Balch,[2,3,4*†] Paulo Artaxo,[5] William J. Bond,[6] Jean M. Carlson,[7] Mark A. Cochrane,[8] Carla M. D'Antonio,[9] Ruth S. DeFries,[10] John C. Doyle,[11] Sandy P. Harrison,[12] Fay H. Johnston,[13] Jon E. Keeley,[14,15] Meg A. Krawchuk,[16] Christian A. Kull,[17] J. Brad Marston,[18] Max A. Moritz,[16] I. Colin Prentice,[19] Christopher I. Roos,[20] Andrew C. Scott,[21] Thomas W. Swetnam,[22] Guido R. van der Werf,[23] Stephen J. Pyne[24]

Fire is a worldwide phenomenon that appears in the geological record soon after the appearance of terrestrial plants. Fire influences global ecosystem patterns and processes, including vegetation

news and views

The wildfire factor

David Schimel and David Baker

Events such as wildfires, occurring on a tiny area of the globe, can have a huge impact on the global carbon cycle. This much is plain from investigation of the terrible fires that afflicted Indonesia five years ago.

Implementation of National Fire Plan treatments near the wildland–urban interface in the western United States

Tania Schoennagel[a,1], Cara R. Nelson[b], David M. Theobald[c], Gunnar C. Carnwath[b], and Teresa B. Chapman[a]

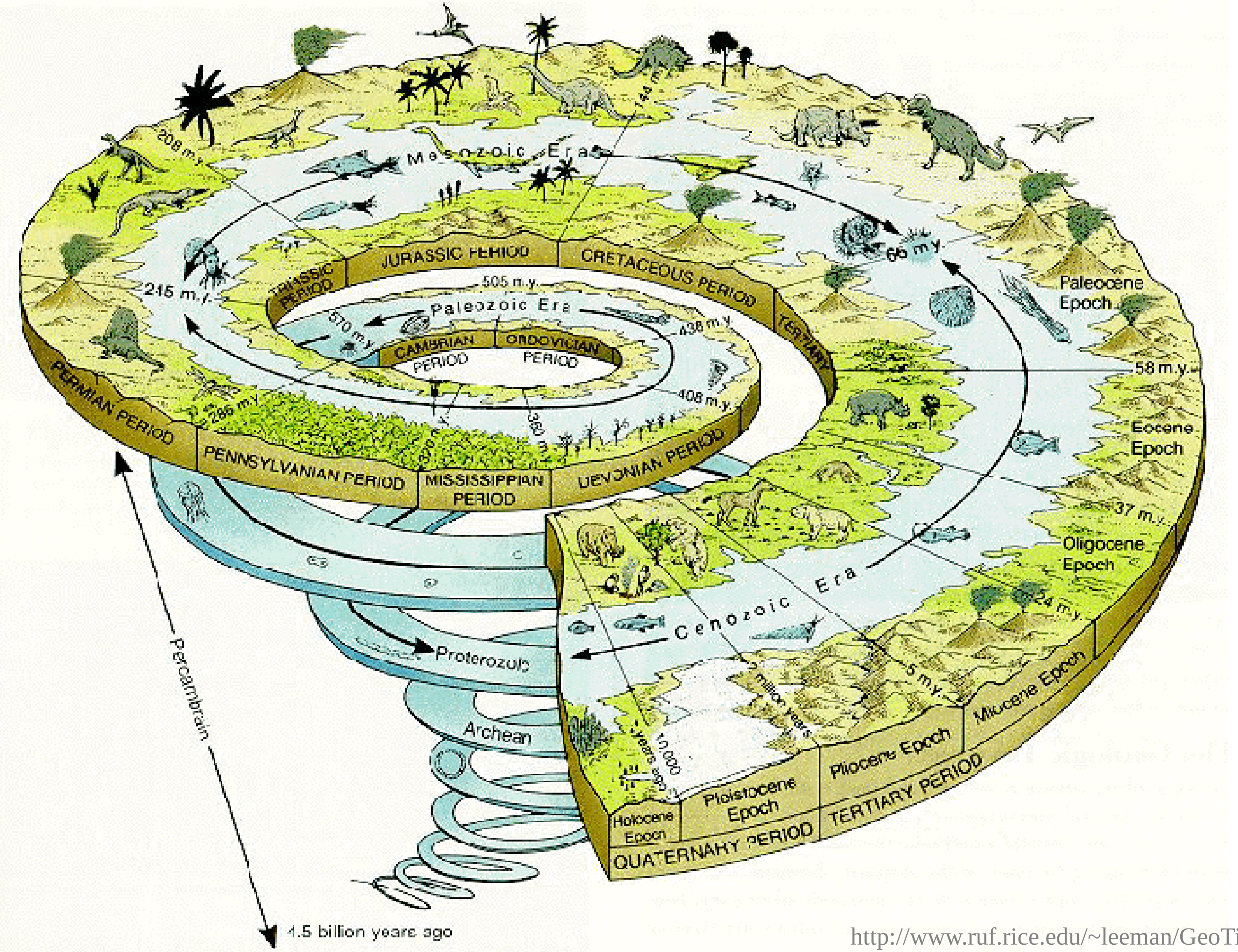
Key Questions for Today's Class

1. **What can we learn from the past?**
2. **How do we learn from the past?**
3. **What have we learned?**

1. What can we learn from the past?

A. Context and perspective

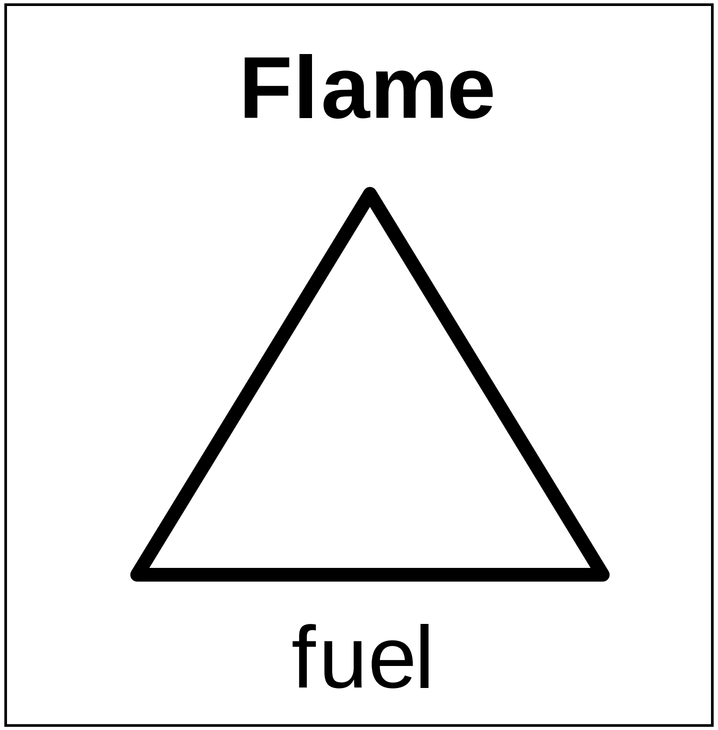
How old is fire?



http://www.ruf.rice.edu/~leeman/GeoTimeSpiral.gif

What do we need for fire?

1. **Fuel**
2. **Oxygen**
3. **Ignition**



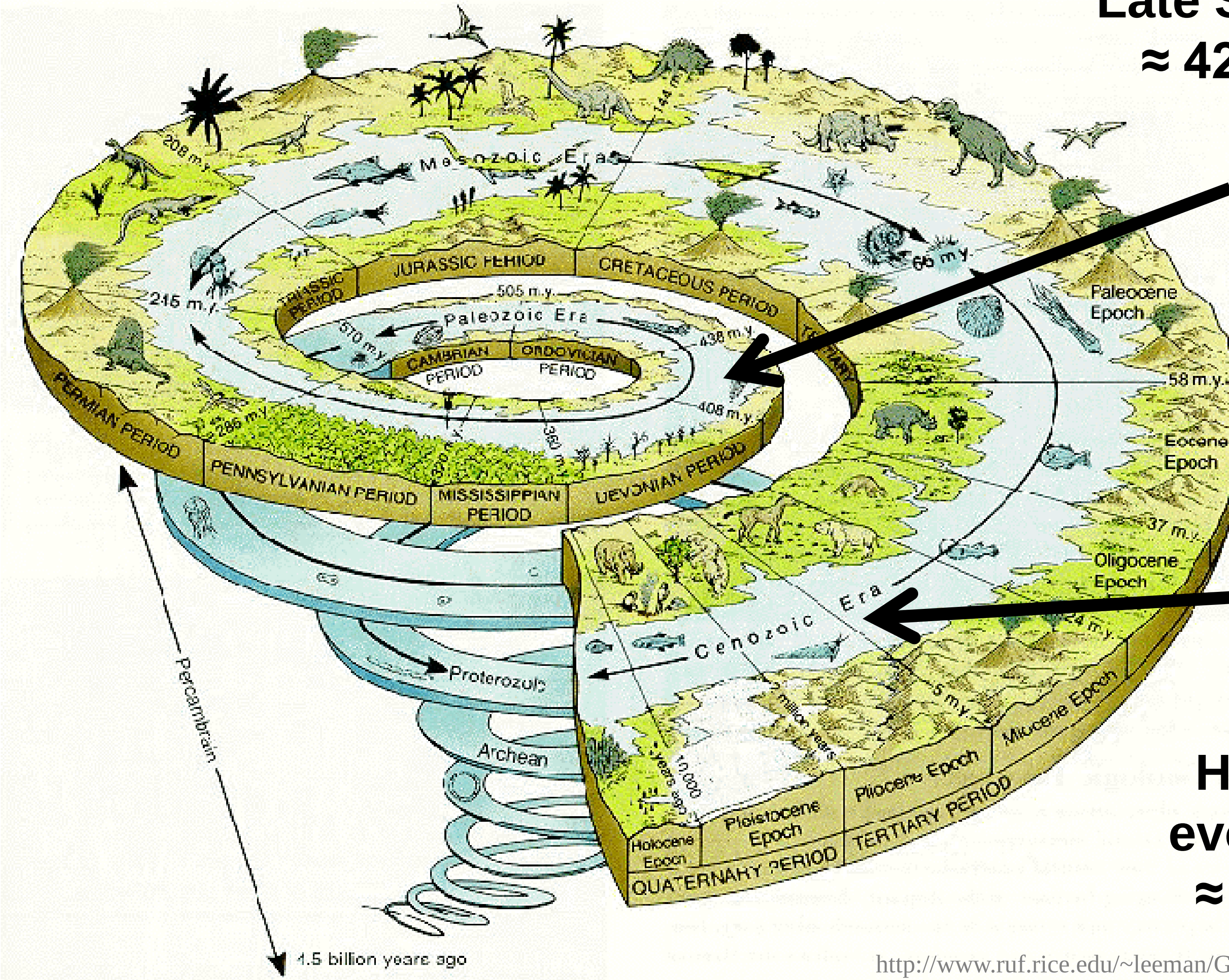
What do we need for fire?

1. **Fuel** - **Terrestrial vegetation**

2. **Oxygen** - **Oxygen – 13-35%** (today = 21%)

3. **Ignition** - **Lightning, volcanoes, humans**

How old is fire?



Late Silurian,
≈ 420 mya

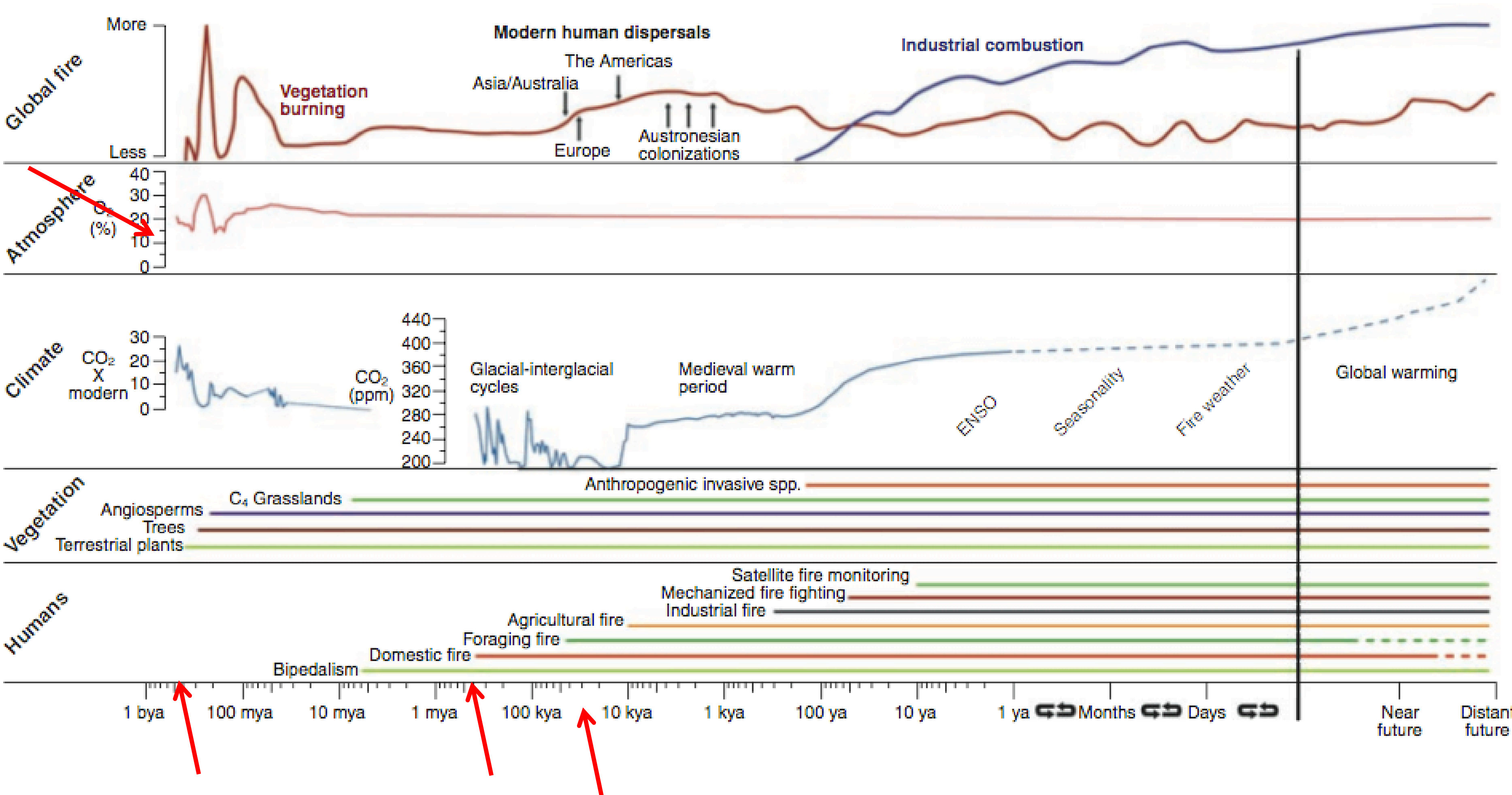
Human evolution
≈ 5 mya

http://www.ruf.rice.edu/~leeman/GeoTimeSpiral.gif

420 million 13%

400,000 50,000-10,000

Historical precedence: (Bowman et al. 2009)



Context and perspective

Fire is a longstanding natural process, present throughout the evolution of the life and much of the planet

“Fire is something that ecosystems *do*, not something that *happens to them*” - D. Falk

“Natural phenomenon, human disaster”

- My high school headmaster

Erickson Creek Fire, Interior Alaska, 2003

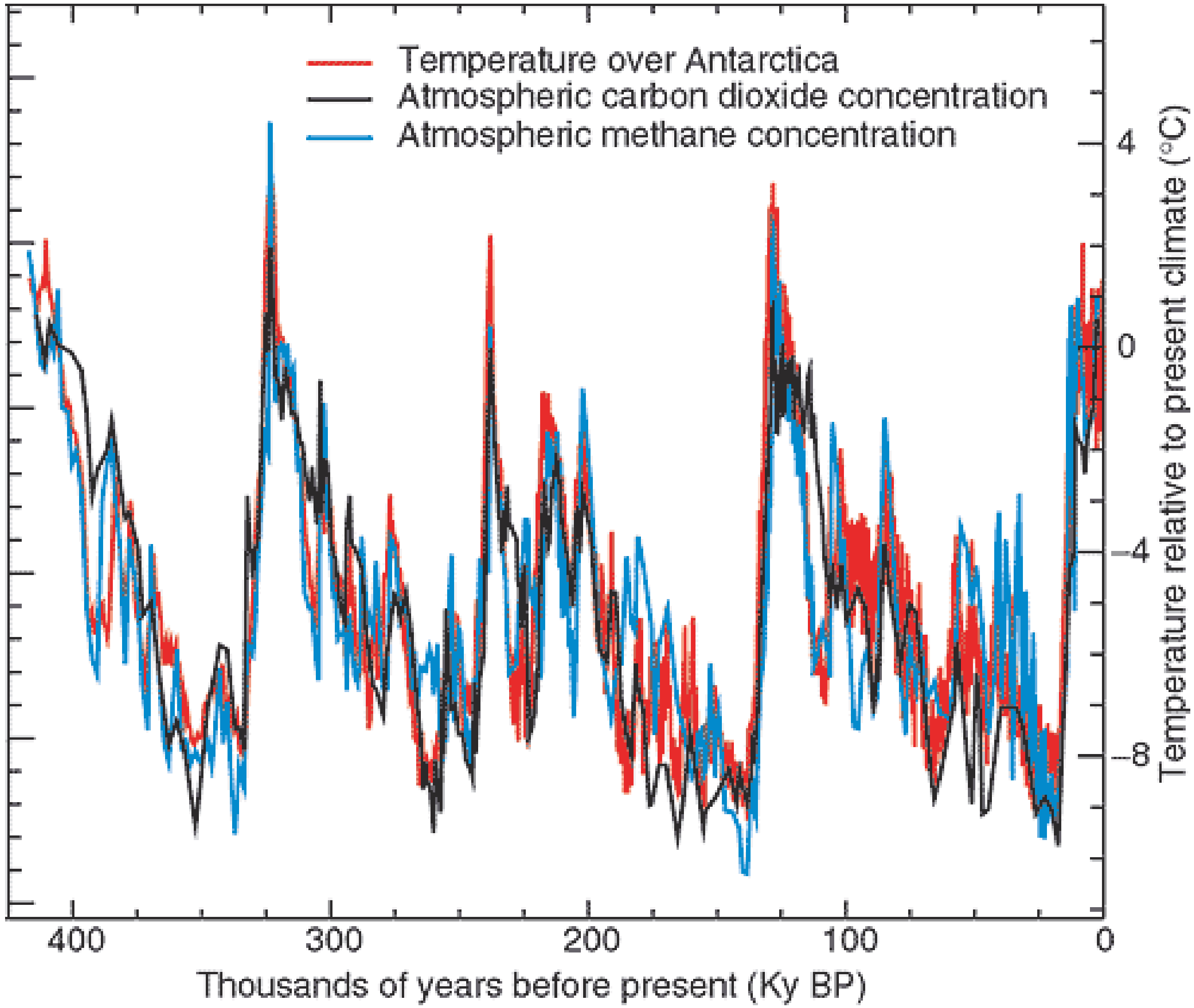
1. What can we learn from the past?

A. *Context and perspective*

B. ***How does fire respond to environmental change? Use the past as a natural experiment.***

The past as a natural experiment

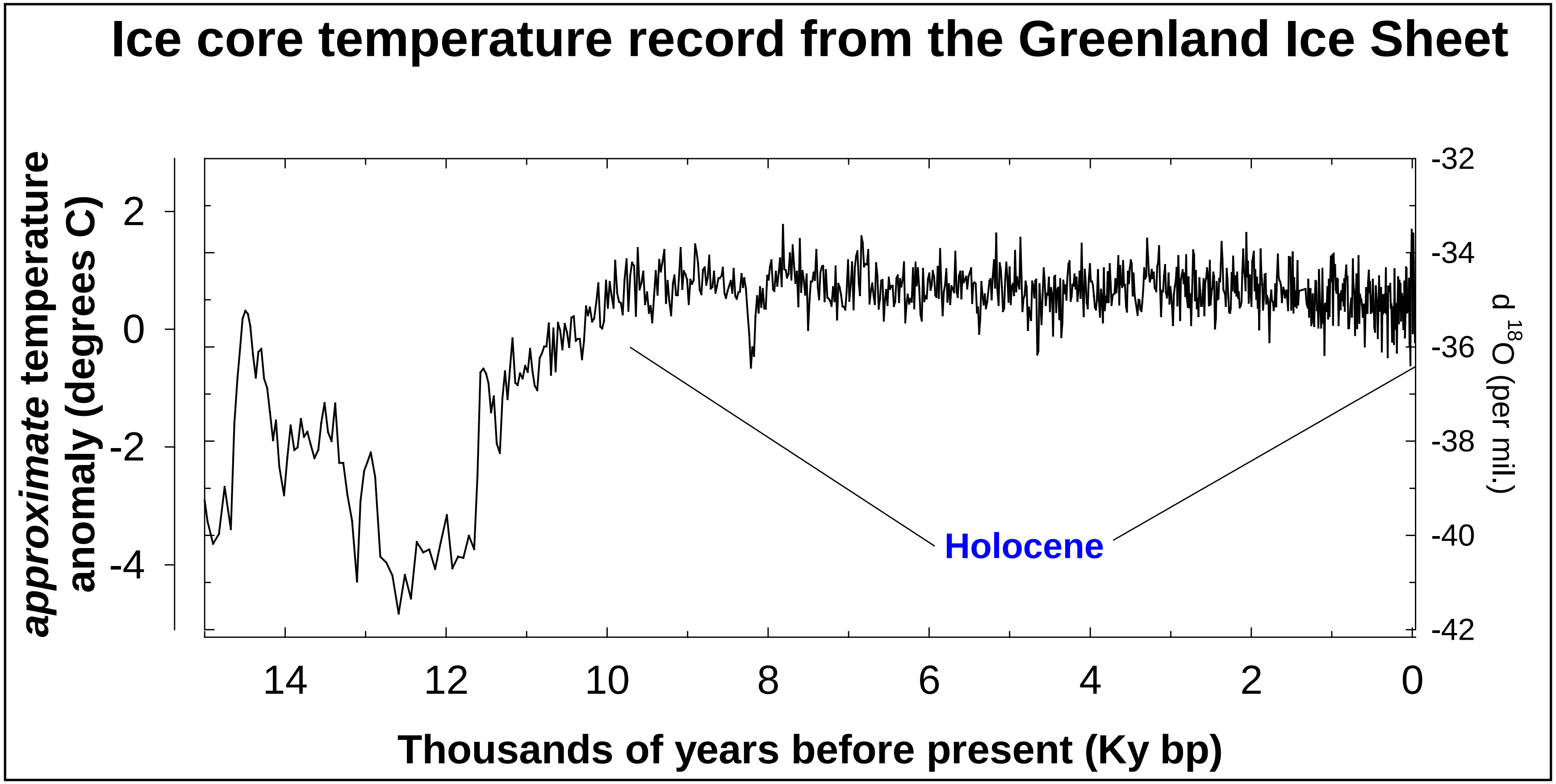
Multi-millennial – millennial: glacial / interglacial periods



Graphic: IPCC: http://www.grida.no/climate/ipcc_tar/wg1/index.htm

The past as a natural experiment

Millennial to centennial: glacial-Holocene transition

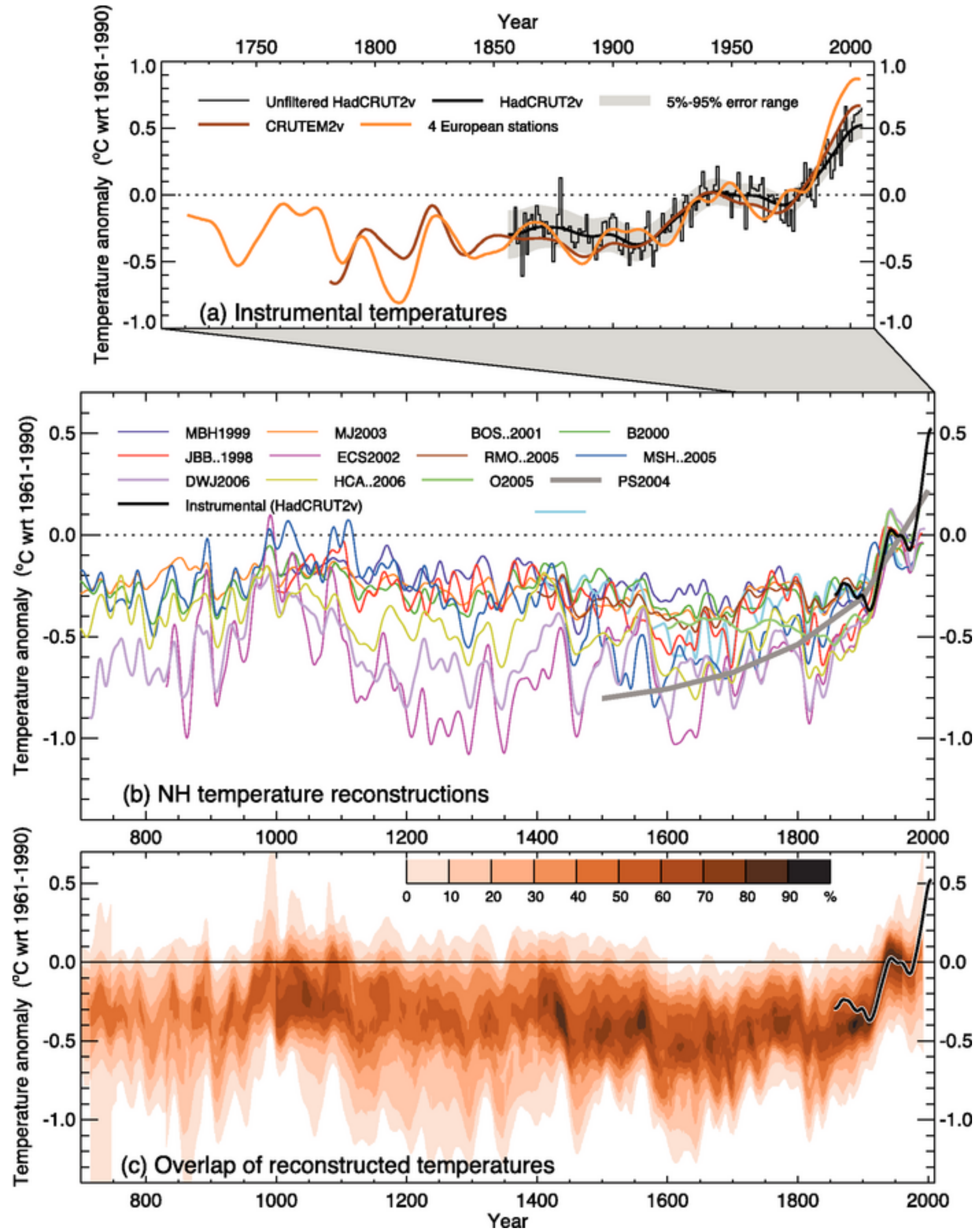


Data: Greenland Ice Sheet Project II (GISPII) http://www.ngdc.noaa.gov/paleo/icecore/icecore-varlist.html

The past as a natural experiment

Centennial-decadal: past 1000 years

Earth's history is filled with well-understood environmental variability, at multiple scales



Graphic: IPCC 2007: http://www.ipcc.ch/publications_and_data/ar4/wg1/en/figure-6-10.html

Key Questions for Today's Class

1. **What can we learn from the past?**
   a) **Context and perspective**
   b) **How fire responds to environmental change**

2. **How do we learn from the past?**

Reconstructing the past

Proxy – a stand in

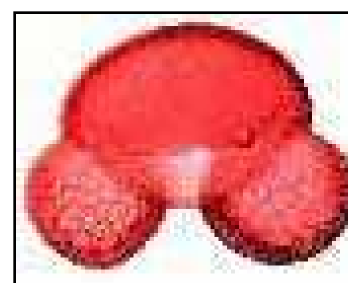
Biological Proxies:

- tree rings
- pollen
- forams
- diatoms

Physical Proxies:

- charcoal
- isotopes
- glaciers
- boreholes

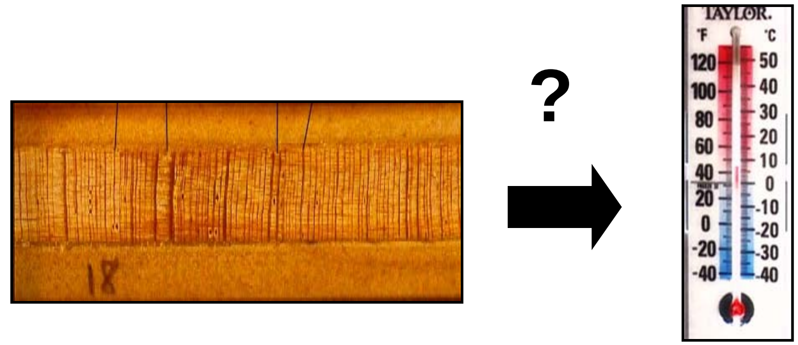



Images: P. Higuera, L. Brubaker; http://www.ncdc.noaa.gov/paleo

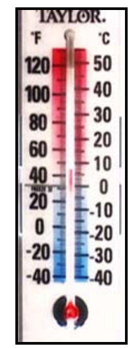
Important characteristics of all proxies:

- *Indirect* measures

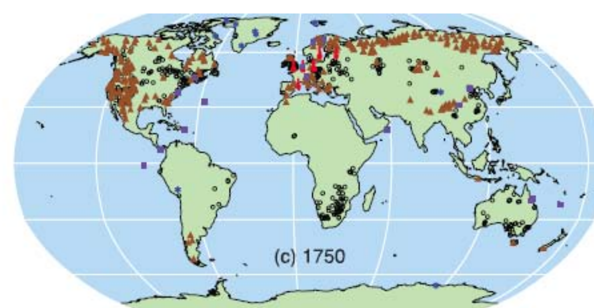


- Precision varies

vs.



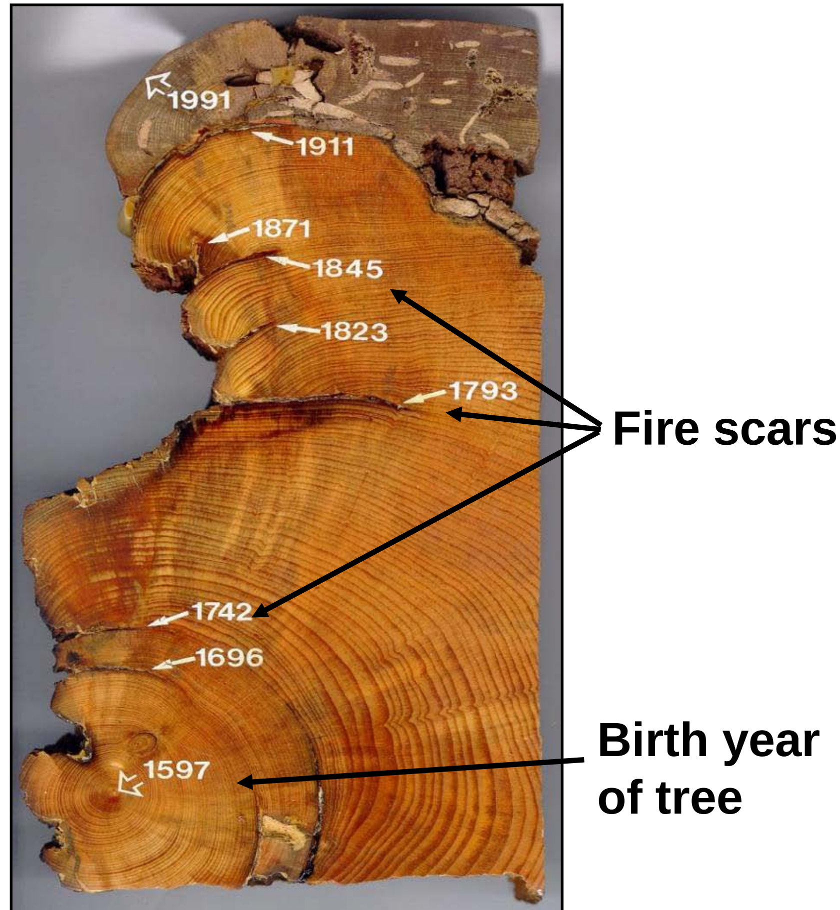
- Availability varies



Images: http://www.ncdc.noaa.gov/paleo; http://web.utk.edu/~grissino/default.html; http://www.ipcc-wg2.org/index.html

Fire-scarred trees: cambium killed by fire on a *portion* of the tree; growth around scar used to determine date of fire

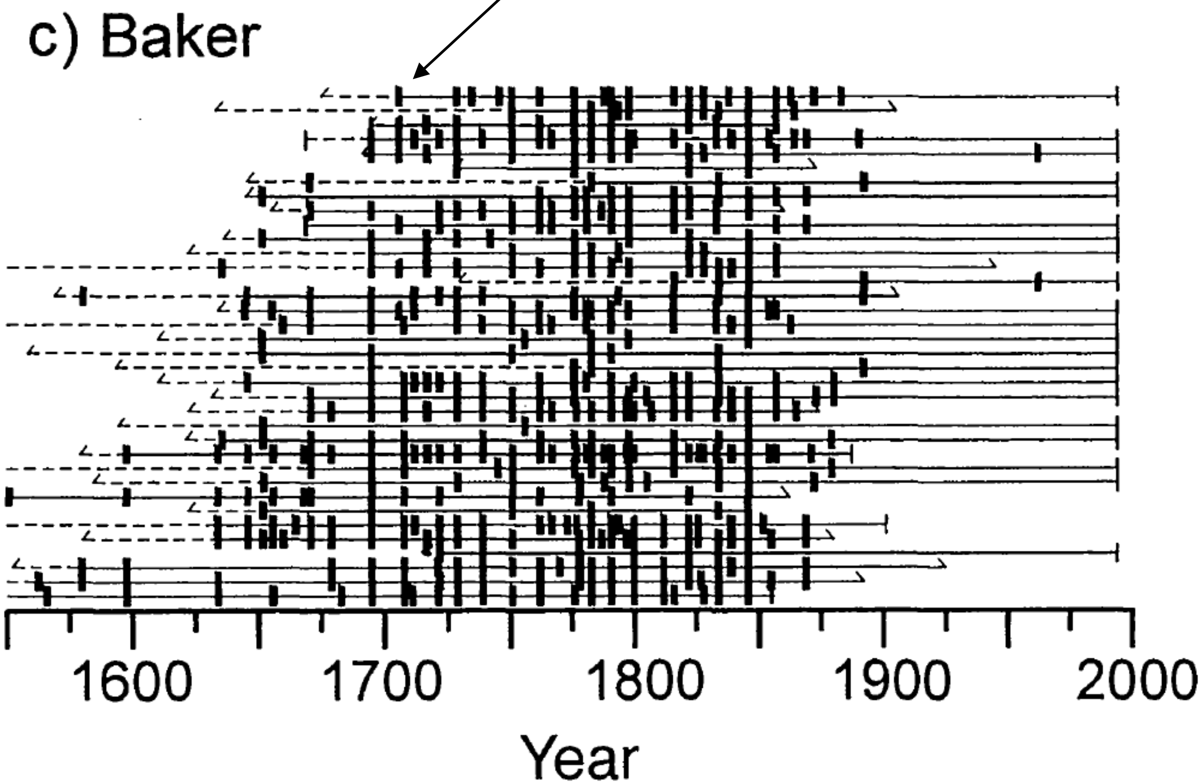
Fire scared ponderosa pine.

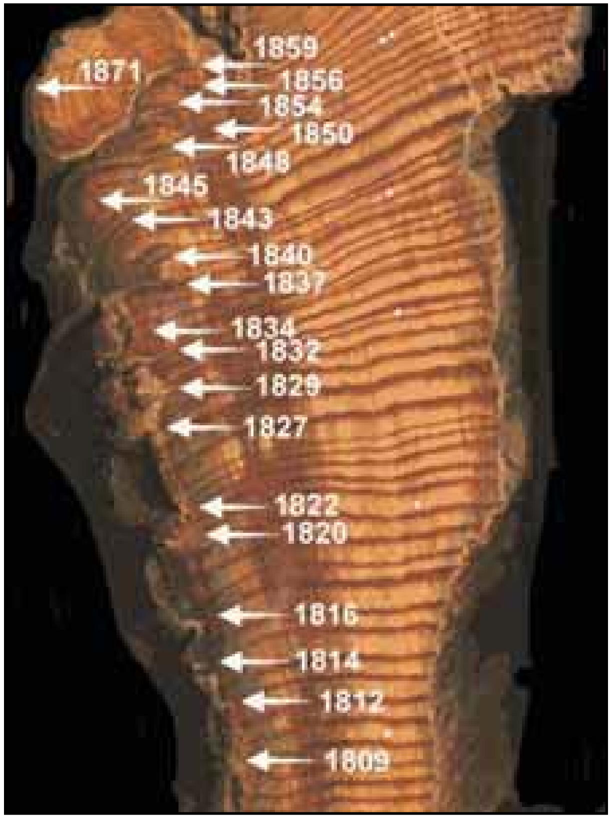


http://www.ncdc.noaa.gov/paleo/impd/firescar-photo.html

Fire-scarred trees:

Fire scars from individual trees





Heyerdahl, E. K., L. B. Brubaker, and J. K. Agee. 2001. Spatial controls of historical fire regimes: A multiscale example from the interior west, USA. Ecology **82**:660-678.

Lake-sediment records

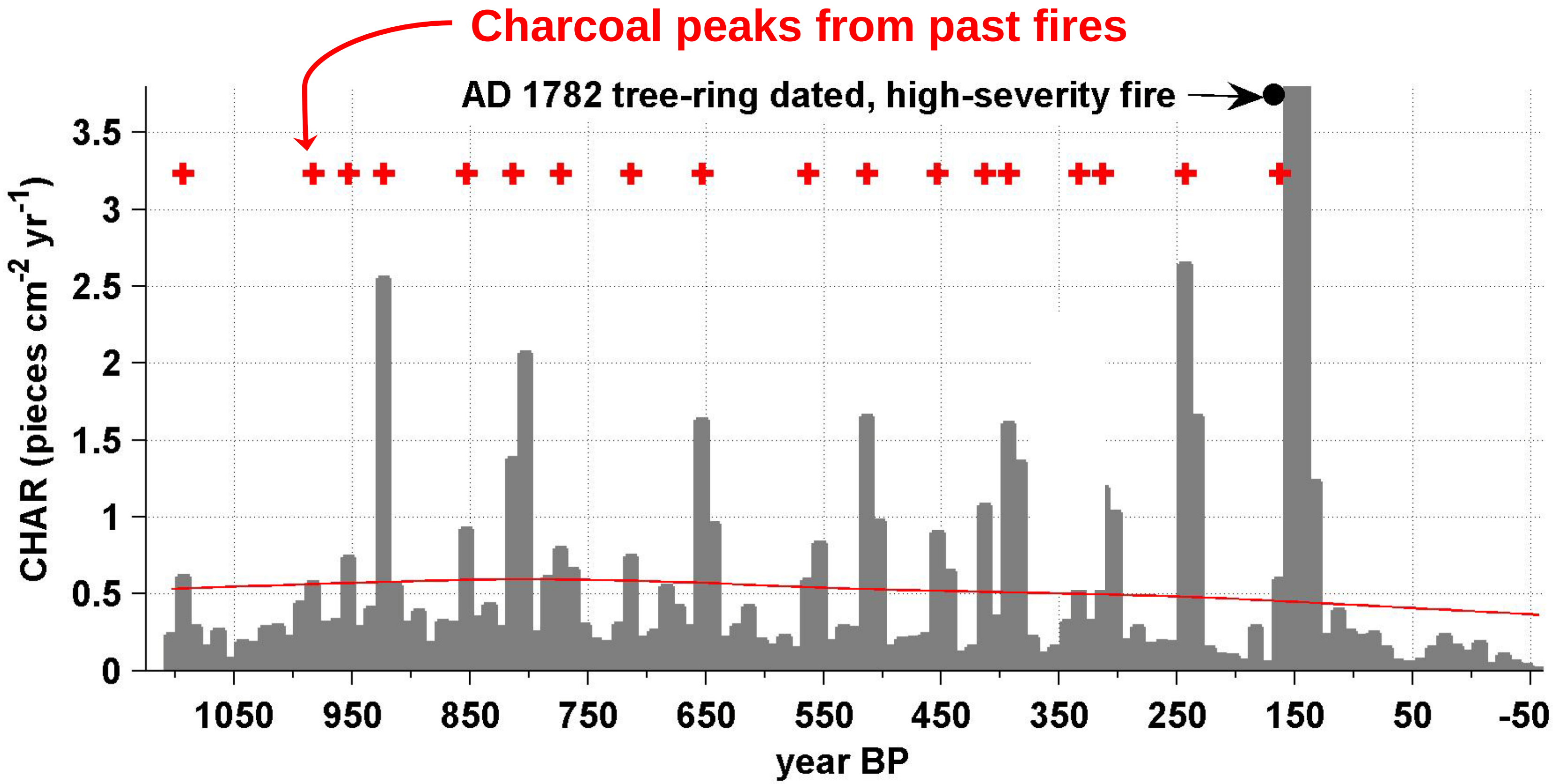
pollen:

macrofossils:

charcoal:

Lake-sediment records

Chickaree Lake, RMNP, CO:



Higuera et al. in prep.

Geomorphic Records

Severe burns

- smooth soil surfaces
- reduced infiltration
- greatly increased surface runoff

'Large fire-related events'

Meyer et al. 1992

Geomorphic Records

Fire-related sedimentation events

1997 deposits

197 ± 43

411 ± 31

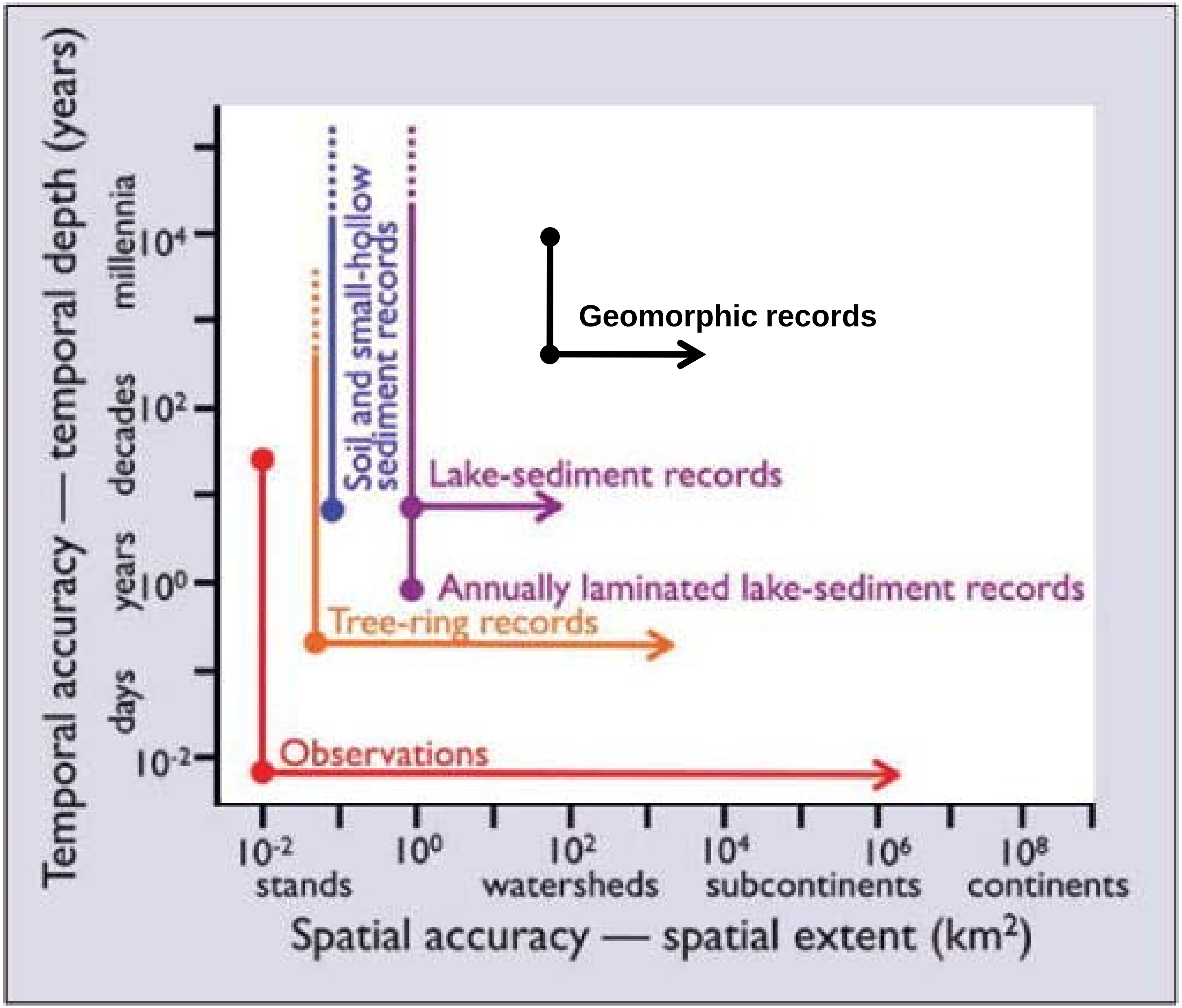
1100 ± 43

1651 ± 44

1722 ± 43

Pierce, Meyer, et al. 2006

Accuracy of fire history proxies:



Modified from Gavin et al. 2007

Key Questions for Today's Class

1. **What can we learn from the past?**
   a) **Context and perspective**
   b) **How fire responds to environmental change**

2. **How do we learn from the past?**

3. **What have we learned from the past?**

3. What have we learned from the past?

A. Climate has been a primary control of biomass burning, at multiple time scales

Millennial, Global

Quaternary Science Reviews 29 (2010) 2918–2930

Fire regimes during the Last Glacial

A.-L. Daniau [a,*], S.P. Harrison [a], P.J. Bartlein [b]

[a] School of Geographical Sciences, University of Bristol, Bristol, BS8 1SS, UK
[b] Department of Geography, University of Oregon, Eugene, OR 97403, USA

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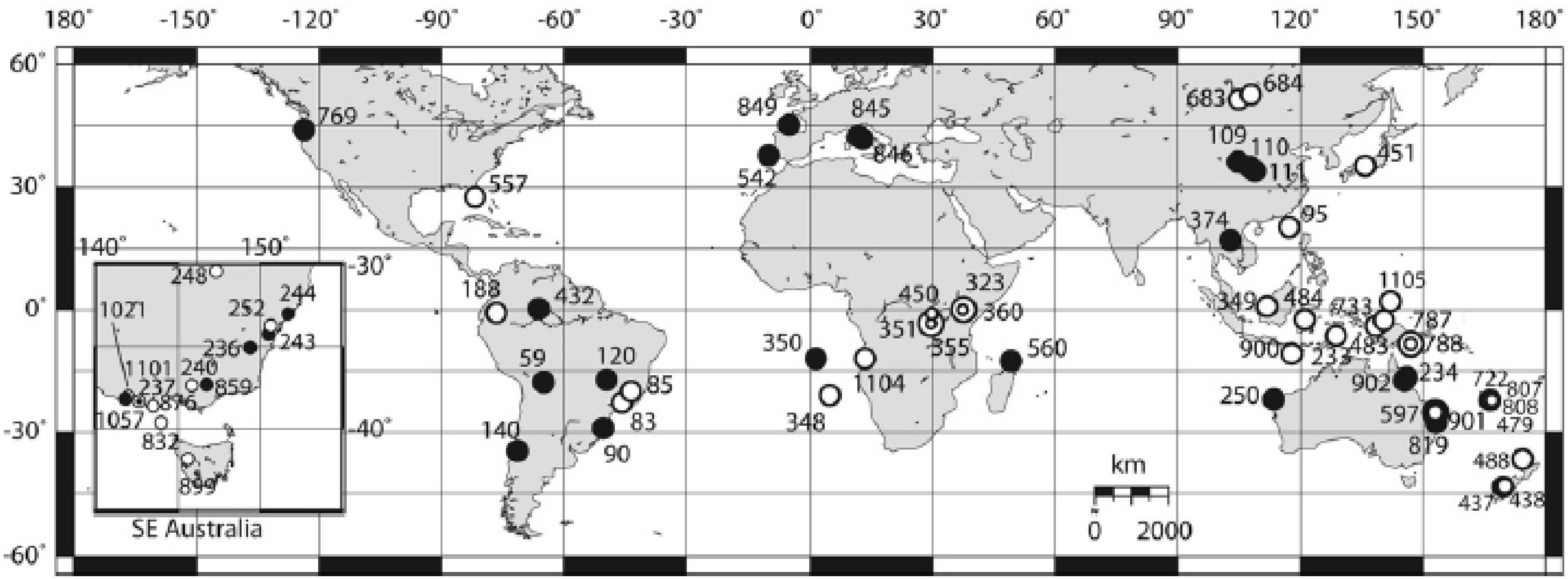
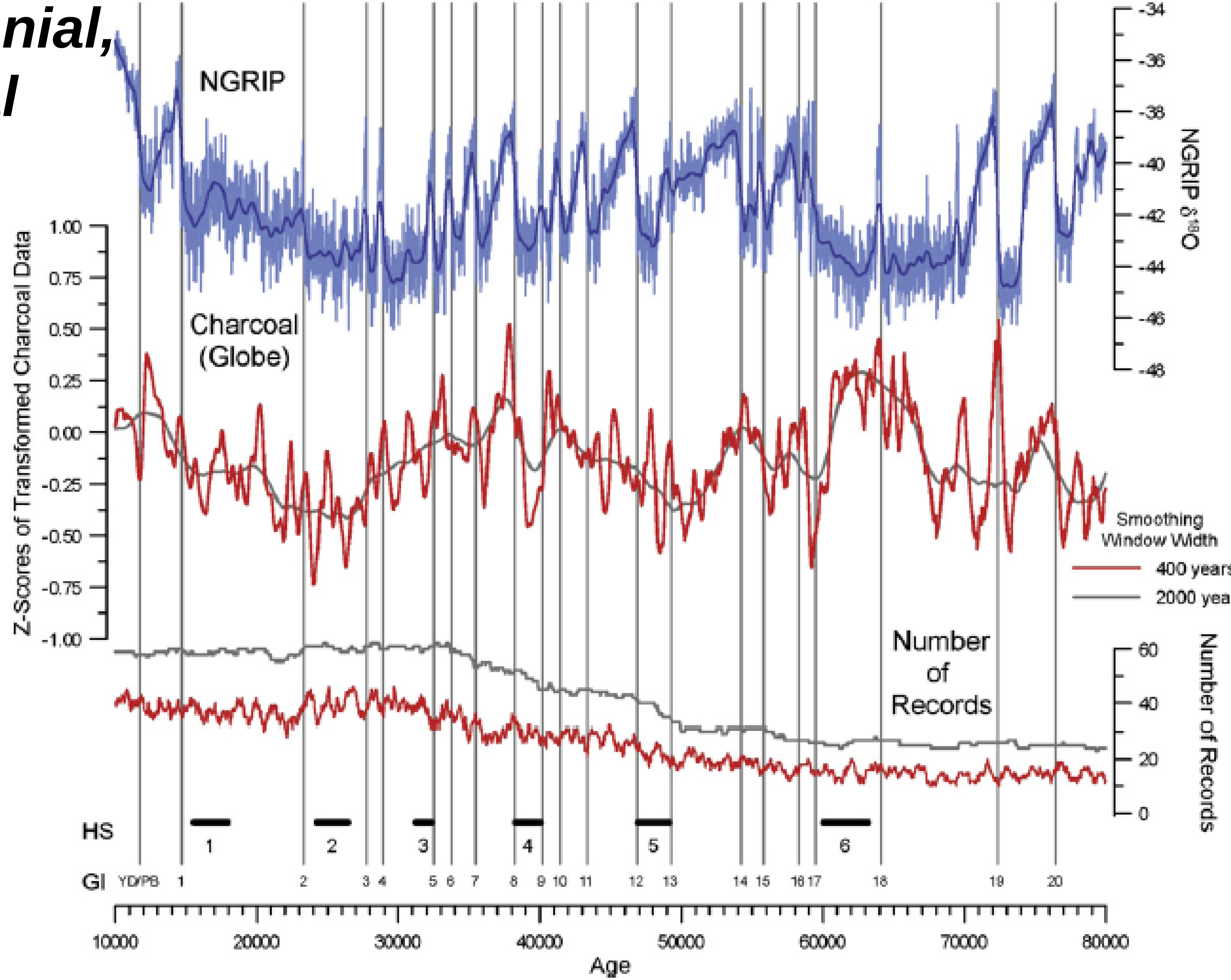


Fig. 1. Location of marine and terrestrial sites with charcoal records covering all or part of the Last Glacial. The sites are classified according to sampling resolution: high (>1 sample per ka) indicated by black circles, or low (<1 sample per ka) indicated by open circles (see Table 1).

Global biomass burning varies with global temperature

Millennial, Global

Charcoal



Temp. proxy

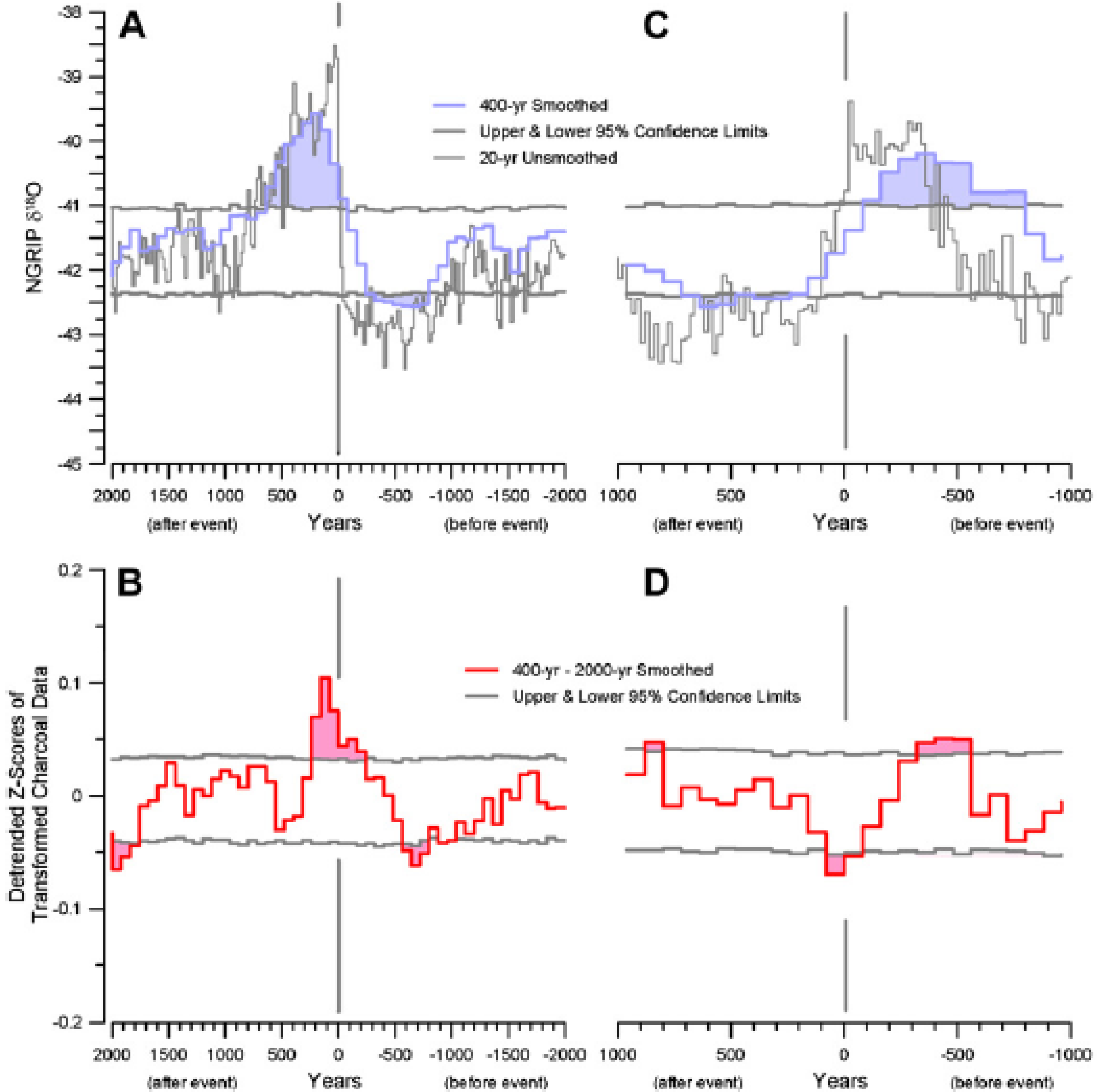
10,000 **Time (yr BP)** **80,000**

Millennial, Global

Climate warming **Climate cooling**

Temp. proxy

Charcoal



After climate event **Before climate event**

Millennial, Hemispheric

Wildfire responses to abrupt climate change in North America

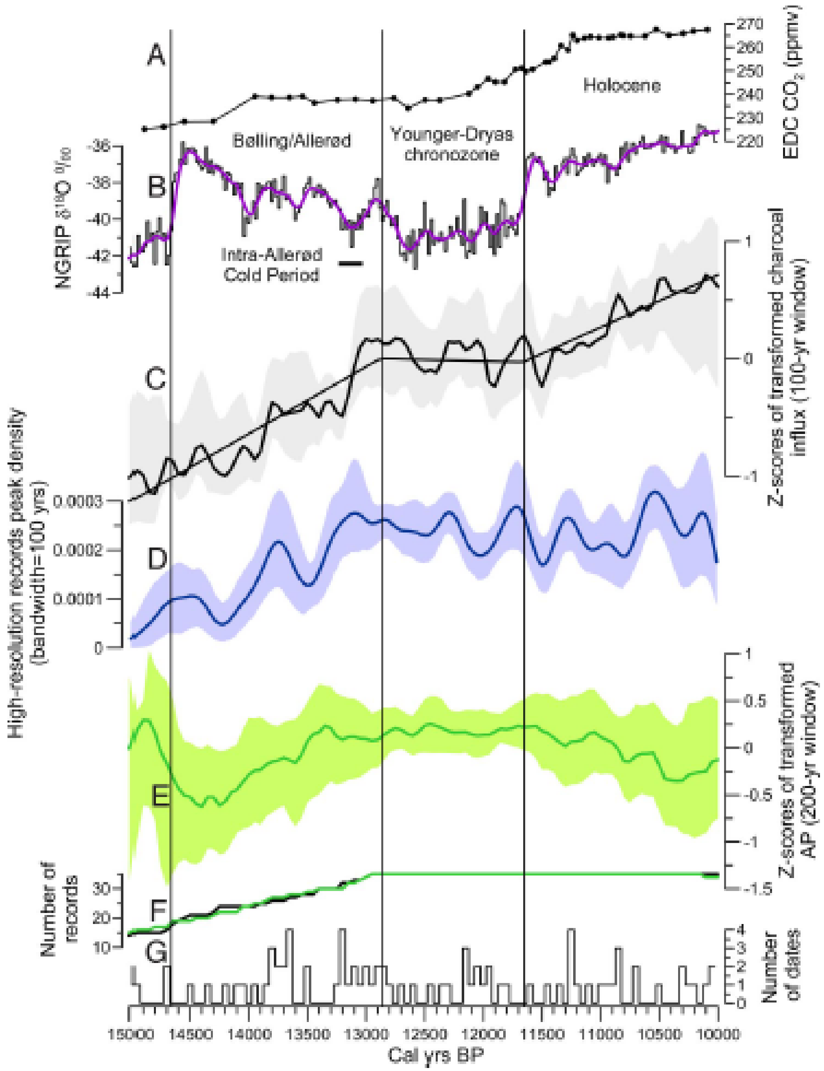
J. R. Marlon[a,1], P. J. Bartlein[a], M. K. Walsh[a], S. P. Harrison[b], K. J. Brown[c,d], M. E. Edwards[e,f], P. E. Higuera[g], M. J. Power[h], R. S. Anderson[i], C. Briles[g], A. Brunelle[h], C. Carcaillet[j], M. Daniels[k], F. S. Hu[l], M. Lavoie[m], C. Long[n], T. Minckley[o], P. J. H. Richard[p], A. C. Scott[q], D. S. Shafer[r], W. Tinner[s], C. E. Umbanhowar, Jr.[t], and C. Whitlock[g]

Temp. proxy

Biomass burning proxy

Fire frequency

Arboreal pollen



15,000 **10,000**

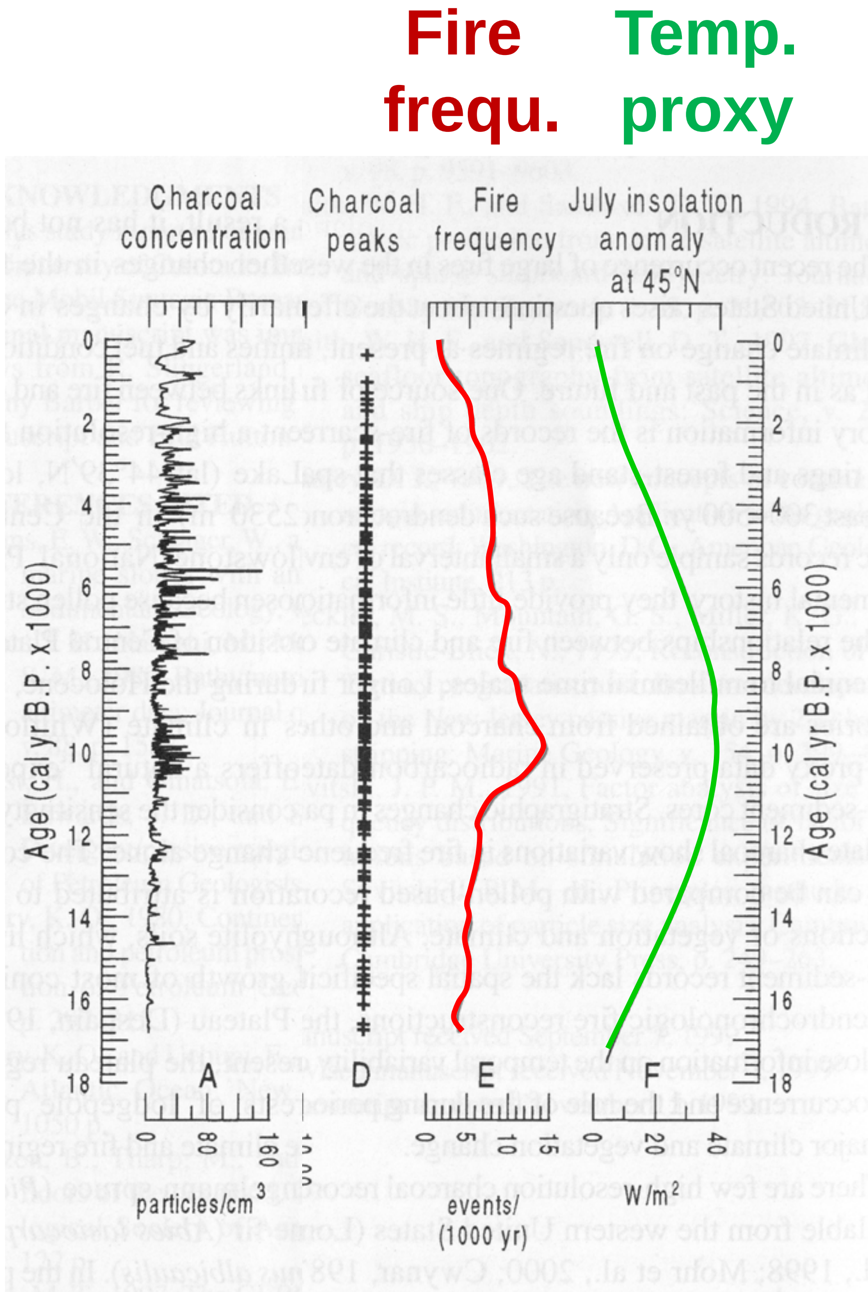
Years before present

Millennial, Regional

Yellowstone NP:

- 17,000 yr. fire history correlates with summer insolation (temp.)

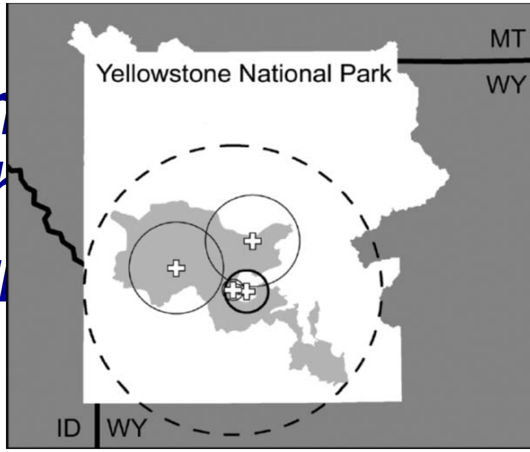
- ***Fire frequencies vary with climate at millennial time scales***

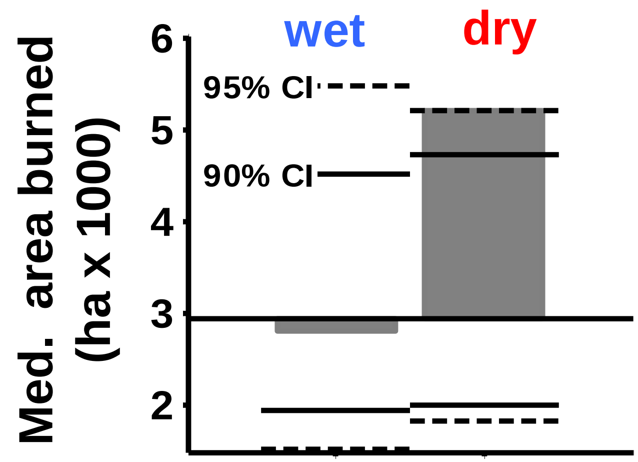


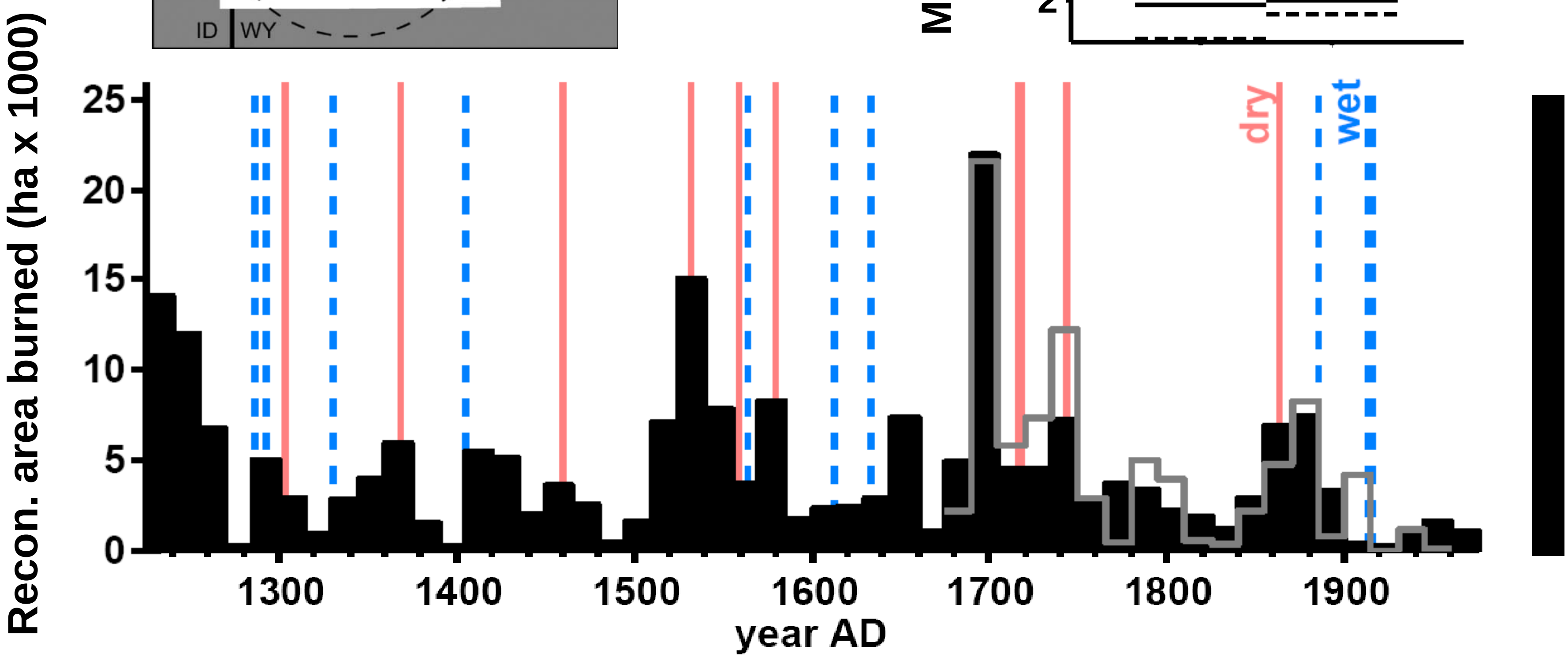
Millspaugh, Whitlock, and Bartlein et al. 2000. Geology 28 (3), 211-214

Centennial

Extrem ***ociated***
with ***ge area***
bur ***50 yr***







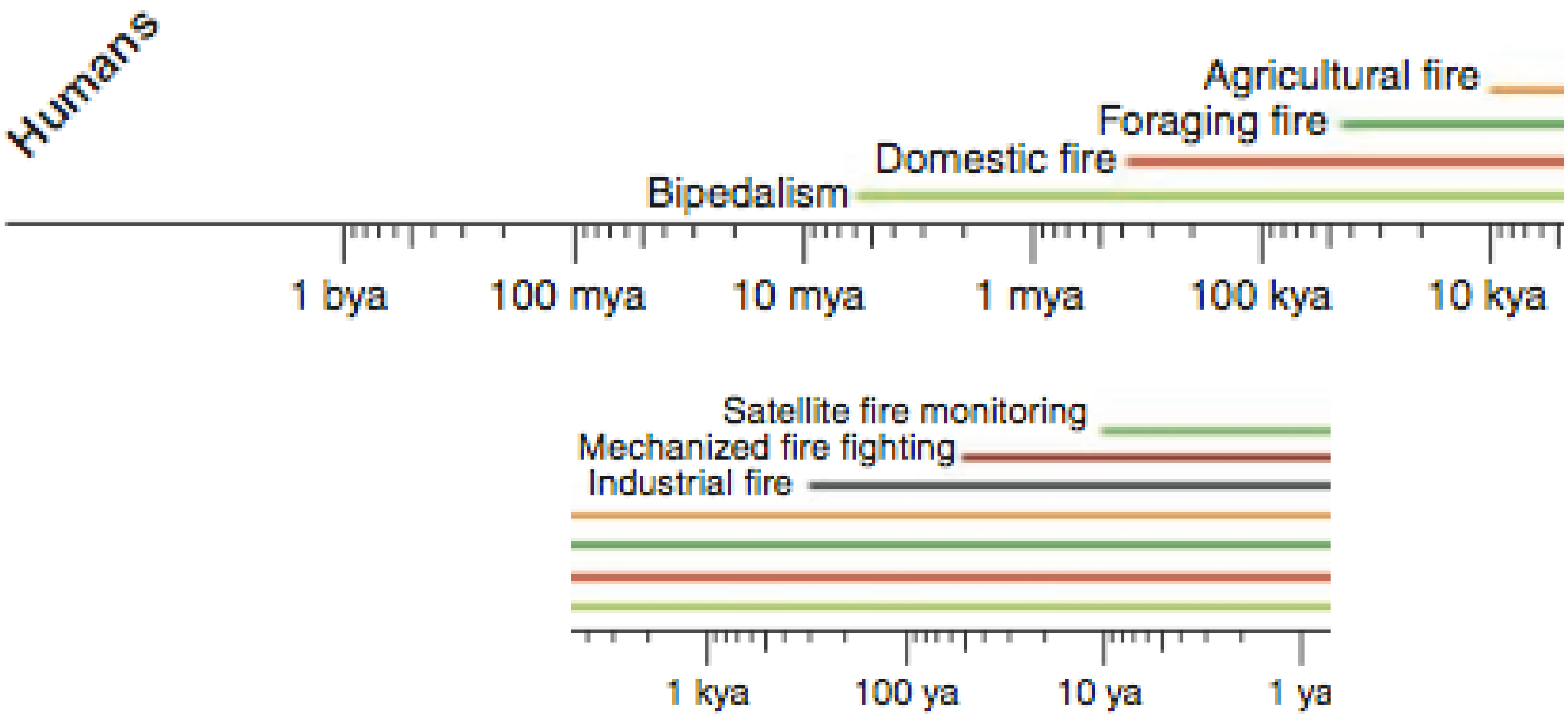
Higuera et al., 2011. Precipitation record: Gray et al. 2007; Tree-ring record: Romme and Despain 1989.

3. What have we learned from the past?

A. ***Climate has been a primary control of biomass burning, at multiple time scales***

B. ***Humans and fire have always been tightly linked, but human impacts on large-scale fire regimes have varied***

Humans and fire: (Bowman et al. 2009)



Years before present

Cottrell 2004

Australian aboriginals and “Firestick farming” – a long-standing and increasingly-relevant question.

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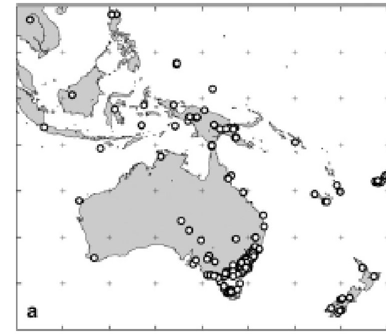
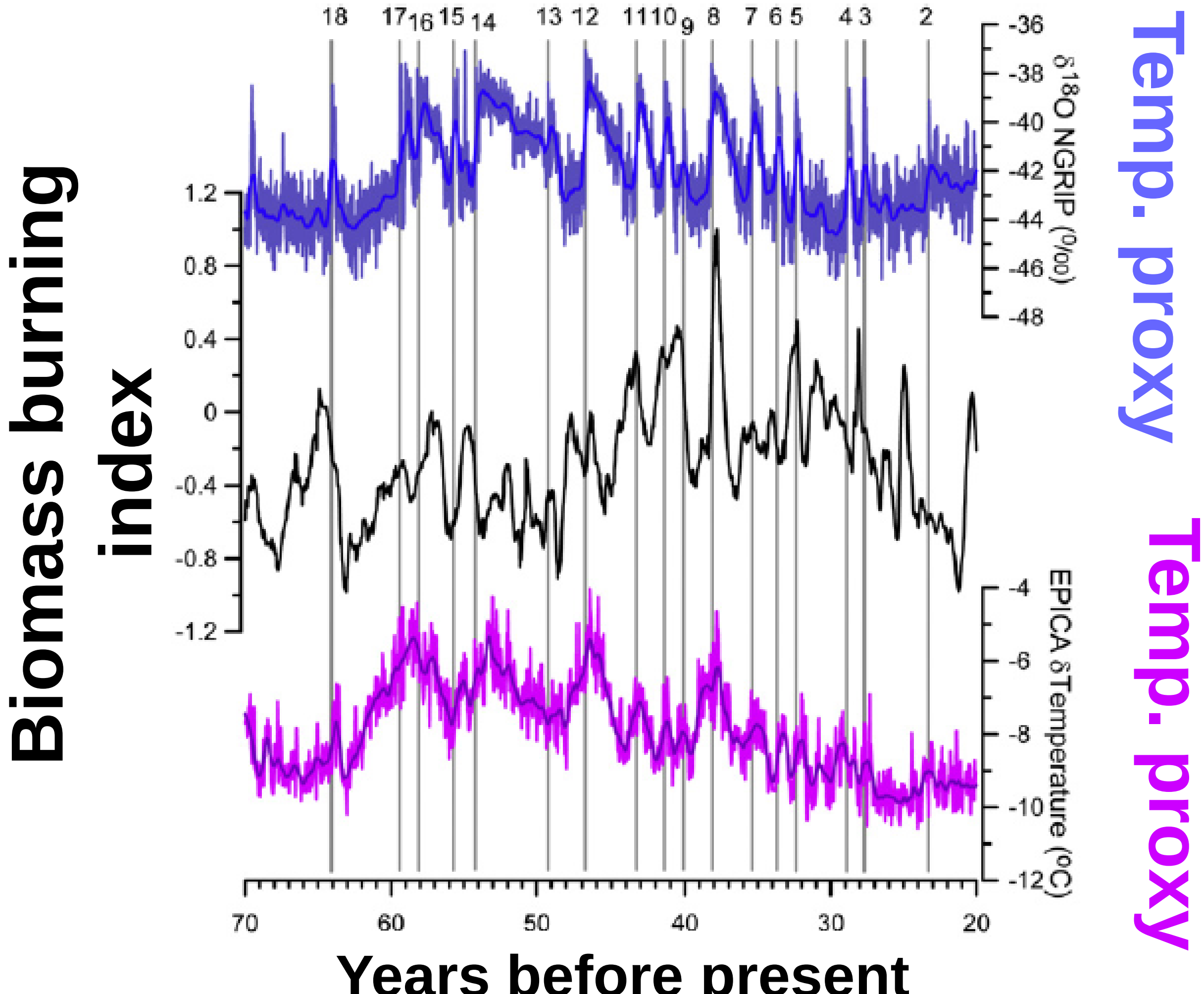


Late Quaternary fire regimes of Australasia

S.D. Mooney[a,*], S.P. Harrison[b], P.J. Bartlein[c], A.-L. Daniau[d], J. Stevenson[e], K.C. Brownlie[f], S. Buckman[f], M. Cupper[g], J. Luly[h], M. Black[a], E. Colhoun[i], D. D'Costa[j], J. Dodson[k], S. Haberle[e], G.S. Hope[e], P. Kershaw[l], C. Kenyon[m], M. McKenzie[l], N. Williams[n]



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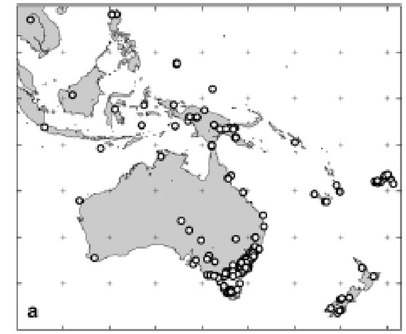
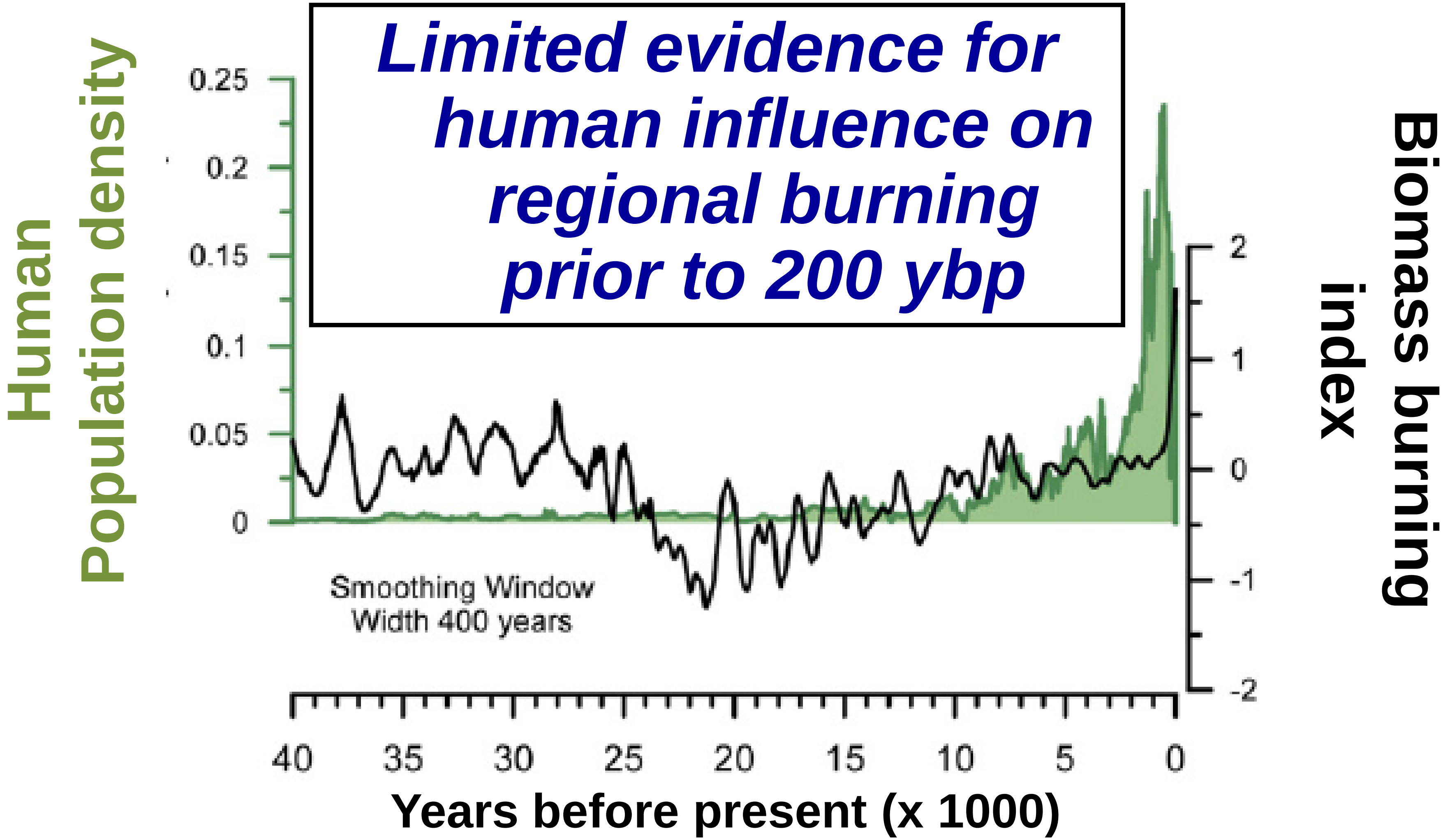




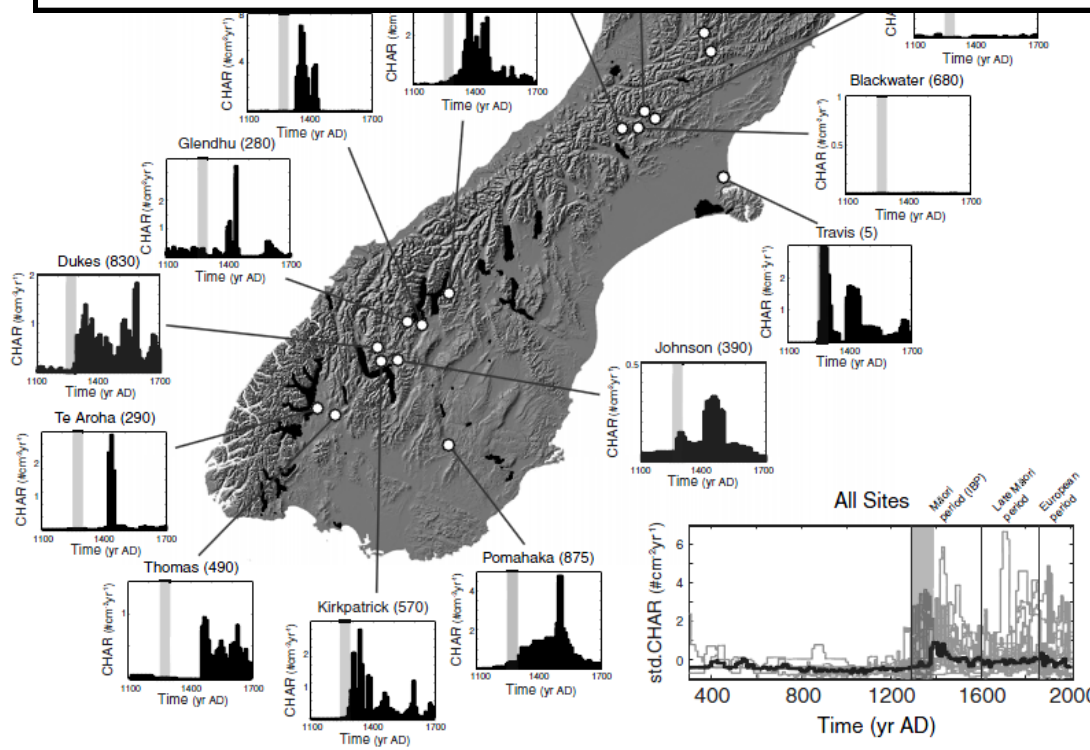
Rapid landscape transformation in South Island, New Zealand, following initial Polynesian settlement

David B. McWethy[a,1], Cathy Whitlock[a], Janet M. Wilmshurst[b], Matt S. McGlone[b], Mairie Fromont[b], Xun Li[c], Ann Dieffenbacher-Krall[d], William O. Hobbs[a], Sherilyn C. Fritz[e], and Edward R. Cook[f]

- **Initial burning period: widespread and coincident with human arrival**

- **Little evidence that climate change played a roll**

Humans had immediate and dramatic impacts on forest communities, via fire.

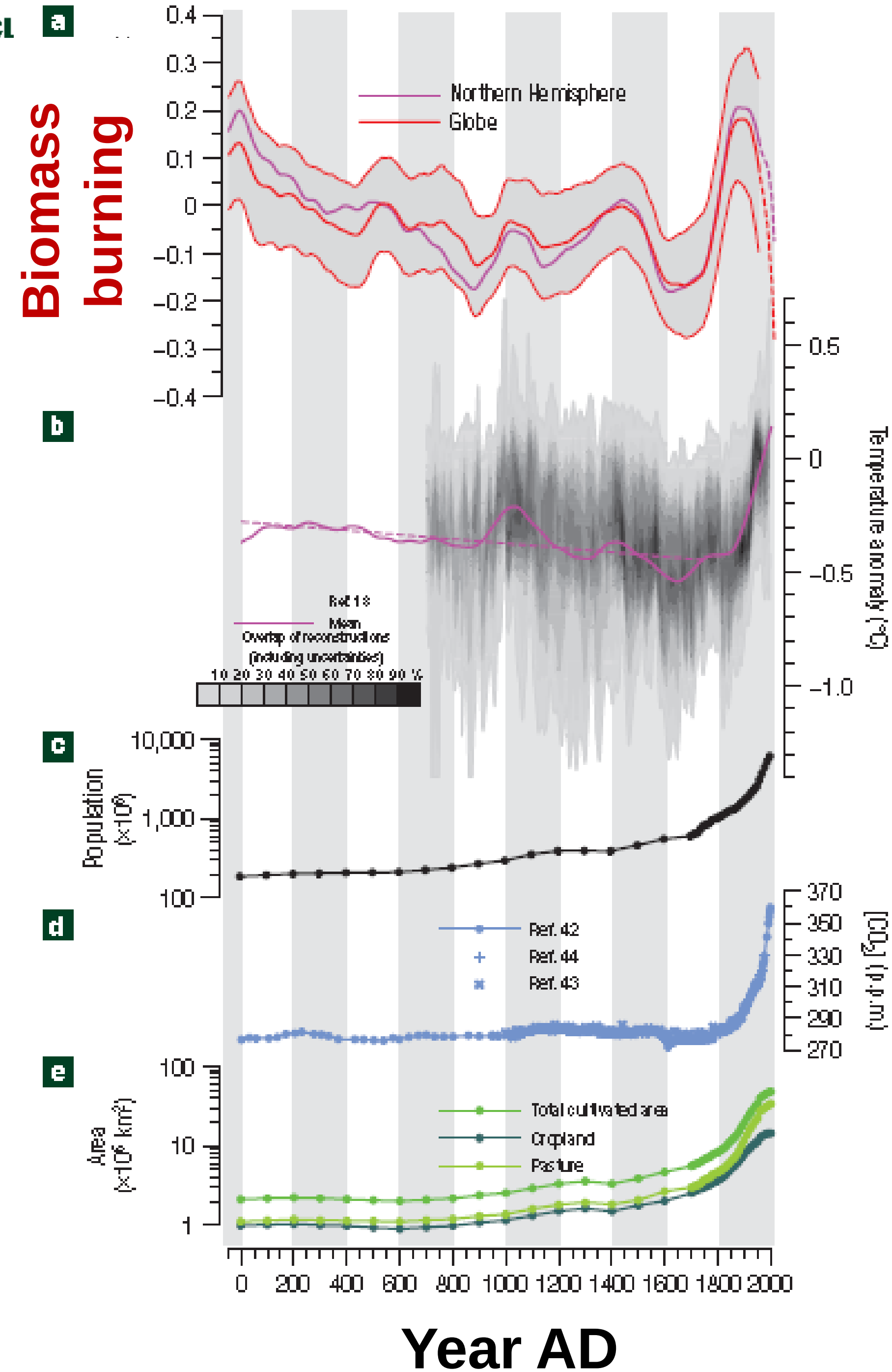


McWethy et al. 2010
Cottrell 2004

Climate and human influences on global biomass burning over the past two millennia

J. R. MARLON[1]*, P. J. BARTLEIN[1], C. CARCAILLET[2], D. G. GAVIN[1], S. P. HARRISON[3], P. E. HIGUERA[4], F. JOOS[5], M. J. POWER[6] AND I. C. PRENTICE[7]

Climate dominant until ca. mid 19th century, then human impacts important, globally



Summary

- **Fire has been a key process in the evolution of our planet, for millions of years**
- **Fire regimes have varied at multiple time scales, largely in response to direct and indirect impacts of climate change**
- **Human have existed with fire for millions of years, and impacts vary among ecosystems and time periods**

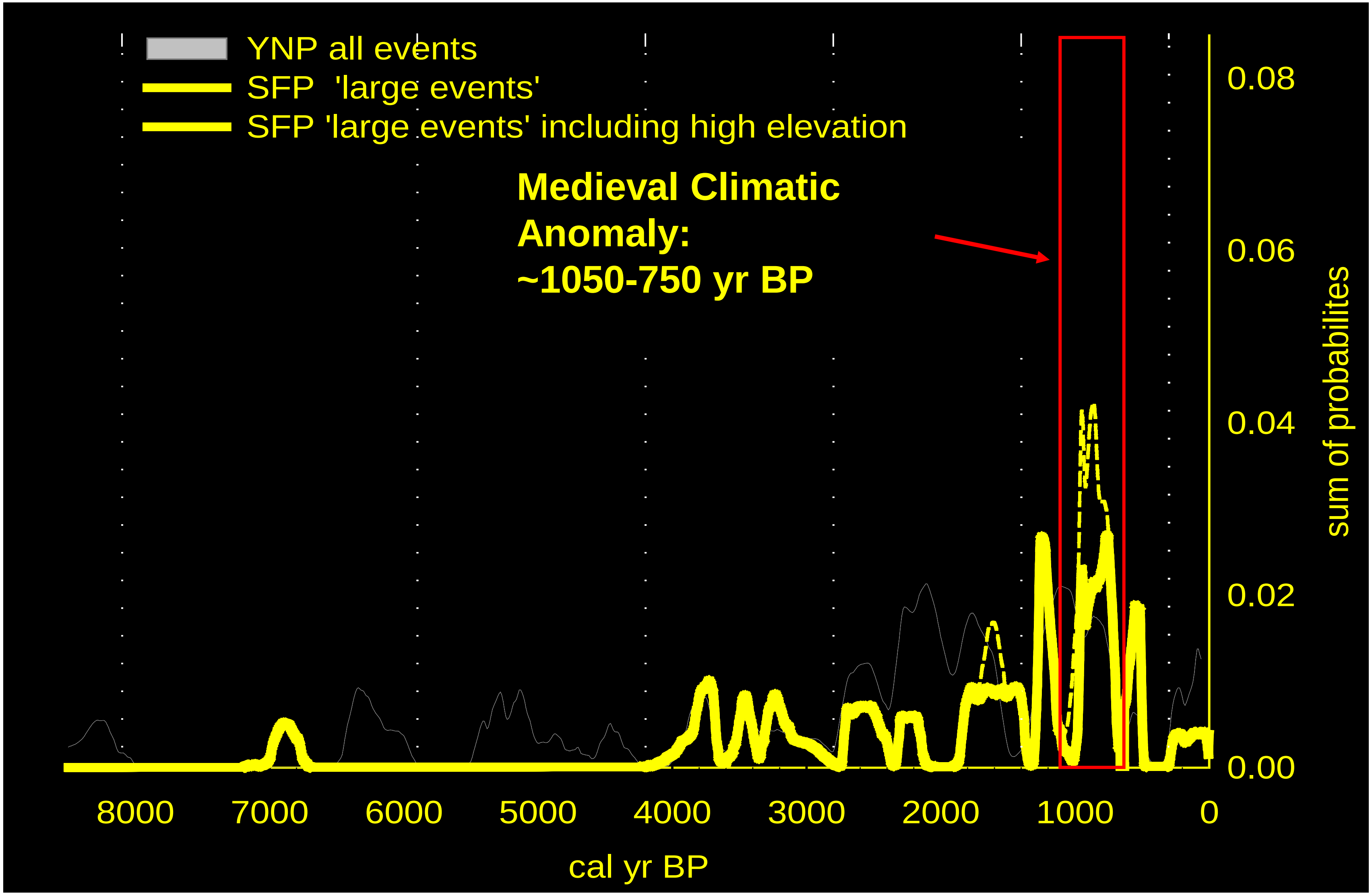
Questions?

High severity 1988 fire in subalpine forest of Yellowstone National Park.

Some Resources

- NOAA Paleoclimate Web Page: http://www.ncdc.noaa.gov/paleo/
  - Information on all aspects of paleoclimate research and findings, including raw data.
- IPCC 2007, Working Group 2 (Scientific Basis): http://www.ipcc-wg2.org/index.html
  - The Intergovernmental Panel of Climate Change's latest report.
- The Ultimate Tree-ring Web Page (literally): http://web.utk.edu/~grissino/default.html
  - Everything you could want to know about tree-ring research.
- Brown University pollen viewer: http://www.geo.brown.edu/georesearch/esh/QE/Research/VegDynam/VegAnima/Viewer31/WebViewer.html

Idaho 'large events' & Yellowstone National Park



Pierce et al. 2004