Forest histories & Forest futures

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Unprecedented climate change

Last 400,000 yrs

>380 ppm in 2005

Last 2000 yrs

Last 150 yrs
“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
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
The diagram illustrates the vegetation changes over time, with ages indicated in radiocarbon years (cal yr B.P., x1000). Different locations are represented by different color schemes:

- **Indian Prairie, OR**
  - Age 0: Tsuga heterophylla, Pseudotsuga, & Abies amabilis forest
  - Age 1-2: Pseudotsuga, Alnus rubra, Thuja plicata, & Tsuga heterophylla forest
  - Age 3-7: Pseudotsuga, Abies, & Quercus forest
  - Age 8-10: Abies forest
  - Age 11-16: Subalpine parkland

- **Little Lake, OR**
  - Age 0-2: Pseudotsuga, Tsuga heterophylla, & Abies forest
  - Age 3-7: Pseudotsuga, Alnus rubra, Thuja plicata, & Tsuga heterophylla forest
  - Age 8-10: Abies forest
  - Age 11-16: Subalpine parkland

- **Crater Lake, CA**
  - Age 0: Tsuga mertensiana & Abies forest
  - Age 1-2: Pseudotsuga, Alnus rubra, Thuja plicata, & Tsuga heterophylla forest
  - Age 3-7: Pseudotsuga, Abies, & Quercus forest
  - Age 8-10: Abies forest
  - Age 11-16: Subalpine parkland

- **Bluff Lake, CA**
  - Age 0: Pseudotsuga, Abies, & Quercus forest
  - Age 1-3: Pseudotsuga, Abies, & Quercus forest
  - Age 4-6: Pinus, Abies forest
  - Age 7-9: Pinus, Abies, & Quercus forest
  - Age 10-12: Pinus & Abies forest
  - Age 13-15: Pinus & Abies forest
  - Age 16: Subalpine parkland

- **Cedar Lake, CA**
  - Age 0-2: Pseudotsuga, Abies, & Quercus forest
  - Age 3-5: Pinus, Abies forest
  - Age 6-8: Pinus, Quercus, & Poaceae forest
  - Age 9-11: Pinus, Quercus, & Poaceae forest
  - Age 12-14: Pinus & Abies forest
  - Age 15-16: Pinus & Abies forest

- **Swamp Lake, CA**
  - Age 0: Abies & Cupressaceae forest
  - Age 1-2: Pinus, Abies forest
  - Age 3-5: Pinus, Abies, & Quercus forest
  - Age 6-8: Pinus, Quercus, & Poaceae forest
  - Age 9-11: Pinus, Quercus, & Poaceae forest
  - Age 12-14: Pinus & Cupressaceae forest
  - Age 15-16: Pinus & Cupressaceae forest

- **Point Reyes, CA**
  - Age 0: Quercus, Asteraceae, & Pteridium woodland
  - Age 1-2: Pinus, Abies, & Cupressaceae forest
  - Age 3-5: Pinus, Abies, & Cupressaceae forest
  - Age 6-8: Pinus, Abies, & Cupressaceae forest
  - Age 9-11: Pinus, Abies, & Cupressaceae forest
  - Age 12-14: Abies & Pseudotsuga forest

References:
- Sea & Whitlock, 1995
- Worona & Whitlock, 1995
- West, 1989
- Smith & Anderson, 1992
- Rypins et al. 1989
Regional vegetation-climate patterns

Updated from Mock and Brunelle, 1999
Geology influences the vegetation

Glacial deposits: grassland

Yellowstone eruptions
rhyolite: lodgepole pine forest

Older volcanic eruptions
andesite: spruce/fir forest

Photo: Tom Murphy
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 annual rate of carbon emissions from fires in Indonesia was 1.2 gigatons, or, forest cover burned should be removed annually.

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 P. D. Perry7

Natural disturbances and the biological legacies produced by them are often poorly understood by policy-makers and natural-resource managers. Recent large-scale natural disturbances include wildfires burned nearly 10 million ha in Indonesia 1997–98, 1 million ha in Russia, 110 million ha in Central and South America and 4 million ha in Brazil (1–2).

Fire in the Earth System


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.

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

Tanja Schoennagel31, Cara R. Nelson32, David M. Theobald33, Gunnar C. Carnwath34, and Teresa B. Chapman35
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

Lightning

Human

All

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?
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.

Cygnet Lake, central YNP

Millspaugh et al., 2000
Different parts of YNP have different fire histories
July/January Precipitation Ratio

Summer-dry

Summer-wet

Jul/Jan

10.0  7.5  5.0  2.5  2.0  1.5  1.25  1.0  0.80  0.67  0.50  0.40  0.20  0.13  0.10

有色

绿色

蓝色
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

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?

Gray & Jorden, 2000
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

- Lake Diamond (elev. 380 m)
- Lake Kirkpatrick (elev. 570 m)
- Lake Thomas (elev. 490 m)
- Lake Te Aroha (elev. 290 m)

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. Carcaillet • 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. Daniau • 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 • D. J. Hallett • P. Higuera • G. Hope • S. Horn • J. Inoue • P. Kaltenrieder • L. Kennedy • Z. C. Kong • C. Larsen • C. J. Long • J. Lynch • E. A. Lynch • M. McGlone • S. Meeks • S. Mensing • G. Meyer • T. Minckley • J. Mohr • D. M. Nelson • J. New • R. Newnham • R. Noti • W. Oswald • J. Pierce • P. J. H. Richard • C. Rowe • M. F. Sanchez Goñi • B. N. Shuman • H. Takahara • J. Toney • C. Turney • D. H. Urrego-Sanchez • C. Umanhnowar • M. Vandergoes • 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


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Nature Geosciences, 2008
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
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 anthropogenetic burning has been large.