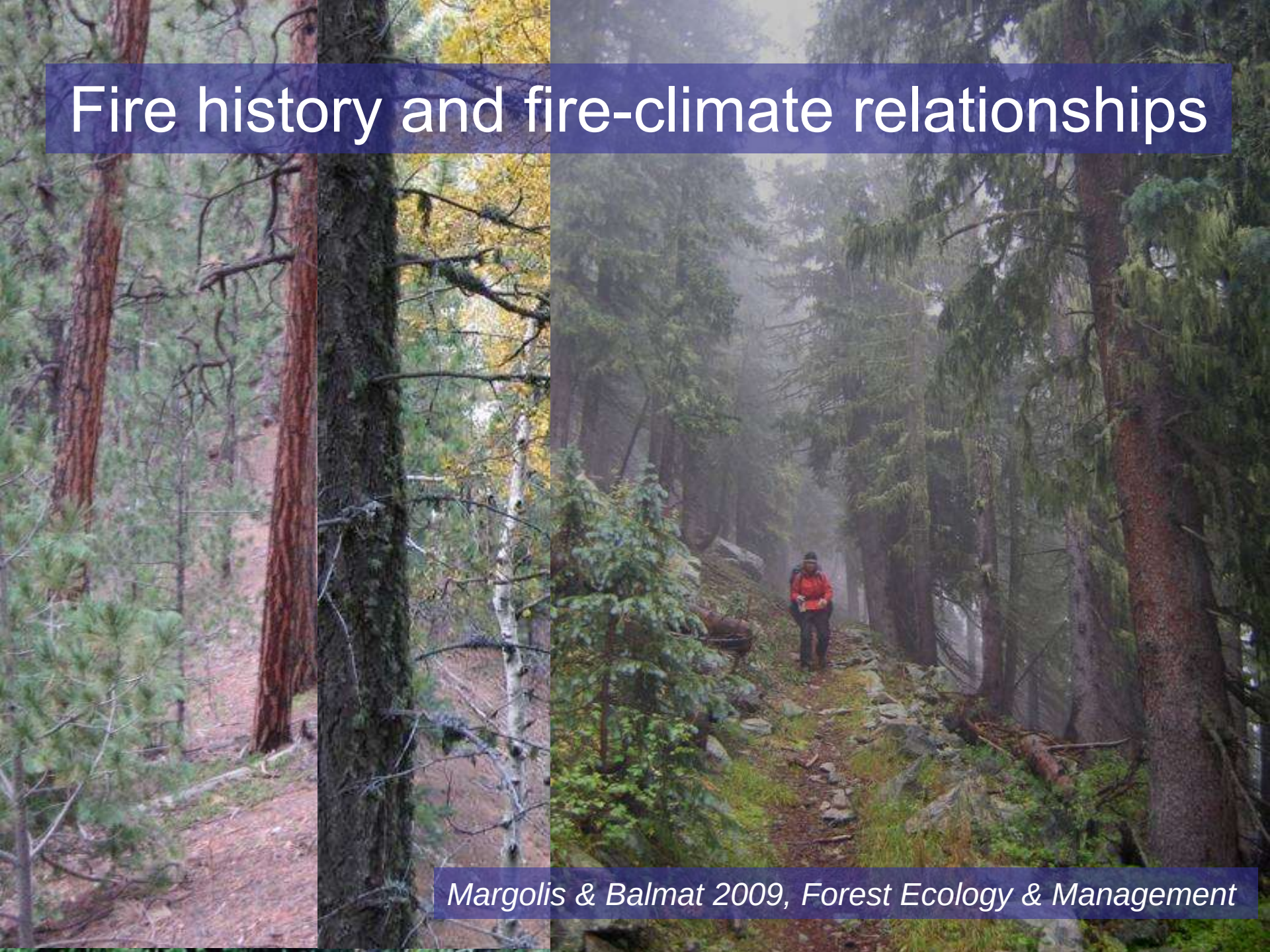
A 700-yr history of fire and streamflow: Santa Fe watershed, New Mexico

Ellis Margolis

Laboratory of Tree-Ring Research, Univ of Arizona

Tucson, Arizona

Fire history and fire-climate relationships



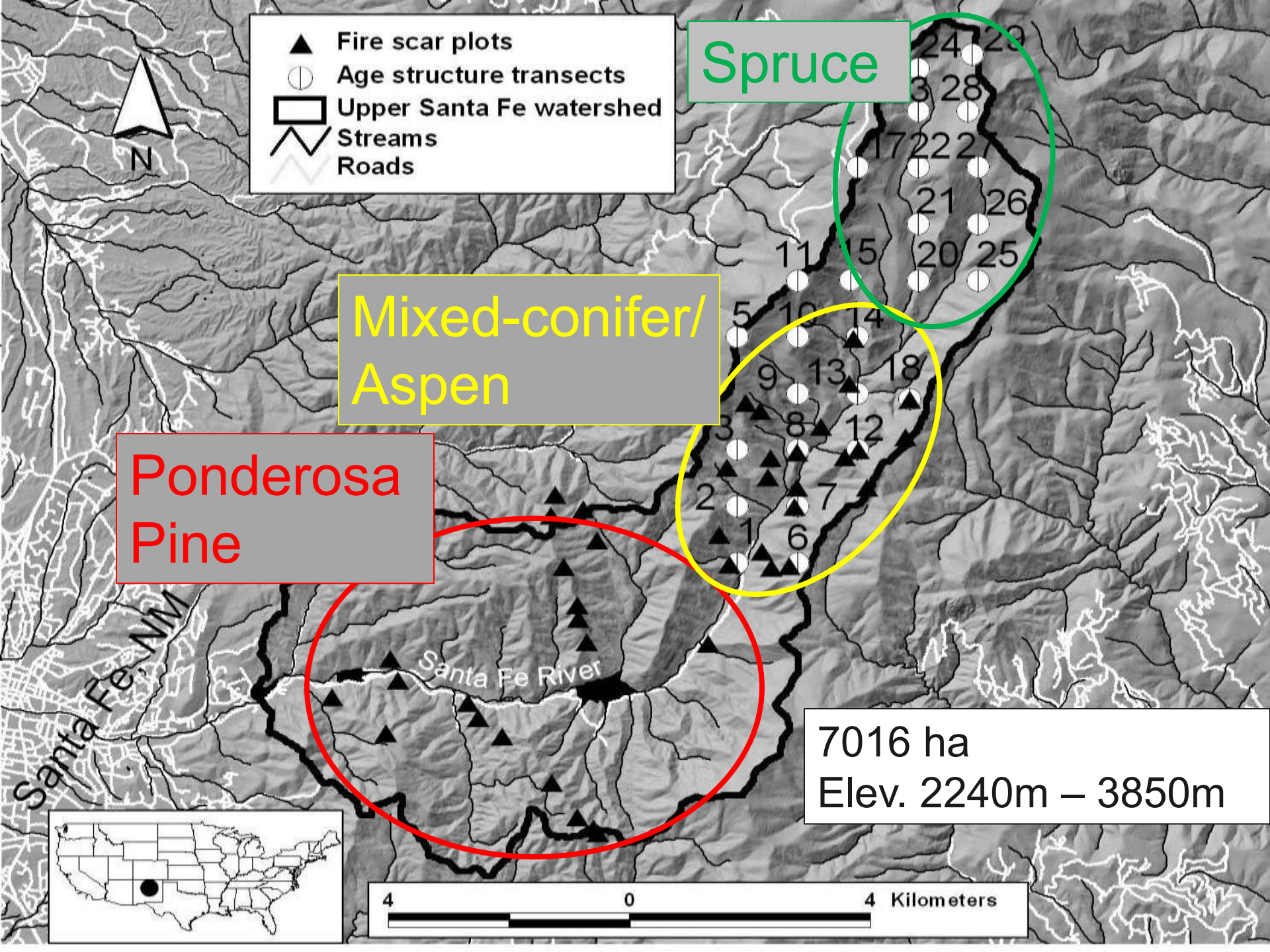
Margolis & Balmat 2009, Forest Ecology & Management


Tree-ring sampling

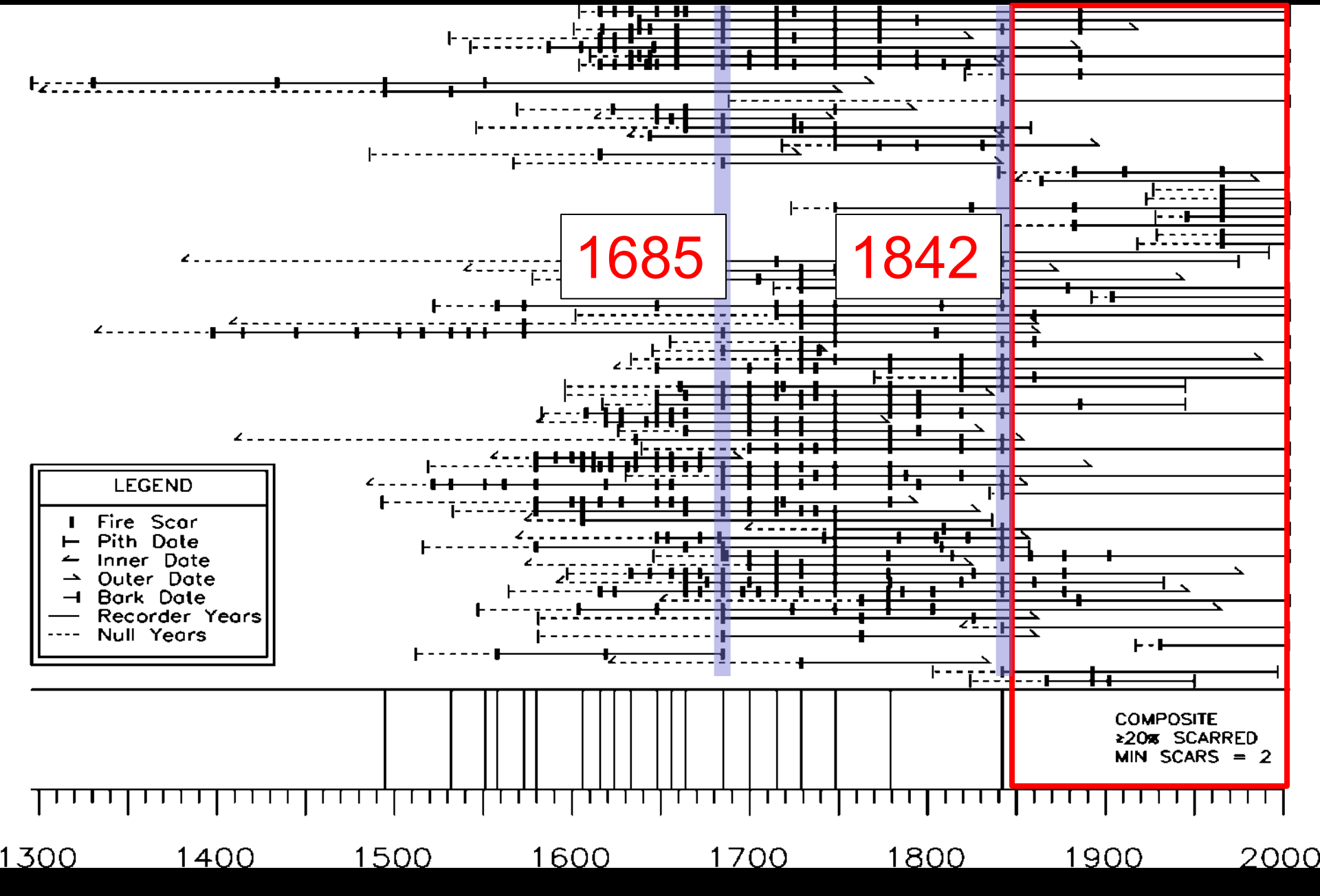
Increment cores:

Determine tree age

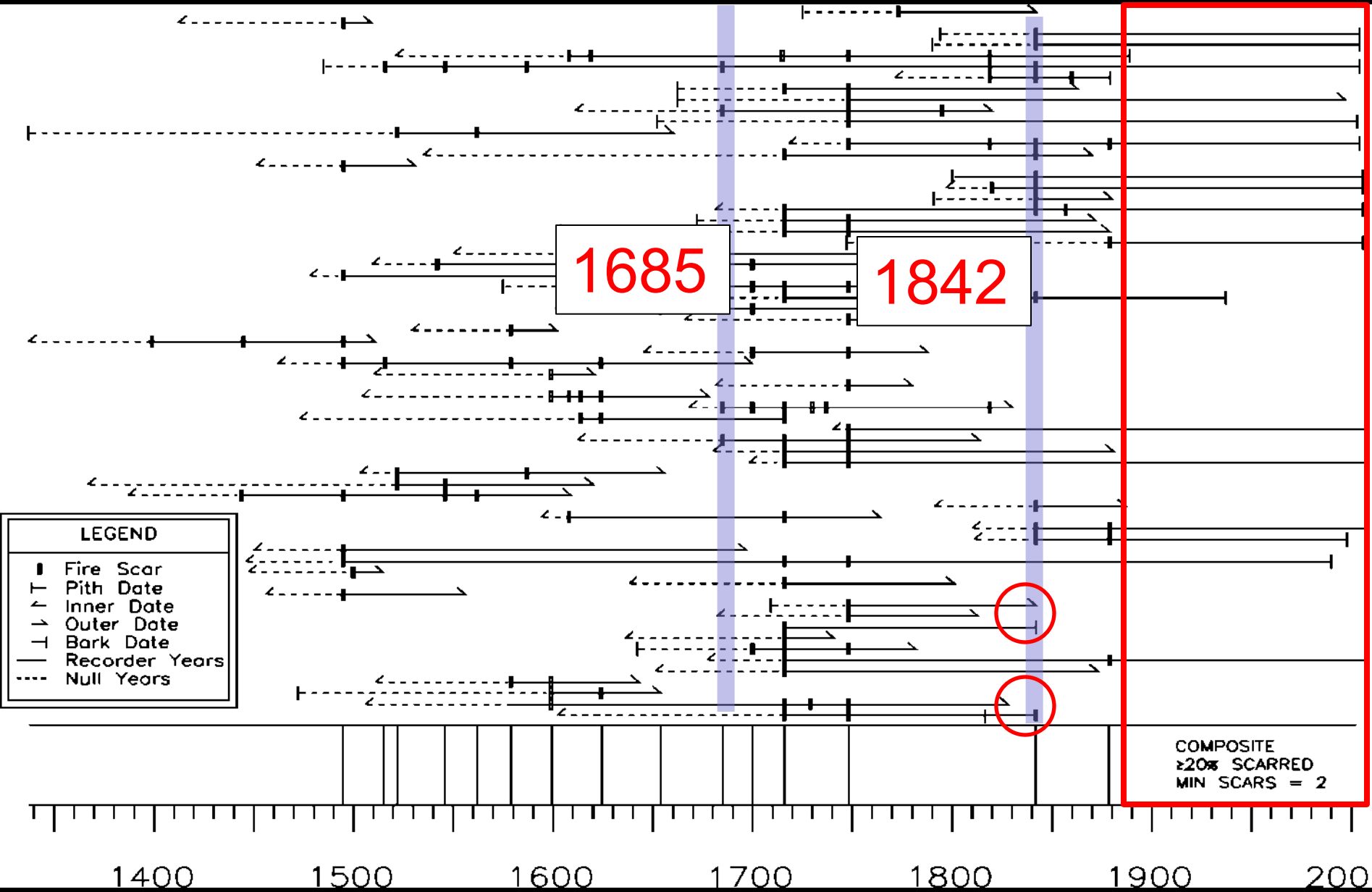

Fire scars


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

Ponderosa pine fire history (1296-2004)



Mixed conifer fire history (1337-2008)

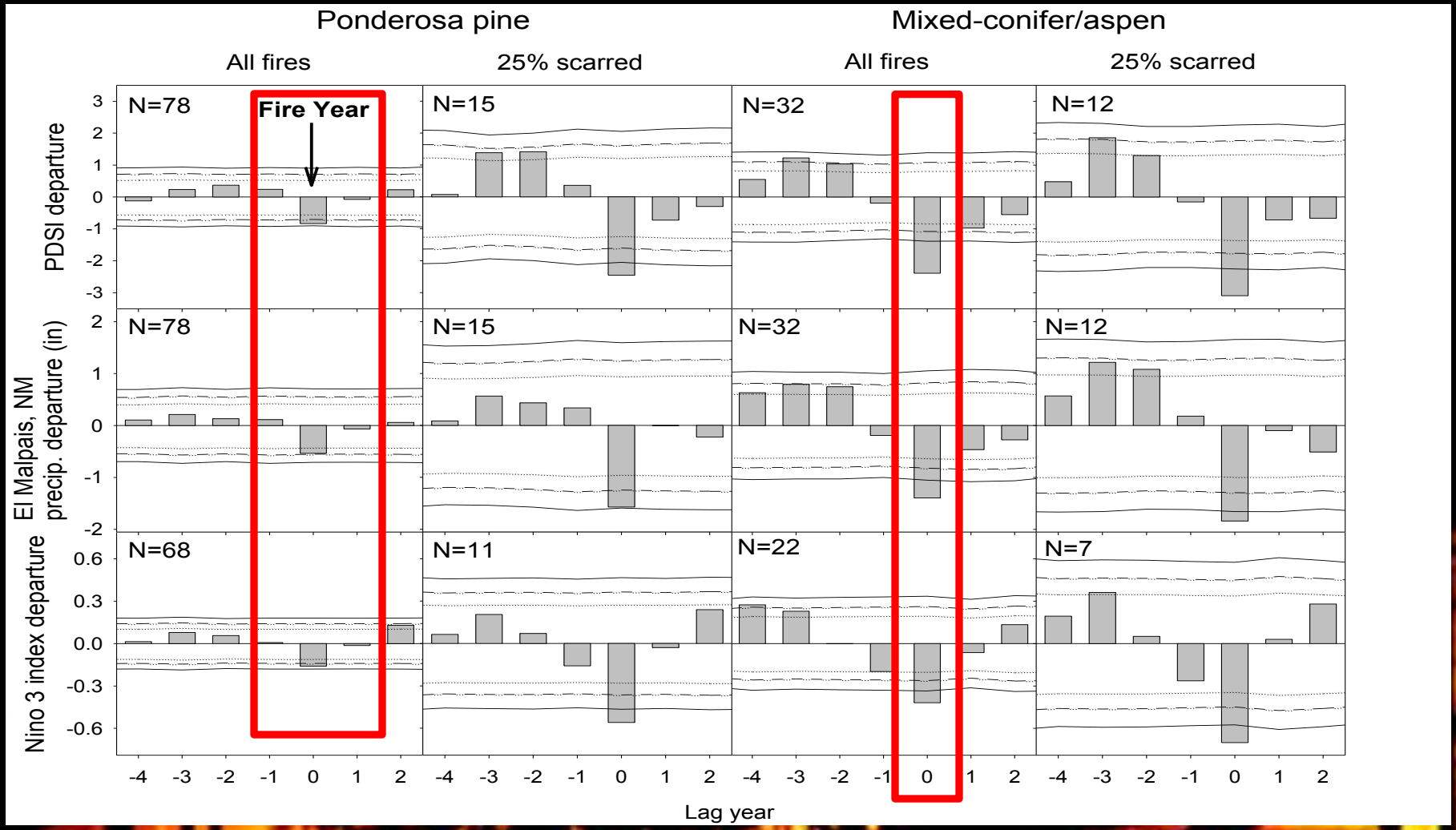


Different fire frequency between ponderosa pine and mixed-conifer/aspen forests

% 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)

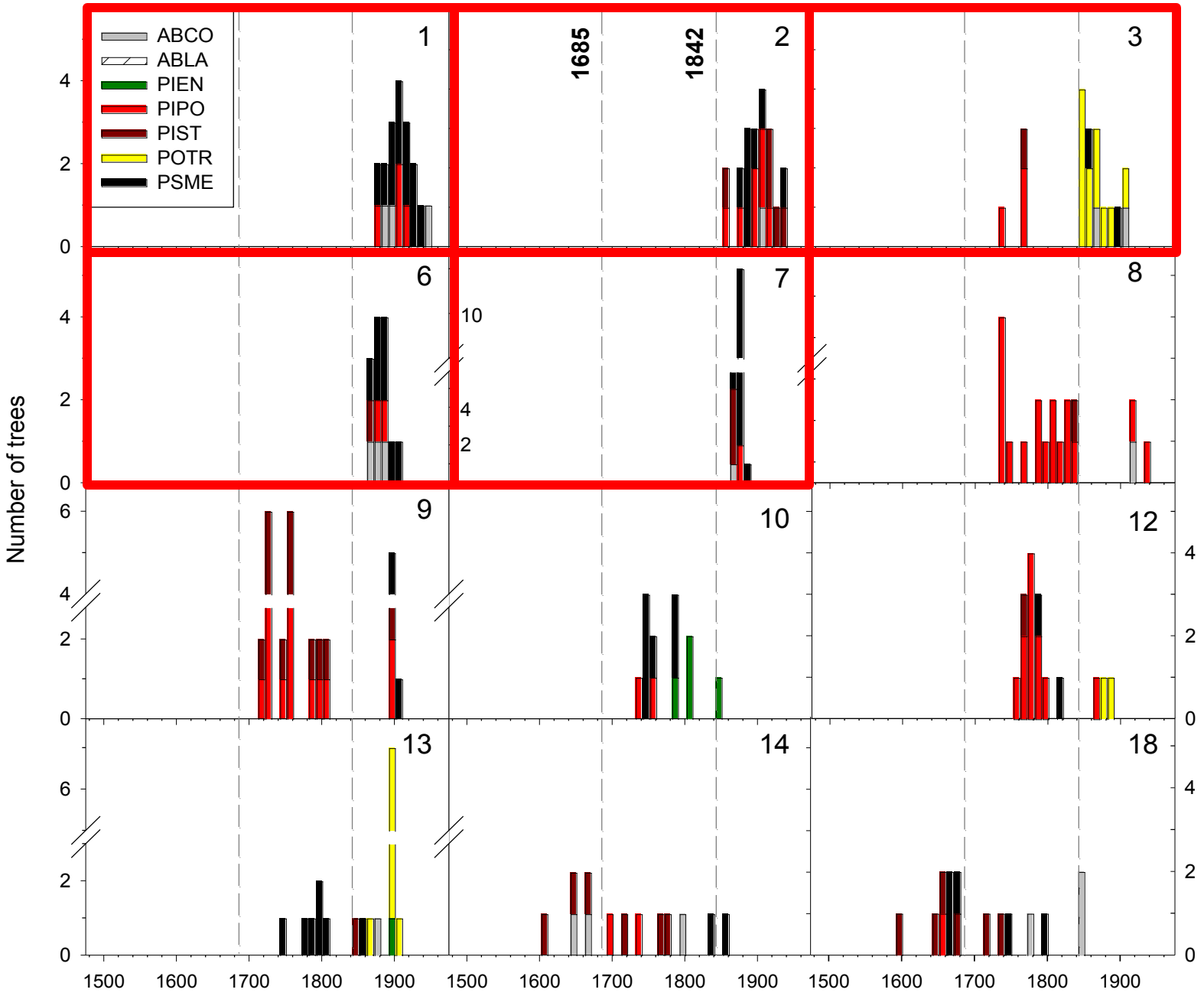
Fire-climate relationships



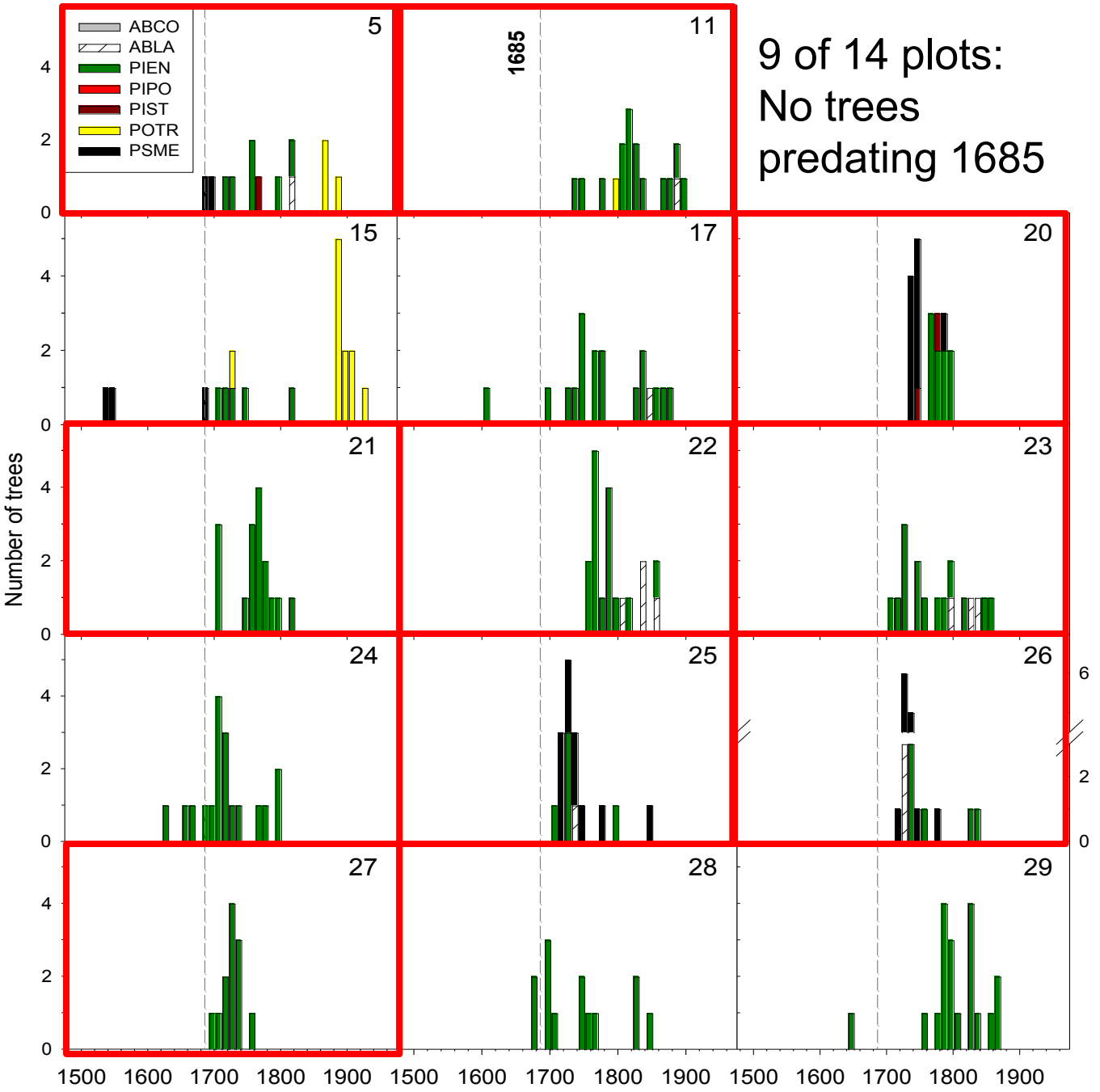
Pipo – mean PDSI, all fires -1.03

MC – mean PDSI, all fires -2.59

Mixed conifer age structure by plot

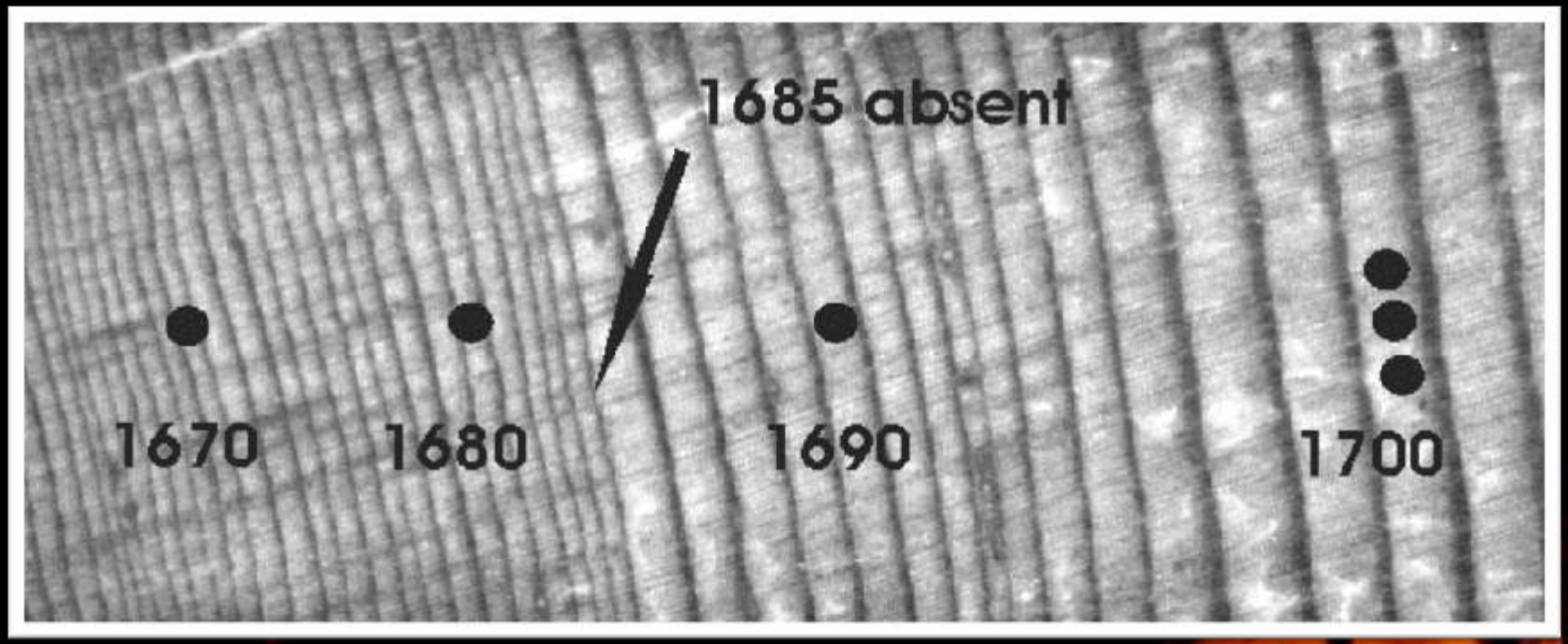


Spruce dominated forest age structure by plot



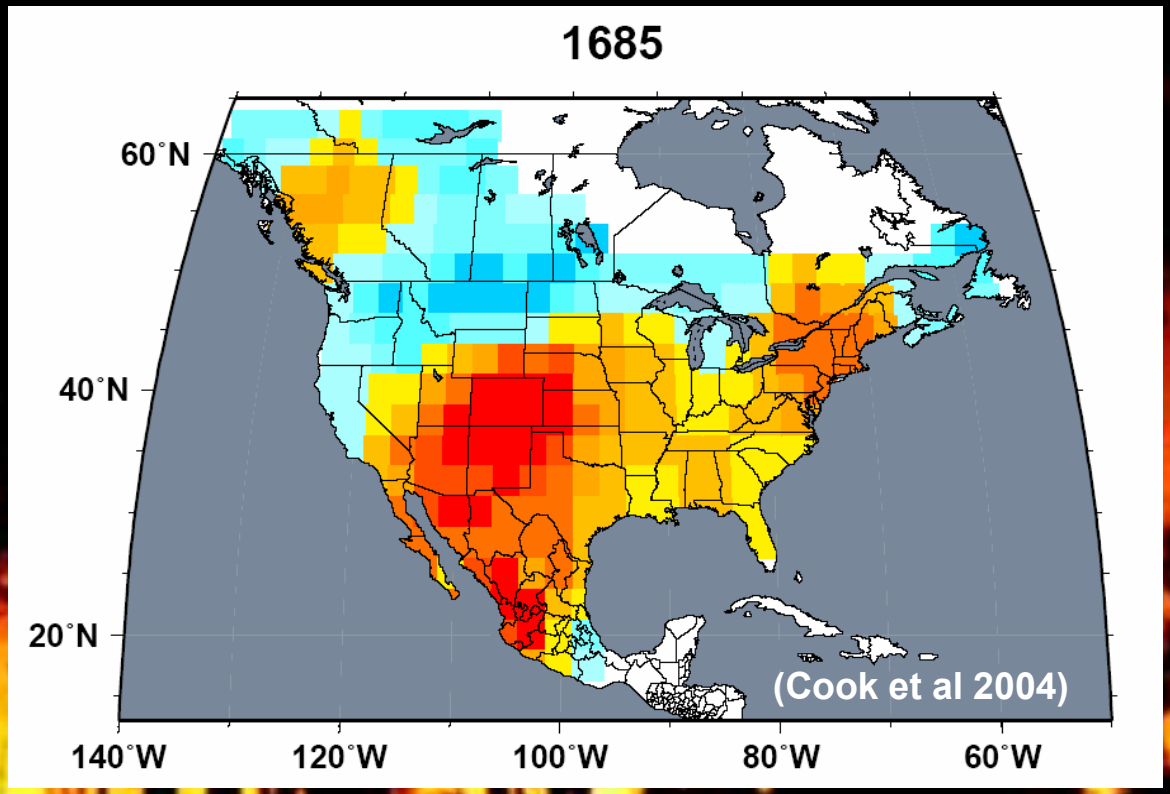
9 of 14 plots:
No trees predating 1685

Growth release following 1685 fire



1685 fire

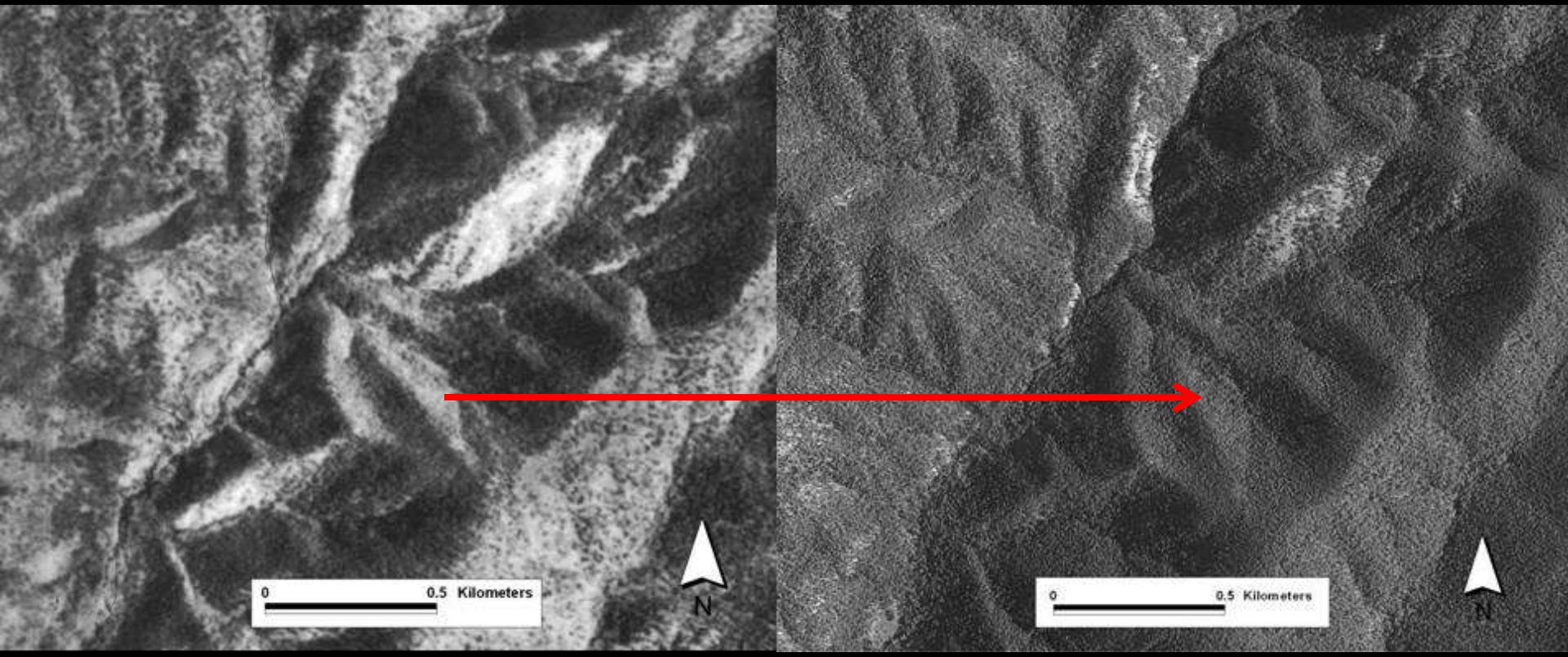
- Recorded by fire scars at 68% of fire scar plots
- Largely stand-replacing in the spruce-dominated forest
- Worst drought yr in over 1000 years; PDSI = – 6.92!



Increased forest density and connectivity: = greater area at risk of stand-replacing fire

1935

2005

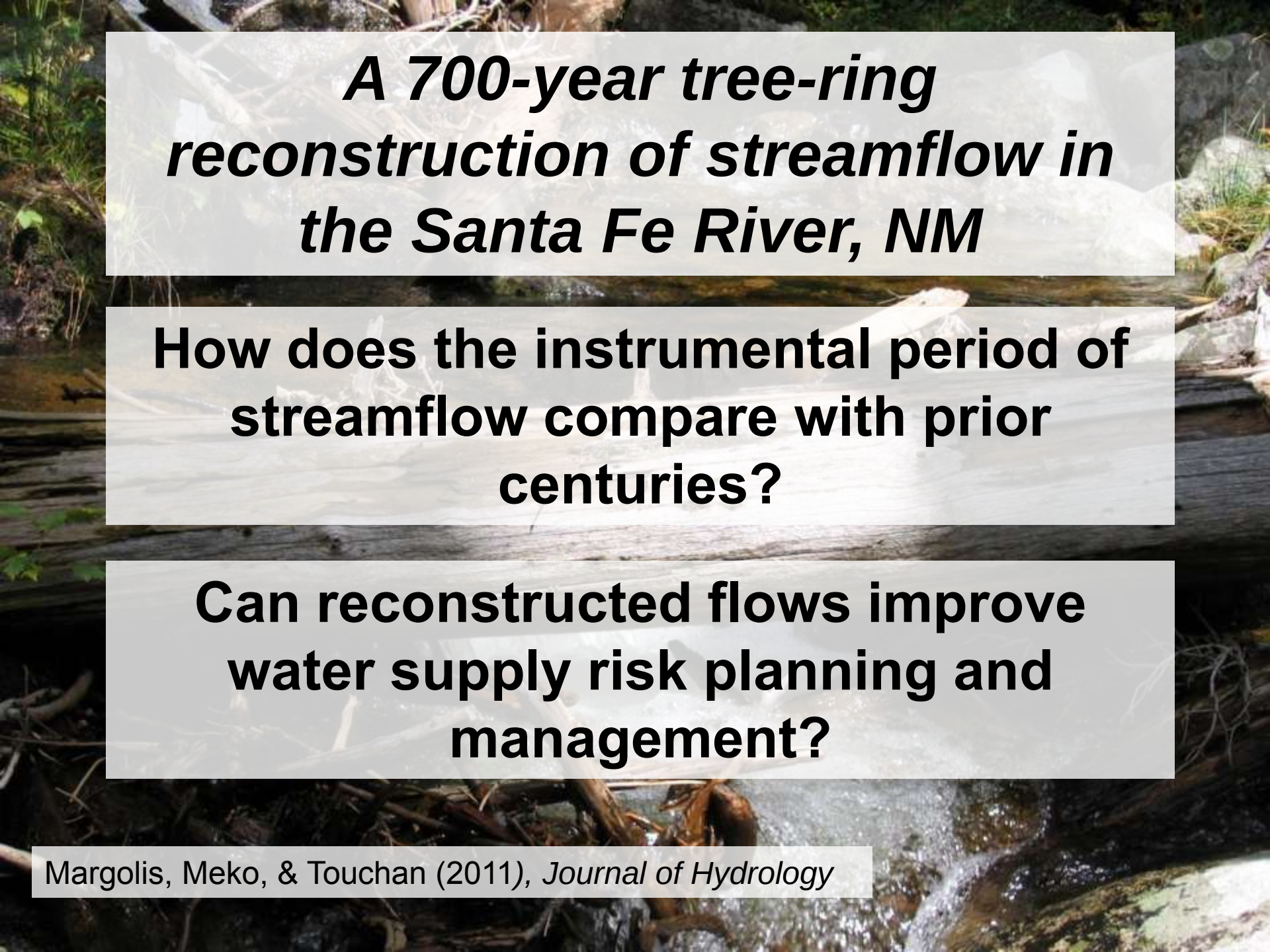


Conclusions

- Fire historically burned across gradients of elevation, forest types and fire severity
- MC/aspen – mixed severity fire regime with small (<100 ha) stand-replacing patches immediately adjacent to low severity patches
- Spruce - last fire (1685) was largely stand-replacing (1200 ha, 93% of sampled area), recorded as fire scars throughout the MC and Pipo, and burned during a severe, regional drought (PDSI = - 6.92)
- The drought-fire relationship suggests that if droughts become more frequent and severe, as predicted, the probability of large, severe fire occurrence will increase

Implications for ongoing treatments

- Pipo – fire source, so treatments in Pipo should lower fire risk in adjacent forests
- MC – increased area at risk of crown fire due to connectivity through infill
- Spruce – burned stand-replacing > 300 yrs ago and it's getting warmer – get ready!
- Water infrastructure still at risk of post-fire sedimentation, floods and ash contamination even after treatment in Pipo



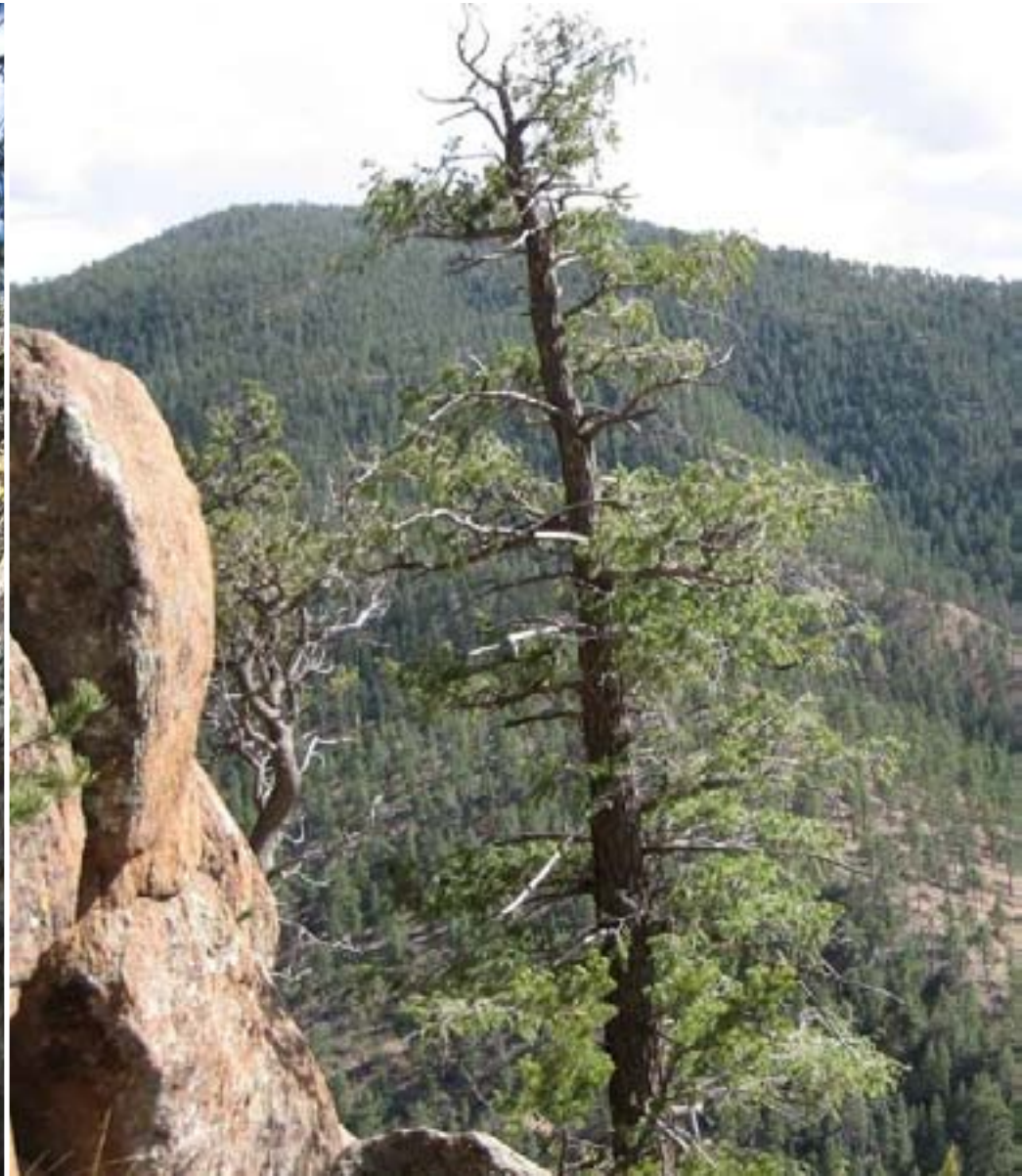
A 700-year tree-ring reconstruction of streamflow in the Santa Fe River, NM

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

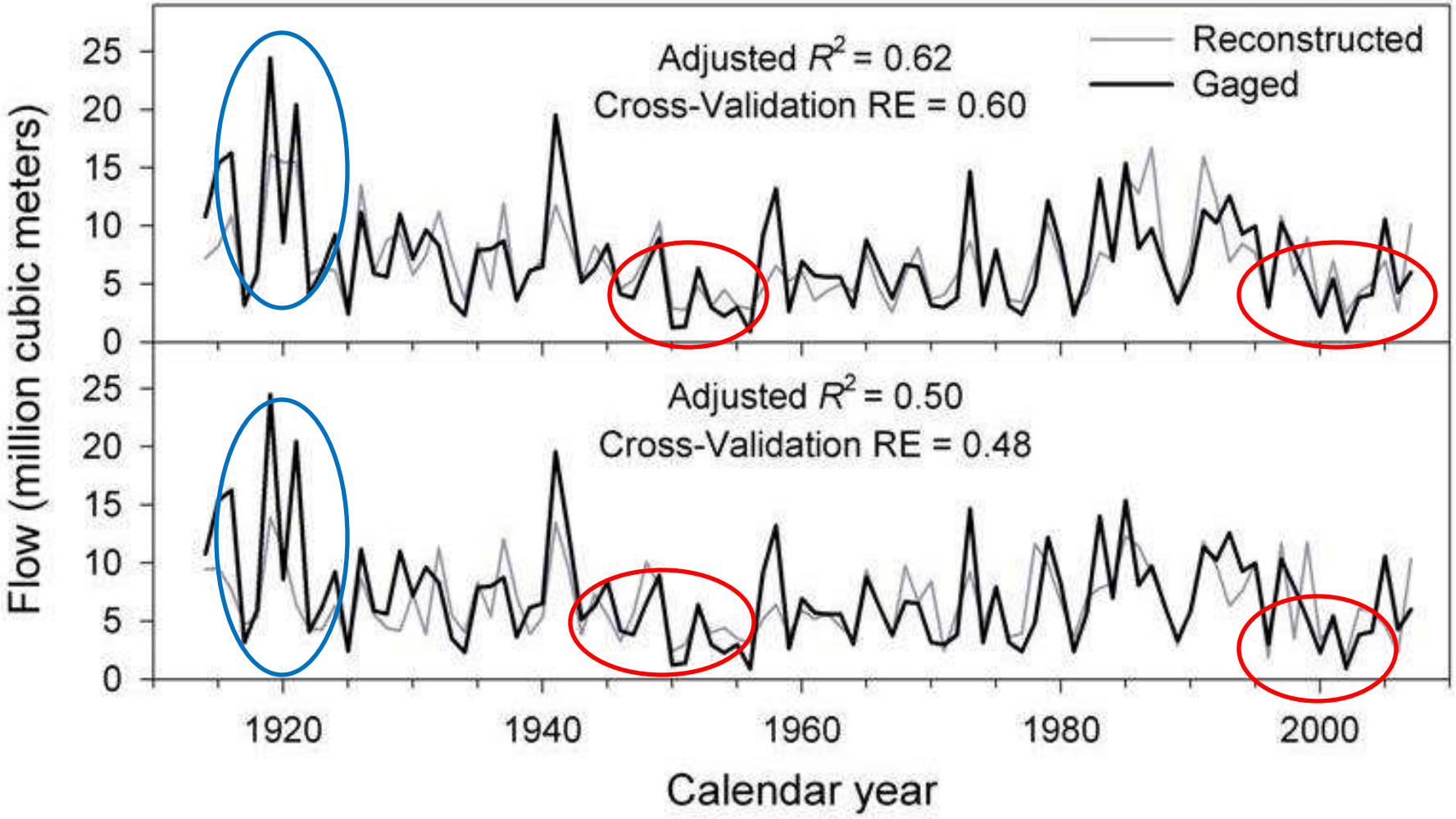
Can reconstructed flows improve water supply risk planning and management?

Margolis, Meko, & Touchan (2011*), Journal of Hydrology*

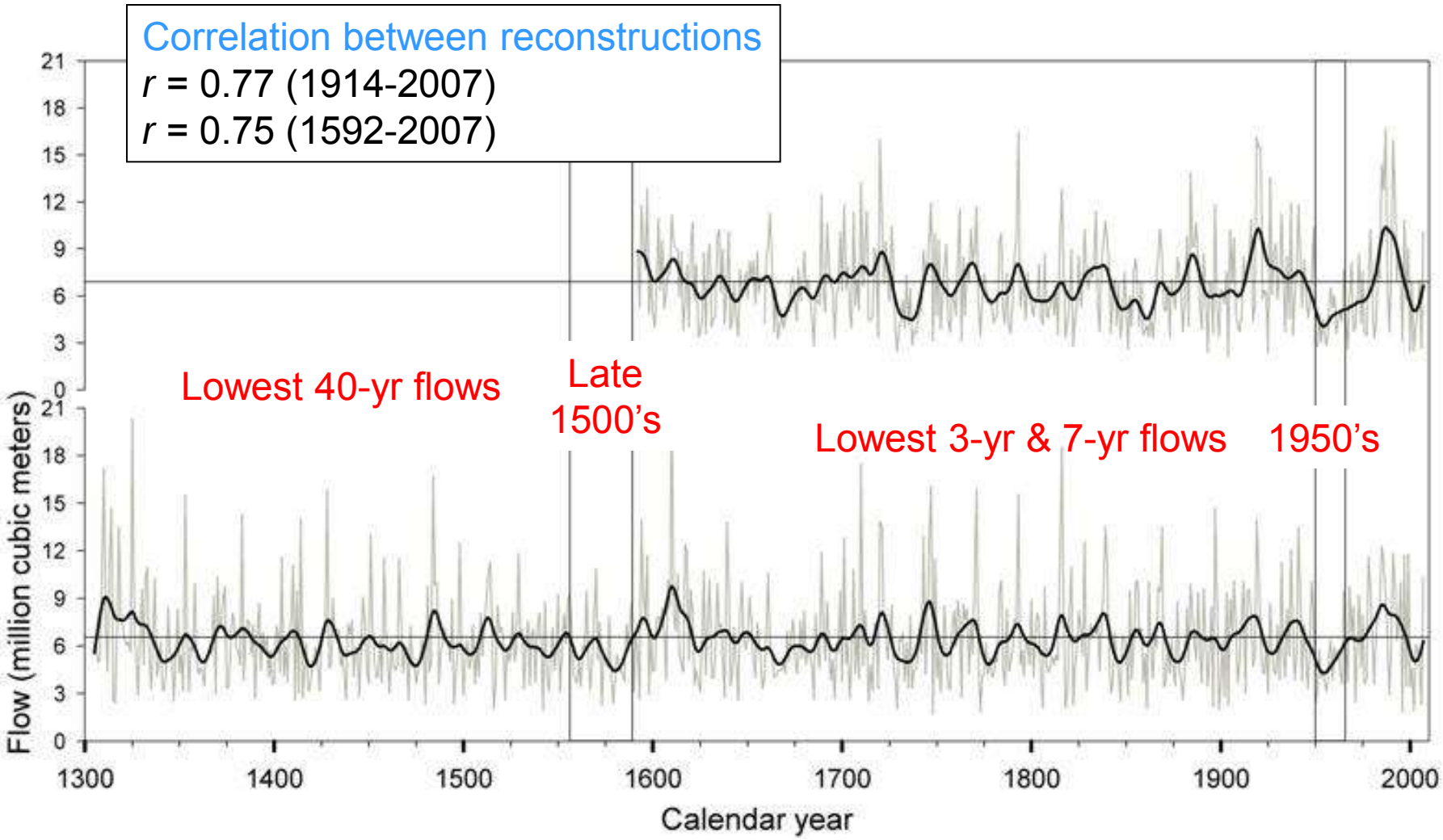
Moisture sensitive trees



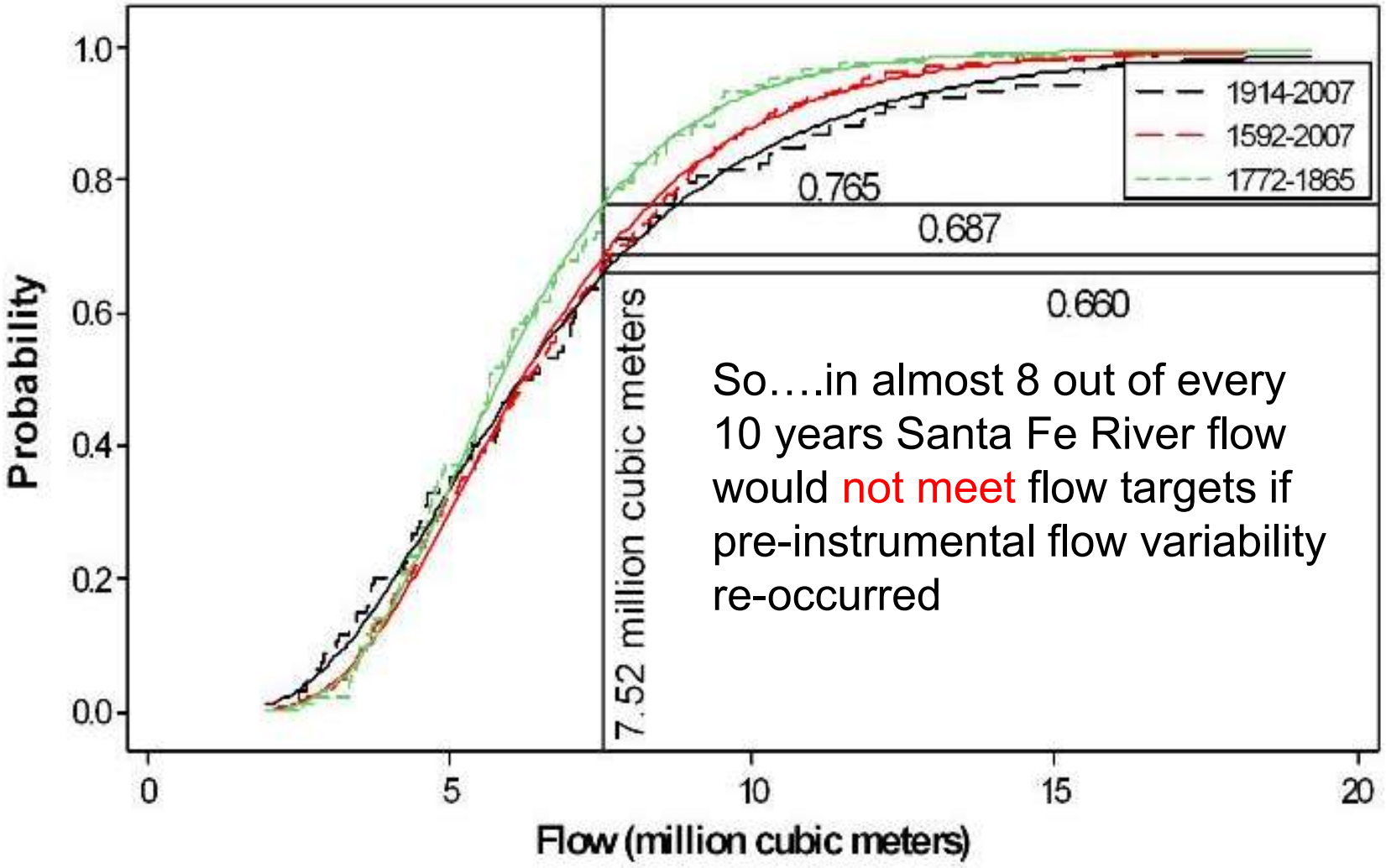
Calibration/Verification (1914-2007)



Streamflow reconstructions



Probability of ***not*** meeting flow target was 10% greater during pre-instrumental period



Santa Fe gaged record in 700-yr context

- Recent extreme low flow events (e.g., 2002) are rare (5^{th} percentile) in the long-term records
- The 1950's drought contained the lowest 3-year and 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 instrumental period
- Ex - 1544-1583 flow estimated at just 86 percent of the 1914-2007 mean
- 10% lower probability of meeting flow targets if 1500's flows occurred again (only 2 out of 10 yrs!)

Management implications

- Fire hazard, severity, and frequency will increase in MC and Spruce with projected climate changes and resulting increased drought stress
- Water – planning can be improved using broader range of (climate) variability contained in 700-yr tree-ring record
- Fire+Water – water supply and the City of Santa Fe is still potentially at risk from post-fire flooding when the upper elevations burn again.

Acknowledgements

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