Tree-ring applications for watershed management

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Outline

- Audience quiz
- Intro to tree-rings
- Applications of tree-rings for:
  - Forest and fire regime restoration
    - Case study: Upper Santa Fe Watershed
  - Water management
    - Case study: Santa Fe River

Who's in the audience?

1. Water resource managers/hydrologists
2. Forest and fire managers
3. Restorationists
4. Other?

And whataya know?

1. Who has ever looked at the rings on a log, a piece of wood, furniture, anywhere?
2. Who's heard of the formal use of tree-ring analysis?
3. In what context was it mentioned?

5 min intro to tree-rings

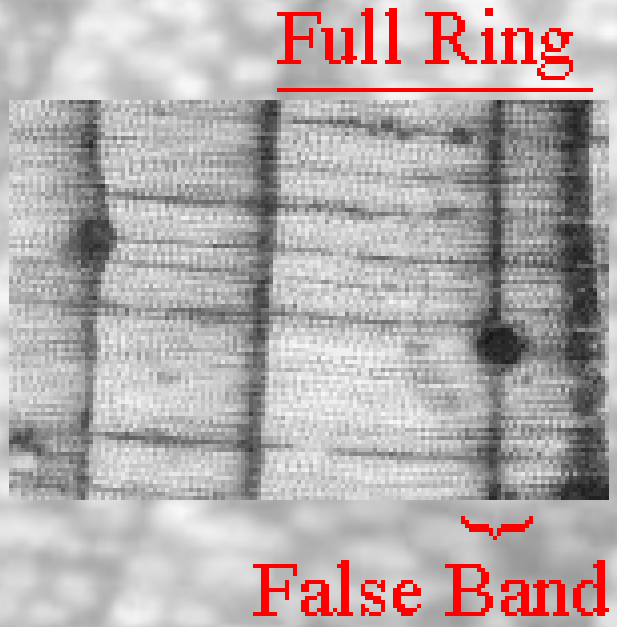
- Study of tree-rings (Dendrochronology) was formalized by an astronomer, A.E. Douglass, in the early 1900's at the UofAz
- Annual ring formation (1 ring = 1 yr)
- SW US is perfect
  - Distinct growing season
  - High interannual climate variability

SW US - precipitation sensitivity

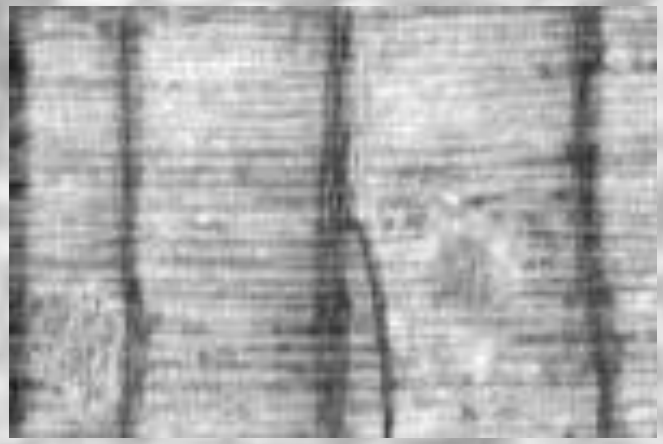
- Water is generally a limiting factor
- Narrow ring = less precipitation
- Wide ring = more precipitation

But it's not just counting rings!

- False rings



- Missing rings



Tree-ring sampling

Increment cores:

1. tree age

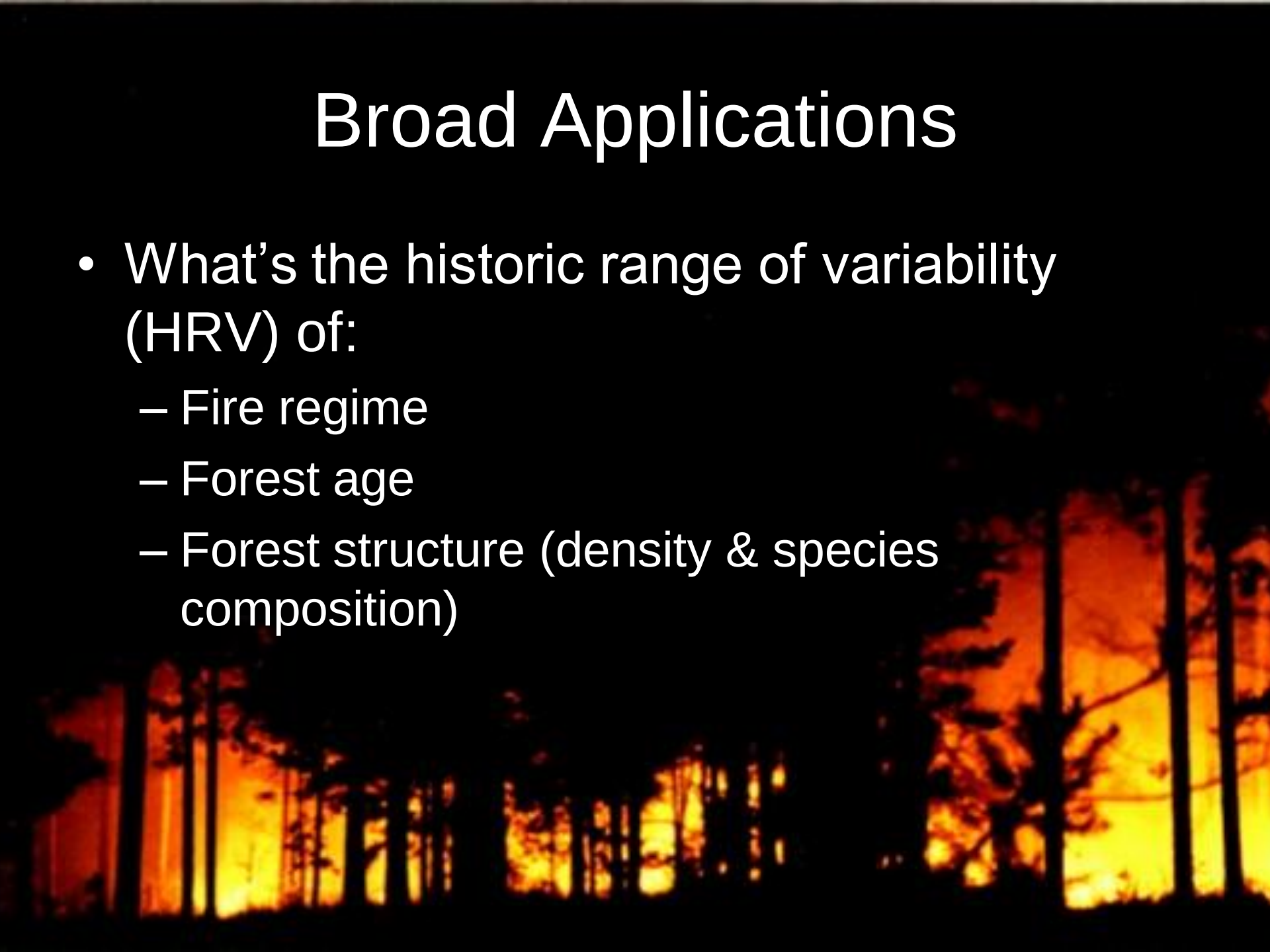
2. climate reconstruction

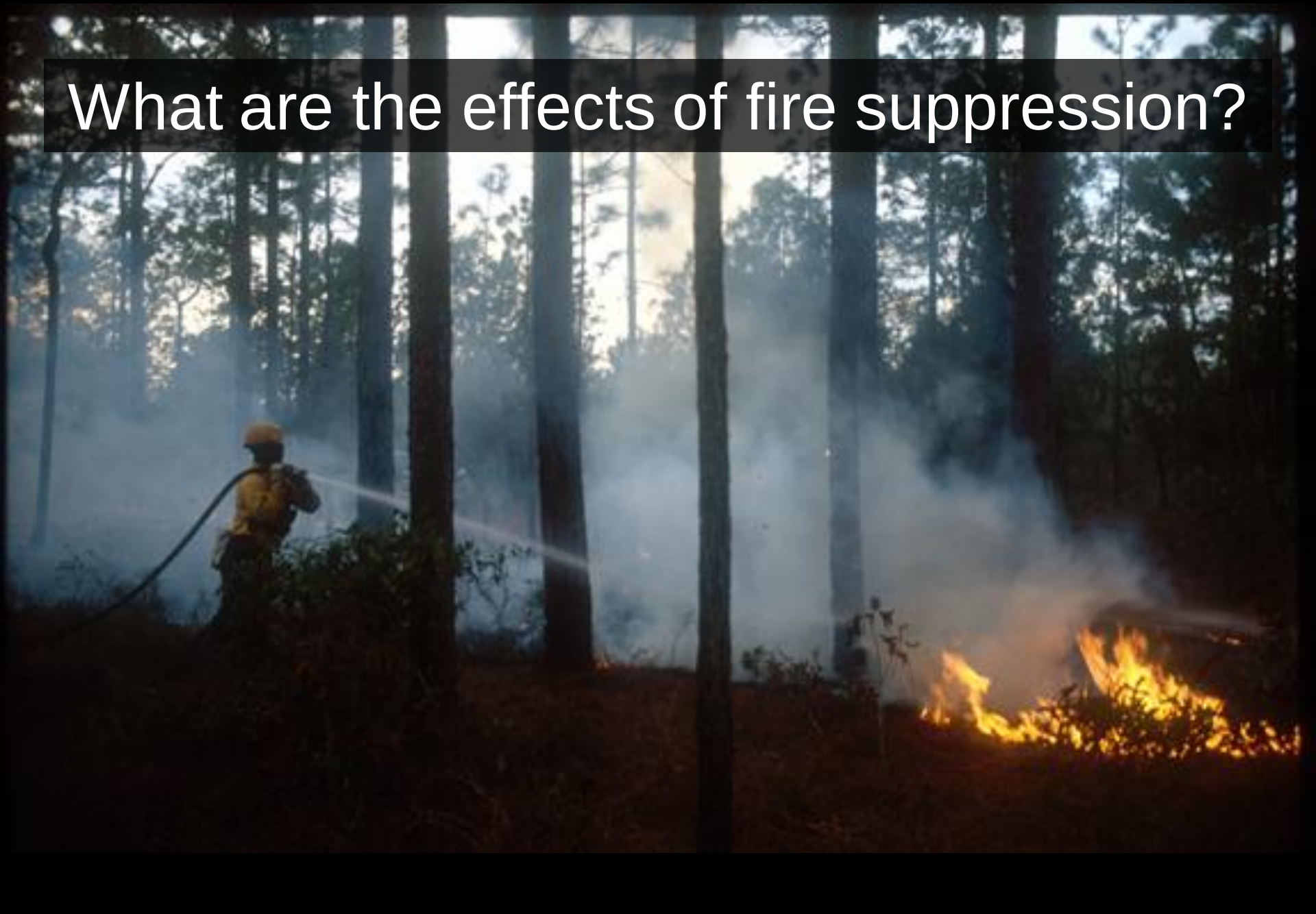

Fire scars

Tree-ring applications for fire regime and forest restoration

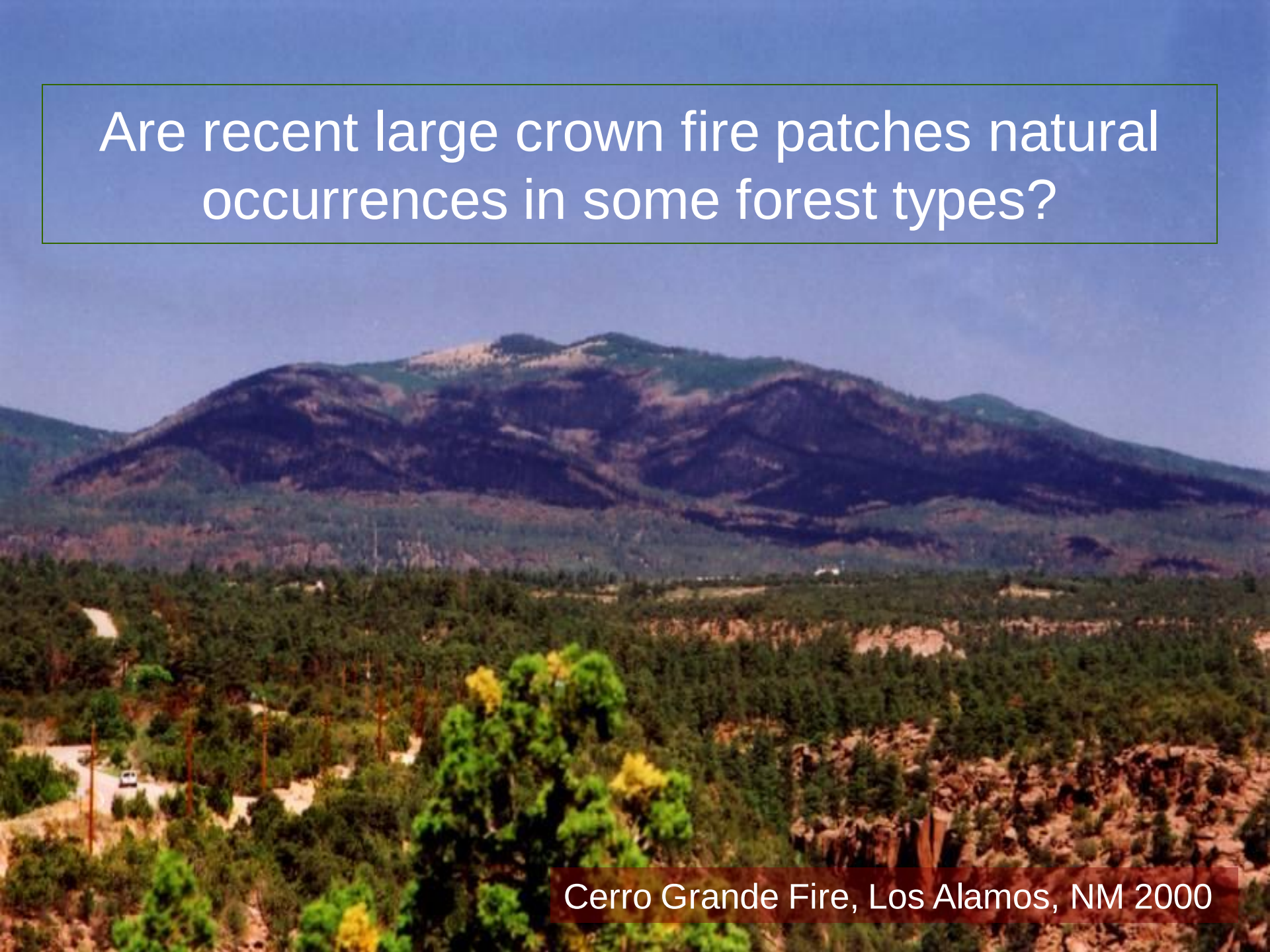
Broad Applications

- What's the historic range of variability (HRV) of:
  - Fire regime
  - Forest age
  - Forest structure (density & species composition)



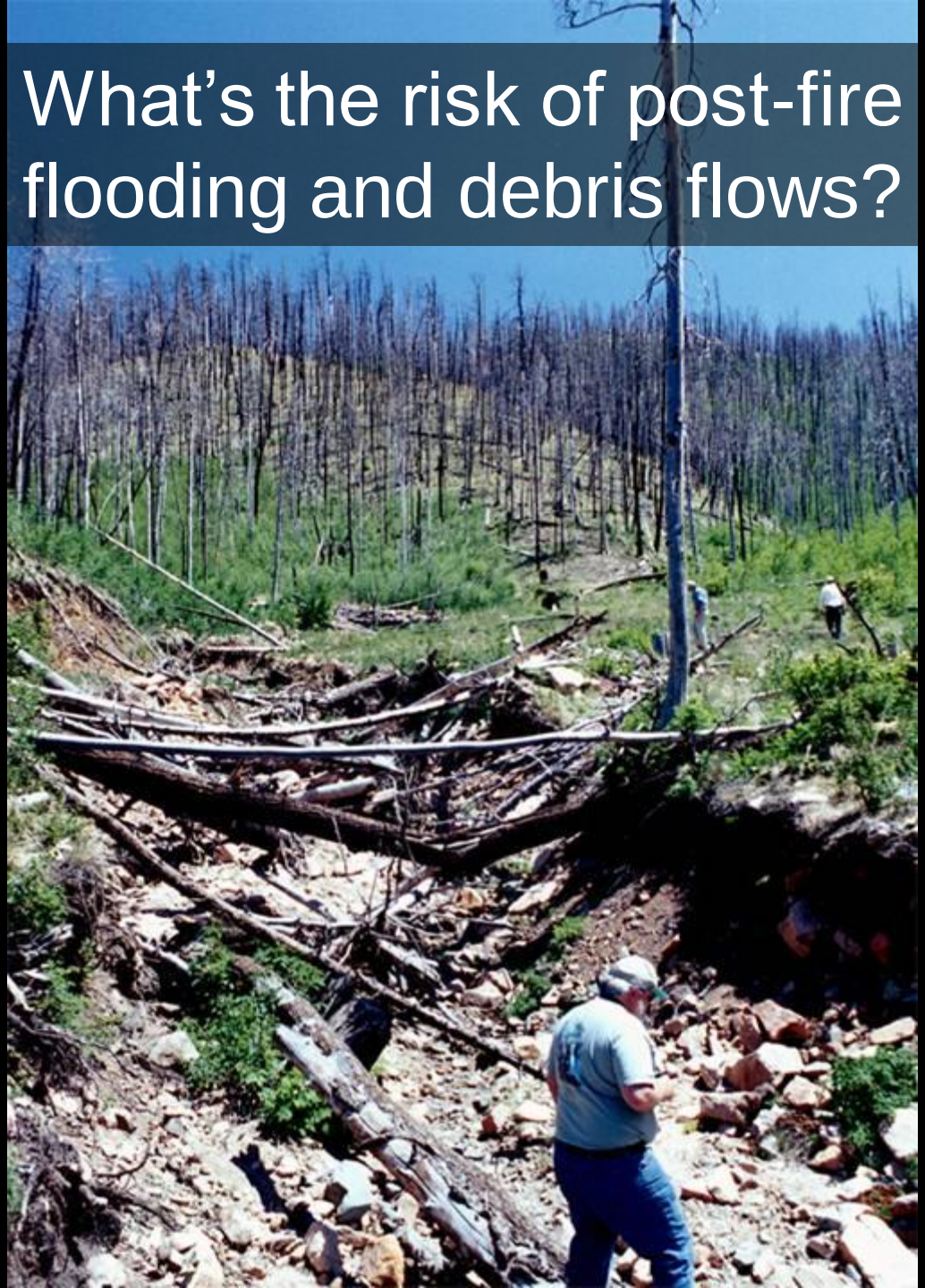

What are the effects of fire suppression?

Are recent large crown fire patches natural occurrences in some forest types?



Cerro Grande Fire, Los Alamos, NM 2000

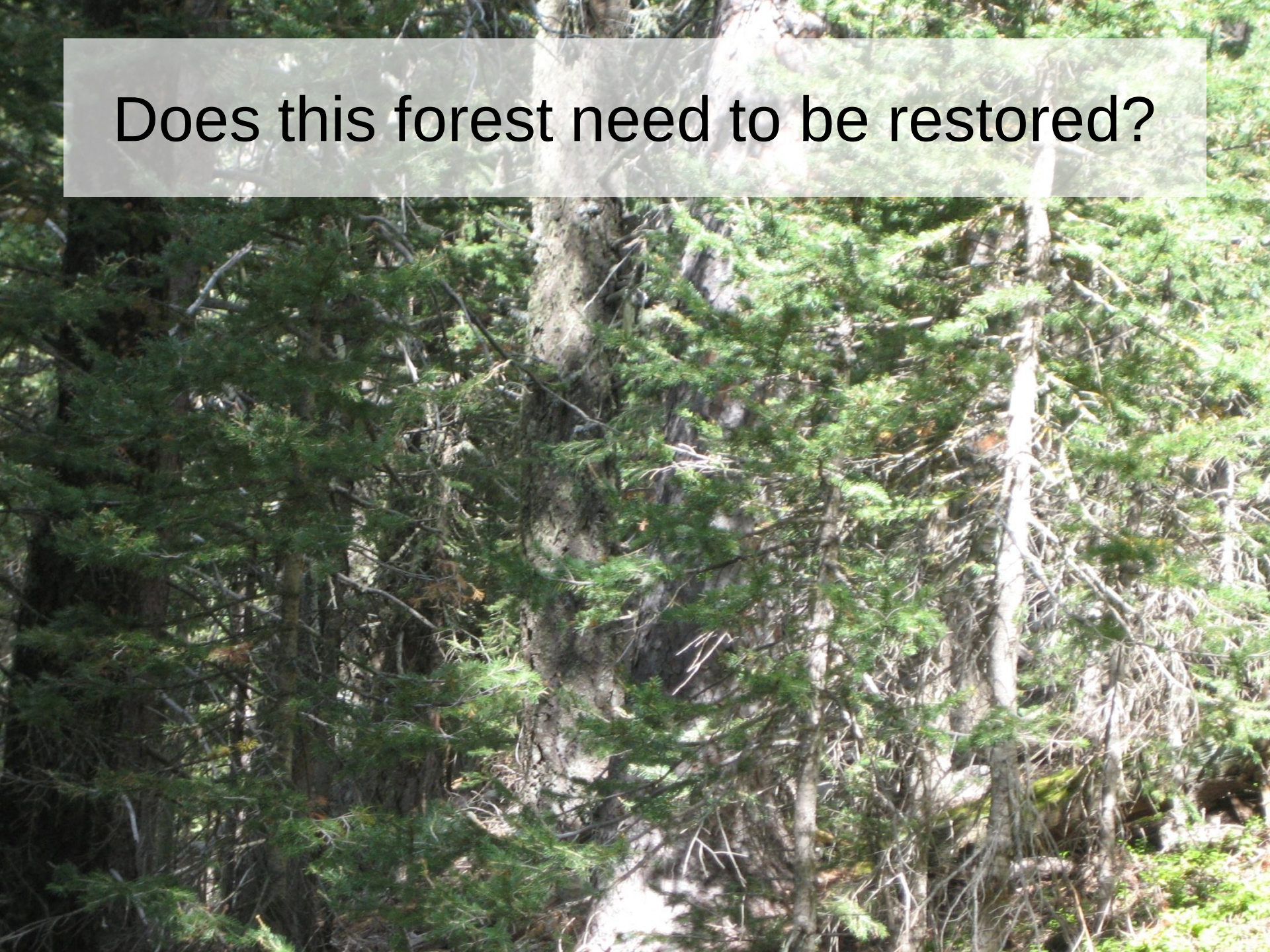
What's the risk of post-fire flooding and debris flows?



How does climate affect fire regimes?

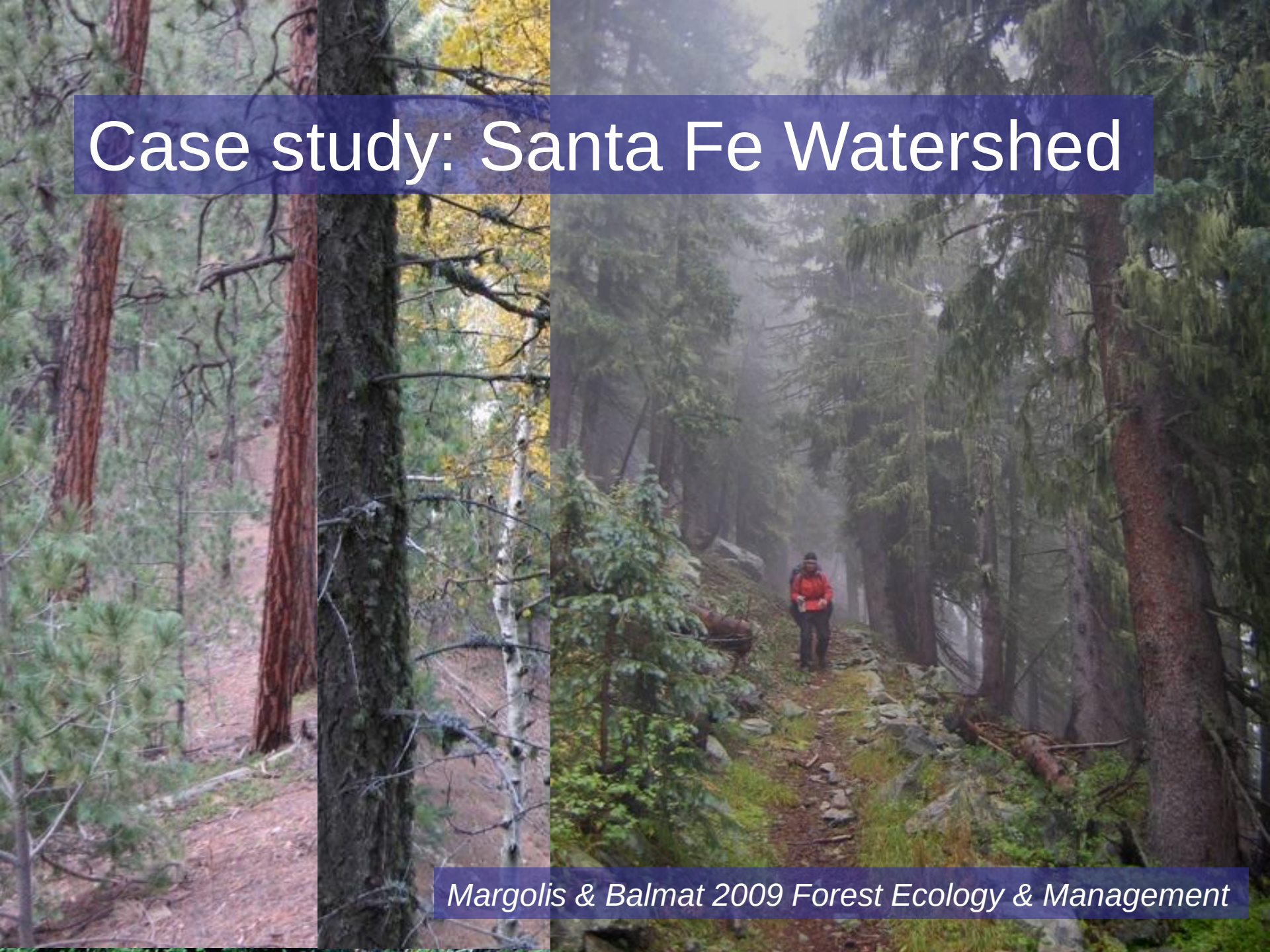
Specific Applications

- Which areas need treatment?
- Treatment prescriptions
- Maintenance prescriptions

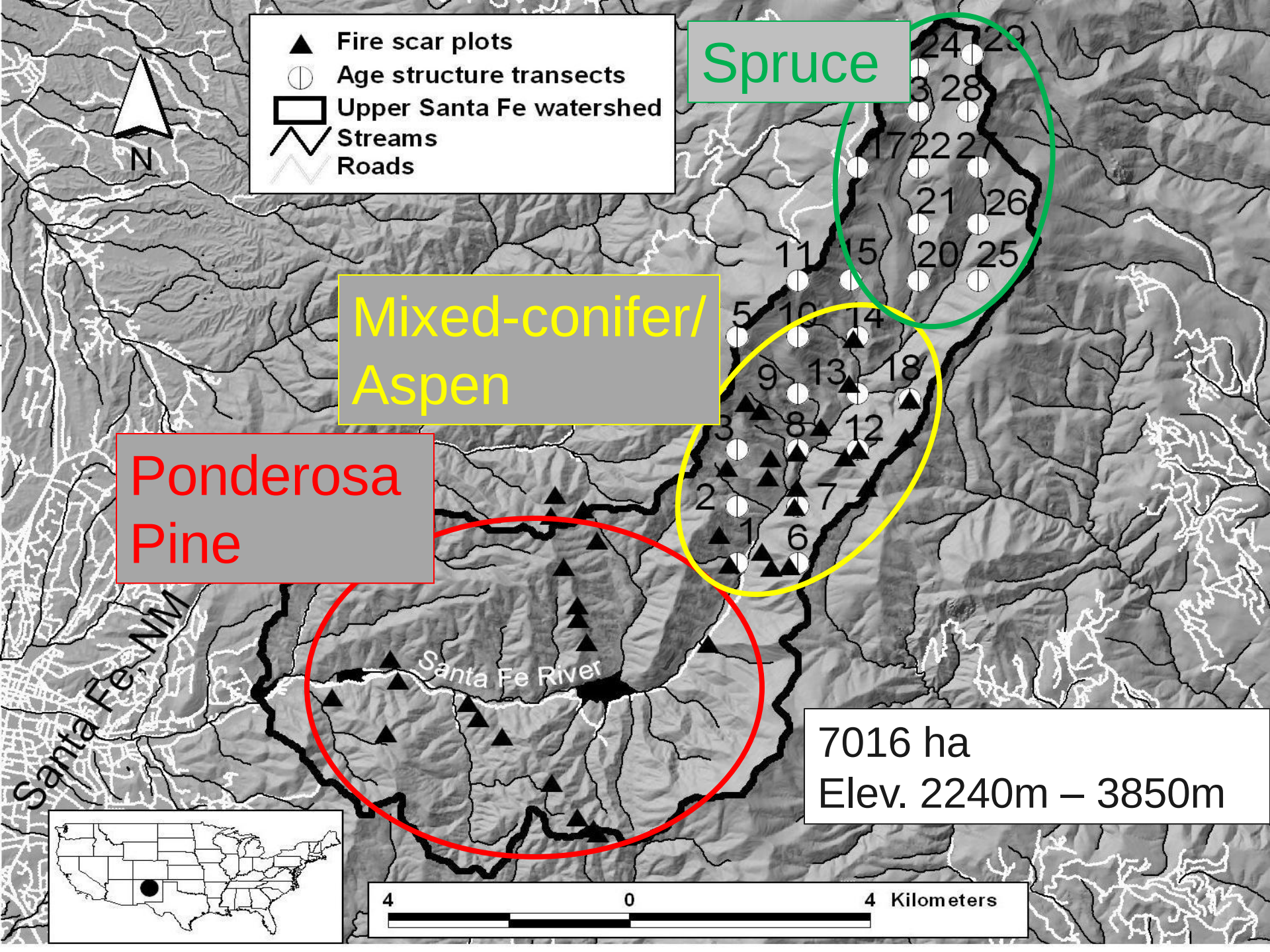

Does this forest need to be restored?


What burn severities and fire intervals should we prescribe?

Case study: Santa Fe Watershed



Margolis & Balmat 2009 Forest Ecology & Management

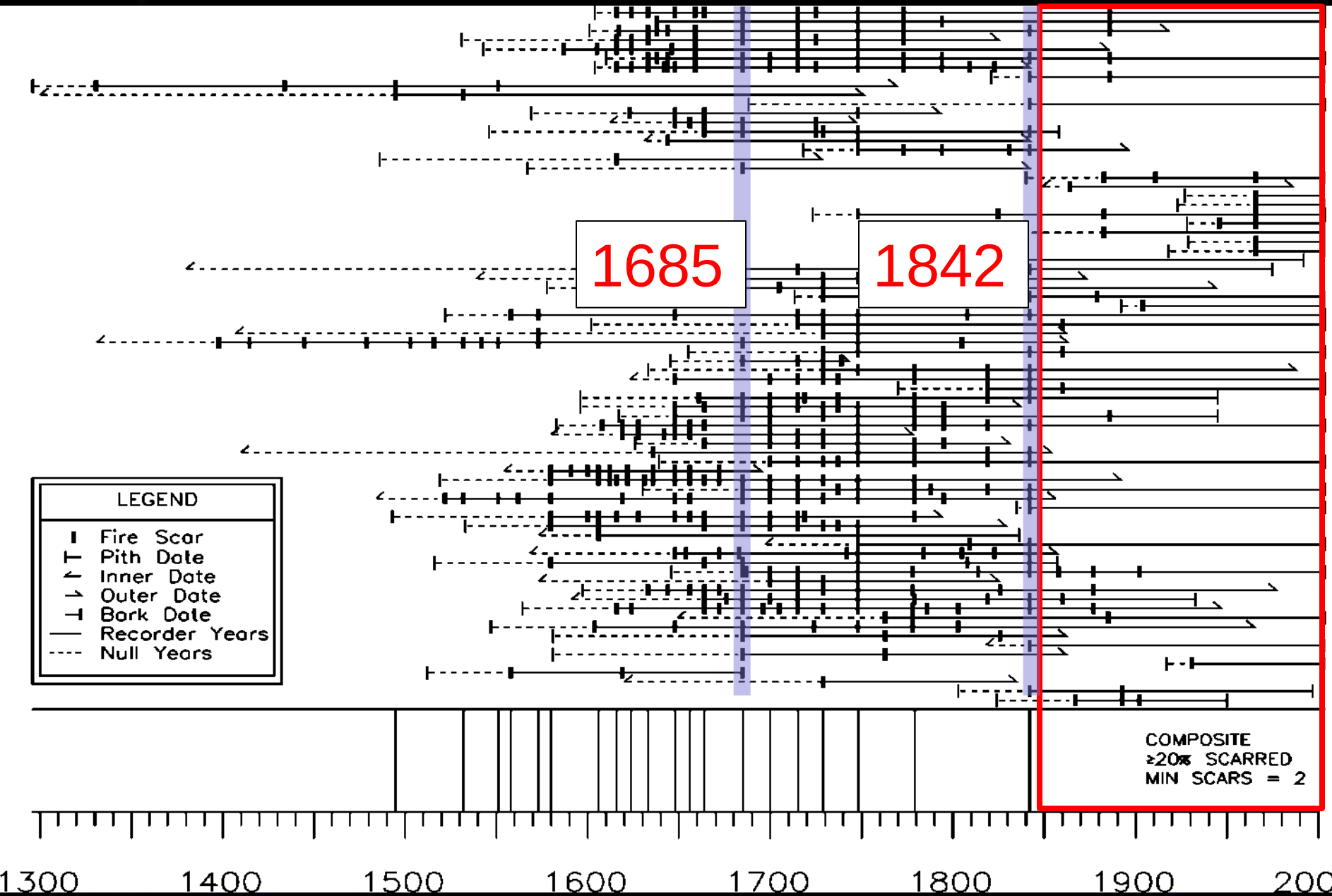

Fire scar plots
Age structure transects
Upper Santa Fe watershed
Streams
Roads
N
Spruce
Mixed-conifer/
Aspen
Ponderosa
Pine
Santa Fe River
Santa Fe, NM
7016 ha
Elev. 2240m – 3850m
4 0 4 Kilometers

Old fire-scarred wood!

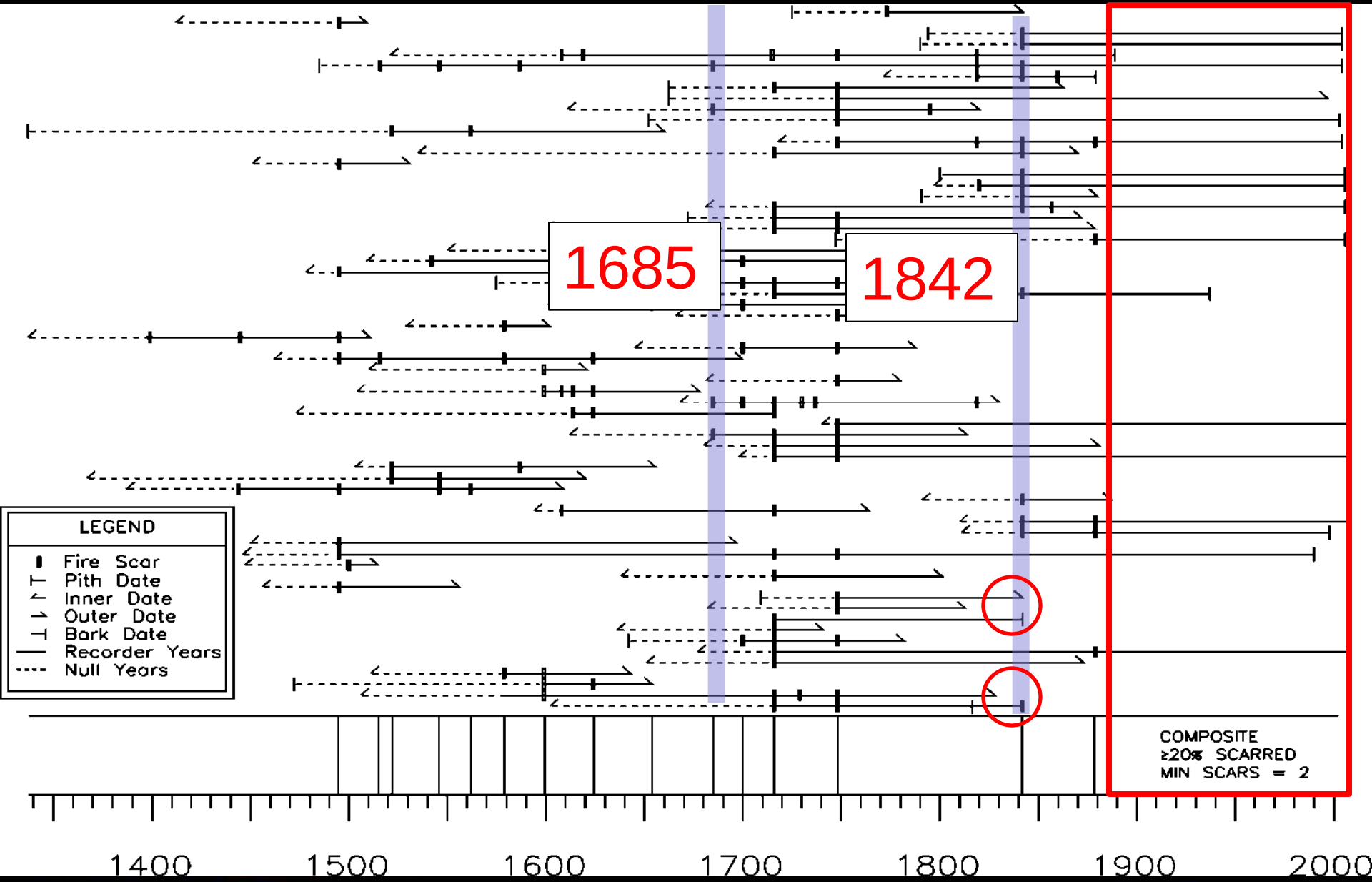
1337 inner ring; 1399 fire scar

1387 inner ring; 1444 fire scar

Ponderosa pine fire history (1296-2004)



Mixed conifer fire history (1337-2008)

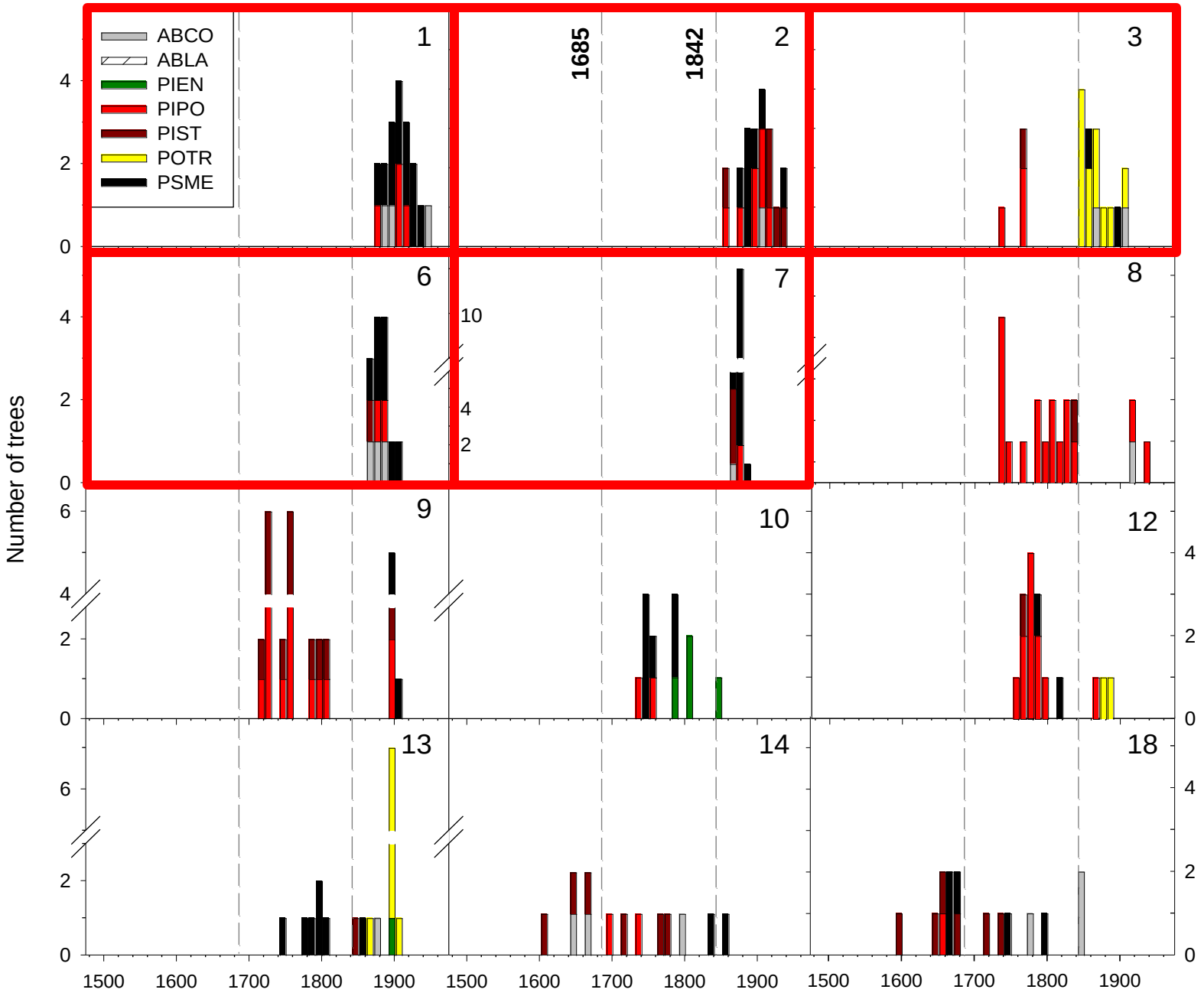


Ponderosa pine and mixed-conifer/aspen forests had different fire frequency

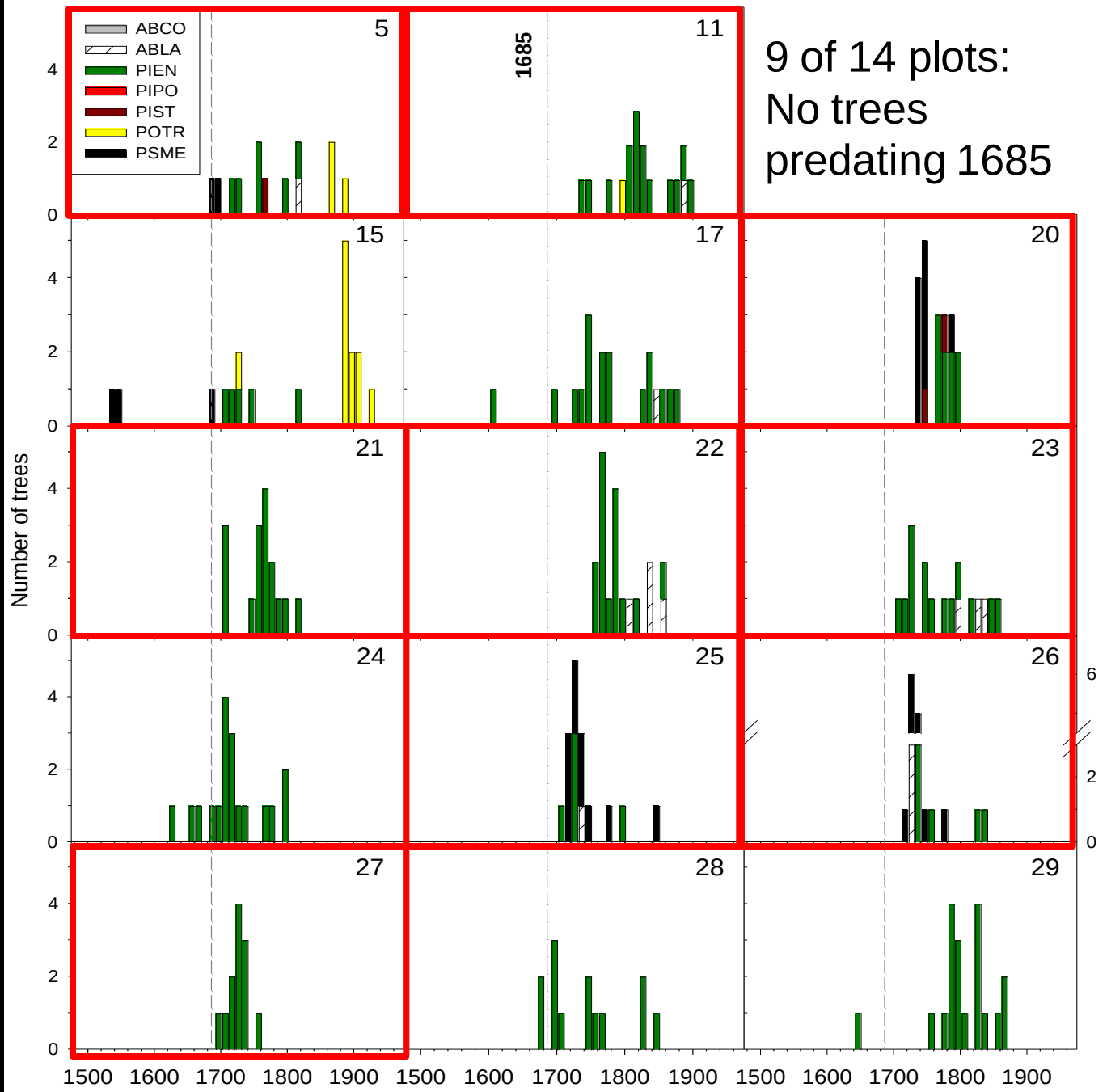
% scarred filter	Intervals (#) Pipo/MC	Mean fire interval (yrs) Pipo/MC	Median fire interval (yrs) Pipo/MC	Weibull median probability interval (yrs) Pipo/MC	Minimum interval (yrs) Pipo/MC	Maximum interval (yrs) Pipo/MC
all fires	76/31	4.32^{+}/12.39^{+}	4.00/12.00	3.76/10.28	1/1	16/31
≥2 trees	48/18	6.79^{+}/21.33^{+}	5.00/16.50	5.81/18.90	1/6	20/71
10%	34/18	9.09^{+}/21.33^{+}	7.00/16.50	7.99/18.90	1/6	25/71
20%	17/14	17.12^{+}/27.43^{+}	15.00/22.50	15.03/24.37	7/6	63/94
25%	14/11	20.79/31.55	15.50/25.00	18.81/27.76	7/6	63/94

+ indicates significantly different ($p < 0.05$) mean fire intervals between Pipo and MC (Student's t-test)

Mixed conifer age structure by plot

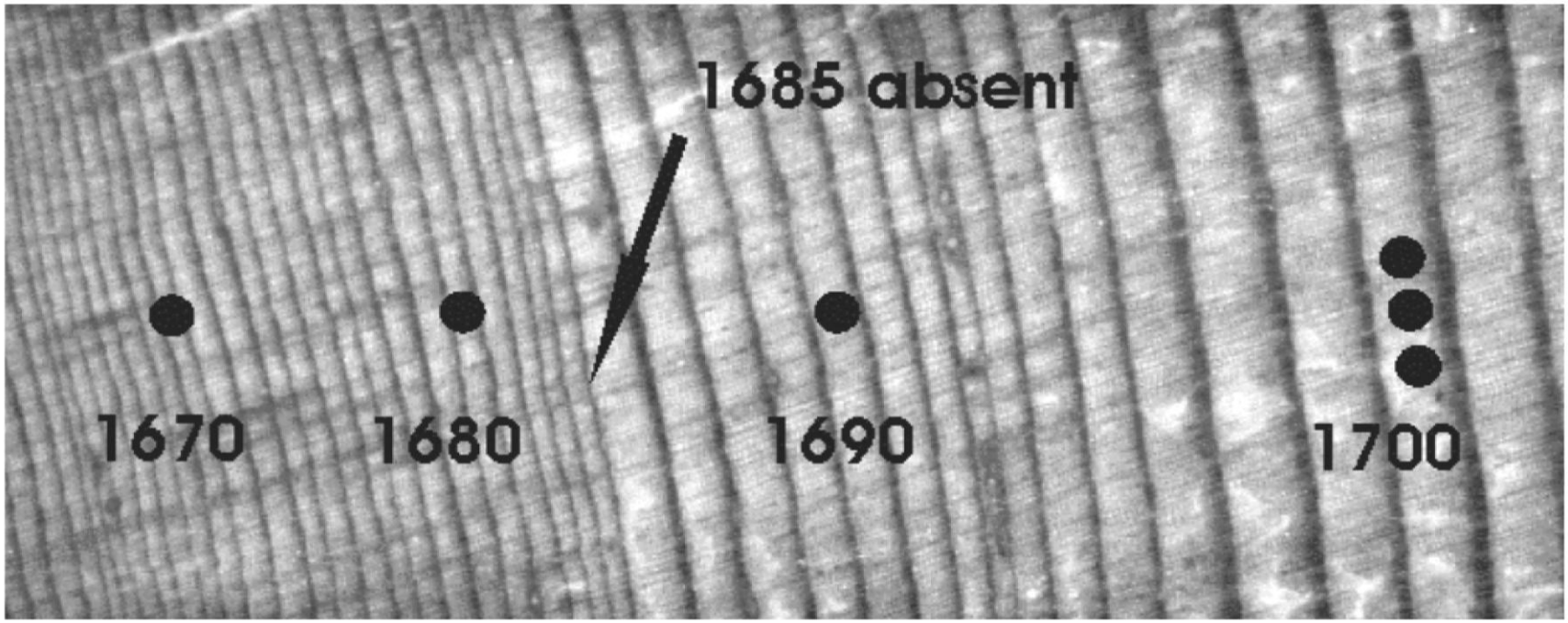


Spruce dominated forest age structure by plot

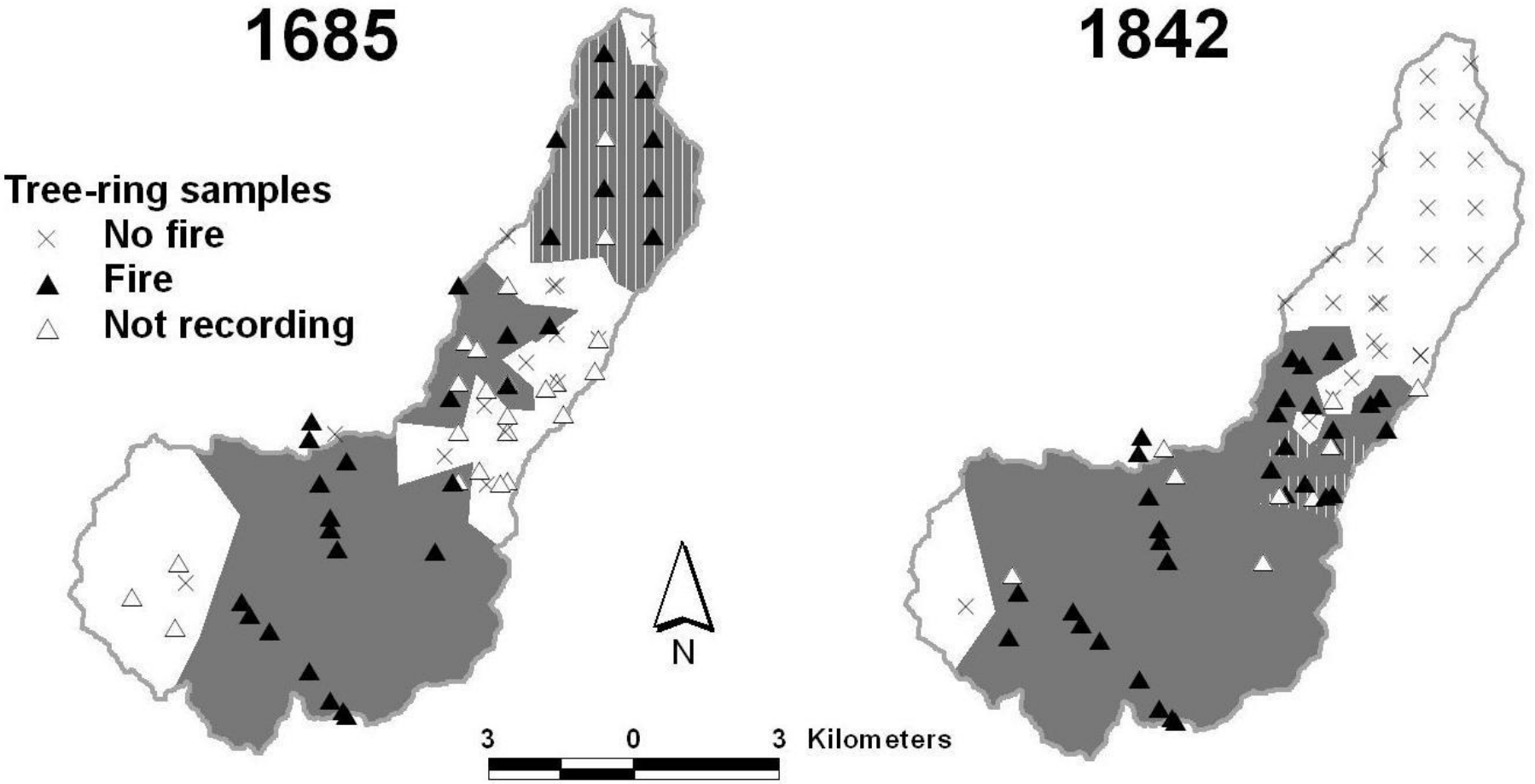


9 of 14 plots:
No trees predating 1685

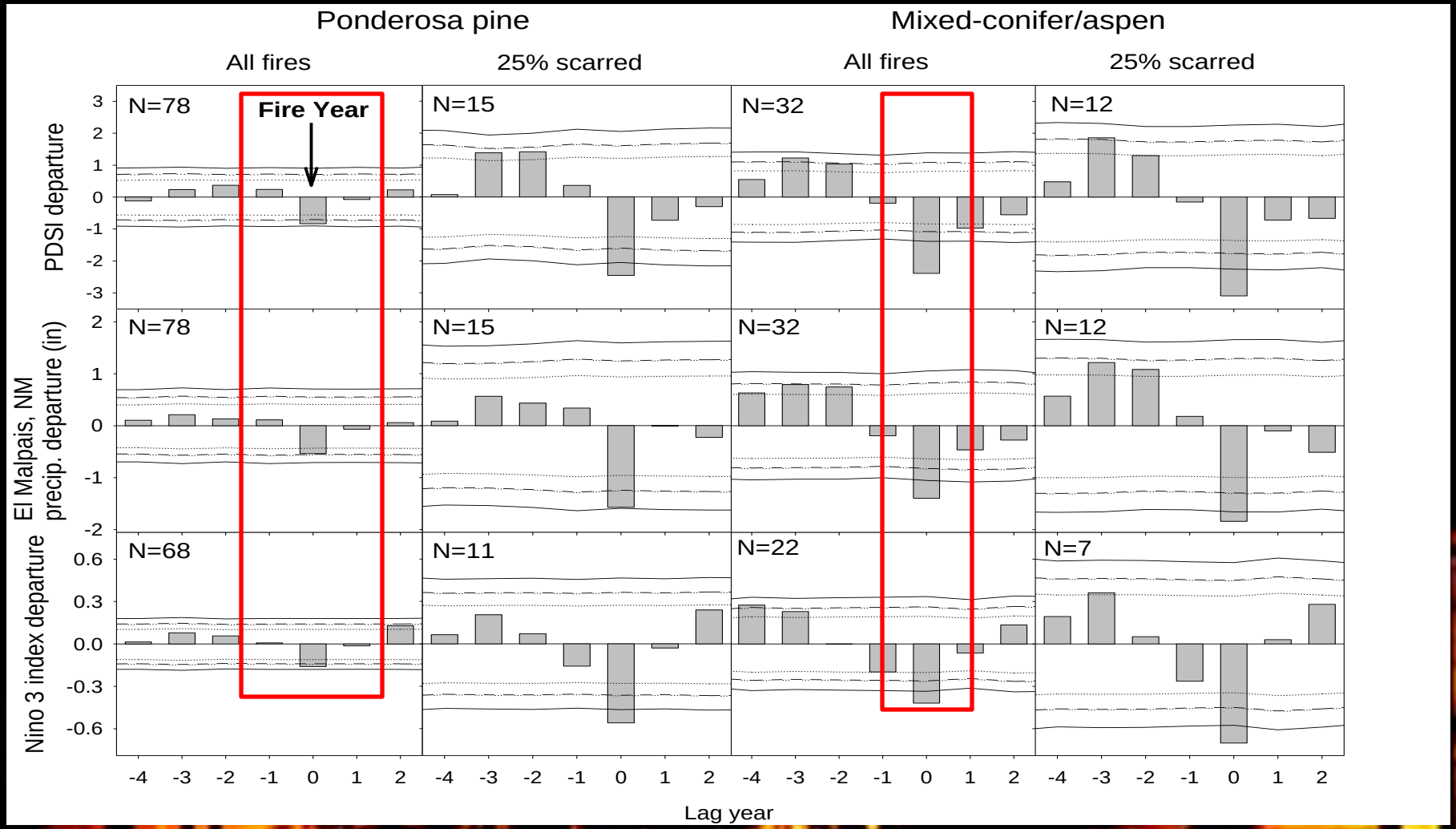
Growth release following 1685 fire



Reconstructed fire area & severity



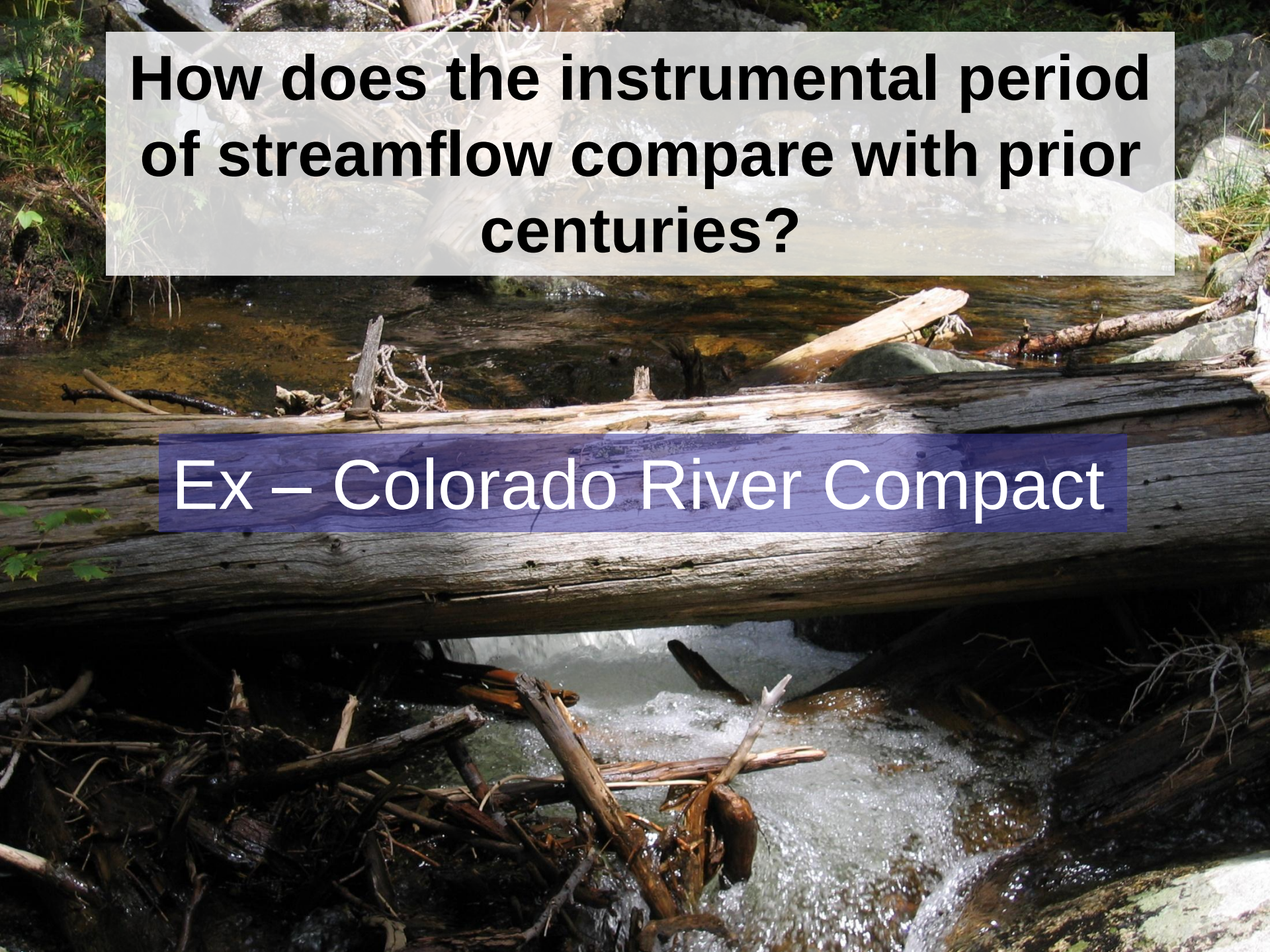
Climatic effects on fire differ between forest types



Summary: guide for forest and fire regime restoration

- Historic range of variability of fire regime and forests
- Fire frequency: historic range of fire intervals = Rx burn intervals
- Severity: Pipo = low severity; MC/Aspen= mixed severity; Spruce = high severity
- Fire size: (reconstructed range of burn areas and stand-replacing patches = guide for Rx burn blocks)
- Seasonality: (natural timing of fires)

Tree-ring applications for water management

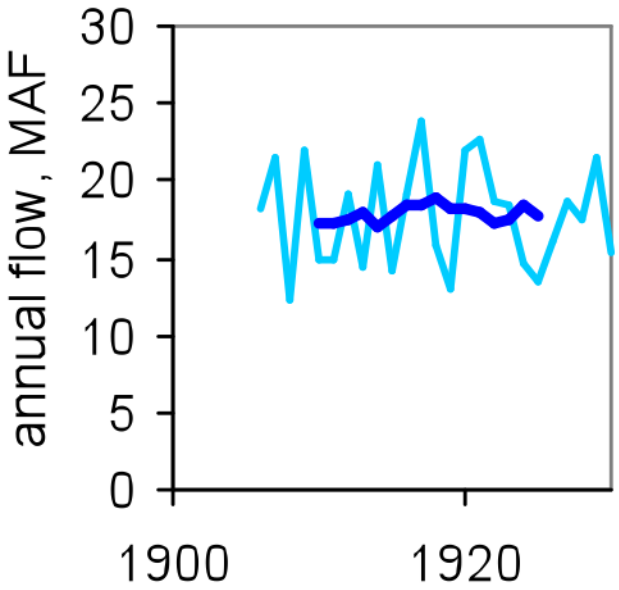


How does the instrumental period of streamflow compare with prior centuries?

Ex – Colorado River Compact

Learning from experience in water management

Colorado at Lees Ferry



http://treeflow.info/

Learning from experience in water management

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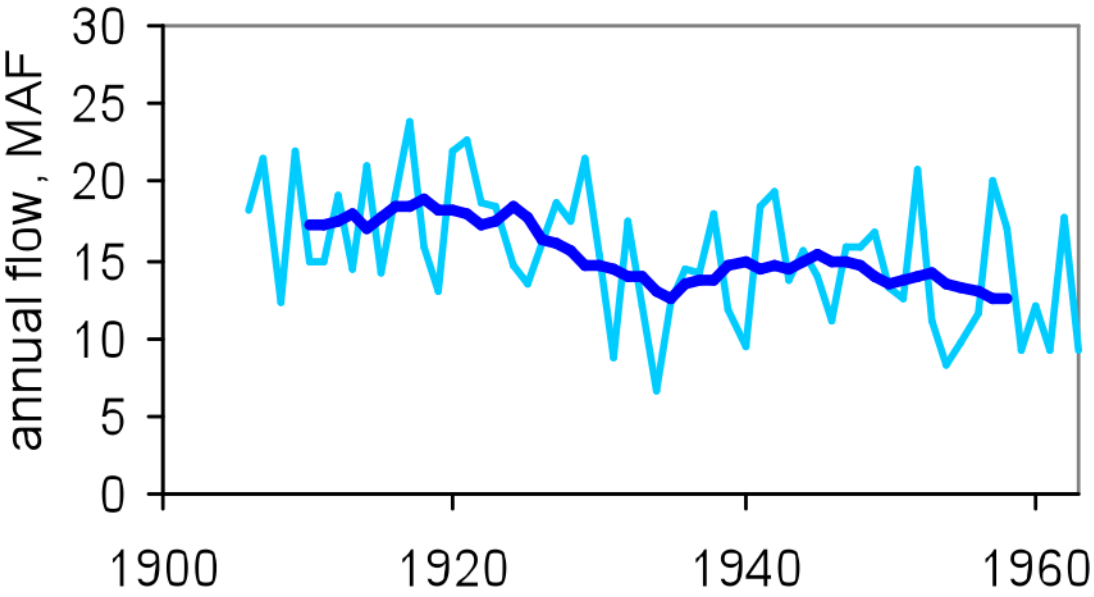

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Learning from experience in water management

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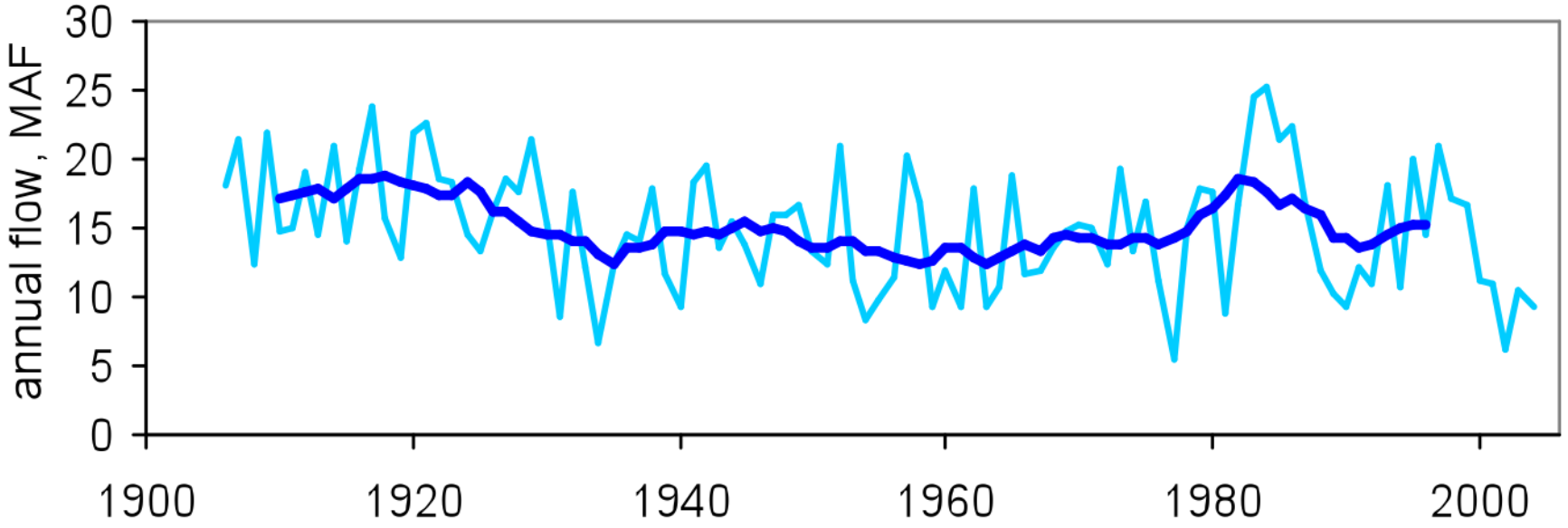

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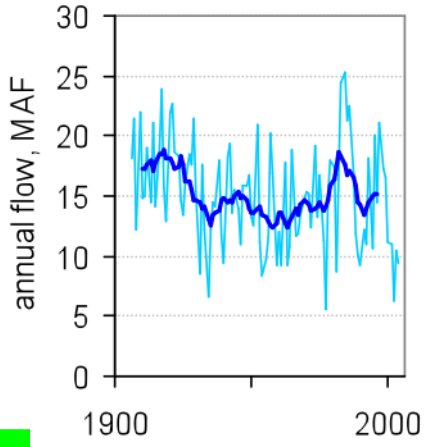
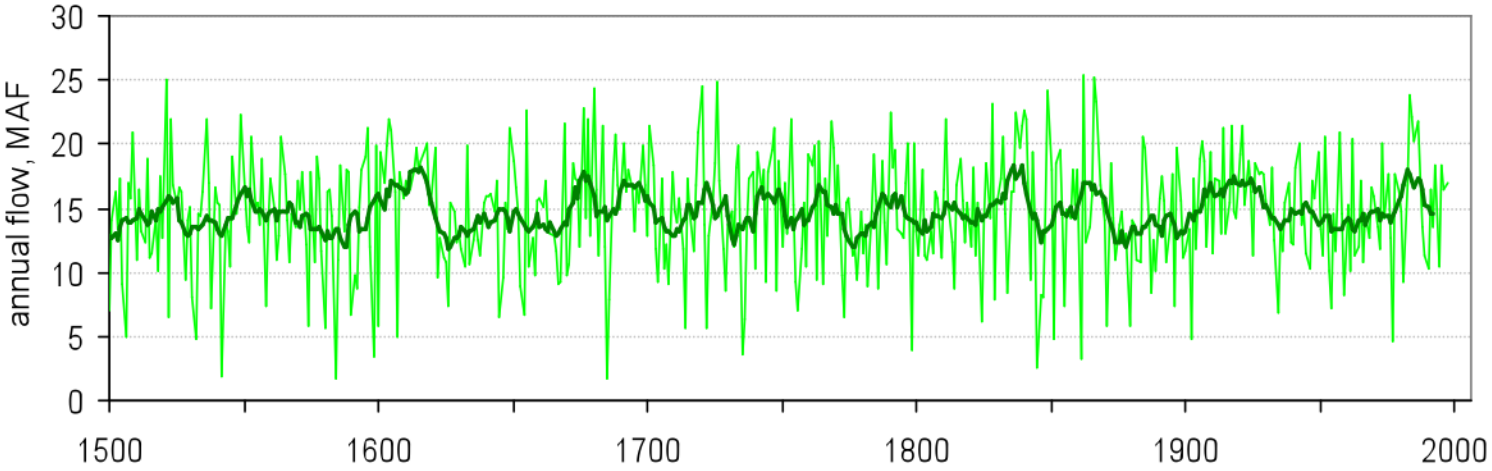
Tree-ring reconstructions provide a much broader context

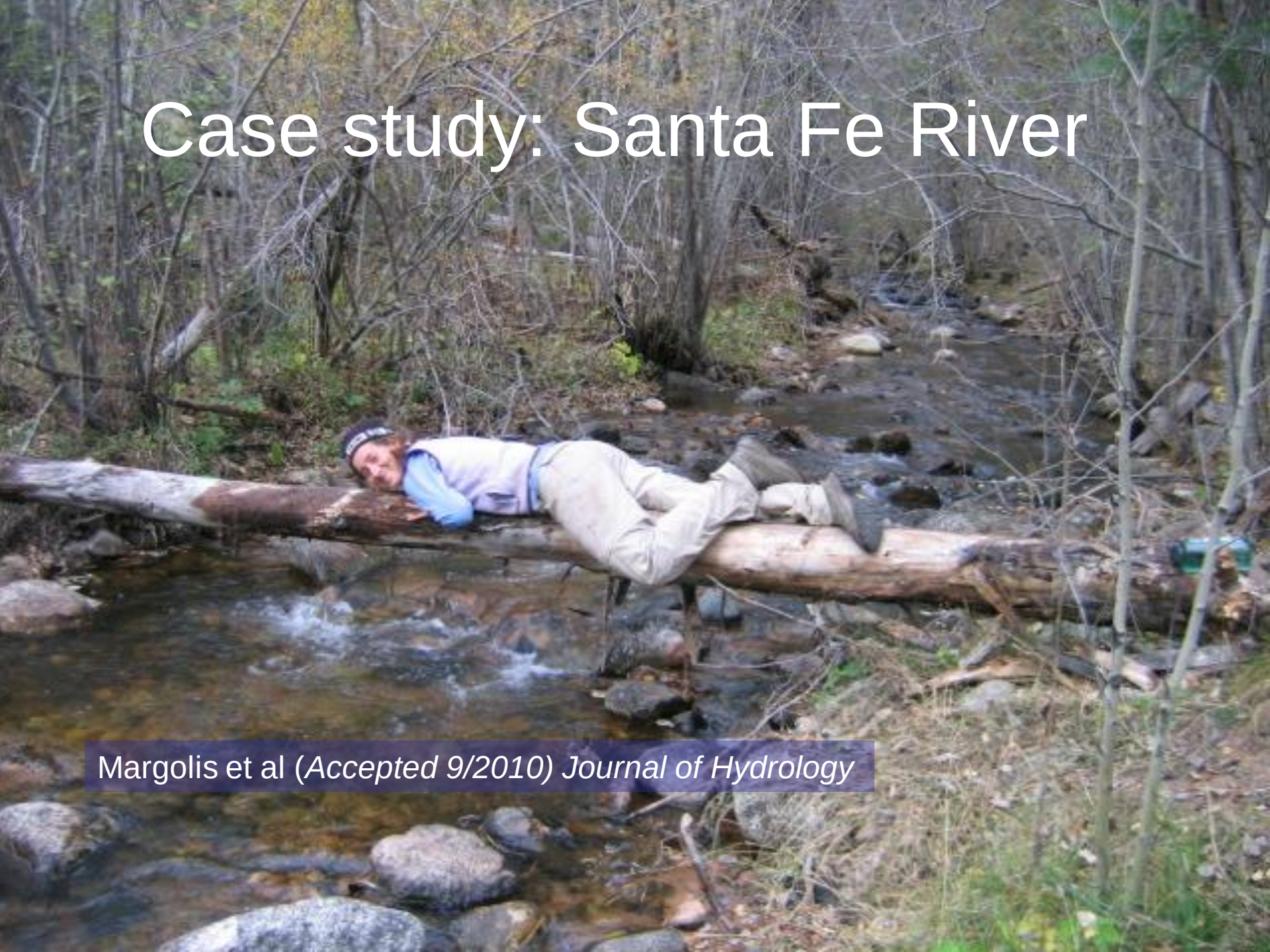
Colorado at Lees Ferry





http://treeflow.info/

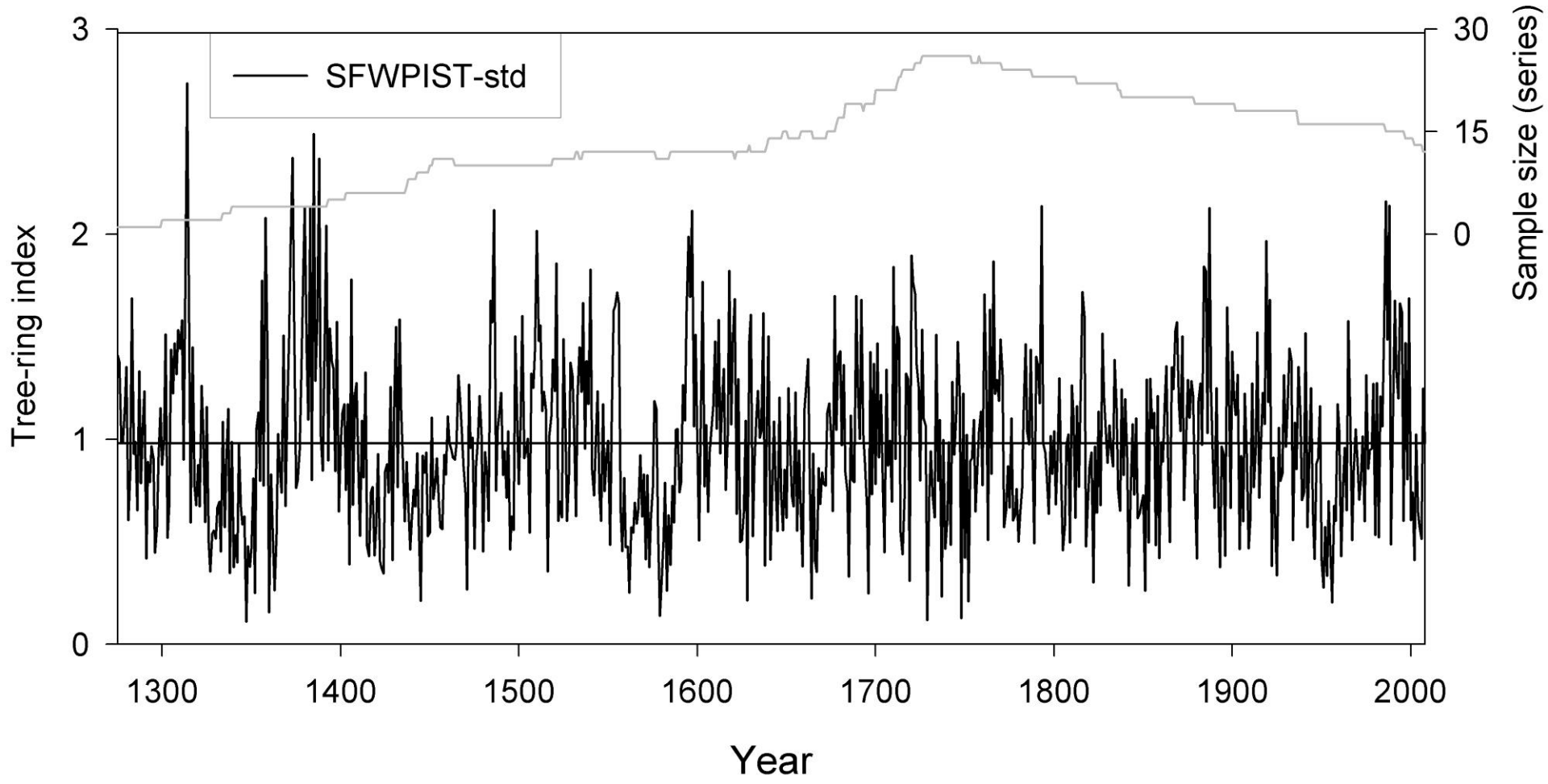
Case study: Santa Fe River



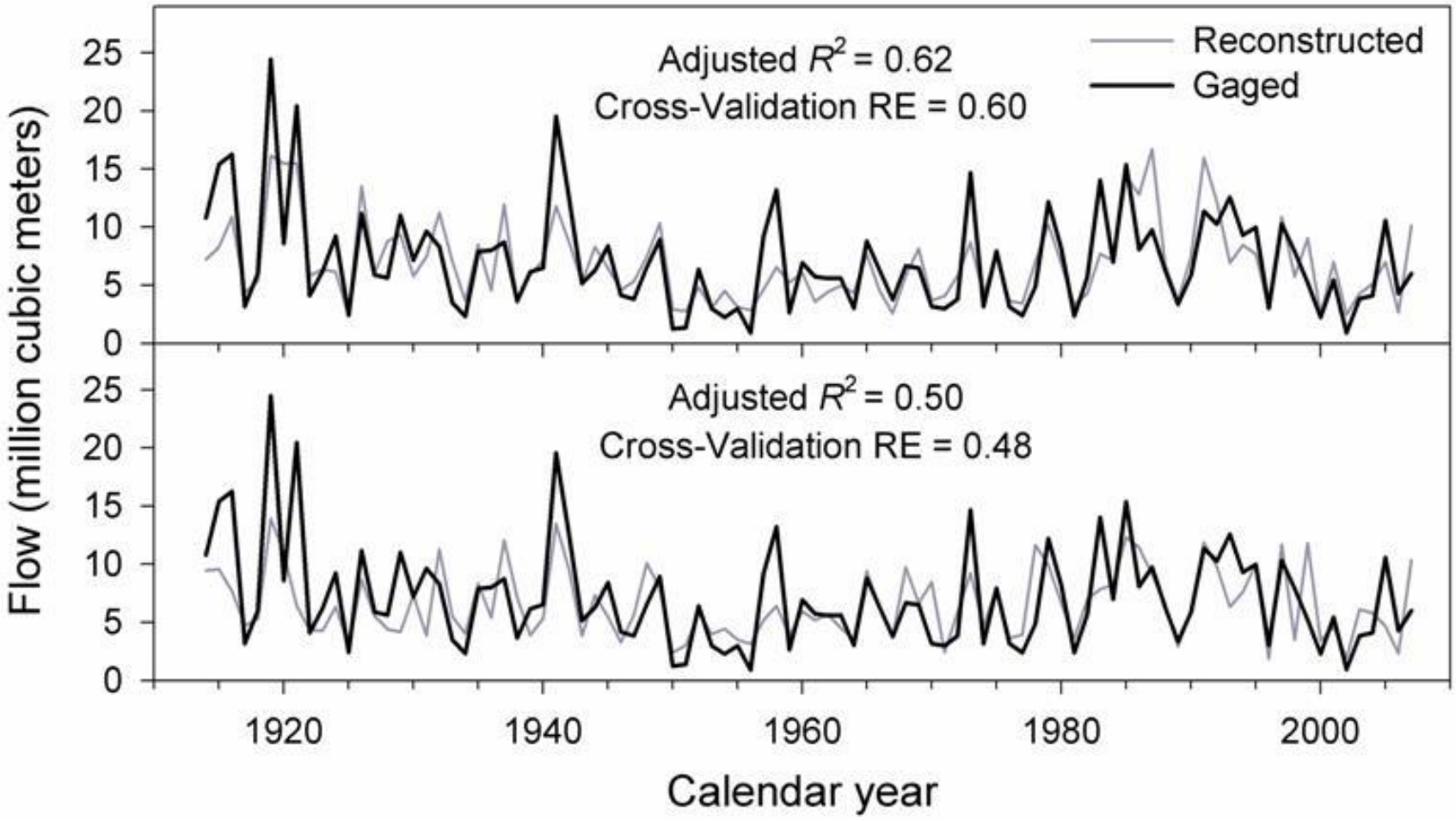
Margolis et al (*Accepted 9/2010) Journal of Hydrology*

Rocky slopes - climate sensitive trees

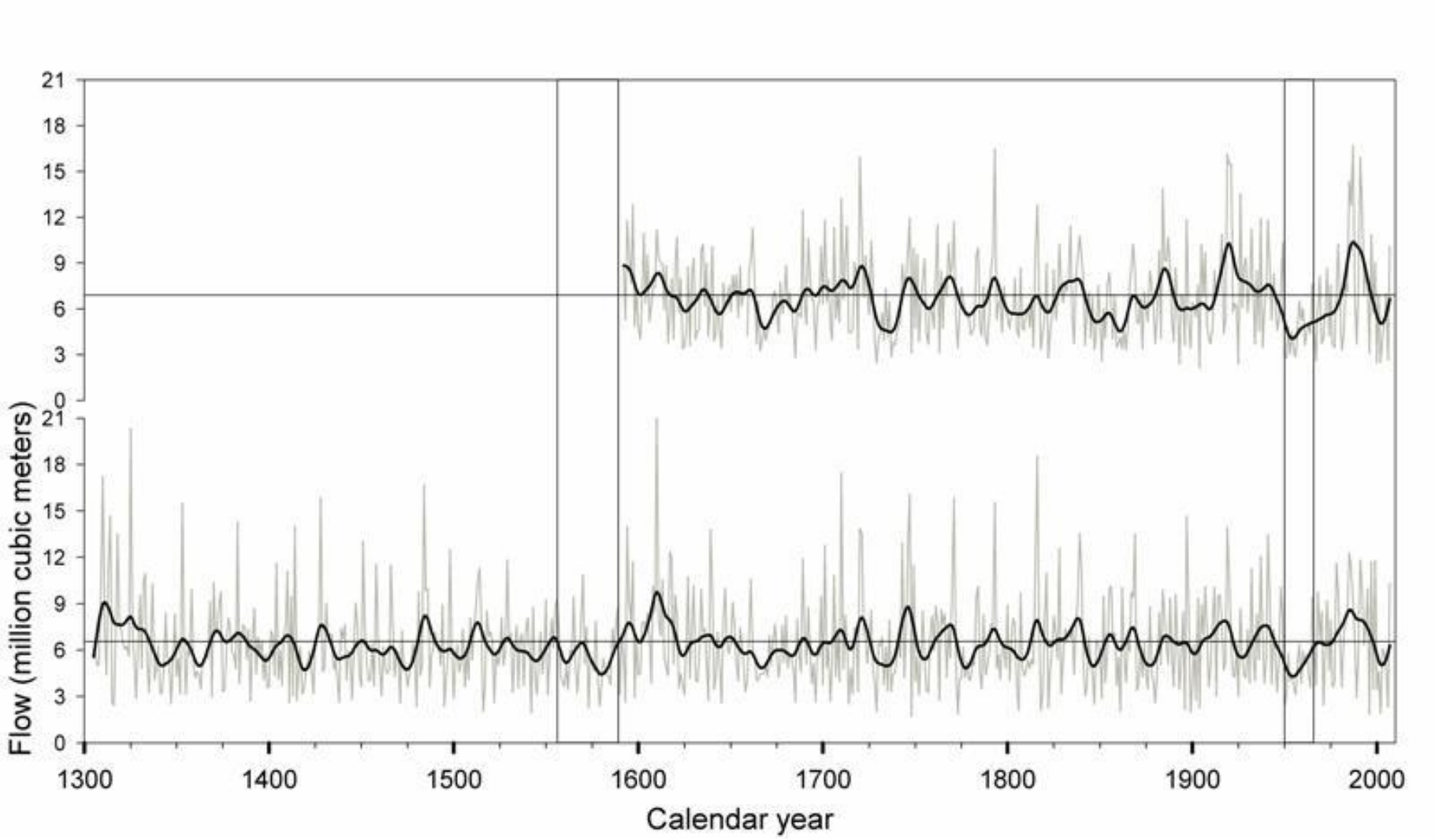
Tree-ring chronology



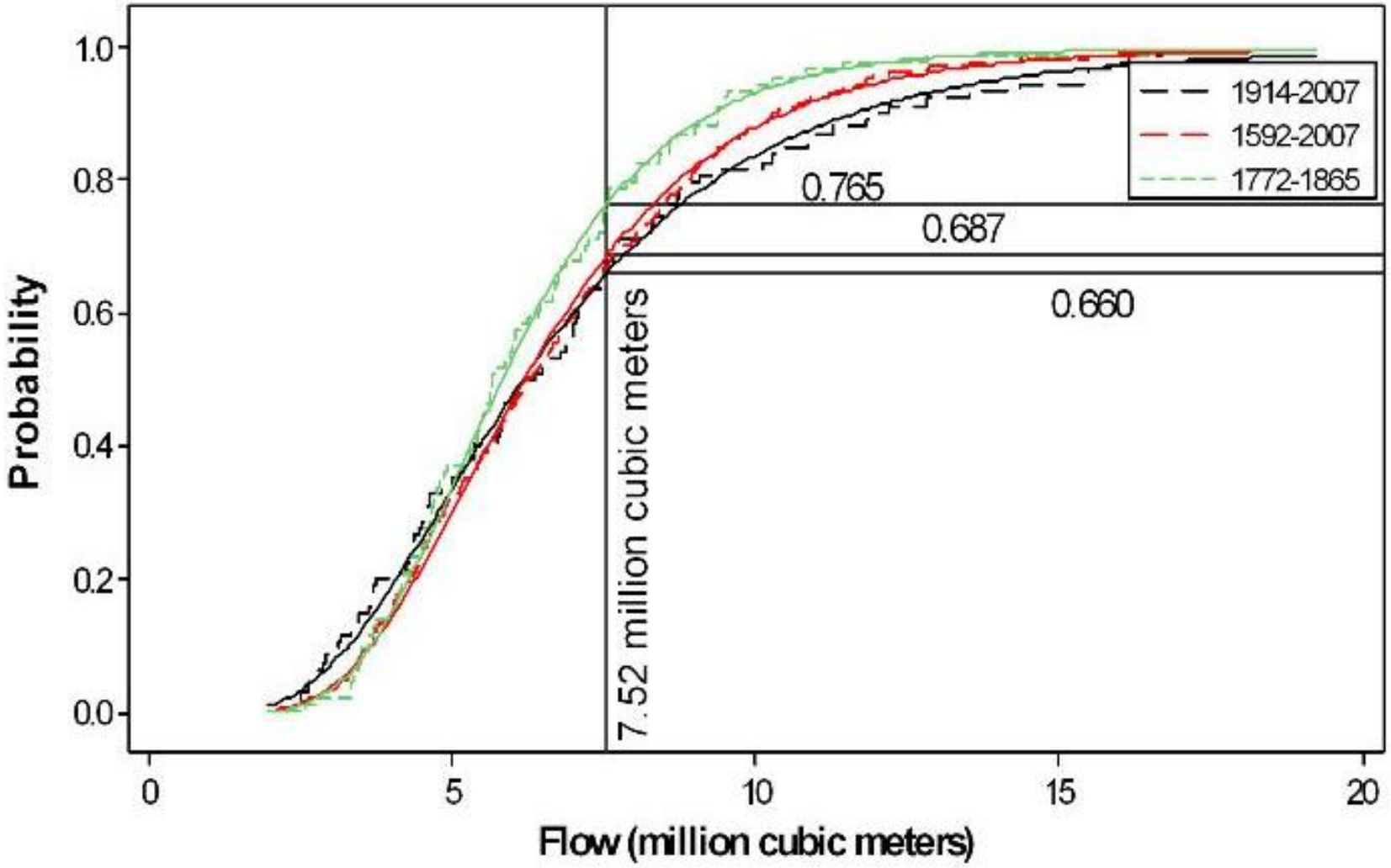
Calibrate tree-ring record with gaged flow



Streamflow reconstructions



Probabilities of meeting flow targets during pre-instrumental droughts

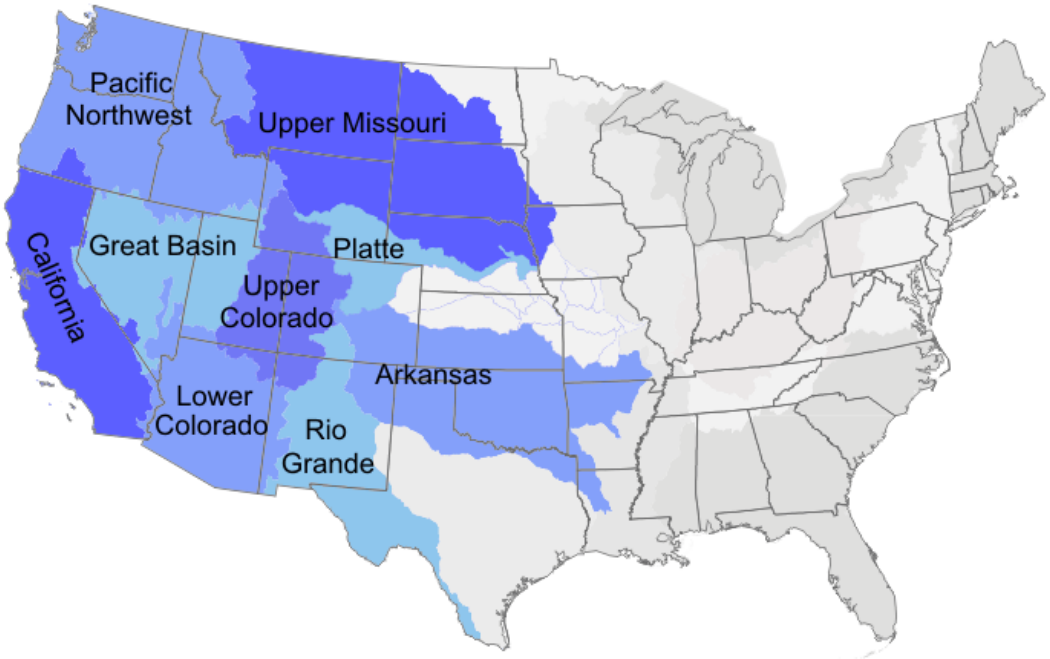


Santa Fe gaged record in 700-yr context

- Recent extreme low flow events (e.g., 2002) are rare (5th percentile) in the long-term records
- The 1950's drought contained the lowest 7-year mean flows over the past 400 to 700 years
- Longer (40-yr) low flows of the 1500's were worse than anything in the 20th century
- Ex - 1544-1583 flow estimated at just 86 percent of the 1914-2007 mean
- 10% lower probability of meeting flow targets if 16th century flows occurred again (only 2 out of 10 yrs)

Streamflow reconstruction resources

http://treeflow.info/



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