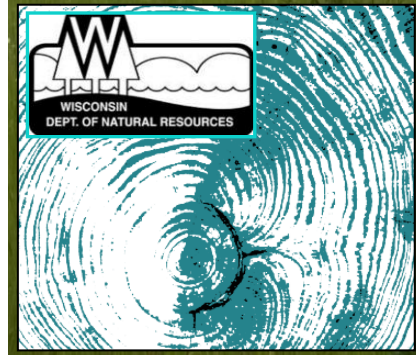
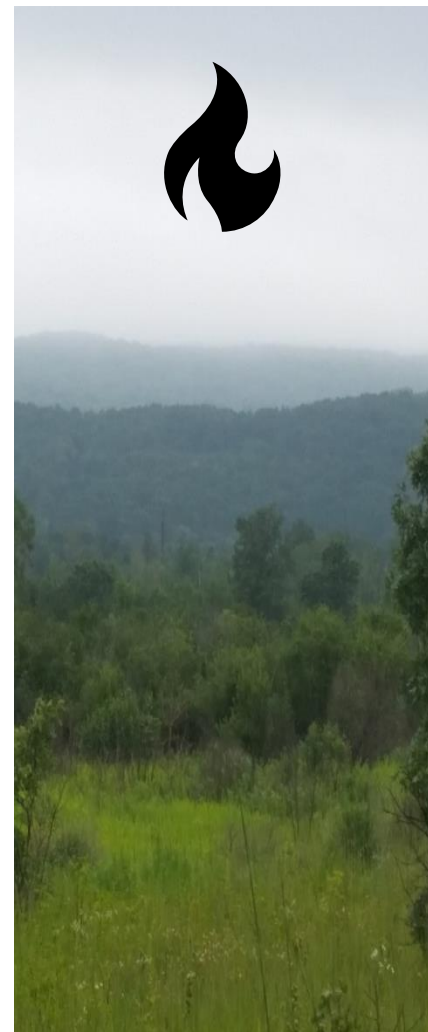


# SEEING THE FOREST FOR THE TREES: ROLE OF FIRE IN CARBON DYNAMICS

- I. Fire Regimes & Carbon Dynamics (resistance vs resilience)
- II. Historical Fire Regimes (pine forests & peatlands)
- III. What does this all mean for resilient systems

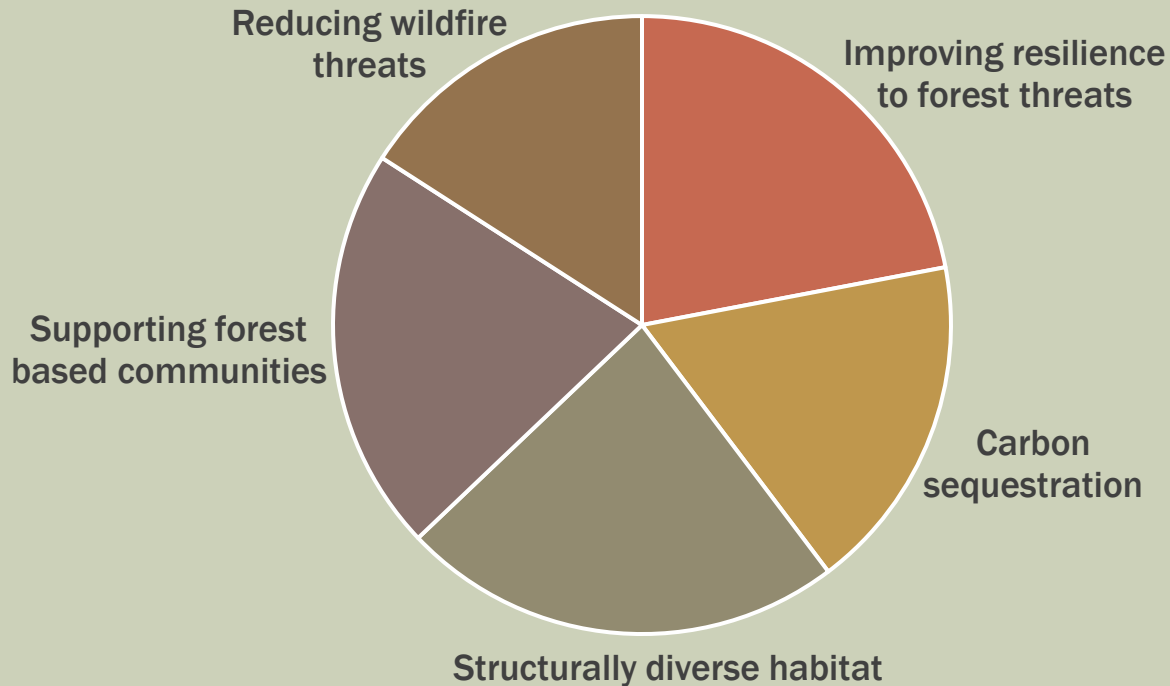
Jed Meunier

Jed.meunier@wisconsin.gov

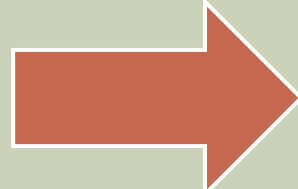
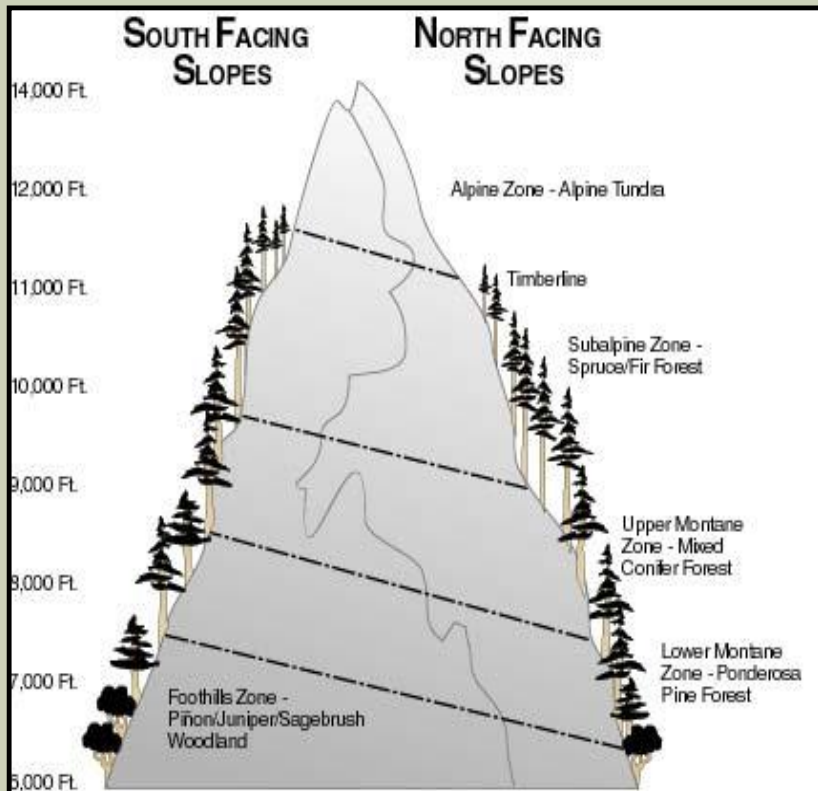


# CHANGING OBJECTIVES OF OUR FORESTS

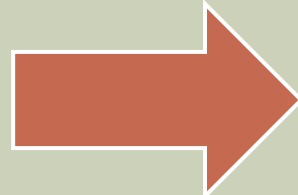
What matters in a quality logging operation?



# UNDERSTANDING FIRE REGIMES (& CARBON DYNAMICS)



Fire resilient



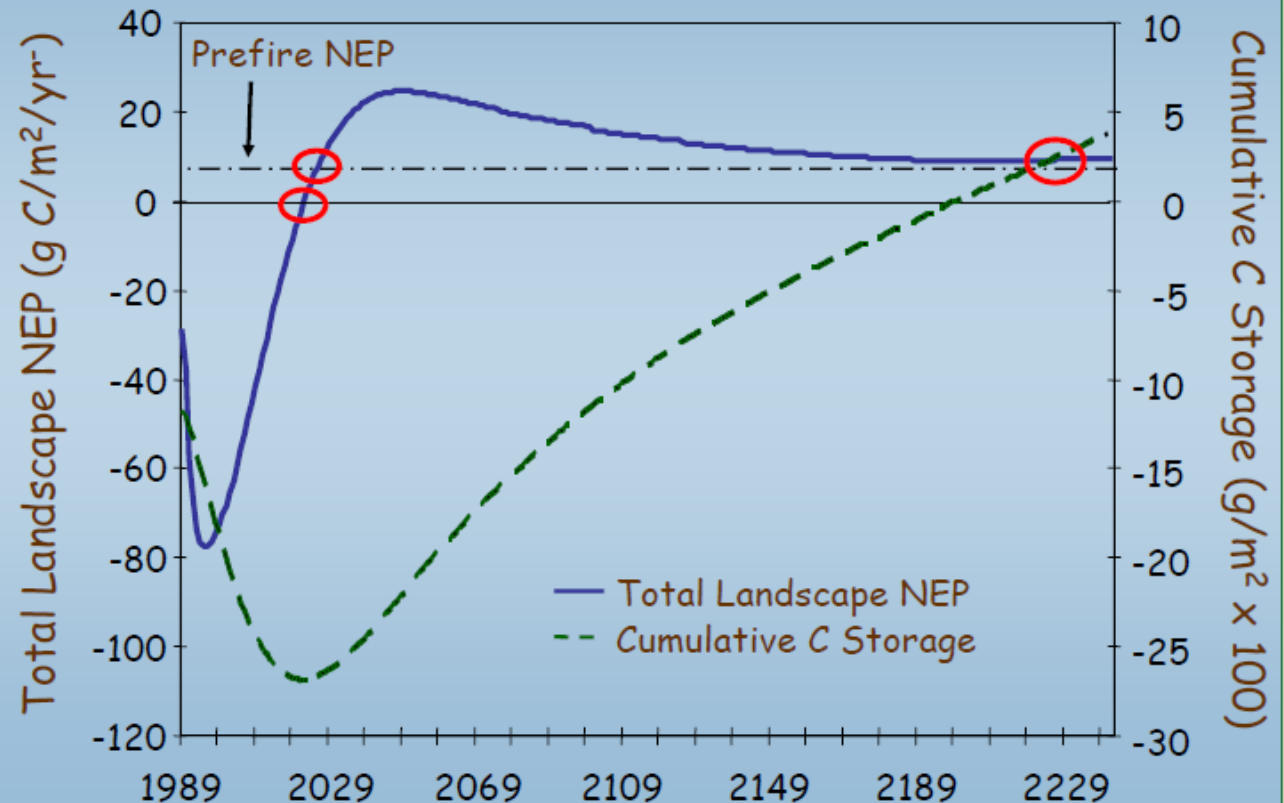
Fire resistant



# CARBON STORAGE ON LANDSCAPES WITH STAND REPLACING FIRES



## Post-fire changes in C storage for Yellowstone



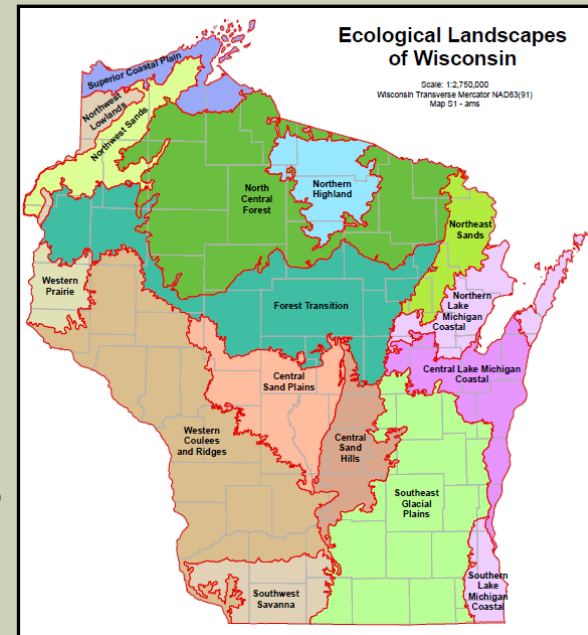
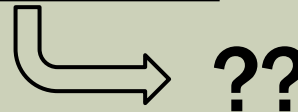
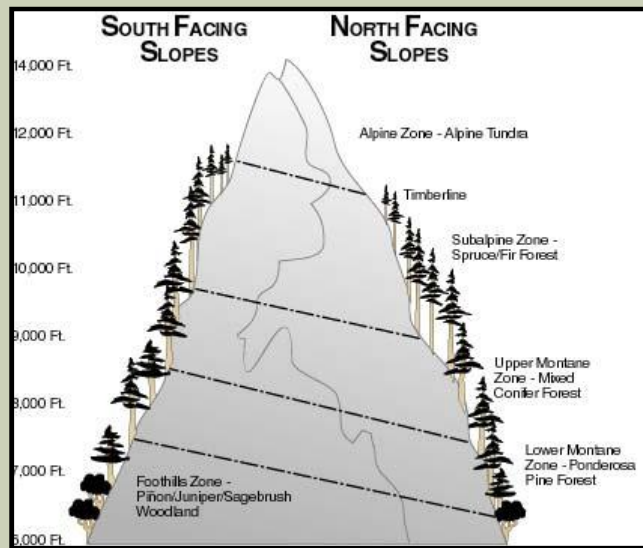
# DYNAMICS IN FREQUENT FIRE LANDSCAPES



Kaibab 1905, USGS



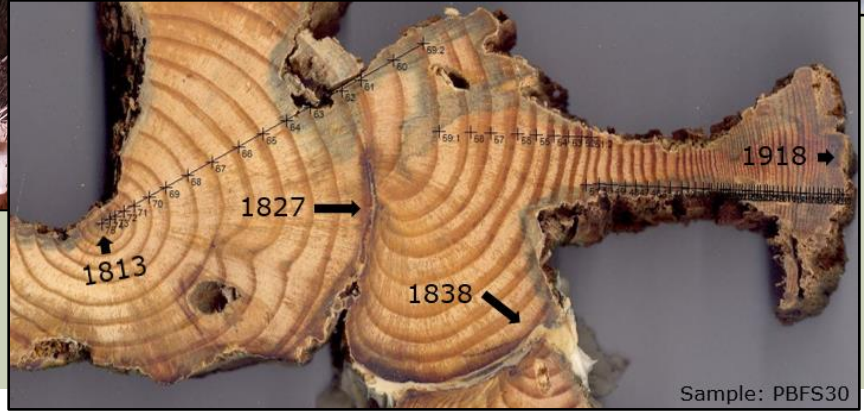
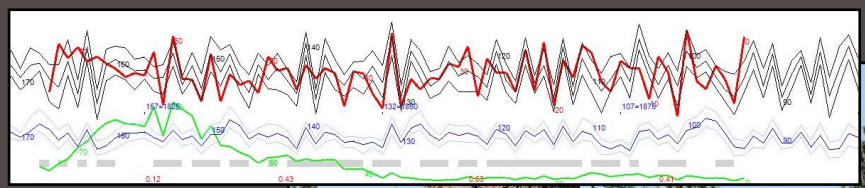
# WHAT ABOUT WISCONSIN SYSTEMS, DO WE UNDERSTAND FIRE & CARBON DYNAMICS



# PINES IN LAKE STATES – EVEN AGE, SINGLE COHORT...

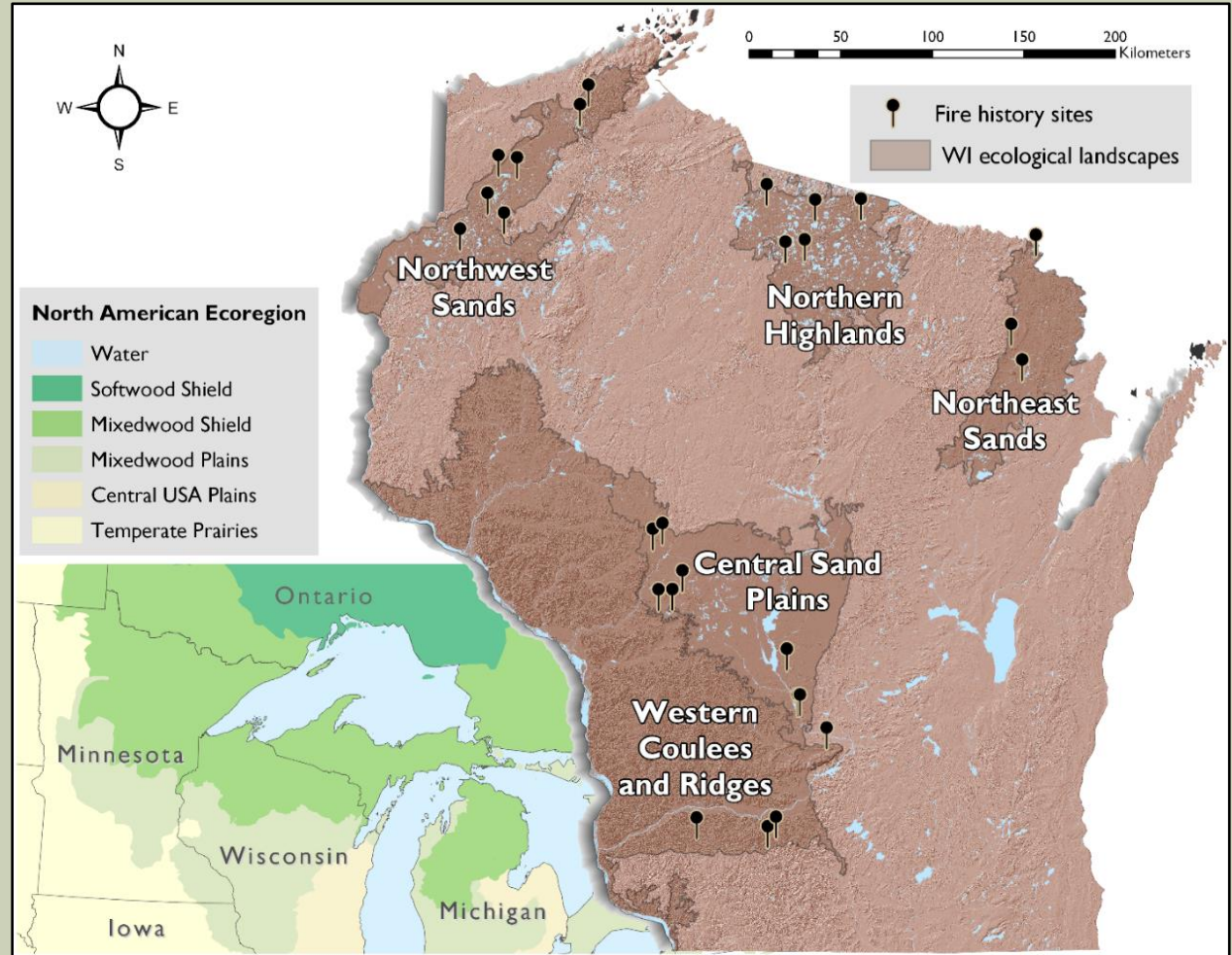
“There are even fewer absolutes in ecology than in forestry, but an emerging operating maxim is *simplification is rarely beneficial.*” Franklin et al. 1986



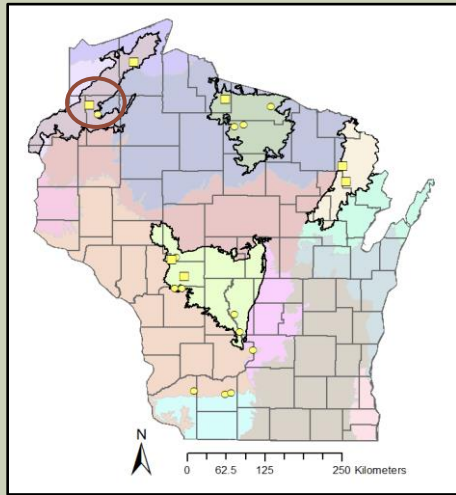




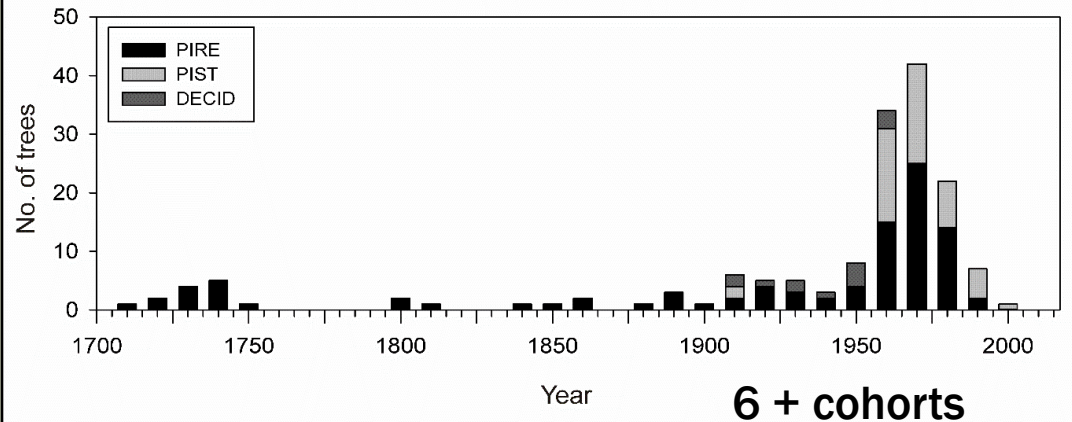
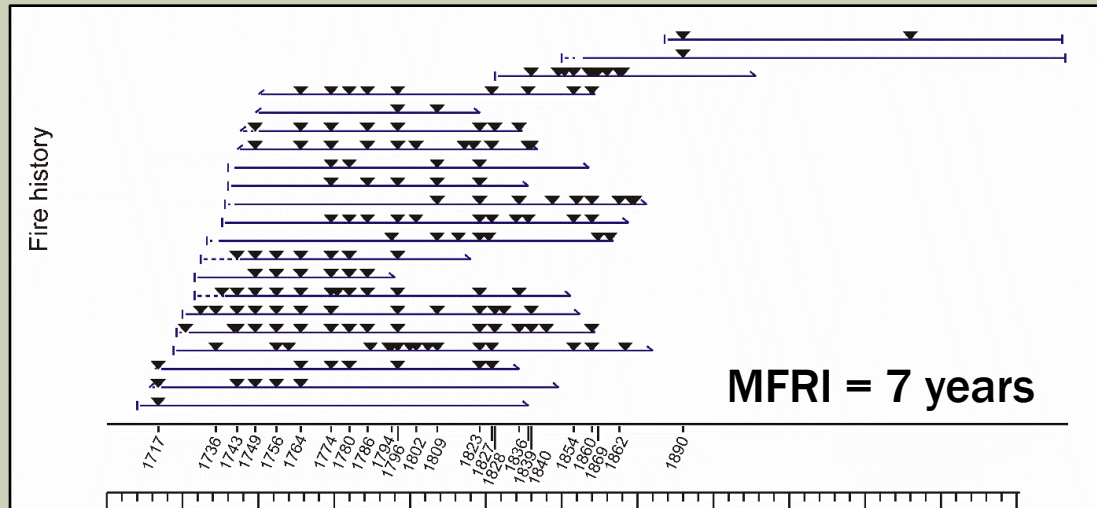
# WI FIRE HISTORY SITES



# FREQUENT FIRE, MULTI-COHORT STRUCTURE



## Totogatic River



# PINE STANDS 4-37X MORE DENSE TODAY

Site	Ecological Landscape	Historical trees/Ha	Current trees/Ha
Camp Bird	NE Sands	140	833
Wolf Lane	NE Sands	72	1,294
Frog Lake	N. Highlands	36	1,318
Cathedral Point	N. Highlands	288	1,344
Totogatic River	NW Sands	172	1,828
Inch Lake	NW Sands	112	982
Wildcat Ridge	C. Sands	256	995
Bruce Mound	C. Sands	112	1,032

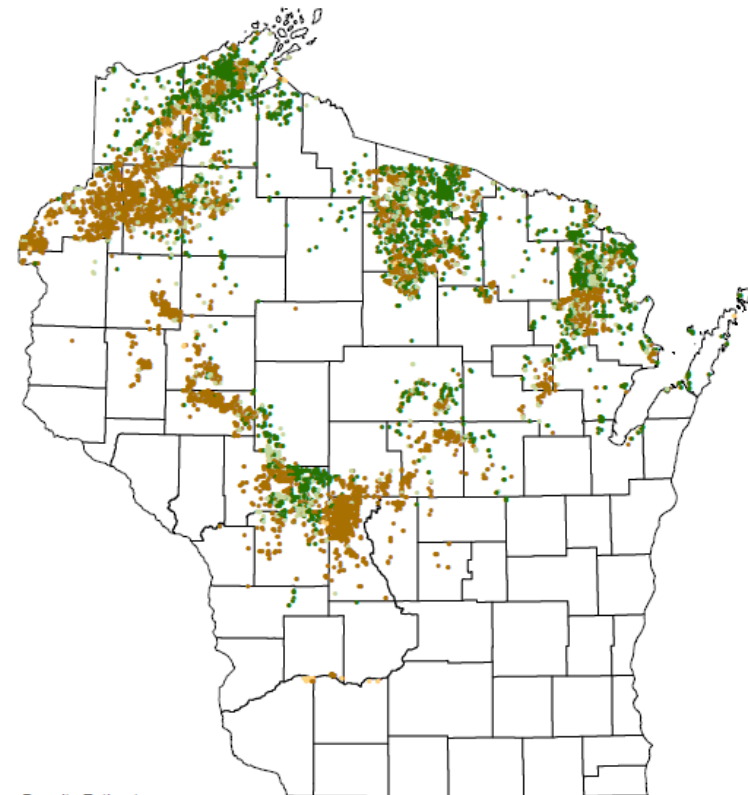
Meunier et al. 2019, Ecology

## Trees/ha

- Forest: >99
- Woodland: 47-99
- Savanna: 0.5-47
- Prairie: <0.5

- Curtis 1959, Anderson & Anderson 1975

Public Land Survey Witness Trees  
Red Pine



Density Estimate

- Closed Forest
- Woodland
- Savanna
- Prairie

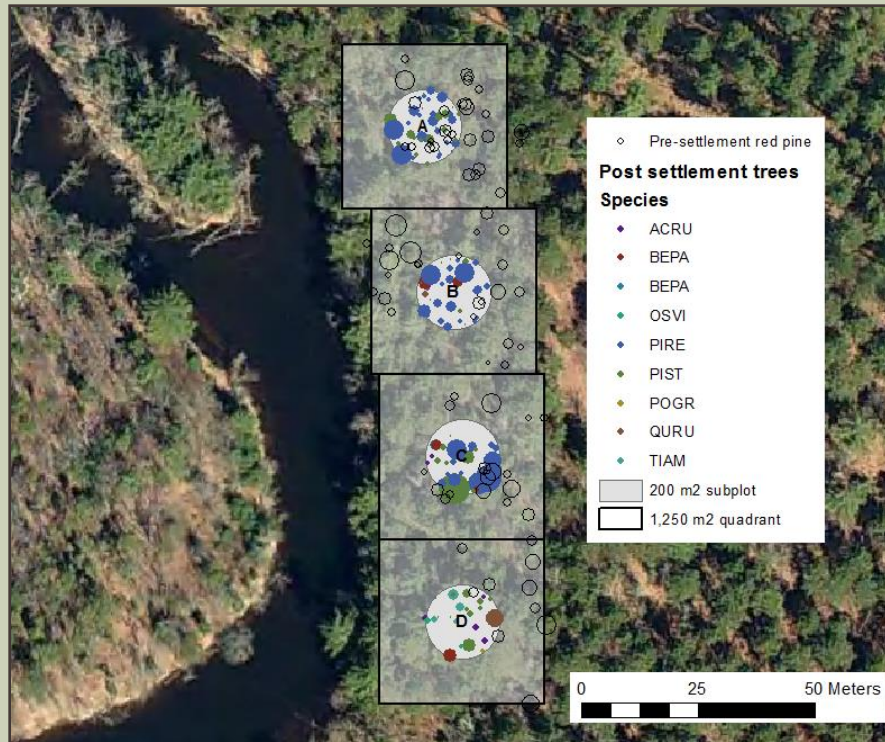


0 15 30 60 90 120 Miles  
0 20 40 80 120 160 Kilometers

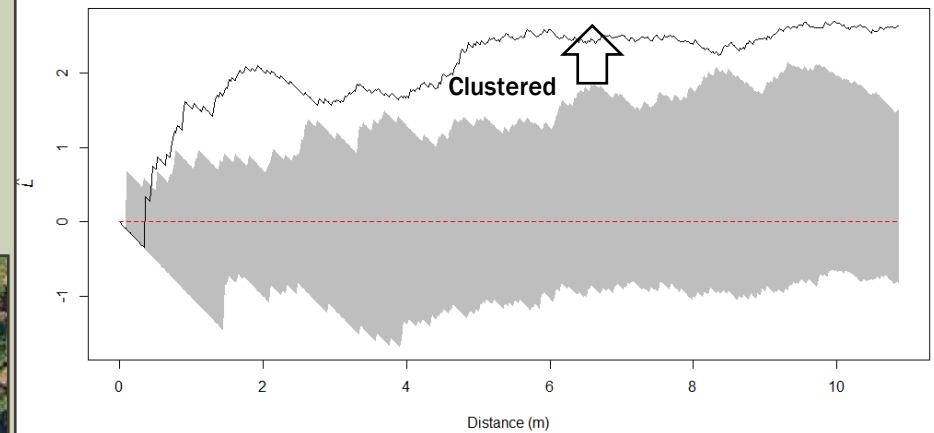
Map produced by Monika Shea (mshea3@wisc.edu)  
Forest Landscape Ecology Lab  
University of Wisconsin-Madison  
February 26, 2016

# HISTORICAL VS CURRENT SPATIAL PATTERNS

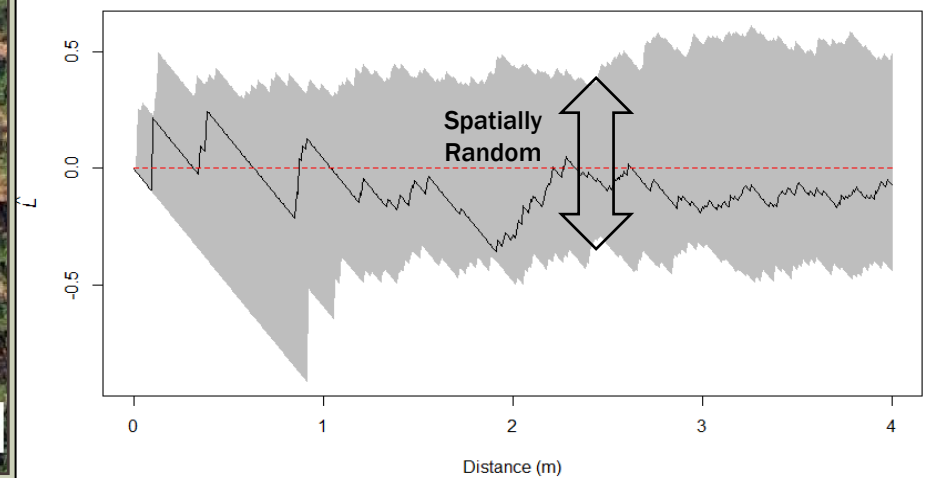
- Tells us about recruitment/mortality & drivers



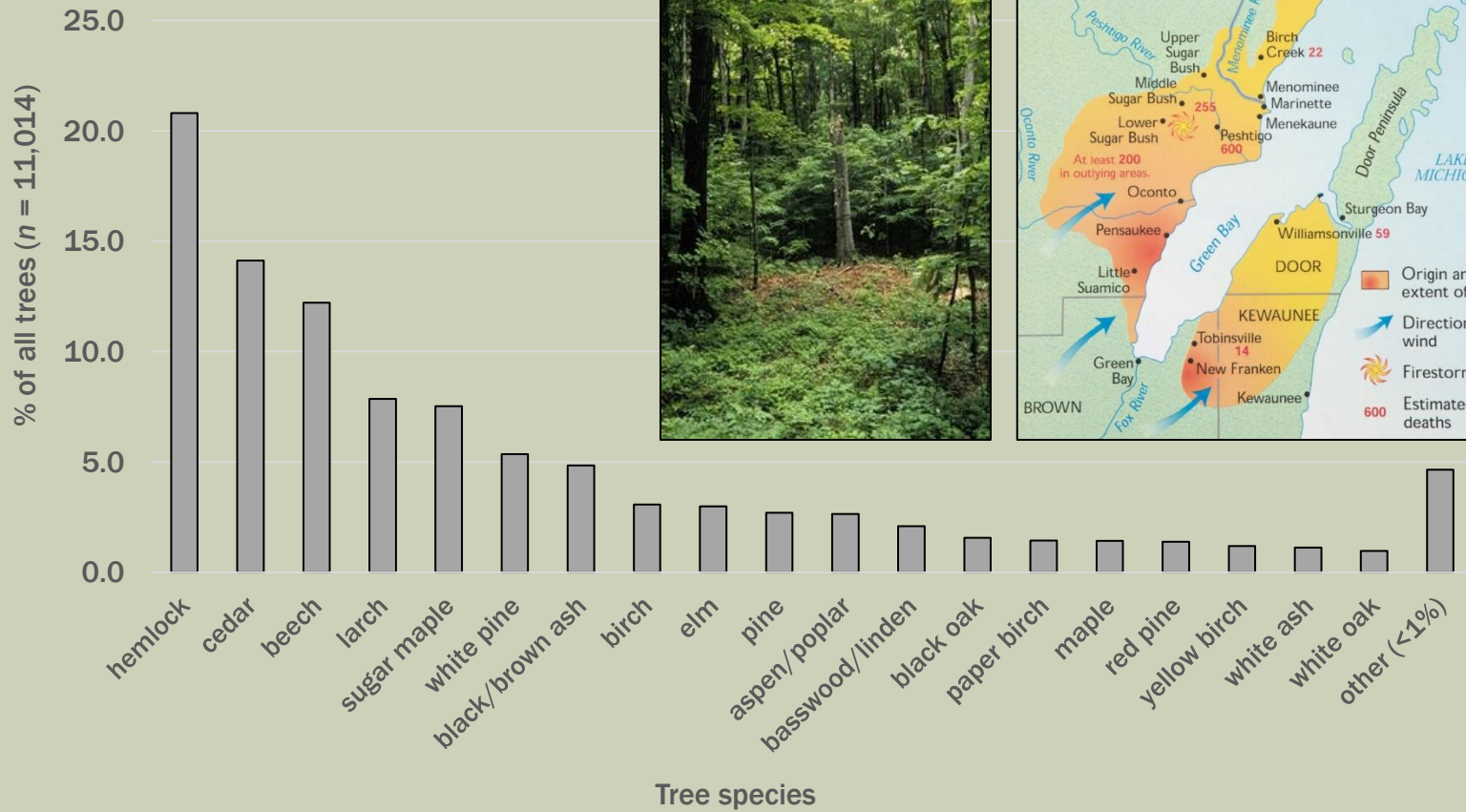
Historical forest = trees clustered



Current forest = spatially random

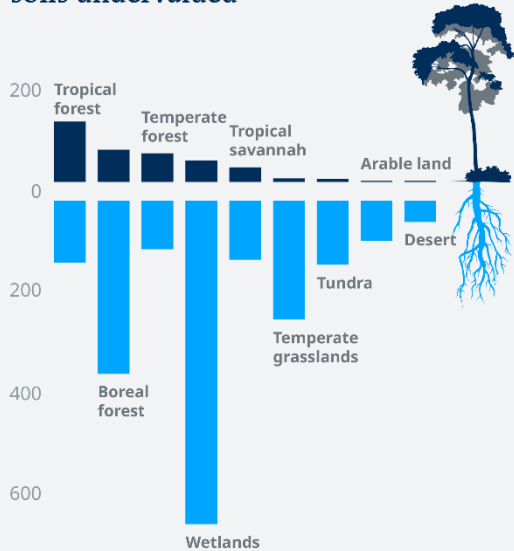


# FIRE RESISTANCE VS RESILIENCE (& CARBON!)



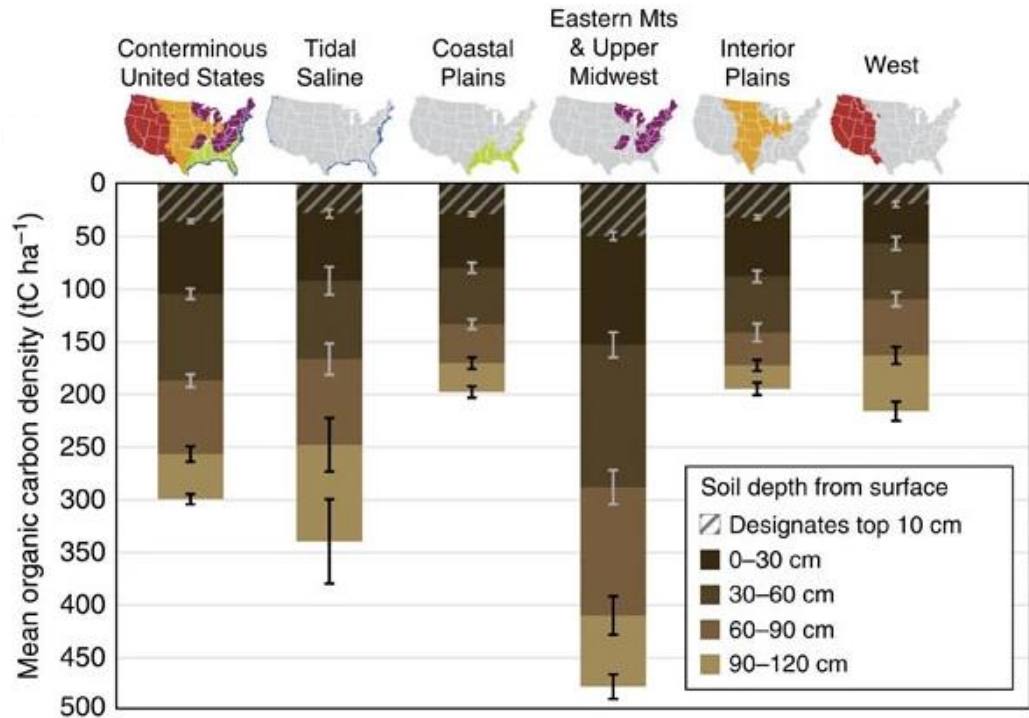
# BELOW GROUND CARBON STORAGE

## CO<sub>2</sub> storage: Flora overvalued, soils undervalued



Average stored carbon in tons per hectare at a ground depth of one meter

Source: World Climate Council (IPCC)



Nahlik, A., Fennessy, M. Carbon storage in US wetlands. *Nat Commun* 7, 13835 (2016). <https://doi.org/10.1038/ncomms13835>

# HISTORICAL FIRE REGIMES OF SUB-BOREAL PEATLANDS



# SMOLDERING FIRES - LARGEST, MOST DESTRUCTIVE MEGAFIRES FEW HAVE HEARD OF



Indonesia, 2015 - > 1.5 million acres of peatlands burned

Tuesday, Nov 08 2022 All Cities Choose Your City

The Siberian Times *I love Siberian women, they are incredible. French actress Carole Bouquet, 2019*

Home News Features Business City Focus Sport Culture Science Health & Lifestyle Ecology Weird & Wonderful

## Zombie fires burn at -60C outside Oymyakon, the world's coldest permanently inhabited place

By Anna Liesowska  
02 December 2021

Local photographer captures pillars of smoke rising above the underground peat fire.

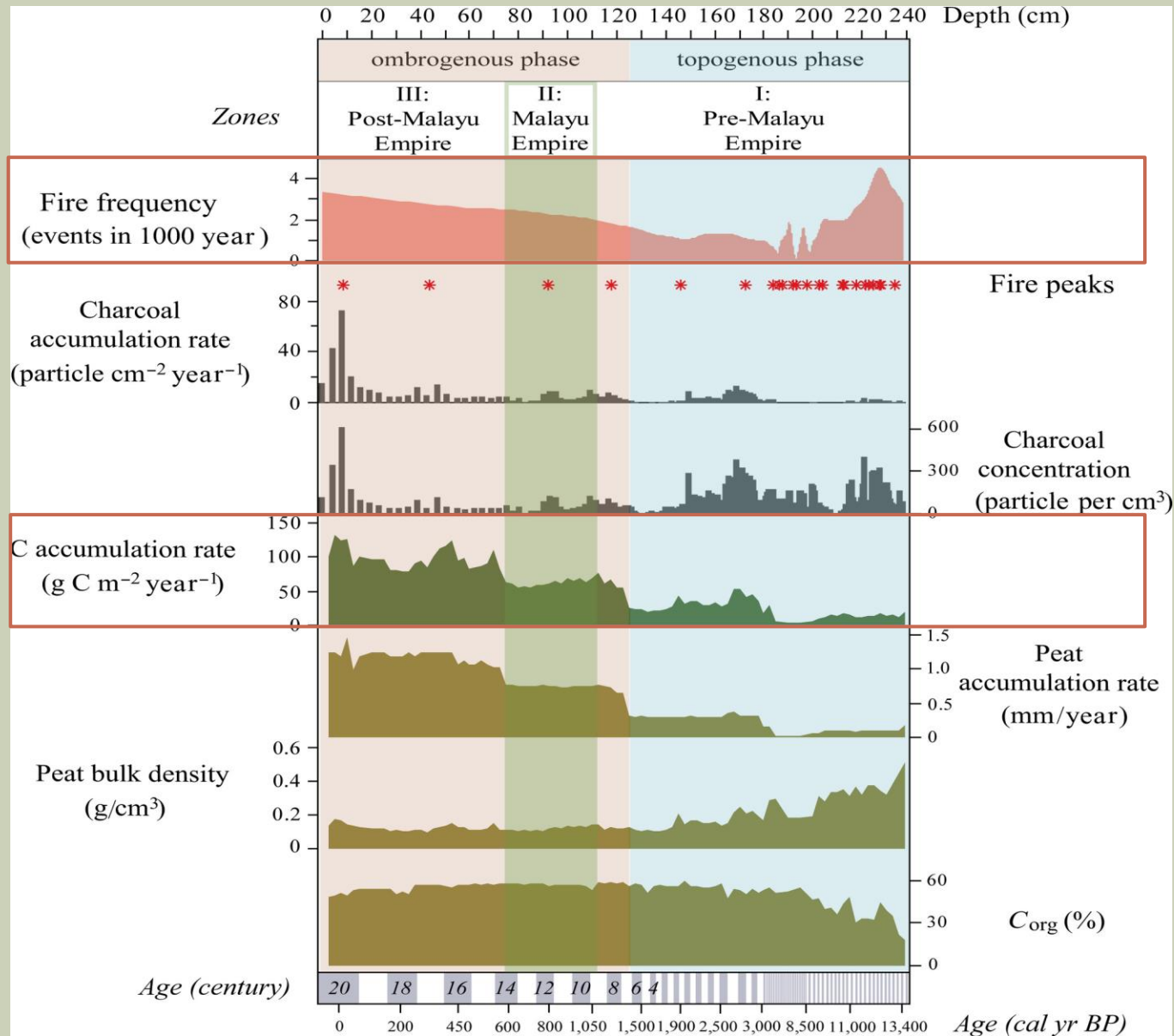
A photograph showing a landscape covered in deep snow. In the foreground, a small fire is burning, with thick white smoke rising from it. The background shows snow-covered trees and hills under a pale sky. The sun is visible on the horizon, creating a soft glow.

Peat deposit pictured burning at -60C outside Oymyakon, the Pole of Cold. Picture: Semyon Sivtsev

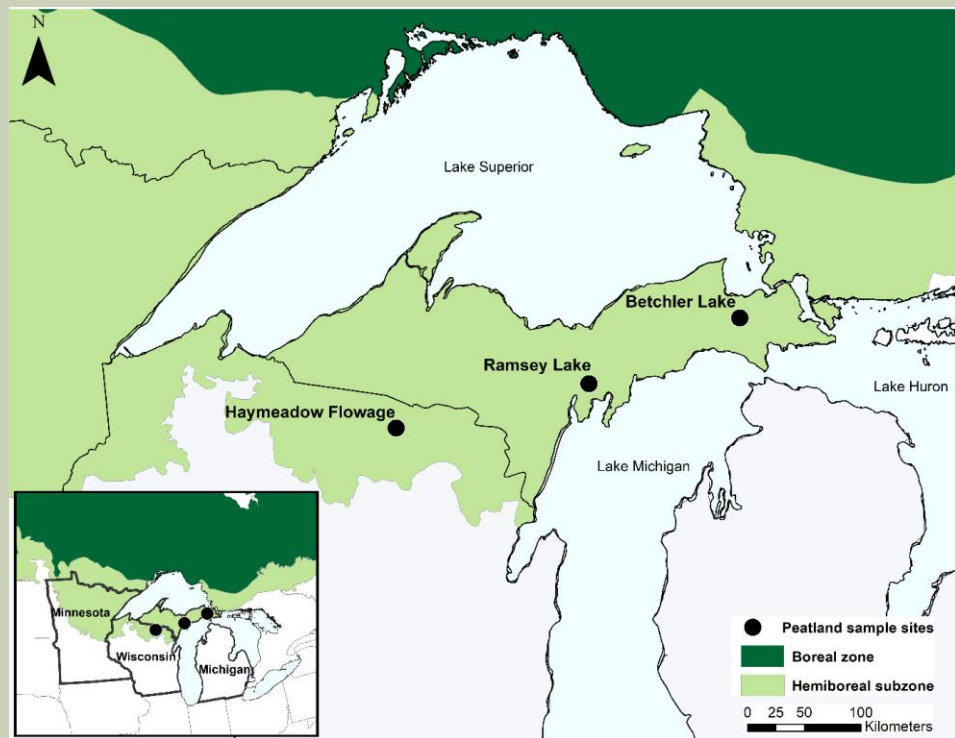


# CENTRAL SUMARA, INDONESIA PEATLAND DISTURBANCE VIA PALEOECOLOGY

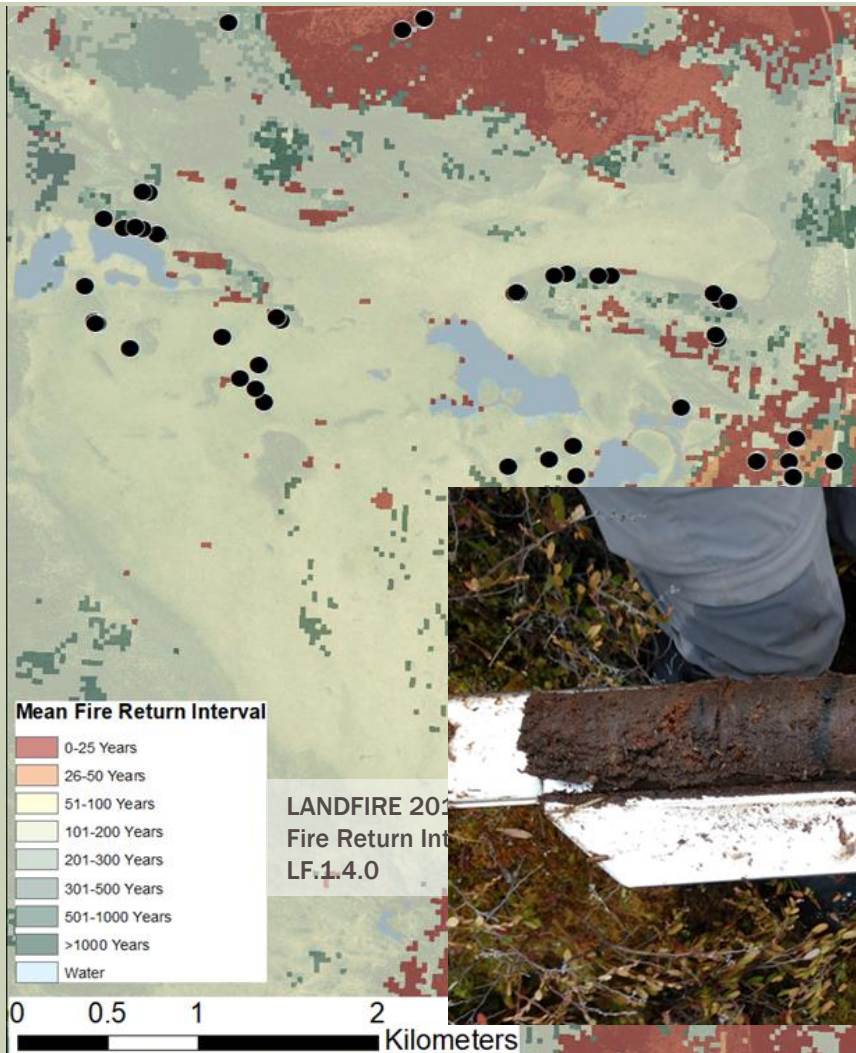
Hapsari et al., 2018, Ecology



# PEATLAND STUDY SITES



# SUB-BOREAL PEATLAND FIRE RETURN INTERVALS

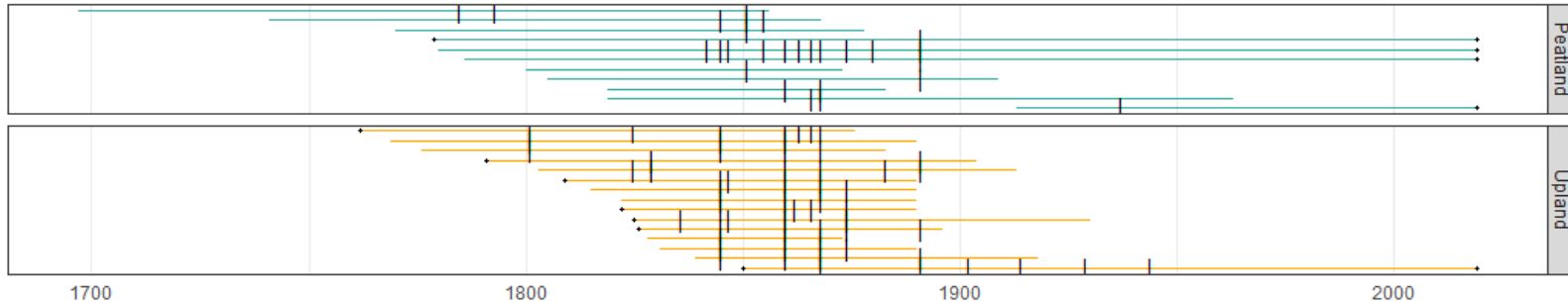


> 1000s years



# FIRES WERE SUPRISINGLY FREQUENT IN OUR SITES

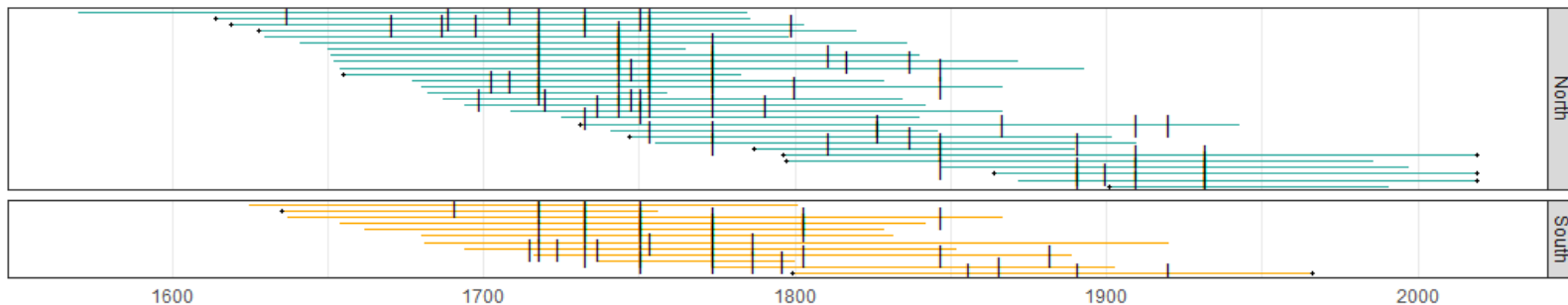
Haymeadow Flowage (MFRI: 7-18)



Widespread fire years:

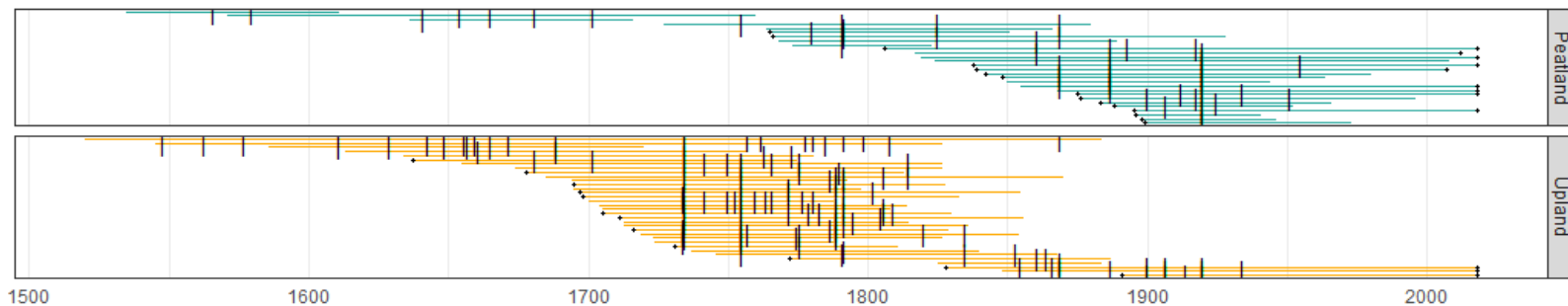
1845, 1847,  
1860, 1863,  
1866, 1868,  
1874, 1891

Ramsey Lake (MFRI: 8-24)



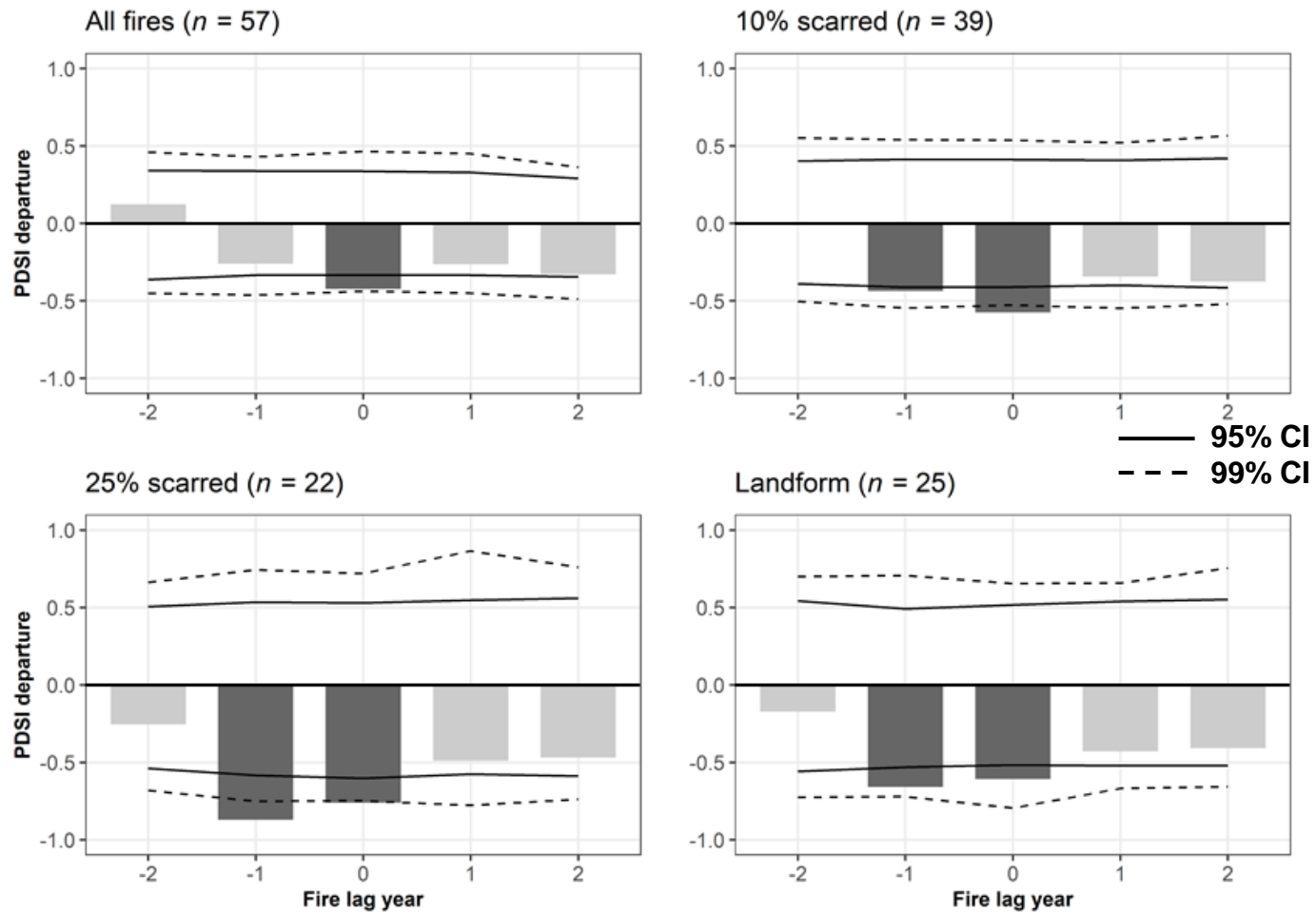
1665, 1681,  
1702, 1755,  
1791, 1792,  
1869, 1887,  
1900, 1907,  
1920, 1934

Betchler Lake (MFRI: 5-34)



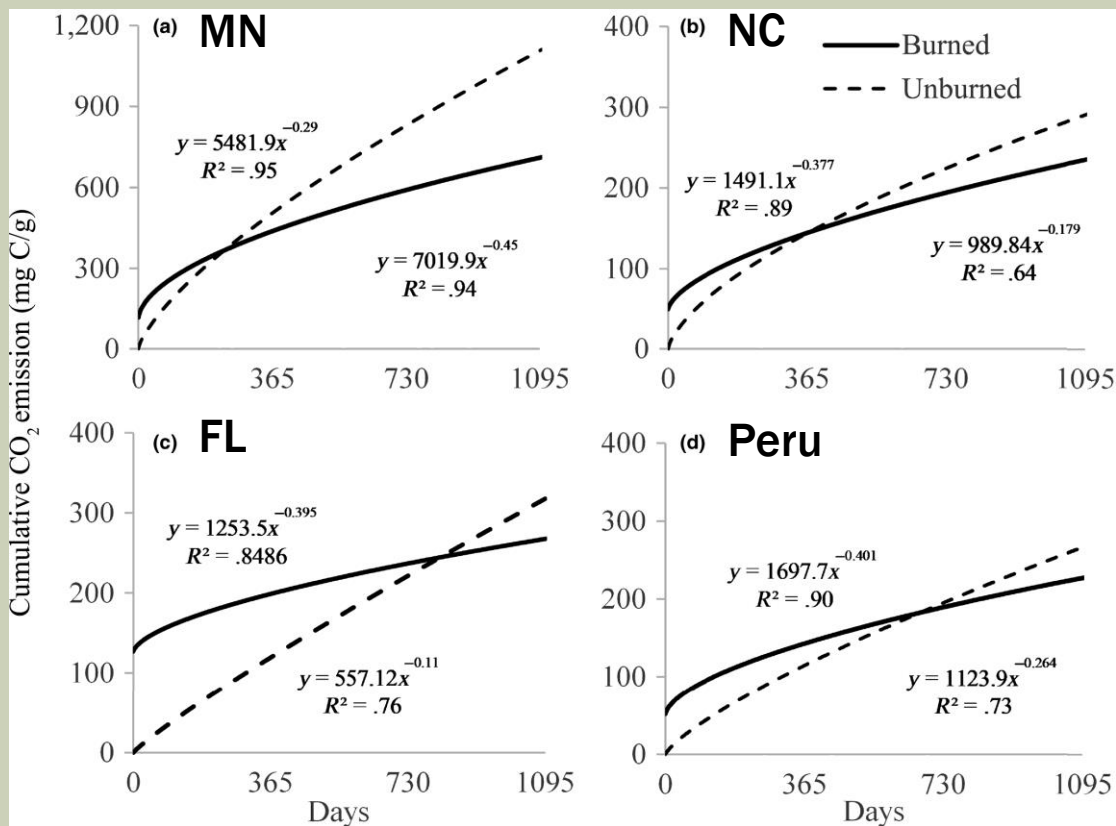
1718, 1733,  
1737, 1751,  
1754, 1774,  
1847, 1891,  
1920

# FIRES TENDED TO BURN IN MODERATELY DRY CONDITIONS

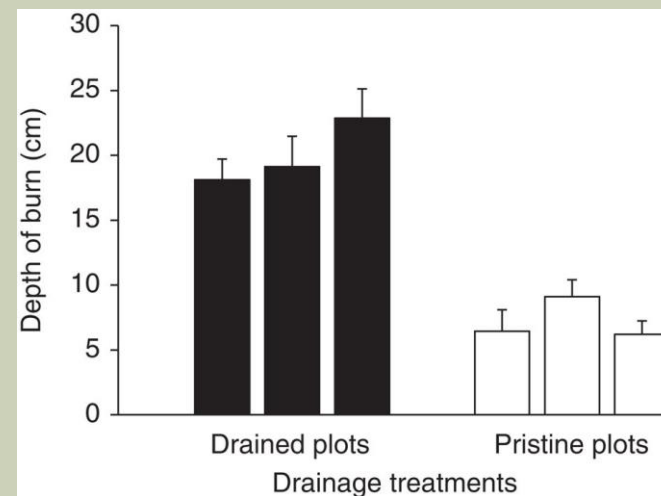


# LOW-SEVERITY FIRE AS A MECHANISM OF ORGANIC MATTER PROTECTION IN GLOBAL PEATLANDS: THERMAL ALTERATION SLOWS DECOMPOSITION

Flanagan, 2020, Global Change Biology



Experimental drying intensifies burning & carbon losses in a northern peatland

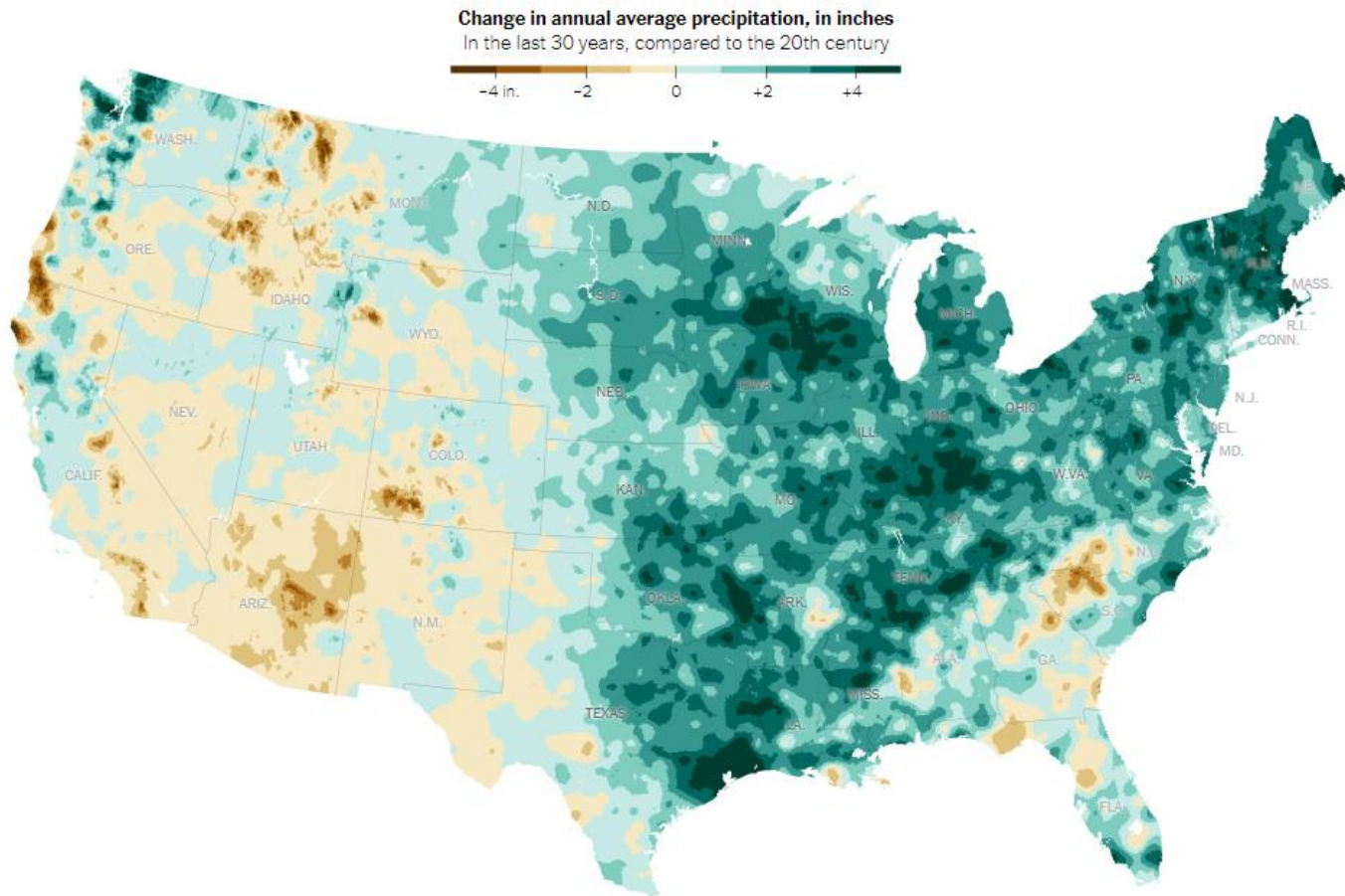


Turetsky et al. 2011, Nature Communications

# IV. WHAT DOES ALL THIS MEAN FOR RESILIENT SYSTEMS?



# “A TALE OF TWO AMERICAS” – NYT, 2021



Source: [NOAA's National Centers for Environmental Information](#)



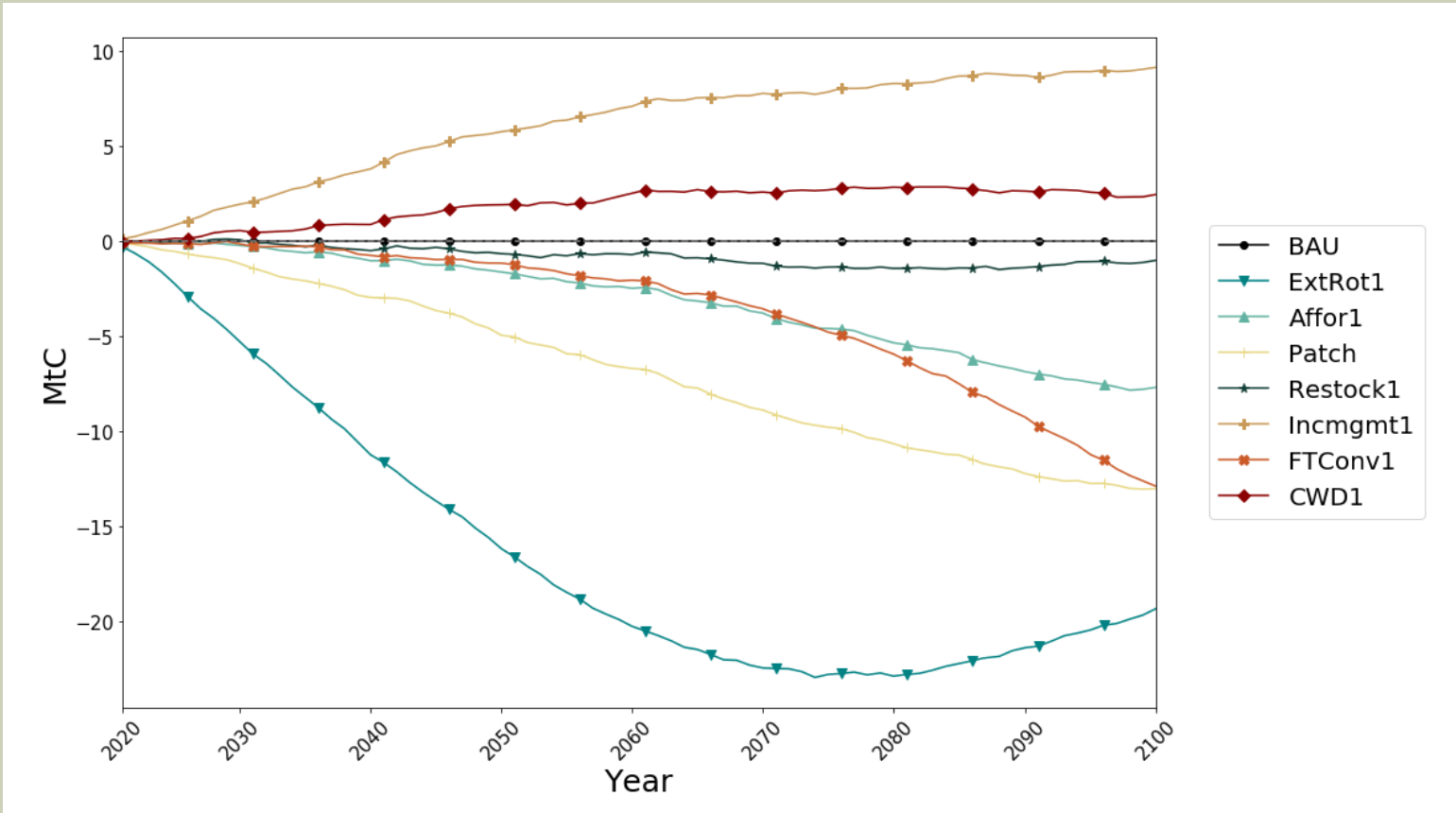
# TRILLION TREES CAMPAIGN

- In Wisconsin by 2030:
  1. Plant - 75 million trees
  2. Conserve - 125,000 acres
  3. Restore - ??



# CARBON DYNAMICS VIA FOREST MANAGEMENT

Scenarios standardized to baseline



# CONTROLLED BURNING CAN OFFSET OUR CARBON EMISSIONS

Planting trees and suppressing wildfires do not necessarily maximize the carbon storage of natural ecosystems. A new study has found that prescribed burning can actually lock in or increase carbon in the soils of temperate forests, savannahs and grasslands.

Adam F. A. Pellegrini, Jennifer Harden, Katerina Georgiou, Kyle S. Hemes, Avni Malhotra, Connor J. Nolan, Robert B. Jackson. Fire effects on the persistence of soil organic matter and long-term carbon storage. *Nature Geoscience*, 2021; DOI: [10.1038/s41561-021-00867-1](https://doi.org/10.1038/s41561-021-00867-1)

*Nature Geoscience*



**“PRESENT-DAY PROBLEMS IN CONSERVATION AND LAND USE, VIEWED IN THE LIGHT OF CONTEMPORARY EVIDENCE ALONE, OFTEN BAFFLE THE INVESTIGATOR. THE SAME PROBLEM, VIEWED IN THE LIGHT OF HISTORY, MAY OFTEN BE DECIPHERED AS THE REPETITION OF SOME HISTORIC PATTERN.” - A. LEOPOLD 1940**

