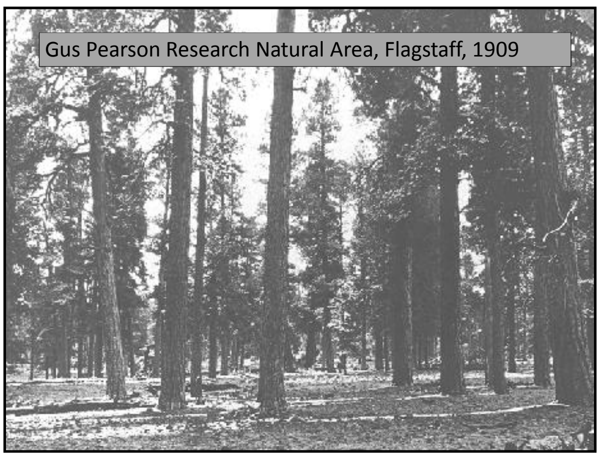
4.3 Surface and mixed-severity fire regimes

Forest surface fire regimes

- Widely distributed in North America and worldwide
- Generally high-frequency, short intervals
- Associated with open stand structures, high crown lift
- Mortality low in large adult trees, highest in seedlings and saplings

What kinds of ecosystems support surface fire regimes?

- Very widespread among western conifer forests in the Interior West
  - Ponderosa, Jeffrey pine forests
  - Dry mixed-conifer (Douglas-fir, Grand fir)
- Oak woodlands and some piñon-juniper woodlands also supported surface fire regimes
- May have also been widespread in Eastern deciduous forests prior to European arrival (why?)



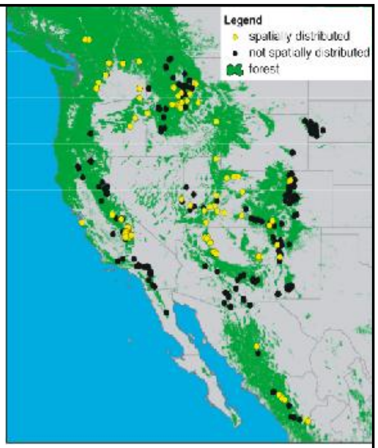
Gus Pearson Research Natural Area, Flagstaff, 1909

Where do surface fire regimes occur?

An updated map of 850 North American fire history sites and networks

• Allows analysis of broad-scale patterns of synchrony

Falk et al., 2011



Reconstructing fire history

- Create site-specific fire history records as reference for restoration and climate analysis
- Samples collected from scarred trees, typically in plots or across landscape
- Allows reconstruction of multi-century, spatially explicit fire records with exact dating

Review of fire scar formation

Photo: T.W. Swetnam

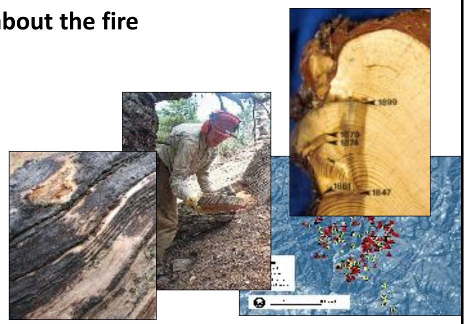
- Death of cambial tissue is a function of temperature and time of exposure
- Lethal temperature is 60-65°C (140-150°F)
  - proteins denature
  - damage to membranes
- What factors influence:
  - temperature at cambium?
  - residence time of heating?

The 4 stages of fire scar formation:

1. Surface fire heats and kills a portion of cambium, but tree survives.
2. Multiple fires leave successive scars on tree
3. In cross-section, these areas of dead cambium can be dated to year
4. In some cases, intra-ring position shows the season of fire

What are the properties of a surface fire regime?

Remember: we are reconstructing these from fire scars…what does this tell you about the fire severity?



Fire effects in surface fire regimes:

- Tree mortality: varies by size class
- Highest mortality in **<u>small trees</u>**
  - ≤ 2% overstory trees (≥ 40 cm diameter: dbh) killed
  - ≥ 80-95% saplings and understory trees (≤ 15 cm dbh) killed
- Grass mortality?
- Soil loss and hydrophobicity?
- Animal mortality and habitat alteration?

What about fire behavior?

- Fuel layers: mostly burning ground and surface fuels
  - Grasses, litter, 1-hour and 10-hour fuels
- Overall flame height ≤ 2 m
- Headfire spread rate ≈ 3 - 4 m min^{-1}
- Fireline intensity ≤ 1000 kw m^{-1}
- Torching index ≥ 40 km hr^{-1}, crowning index ≥ 65 km hr^{-1}
  - That is: it takes <u>high</u> winds to move fire up into canopy

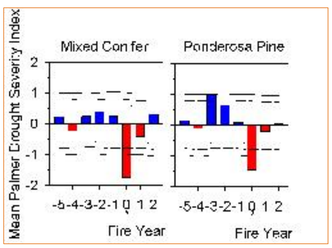
Agee 1993, Sackett and Haase 1996, Pyne, Andrews *et al.* 1996

Seasonality

- In the Southwest US and northern Mexico:
  - associated with atmospheric uplift (instability) and lightning storms in the arid foresummer (April-May-June)
    - Pre-monsoon fires in AZ and NM
- In southern California:
  - more likely during the arid Mediterranean summer/fall
- In the Northwest US:
  - Associated with late summer drought
    - As of yesterday, > 250,000 acres burning in Washington, Oregon, and Idaho. Some of these fires have been burning since late July.

Climate: usually occur in dry years following 1-2 wet years

- Fire years often associated with La Niña (dry) winters
- Preceding years often cool/wet, which leads to more production of fine fuels
- Contrast between fuel-limited and non fuel-limited systems



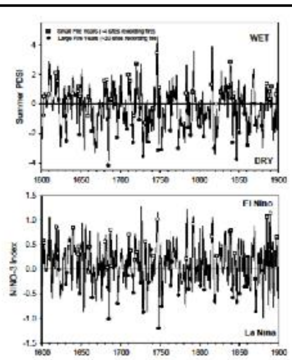
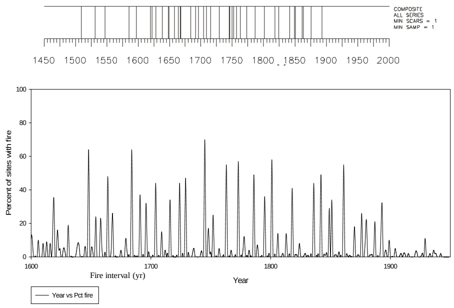


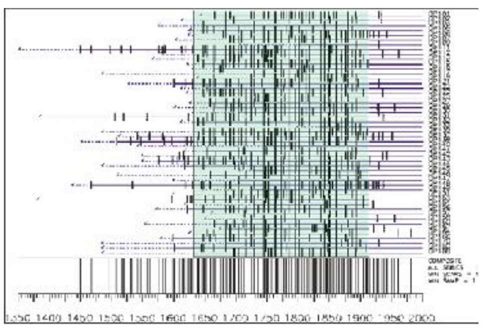
Figure 9.3. (Upper plot) Tree ring reconstructed summer (July August) Palmer Drought Severity Index (solid line) (from Cook et al. 2004), shown with the largest and smallest regional fire years identified from the 120-site fire-scar network from the Southwestern U.S. (Lower plot) Tree ring reconstructed NINO3 index of sea surface temperatures (Cook 2000), shown with the same set of largest and smallest regional fire years.

- Large regional fire years strongly associated with drought (negative Palmer Drought Index) and La Niña ("cool phase") conditions in the Pacific
- Small regional fire years associated with wet winters and El Niño (warm) phase

Fire intervals: years between fires



Surface fire regimes: Usually high fire frequency = **short intervals**



Fire frequency

f = number of fires / time

Example:

23 fires from 1773 to 1878

= 23 / (1878-1773) = 23/105

= 0.219 fires / yr

= 2.19 fires / decade

Mean and median fire interval

I = years / fires

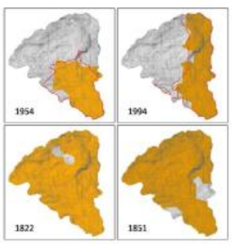
List out fire years, find number of years between successive fires

Take the mean of all these <u>intervals</u>

N.B.: number of intervals will be one less than number of fires (why?)

<u>Median</u> fire interval often more robust estimate because less affected by extreme values

What about fire sizes?



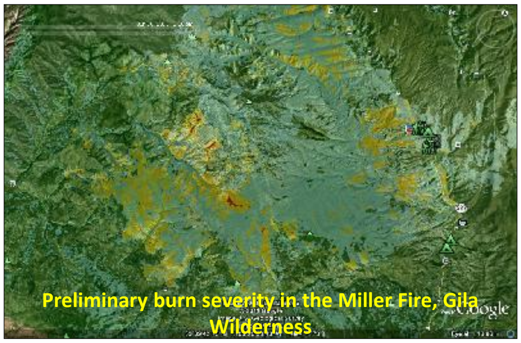
Farris et al. 2010

- Historically, surface fires could be <u>very</u> large (tens of thousands of ha)
- Example: recent fire-scar study in the Rincon Mountains shows that low-severity surface fire spread over almost the entire range at regular intervals

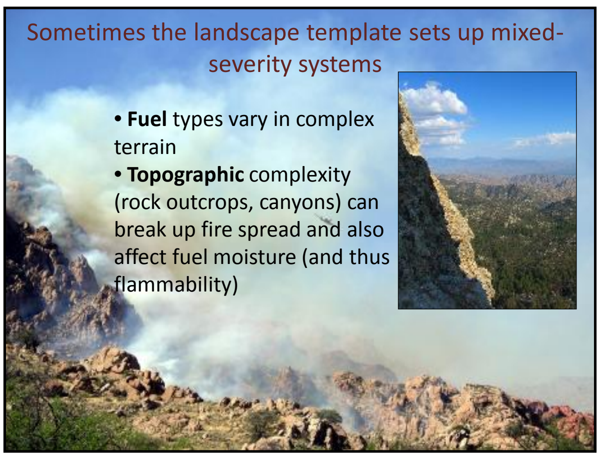
What about mixed-severity fire regimes?

- Combine elements of both high- and low-severity fire
- Spatial mixed: leave behind a spatial mosaic of burn severity (<u>very</u> common!)
- Temporal mixed: period of low-severity fires, punctuated periodically by high-severity events
- Typical fire regime of mixed conifer forests

Miller Fire, Gila Wilderness 2011: An 88,000 acre mixed severity fire

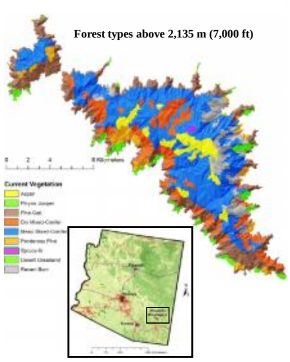


Sometimes the landscape template sets up mixed-severity systems



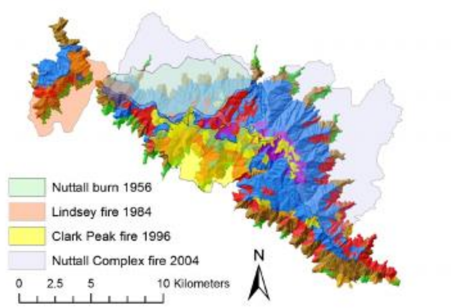
- **Fuel** types vary in complex terrain
- **Topographic** complexity (rock outcrops, canyons) can break up fire spread and also affect fuel moisture (and thus flammability)

The Pinaleño Mountains

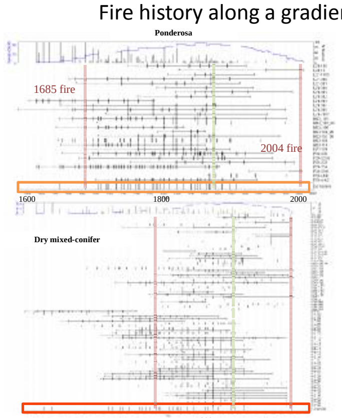


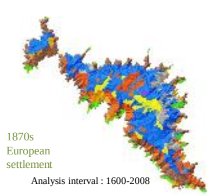
- Steep vertical gradient
- Representative forest types
- Southern-most spruce-fir forest
- High species diversity

Recent fires



Fire history along a gradient of elevation

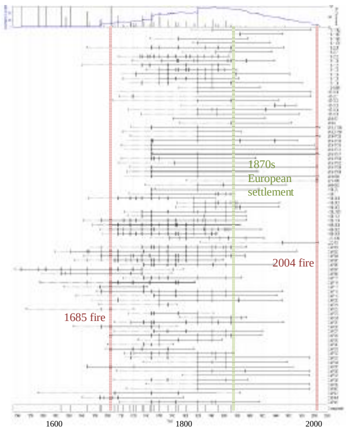




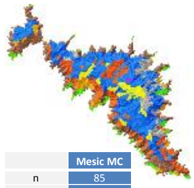
Analysis interval : 1600-2008

	Ponderosa	Dry MC
n	27	80
Small fire 10% MEI (yrs)	5.0	8.9
Med. Fire 20% MEI (yrs)	8.1	12.81
Large fire 50% MEI (yrs)	16.3	22.8

Fire history of mesic mixed-conifer

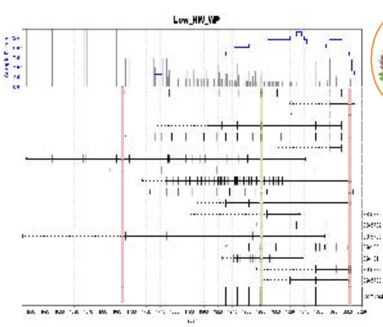


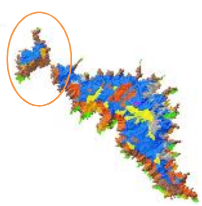
Analysis interval : 1600-2008



	Mesic MC
n	85
Small fire 10% WMEI (yrs)	7.5
Med. Fire 20% WMEI (yrs)	11.8
Large fire 50% WMEI (yrs)	24.4

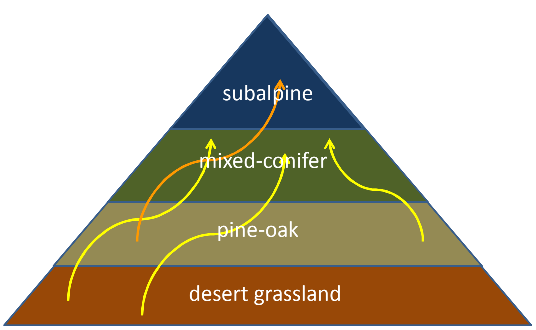
West Peak fires





	West Peak
n	18
Small fire 10% WMEI (yrs)	7.79
Med. Fire 20% WMEI (yrs)	9.62
Large fire 50% WMEI (yrs)	32.08

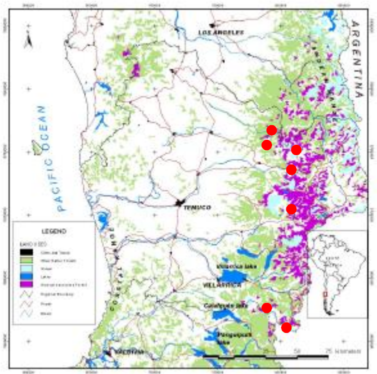
Landscape linkages in the Pinaleño fire regime



Studying a low-moderate severity fire regime in Chile

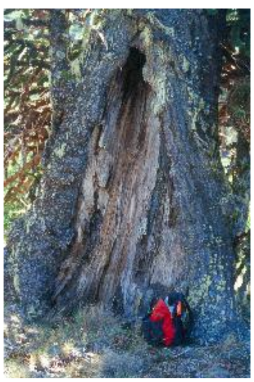
Study areas

Malleco NR
Tolhuaca NP
Villarrica NP
Malacahuello NR
Nalcas NR
Conguillio NP

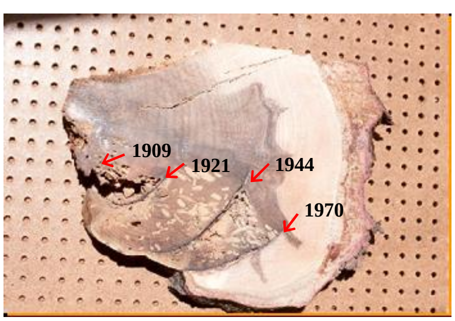


Mauro Gonzalez, Universidad Austral de Chile

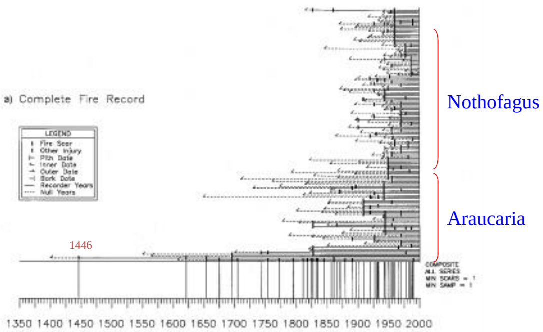
Fire scars



Fire-scar in *Araucaria araucana*



Complete fire record (n=144)



Your turn (on your own or in pairs)

- Tree-ring record for 1648 – 1752 in a New Mexico ponderosa pine forest
- Fire scars found:
  - 1648, 1664, 1685, 1709, 1716, 1724, 1729, 1748, 1752
- Calculate: fire frequency and mean fire interval (using interval method)

Fire frequency

f = number of fires / time

9 fires from 1648 to 1752

= 9 / (1752 - 1648) = 9 / 104

= 0.087 fires / yr

= 0.87 fires / decade

Fire interval

I = years / fires

Fire intervals = 4, 19, 5, 8, 7, 24, 21, 16 yr

- Sum intervals = 104 yr / 8 intervals = 13 yr mean fire interval

Median fire interval = (8+16)/2* = 12 yr

* Because even number of members of series

Reordered series: 4,5,7,8,16,19,21,24