Forest histories & Forest futures

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Unprecedented climate change

Last 400,000 yrs

Temperature and CO₂ concentration in the atmosphere over the past 400,000 years (from the Vostok ice core)

>380 ppm in 2005

Last 2000 yrs

Last 150 yrs

Carbon Dioxide

in atmosphere at Mauna Loa (approx 372 in 2003)

Approx. 14°C 58.4°F in 1998 (hottest year measured)

Temperatures AD 200-2000,

from proxy temperature indicators and direct measurement (red),
“History is more or less bunk.”

~Henry Ford, 1916
Lakes are the place!
Eruption 7676 yrs ago
Sediment records with annual precision

Crevice Lake, YNP
MSU Paleoecology Lab
Douglas-fir pollen (80 microns)

Ragweed pollen (30 microns)

Charcoal particles

Fossil beetle remains
Climate
(climate variability, mean state)

Fire
(frequency, size, intensity)

Vegetation
(composition, structure)

Humans
(ignition, suppression)
GYE: 20,000 years ago

Smith & Siegel, 2000
GYE ~17,000 years ago

GYE today
Climate
(climate variability, mean state)

Fire
(frequency, size, intensity)

Vegetation
(composition, structure)

Humans
(ignition, suppression)
40,000 years of vegetation dynamics at Little Lake, OR

Worona & Whitlock, 1995
Long et al., 1998
Grigg et al., 2003
Little Lake, Oregon Coast Range

Worona & Whitlock, 1995
20,000 years ago:
Full-glacial cold dry period

15,000 years ago
Late-glacial warming

present
Regional vegetation-climate patterns

Updated from Mock and Brunelle, 1999
Location matters

- rhyolite
- andesite
- glacial
Geology influences the vegetation

Glacial deposits: grassland

Yellowstone eruptions
rhyolite: lodgepole pine forest

Older volcanic eruptions
andesite: spruce/fir forest

Photo: Tom Murphy
Cygnet Lakes, Yellowstone NP
Cygnet Lake on rhyolite

Millspaugh et al., 2000
Cygnet Lake on rhyolite

Millspaugh et al., 2000
Cygnet Lake on rhyolite

Millspaugh et al., 2000
Geology has affected the vegetation history

Glacial deposits: grassland

Yellowstone eruptions rhyolite: lodgepole pine forest

Older volcanic eruptions andesite: spruce/fir forest

Photo: Tom Murphy
~Lessons learned~

• Lakes are excellent sources of environmental information;

• Large-scale patterns in vegetation change are a response to large-scale changes in climate;

• At single sites, vegetation changes can be large and rapid;

• Challenge is to separate climate from local drivers of environmental change.
Climate (climate variability, mean state)

Fire (frequency, size, intensity)

Vegetation (composition, structure)

Humans (ignition, suppression)
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.

In 1997-98, the southeast wind pattern—normally D-1 Southerly and central D-1—was perturbed by human activity.

Fire in the Earth System

David J. S. Bowman,1 Jennifer K. Baich,2,4†, Paulo Artaxo,5 William J. Bond,1
Jean M. Carlson,7 Mark A. Cochrane,8 Carla M. D’Antonio,9 Ruth S. DeBries,10 John C. Doyle,11
Sandy P. Harrison,12 Fay H. Johnstone,13 Jon E. Keeley,14,15 Meg A. Knapp,16
Christian A. Kull,17 J. Brad Murray,18 Max A. Moritz,14 L. Colin Prentice,19 Christopher I. Roos,20
Andrew C. Scott21 Thomas W. Swetnam,12 Guido R. van der Weij,22 and Stephen J. Pyne24

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

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

Tanja Schoennagel1, Cara R. Nelson2, David M. Theobald3, Gunnar C. Carnwath4, and Teresa B. Chapman5

Seemingly unprecedented events in human lifetimes can be business-as-usual when viewed on longer time-frames. But that’s not always recognized. For example, management strategies in the United States that seek to restore landscapes

In the past 15 years, the western United States has experienced some extreme fires—noteable for their size and severity. The annual costs of fire suppression now exceed $1.6 billion, and the ceiling seems nowhere in sight.

In the absence of large fires during most of
Fires are nothing new!

35-55-my-old *Sequoia* have fire scars
Different explanations at different spatial and temporal scales.
Fires in the Western U.S.

Lightning-Started Fires 1986-1996

Human-Started Fires 1986-1996

National Fire Occurrence Data Base  http://www.fs.fed.us/fire/fuelman/

P.J. Bartlein, unpub.
1986-1996 Daily Fire Starts

Bartlein et al. (2003)
Years with Large Area Burned are associated with:

- Well-developed upper-level ridge
- Sinking air
- Persistent high pressure system

Bartlein, unpublished
How frequent are large severe fires?

Yellowstone NP 1988
Fire history:
Fire-scars on tree rings

- Extend back 300-500 years
- Spatially & temporally precise
- Describe fires that don’t kill trees
Fire history:
Charcoal records

• 1000s years old
• Describe severe fires
• Register local & regional fires
Fire-climate linkages on millennial time scales

Fire frequency changed, even when vegetation did not.

Millspaugh et al., 2000
Different parts of YNP have different fire histories
C. Briles
J. Mohr, T. Minckley
M. Power, C. Whitlock
A. Brunelle, C. Whitlock
S. Millspaugh, C. Whitlock, R. Sherriff
C. Long, M. Worona
C. Briles
J. Mohr, T. Minckley
Patterns of past fire occurrence

Whitlock et al., 2008
~Lessons learned~

Fire and climate are closely linked on many time scales:

• Information from historical, tree-ring, and charcoal records;

• Large-area burns associated with predictable circulation patterns;

• We’ve had lots of fires, and regional differences in fire history. Knowing time of last fire is not enough.
Climate (climate variability, mean state)

Fire (frequency, size, intensity)

Vegetation (composition, structure)

Humans (ignition, suppression)
Fire-human linkages

Patagonia?

American West?
Willamette Valley Fire History

Walsh, 2008
Willamette Valley, western Oregon

- Prehistoric human influence is localized;
- Decrease in fires in last 600 years;
  - Cooler climate during Little Ice Age?
  - Decrease in human populations?
- Euroamericans burned a lot initially.
Can we separate human-set fires from natural ones?
Before the Māori arrived

- Fires were generally rare.
- Fire return intervals typically > 500 yrs
- Native species not adapted to fire and highly vulnerable

Ogden et al., 1998
After Māori arrived

- Fire frequency increased dramatically;
- Fire return intervals < 20 yrs;
- Dramatic shift in vegetation from forest to grasses and shrubs.
NZ loss of forest in the last 700 years
Initial Burning Period
(AD 1250-1400)

McWethy et al., 2009
Response of watersheds to Initial Burning Period

Years before fire

Years after fire
Unresolved Questions

• What motivated Māori burning?
• What is the spatial pattern of burning?
• Why did burned forests NOT recover?
• What role did climate play?
Global patterns in fire history
(Global Palaeofire Working Group, IGBP activity)

Changes in fire regimes since the Last Glacial Maximum:
an assessment based on a global synthesis and analysis
of charcoal data

M. J. Power · J. Marlon · N. Ortiz · P. J. Bartlein · S. P. Harrison · F. E. Mayle · A. Ballouche ·
R. H. W. Bradshaw · C. Carcaillat · C. Cordova · S. Mooney · P. I. Moreno · I. C. Prentice ·
K. Thonicke · W. Tinner · C. Whitlock · Y. Zhang · Y. Zhao · A. A. Ali · R. S. Anderson · R. Beer ·
H. Behling · C. Briles · K. J. Brown · A. Brunelle · M. Bush · P. Camill · G. Q. Chu · J. Clark ·
D. Colombaroli · S. Connor · A.-L. Daiau · M. Daniels · J. Dodson · E. Doughty · M. E. Edwards ·
W. Finsinger · D. Foster · J. Frechette · M.-J. Gaillard · D. G. Gavin · E. Gobet · S. Haberle ·
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T. Minckley · J. Mohr · D. M. Nelson · J. New · R. Newnham · R. Noti · W. Oswald · J. Pierce ·
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C. Turney · D. H. Urrego-Sanchez · C. Umanhowar · M. Vangergooses · B. Vanniere · E. Vescovi ·
M. Walsh · X. Wang · N. Williams · J. Wilmshurst · J. H. Zhang

Climate Dynamics, 2008
Wildfires have been a natural part of the Earth system for millions of years. A new charcoal database for the past two millennia shows that human activity increased biomass burning after AD 1750 and suppressed it after AD 1870.

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

J. R. Marlon*, P. J. Bartlein¹, C. Carcaill², D. G. Gavin¹, S. P. Harrison³, P. E. Higuera⁴, F. Joos⁵, M. J. Power⁶ and I. C. Prentice⁷

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Global patterns in biomass burning in the last 2000 years: another hockey stick?

Marlon et al., 2008
Global biomass burning trends

- Declined between AD 0-1750 (climate)
- Rose between AD 1750-1870 (forest clearance)
- Declined after AD 1870 (land-use changes)
The impact of contemporary human activity has been to reduce biomass burning.

Marlon et al., 2008
Lessons learned

Fire-human linkages are understandable on multiple spatial and temporal scales:

- Prehistoric burning was localized in western US;
- Anthropogenic burning in the absence of natural fires is profound and long-lived;
- Charcoal levels have declined in last century (fire elimination and land-cover change).
“As a rule, we get as much information out of what [history] does not say as we get out of what it does say...history consists of two equal parts: one of these halves is statements of fact, the other half is inference, drawn from fact.”

~Mark Twain, 1901
Why history?

- Understanding forest resilience requires historical perspectives
- Ecosystems change on all time scales, but which is the most relevant for managing forests in the face of climate change?
- Scale and impact of recent anthropogenic burning has been large.

Suppression costs (Forest Service):
- 2002: $1.2 billion
- 2006: $1.5 billion
- 2007: $1.4 billion

Westerling et al., 2006

Forest Vulnerability: Early – Late Moisture Deficit