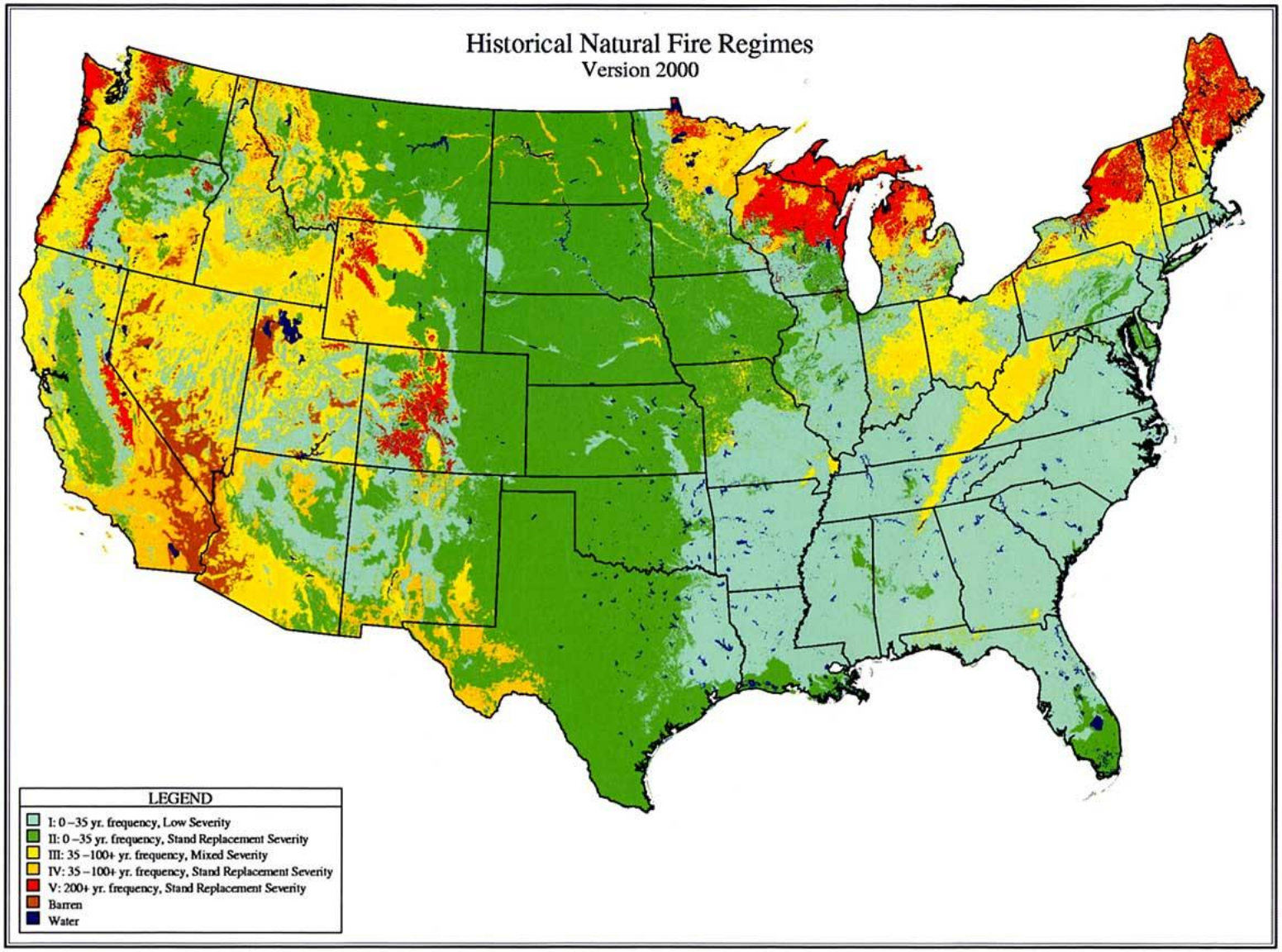
Subalpine/Upper Elevation and Boreal Fire Regimes

Tom Swetnam

October 17, 2012

Invited lecture, RNR 355



Schmidt et. al. USDA Forest Service General Technical Report RMRS-GTR-87. 2002.

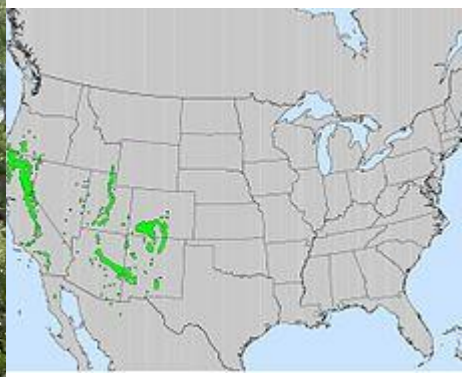
Lodgepole pine – Pinus contorta

www.conifers.org

Giant sequoia, partially serotinous cones

Engelmann spruce – Picea engelmannii

White fir – Abies concolor



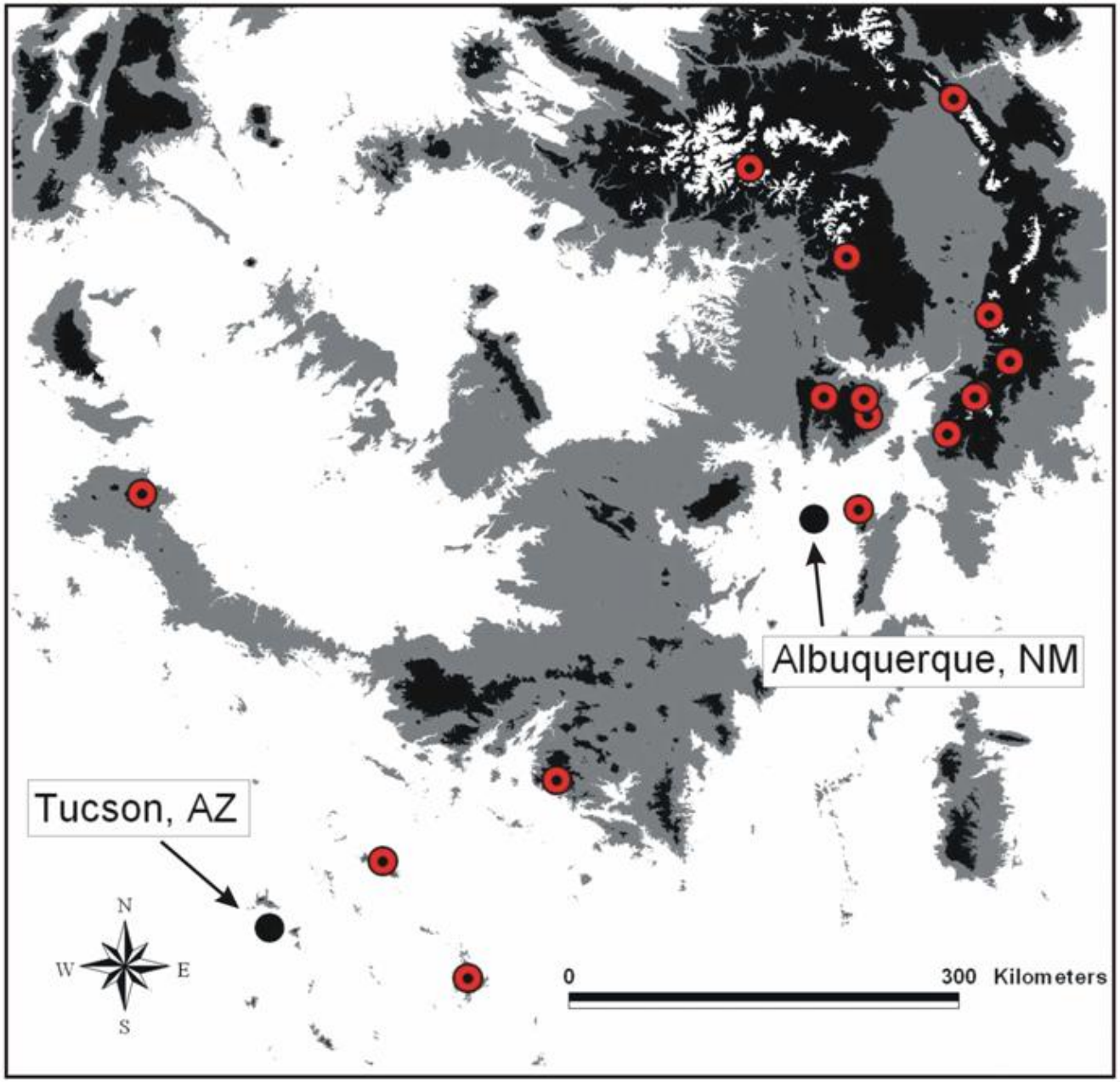
USFS, 1926


51.


Jicartita Mountain, Sangre de
Cristos, NM

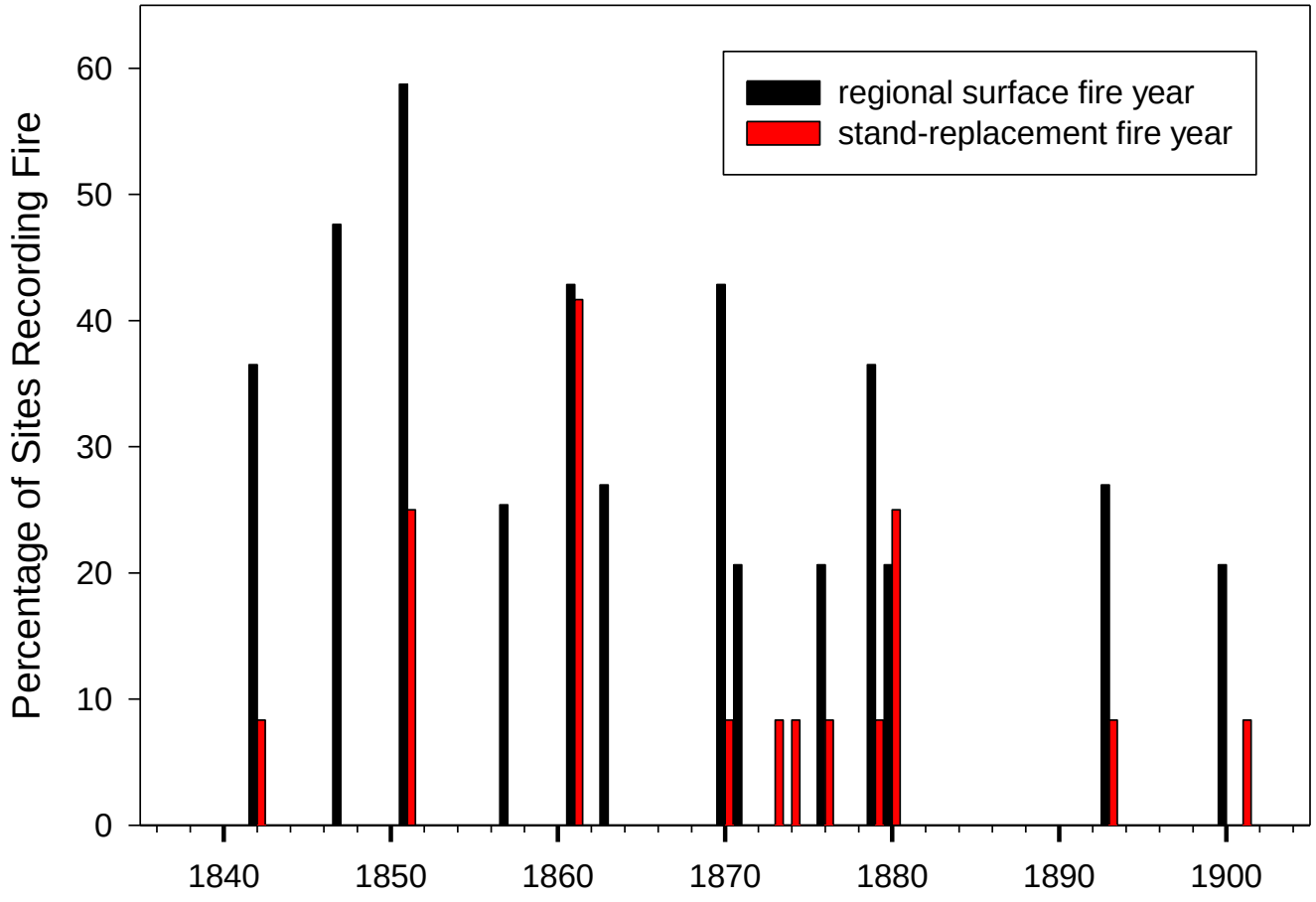
A stand-replacing fire history in upper montane forests of the southern Rocky Mountains. Margolis, Swetnam, Allen, 2007. Canadian Journal of Forest Research 37:2227-2241.

Upper Elevation Stand-Replacing Fire History Network



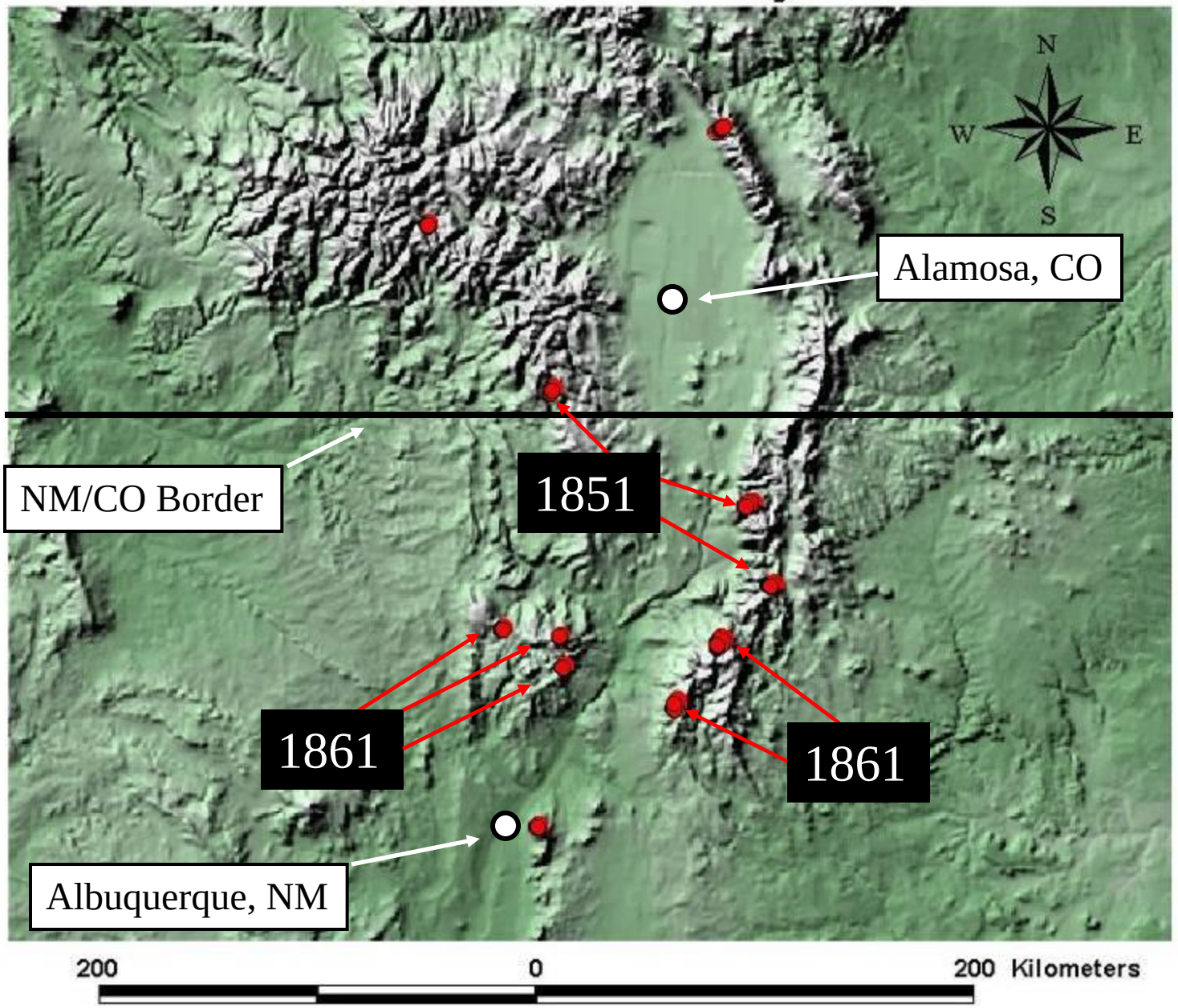
Ellis Margolis, Diss. UA

Regional crown fire and regional surface fire events in the Southwest were often synchronized. It is unknown at this time to what degree this was due to fire spread from low to high elevations (or vice versa), or climate.



Margolis et al. 2007

Upper Rio Grande Basin
Crown Fire History Sites

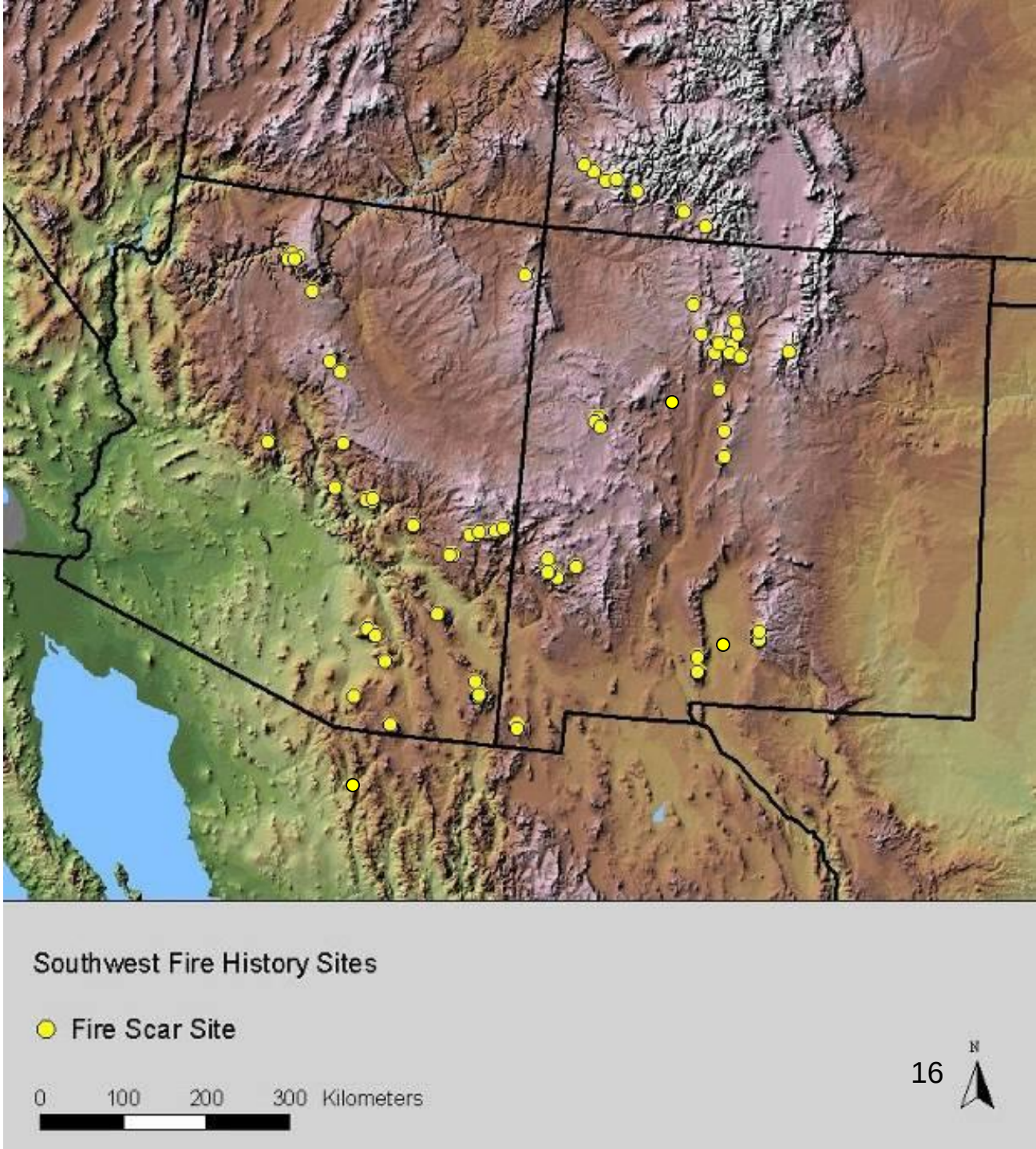


The fire-scar chronology network in southwestern North America currently includes about 120 sites.

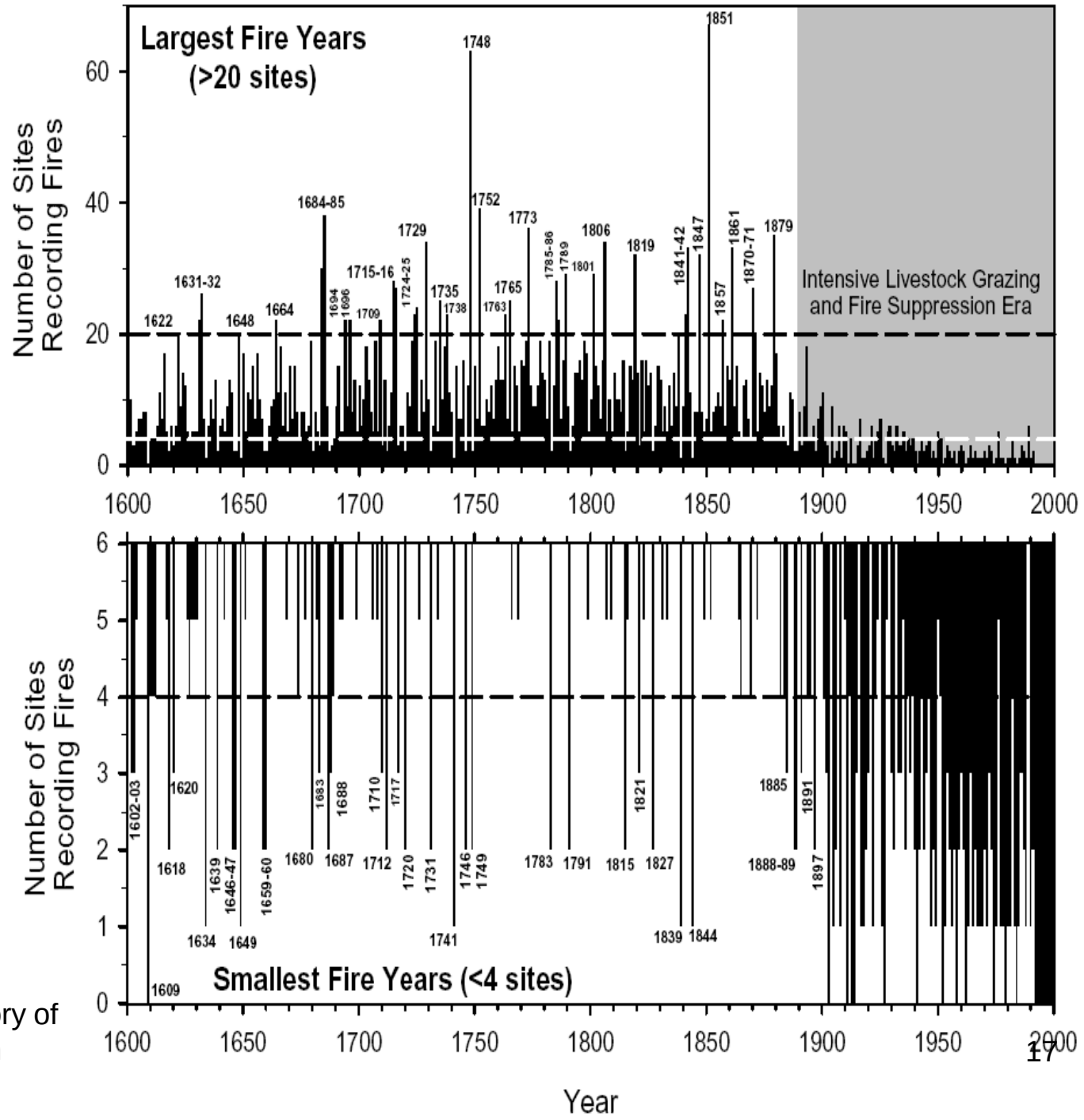
Most sites 10-100 ha, some >1000 ha. Typical sample sizes ≈ 10-50 fire scarred trees, hundreds in a few cases.

The SW fire history network represents the collective effort of many people and institutions over more than 3 decades.

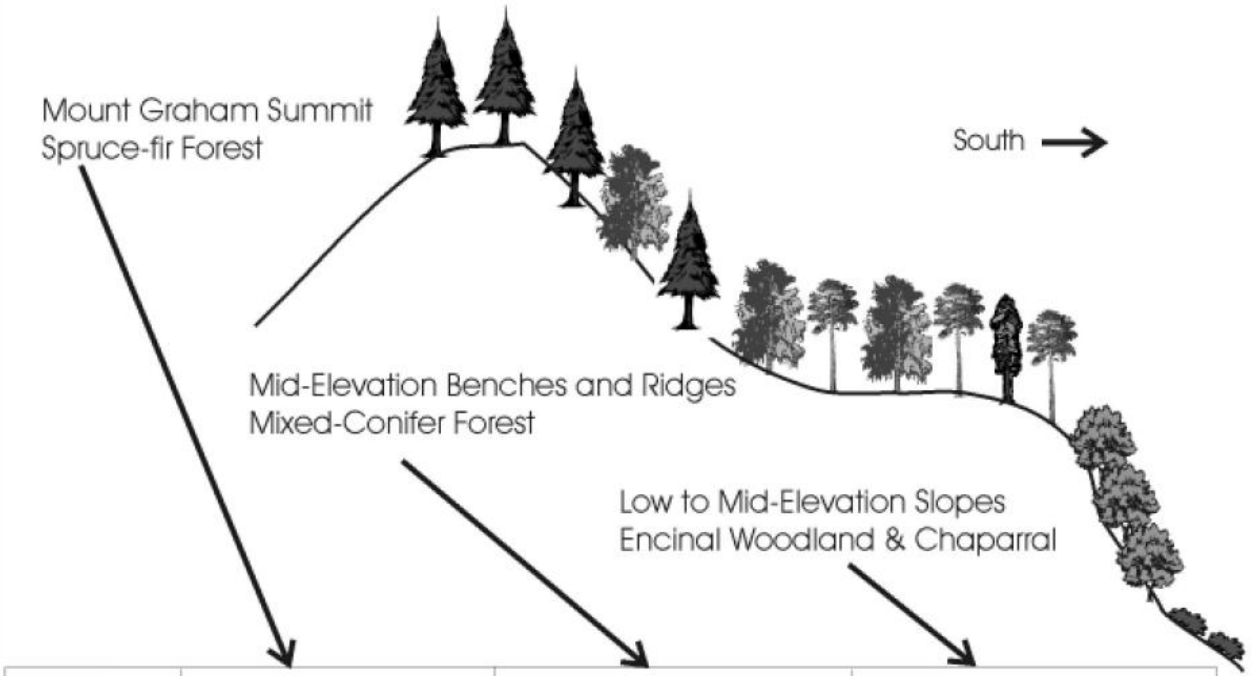
T.W. Swetnam, Laboratory of Tree-Ring Research



Synchrony is evident both in timing of fire events, and lack of events in multiple sites.

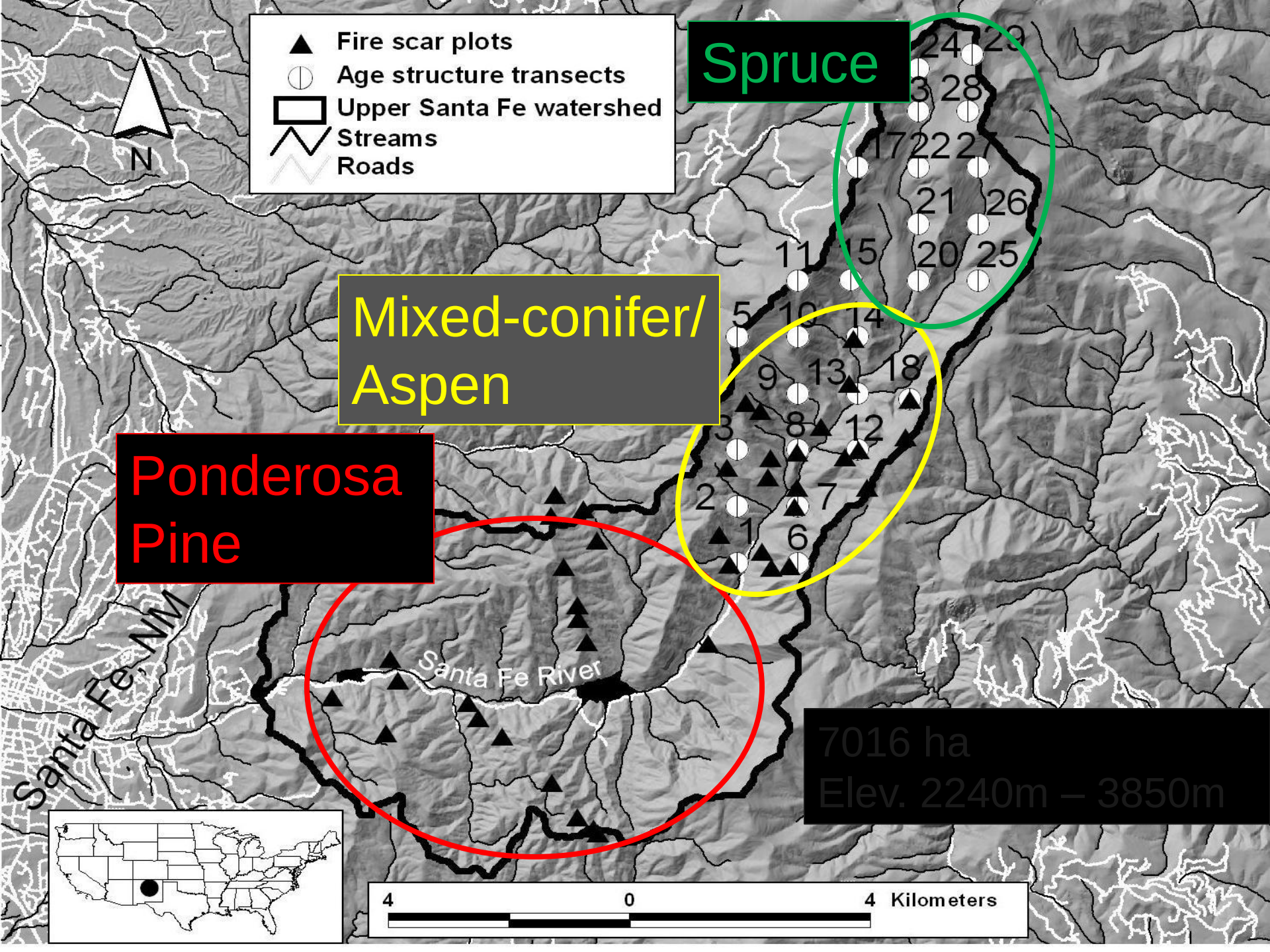


T.W. Swetnam, Laboratory of Tree-Ring Research

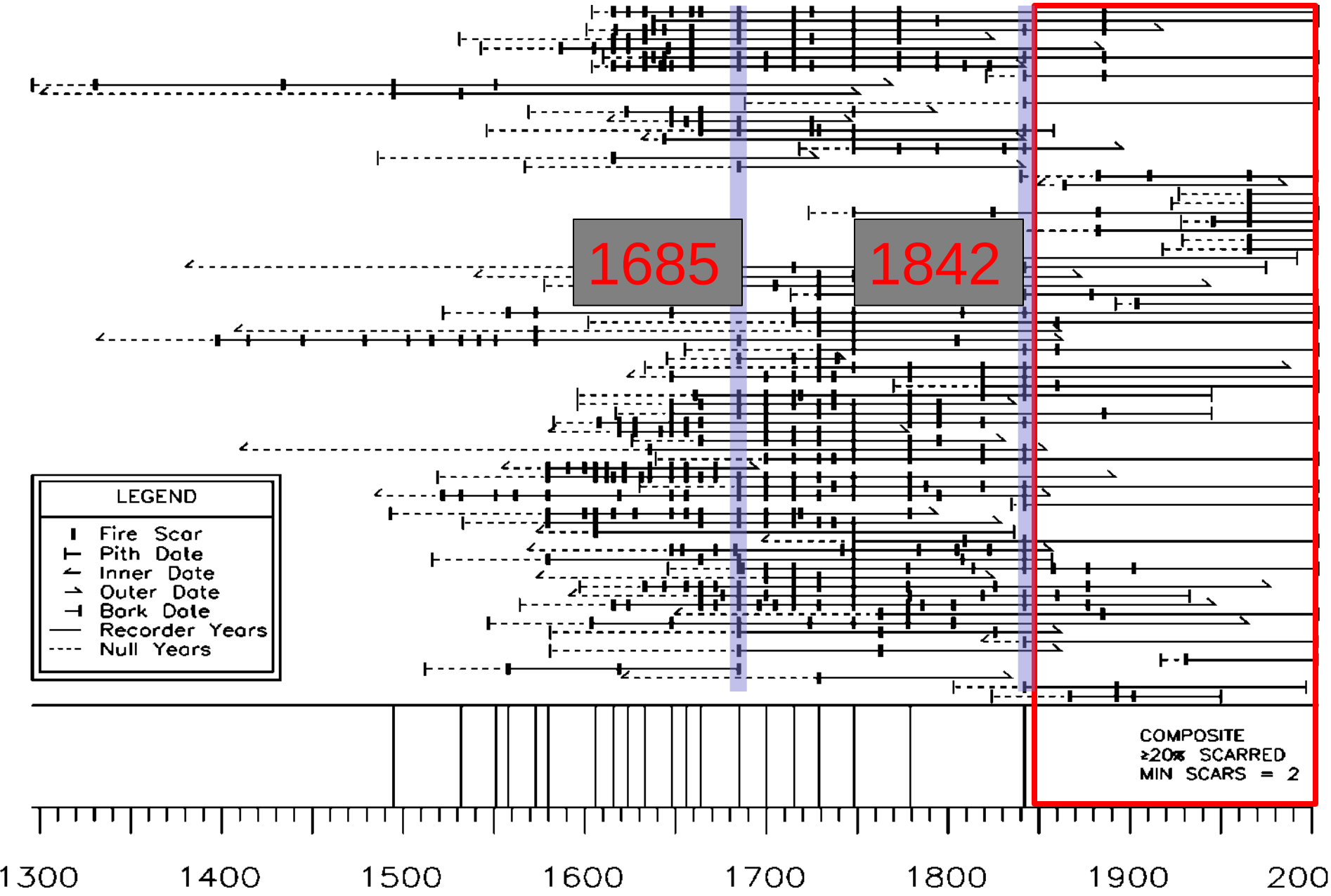


Tree Species:	*Picea engelmanni* *Abies lasciocarpa* *Abies concolor* *Populus tremuloides*	*Pinus ponderosa* *Pinus strobiformis* *Pseudotsuga menziesii* *Abies concolor*	*Quercus species* *Juniperus species* *Arctostaphylos species*
Elevation:	9,500-10,600 ft (3,000-3,300 m)	8,000-9,500 ft (2,800-3,000 m)	6,500-8,000 ft (2,000-2,800 m)
Fire Regime:	Infrequent (150y+ FRI), stand-replacing, high intensity & severity	High frequency (5-35y FRI), surface fire & small patch crown fire, low to moderate severity	Moderate frequency (35 to 100y+FRI?), Surface fire & moderate to large patch crown fire, moderate to high severity

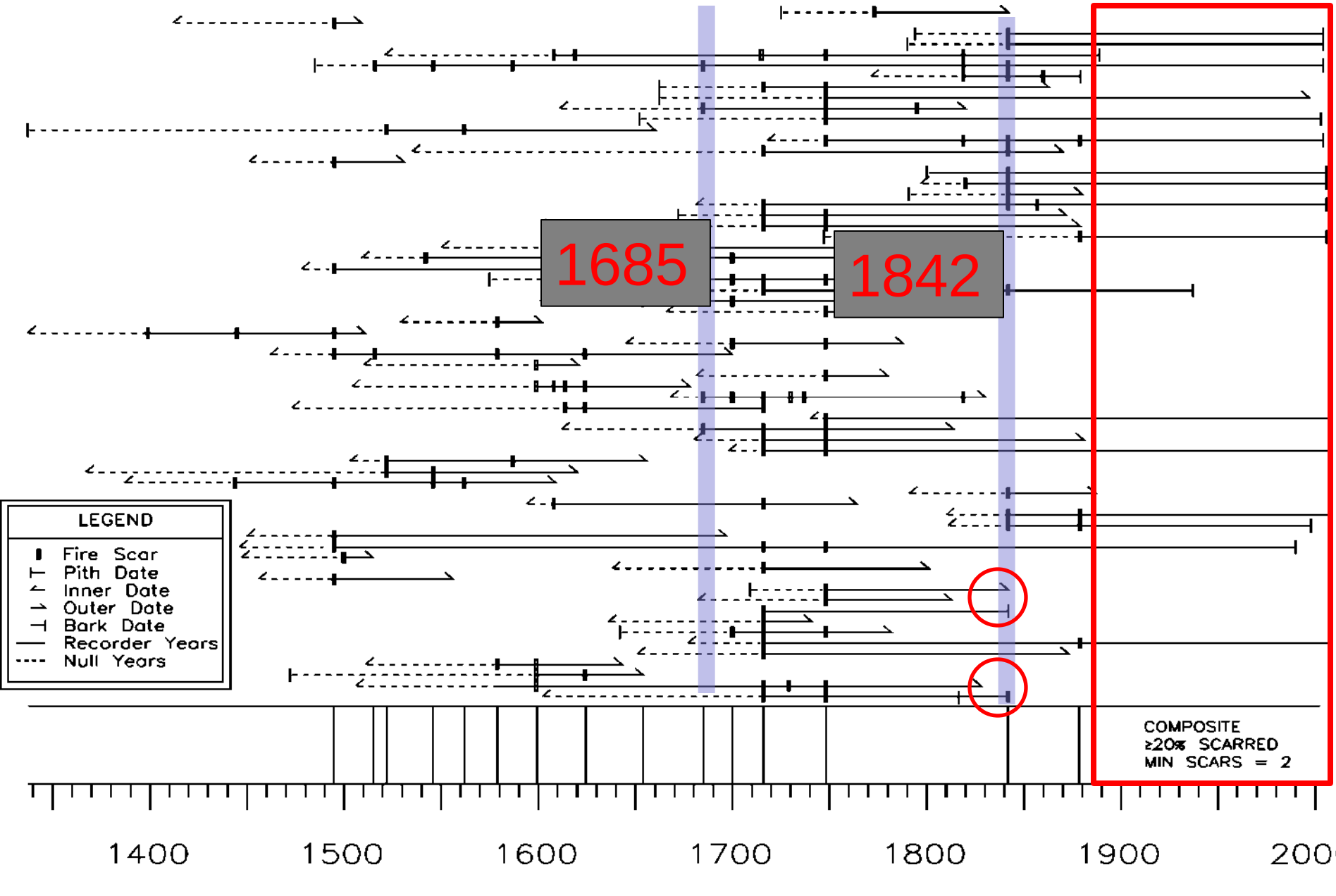
Swetnam, T. W., C. H. Baisan, H. D. Grissino-Mayer. 2009. Chapter 3: Tree-ring perspectives on fire regimes and forest dynamics in mixed conifer and spruce-fir forests on Mt. Graham. Pages 55-67, In: H. R. Sanderson and J. L. Koprowski, editors. The Last Refuge of the Mt. Graham Red Squirrel: Ecology of Endangerment, University of Arizona Press, Tucson. 427p


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

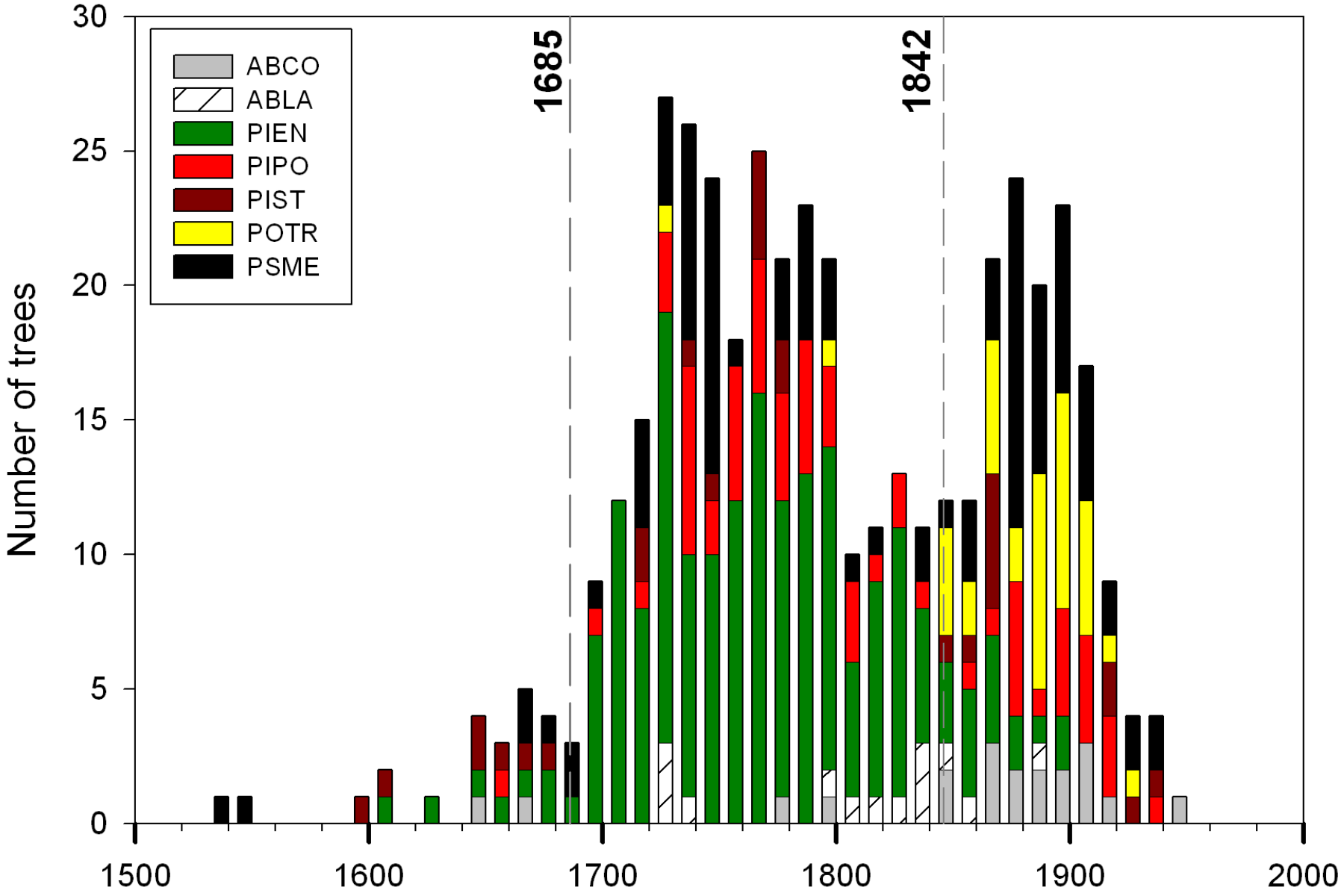
Ponderosa pine fire history (1296-2004)



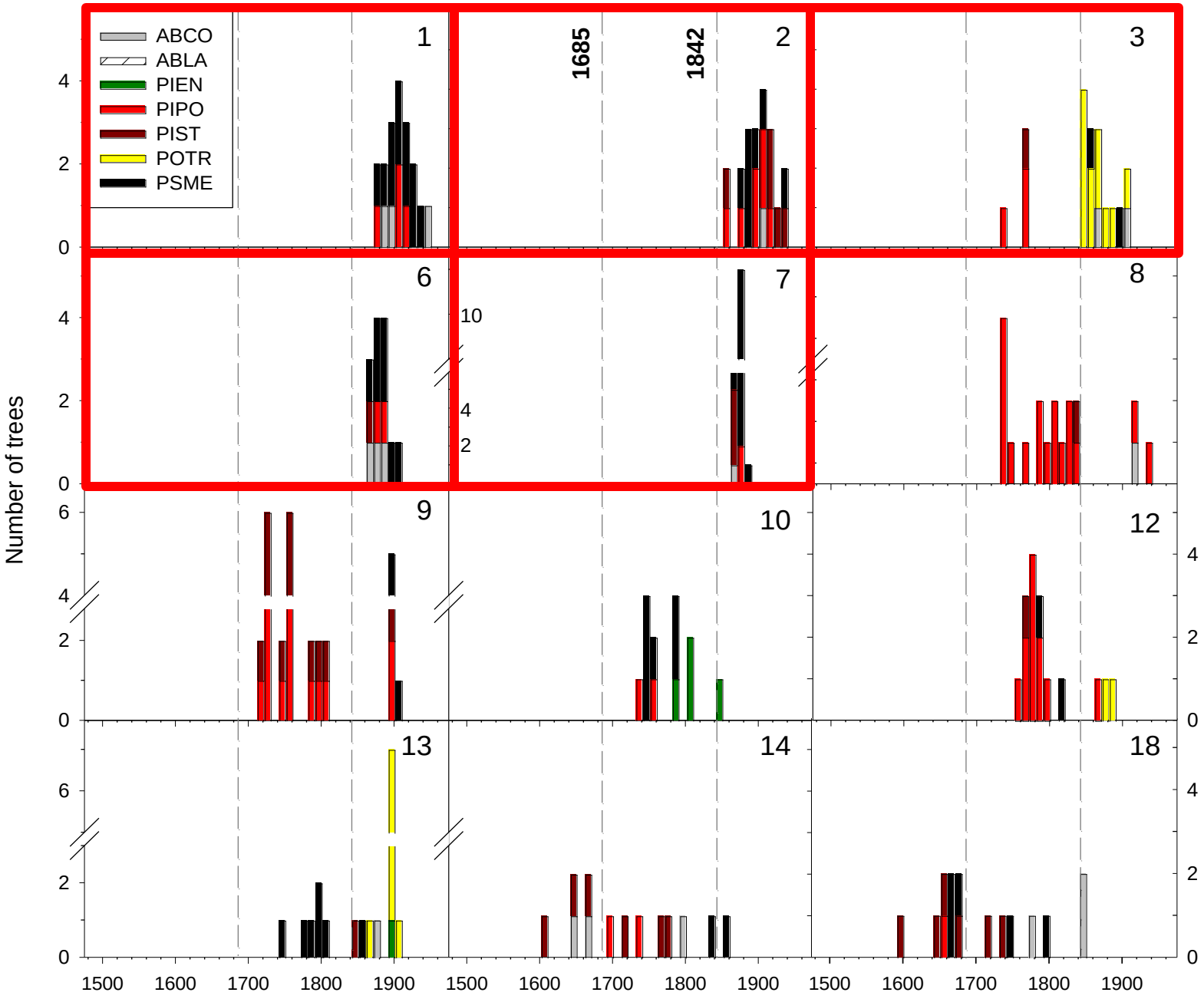
Mixed conifer fire history (1337-2008)



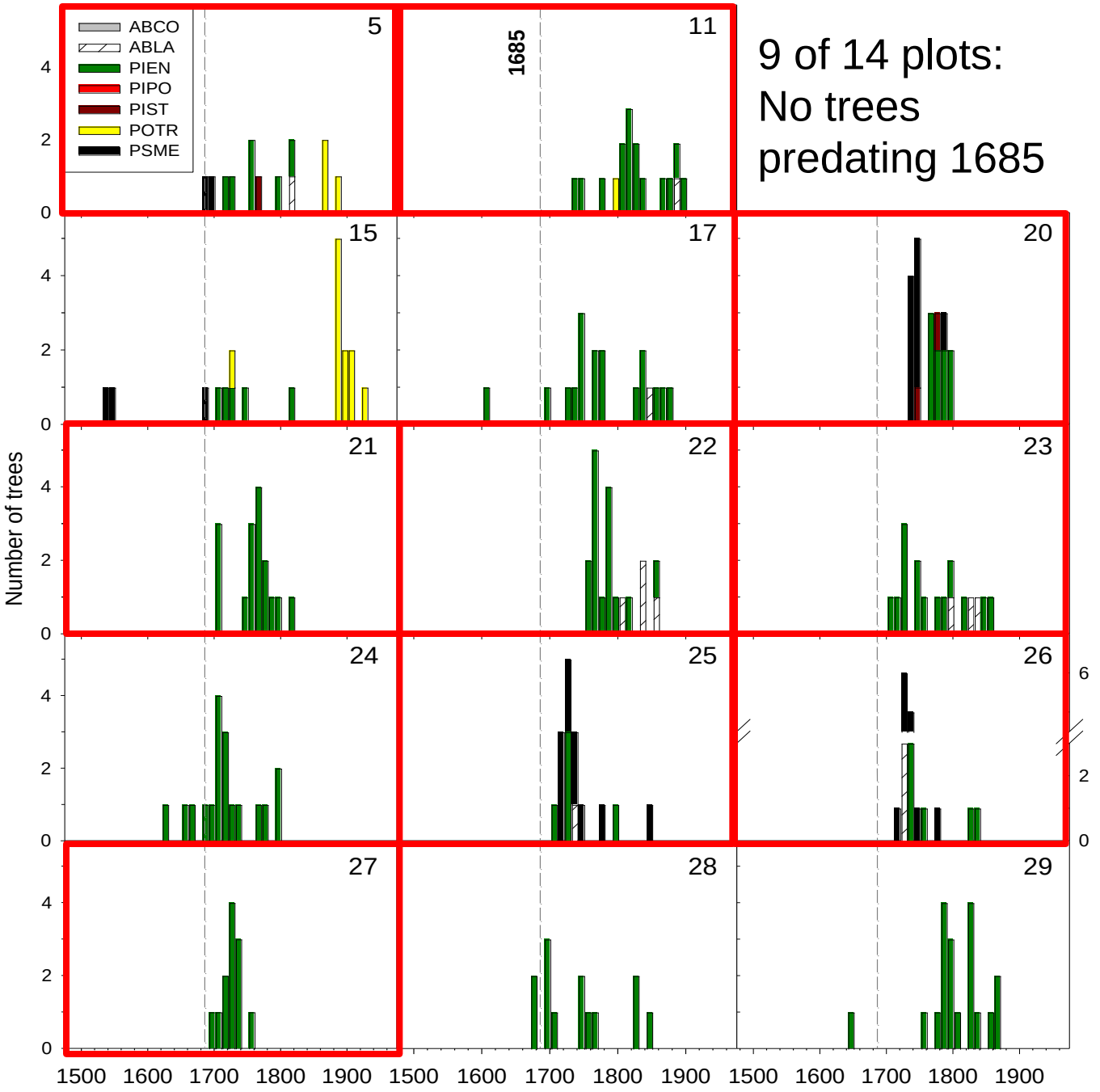
Mixed conifer/aspen & spruce forest age structure



Mixed conifer age structure by plot

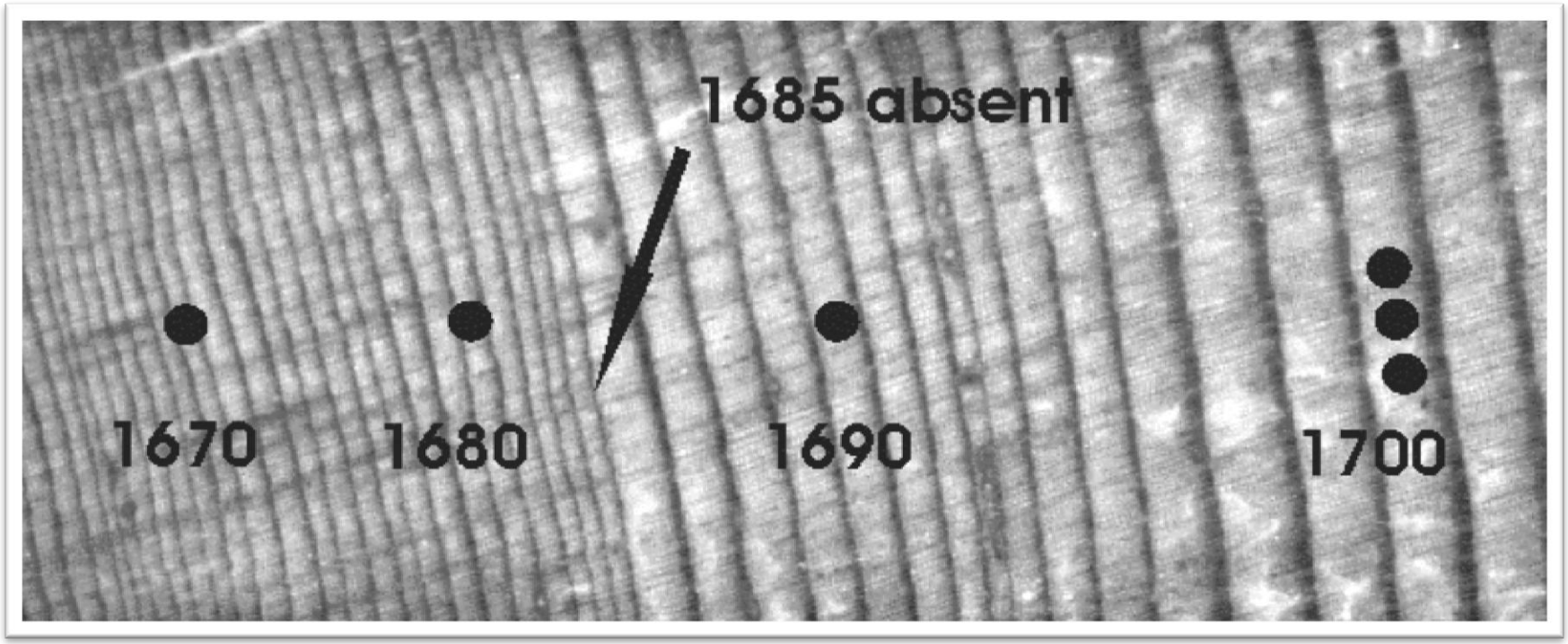


Spruce dominated forest age structure by plot



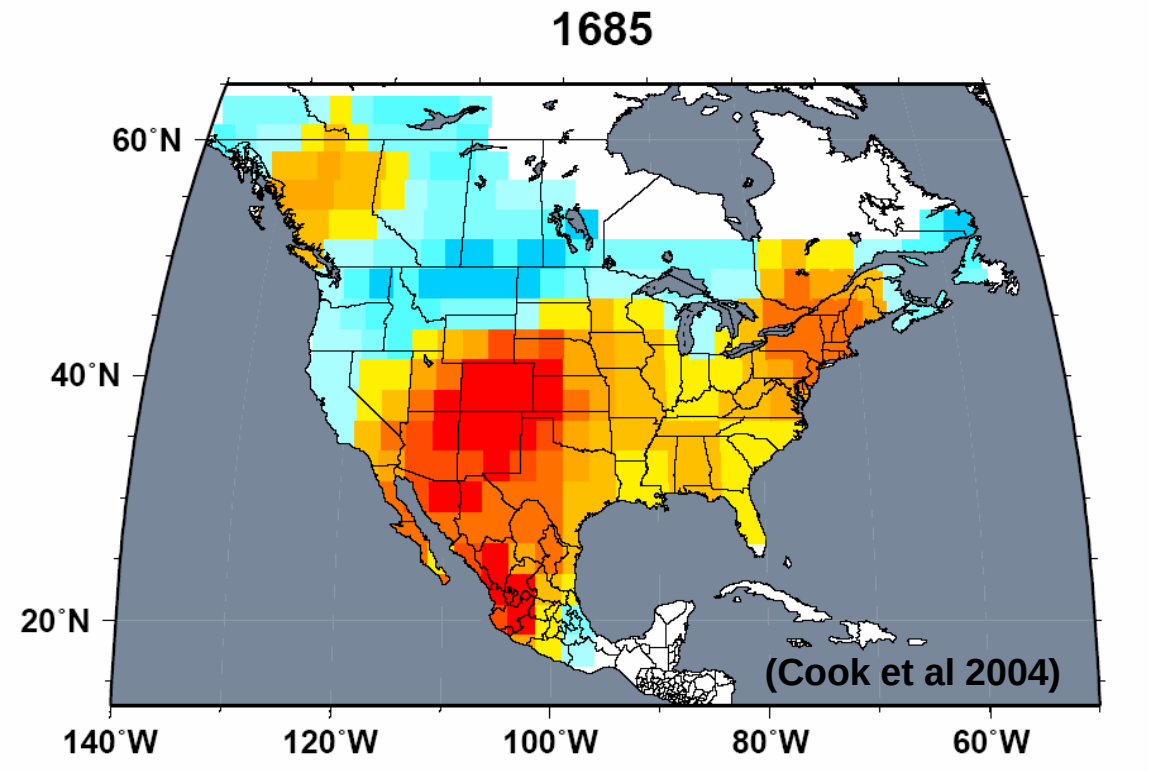
9 of 14 plots:
No trees predating 1685

Growth release following 1685 fire

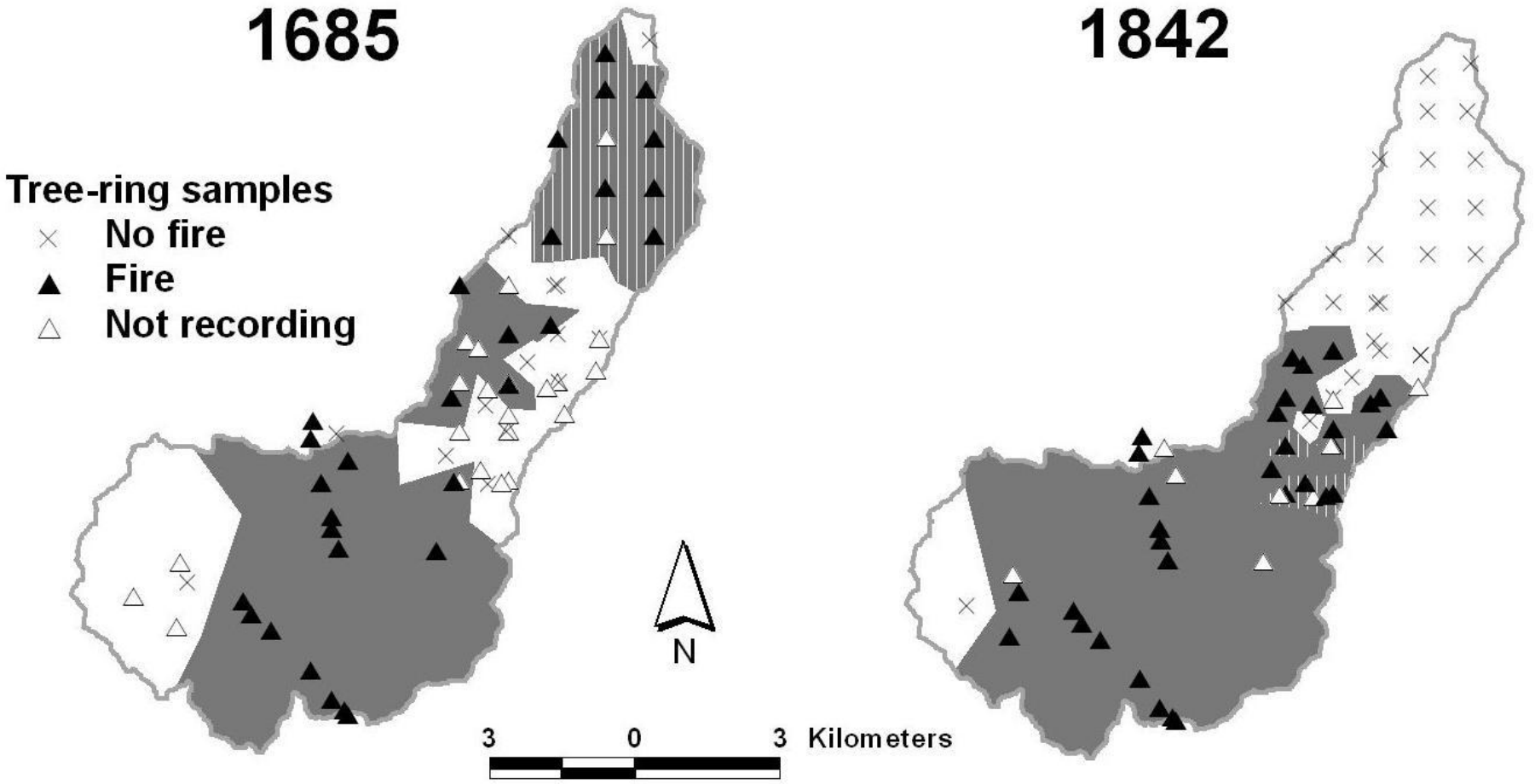


1685 fire

- 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!



Reconstructed fire area & severity



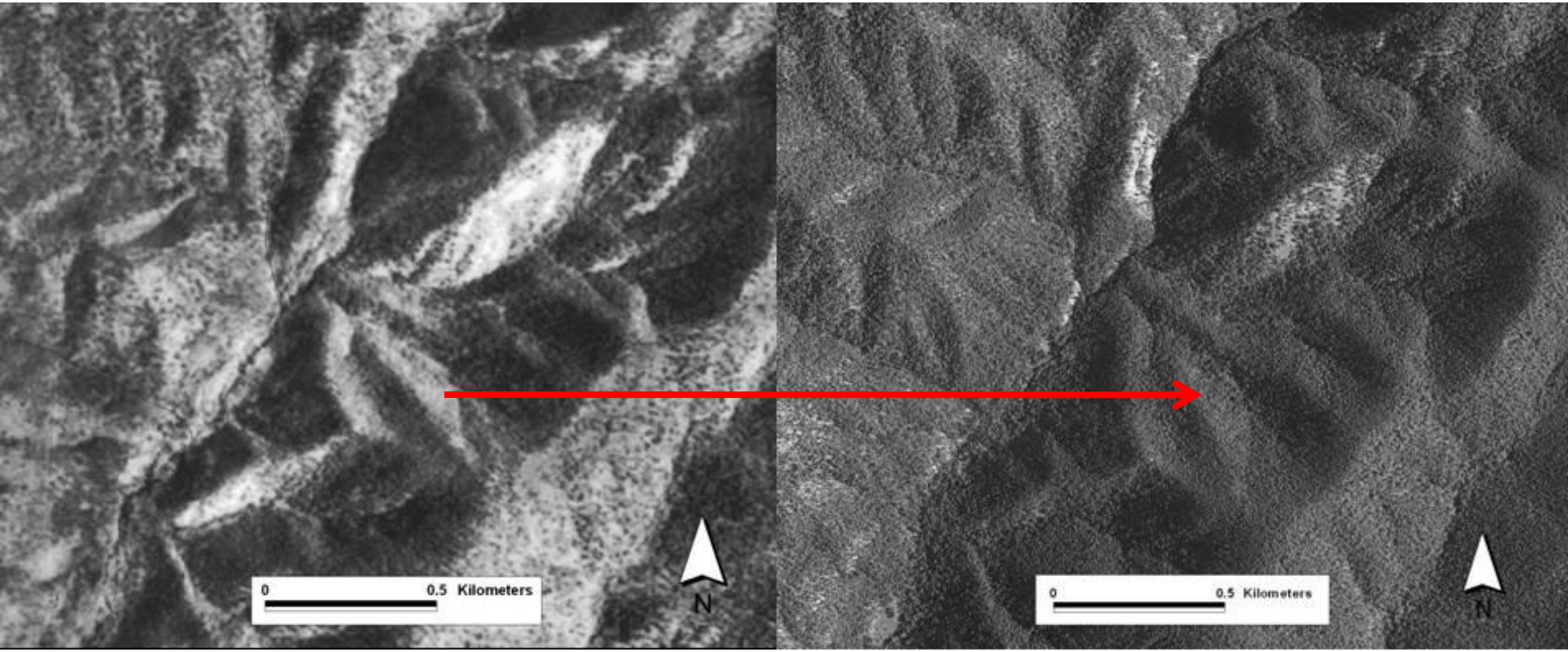
PDSI = - 6.92

PDSI = - 4.90

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

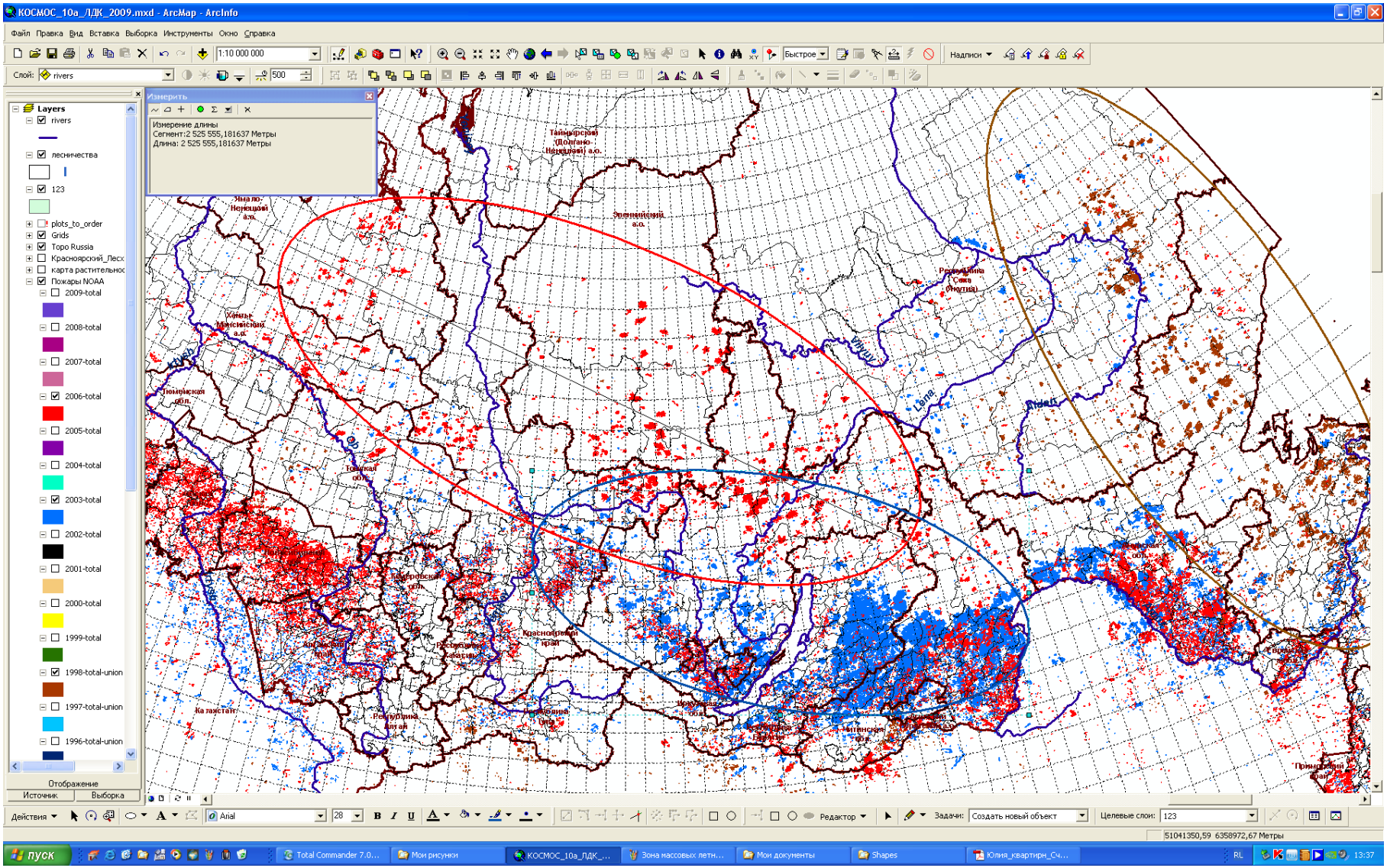
1935

2005



Pinus sylvestris forests of Scandinavia and Eurasia have VAST potential for developing very long fire scar chronologies and extensive networks.

Clusters of catastrophic fires in Khabarovsk kray, 1998, Transbaikal region, 2003, and Central Siberia, 2006




07/19/2011 13:38


07/17/2011 18:43

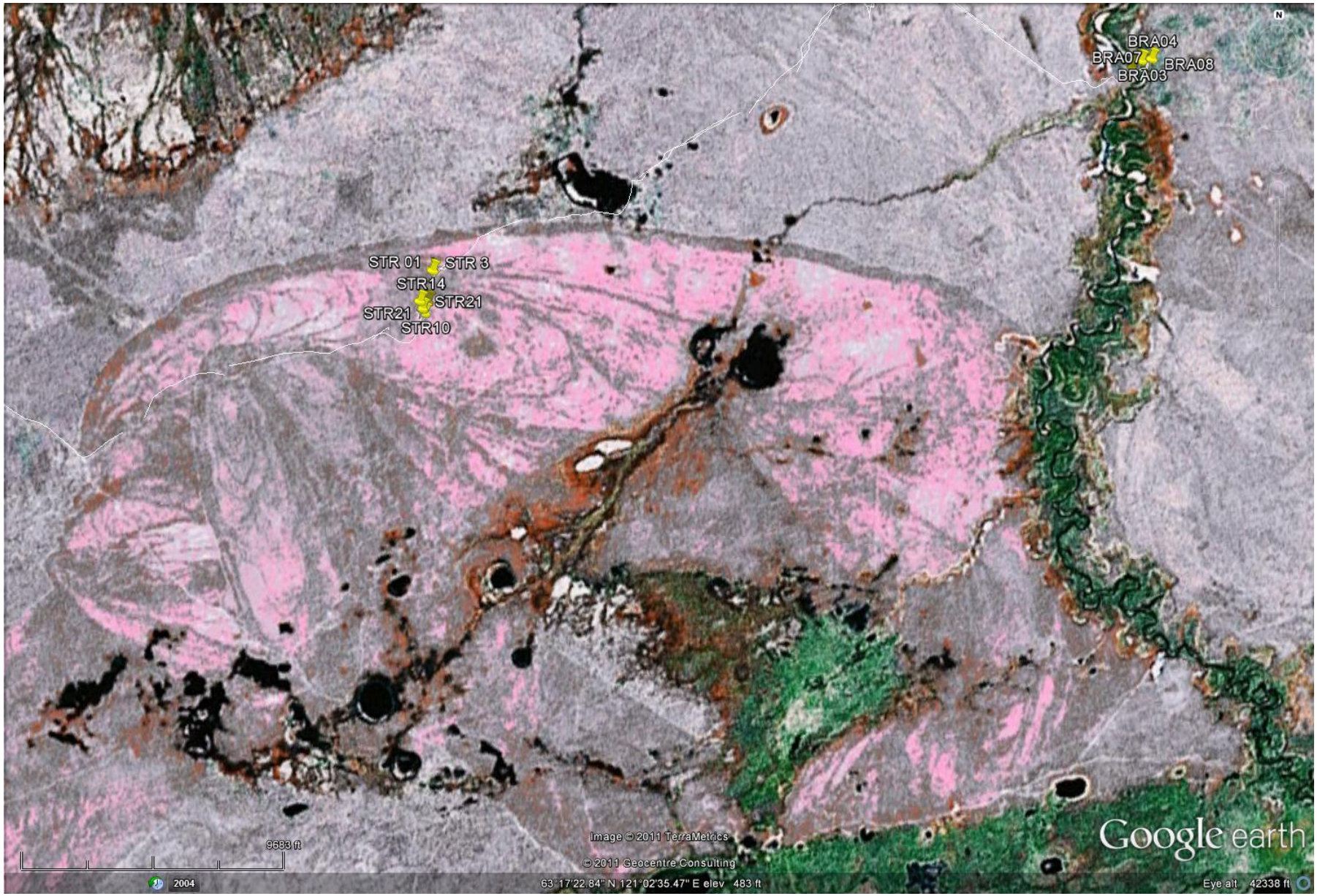
Burn strips and surviving tree “streets” on one of the 1988 Yellowstone fires in lodge pole pine and spruce fir. Linear runs and the tree “streets” are characteristic of HRVs, and Haines has a hypotheses about how the streets are formed as consequence of paired, counter-rotating vortices. There has been no study of these phenomenon in the SW, to my knowledge. Yet, these patters can be observed, I believe, un recent and past fires. The legacy of these patterns might even be preserved over very long time periods in tree ages and directionality of fire scars.

Elliptical Tree Crown Streets on Richardson Fire in Alberta, 700K HA, June 2011
Photo from Brian Stocks

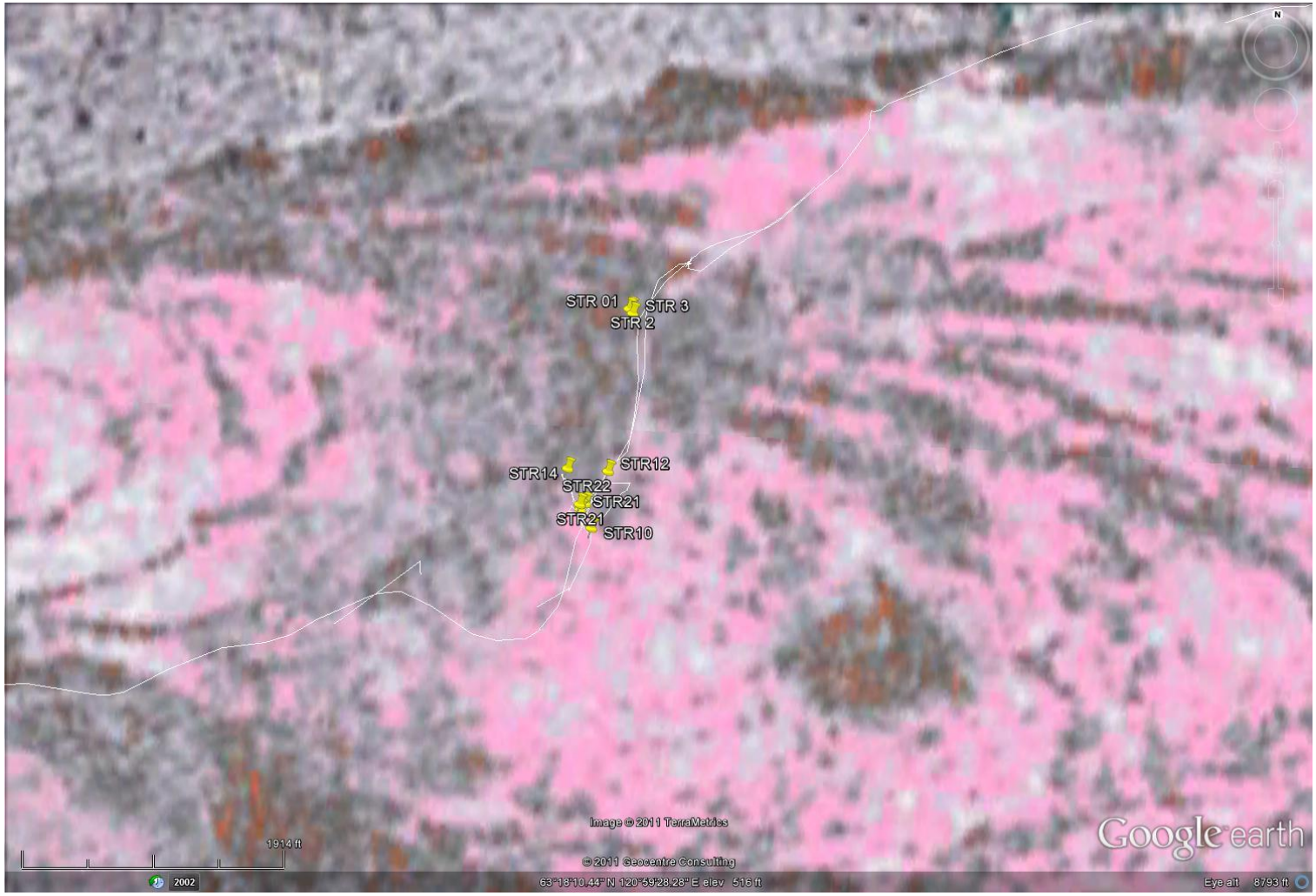
While traveling about 25 miles SE of Verkhnevilyuysk, Siberia on July 17, 2011 we observed and traveled through a number of very striking, lengthy tree streets within large crown fire burns in Pinus sylvestris forest. We sampled fire scarred trees within the streets and in the open crown fire killed area nearby. The site was labeled STR.

Charring on tree boles within the tree streets was still quite observable. In general, we noted that the bole charring tended to be on the crown fire burn side of the tree street, rather than toward the center of the burn street, as predicted by the Haines model of tree street formation. But we did not quantify the consistency of this pattern.

Linear and elliptical shaped tree streets in crown fire burned stands of Pinus sylvestris. Individual fire scarred tree-ring samples are the yellow pushpins.

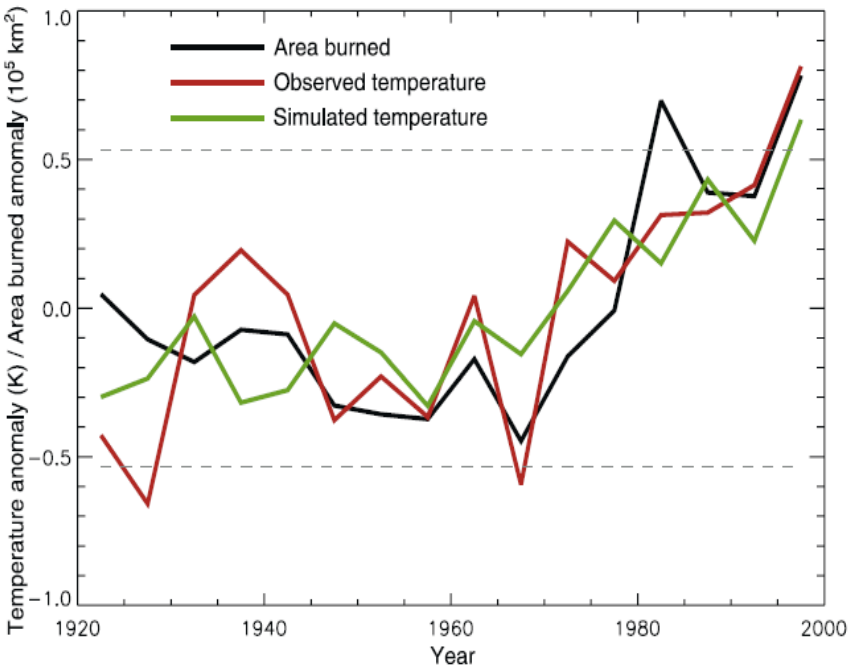


This distinctive pattern only shows in the Google Earth imagery that comes up with the “historical” imagery option turned off. The date 2004 shows at left bottom. The resolution of the image is low, unfortunately. I do not know why the burned areas appear pink. The gray strips are the surviving tree streets, and the gray/whitish areas to the north and west are living P. sylvestris forest with Cladonia lichen ground cover.

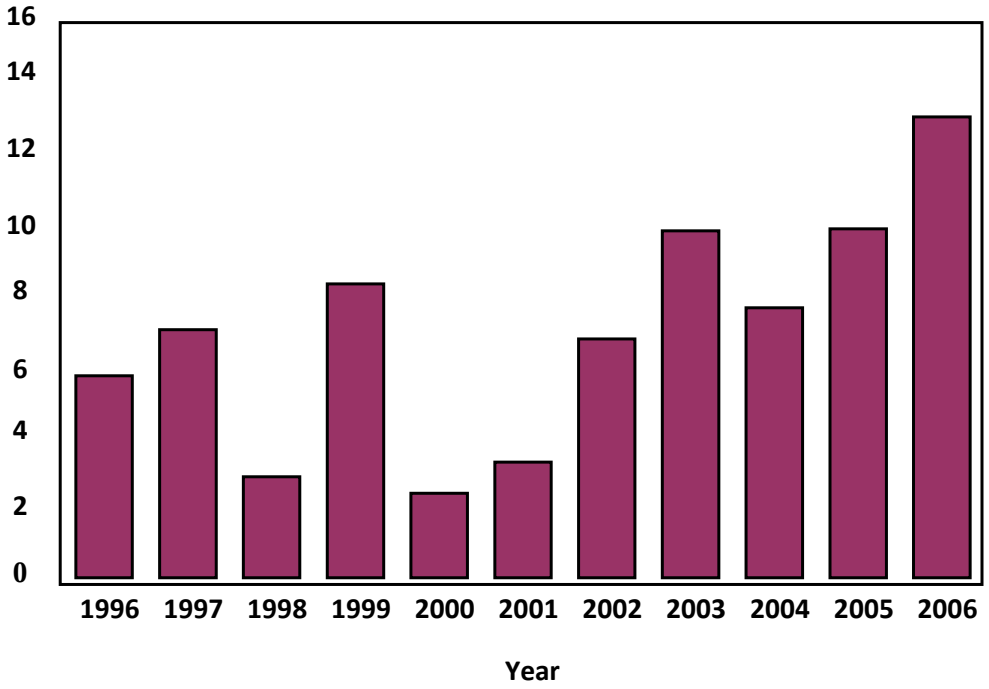


Area burned has increased across Canada and Alaska, and these trends are very likely related to recent warming trends.

Canada Burned Area



Central Siberia Burned Area



Gillett et al., Geophysical Research Letters, 2004 –Canada

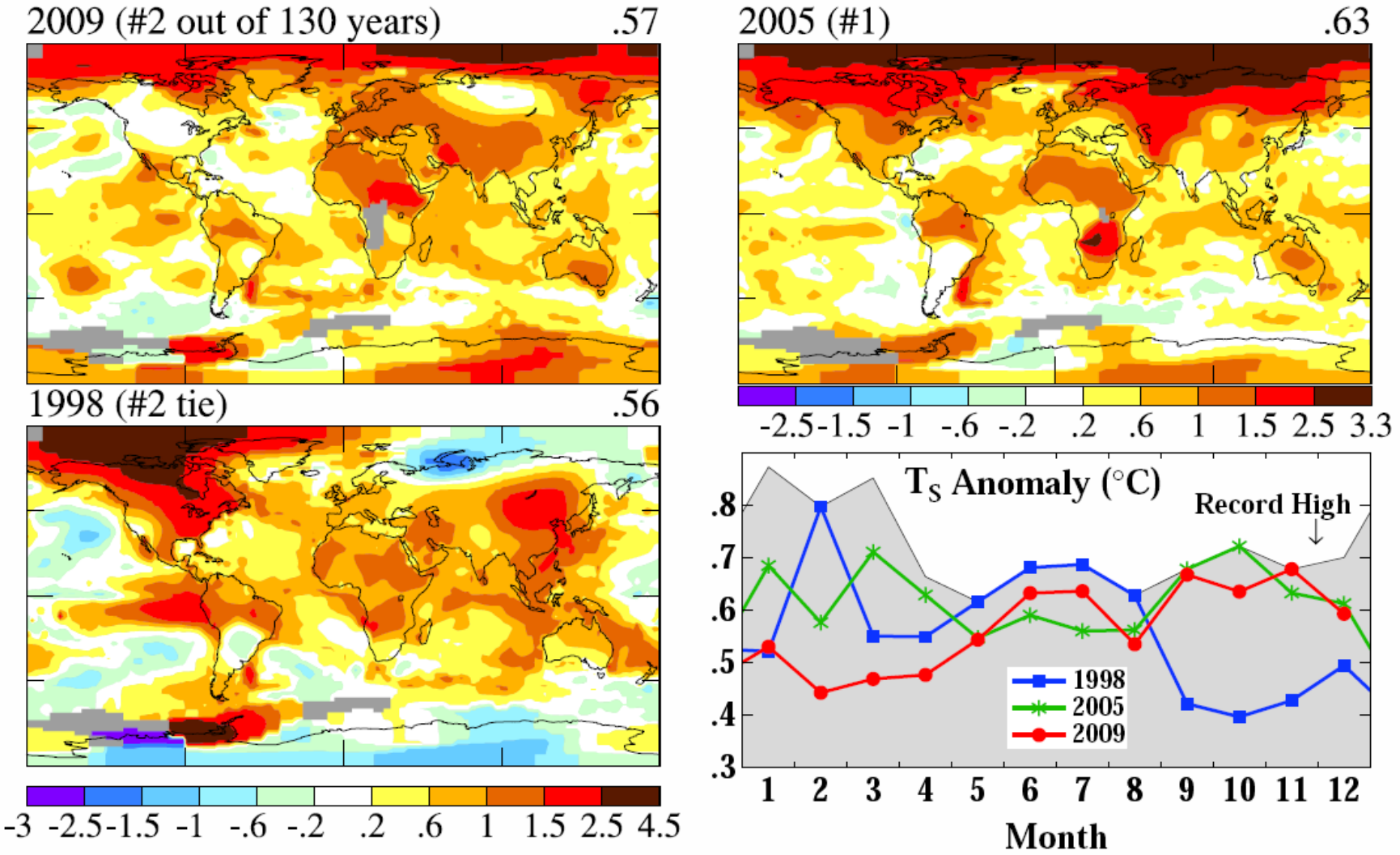
-At least a doubling of annual area burned between 1950s and 1990s

The area burned annually in the Krasnoyarsk Region of central Siberia from 1996-2006. For the last 4 years (2003-2006) the burn area has been above the 11-year average of 5.78 million ha. Data from Anatoly Sukhinin.

Photos: C.D. Allen

Photo: C.D. Allen

Annual Mean Surface Temperature Anomaly (°C)



Base Period: 1951-1980

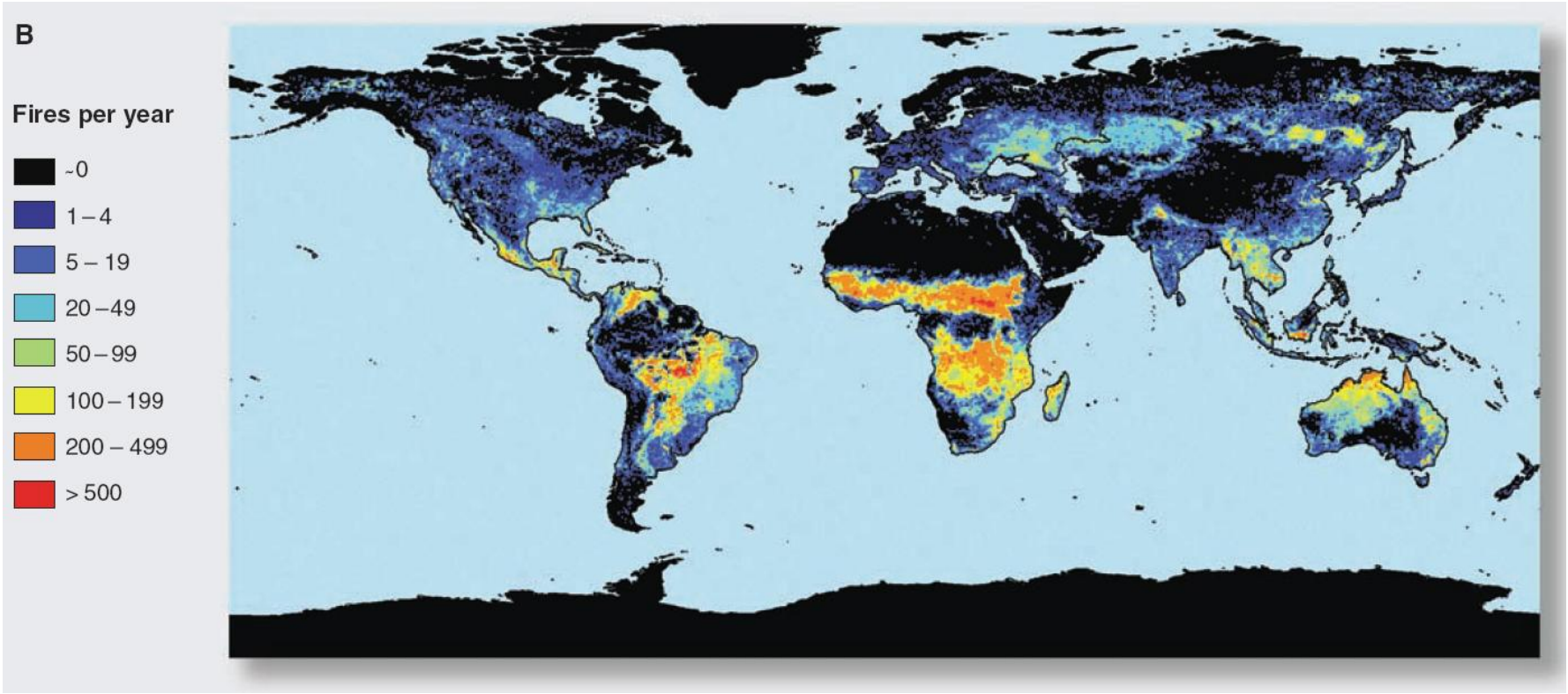
http://data.giss.nasa.gov/gistemp/

Fire in the Earth System

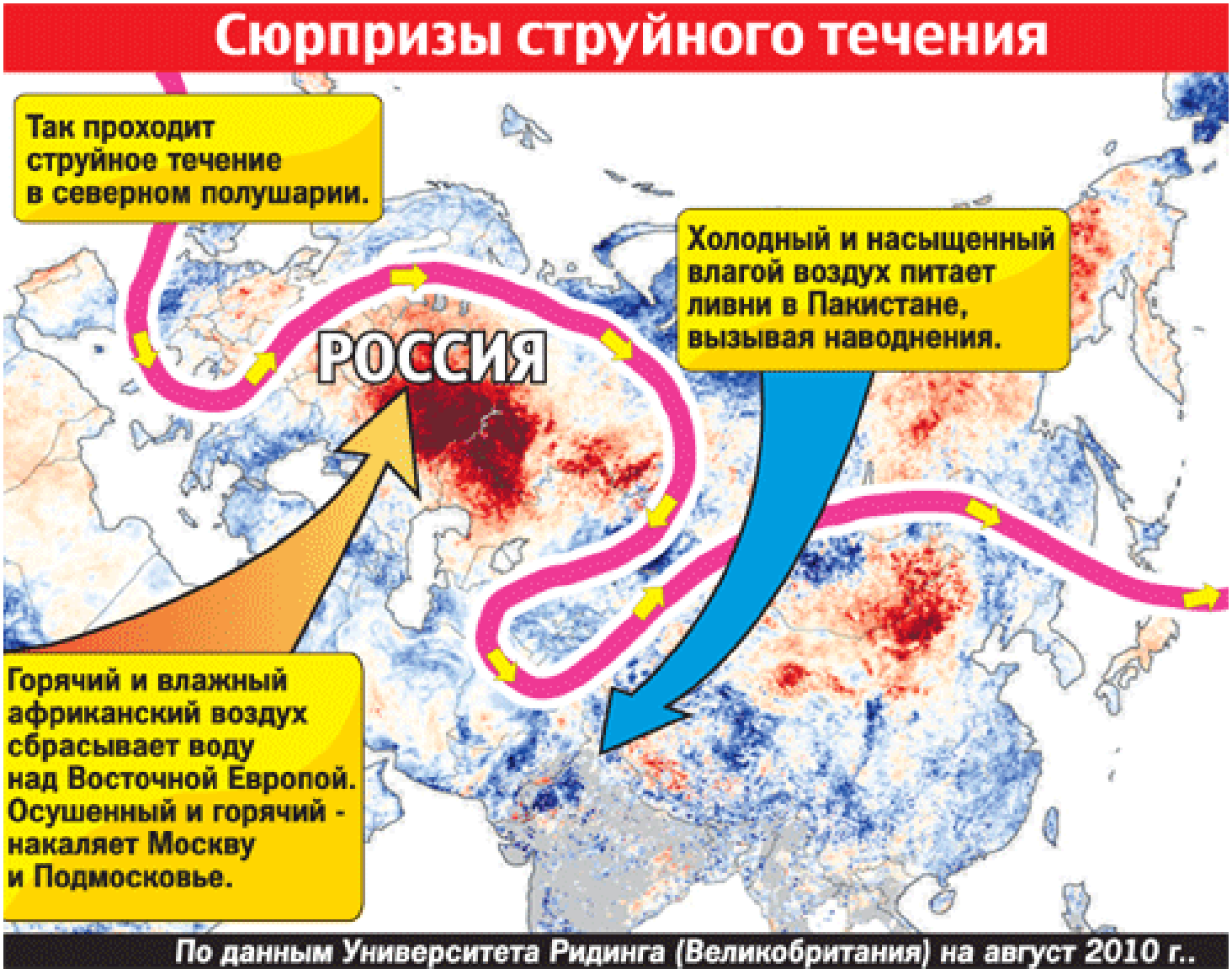
REVIEW

David M. J. S. Bowman,[1*] Jennifer K. Balch,[2,3,4*†] Paulo Artaxo,[5] William J. Bond,[6] Jean M. Carlson,[7] Mark A. Cochrane,[8] Carla M. D'Antonio,[9] Ruth S. DeFries,[10] John C. Doyle,[11] Sandy P. Harrison,[12] Fay H. Johnston,[13] Jon E. Keeley,[14,15] Meg A. Krawchuk,[16] Christian A. Kull,[17] J. Brad Marston,[18] Max A. Moritz,[16] I. Colin Prentice,[19] Christopher I. Roos,[20] Andrew C. Scott,[21] Thomas W. Swetnam,[22] Guido R. van der Werf,[23] Stephen J. Pyne[24]

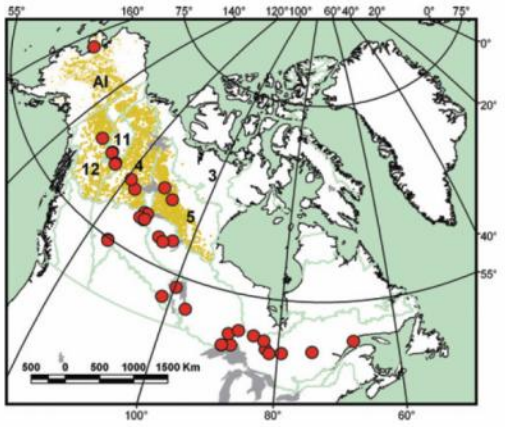
SCIENCE VOL 324 24 APRIL 2009

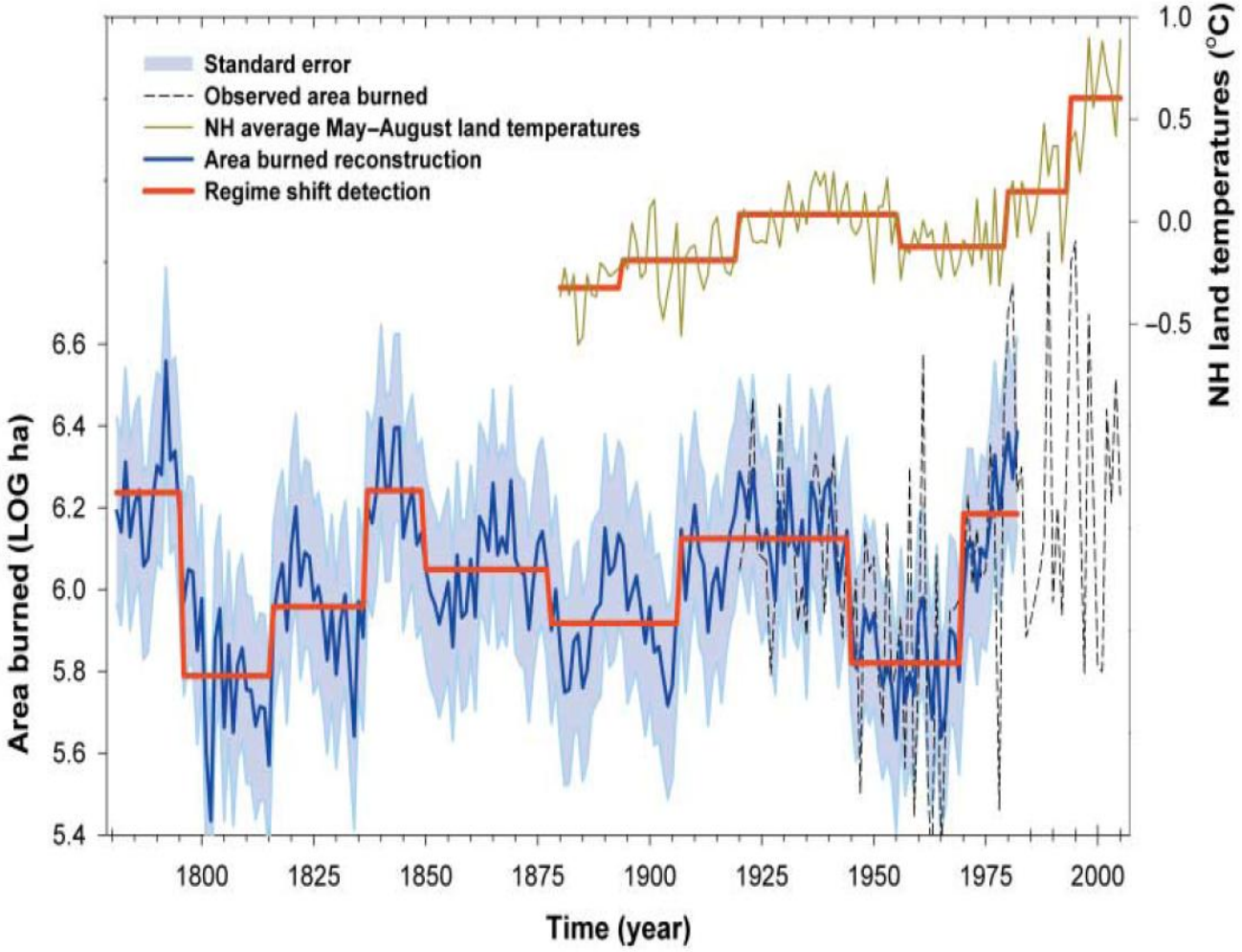


High speed Air Jet Stream in Stratosphere (16 km altitude, 500 km/h). Source: Reading University of Great Britain --- This is the planetary wave/jet stream pattern responsible for heat wave and wildfires in Moscow region and flooding in Pakistan, June-July 2010



Girardin has used a Canadian network of ring-width chronologies to reconstruct Canadian area burned back to 17th century.

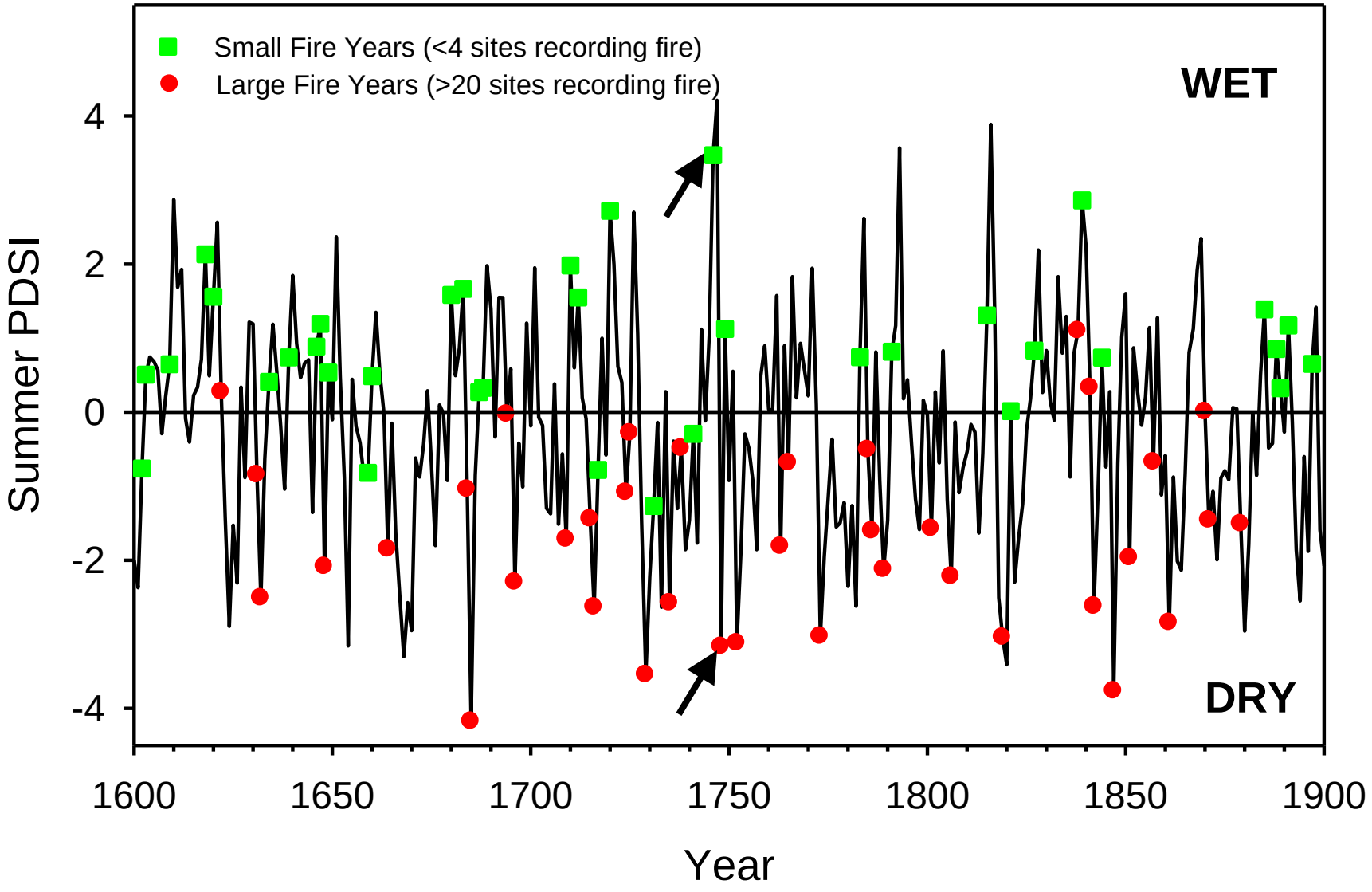




Martin P. Girardin. Interannual to decadal changes in area burned in Canada from 1781 to 1982 and the relationship to Northern Hemisphere land temperatures Global Ecology and Biogeography, (Global Ecol. Biogeogr.) (2007)16, 557–566

The photos don’t do justice to the striking visual appearance of the long, linear tree streets on the ground. The line of streets extended far into the distance, and we could see parallel tree streets off in other directions. This view is from within the street we sampled, looking down the length of it, perhaps looking west (?). On the far right in the background a second tree street can be seen.

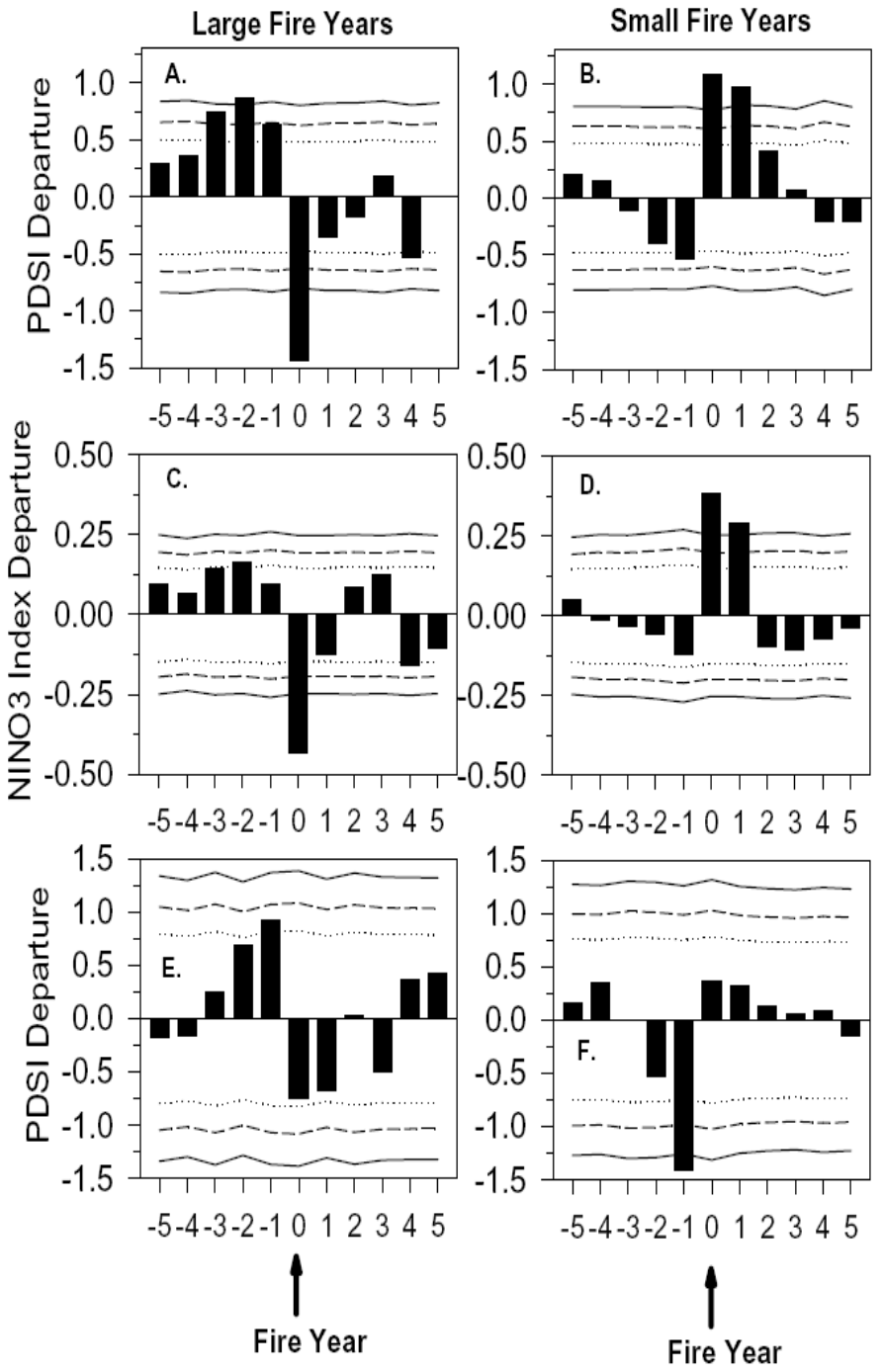
Regional large and small fire years in the Southwest are strongly linked to wet and dry conditions.



Superposed epoch analyses shows important lagging patterns in climate-fire relations in tree-ring and modern records.

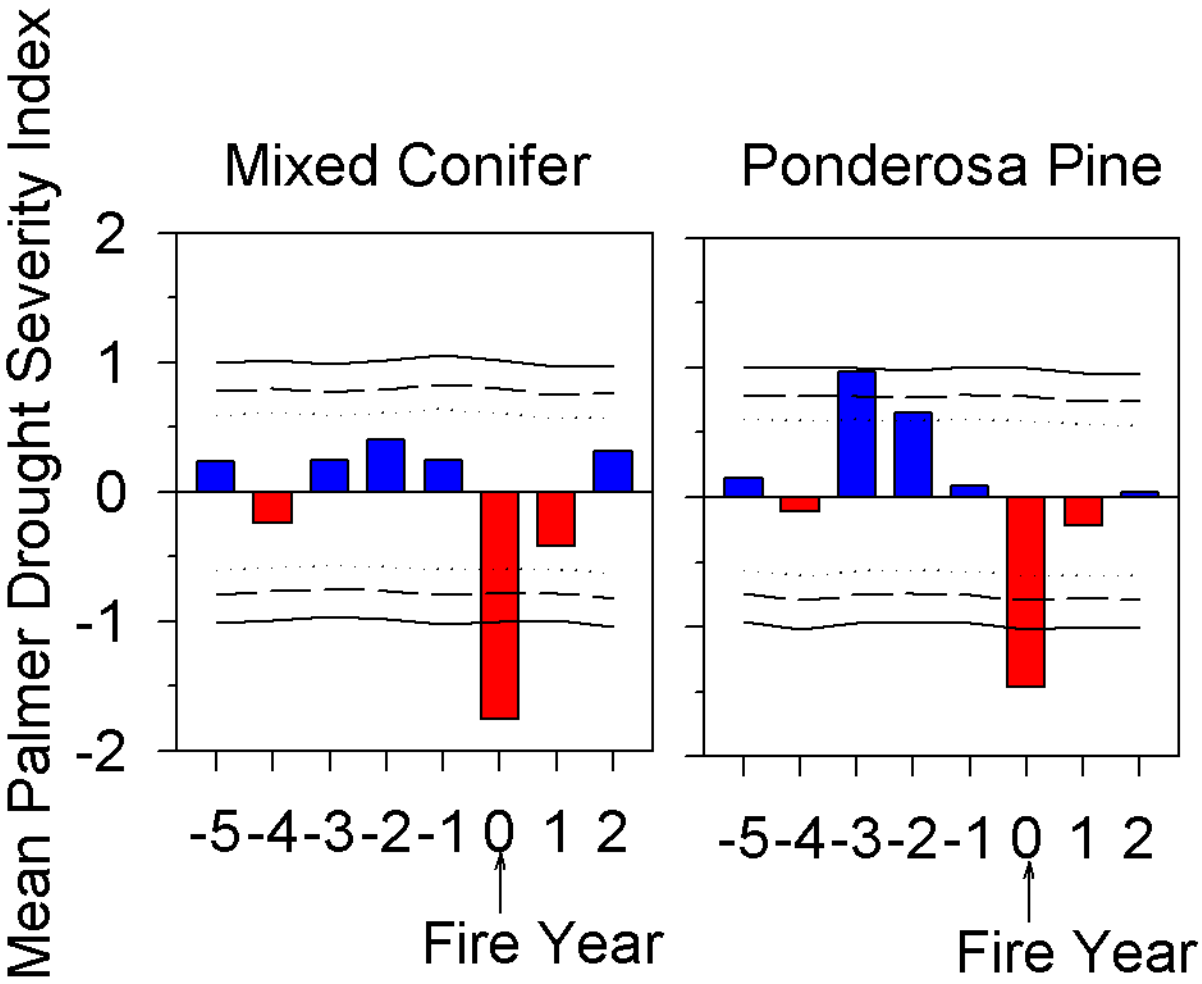
1600-1900

1905-2004

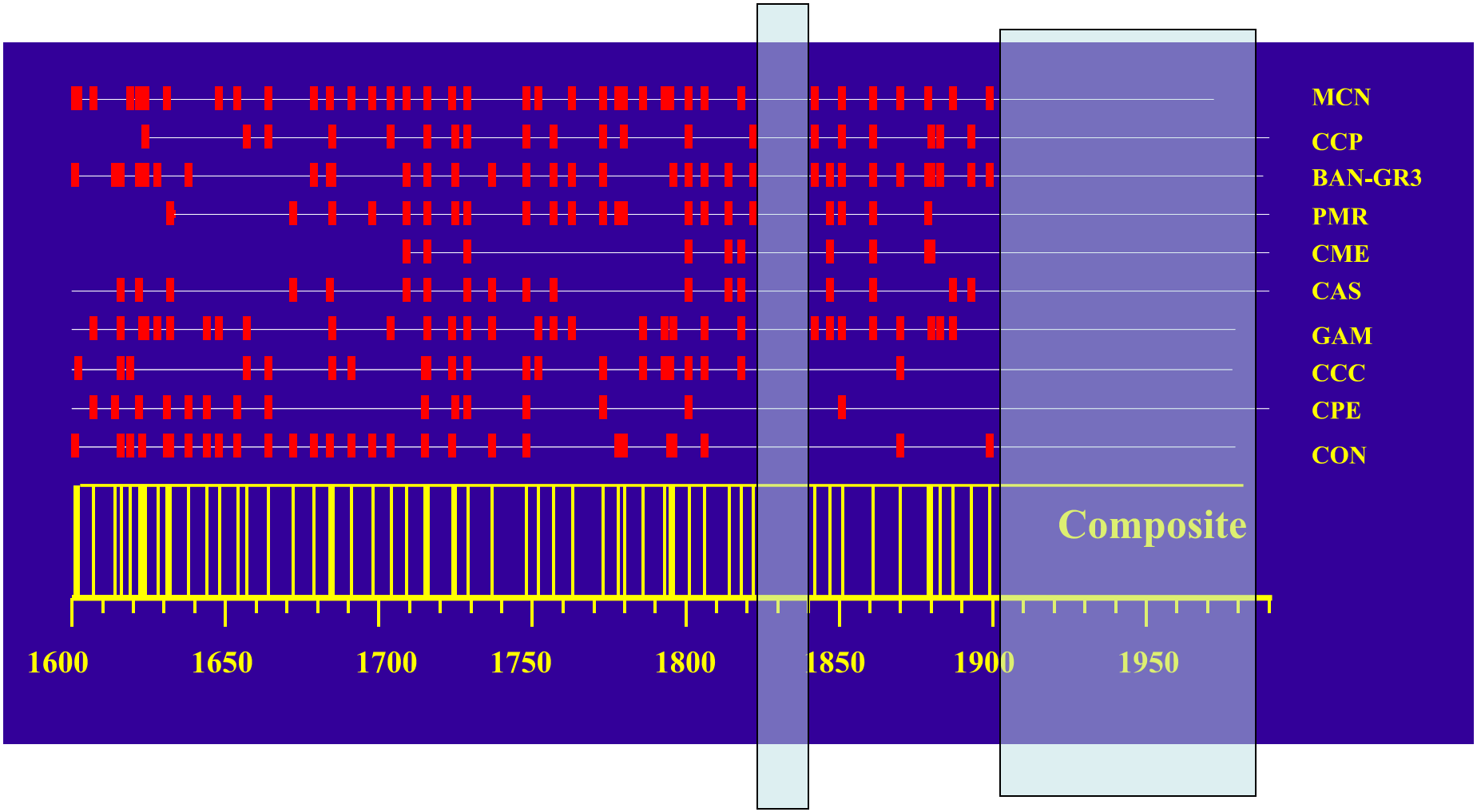


Prior years wet conditions appears to be largely a factor in lower elevation pine-dominant forests where grass fuels are limiting to fire ignition and spread.

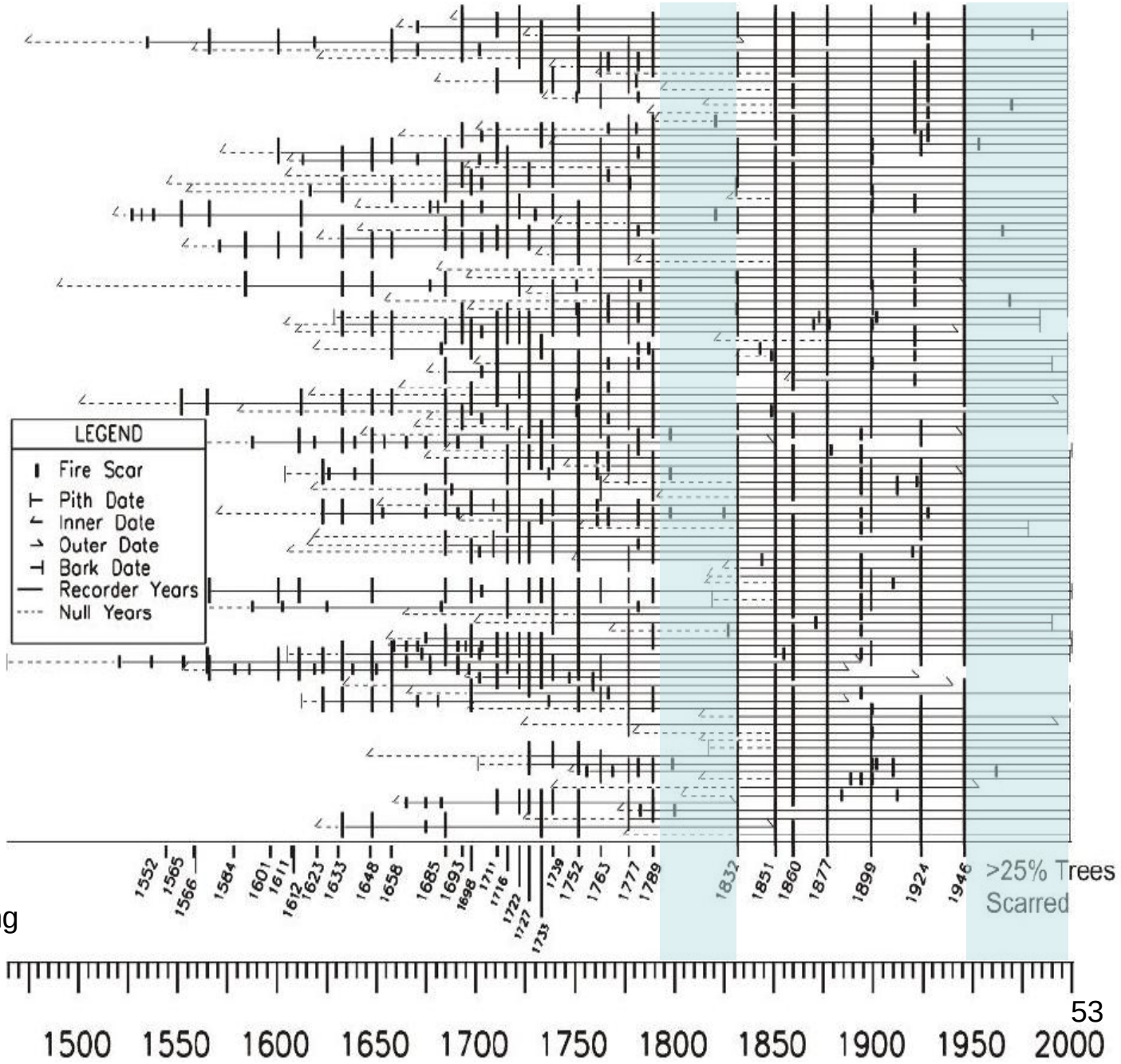
Large Fire Events, SW US, 1700-1900)



Composite fire scar chronologies from 10 forest stands In the Jemez Mountains, New Mexico

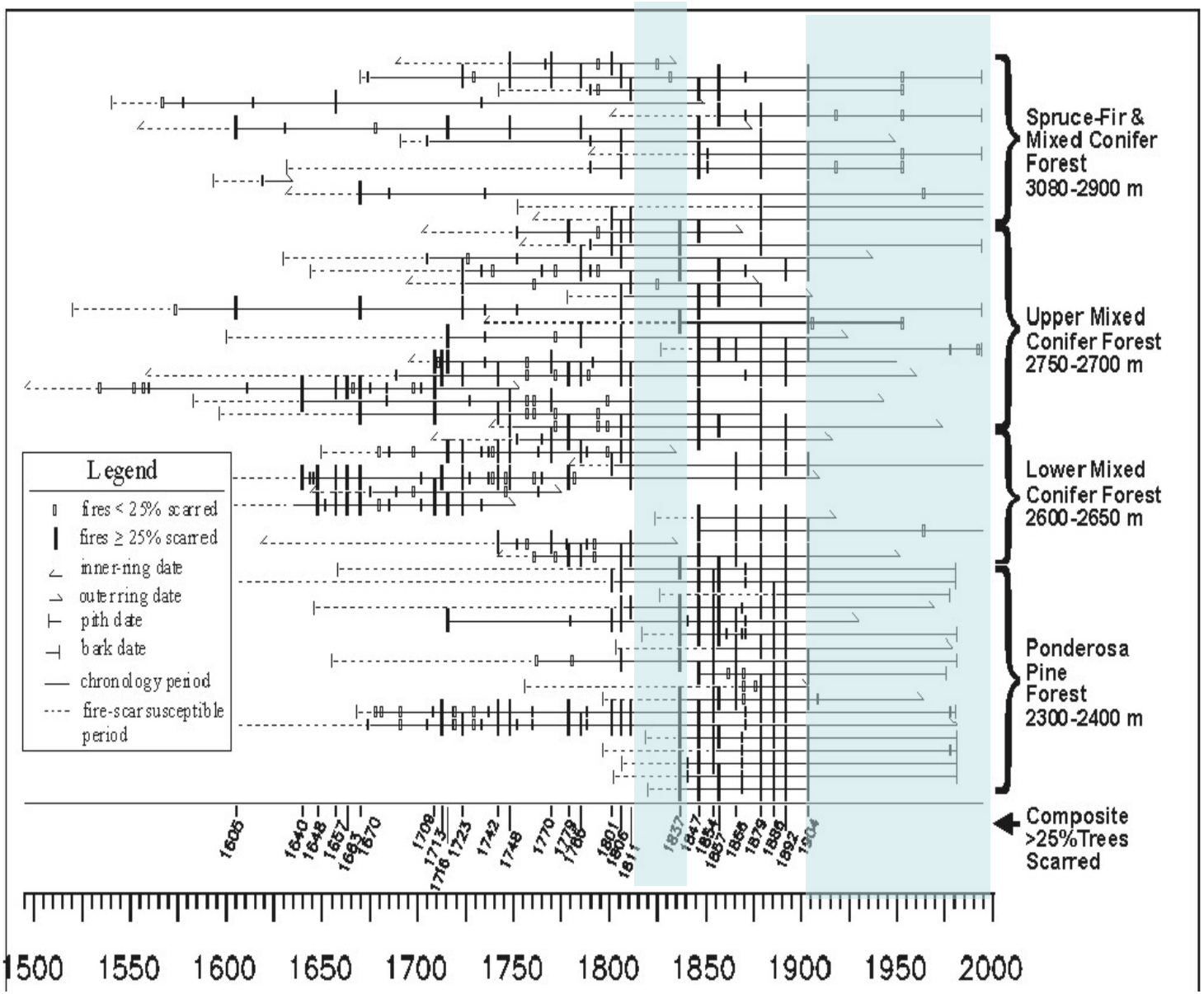


Fire-scar chronology, Sierra San Pedro Martir, Baja, MX. Stephens et al. 2003

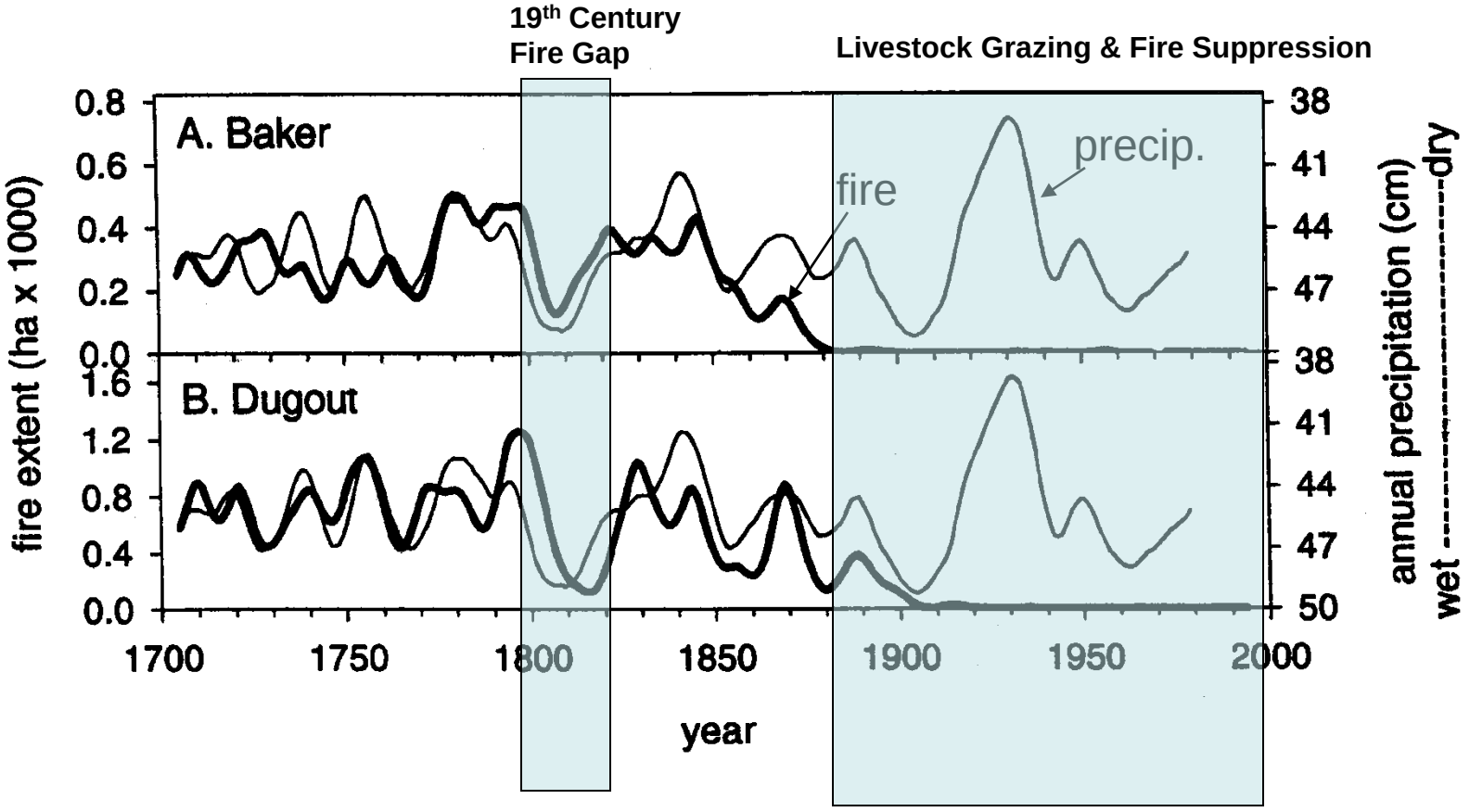


T.W. Swetnam, Laboratory of Tree-Ring Research

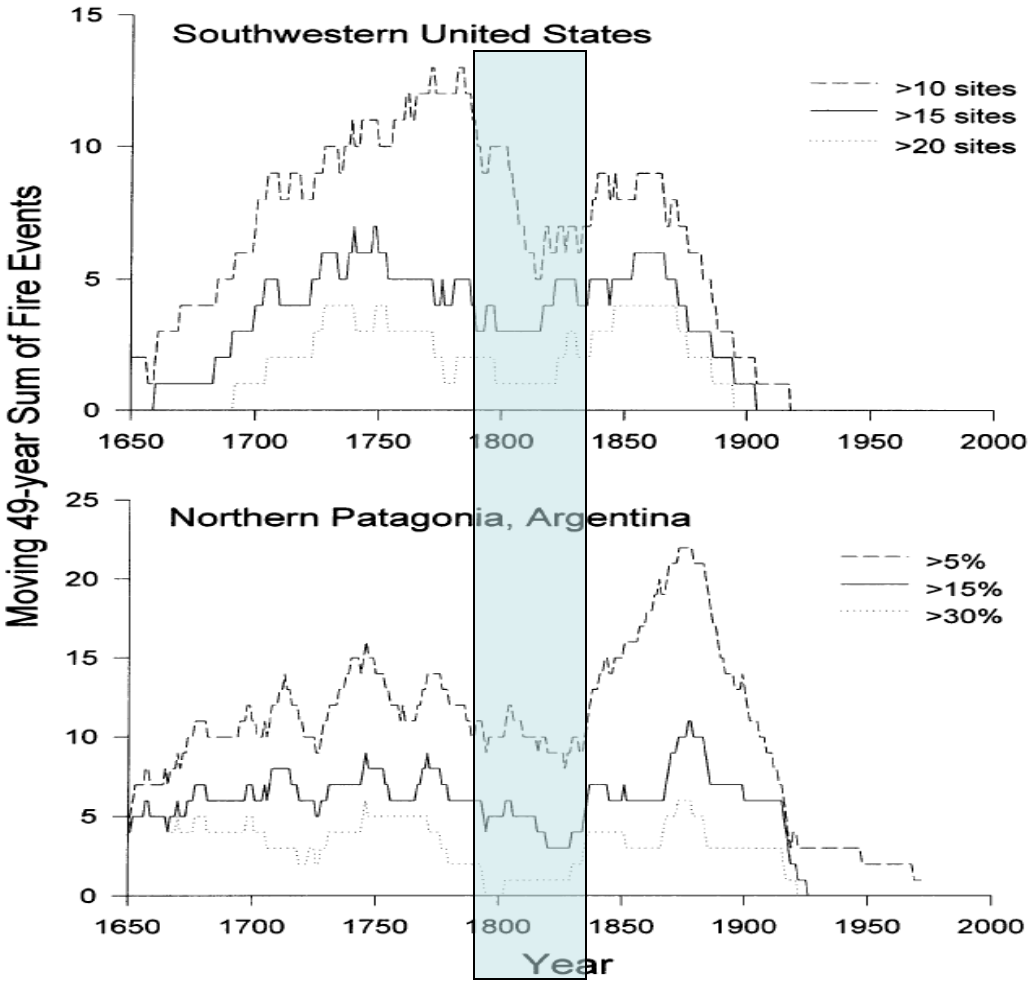
Gila Wilderness fire history elevational transect.



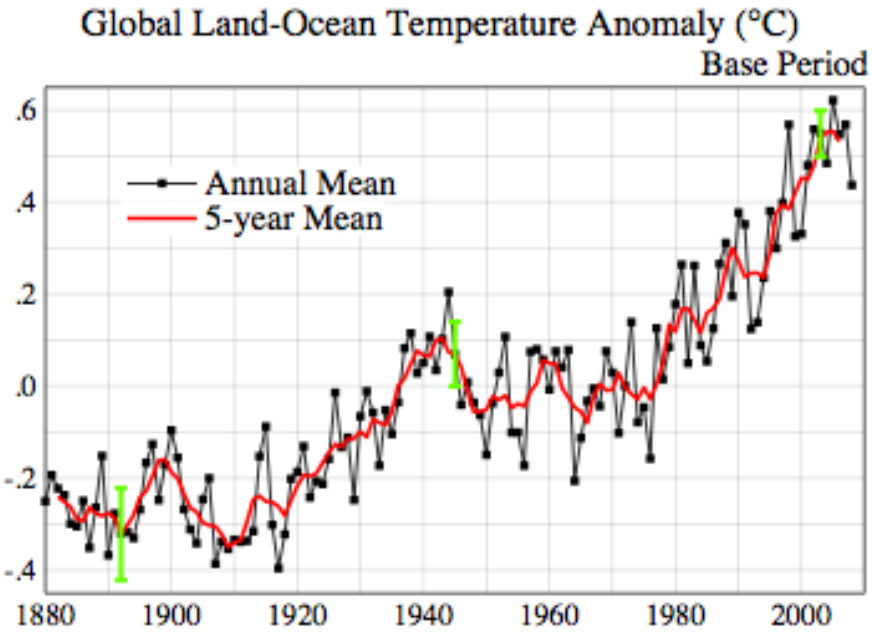
Fire extent in eastern Oregon is correlated with decadal-scale variations in annual precipitation.

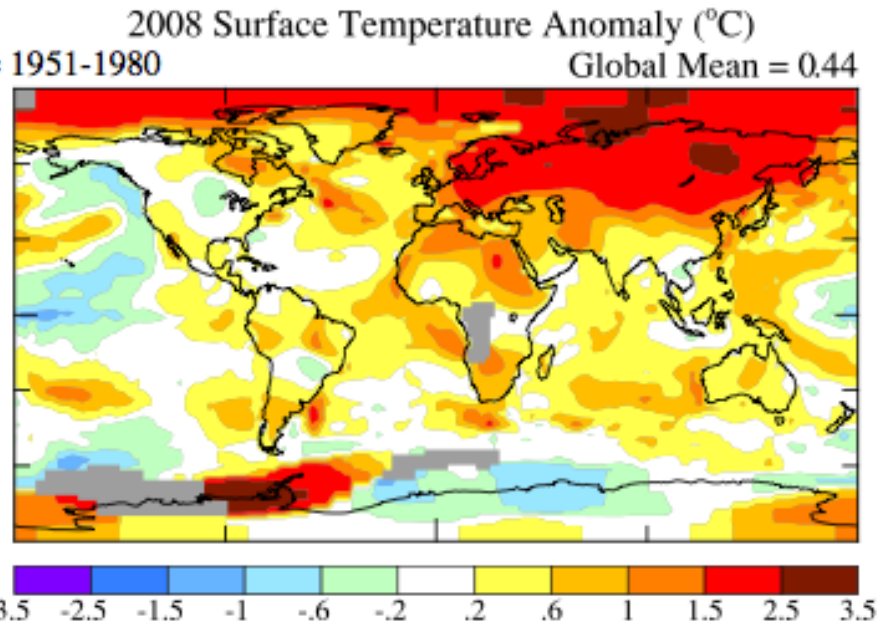


Fire histories in both the SW US, and Patagonia show reduced fire frequency during the period circa 1780-1840.



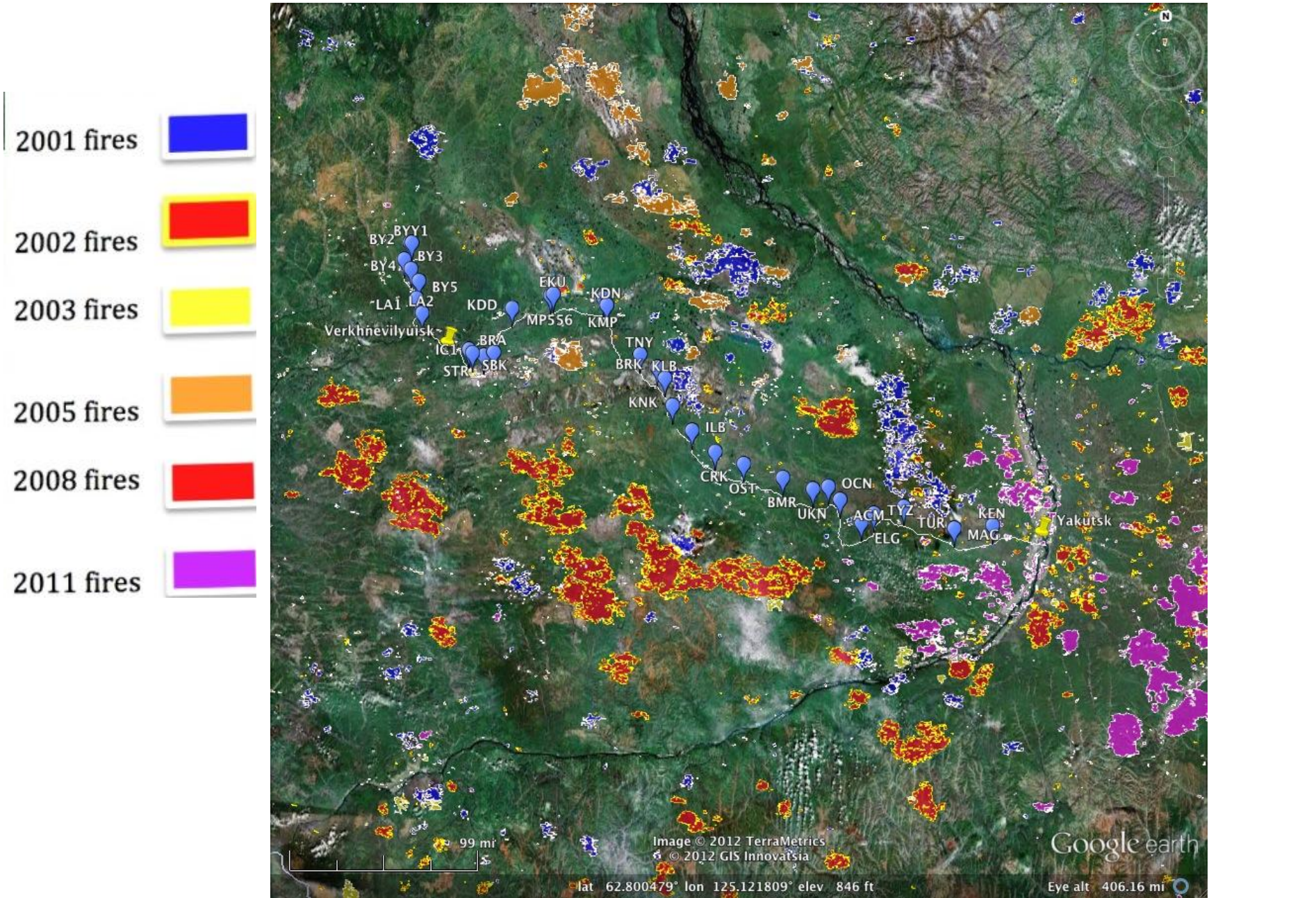
Global temperatures are clearly warmer in the past two decades than earlier decades of the past century (and probably for 1,000 or more years). The strongest warming trends are in high latitudes, especially in the arctic and boreal zones.





http://data.giss.nasa.gov/gistemp/2008/

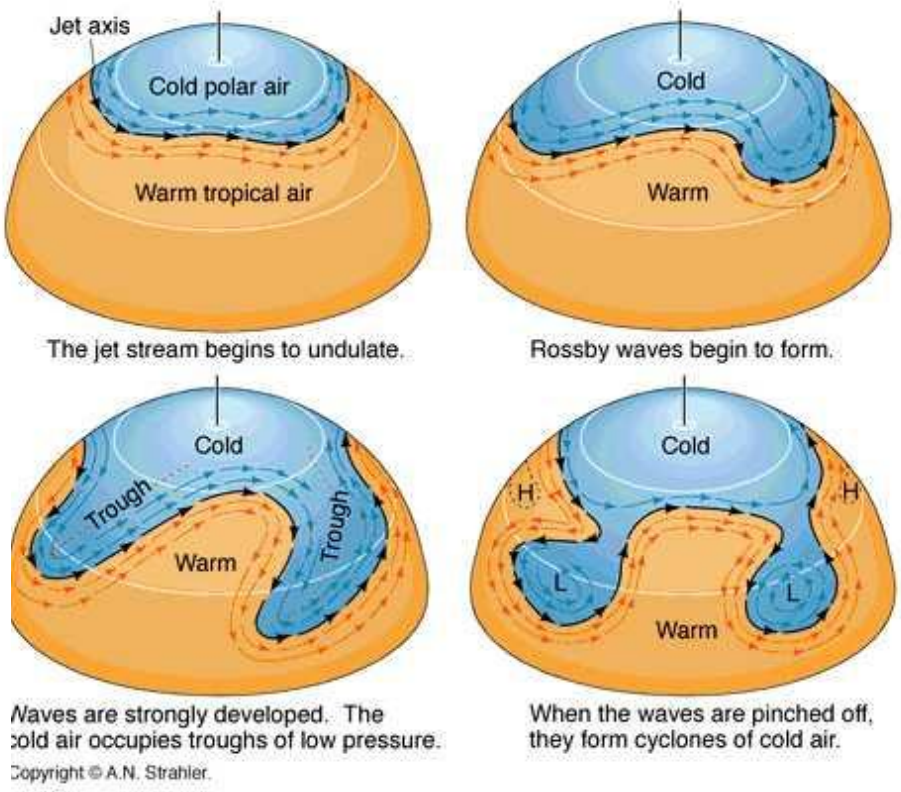
University of Arizona Lab. of Tree-RIng Research, V.N. Sukachev Institute, Fire History Expedition, July 2011; Yakutsk to Verkhnevilyuisk, Yakutia



Strong pole-to-equator gradients

Weak pole-to-equator gradients

As wavy jet stream develops, the ridge/trough patterns penetrate further north/south, and they may persist for days to weeks; anti-cyclonic systems, and cold front passages



Paper in Press

GEOPHYSICAL RESEARCH LETTERS, doi:10.1029/2012GL051000

Evidence Linking Arctic Amplification to Extreme Weather in Mid-Latitudes

Key Points

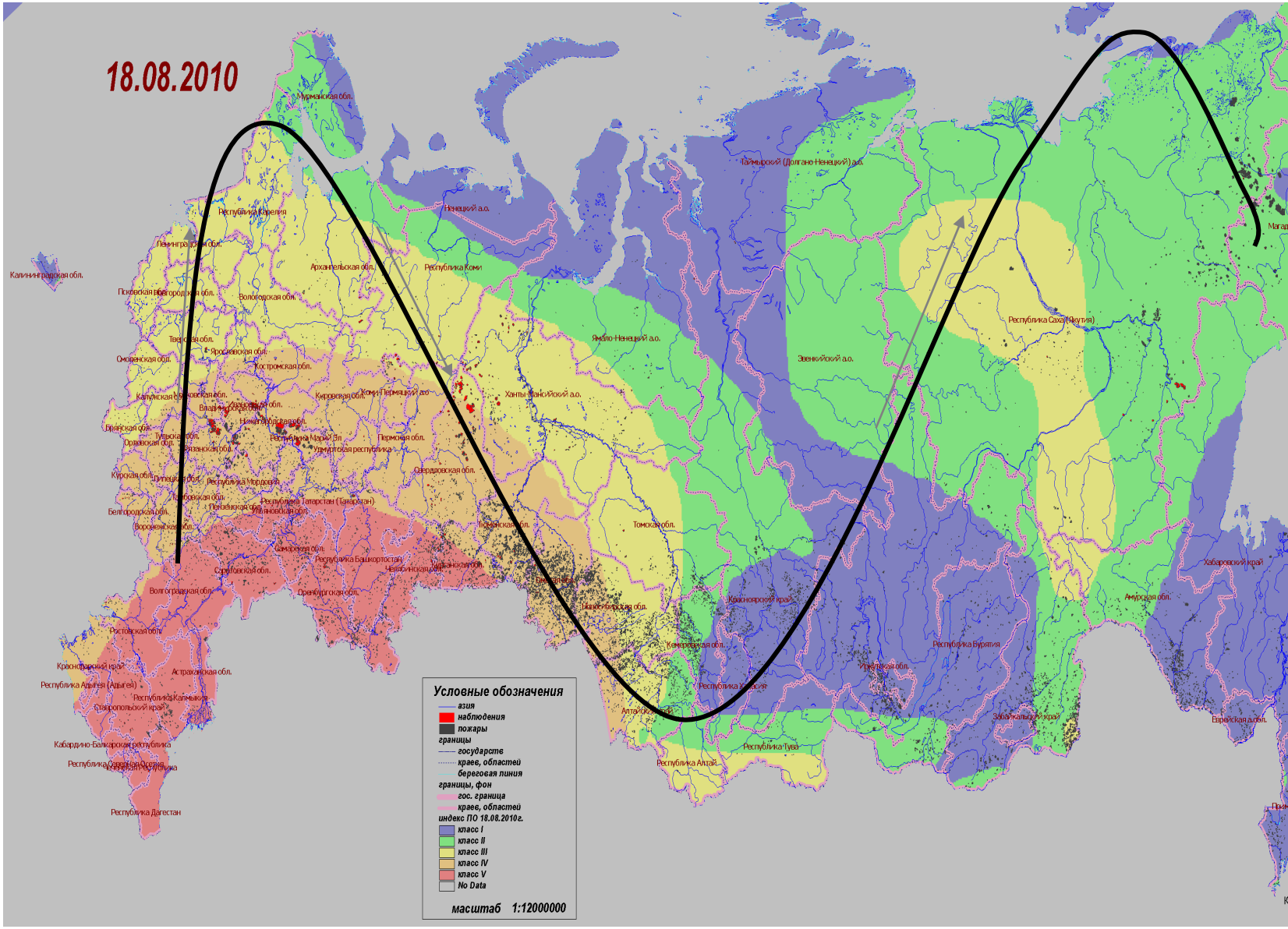
- Enhanced Arctic warming reduces poleward temperature gradient.
- Weaker gradient affects waves in upper-level flow in two observable ways.
- Both effects slow weather patterns, favoring extreme weather.

Authors:

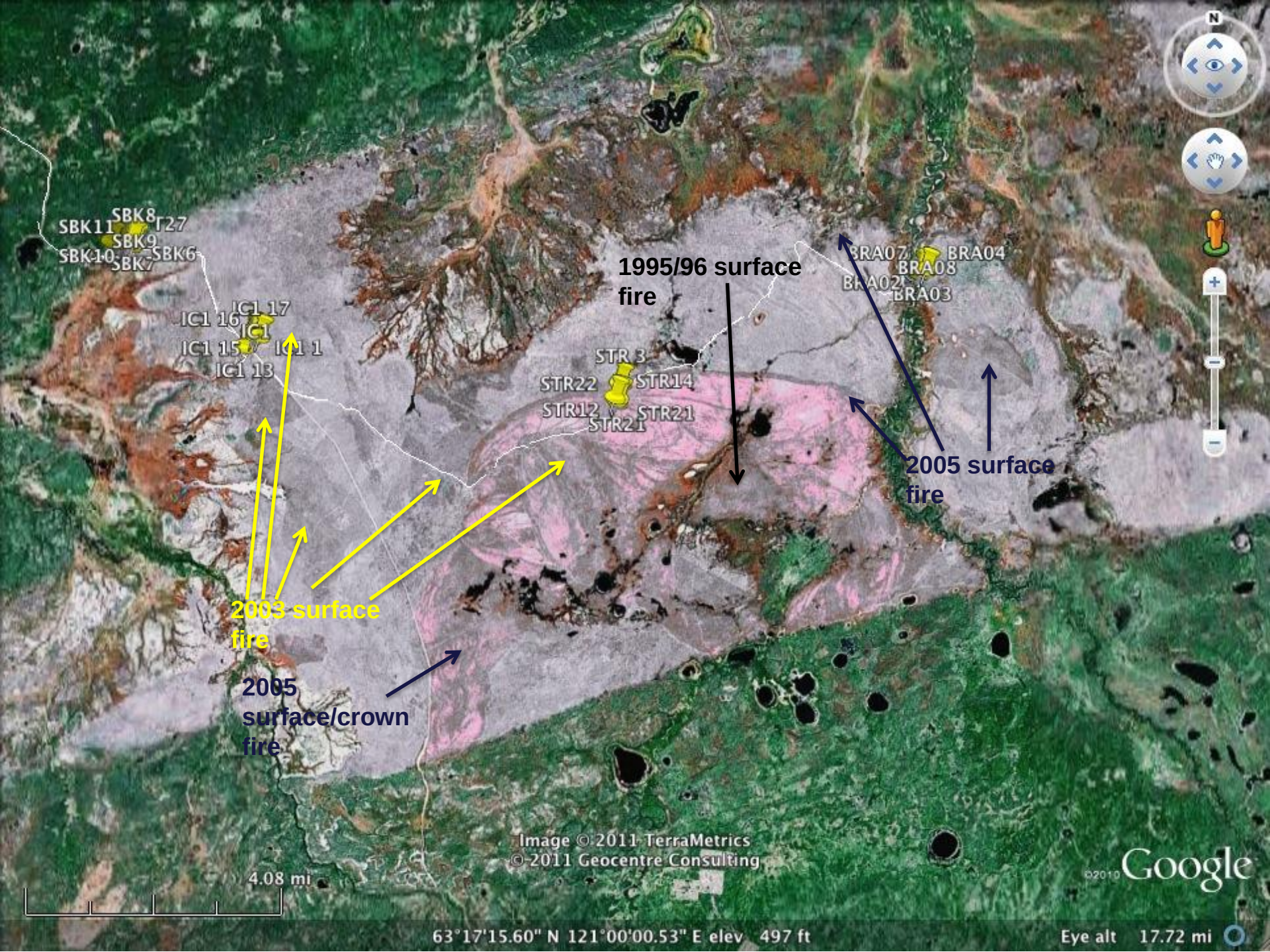
Jennifer A. Francis

Steve J. Vavrus

Fire Danger Class Distribution in Russia 18.08.2010



Charring on tree boles within the tree streets was still quite observable. In general, we noted that the bole charring tended to be on the crown fire burn side of the tree street, rather than toward the center of the burn street, as predicted by the Haines model of tree street formation. But we did not quantify the consistency of this pattern.


SBK11
SBK8
T27
SBK9
SBK10
SBK7
SBK6
IC1 16
IC1 17
IC1
IC1 15
IC1 1
IC1 13
STR 3
STR22
STR14
STR12
STR21
STR21
BRA07
BRA04
BRA08
BRA02
BRA03
1995/96 surface fire
2005 surface fire
2003 surface fire
2005 surface/crown fire
Image © 2011 TerraMetrics
© 2011 Geocentre Consulting
4.08 mi
©2010 Google
63°17'15.60" N 121°00'00.53" E elev 497 ft
Eye alt 17.72 mi