Trees Don't Read Textbooks:

New Insights from Old Forests

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Kentucky State Nature Preserves Commission

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Tree-Ring Lab
Lamont-Doherty Earth Observatory

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Harvard Forest

Scientific Value of Trees in Old-Growth Natural Areas

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ABSTRACT: Many applications of dendrochronology (tree-ring analysis) depend on long time series (hundreds of years) of ring-width data, which are obtained only from old trees. The clear value of old trees is in the opportunity to study long-term phenomena by looking back in time instead of waiting for hundreds of years to elapse. For this reason, dendrochronologists consider old-growth forests to be vitally important, especially those managed to preserve natural processes. With rigorous analysis, including specialized time-series statistical procedures, tree rings can be enlightening for various fields within the biological, chemical, and physical sciences.

INTRODUCTION

Dendrochronology, the study of the past using tree rings, depends largely on old trees for its data base. Variations in annual growth rings of old trees represent information about the past that is impossible to obtain otherwise. Rising concern about global environmental change in our increasingly populous world makes this tree-ring information even more valuable. Old trees, however, often have dollar values associated with them, either for the wood products they provide or for the economic value of the land on which they grow. With these economic pressures to cut large old trees, it is critically important that natural areas are designated that specifically preserve old-growth forests.

BASICS OF DENDROCHRONOLOGY

Dendrochronologists are interested in the varying patterns of relatively wide and narrow rings that trees display in a cross-sectional view. These patterns result mostly from the influence of yearly climatic variation (Fritts 1976) and are common in low productivity forests, such as are found in the arid Southwest (Drew 1972a, 1972b), at high altitudes (Graybill 1987), and at high latitudes (Jacoby and Cook 1981). Distinct ring patterns also are present in some tree species of subhumid areas (Cook 1985a) and swamps (Stahle et al. 1985). In addition to ring-width variation, dendrochronologists increasingly are interested in intra-ring variation of wood density, which also responds to climatic variation (Conkey 1986).

Dendrochronological analysis begins with crossdating tree rings (Stokes and Smiley 1968), which distinguishes dendrochronology from mere ring counting. The goal of crossdating is to assign an exact year date to every ring of every tree sampled from within a site, based on ring-width patterns common throughout the site. By matching these patterns across several trees, ring growth anomalies such as missing or false rings are accounted for. This goal is attained in most studies, especially in those using tree species that are sensitive to yearly climate variations. Admittedly, in some cases exact year dates cannot be given confidently to all rings from a site; this can result from a complacent response to climate variation, a lack of effective climate variation, or an extreme quantity of ring growth anomalies.

After crossdating, each tree-ring series is measured, usually to a precision level of ±0.01 mm (Jacoby 1982). The measured tree-ring series, which exhibit both stand-wide and individual variation over time, are then detrended by any of various standardization techniques (Fritts 1976). Standardization essentially converts a series of raw ring-width measurements into indices of relative growth, which have a relatively stable mean and variance across the time span (Cook 1987).

After this preliminary analysis of crossdating, measuring, and standardizing, tree-ring indices may be correlated with meteorological data in a process called climate modeling. This modeling discovers which climate indicators (e.g., monthly sums and averages of precipitation and temperature) account for the most tree-ring variation. Once a climate model is developed and verified, it can be extrapolated back through the entire length of the tree-ring data, which may

Trees Don't Read Textbooks

Silvics of North America

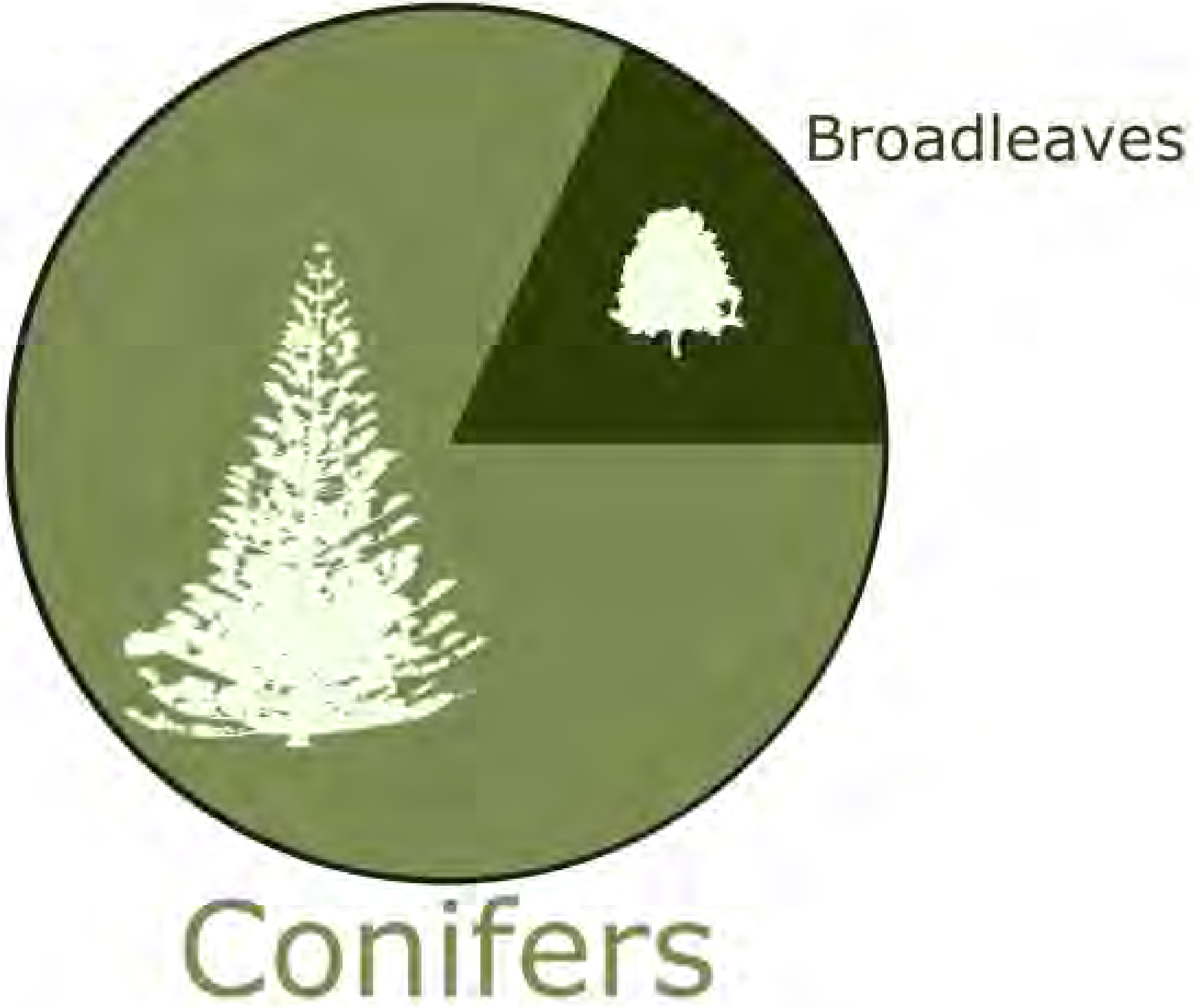
Volume 1: Conifers

Silvics of North America

Volume 2: Hardwoods

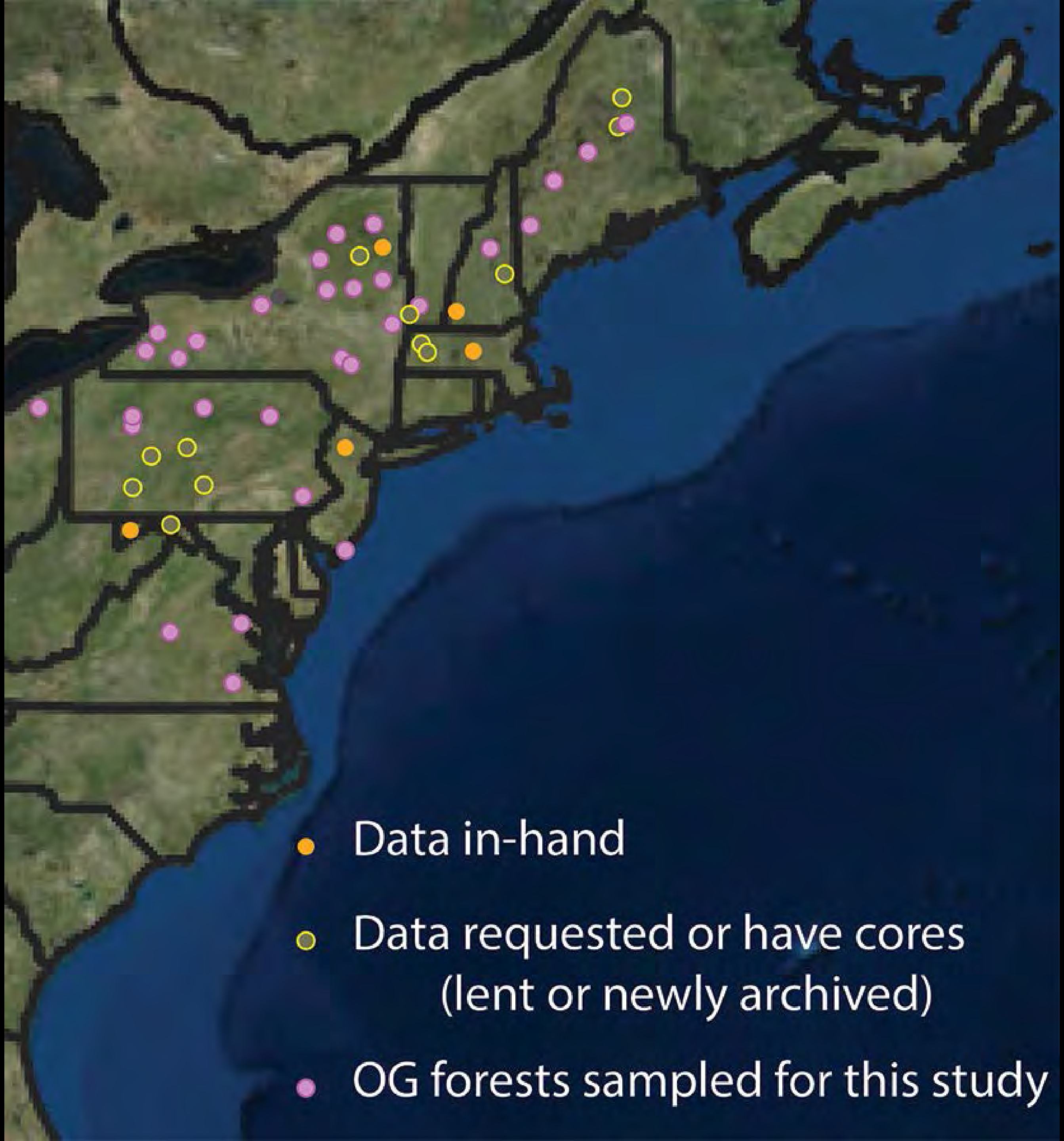
Of the 4,400+ publicly available tree-ring collections,

81% are conifers



Zhao et al., 2019

Redefining the Ecological Memory of Disturbance Over Multiple Temporal and Spatial Scales in Forest Ecosystems



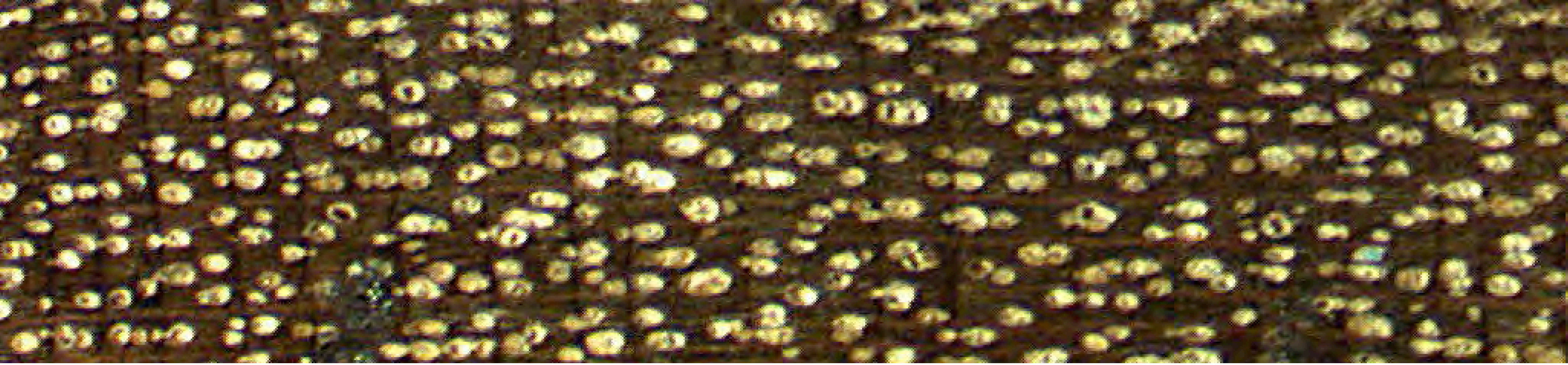
40-50 forests

70-90 plots

~3000 trees

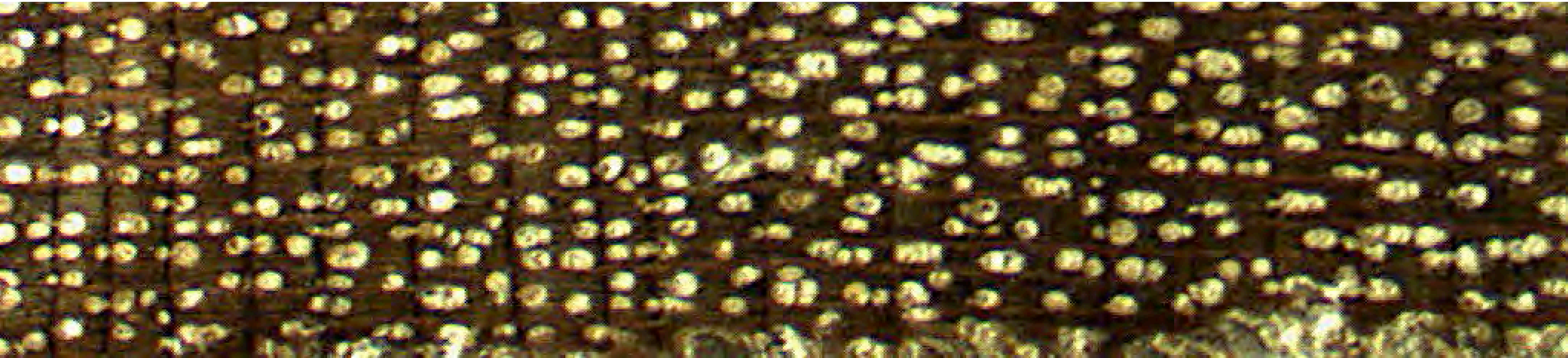
~ 12 Northern Hardwood

~30 species

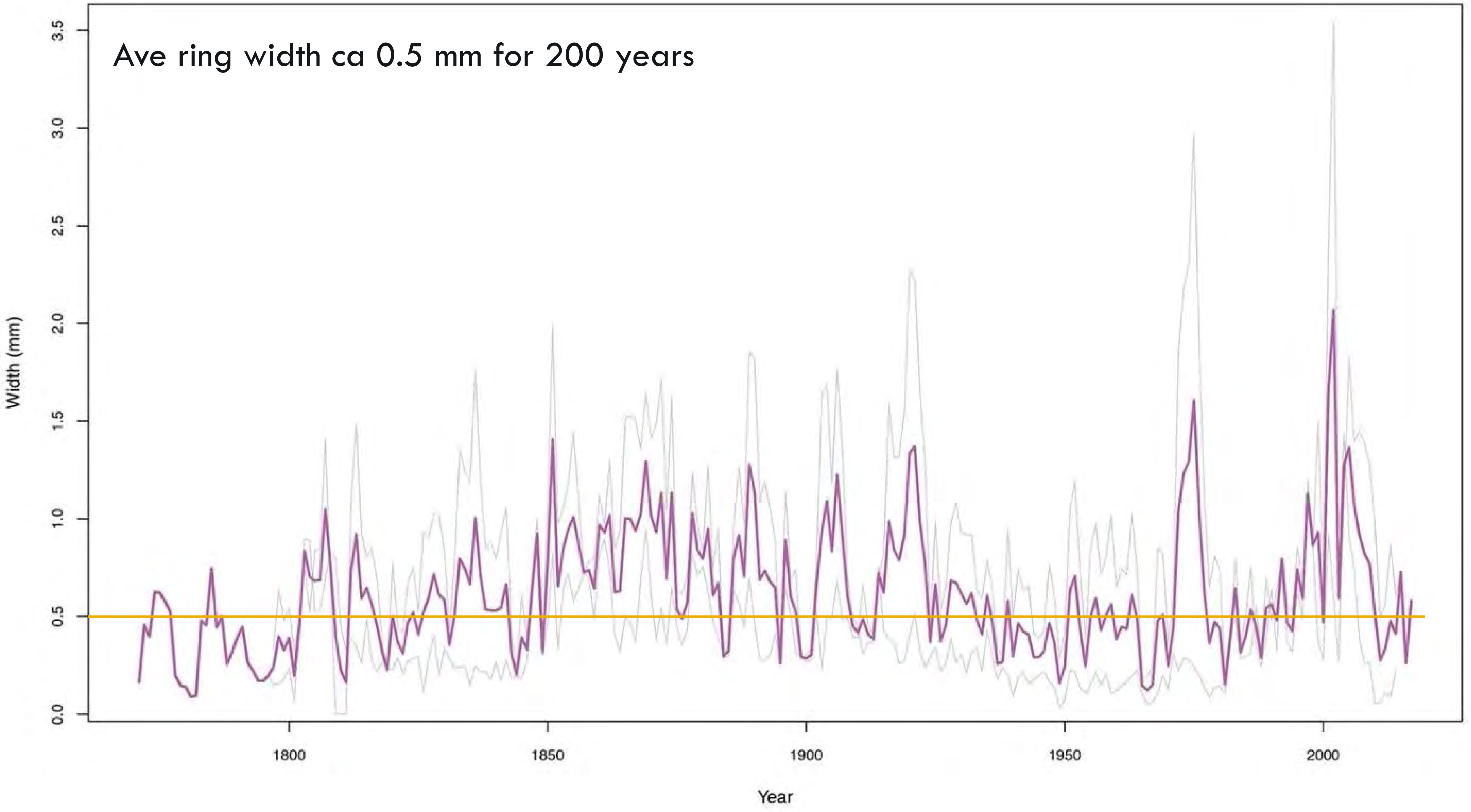


Trees Don't Read Textbooks:

Understory Resilience

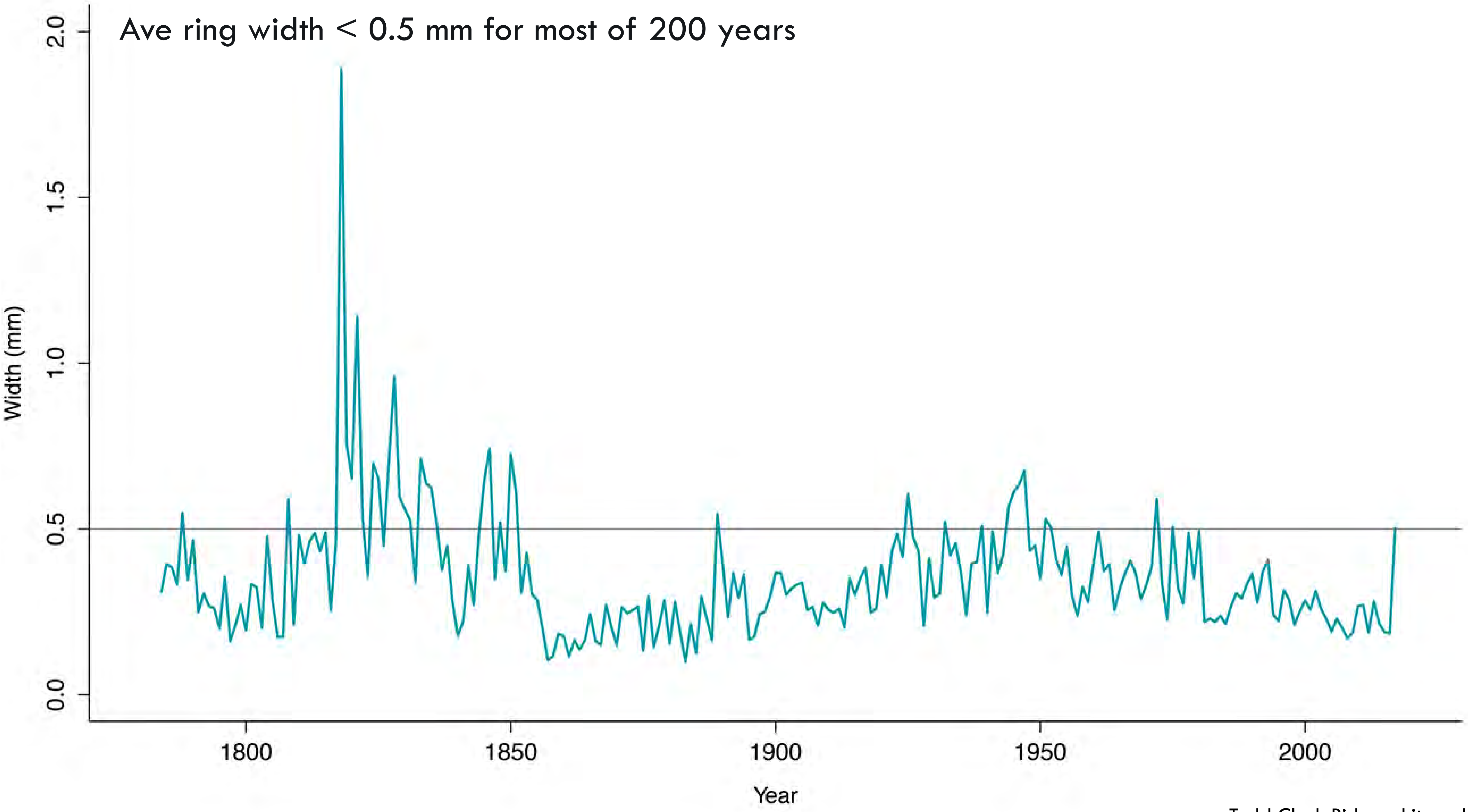


tree #68, DBH = 33.5 cm DBH, recovered ca 1/2 of the radius

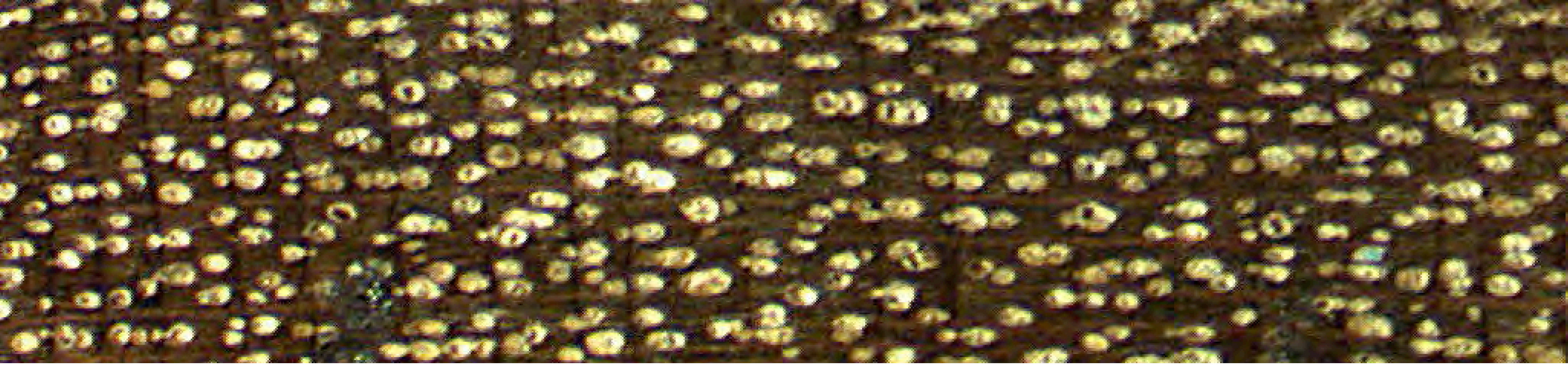

Ave ring width ca 0.5 mm for 200 years
Width (mm)
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
1800
1850
1900
1950
2000
Year


Todd Clark Ridge
White Oak

Ave ring width < 0.5 mm for most of 200 years

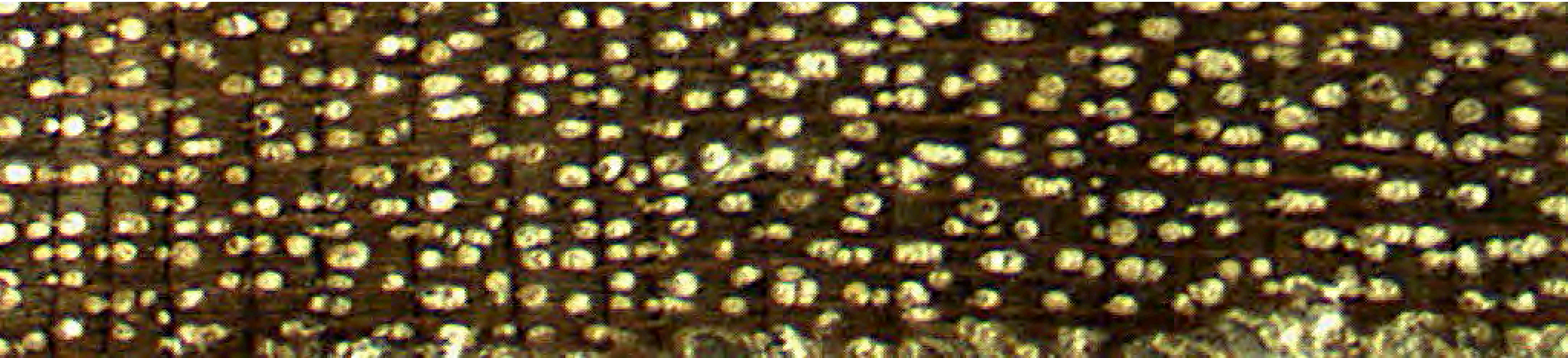


Todd Clark Ridge white oak



Forests Don't Read Textbooks:

Long-term Forest Development



Are Northern Hardwood Forests soley driven by gap dynamics & cyclical succession?

Blanton Forest, KY, July 2006

Received the above in good order (date) Mar 30, 1941

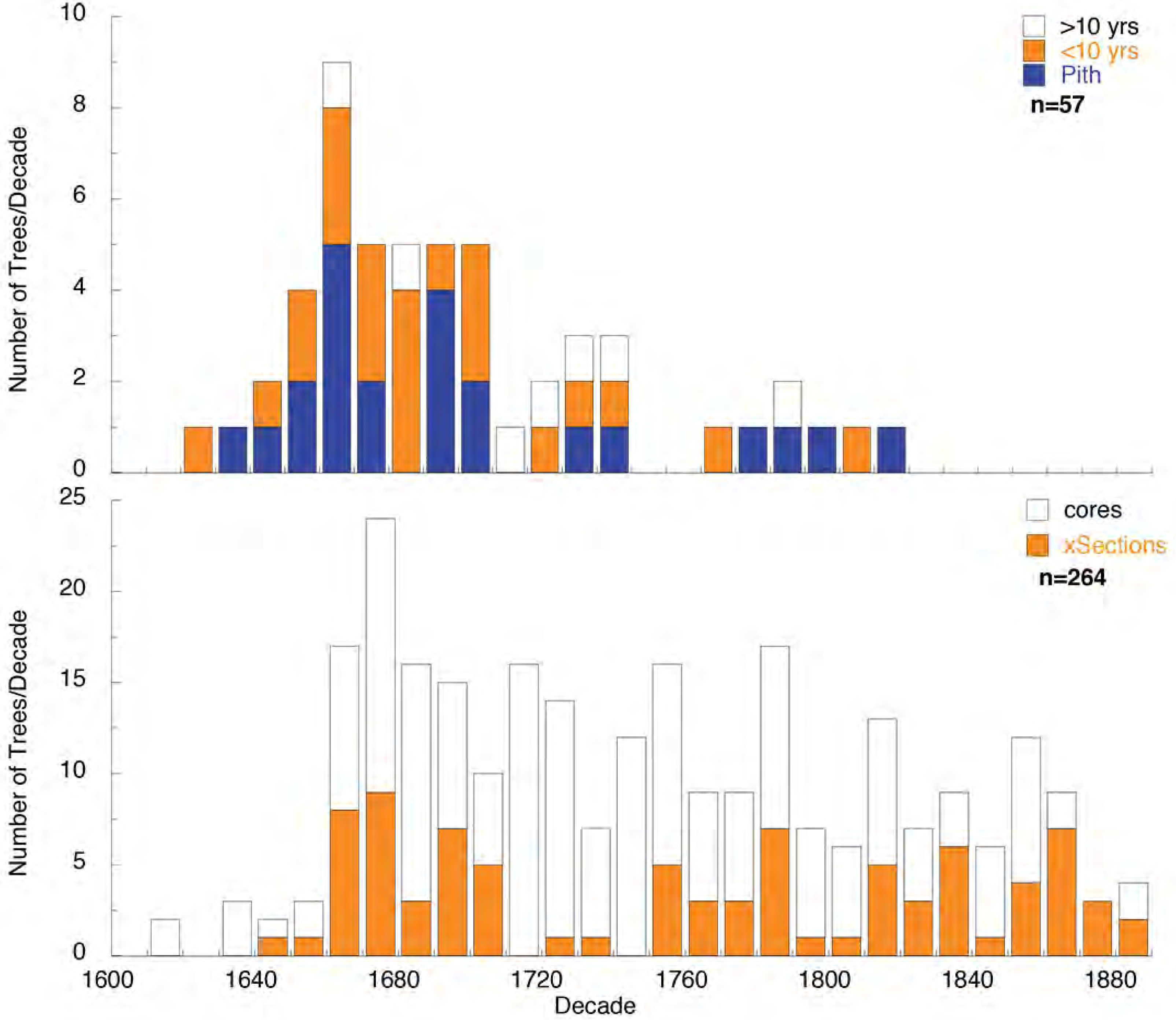
F. Hawley

RETAIN THIS COPY FOR YOUR RECORDS.

Dr. Florence Hawley

Hawley Collection
1938-1942

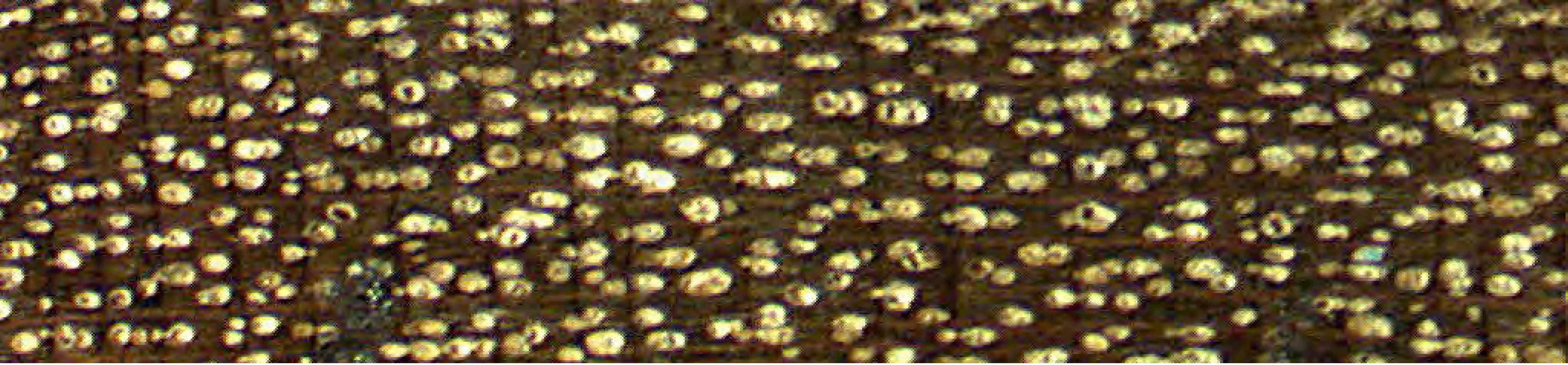
The Kentucky Wall
1981-2009



Trouet et al., 2017

Pederson et al 2017

One piece at a time…



Trees Don't Read Textbooks:

Longevity

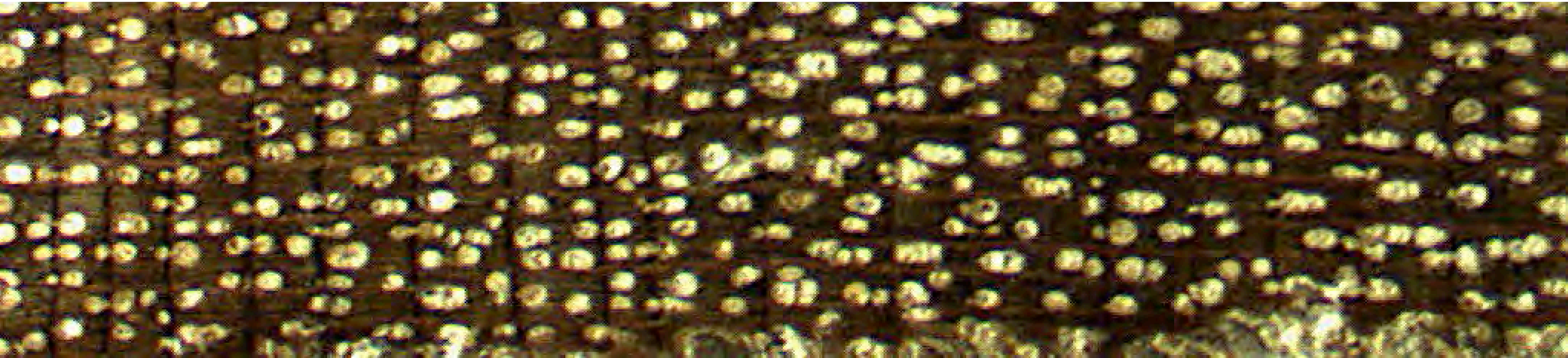


Table 1 – Comparison of maximum ages from the Silvics of North America (Honkala and Burns, 1990), Hough and Forbes (1943) and recently acquired data.

Species	Silvics Manual[a]	Hough & Forbes	New Data (location)	Difference[b]
			--years--	
Acer rubrum	150[a]	290	300[c] (Catskill Mtns., NY)	150
Betula lenta	265	265	361 (New Paltz, NY)	96
Carya ovata	300[a]	n/a	354 (Geo. Washington Nat. For., VA)	54
Magnolia acuminata	150	310	348 (Geo. Washington Nat. For., VA)	198

Pederson et al., 2007



Anthony Kelly

CucumberTree

~ 430 yrs

photo by
Ed Frank

Tulip-poplar 525 years as of 2023… & it is hollow

Yellow Buckeye

Likely lives 500 years

White Ash

310 years, missed pith

Likely lives 400 years?

Red Maple

340+ years old

Tsuga canadensis (Eastern Hemlock)

Likely most cored tree in eastern North America

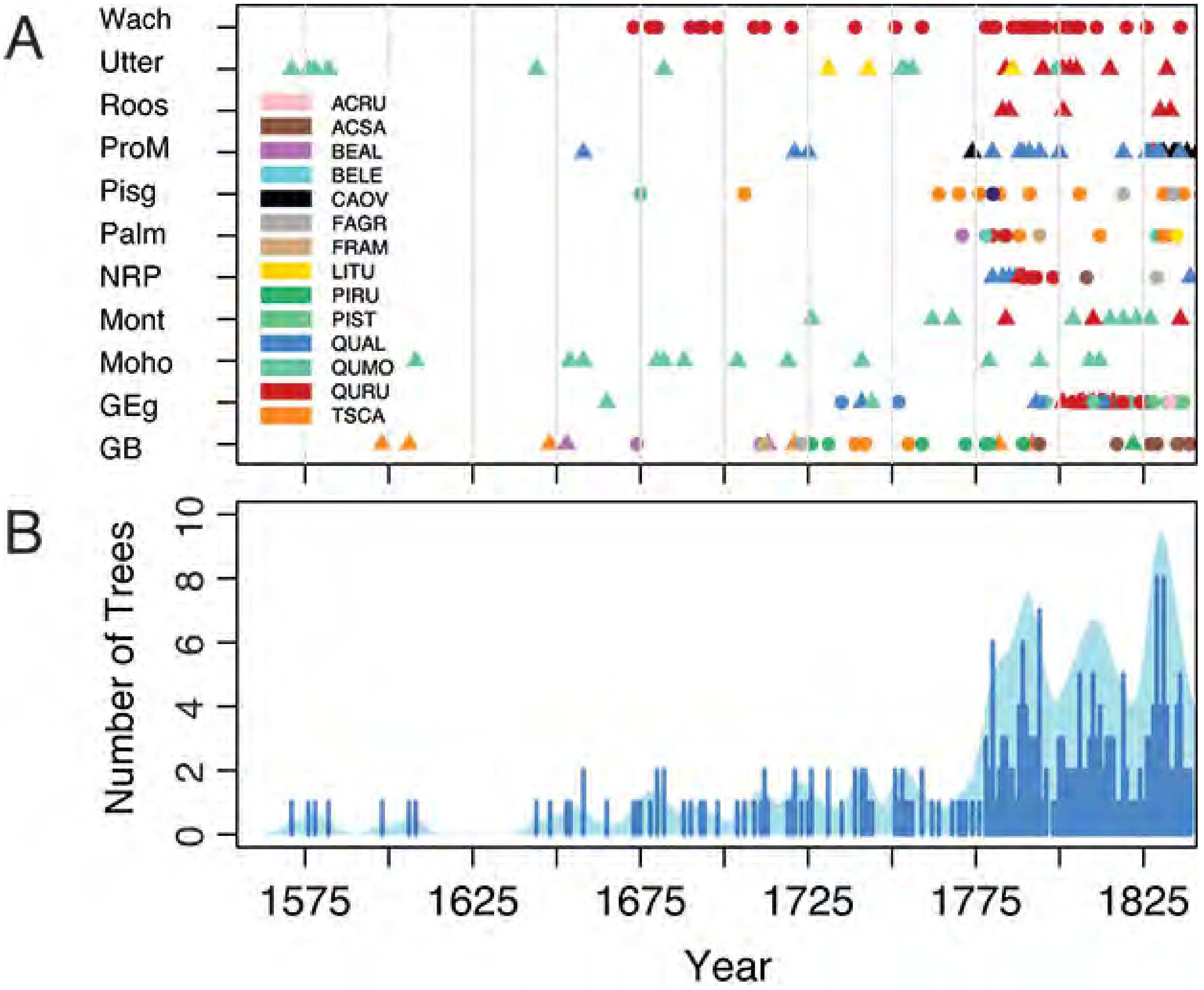
- max age of 555 years established in 1978

651 years old

Trees Don't Read Textbooks or There is still so much to learn

Big Moose Lake, Adirondacks, USA

Evidence Suggestive of Synchronous Canopy Disturbance, Northeastern USA, 1780s & 1790s, late 1820s



Pederson et al. 2017

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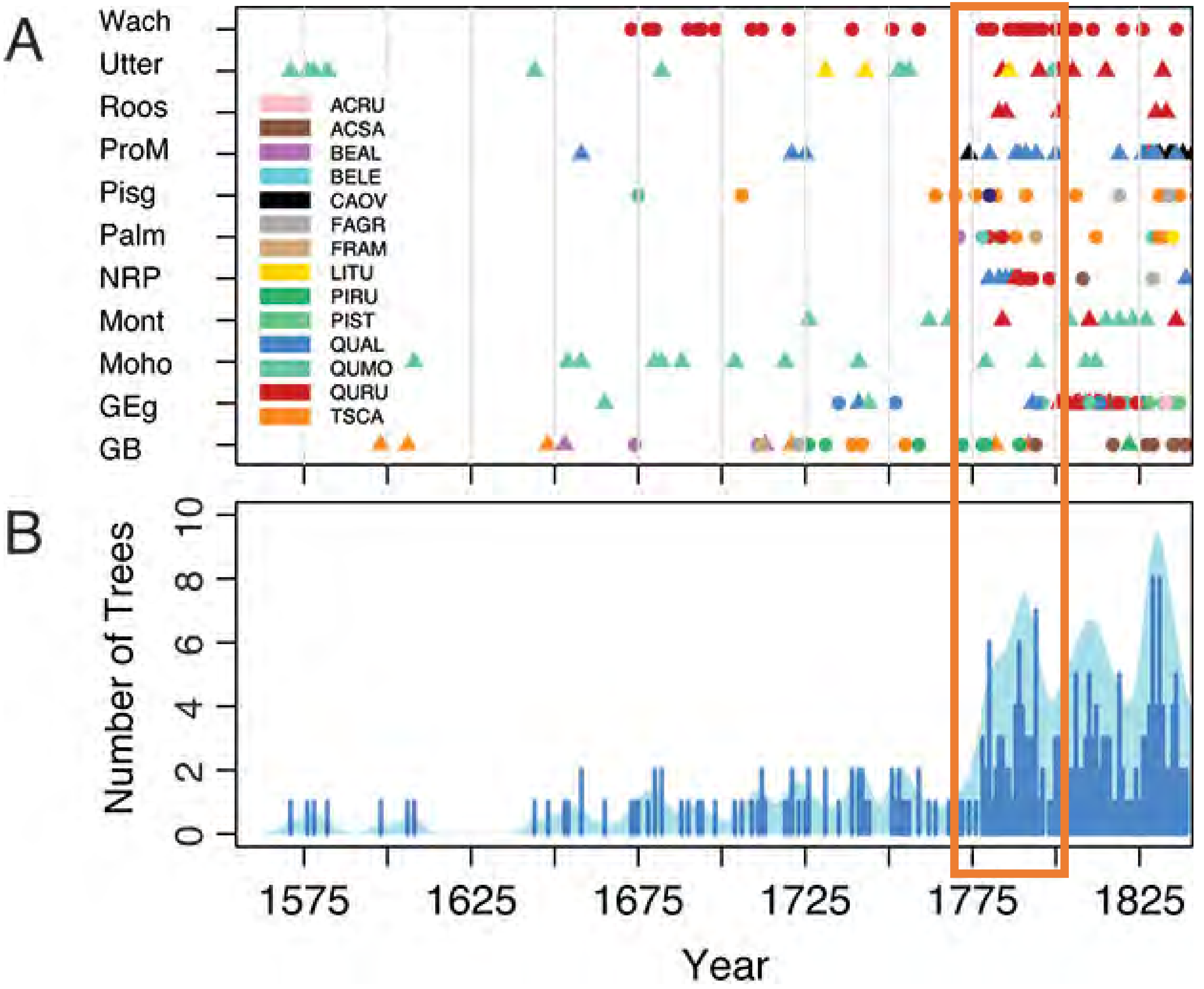
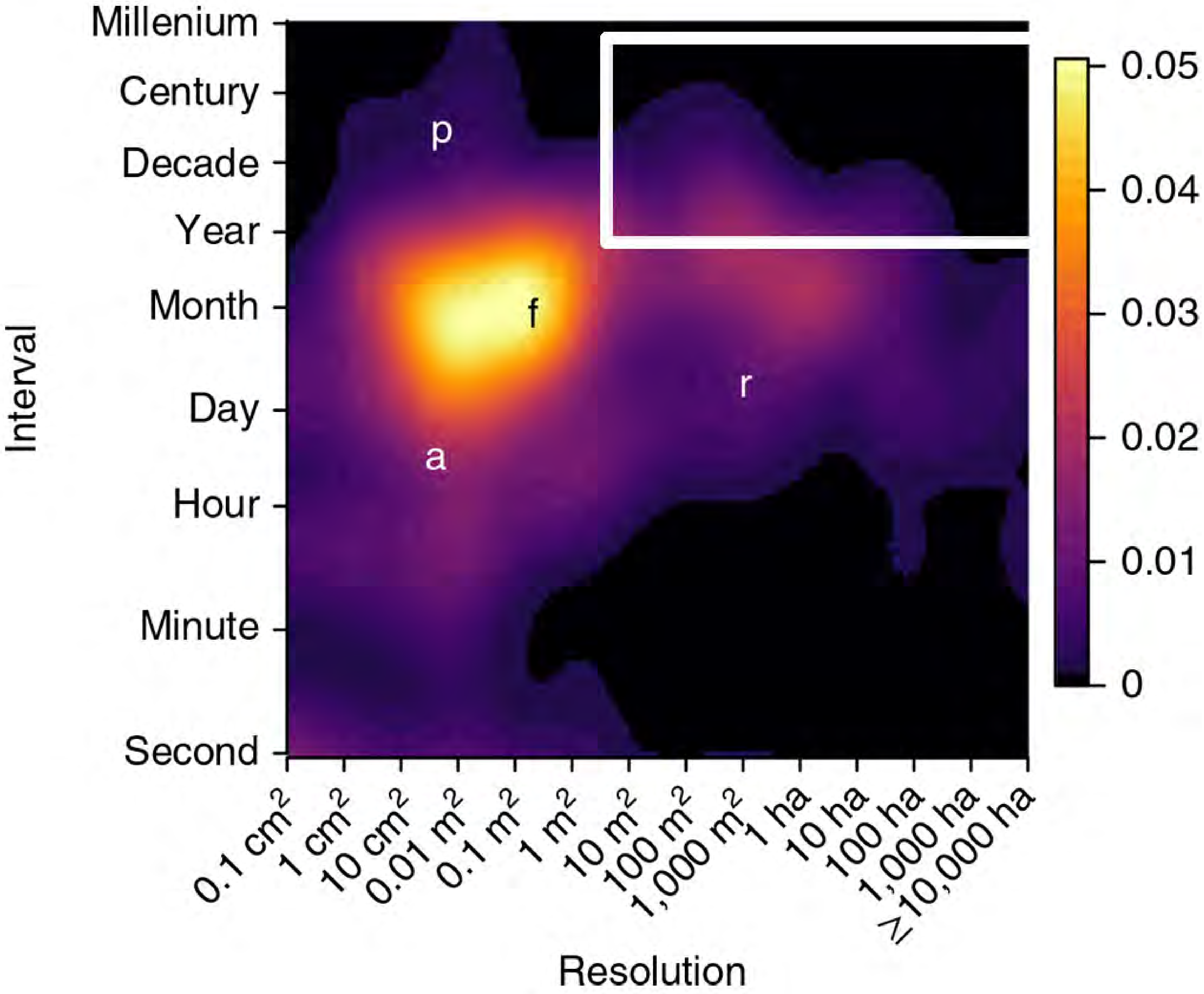


Pederson et al. 2017



adapted from (Estes *et al.*, 2018)

A Spatiotemporal Black Hole in Ecology:

From Landscape to Region+ scale

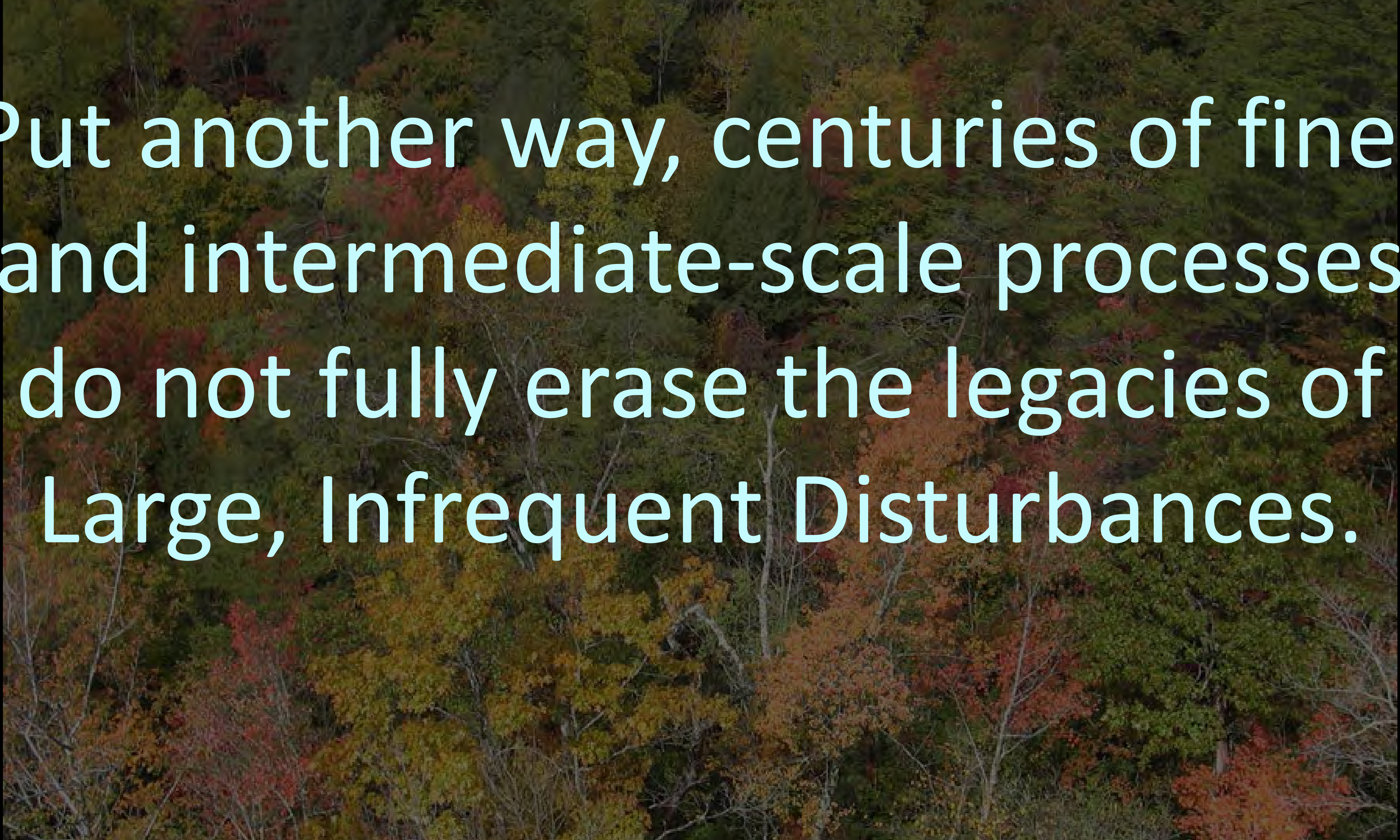
over

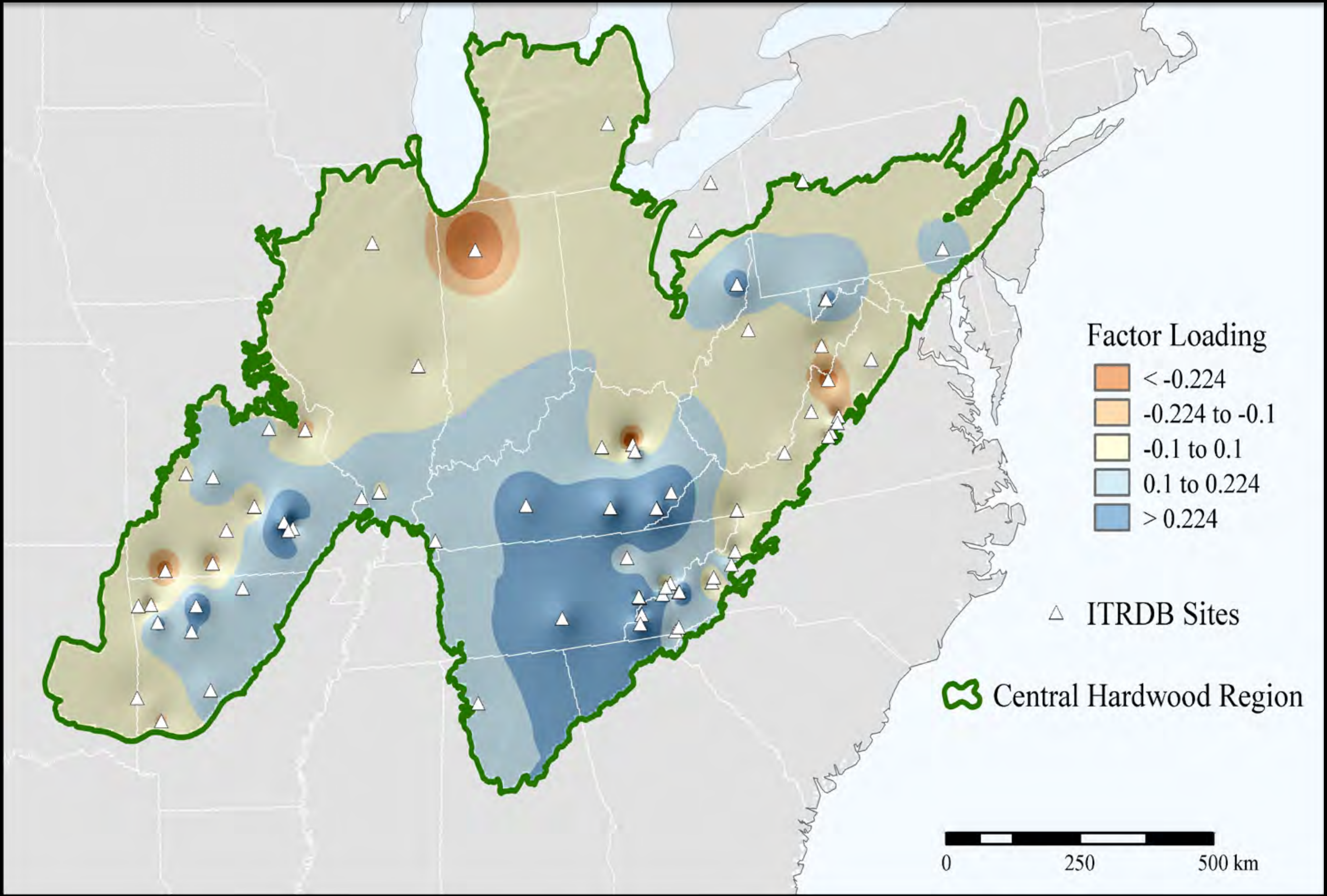
Decades to Centuries+

Conundrum in Temperate Mesic Forests: presence of early successional species in old-growth forests

Smoky Mtns, USA

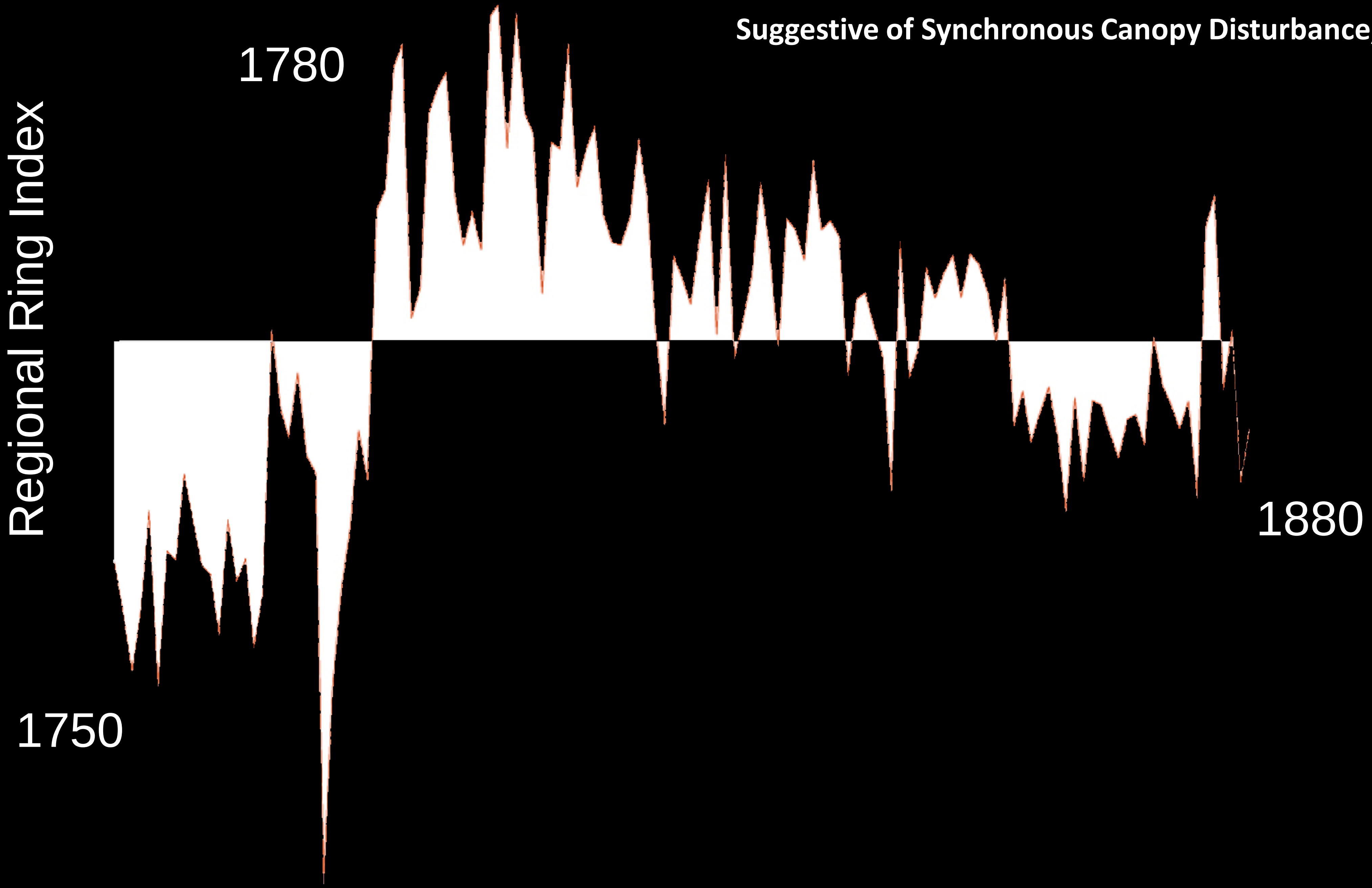
Pederson et al 2017


Put another way, centuries of fine- and intermediate-scale processes do not fully erase the legacies of Large, Infrequent Disturbances.



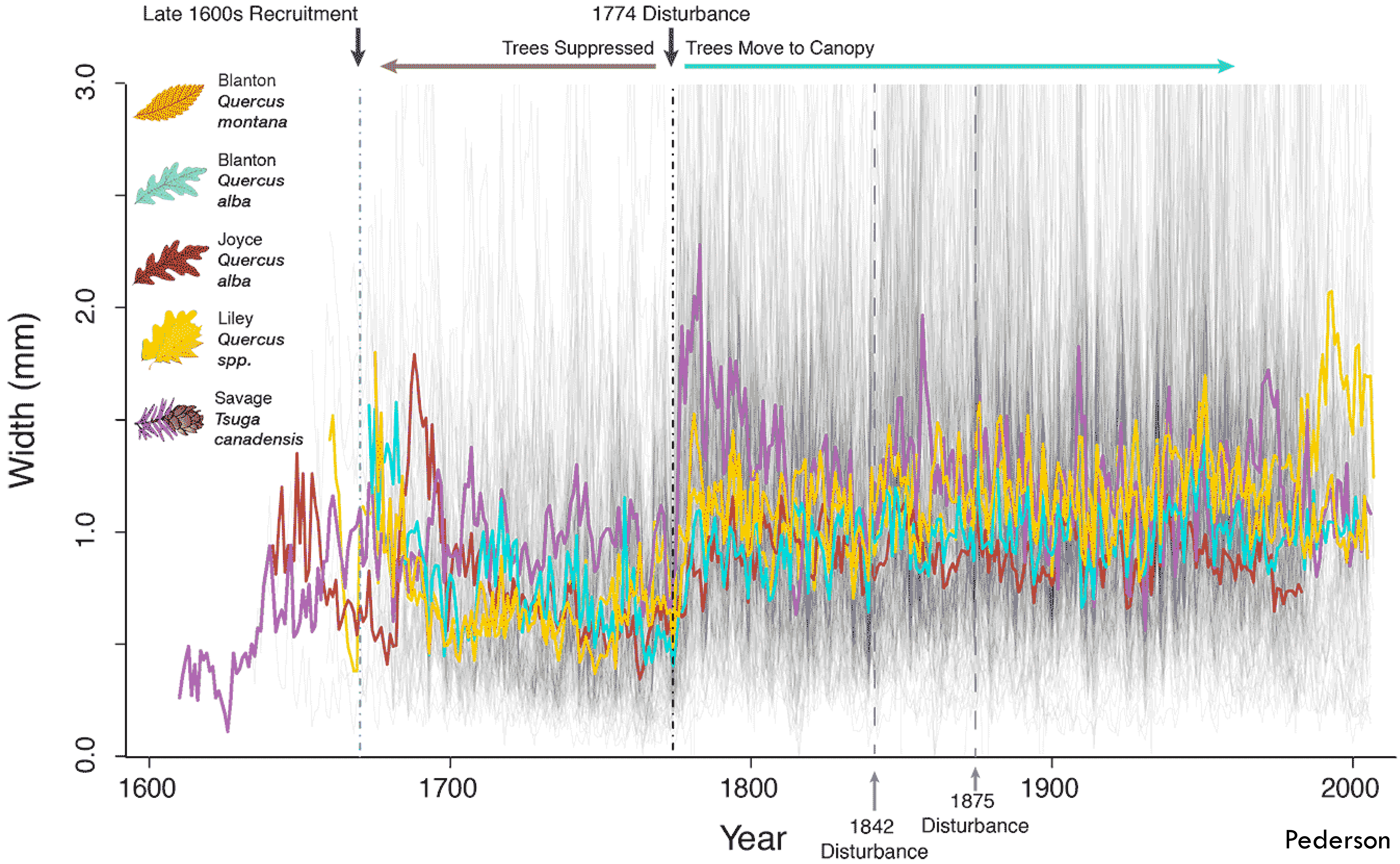
Pederson et al., 2014 Ecol. Mono.

Suggestive of Synchronous Canopy Disturbance, 1770s

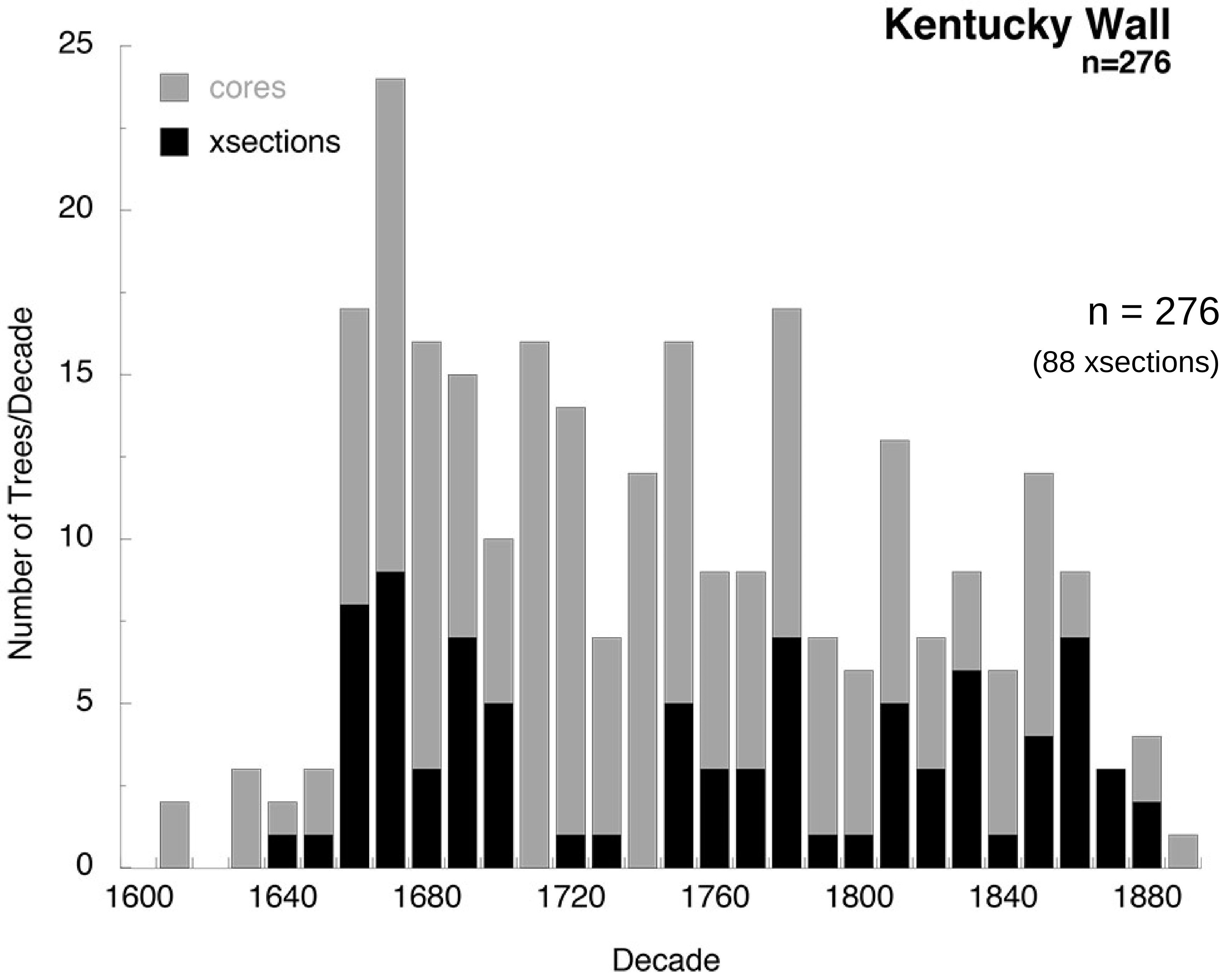


Pederson et al., 2014 Ecol. Mono.

Abrupt, Synchronous Disturbance Across a Mesic Forest Region



Pederson et al. 2014



Kentucky Wall
n=276
cores
xsections
n = 276
(88 xsections)
Number of Trees/Decade
0
5
10
15
20
25
1600
1640
1680
1720
1760
1800
1840
1880
Decade

How long *do* trees live?

photo by
Jane Foster

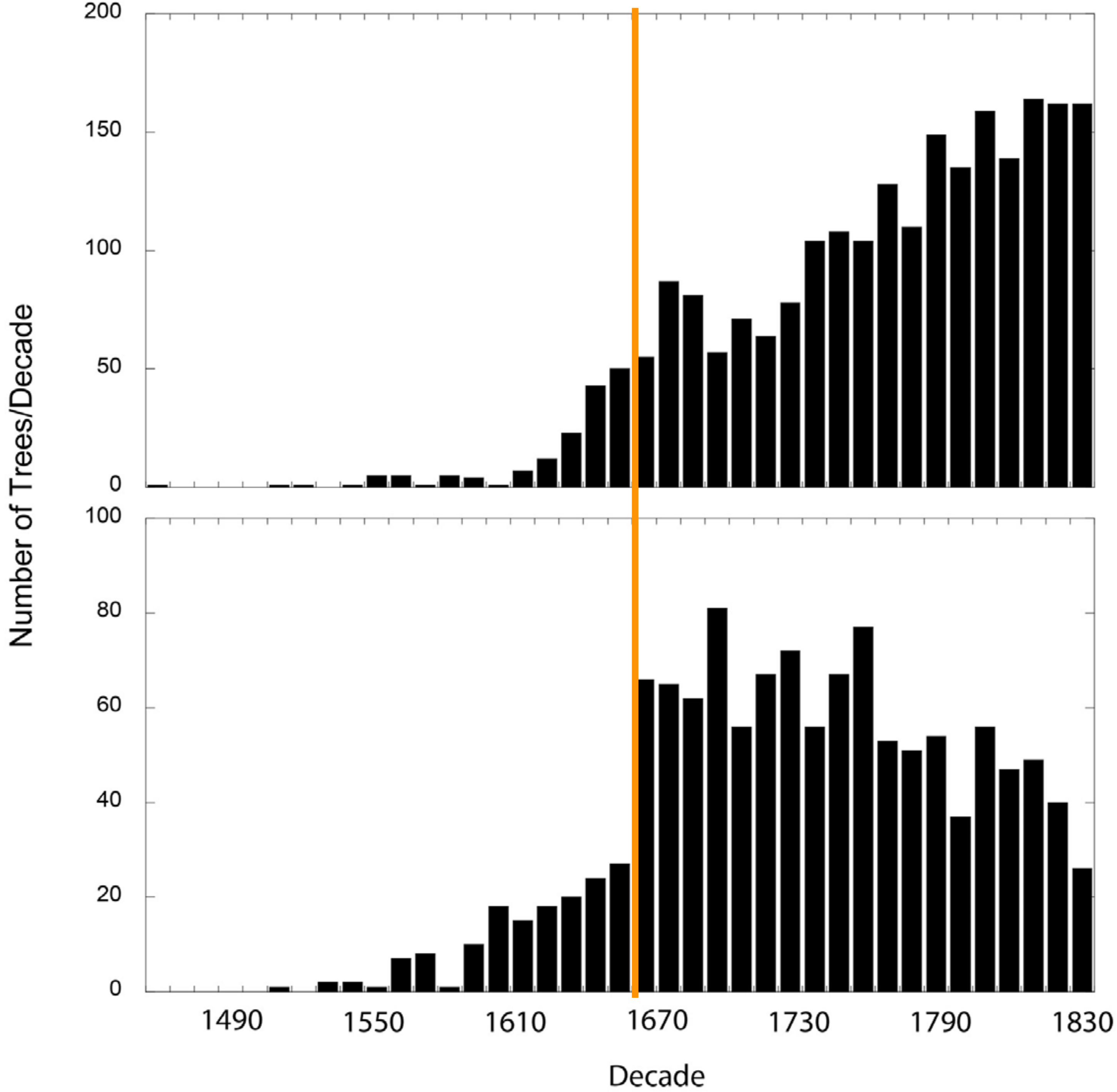
Yellow Birch

363 years

Inner ring 1653

Hollow


Evidence Suggestive of Synchronous Canopy Disturbance, 1650-1690

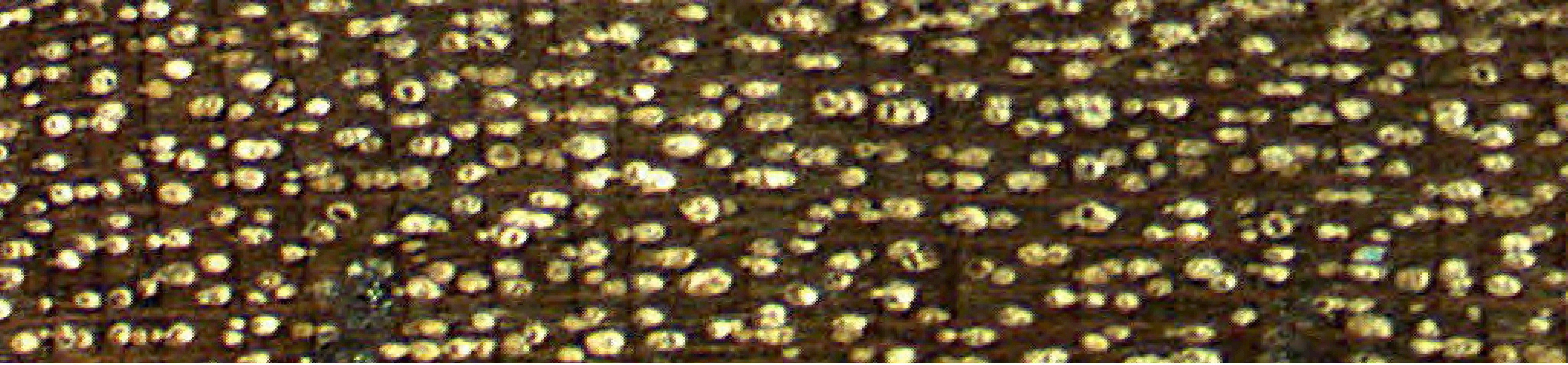


Plot-level & representative sampling

Most not crossdated

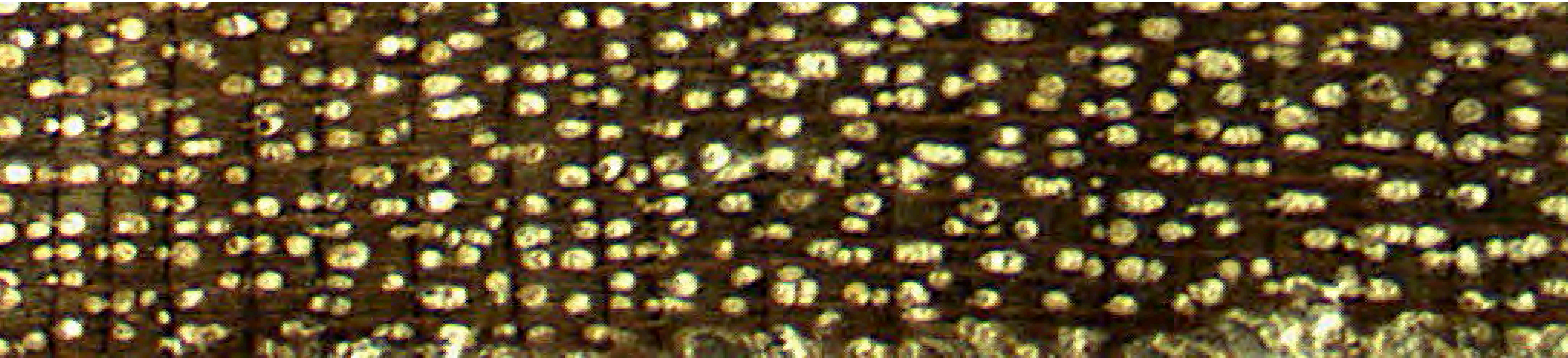
Targeted Sampling: old trees & historic timbers

Crossdated

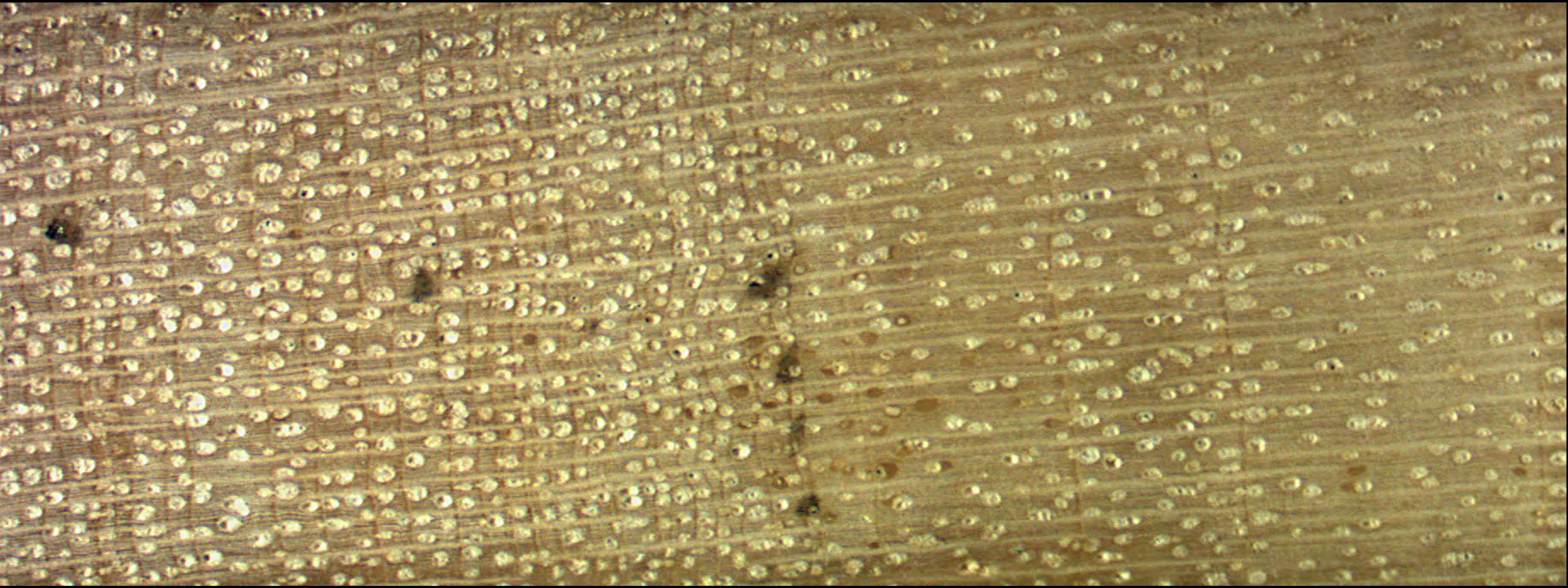


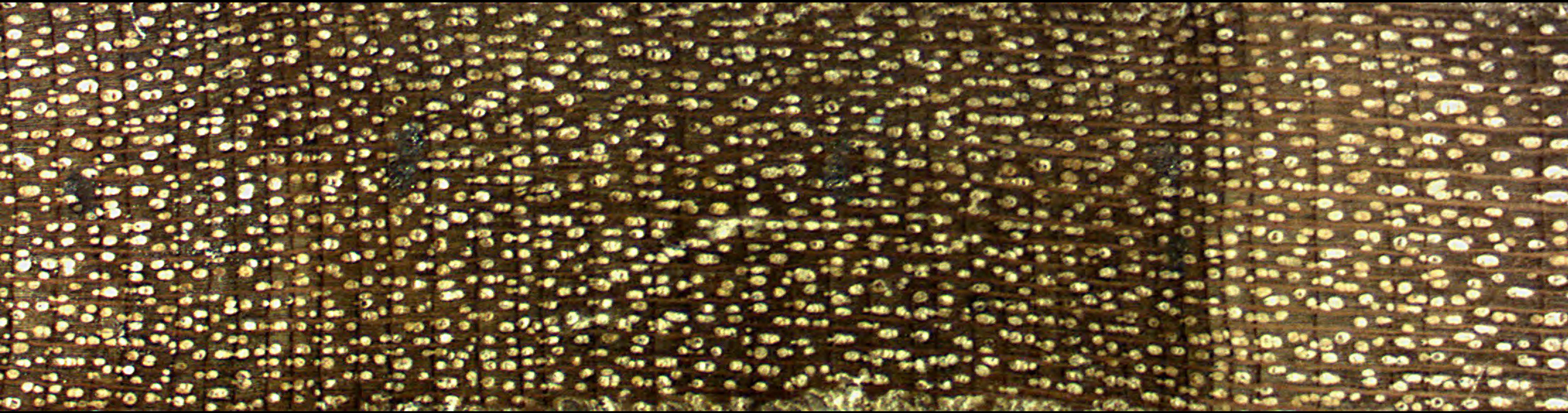
Does Sugar Maple Even Read Textbooks?

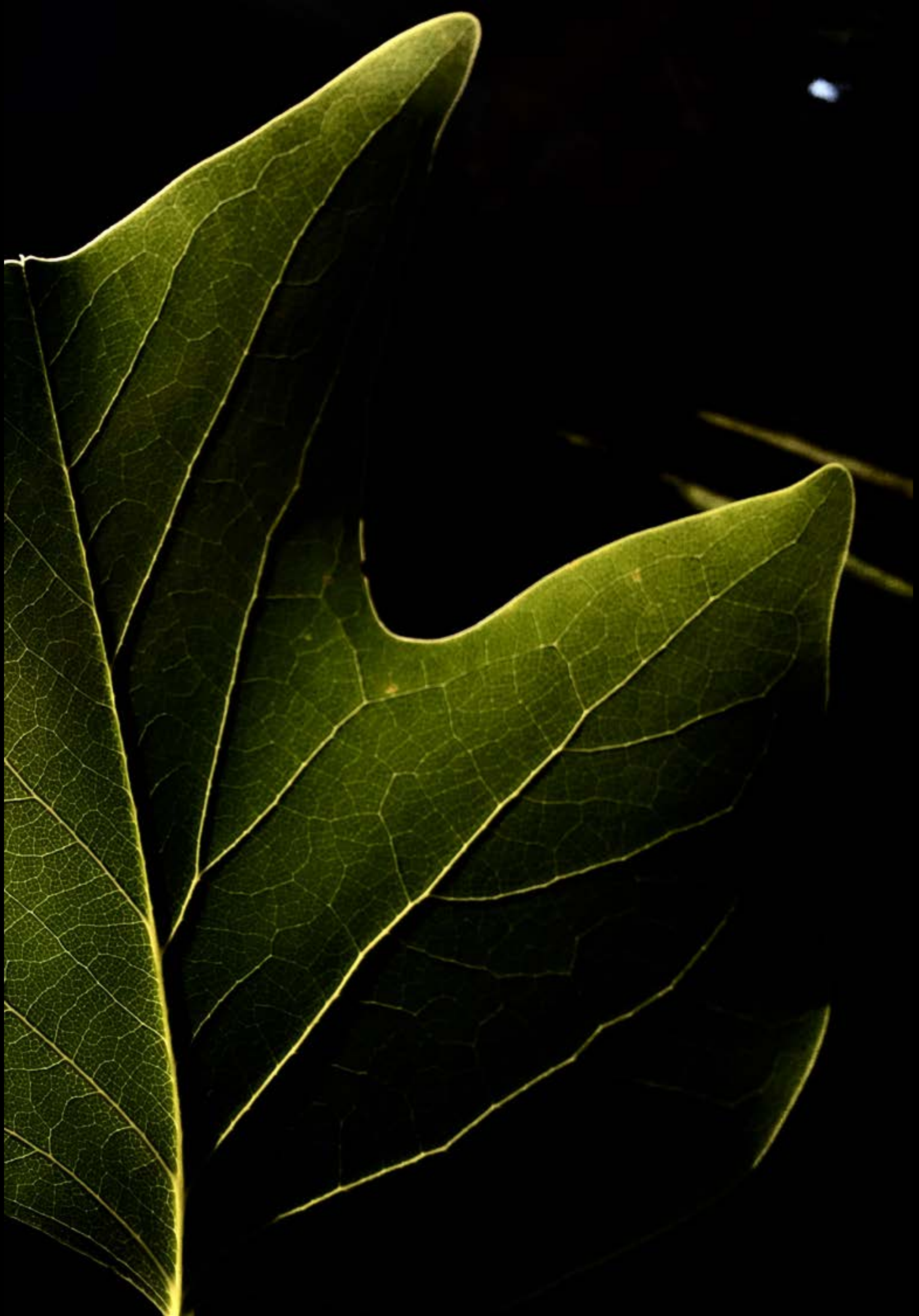
Longevity & Growth Rates



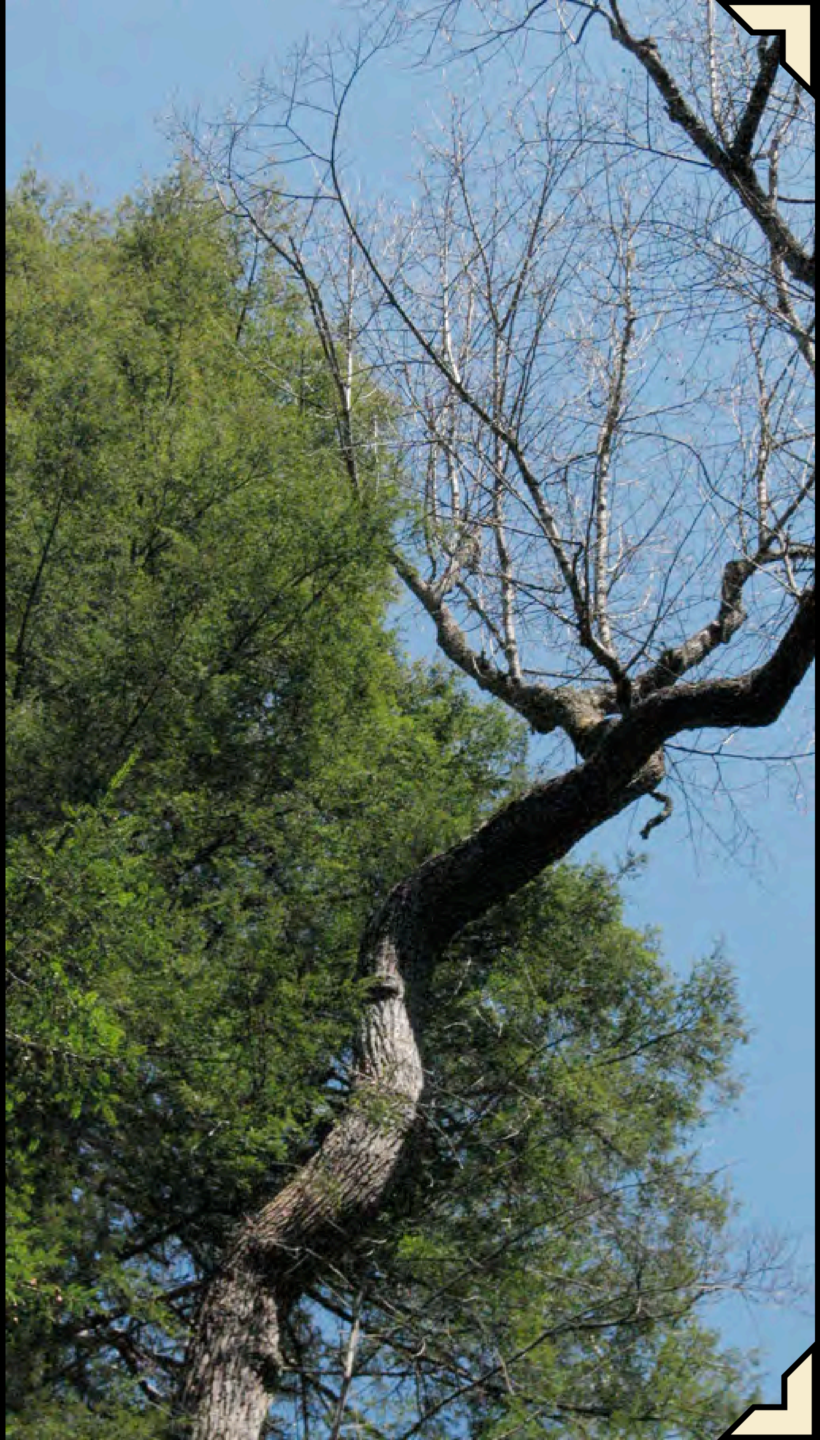
Red House, Allegany State Park, NY

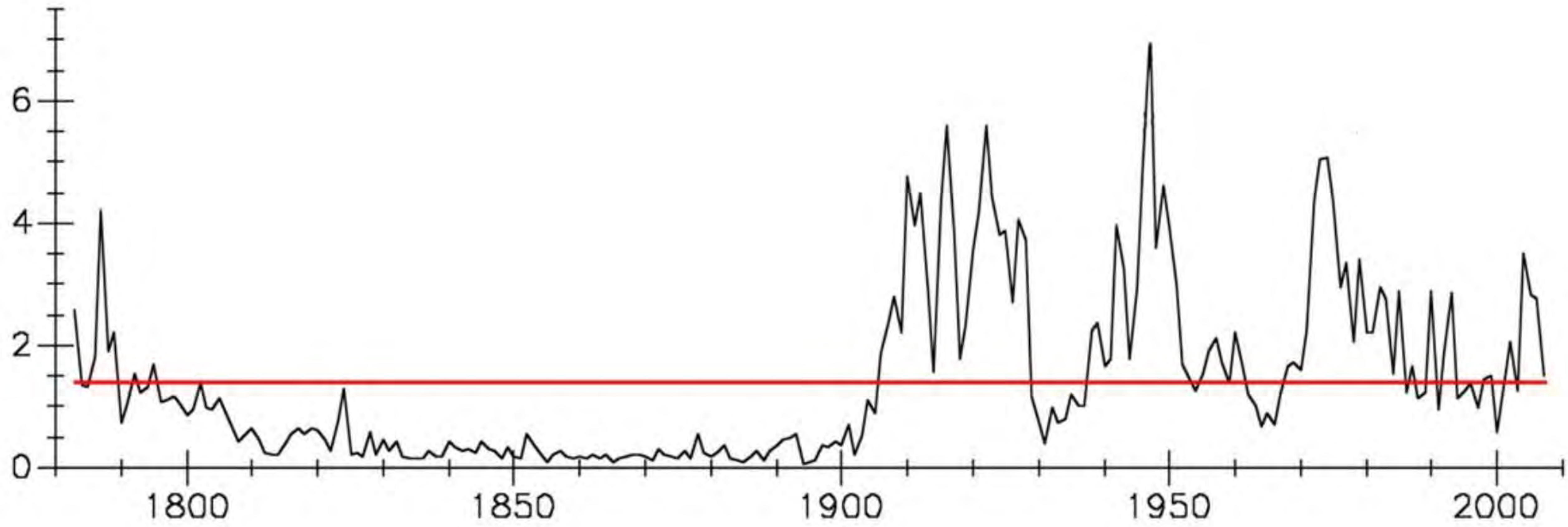












While generally true…

Aesculus flava

Likely can live 500 years

Tuliptree

Broken top

Smoky
Mtns