Native Americans, Smokey Bear and the rise and fall of eastern oak forests

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Forest change (dynamics) remains very important topic of scientific study

Main drivers include forest succession, disturbance (natural and human), forest health issues and climate

Scientists have very strong opinions about which is most important (climate vs. land-use debate)

Climate is important, but other factors, such as fire and other disturbances, should not be dismissed

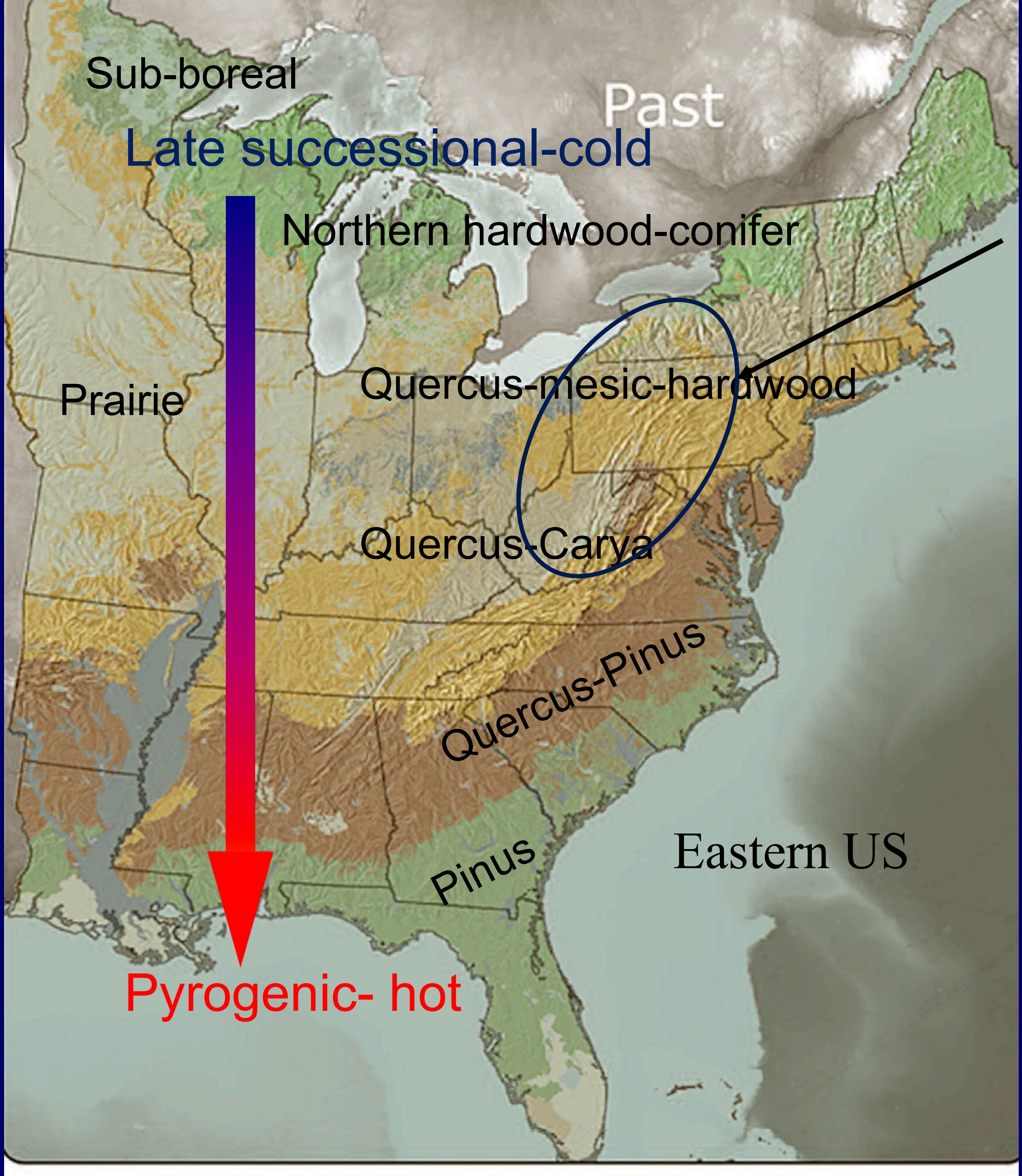
Prior to 1500, Native Americans (NA-Indians) inhabited most of the U.S.

Indian burning was a dominant factor over last 5000+ years, maybe more imp. than climate change

My research investigated major forest change (rise and fall of tree species) and drivers of change in eastern US.

Talk Themes:

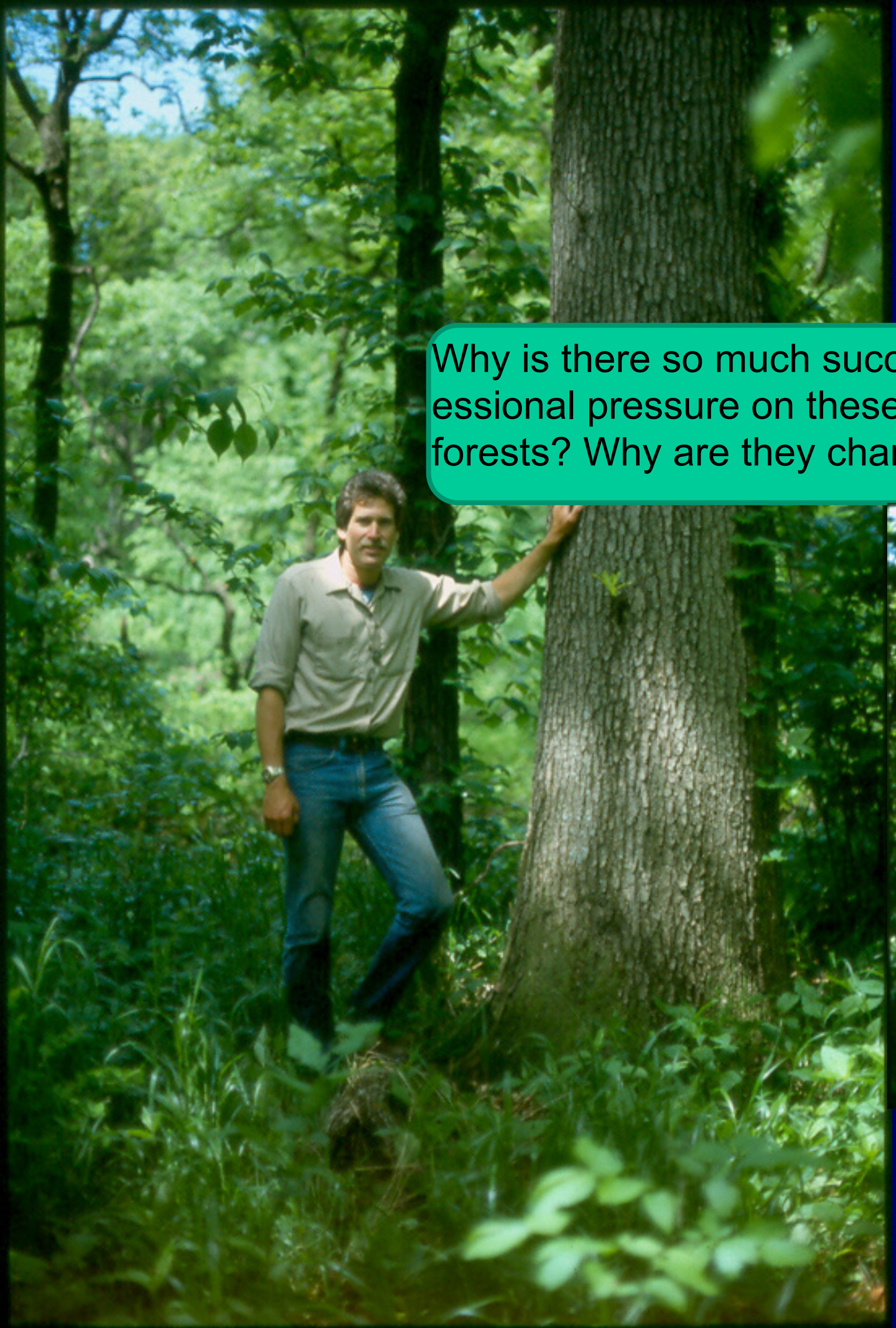
- American Indians as ecological (fire) managers
- Fire cycle and land-use after European settlement
- European settlement impacts on forest composition
- Recent drivers of forest change
- Current threats to eastern forests (deer?)
- How to better manage forest



Study region:
Forest types and fire cycles follow N-S gradient

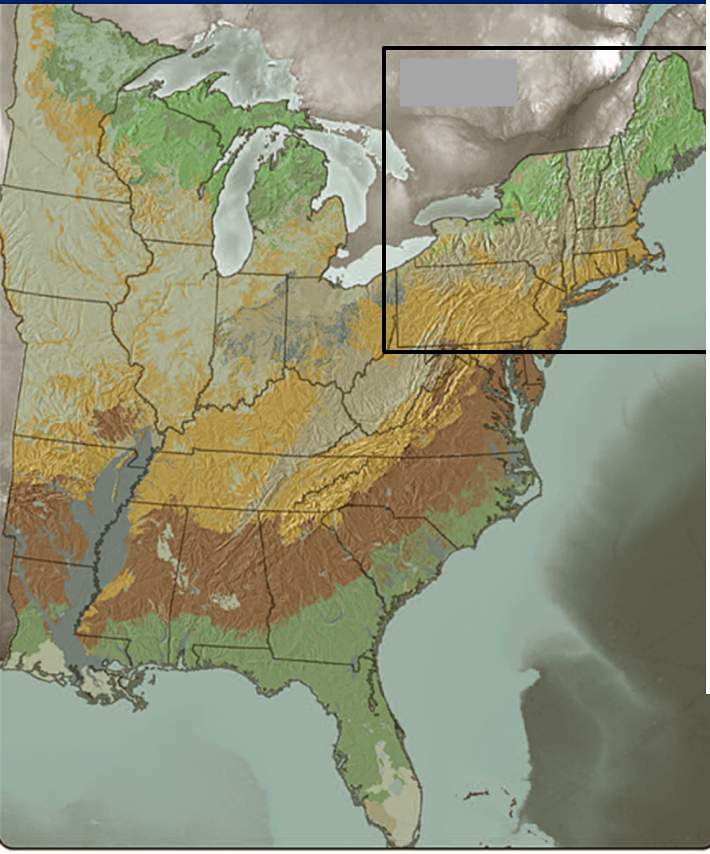
How I got started- Konza Prairie Kansas (1983)

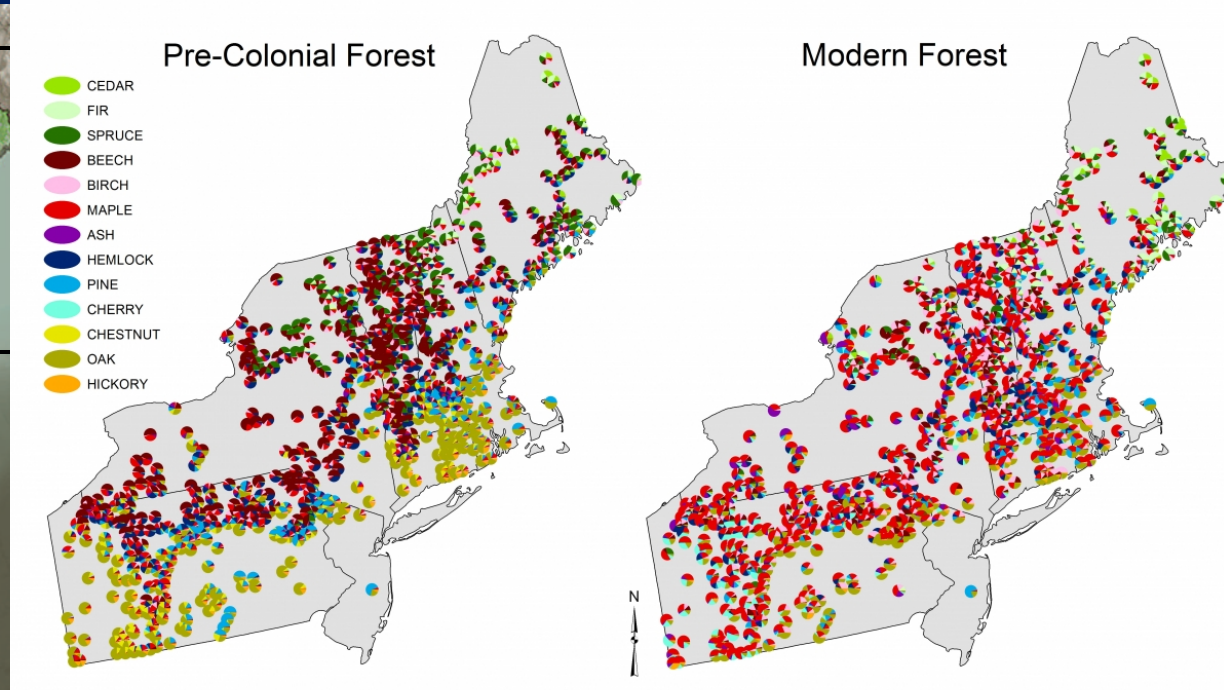
Oak forests within fire-maintained grassland



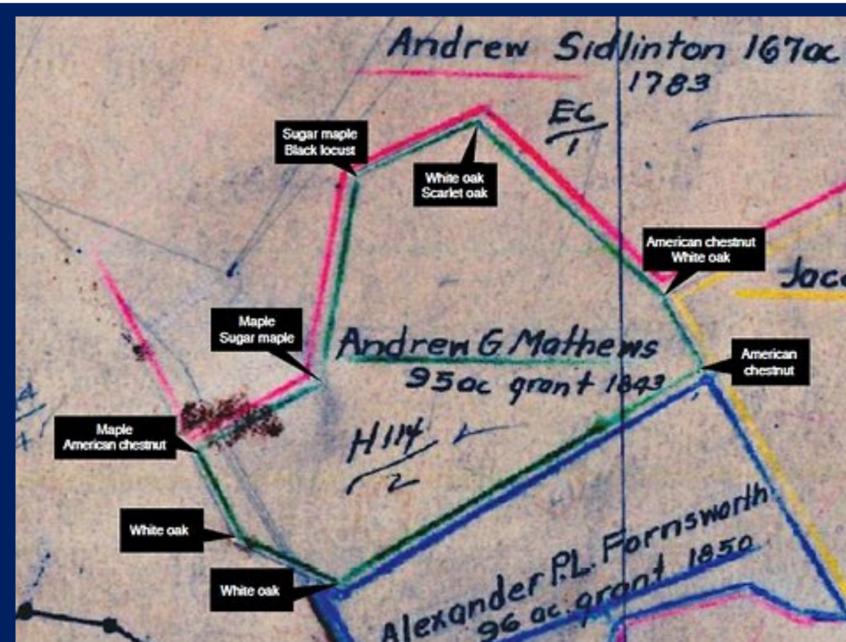
Why is there so much succ-essional pressure on these forests? Why are they changing

Fire and oak hypothesis- forest succession was checked by frequent fires in the past (mainly Native American)



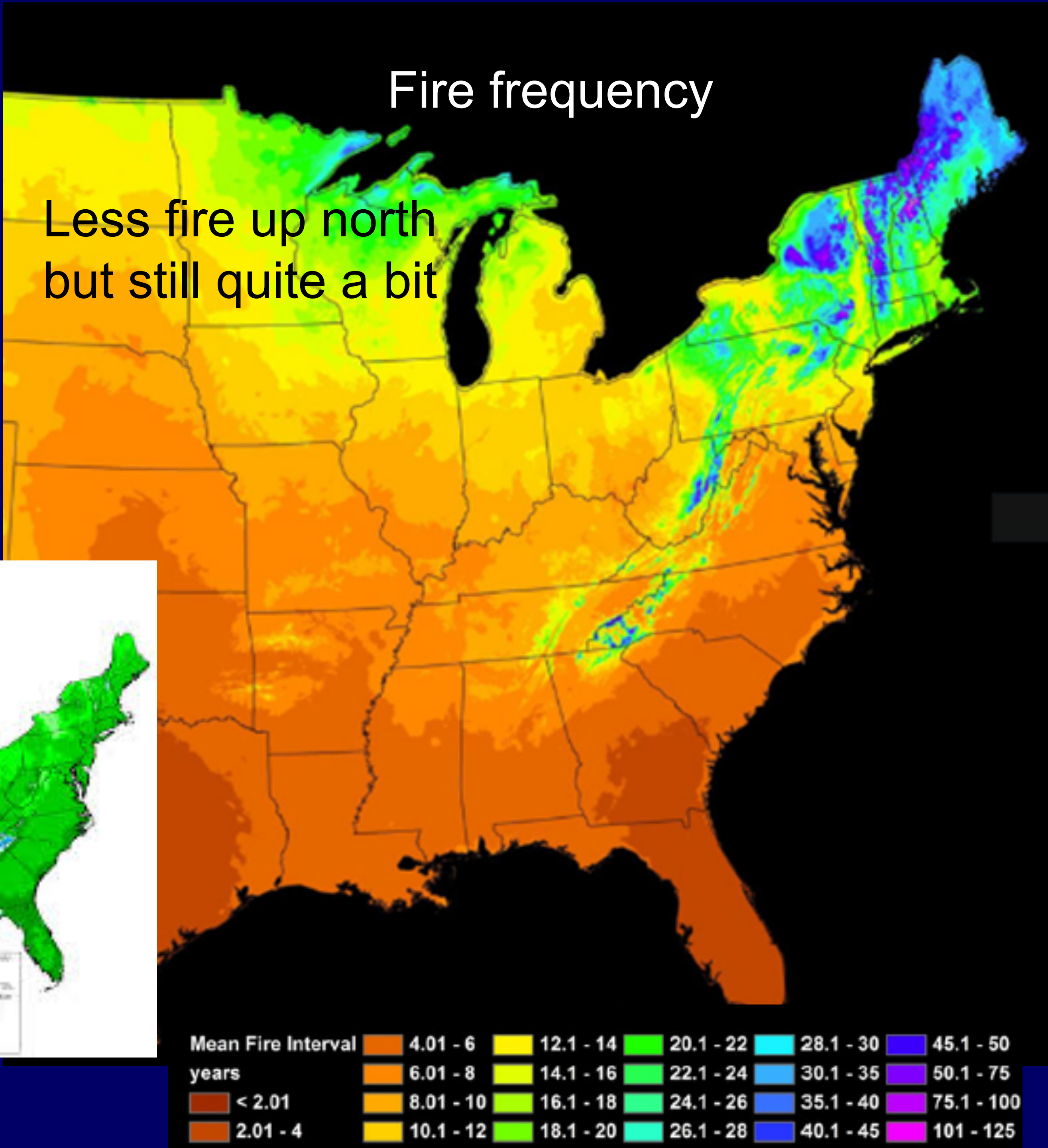


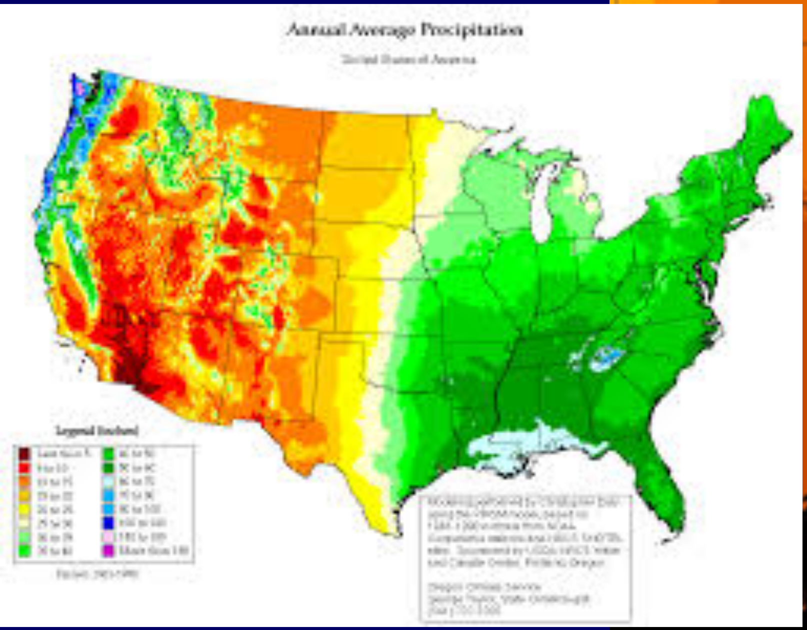
My work utilizes early survey (witness tree) records (1700s and 1800s). Compared with modern-day surveys (FIA)



Most US forests had a history of frequent fire before 1940. Guyette et al. 2012

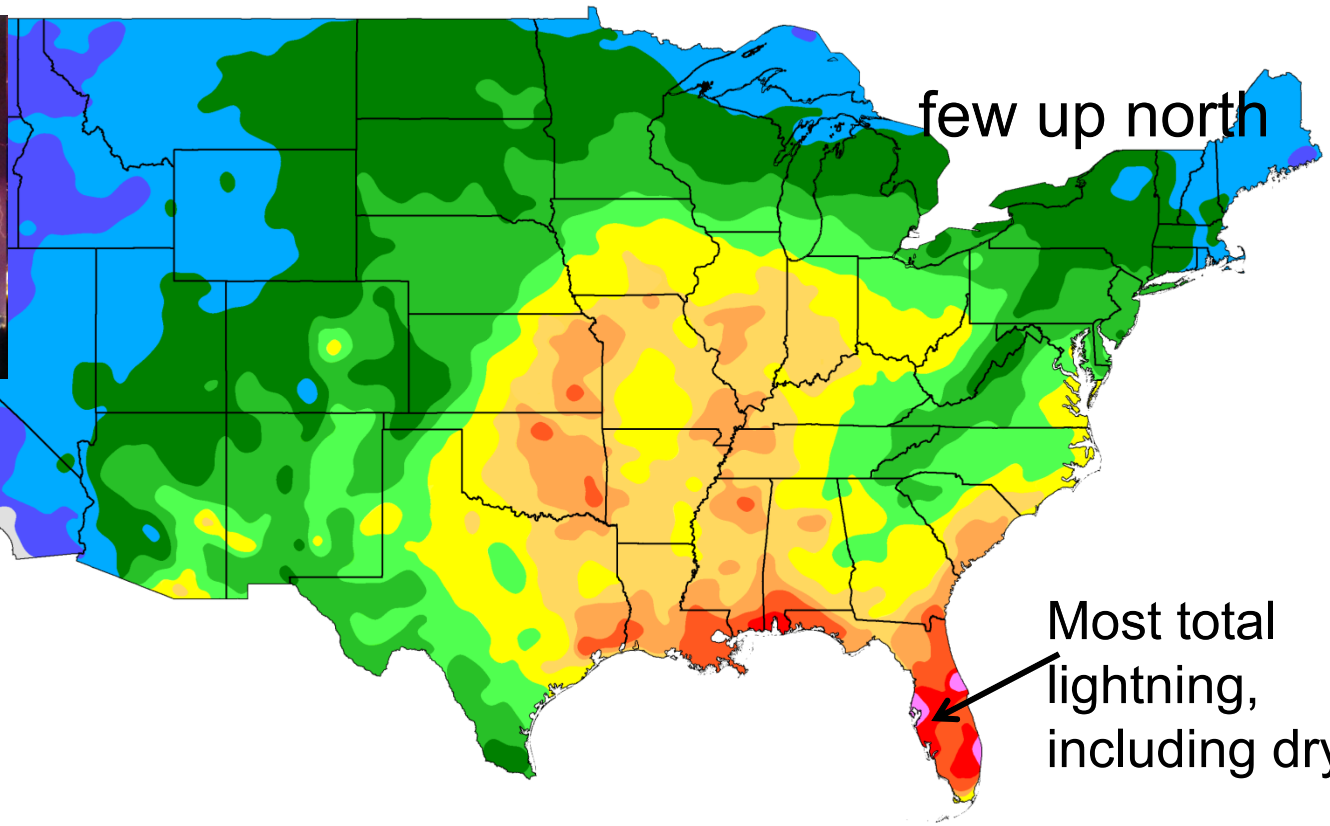
Despite adequate rainfall in east





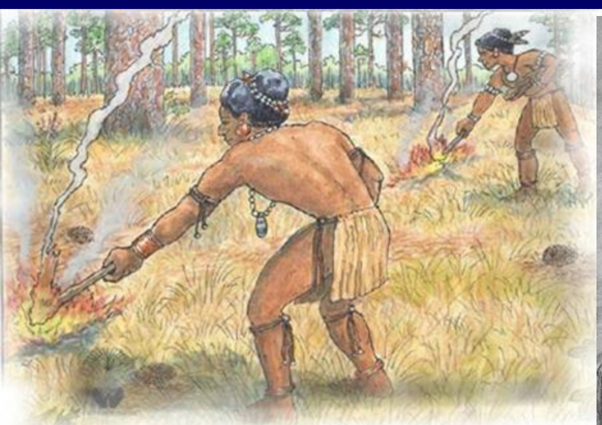
Does Climate or Humans control fire?

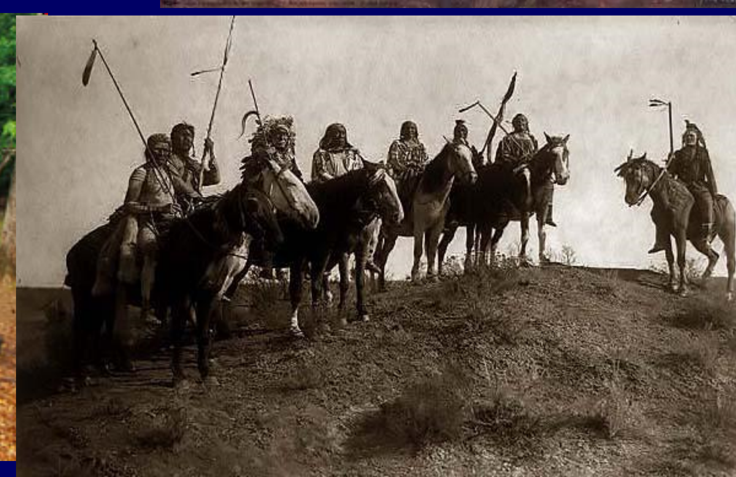
Fire needs Dry lightning. Rare in most of eastern U.S.



If lightning fires were not that extensive….

The human-fire hypothesis: Native American use of fire





Indian burning often observed by early explorers

Native American uses of fire

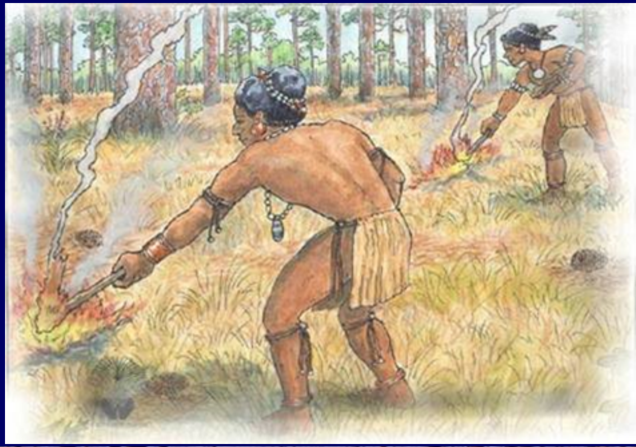
Hunting- driving game animals
Crop and forest management
Creating and preserving agric. fields
Getting rid of unwanted tree species
Promoting desired species
Fireproofing areas
Pest management
Warfare & signaling
Clearing areas for travel- open forests
Felling trees and clearing land
Culture of burning, very good fire managers!

Fire was essential to Indian diet

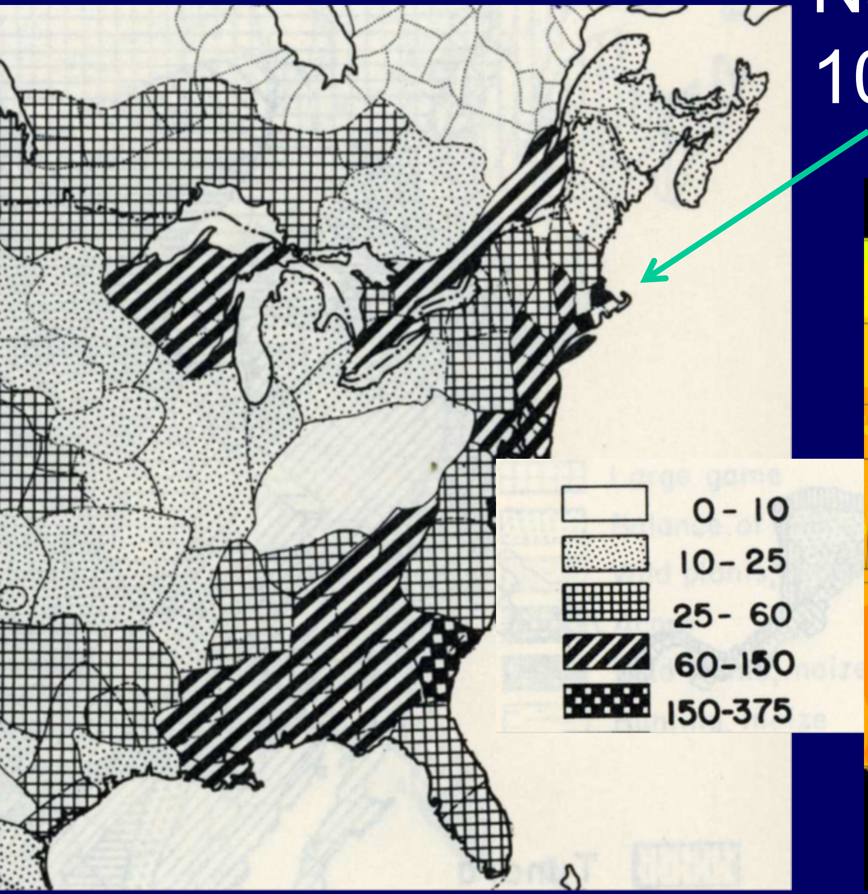
(Abrams and Nowacki 2008). To promote mast-fruit trees, shrubs, grasses (grains) attract, feed game they hunted

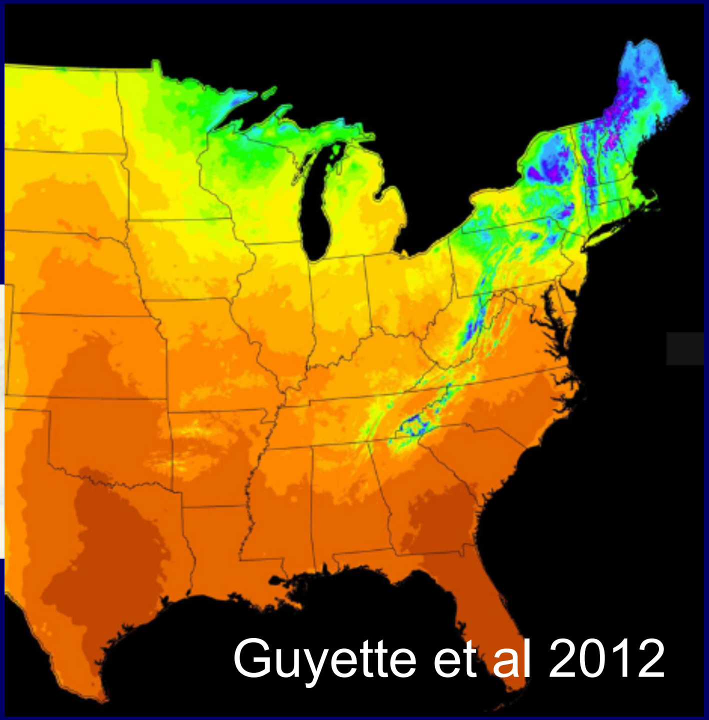
Broad-leaf, mesic forests in much of the eastern US are not very conducive to burning.

Human effort and timing (dry spring season) is needed to explain so much past fire in the east.



Native American population (per 100 km^2) in 1492 (Driver 1969)

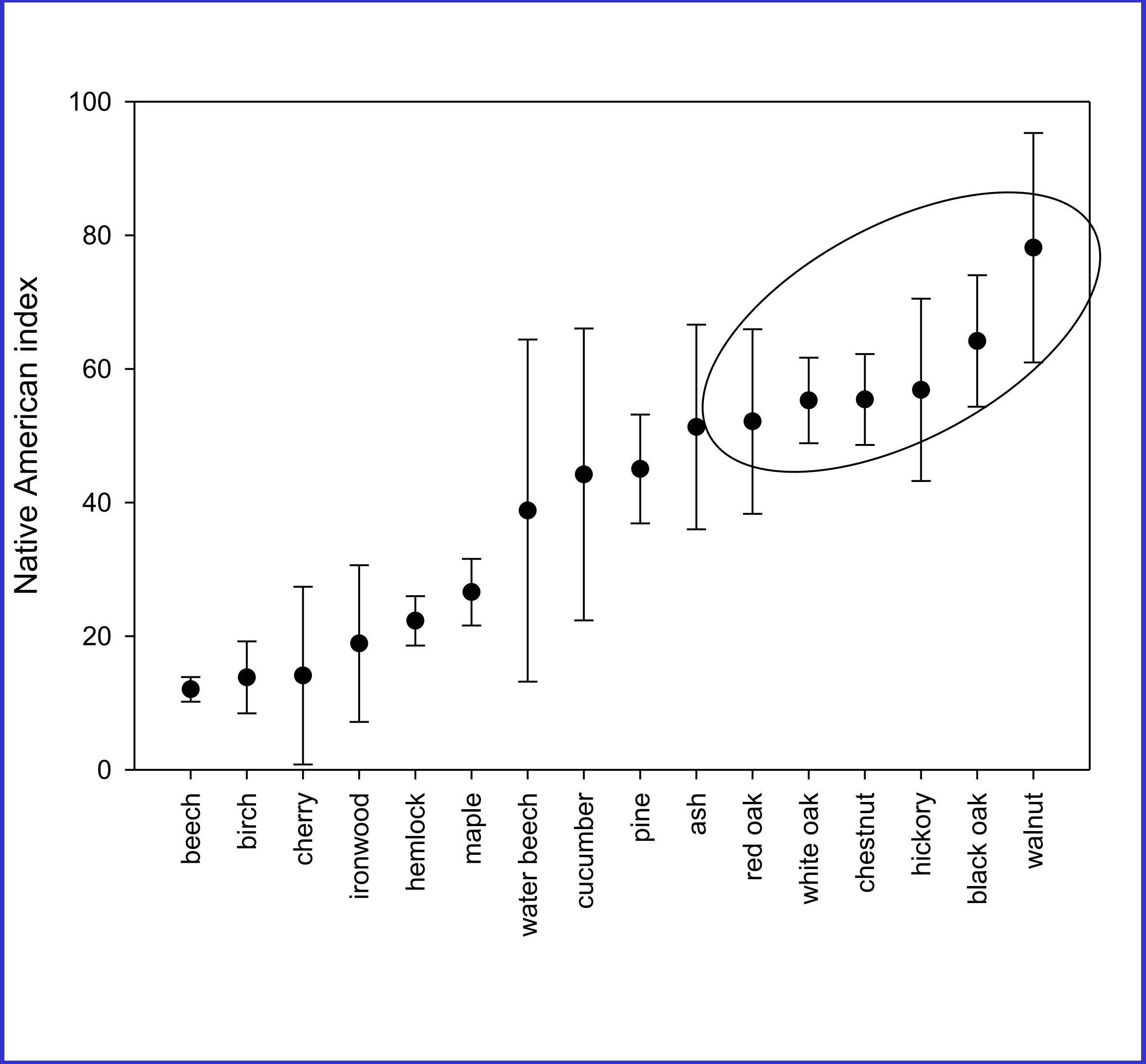




NA pop. #'s and fire frequency are related. Explains high fire freq. in cold, moist northern states

Did Native Americans alter the original forests?

Discrete bands of fire adapted forests along Indian trails and villages (and soil charcoal) within mesic forests in northern PA



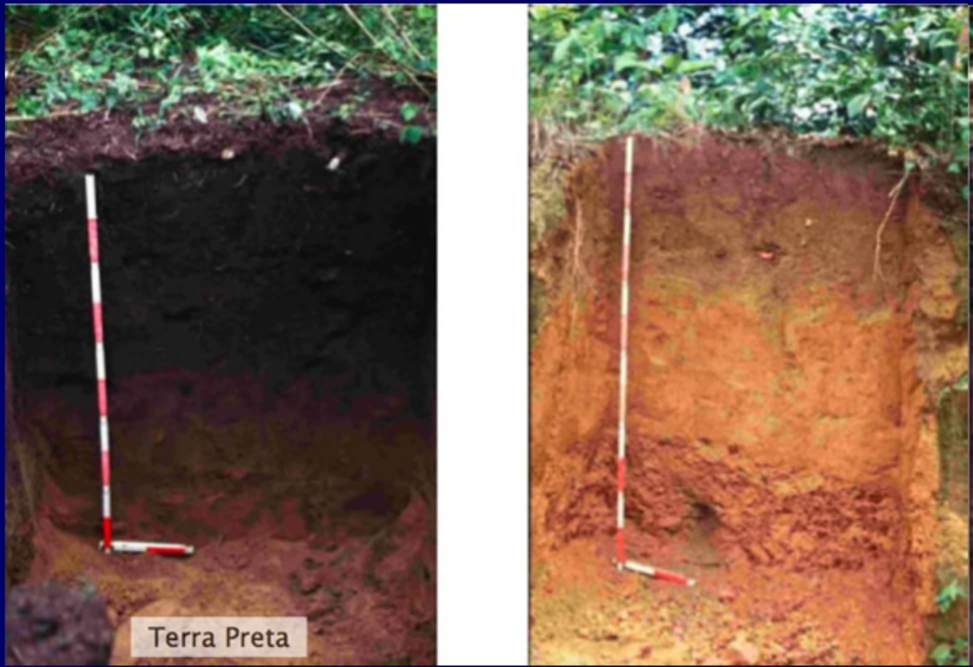
Oak, chestnut, hickory, and walnut were associated with NA Villages. Clearing and burning activities probably promoted these mast species, important to their diet (Black, Ruffner, Abrams 2006)

Did American Indians alter soils to increase fertility for agricultural crops?

Black earth is a “man-made soil” with darker color

By adding animal waste, crop residue, charcoal to enhance soil fertility and crop productivity

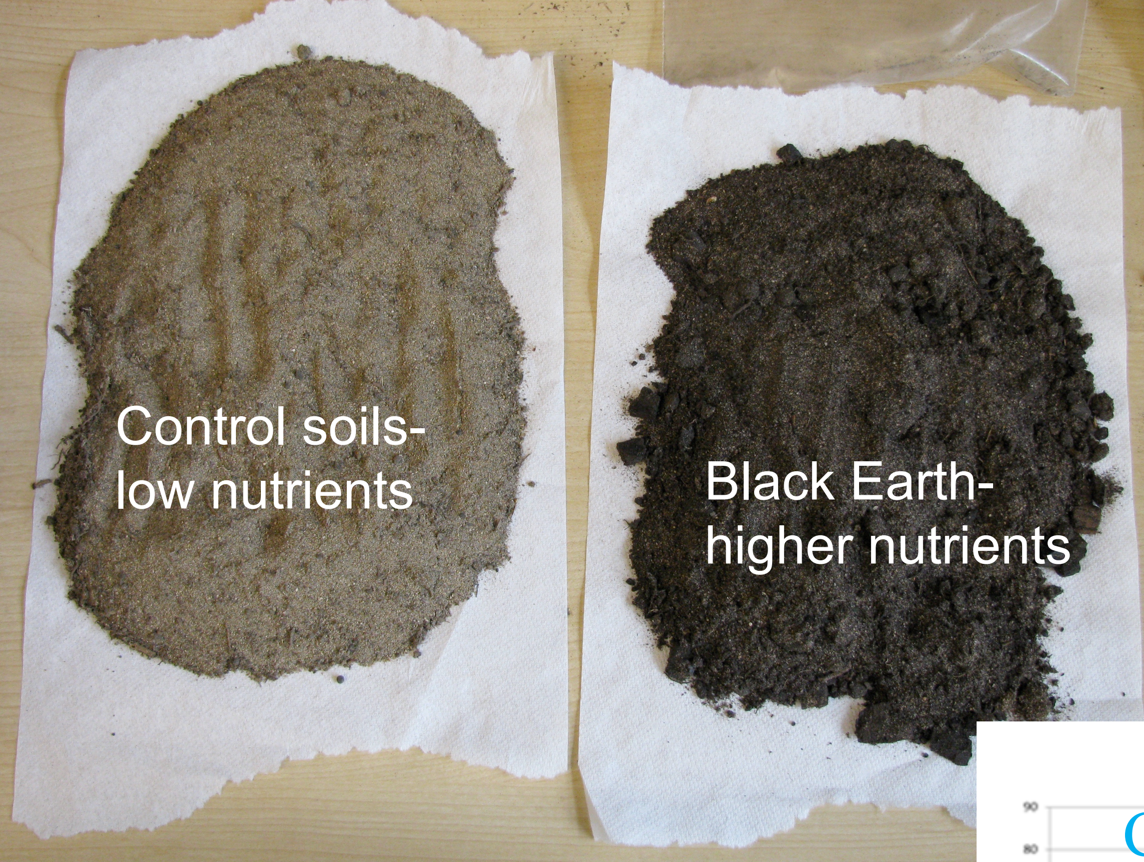
These are typically embedded in a landscape of infertile (sandy) soils.

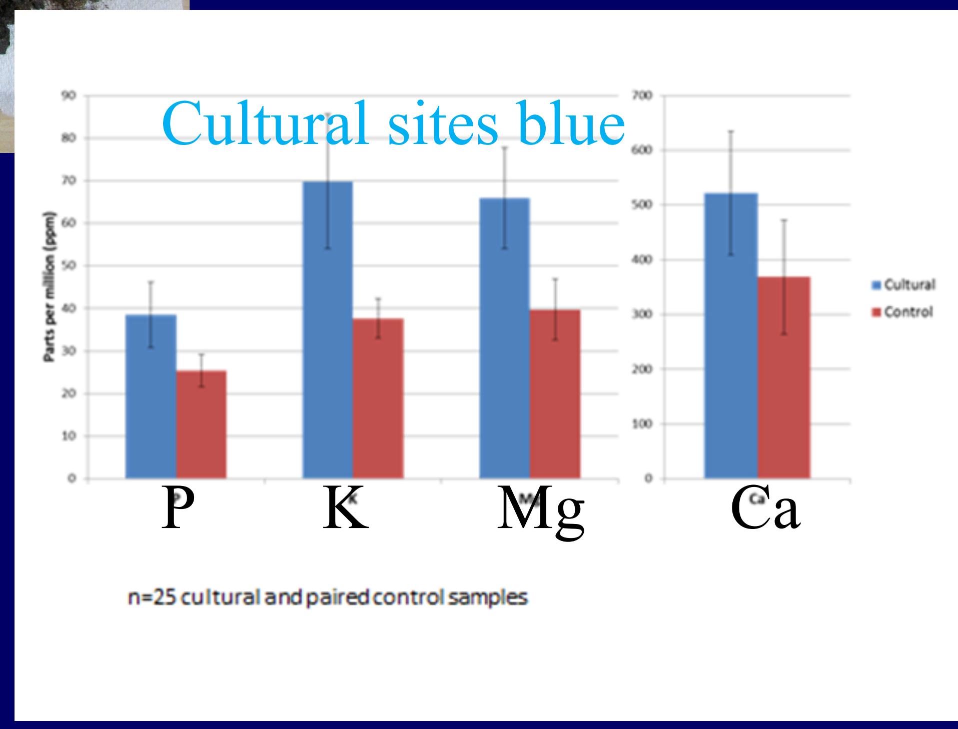



Native American old-field village site in
Fort Drum, New York
2008/06/06

Chenopodium (lamb's quarter) still present; was planted by Native Americans - seeds were ground into flour.

Soils sampled (n=25) from Native American and Control (sandy) sites


Control soils-
low nutrients
Black Earth-
higher nutrients

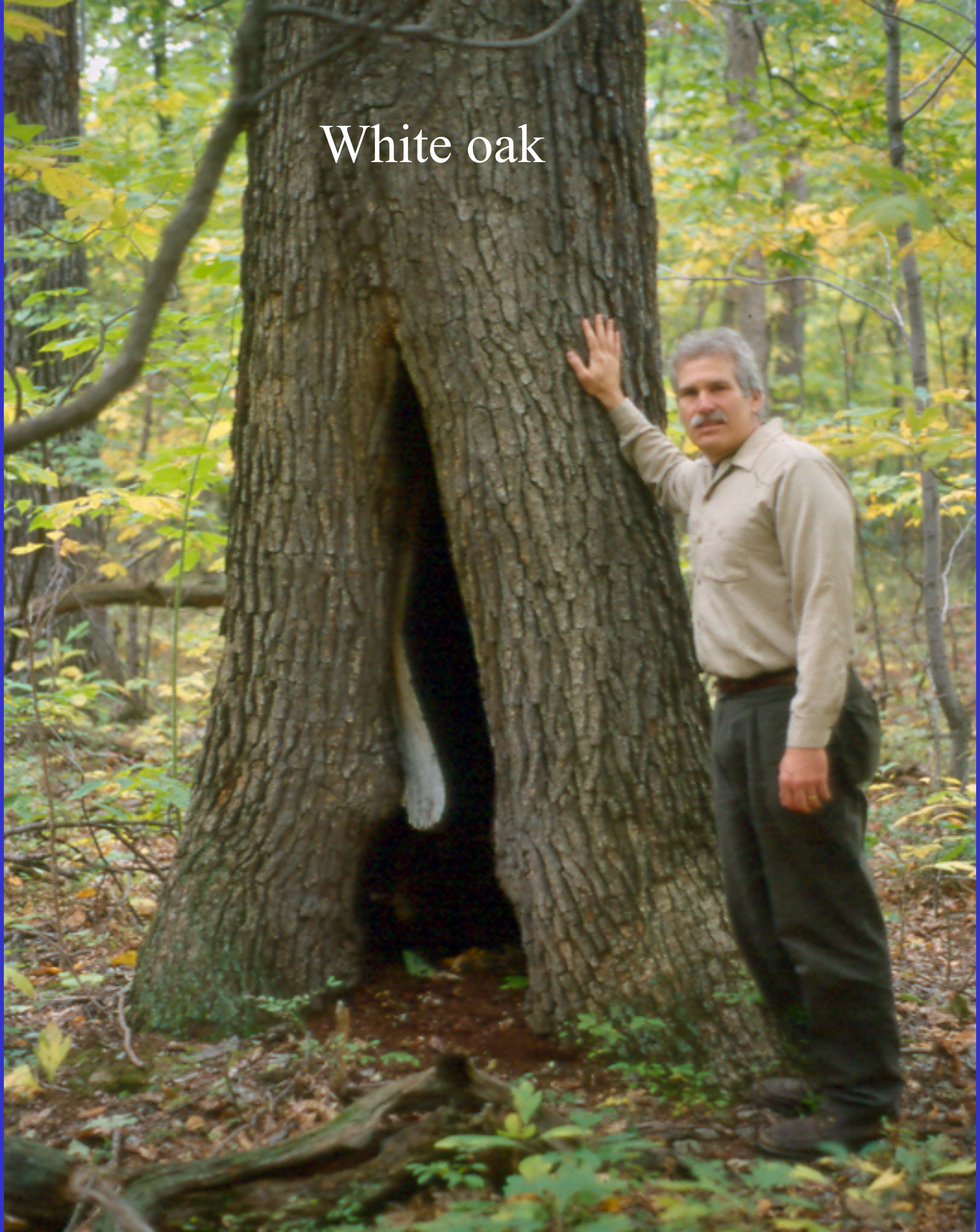

Cultural sites blue
Parts per million (ppm)
90
80
70
60
50
40
30
20
10
0
700
600
500
400
300
200
100
0
Cultural
Control
P
K
Mg
Ca
n=25 cultural and paired control samples

A 400 year history of fire and oak recruitment for old-growth oak forests at Savage Mountain, Maryland

D. Shumway, C. Ruffner, and M. Abrams

CJFR 2001

Red oak
Savage Mt. MD


White oak

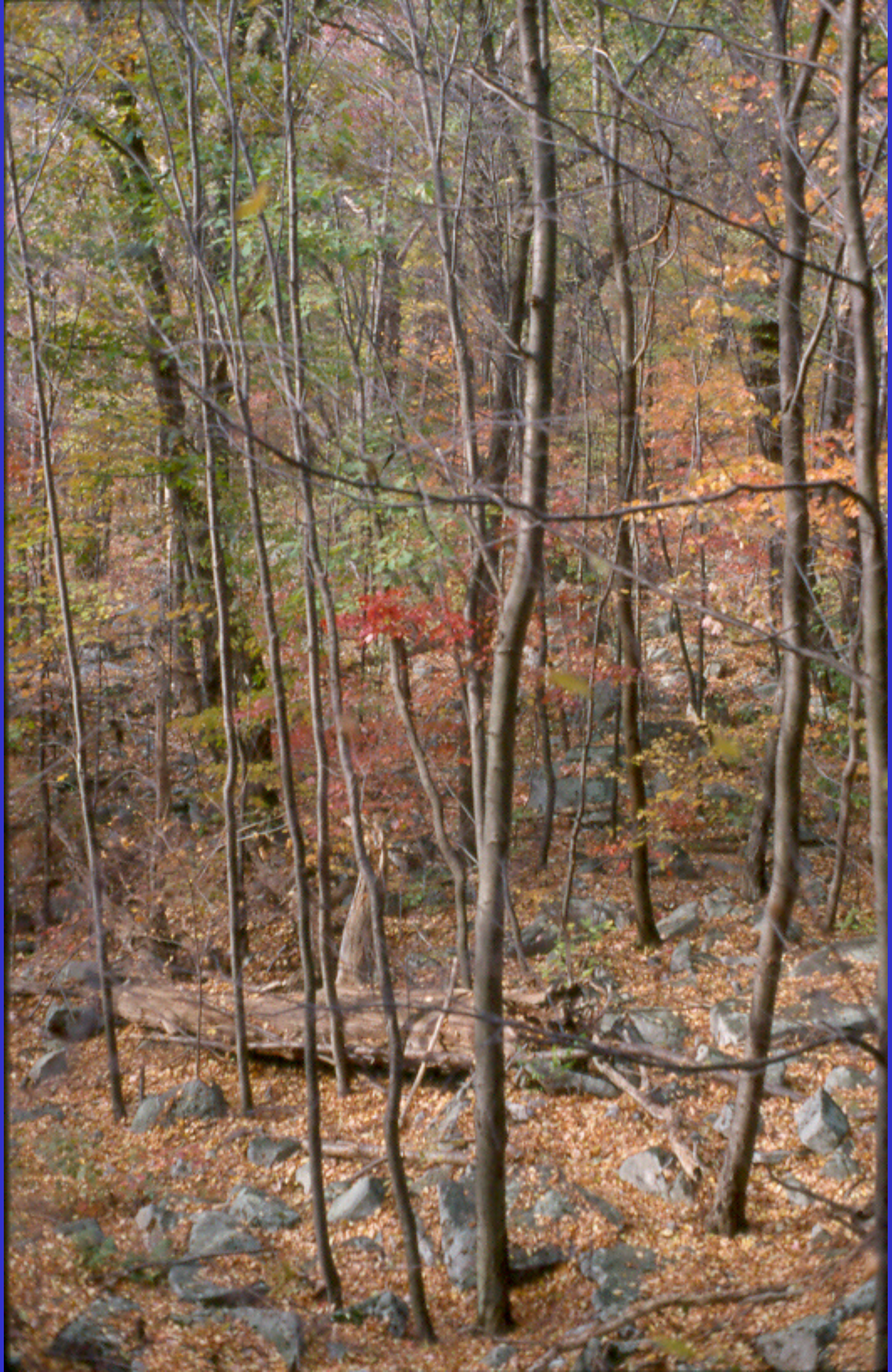
Pre-settlement forest on Savage Mountain: white oak (27%), hickory (18%), black oak (12%), chestnut oak (11%), chestnut (10%), red oak (5%).

In 2000:
Coleman Hollow was red maple (24%), chestnut oak (23%), white oak (20%), red oak (14%), and black oak (9%)

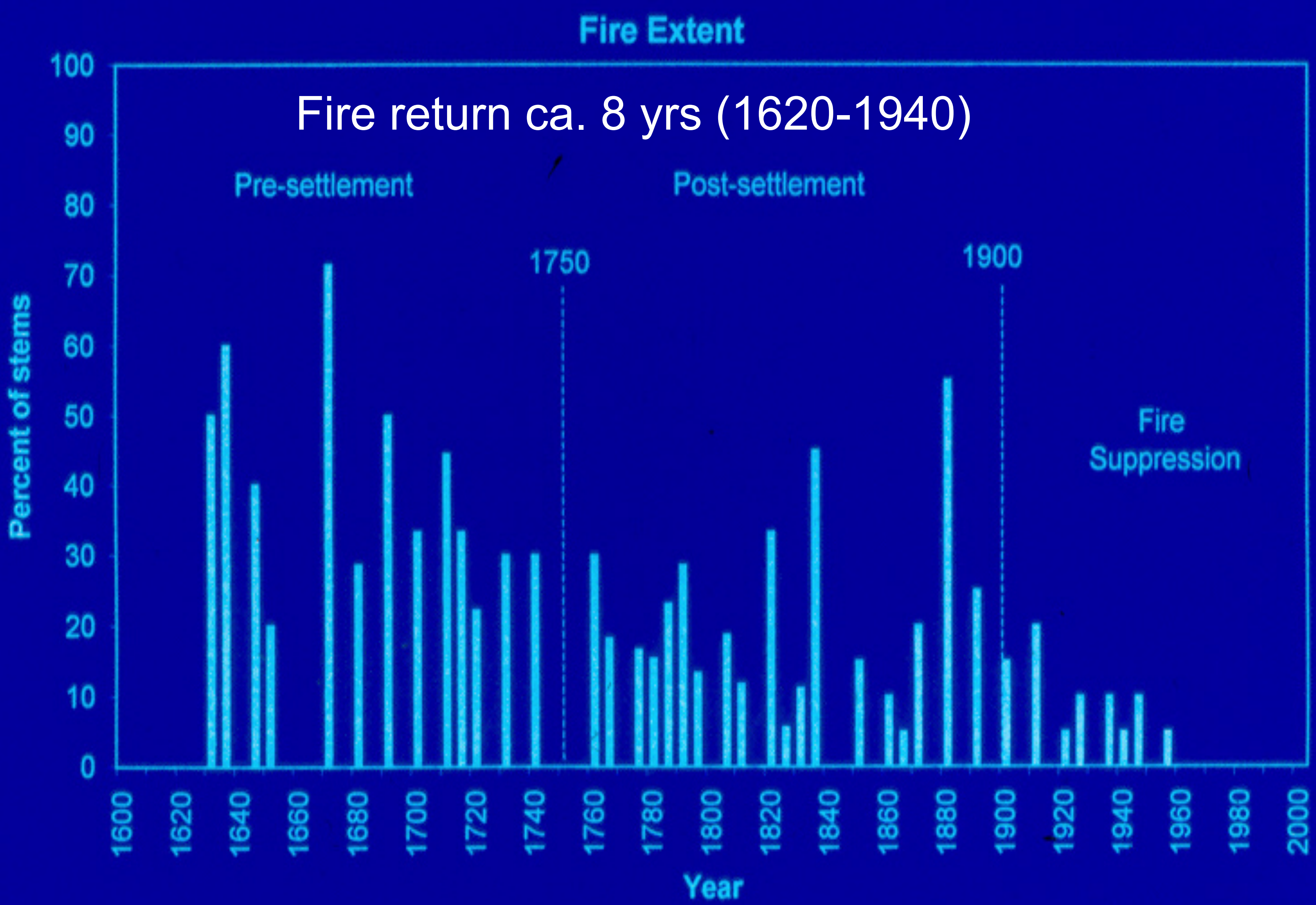
South Savage was chestnut oak (20%), red oak (17%), black birch (18%), red maple (17%), black oak (11%), white oak (6%).

Big increase in red maple and birch, and loss of hickory, white oak and Chestnut (from blight)

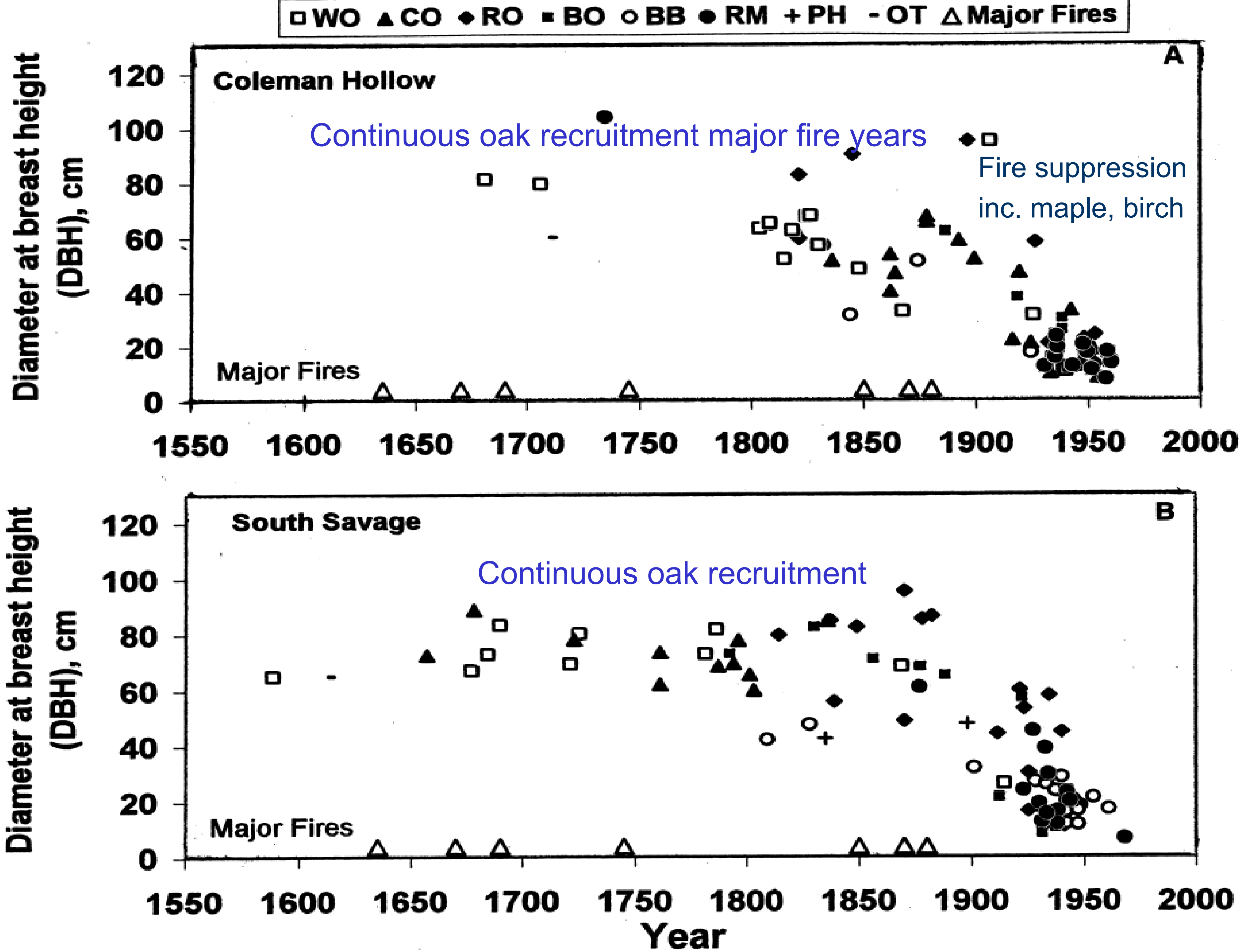
Betula and Acer rubrum in sub-canopy



20 basal cross sections were obtained from a partial timber cut in 1986; evidence of 42 fires from 1615 to 1958.



Fire Extent
Fire return ca. 8 yrs (1620-1940)
Pre-settlement
Post-settlement
1750
1900
Fire
Suppression
Percent of stems
0
10
20
30
40
50
60
70
80
90
100
1600
1620
1640
1660
1680
1700
1720
1740
1760
1780
1800
1820
1840
1860
1880
1900
1920
1940
1960
1980
2000
Year


□ WO ▲ CO ◆ RO ■ BO ○ BB ● RM + PH - OT △ Major Fires
Coleman Hollow
A
Continuous oak recruitment major fire years
Fire suppression
inc. maple, birch
Major Fires
Diameter at breast height (DBH), cm
South Savage
B
Continuous oak recruitment
Major Fires
Diameter at breast height (DBH), cm
Year

Periodic fires 1600-1900 associated with oak recruitment

Red maple and black birch (not in witness tree record) were facilitated by decreased fire > 1900, chestnut blight

Cessation of all oak recruitment after 1940’s.

Direct coupling of fire and oak recruitment or lack of.

Old-growth forest in southern West Virginia (Abrams et al. 1995)

White oak (continuous from 1700-1905), white pine (episodic 1835 and 1875) > red oak, black oak (1880-1900) > red maple, sugar maple, beech (> 1900) will likely replace oak and pine

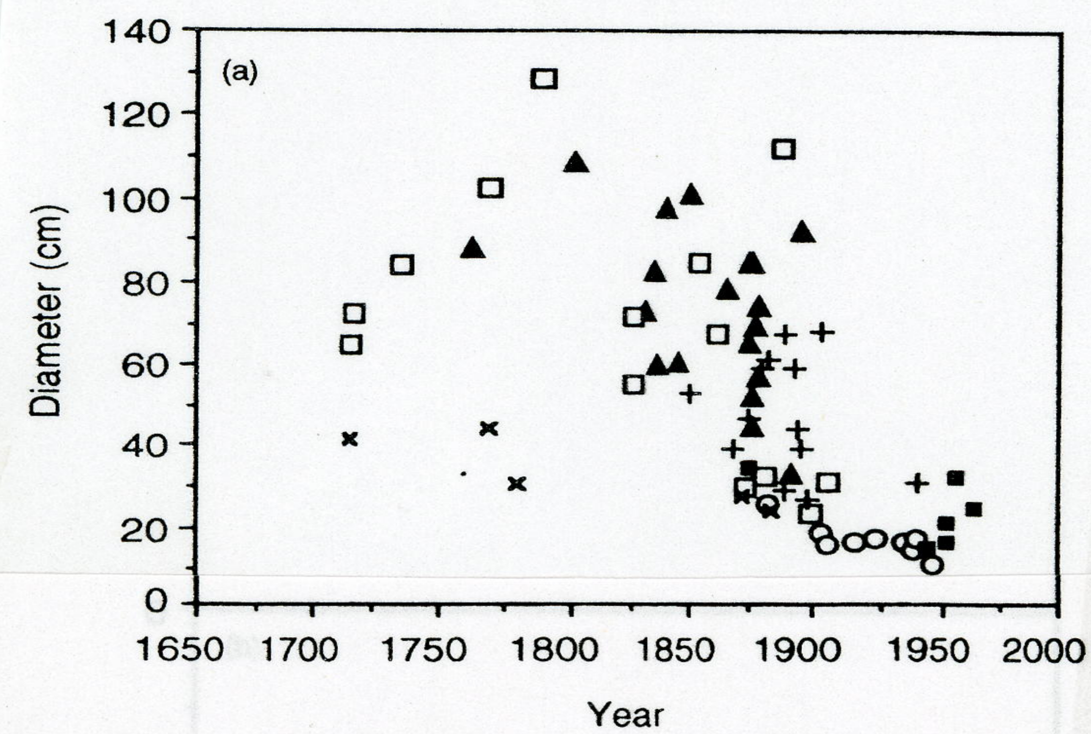


Fig. 4 (a) Age–diameter relationships for all cored trees and the mean ring width index for the oldest trees of (b) four *Quercus alba* and (c) four *Pinus strobus* in the Neola forest. ○, *Acer rubrum*; ▲, *Pinus strobus*; □, *Quercus alba*; +, *Quercus rubra* and *Quercus velutina*; ■, *Tsuga canadensis*, *Acer saccharum* and *Fagus grandifolia*; ×, *Carya glabra*, *Nyssa sylvatica* and *Quercus prinus*.

Maple-beech understory trees

White pine cohort

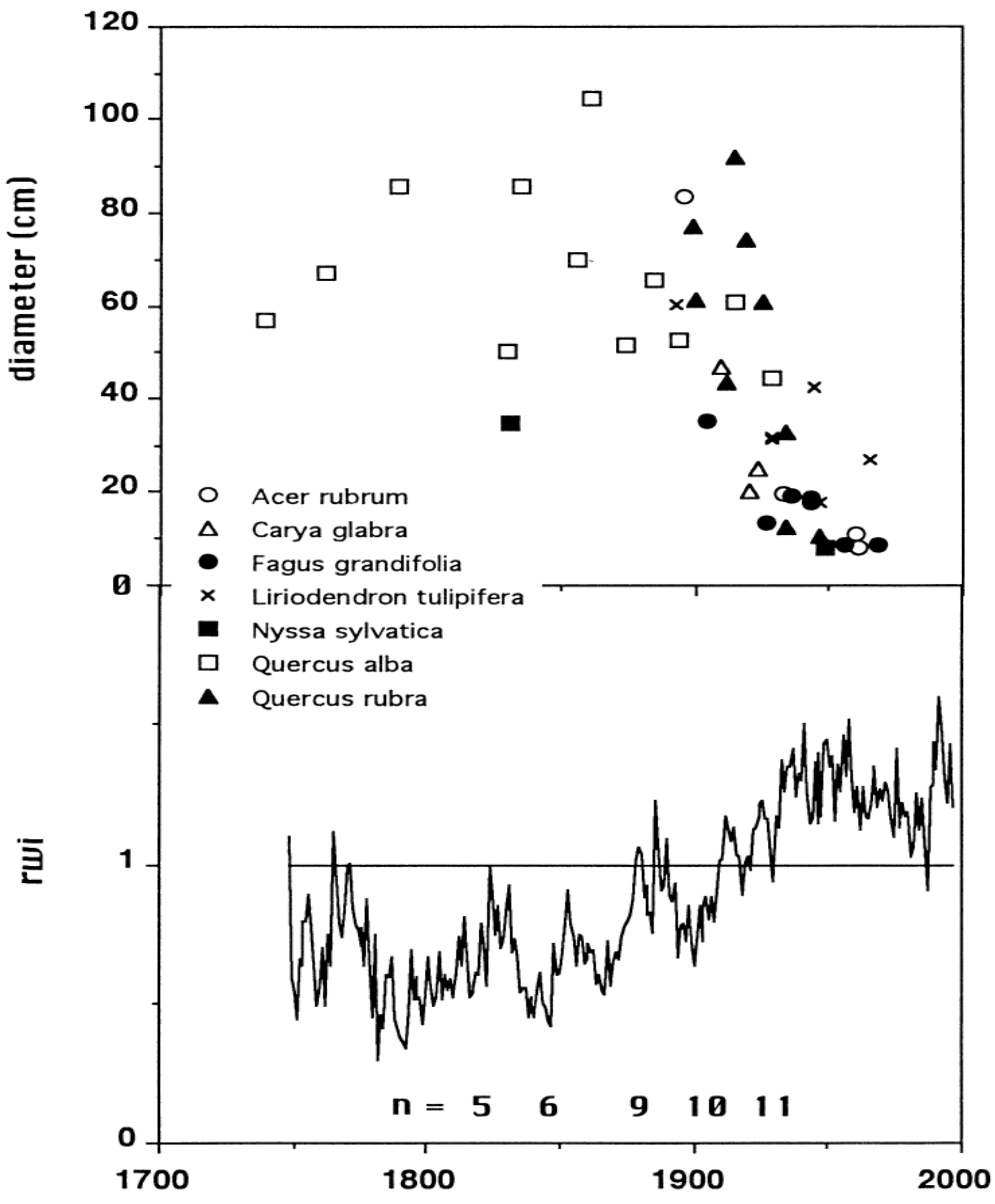
Great Fall, northern VA (Abrams-Copenheaver 1999)

Old-growth Piedmont forest on Potomac River

White, red oak (42%)

Post 1900 increase in beech, poplar, gum

Transitional nature of oak forests due to fire suppression



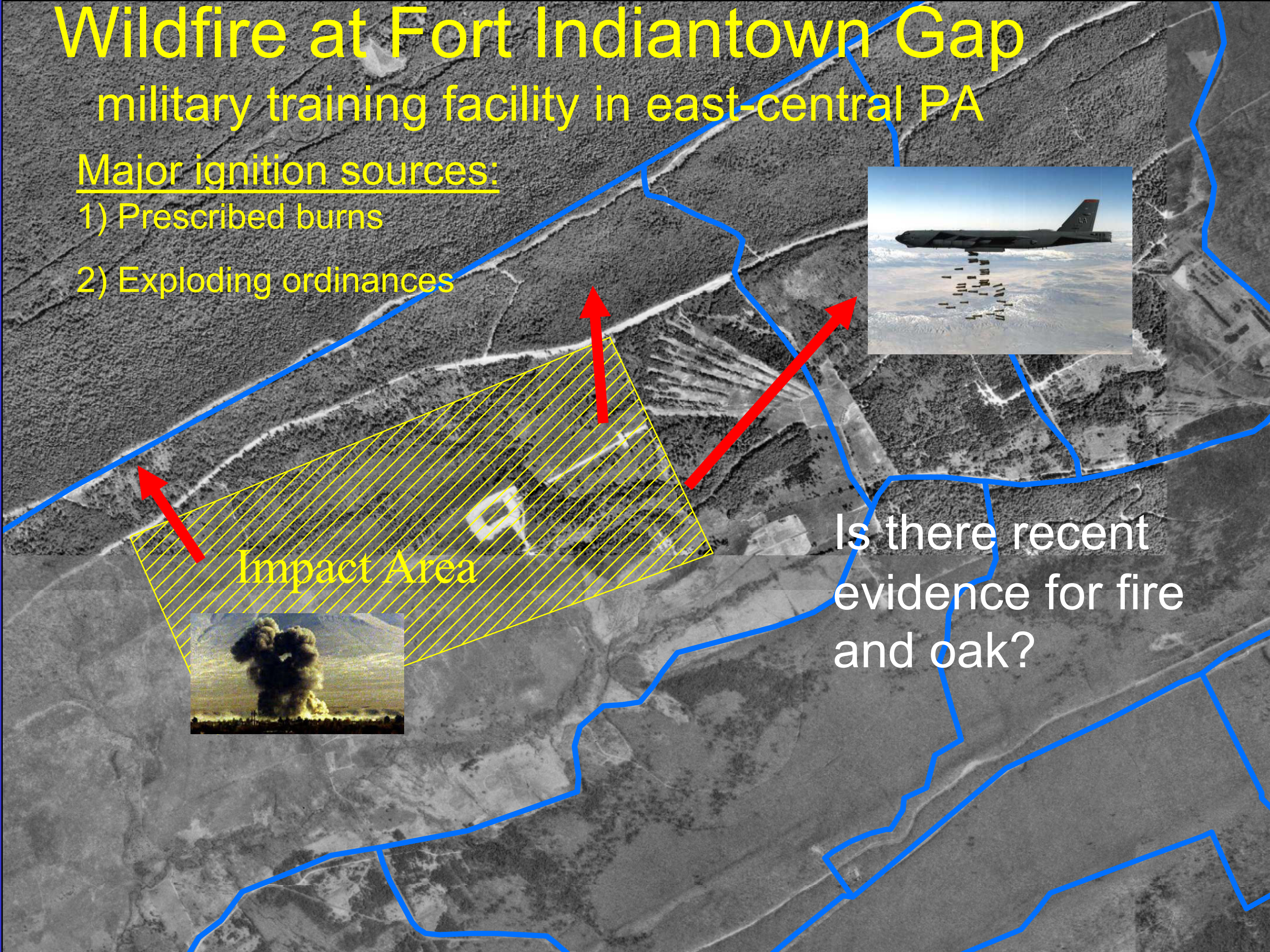
Wildfire at Fort Indiantown Gap

military training facility in east-central PA

<u>Major ignition sources:</u>

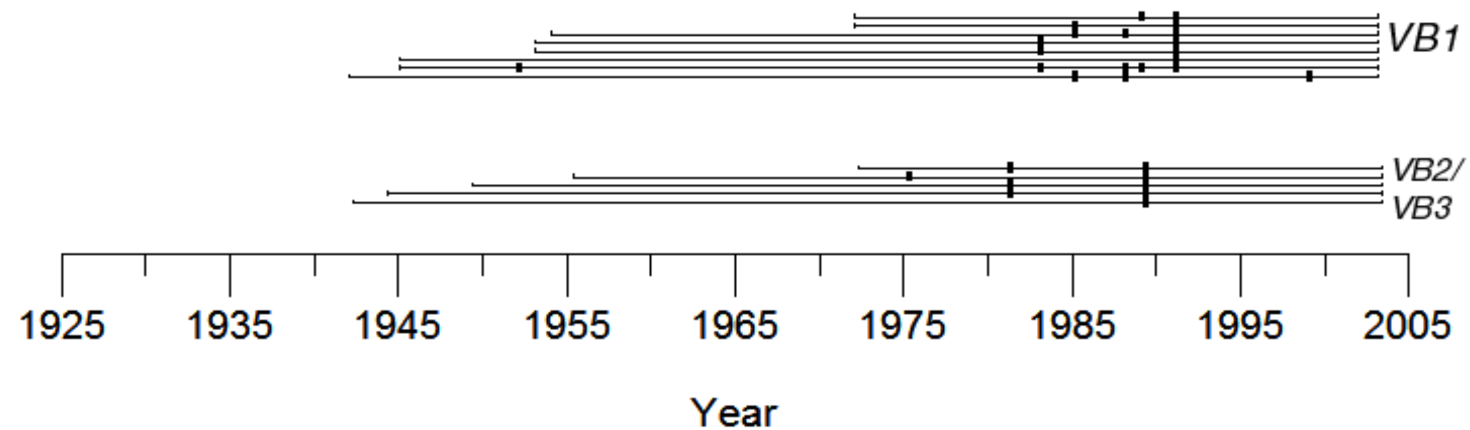
1) Prescribed burns

2) Exploding ordinances



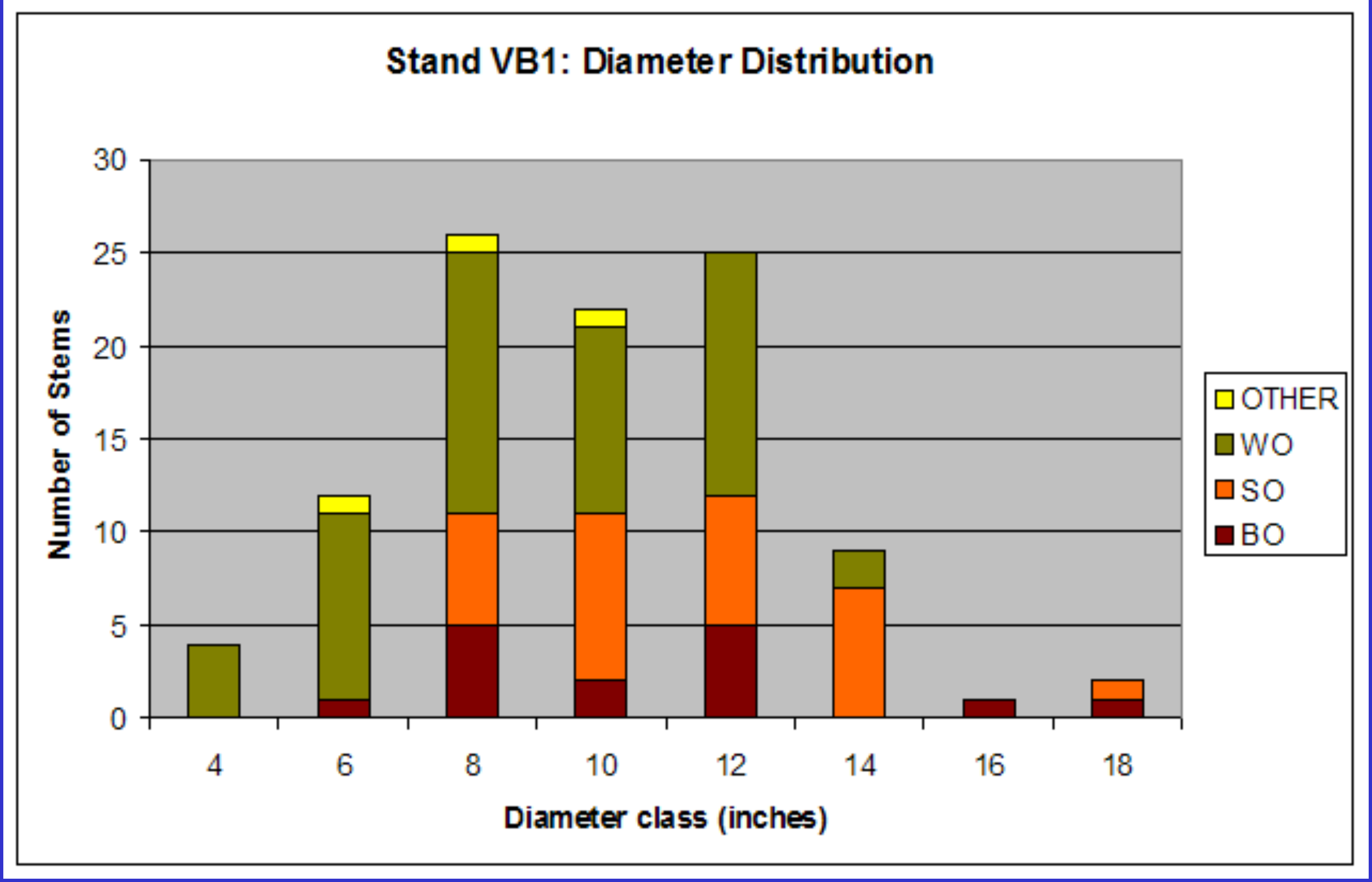
Is there recent evidence for fire and oak?

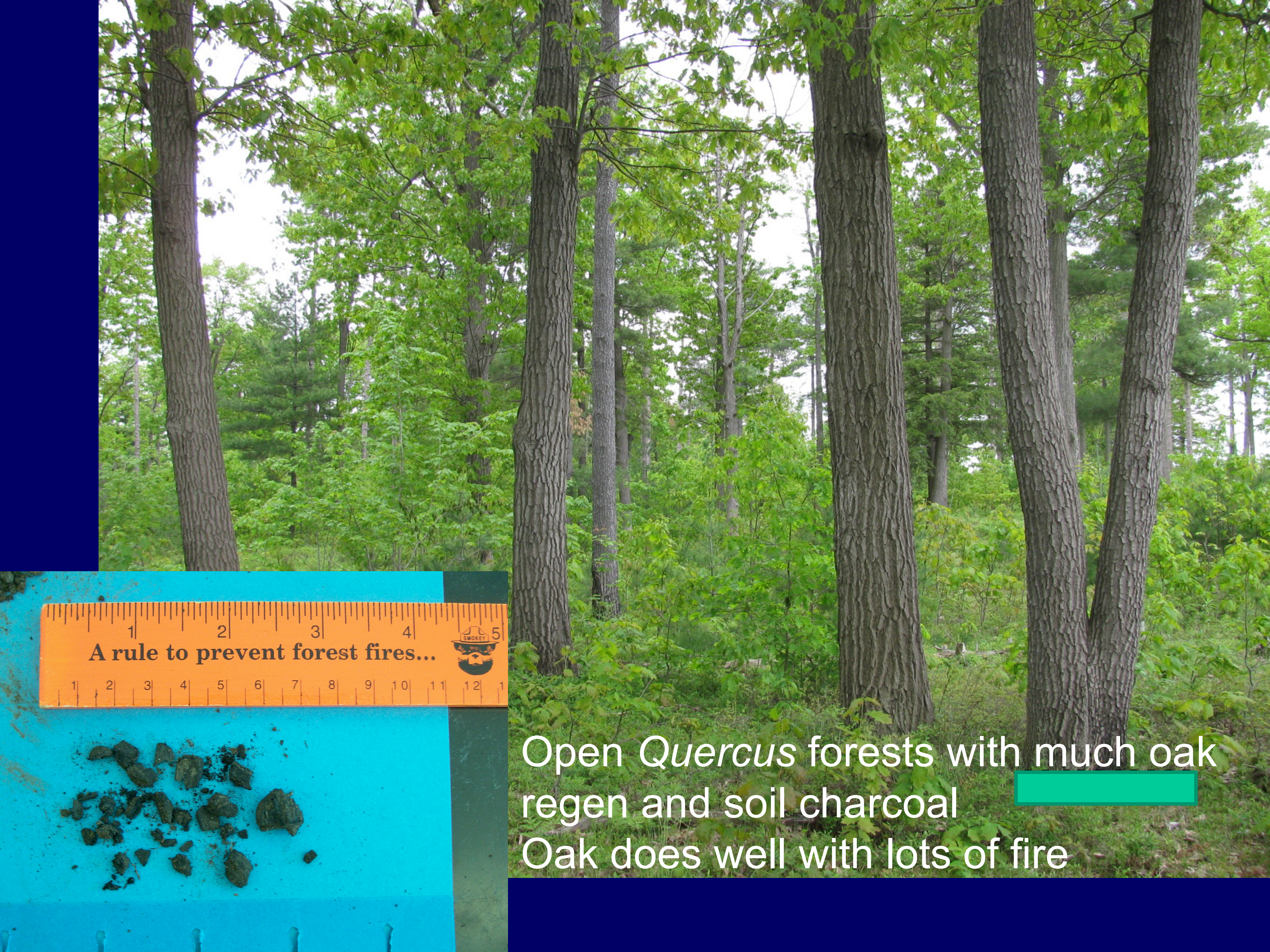
Recent fire history on burned valley sites




Quercus forest burn

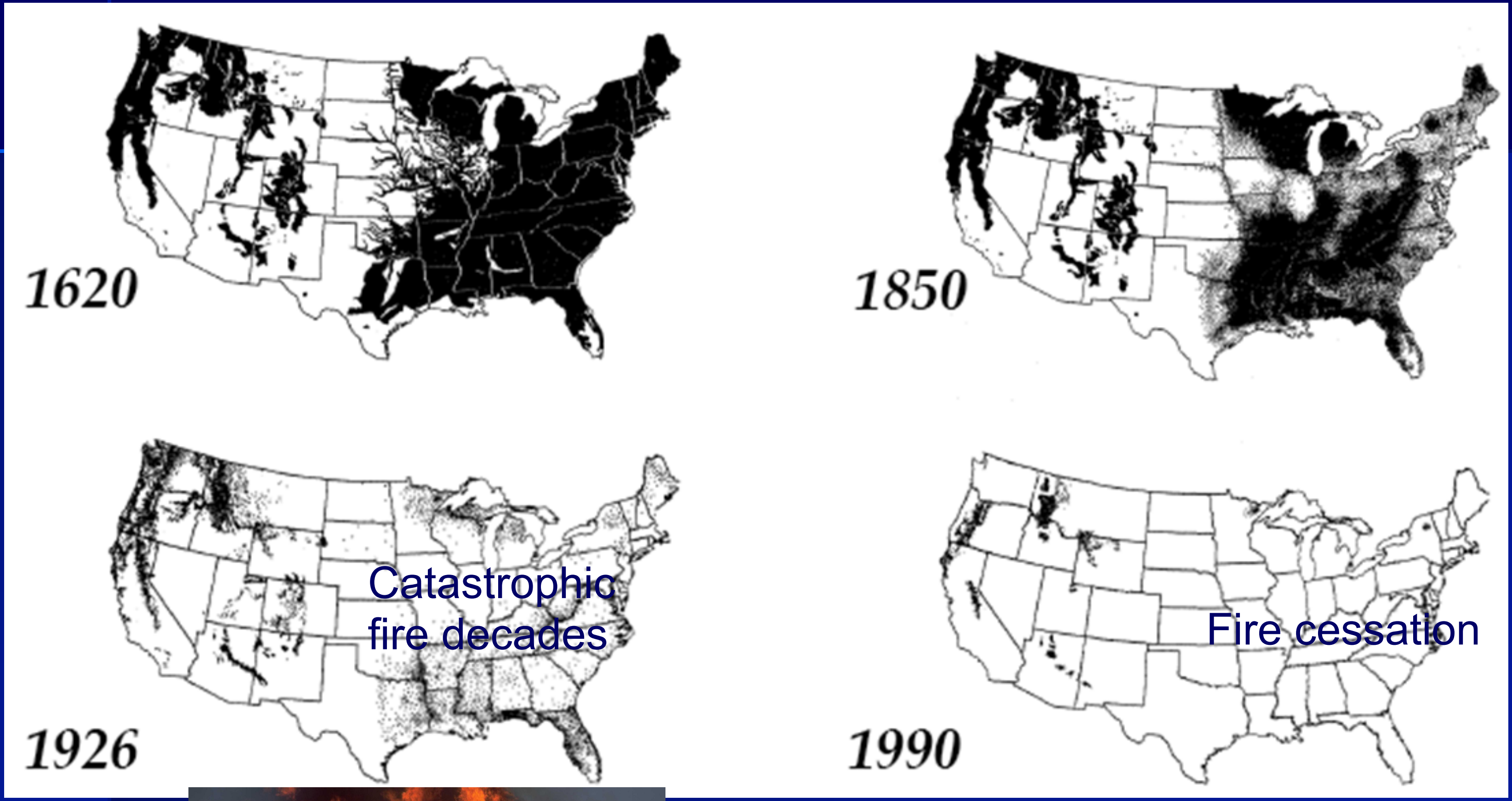
Frequent fire promoted white, scarlet, black oak, while greatly restricting red maple



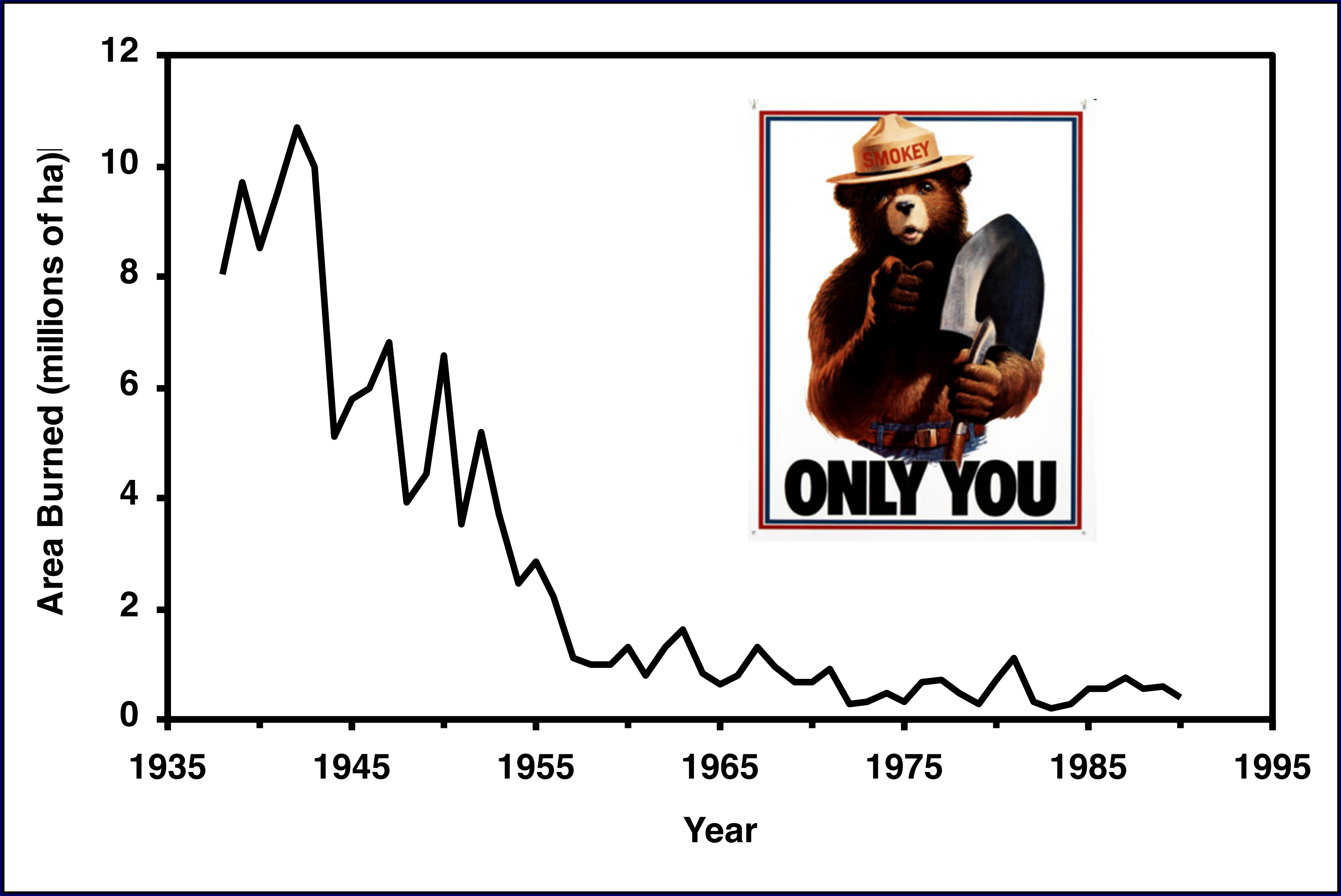


Open *Quercus* forests with much oak regen and soil charcoal
Oak does well with lots of fire

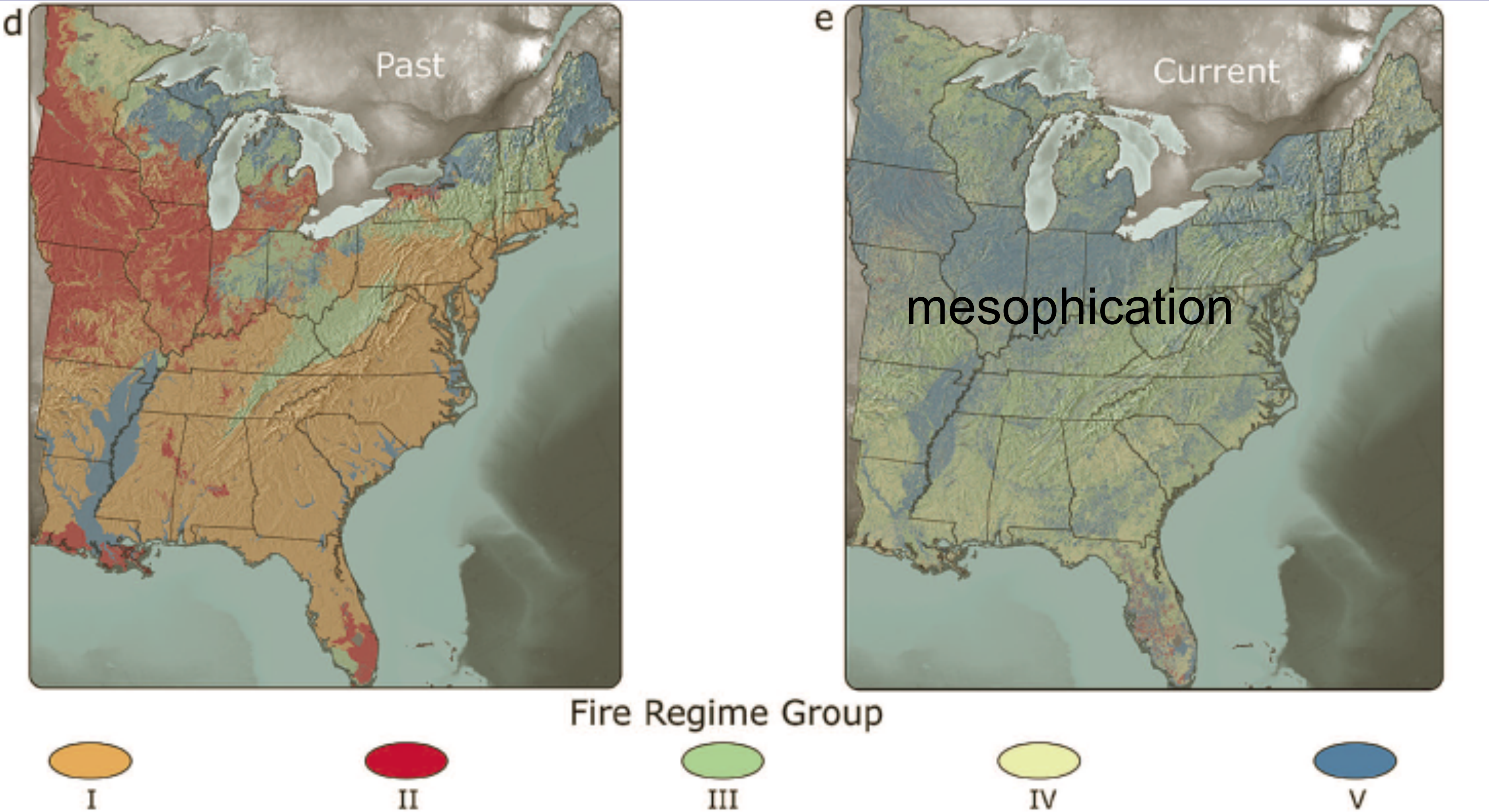
Nation-wide cutting of forests (1880-1930) created vast amounts of fuel that caused catastrophic fires



After the 1870-1930 catastrophic logging and fire era, government mandated fire suppression policy



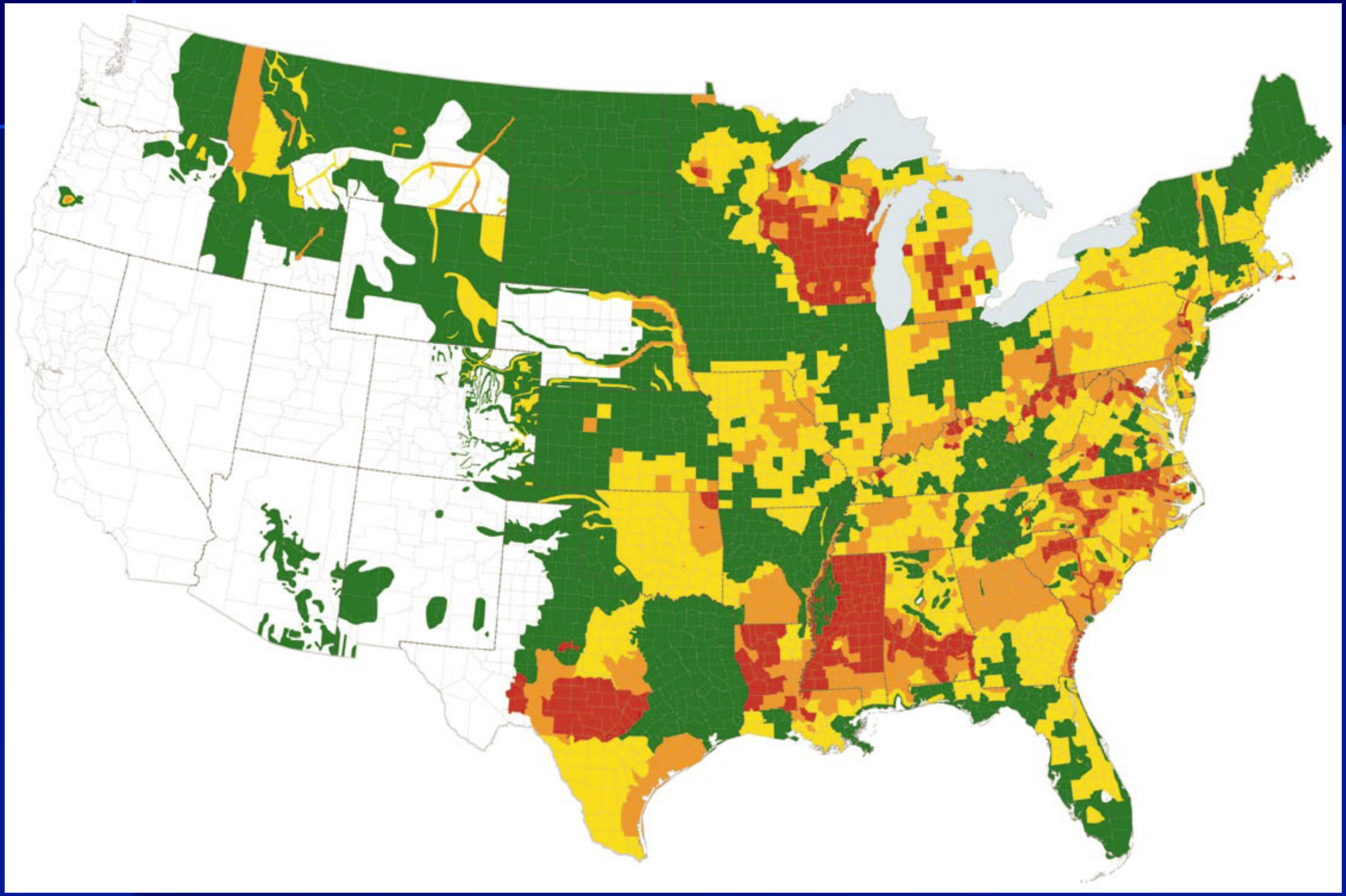
Original fire adapted vegetation converted to mesophytic forests (loss of open forests and grasslands)



Nowacki and Abrams 2008- mesophication of the eastern US

Red maple increasing in unburned oak forest

Many forest in the eastern US have high deer density
Deer density > 20 deer/sq. mile problem for tree regen.



Red= >45 sq.mi

Tan= 30-45

Yellow= 15-30

Green= <15

Walters et al. 2009

No woody vegetation in understory with very high deer density (Valley Forge PA)

What can be done for eastern US forests?

1. Logging of unwanted and invasive tree species – increase light to forest understory

2. Understory fire to prepare proper seedbed, open understory

3. Maintaining relatively low deer populations (?)


Tall deer fence, Mashomack
Preserve, eastern NY (TNC)
2008/07/08

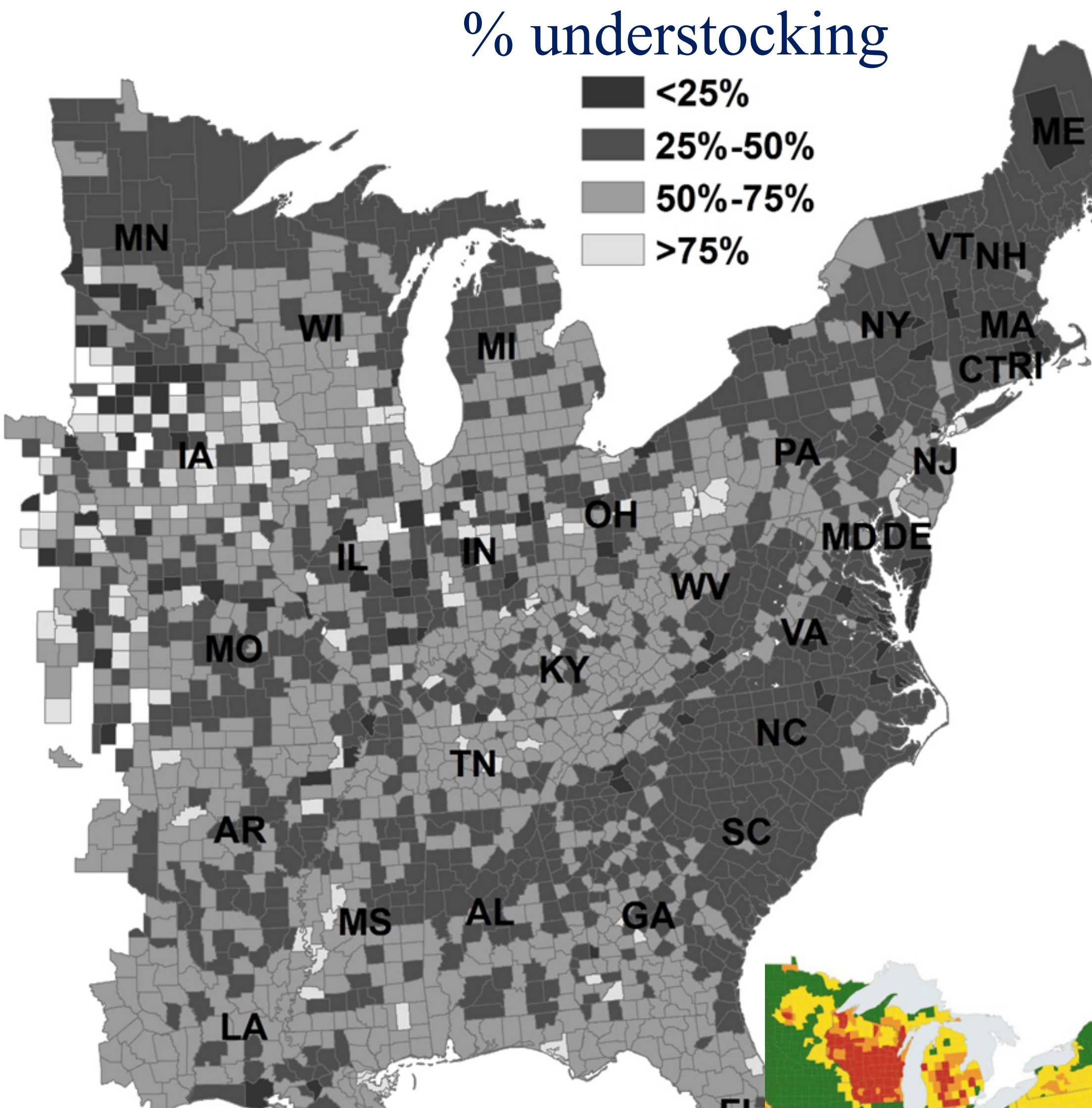
Non-oak trees harvested, area fenced and burned

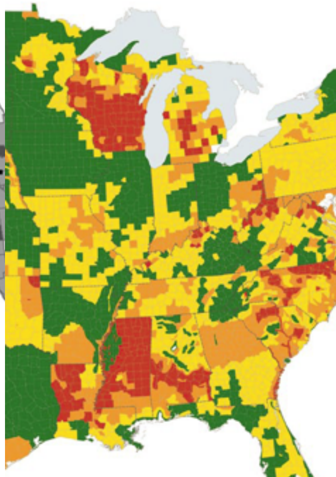
Huge increase in oak regen, esp. after mast years

Is deer density impacting forest density?

Few stand are under-stocked from deer

Densification from undesired trees- red maple invasion from fire suppression despite deer impacts

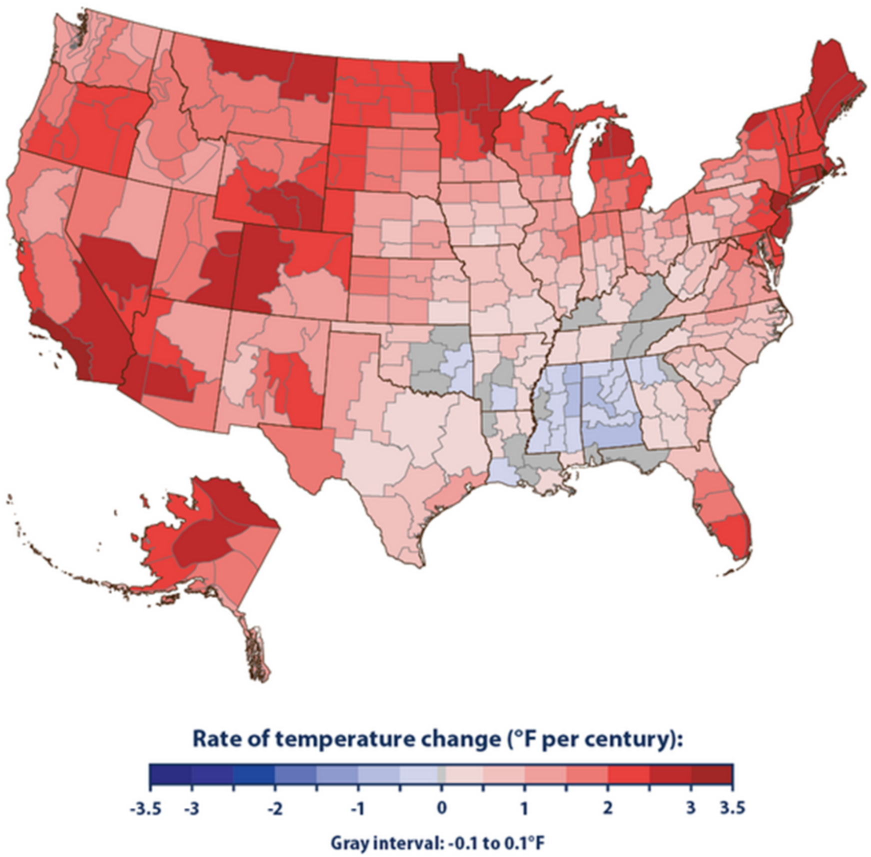




Brice and Abrams 2019

What about climate change? The eastern US is unusual. Most of warming is confined to the north

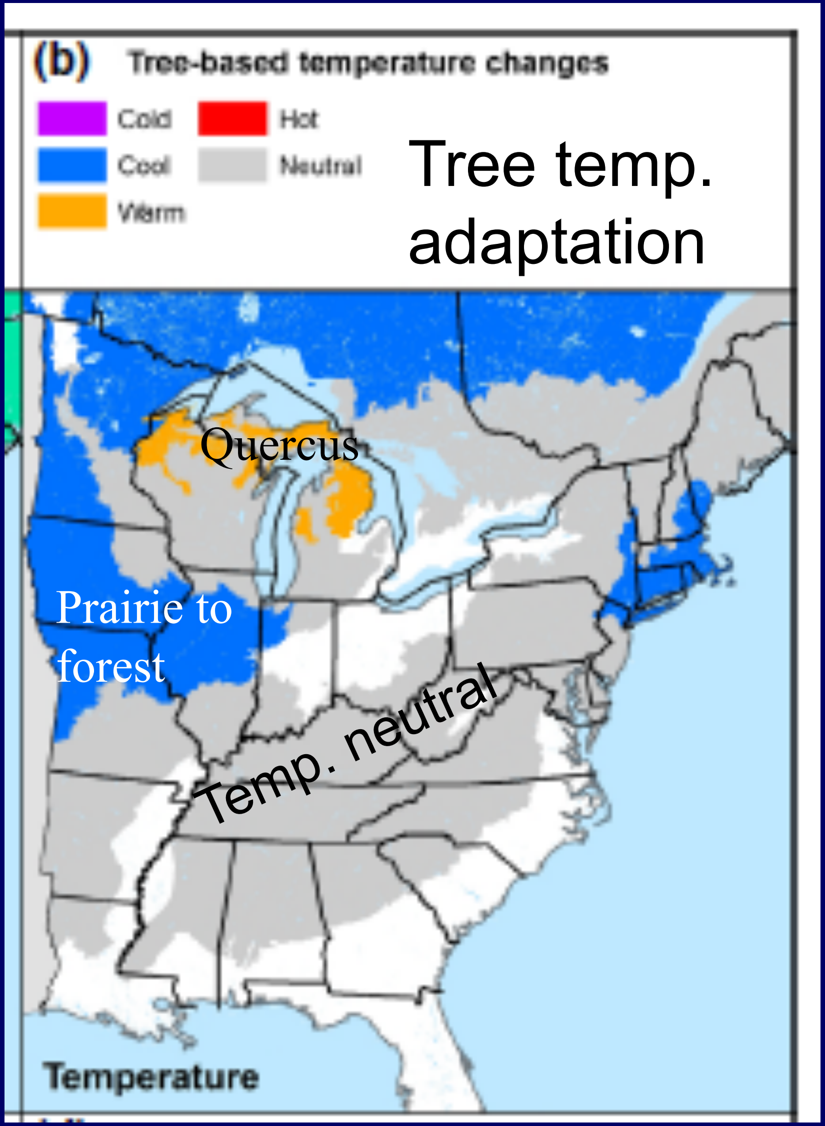
Figure 3. Rate of Temperature Change in the United States, 1901–2015



This figure shows how annual average air temperatures have changed in different parts of the United States since the early 20th century (since 1901 for the contiguous 48 states and 1925 for Alaska). The data are shown for climate divisions, as defined by the National Oceanic and Atmospheric Administration.

Data source: NOAA, 2016[3]

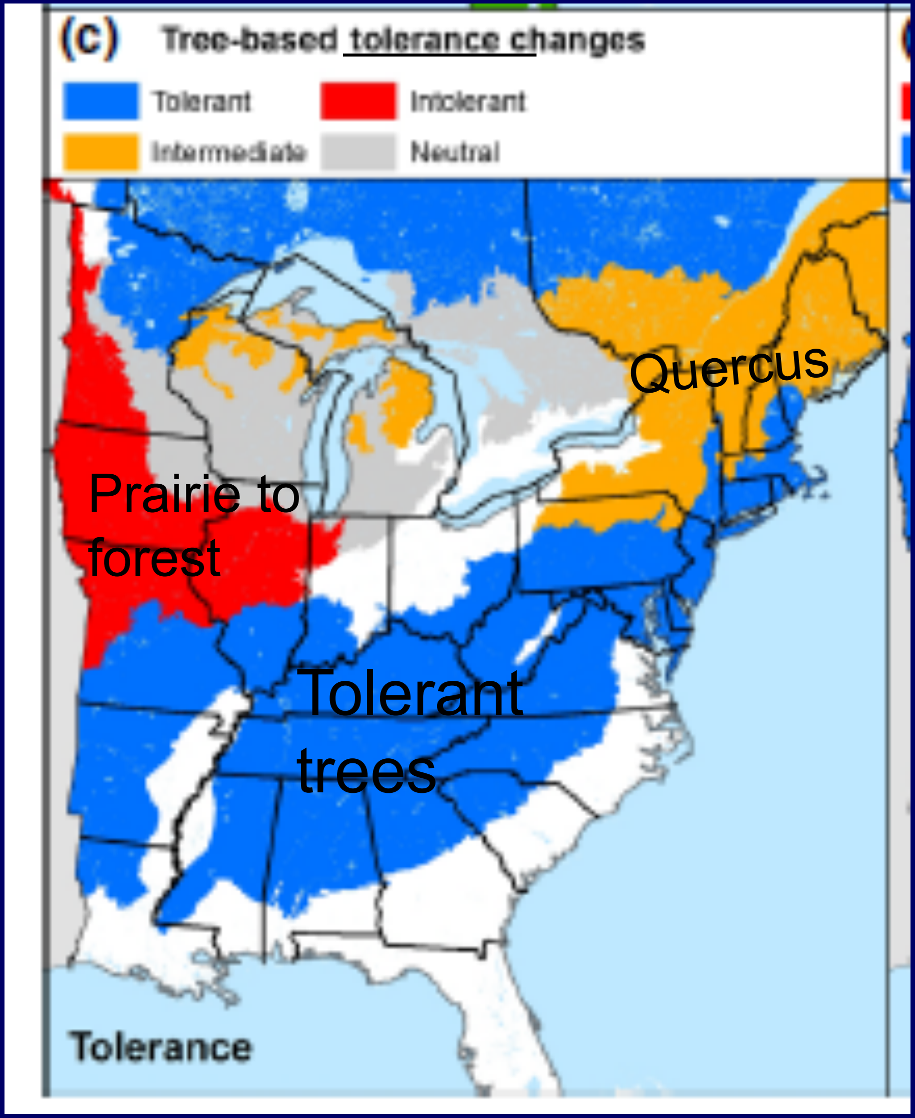
Past (1700s) to present tree adaptation changes



Most areas had temp. neutral changes or increases in cool adapted trees (despite warming)

Quercus (warm) increase in northern forests

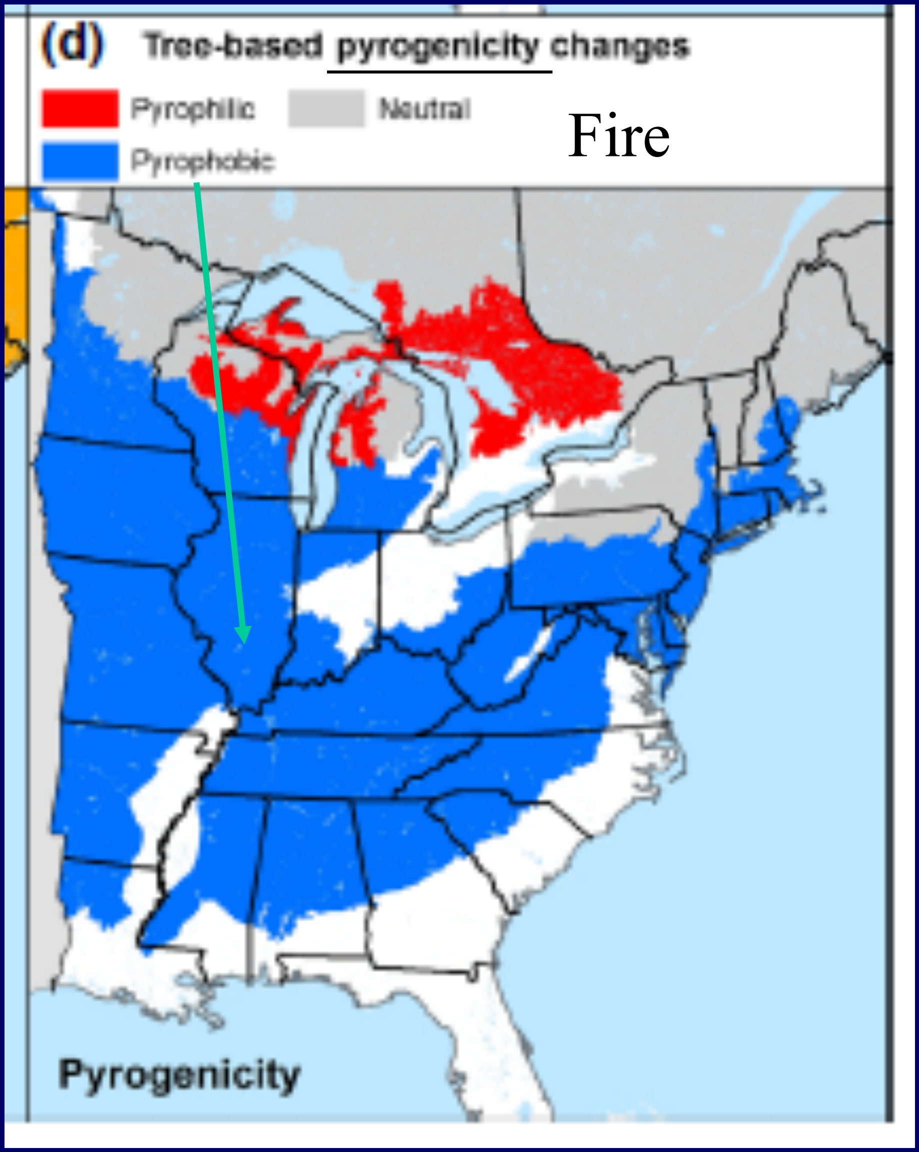
Nowacki and Abrams 2015



Large increase in <u>shade tolerant trees</u>

Trees invaded grasslands prairies

Quercus increased in northeast forests



Major loss of fire adapted trees, (from fire suppression > 1940)

Mesophication of eastern forests

Why did species/genera change abundance?

Shade tolerant trees increase due to fire suppression

Trees invaded grasslands due to fire suppression

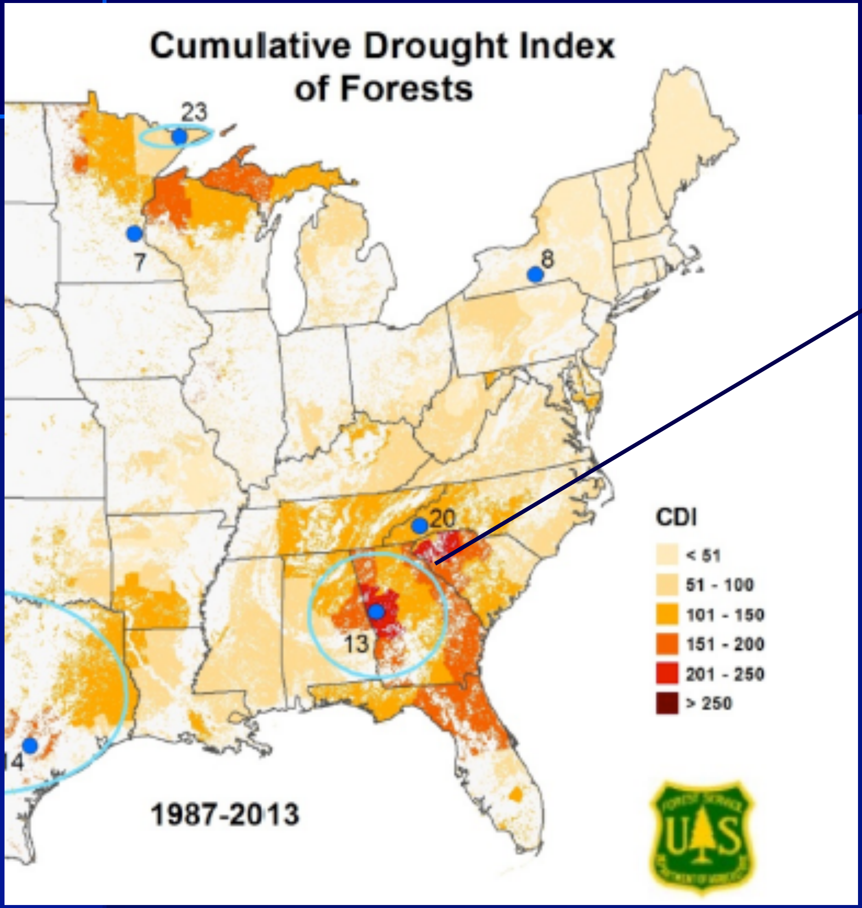
Quercus and *Populus* (north) increase due to extensive cutting

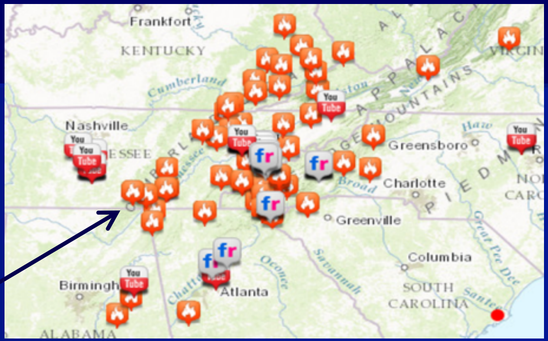
Castanea (cool) decline due to fungus blight

Fagus (warm) decline due to beech bark disease

Climate change not primary driver (but may become more imp. in the future)

Recent droughts and fires (2016) may change forests in a new direction.





Fires

> 60,000 ha burned

Citation: Peters, M.P., L.R. Iverson, S.N. Matthews Spatio-temporal trends of drought by forest type in the Conterminous United States, 1960-2013

<u>Forests becoming more vulnerable</u> to fire, drought. We need to restore fire adapted trees

Conclusions:

Most eastern forests had long history of burning

Smokey the Bear- loss of fire and fire dependent vegetation

Forest densification and mesophication is reducing the economic value (oak to soft maple), biodiversity, habitat and mast production for wildlife

It is making our forest more vulnerable to future drought, warming and possibly future fire

Eastern forests need intensive management and restored fire cycles and fire adapted forests