Ecological silviculture for southern Appalachian hardwood forests

Dr. Tara Keyser (Research Forester), USDA FS, Southern Research Station, Asheville, NC

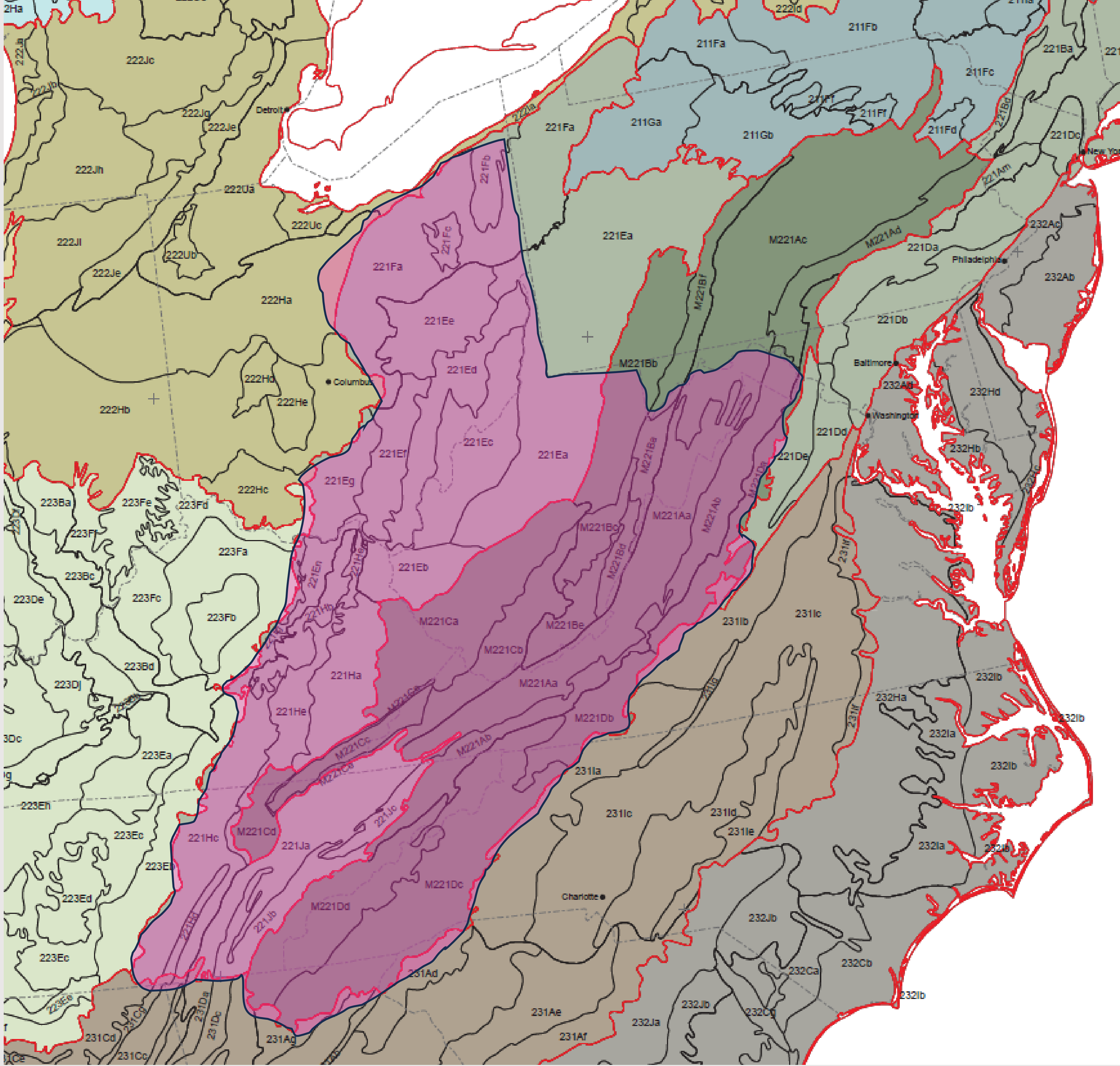
tara.keyser@usda.gov

Roadmap

I. Past land use/disturbance
II. Contemporary forest structure and composition
III. An ecological approach to management

<u>Appalachian region</u>

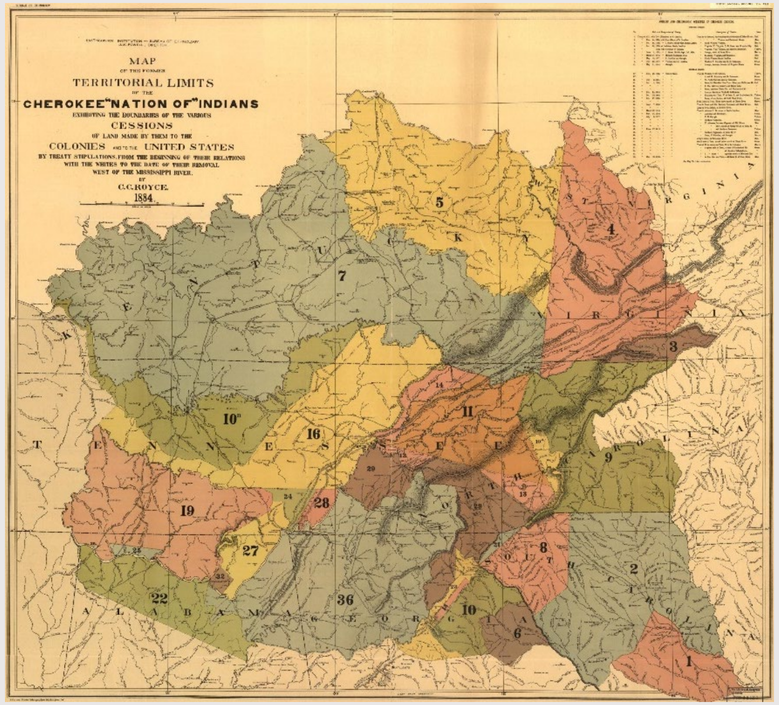
- Ecological sections: Central App Broadleaf Forest (M221A,B,C,D) & Eastern Broadleaf Forest (221E,F,H,J)
- 8-state area: GA, KY, NC, OH, SC, TN, VA, WV



The southern Apps: Thousands of years of disturbance

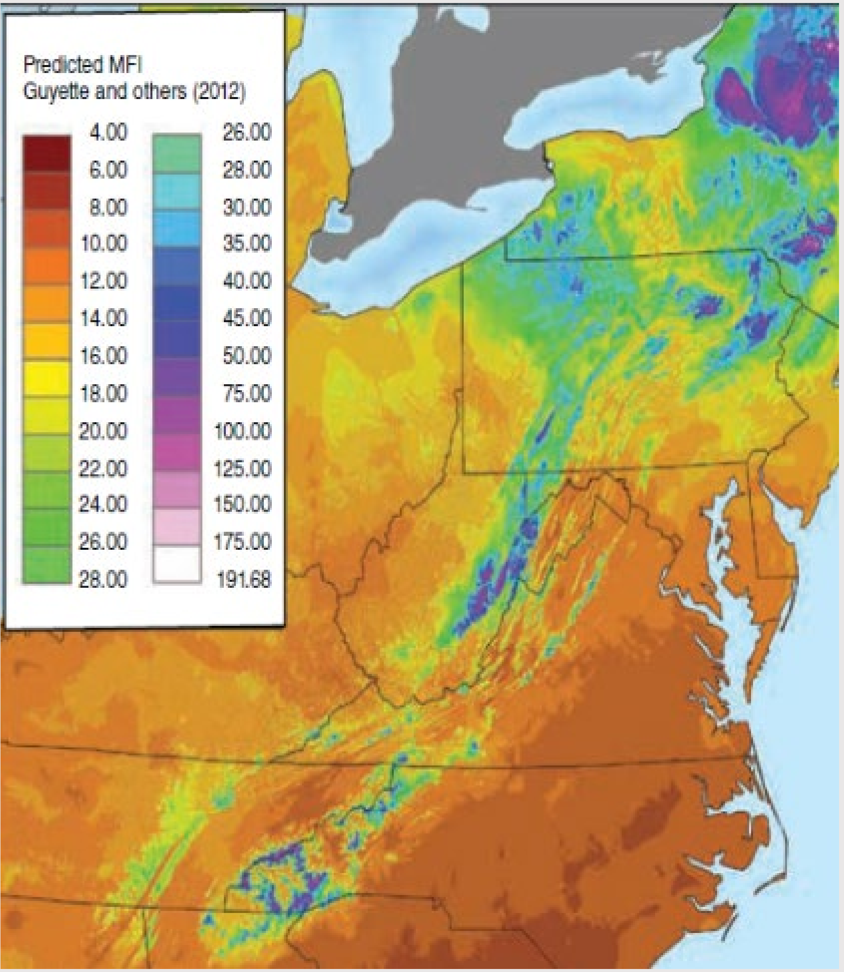
An artist's impression of Town Creek, a South Appalachian Mississippian culture town with ceremonial mound in NC, ancestors of the Cherokee people. https://www.nps.gov/liri/learn/historyculture/cherokee-people.htm

- Oak became a component of eastern forests ~10,000 YBP
- Oaks became dominant by 3,000 YBP (start of the Woodland Era)
  - Permanent large settlements
  - Agriculture was widespread & advanced
- Use of fire was extensive: Correlation b/t the abundance of charcoal in the soil and abundance of oak pollen
  - Attract and/or drive game
  - Clear land for ag and village sites
  - Communication and facilitate travel
  - Promote berry production
  - Facilitate nut/mast collection



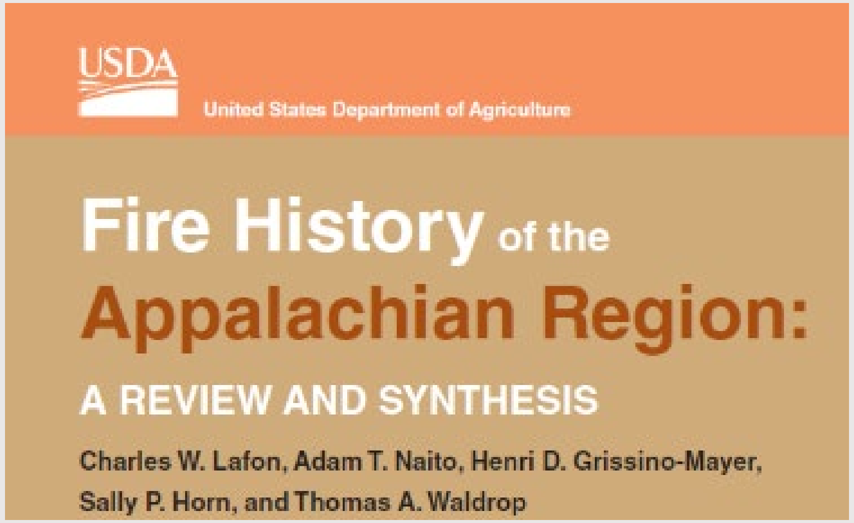
Territorial limits of the Cherokee Nation: Library of Congress

Fire as a key disturbance



Physical model of fire frequency - Guyette et al. 2012

Source	Site name	Composite MFI	Composite WMI
Aldrich and others (2010, 2014)	Kelley Mtn.	3.9	3.7
	Mill Mtn.	5.4	5.1
	Reddish Knob	4.8	4.6
Armbrister (2002)	GSMNP	7.5	6.8
Brose and others (2013, 2015)	Long Branch Hill	19.4	11.2
	Slate Run	14	9.4
	Upper Dry Run	10.9	6.3
DeWeese (2007)	Brush Mtn.	4.1	3.3
	Griffith Knob	2.3	1.9
	Little Walker Mtn.	2.8	2.6
	North Mtn.	3.2	2.6
Feathers (2010)	CRX	6.2	5.6
	CRT	3.4	3
Flatley and others (2013)	House Mtn.	2.6	2.1
	Licklog Ridge	2.2	2
	Linville Mtn.	4	3.4
Harmon (1982)	GSMNP	—	—
Hessl and others (2011)	Pike Knob	—	—
		—	—
		—	—
Hoss and others (2008)	Peters Mtn.	2.5	2.2
Hutchinson and others (2008)	REMA2	9.3	9.1
	REMA3	9	9.2
	Zaleski2	14.5	11.3
	Zaleski3	—	—
	Tar Hollow 2	—	—
	Tar Hollow 3	—	—
LaForest (2012)	Gold Mine	2.1	1.8
	Rabbit Creek	1.9	1.8
	Pine Mtn.	2.4	2.1
Maxwell and Hicks (2010)	Endless Wall	4.5	3.2
McEwan and others (2007)	Eagle Mill	2.1	1.7
	Watch Rock	8.4	8.2
	Ball Diamond	6.6	6.3
	Arch Rock	9	8.1
	Raccoon Creek	6.4	5.7
	Shawnee	5.3	4.7
	Road Branch	8.6	6.7
	Dickerson Hollow	12.2	11.1
	Silver Creek	—	—
McEwan and others (2014)	Big Everidge Hollov	9.3	—
Schuler and McClain (2003)	Pike Knob	19.5	17.1
Shumway and others (2001)	Big Savage Mtn.	8.2	7.6
Sutherland (1997)	REMA	5.4	3.6



- Physical models show a wide range in the Fire Return Interval (FRI) across the Appalachians
    - ~6 yrs to 40+ yrs
- Fire chronology studies (*location-specific*) confirm physical models
    - ~2 yrs to 20 yrs

Fire chronology-based fire: Lafon et al. 2017

The southern Appalachians: Thousands of years of disturbance

- Contact with European explorers occurred in the 1500s
- Depopulation of Indigenous Peoples resulted from disease, warfare, and eventually forced relocation
- European settlement in Appalachians varied, but really started to increase by the late 1700s – *after depopulation of Indigenous Peoples*
- Early European settlers had a subsistence living lifestyle
  - Typical: 20% pasture, 25% cultivated, 45% forest
  - Average family used 15 cords of wood/year (Nesbitt 1941)
  - Use of fire continued (clear land, browse for livestock) and often increased, with fire often more frequent and/or intense

NPShistory.com: NA:95G-212633

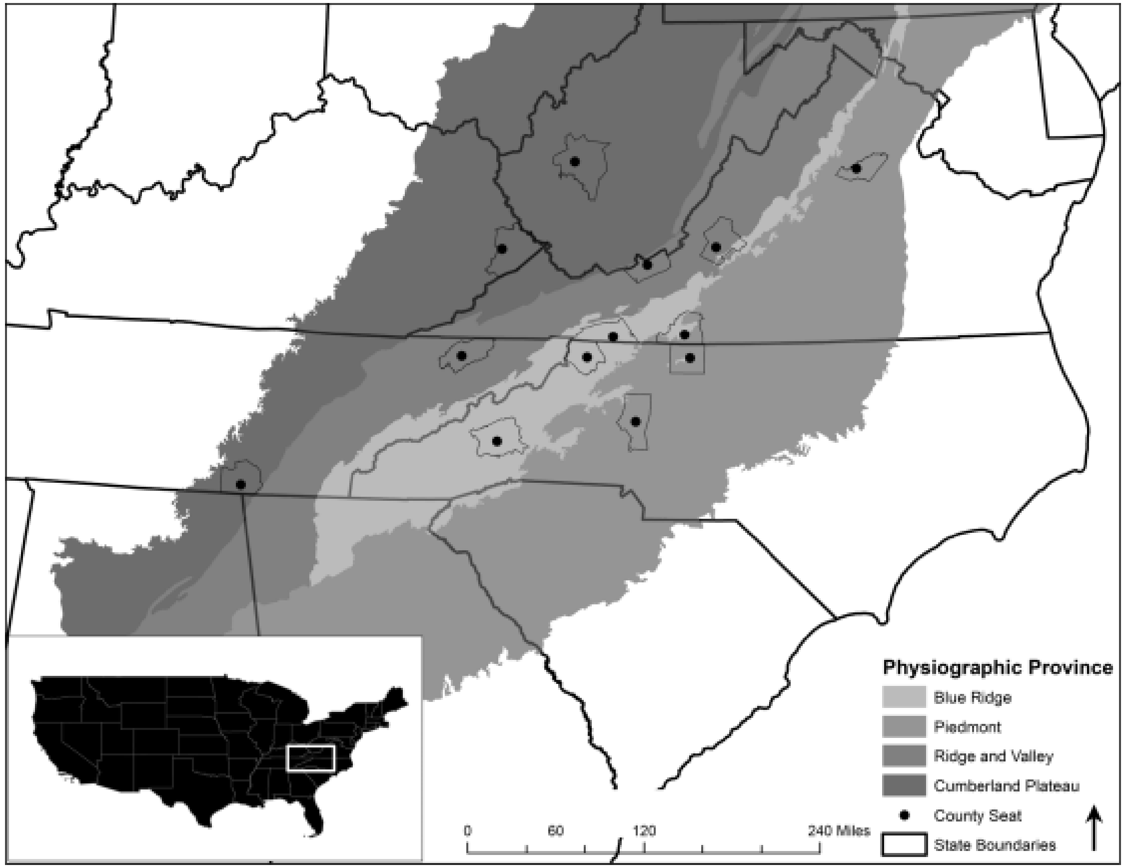
Agricultural Resources and Possibilities, 1907

Photos: Yarnell (1998)

Witness tree records ~settlement

Common name	# stems (% total) recorded
White oak	9,701 (31%)
Black oak	**2,314 (8%)**
Hickory	**2,127 (7%)**
Chestnut	**2,100 (7%)**
Beech	**2,056 (7%)**
Red oak	**1,558 (5%)**
Pine	**1,511 (5%)**
Yellow-poplar	1,271 (4%)
Scarlet oak	1,260 (4%)
Sugar maple	987 (3%)
Post oak	925 (3%)
Dogwood	808 (3%)
Red maple	691 (2%)
Chestnut oak	646 (2%)
Blackgum	606 (2%)
Ash	564 (2%)
Black walnut	428 (1%)
Basswood	401 (1%)
Buckeye	336 (1%)
Locust	286 (1%)
Sourwood	233 (1%)
Total	**30,809**

Common witness trees reported in land surveys from 1734 to 1830 in 13 counties in the southern Appalachian Mountains (*Copenheaver and Keyser 2016*)



A (drastic) change in the disturbance regime

Eastern TN State University

Southern Appalachian brook trout foundation

The late 1800s and into the early 1900s brought about a period of unregulated timber extraction.

In 1908, it was estimated that in western NC, 50% of forestland was owned by large companies, and 86% of the acreage in the Blue Ridge Mountains was either cleared, burned, or both.

Wildfires were common and much more intense than the purposeful fires set by Indigenous Peoples before European settlement and those by European settlers

http://npshistory.com/publications/usfs/region/8/history/chap1.htm

http://npshistory.com/publications/usfs/region/8/history/chap1.htm

http://npshistory.com/publications/usfs/region/8/history/chap1.htm

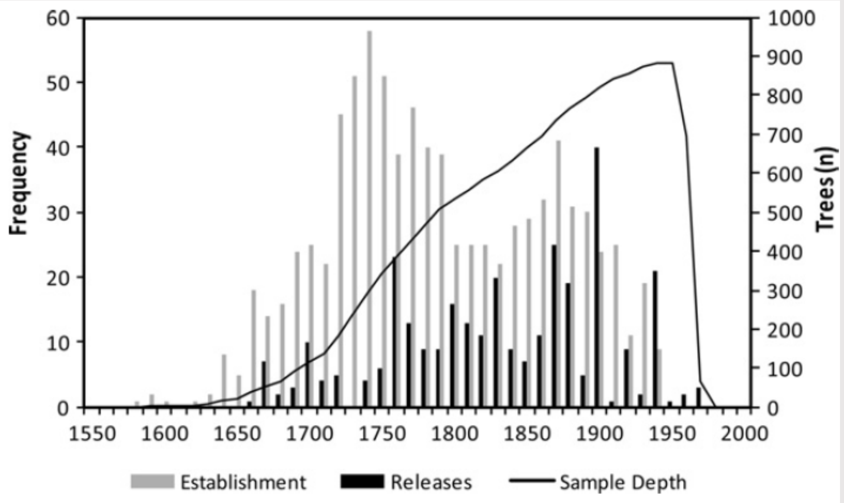
Library of Congress

Result: Cutover and degraded forests

Cutover and degraded land was abandoned (NFS in East) → Subsistence living transitioned to industrialization/ urban lifestyles → Fire suppression and exclusion → Keystone species (American chestnut) functionally extirpated → Forests re-grew and are the forests that dominate the present-day landscape → Stand-level overstory disturbance rates decreased relative to pre-European settlement rates

Korstian, 1930

Land abandonment



Buchanan & Hart (2012): Fig. 5. The establishment frequency, release frequency, and sample depth the 44 analyzed *Quercus alba* sites.

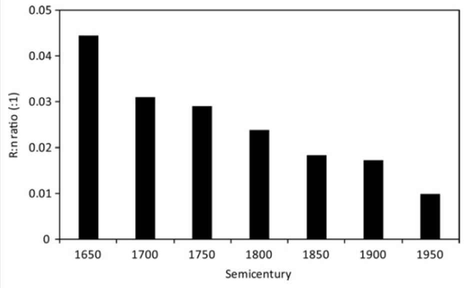
Library of Congress

Functional extirpation of keystone species

Indigenous Peoples – burning & other land uses

Early European settlement pasture, agriculture, girdling & fire *(Yarnell 1998)*

Agricultural Resources and Possibilities, 1907



Reduced overstory disturbance; Buchanan & Hart 2012

Wood utilization - subsistence agriculture

15 cords/family/yr (Nesbitt 1941)

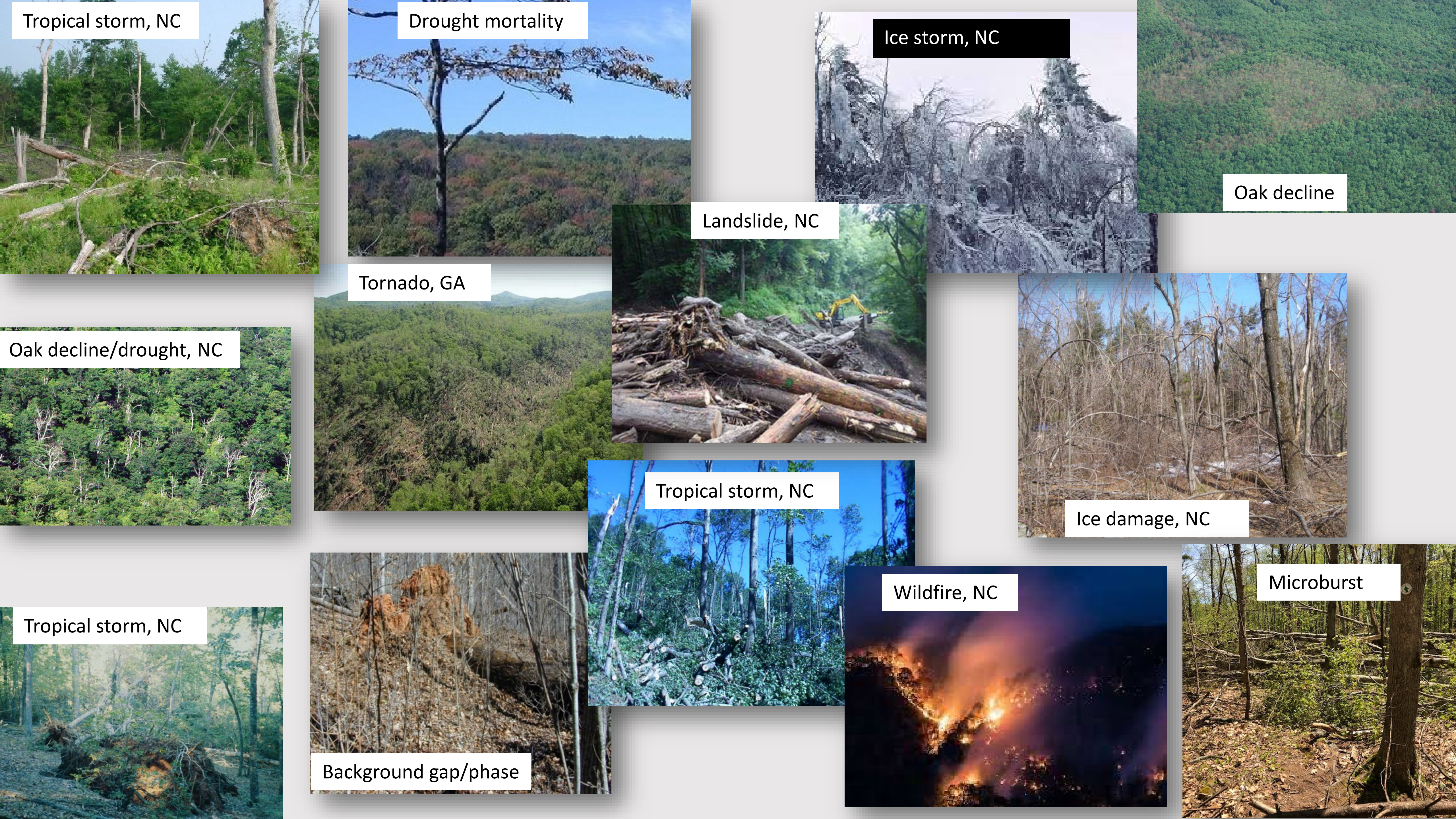
Fire suppression

Korstian 1930

Land abandonment

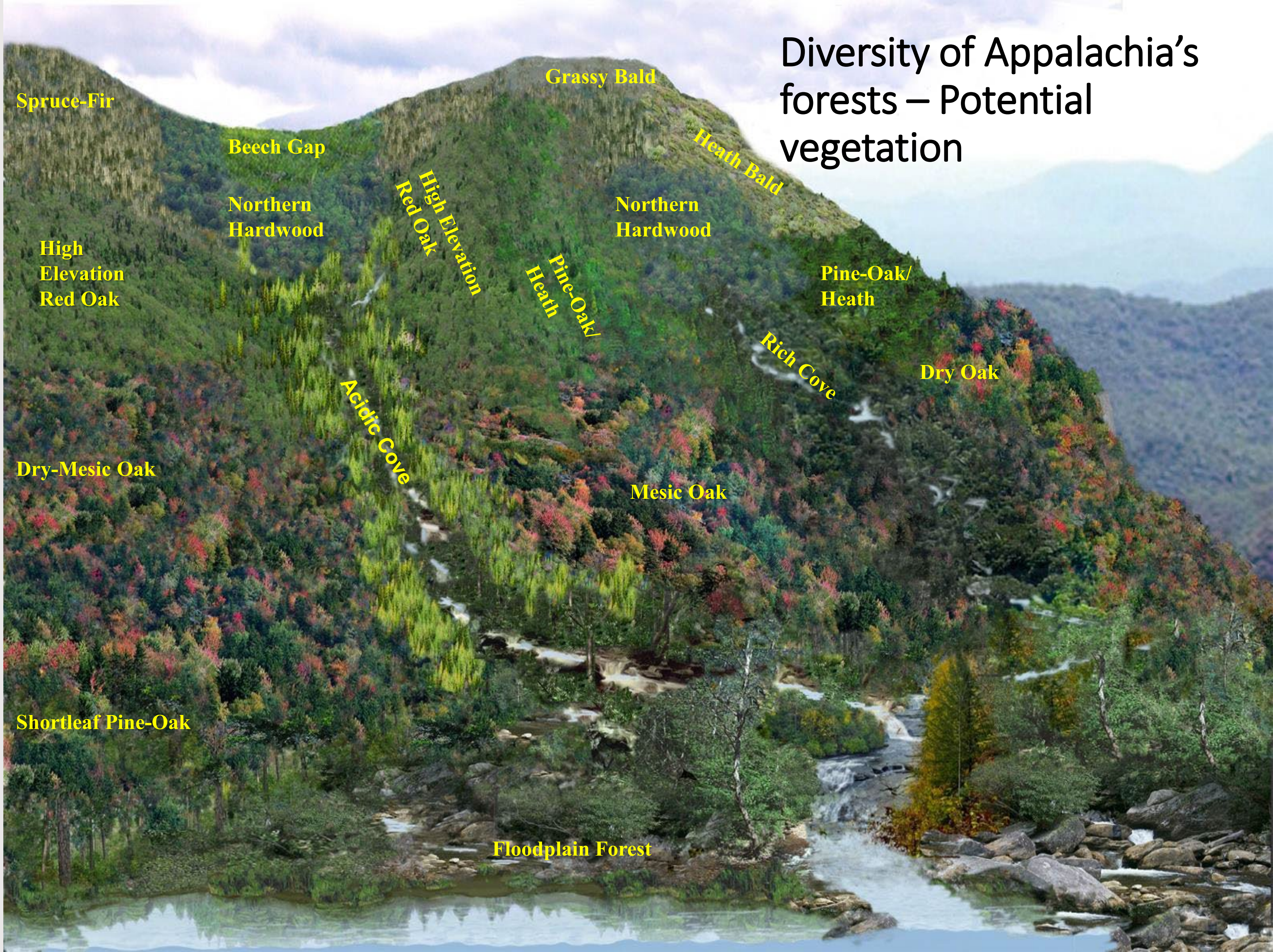
Exploitive logging/wildfires

Industrialization

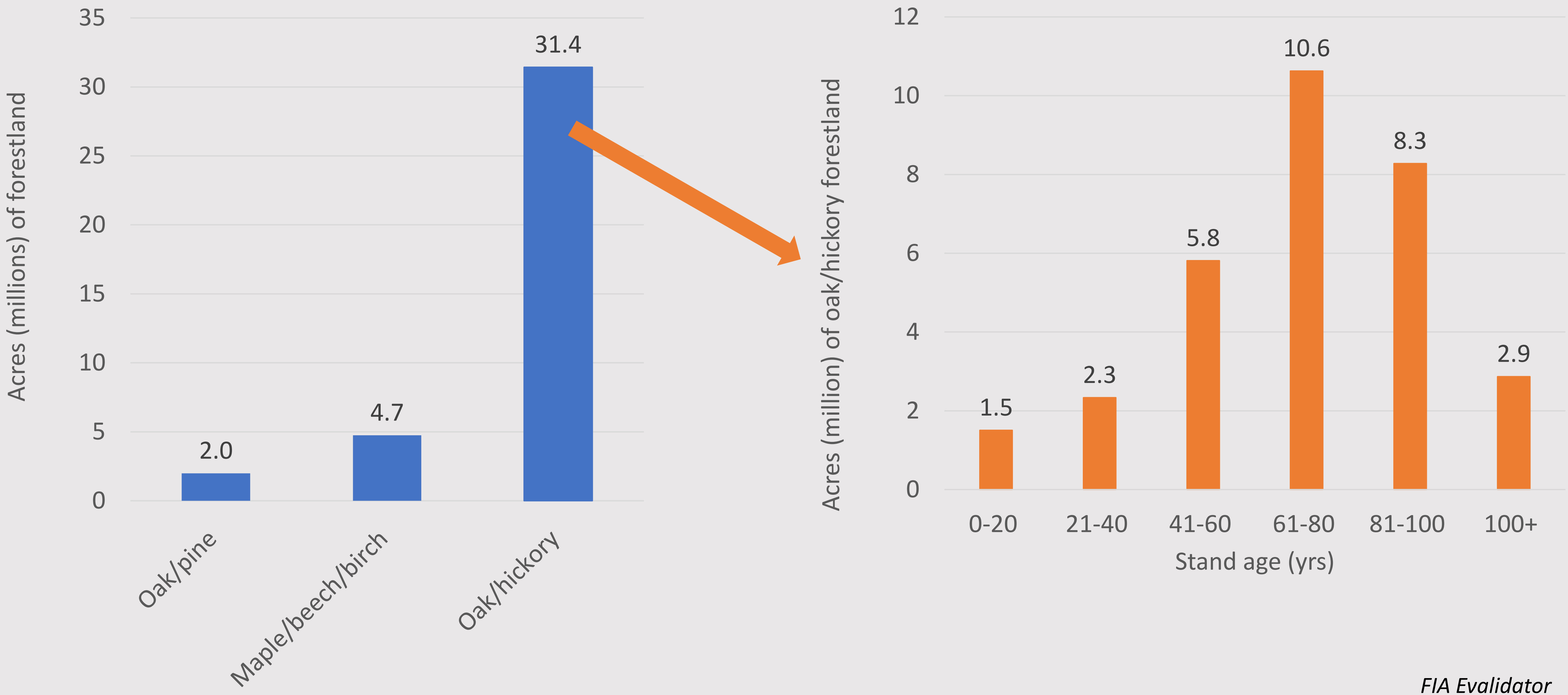

Tropical storm, NC
Drought mortality
Ice storm, NC
Oak decline
Landslide, NC
Tornado, GA
Oak decline/drought, NC
Ice damage, NC
Tropical storm, NC
Microburst
Wildfire, NC
Tropical storm, NC
Background gap/phase

Diversity of Appalachia's forests – Potential vegetation

Disturbances, both human and natural, interact with our diverse environmental conditions *(topography, microtopography, geology, soils, climate)* to influence forest conditions across the Appalachians



Contemporary forest conditions



FIA Evalidator

Lack the diversity in forest structures across the landscape that were present prior to land abandonment



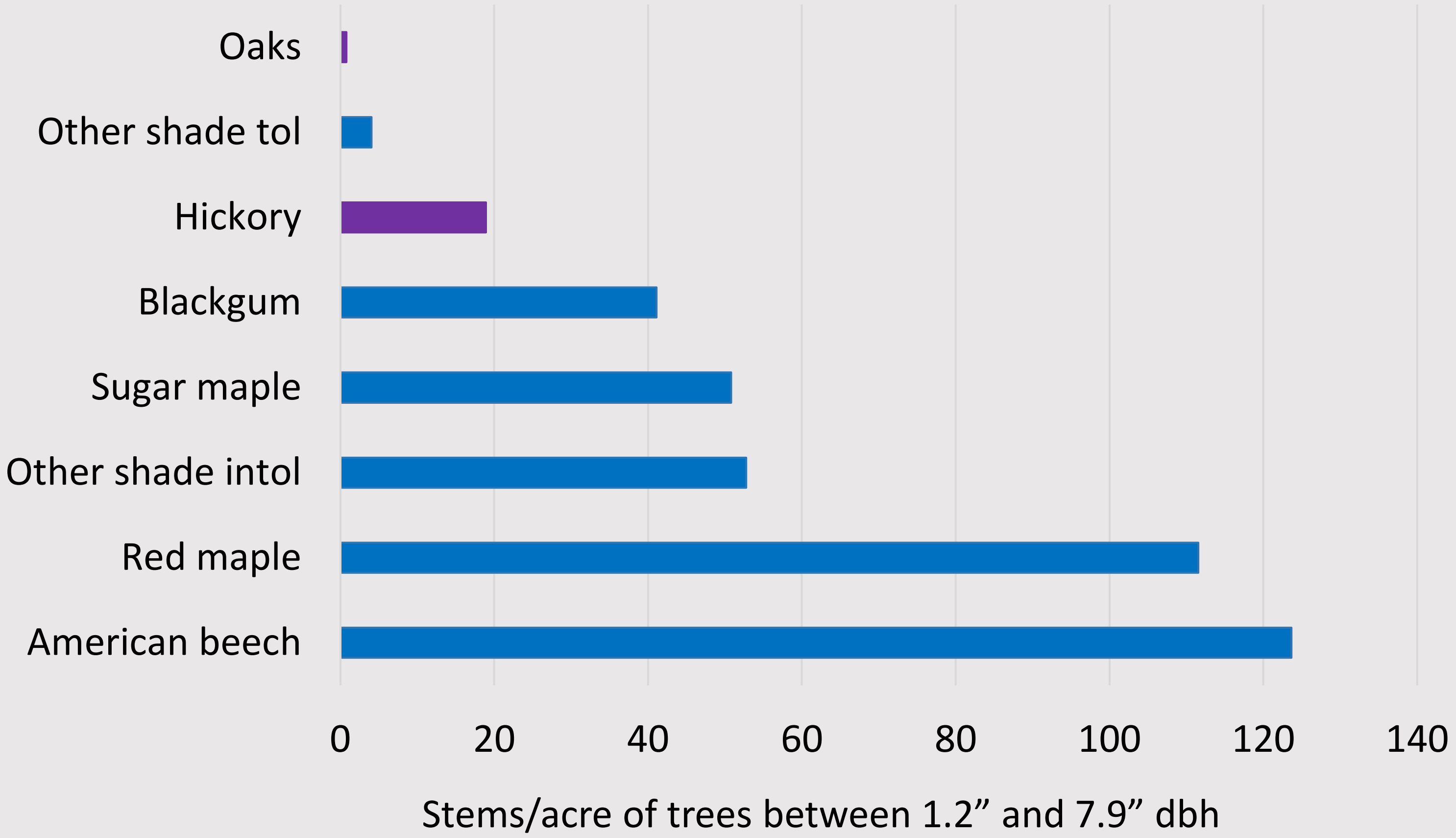




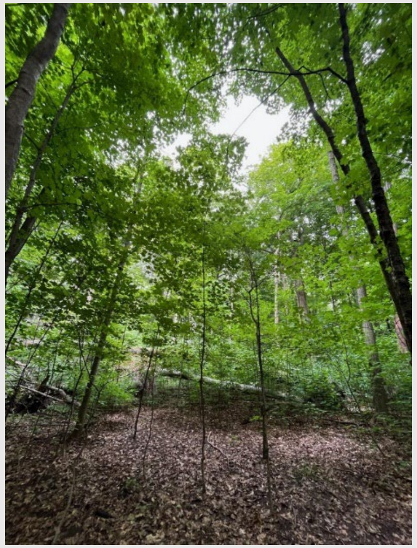




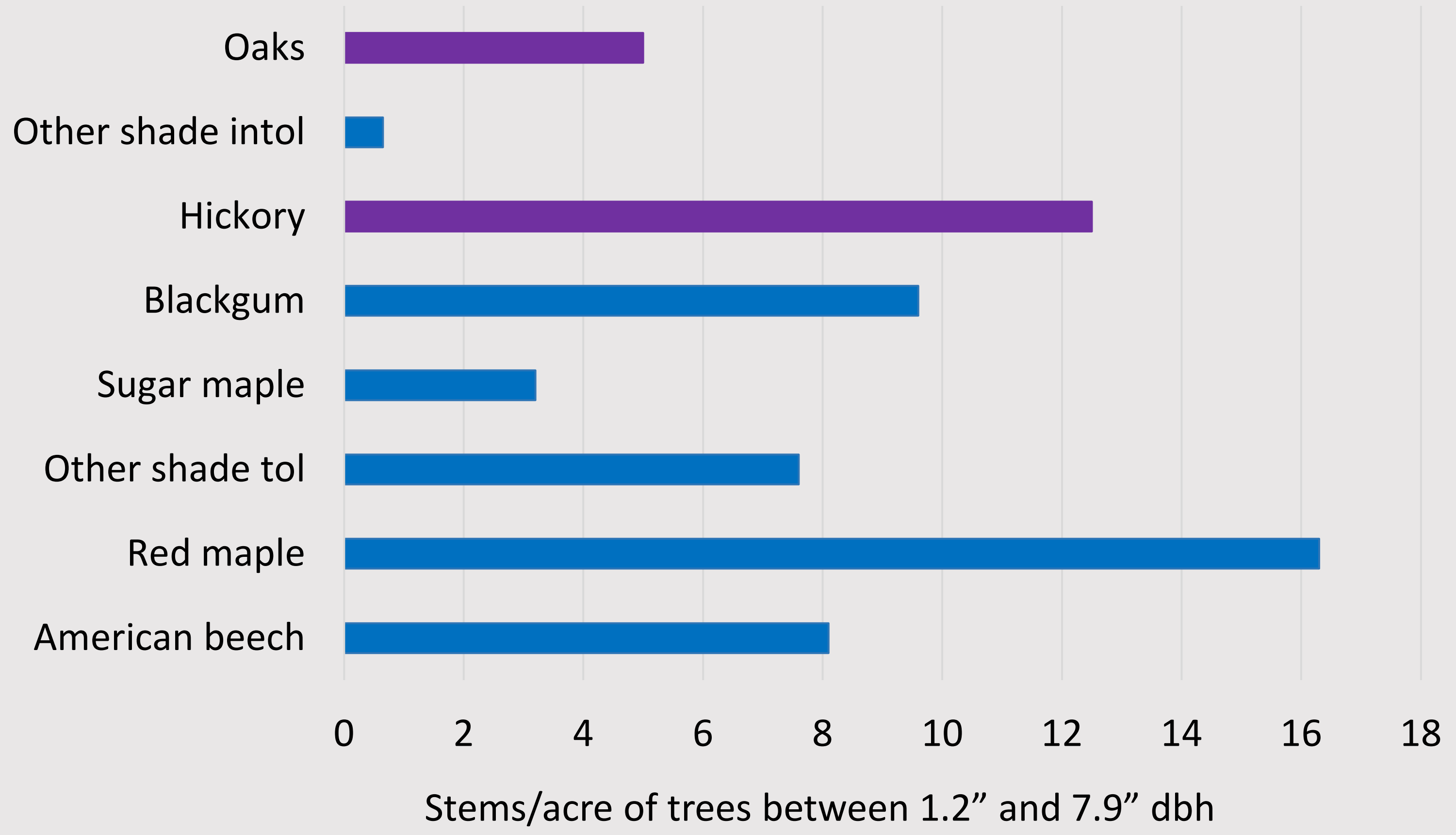
Closed successional forests: small gaps **W/O** previous disturbance

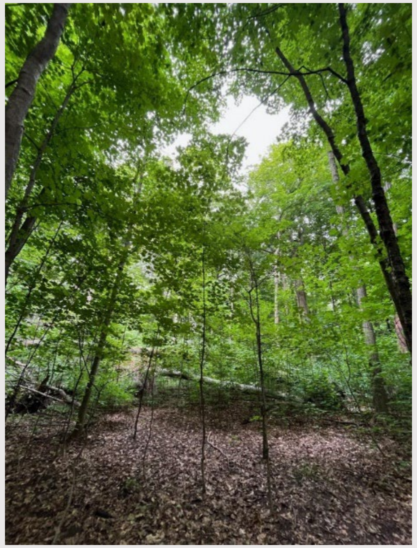


Data from Hutchinson et al. 2012



Closed successional forests: small gaps WITH previous disturbance

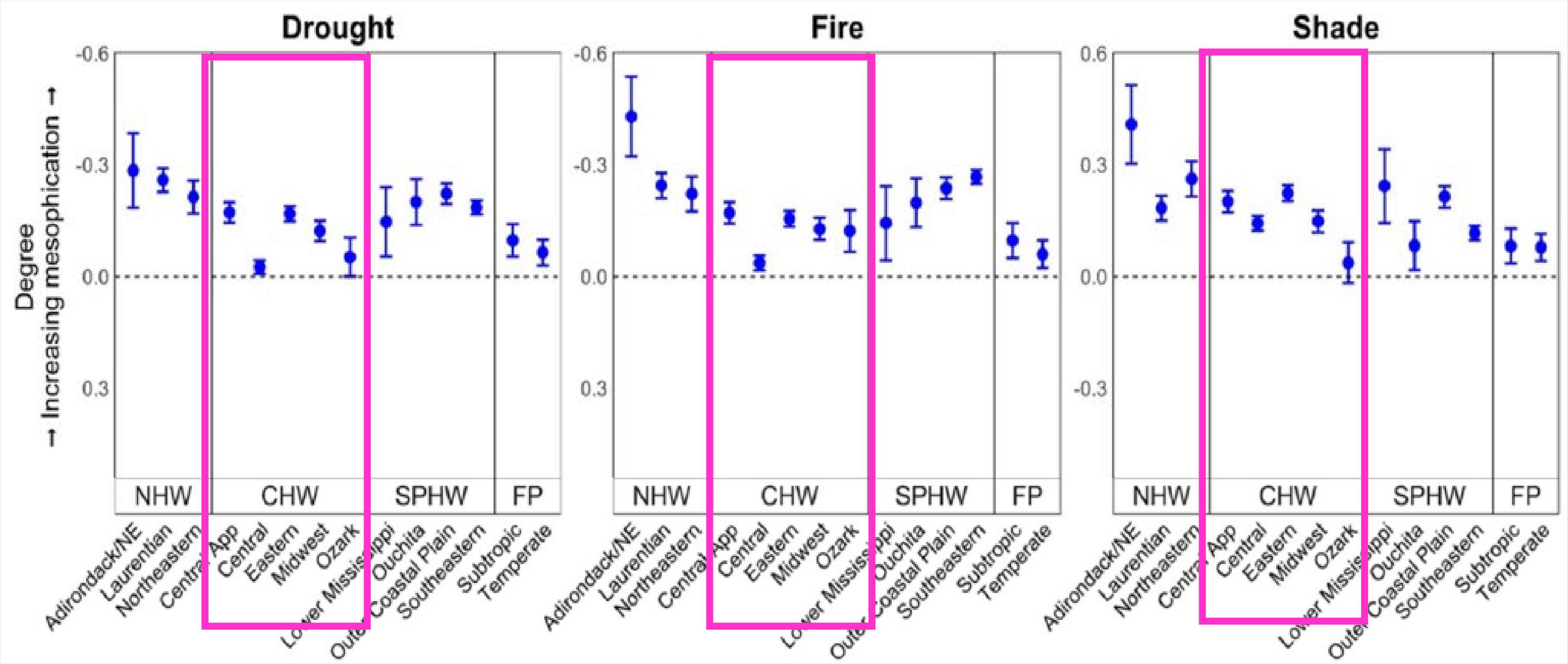




Data from Hutchinson et al. 2012

Landscape trends in mesophication

- Difference in the CWM of drought, fire, and shade tolerance ratings between the overstory (≥10”) & midstory (≥5 and <10”)
- Evidence for successional dynamics that predict increasing shade tolerance through time coincident with less fire- and drought-tolerant forests in much of the eastern US
- Increasing severity of mesophication as stand ages increases

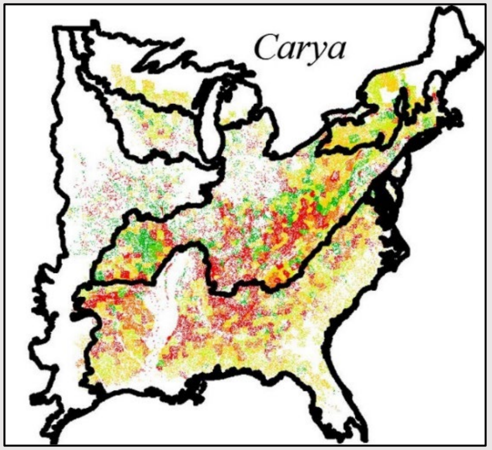


Woodbridge et al. 2023

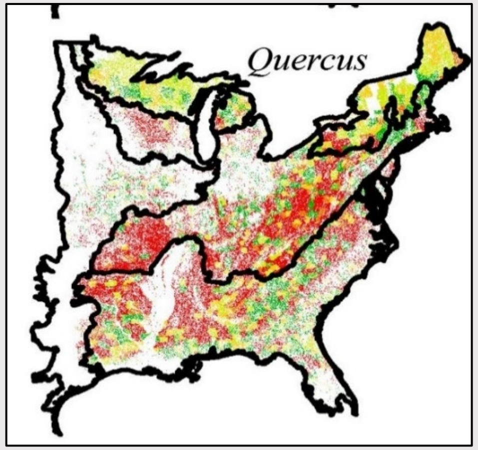
Trends in species importance & mesophication

Changes in species importance (relative density + relative volume)/2) (1980-2015)

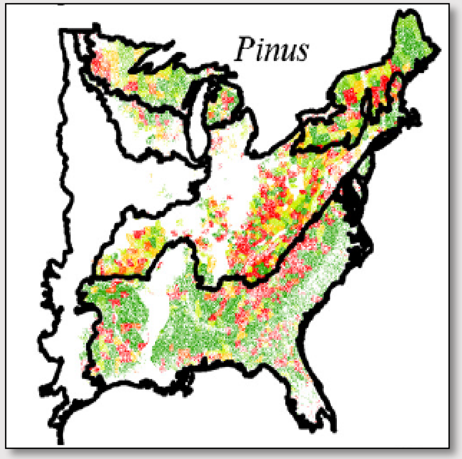
Hickory



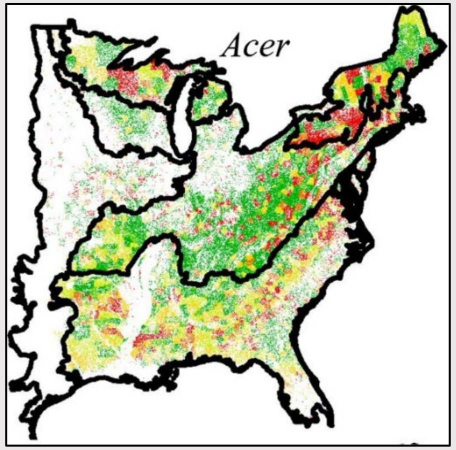
Oak



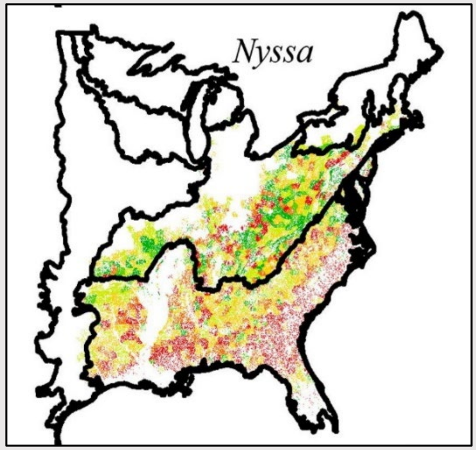
Pines



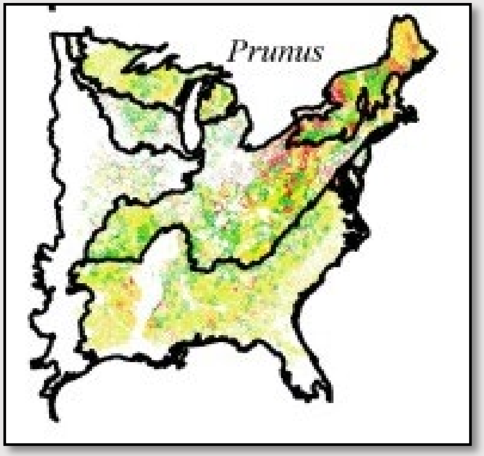
Maple

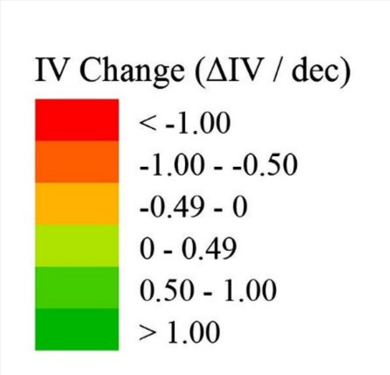


Gum



Cherry





Knott et al. 2019

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Oaks are dying at record rates across Chesapeake region

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H.R. 5582 (IH) - White Oak Resilience Act

THE COURIER

TOP STORY

Mystery disease and drought is killing Iowa's white oaks

ERIN JORDAN The Gazette Nov 7, 2022 Updated Dec 12, 2022

The Washington Post
Democracy Dies in Darkness

D.C., Md. & Va. The District Maryland Virginia Crime & Public Safety Local Education Obituaries Transportation Capital Weather Gang

LOCAL

Across the Mid-Atlantic, giant oak trees are dying

By Alisa Tang
November 25, 2021 at 4:00 a.m. EST

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NEWSROOM: TEXAS A&M FOREST SERVICE CONFIRMS INCREASE OF POST OAK MORTALITY IN TEXAS

Oct. 20, 2016 — COLLEGE STATION, Texas — Post oak trees across the state are facing higher mortality rates in both

JOURNAL ARTICLE

Threats to Oaks in the Eastern United States: Perceptions and Expectations of Experts

Anna O Conrad, Ellen V Crocker, Xiaoshu Li, William R Thomas, Thomas O Ochuodho, Thomas P Holmes, C Dana Nelson

Journal of Forestry, Volume 118, Issue 1, January 2020, Pages 14–27, https://doi.org/10.1093/jofore/fvz056
Published: 28 November 2019 Article history

radio IQ | wvtf Virginia's Public Radio

News

Virginia oaks in danger

RADIO IQ | By Sandy Hausman
Published November 7, 2022 at 5:46 PM EST

LISTEN • 3:26

American Forests What We Do Our Approach Resources

Barr Announces Formation of Congressional White Oak Caucus

April 8, 2022

Washington, D.C.– Today, U.S. Congressmen Andy Barr (R-KY), Steve Cohen (D-TN), Scott DesJarlais (R-TN) and Ami Bera (D-CA) announced the creation of the

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Gypsy Moths On The Decline — For Now — But Damage Is Already Done

03:44

dcist

DEC 20, 2023, 9:05 AM

Local Forests Are Failing To Produce The Next Generation Of Trees

Jacob Fenston Tyrone Turner

CONSERVATION & SUSTAINABILITY

PrairieFarmer

Why are white oak trees dying?

Tree Talk: A new disease is moving into Illinois from Missouri, and it's rapidly killing white oak tre

Fredric Miller 3 Min Read

JOURNAL ARTICLE EDITOR'S CHOICE

The Drought Response of Eastern US Oaks in the Context of Their Declining Abundance

Kimberly Novick, Insu Jo, Loïc D'Orangeville, Michael Benson, Tsun Fung Au, Mallory Barnes, Sander Denham, Songlin Fei, Kelly Heilman, Taehee Hwang, Tara Keyser, Justin Maxwell, Chelcy Miniat, Jason McLachlan, Neil Pederson, Lixin Wang, Jeffrey D Wood, Richard P Phillips

BioScience, Volume 72, Issue 4, April 2022, Pages 333–346,
ttps://doi.org/10.1093/biosci/biab135
ublished: 25 January 2022

Phytophthora cinnamomi as a Contributor to White Oak Decline in Mid-Atlantic United States Forests

M. E. McConnell and **Y. Balci,** Department of Plant Science and Landscape Architecture, University of Maryland, College Park, MD 20742

Open Access | Feature Paper | Article

Forest Regeneration Following Emerald Ash Borer (*Agrilus planipennis* Fairemaire) Enhances Mesophication in Eastern Hardwood Forests

by Benjamin Dolan [1,*] and Jason Kilgore [2]

[1] Department of Biology, University of Findlay, 1000 North Main Street, Findlay, OH 45840 USA
[2] Biology Department, Washington & Jefferson College, 60 South Lincoln Street, Washington, PA 15301 USA
[*] Author to whom correspondence should be addressed.

Forests **2018**, *9*(6), 353; **https://doi.org/10.3390/f9060353**

WILDLIFE & NATURE

For Better and Worse: Statewide Oak Tree Mortality Changes Rhode Island's Landscape

By Cynthia Drummond / ecoRI News contributor | June 3, 2021 | Share

Naturalist's Notebook

Threats to the Tree of Life

Magnificent, strong and once thriving in Appalachian forests, oaks now struggle to regenerate. As deadly diseases spread in other regions, a new alliance is emerging to protect this key species.

Eliza Laubach | December 16, 2019 | No Comments

Provisioning services

Gerald Holmes, Strawberry Center, Cal Poly San Luis Obispo, Bugwood.org.

- Timber/fiber, Fuel wood
- Non-timber forest products/human food resources
- Medicinal products
- **Water:** Forests in the Southeast deliver surface drinking water to 48.7 million people
- Streams from the southern Appalachian region alone providing water supplies to 10 million people
- After accounting for climate, the process of mesophication reduced annual water yield in western NC watersheds by as much as 18% (Caldwell et al. 2016)
- On an average summer day, a 12”:
  - Red maple uses 17 gallons of water
  - White oak uses 5 gallons of water

Regulating services

Carbon sequestration & storage

- Replacement of oaks/hickories by mesophytic tree species coupled with mild, but chronic, reductions in water availability can decrease the C sink of deciduous forests by up to 17% in the next few decades (Brzostek et al. 2014)
- As mesophication continues, sensitivity of the ecosystem to drought over the course of the growing season will cause larger reductions in growth and carbon sequestration (Au et al. 2020)

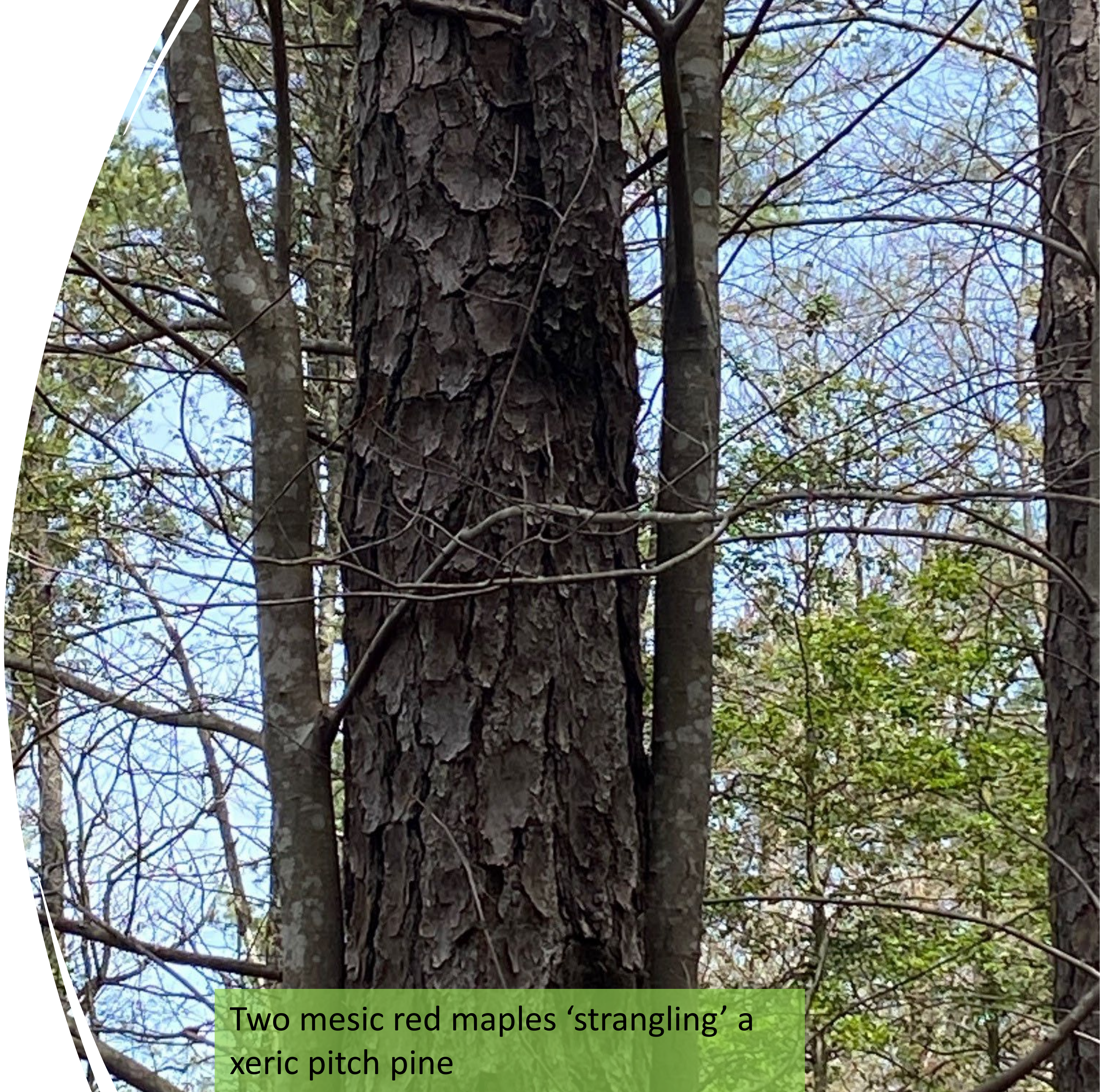
Supporting services

- Wildlife habitat: Acorns are considered a keystone forest food resource: >90 wildlife species rely on or benefit from acorns as food resource
- Bark texture, leaf structure, and leaf chemistry support arthropod populations which enhances bird diversity and abundance
- Nutrient cycling (Alexander and Arthur 2014)

Cultural services

- Recreation-$$$
- Tourism-$$$
- Spirituality
- Artistic inspiration/appreciation

Short break for questions


Two mesic red maples 'strangling' a xeric pitch pine

Climate change winners (Blue Ridge Mtns – M221D)

Species	Adaptability	Habitat change (CI85)	Capability to cope (CI85)
Chestnut oak	High	No change	Very good
Northern red oak	High	Small increase	Very good
Scarlet oak	Medium	No change	Fair
White oak	High	Small increase	Very good
Black oak	Medium	Large increase	Very good
Southern red oak	High	Large increase	Very good
Pignut hickory	Medium	Small increase	Good
Mockernut hickory	High	Large increase	Very good
Blackgum	High	Small increase	Very good
Yellow-poplar	High	Small decrease	Good
Red maple	High	Small decrease	Good
American beech	Medium	Small increase	Good
Shortleaf pine	Medium	Large increase	Very good
Pitch pine	Medium	Small increase	Good

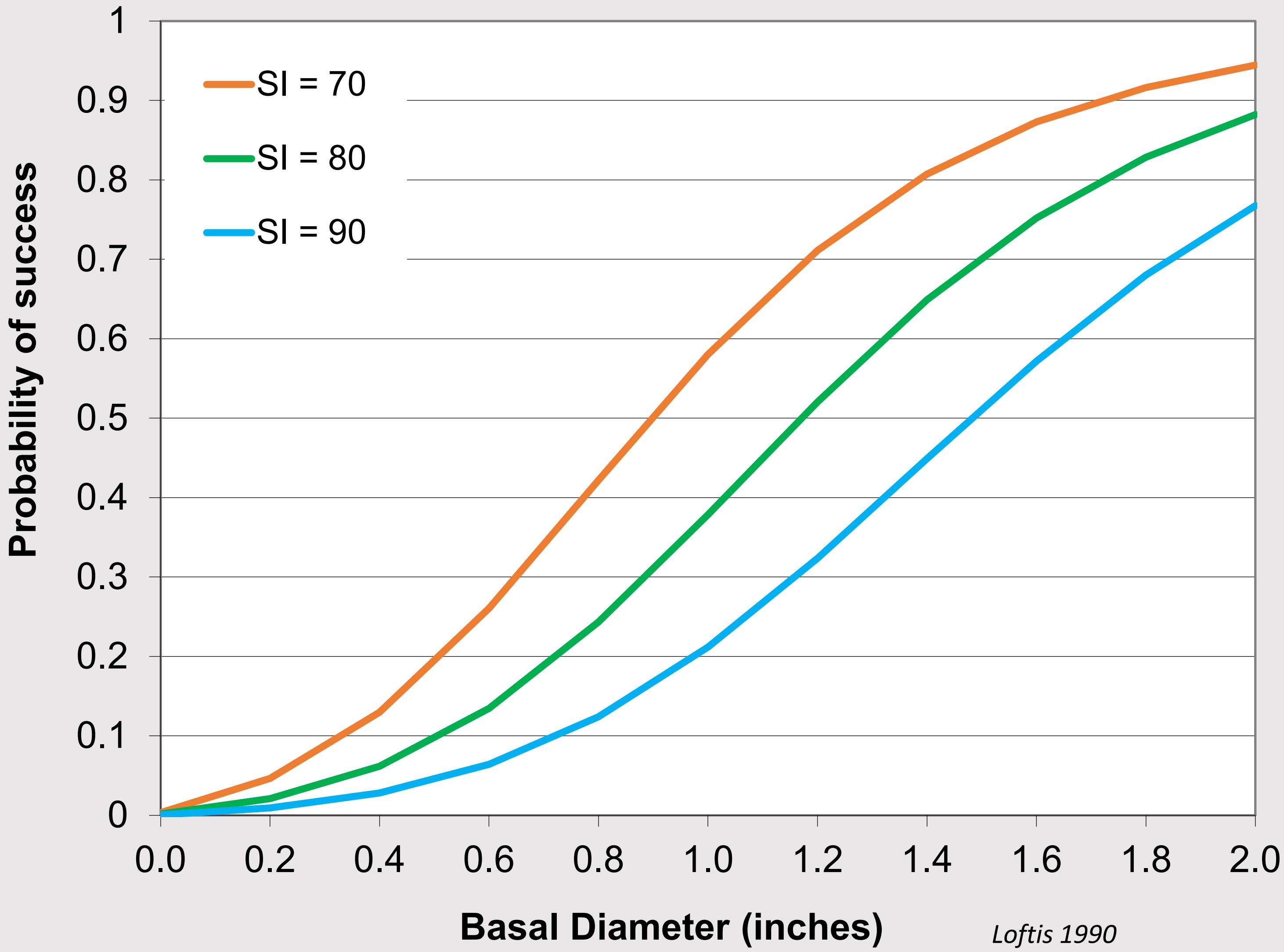
FOREST SERVICE U S DEPARTMENT OF AGRICULTURE

Climate Change Atlas

USDA FS, Climate Change Tree Atlas (v4);
https://www.fs.usda.gov/nrs/atlas/tree/

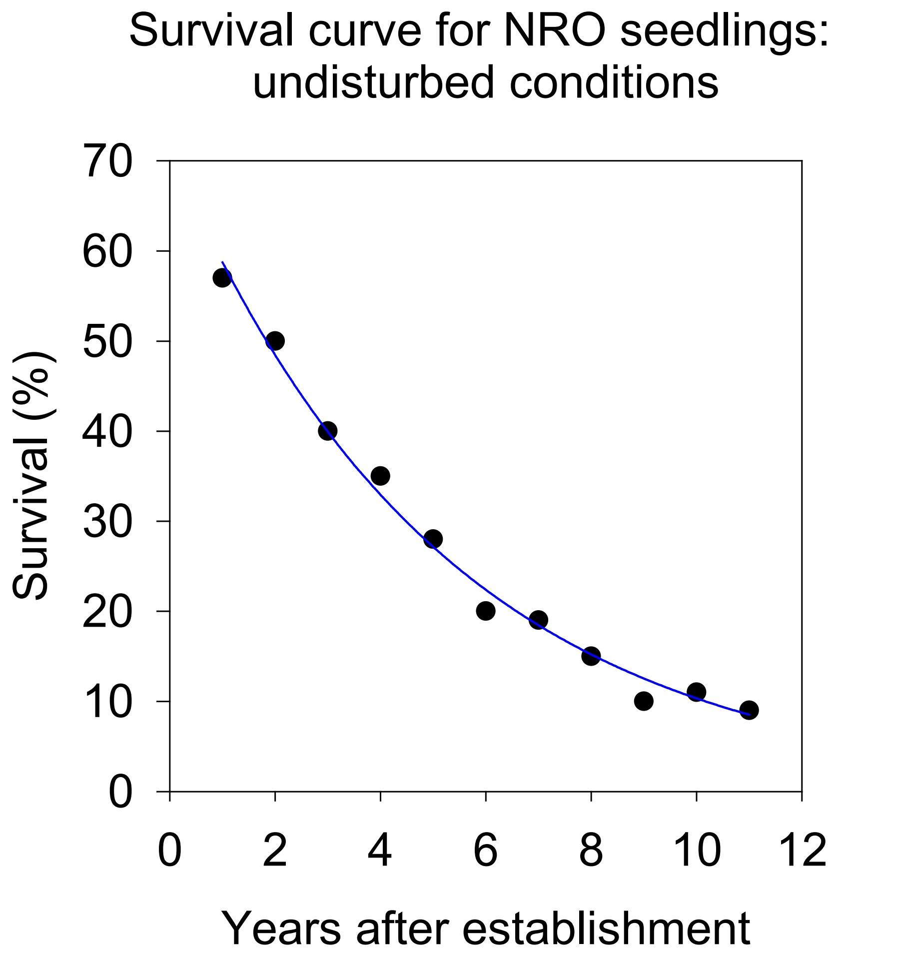
Oaks – adapted to frequent disturbance

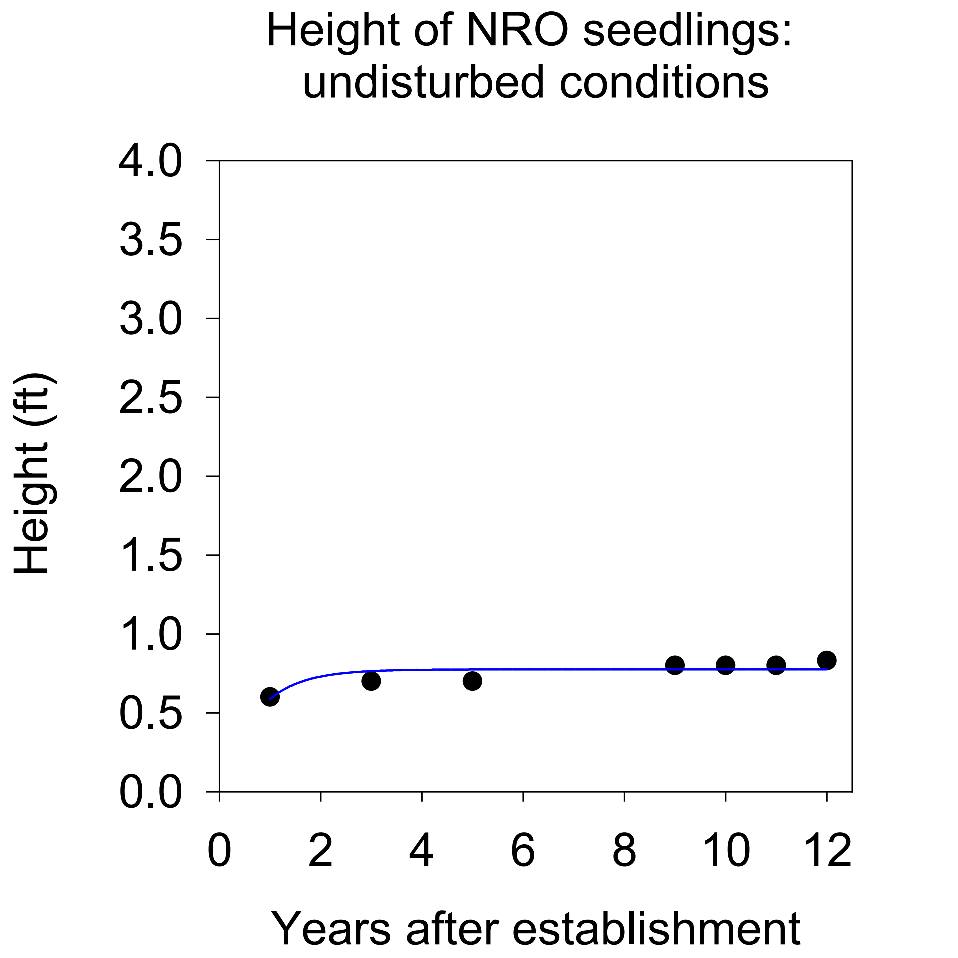
- Oaks, hickories, and many other species are mid-tolerant of shade are ***advanced growth dependent***
    - ***If oak isn't in the stand prior to disturbance (as advance reproduction OR stump sprouts), it is not going to magically show up in your stand after a disturbance and be successful!!***
- Successful oak regeneration and recruitment is dependent sprouting from mature trees **AND** the existence of ***large*** oak/hickory saplings (stems ~>4.5')



Loftis 1990

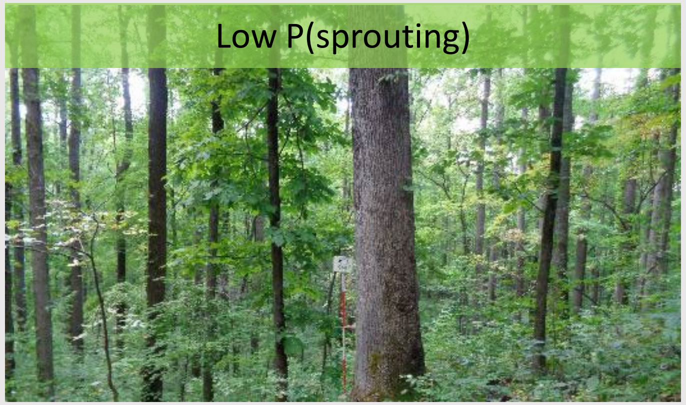
NRO population dynamics in the absence of disturbance





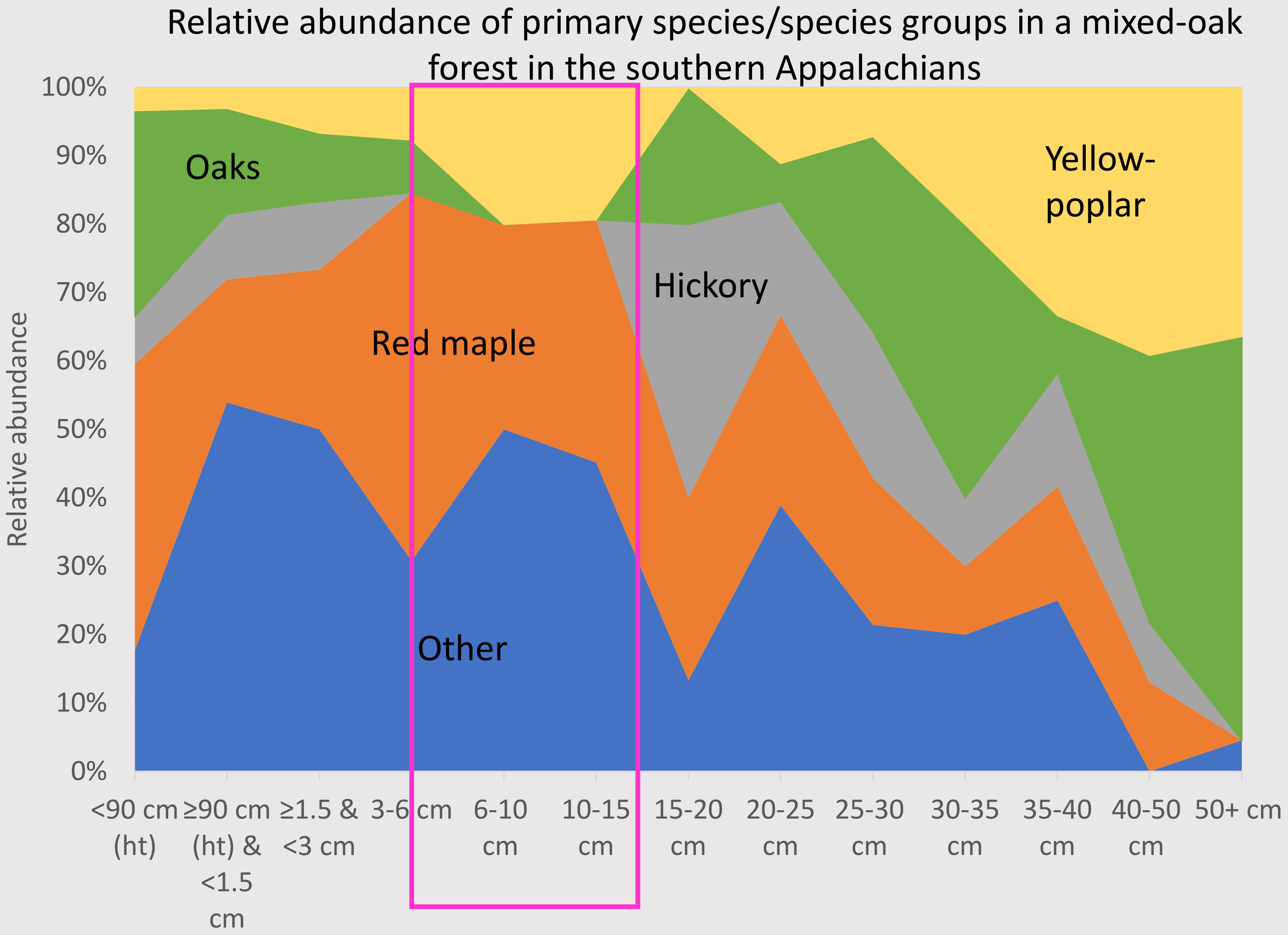
- Similar findings to recent study by Brose and Rebbeck (2017); low survival and height growth in undisturbed conditions:
    - Black oak
    - Chestnut oak
    - Northern red oak
    - White oak

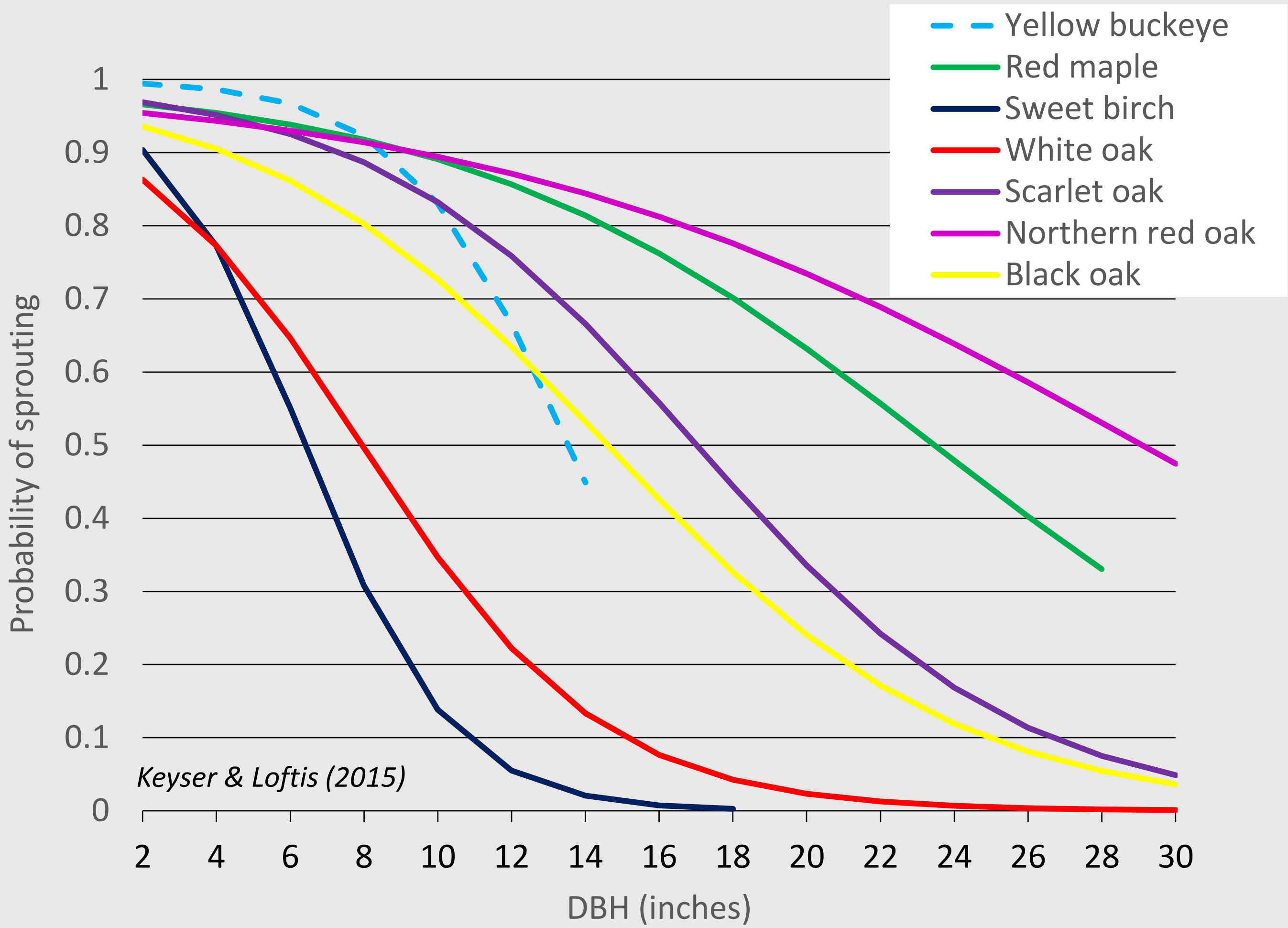
Loftis (1983)


Low P(sprouting)


Typical small oak seedling


New poplar seedlings


Relative abundance of primary species/species groups in a mixed-oak forest in the southern Appalachians
Relative abundance
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Oaks
Yellow-poplar
Hickory
Red maple
Other
<90 cm (ht)
≥90 cm (ht) & <1.5 cm
≥1.5 & <3 cm
3-6 cm
6-10 cm
10-15 cm
15-20 cm
20-25 cm
25-30 cm
30-35 cm
35-40 cm
40-50 cm
50+ cm



Species	Sprout rate
Striped maple	80
Sugar maple	74
Hickory	95
American beech	93
Yellow-poplar	80
Cucumbertree	67
Fraser magnolia	95
Blackgum	72
Sourwood	97
Silverbell	100
Chestnut oak	78
White basswood	99

Basic tenets of the oak regeneration process

- Oaks must be in your stand before disturbance
- Don't count on stump sprouts: If they sprout, it's great, but don't rely on sprouting
- Oak seedlings must be present in "adequate" numbers (*more is always better*)
- Low to moderate severity disturbances (repeated and in advance of the overstory disturbance/release events) are necessary for oak seedlings to grow into competitive sources of regeneration….**MANAGING UNDERSTORY LIGHT**
- Canopy-disturbance(s) must occur for competitive oak seedlings to recruit into canopy positions
- Ongoing low to moderate severity disturbances must likely continue at varied spatial and temporal scales to manage competition and facilitate ongoing recruitment

Historic disturbance regime as a recipe for ecological oak regeneration

Disturbance regime that has perpetuated oak/hickory forests (across space & time) ***prior to exploitive logging*** was based on frequent, low-severity disturbances (e.g., fire, grazing), punctuated by intermediate disturbances/release events (e.g., wind, ice, drought)

These intermediate severity/frequency disturbances rarely cause complete overstory removal; ecological memory maintained

Canopy gaps are an integral component of the disturbance regime and, depending on composition and size distribution of the understory at the time of gap formation, create opportunities for recruitment for species across the shade-tolerance spectrum

Windthrow-caused gaps - Hurricane Opal (1994), western NC

Historic disturbance regime as a recipe for ecological oak regeneration

Manage understory light (prior to disturbance)

- Prescribed fire
- Thinning
- Midstory removal*

Manage release events

- Regeneration harvests

Managing competition (after disturbance)

- Prescribed fire
- Chemical release treatments
- Mechanical release treatments
- Invasives control (chemical)

Crown-touch release trts

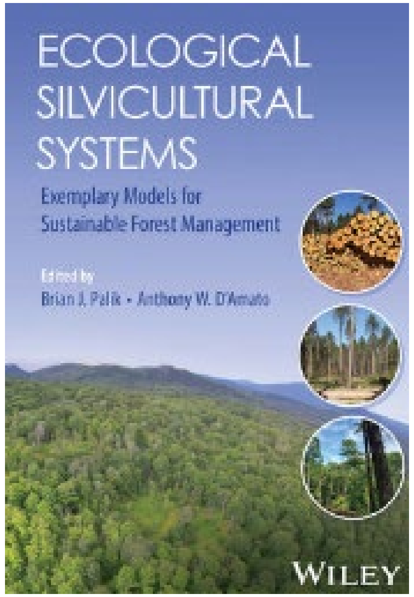


Table 8.2 An ecological silvicultural system for southern Appalachian mixed-oak forests.

Stage	Years	Potential actions	Outcome
Disturbance/ Legacy creation	0	Initial harvest for an irregular shelterwood expanding-gap system (occurs in Mature or Old Forest); create snags and leave deadwood	Continuity of structure; initiate preforest stage
Preforest	1–10	Site preparation to remove non-merchantable stems following harvest Midstory removal treatment	Midstory removal treatments are important for manipulating understory conditions to favor development of mid-tolerant species
Young forest	10–40	Competition control; crown-touch release treatments	Increase competitiveness of established mid-tolerants
	40–70	Pre-commercial thinning; continued competition control; midstory removal	
Mature forest	70–120	Initial harvest followed by expansion entries every decade up to four times; additional entries to regenerate new areas; site preparation and competition control between entries	Increase growth and canopy heterogeneity; add microsite variability; establish new cohorts; release oak and hickory regeneration with subsequent entries; create 5 age classes
Old forest	100+	Oak and hickory should represent ≥30% of stand composition; expand natural gaps or initiate new harvest sequence	Enrich species, maintain structurally complex and diverse conditions

The Irregular Shelterwood System: Review, Classification, and Potential Application to Forests Affected by Partial Disturbances

Patricia Raymond, Steve Bédard, Vincent Roy, Catherine Larouche, and Stéphane Tremblay

Three 'variants' described by Raymond et al. 2009

Expanding gap – Bavarian (Bayerischer) Femelschlag

Continuous cover – Swiss/Baden/Badischer Femelschlag

Extended – akin to two-aged

Expanding gap Femelschlag

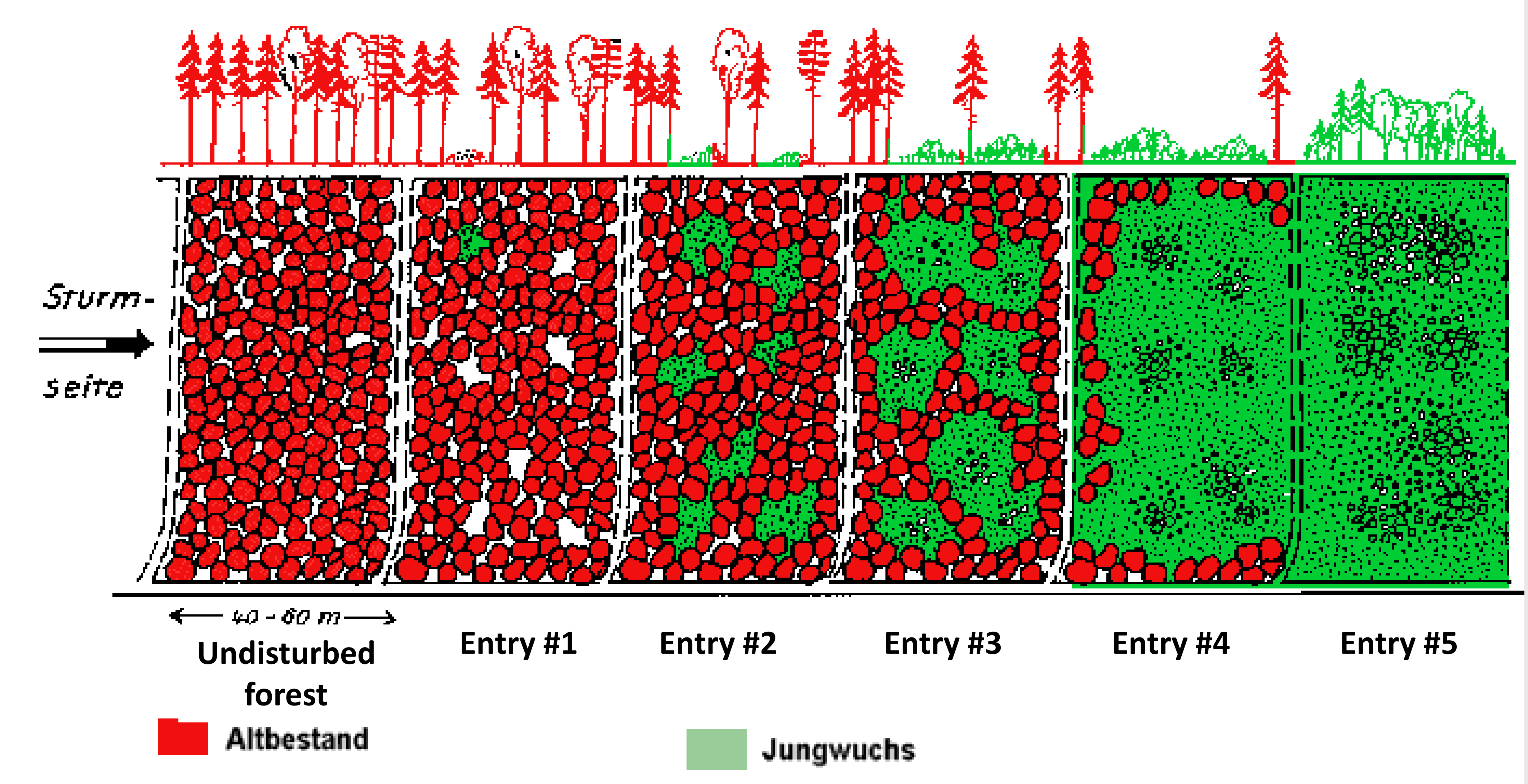


Figure depicts 5 entries, but it's flexible and can be adapted to site-specific conditions

WHY? - LIVING ON THE EDGE

Support for implementing 'expanding gap' Femelschlag in upland oak forests

2021 Forest Stewards Guild tour participants view a 0.25-acre gap in the Appalachian Femelschlag, Asheville, NC

Support for ‘expanding gap’ Femelschlag: gaps & light

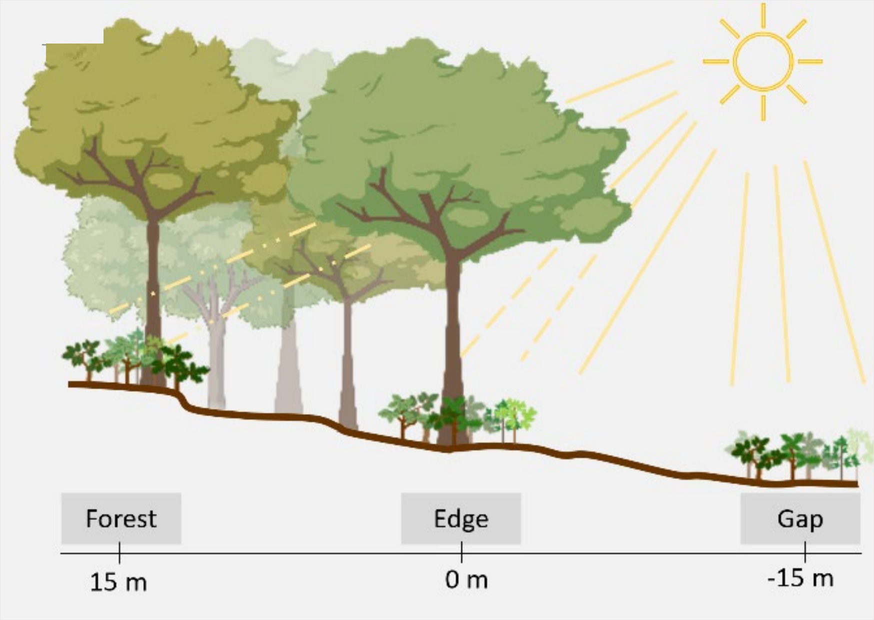
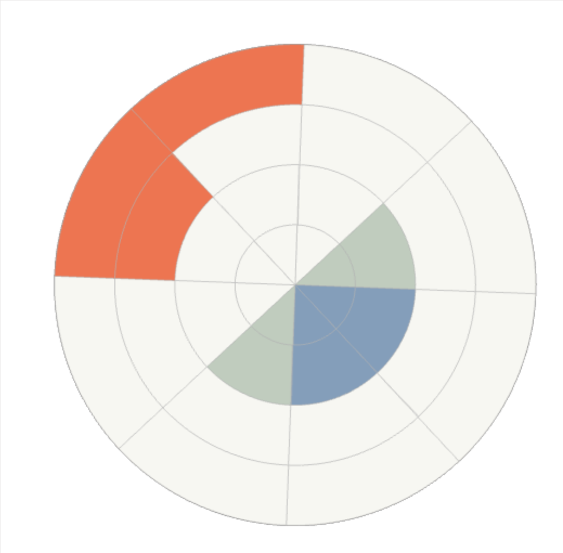


Diagram courtesy of Morgan Arteman, PhD candidate, NC State University

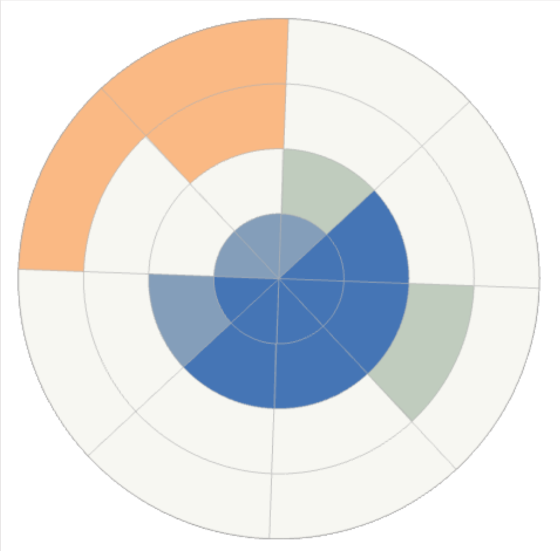
Lu et al. 2018

Support for ‘expanding gap’ Femelschlag: Stem-mapped data in group openings *(unpublished data from Schnake et al.)*

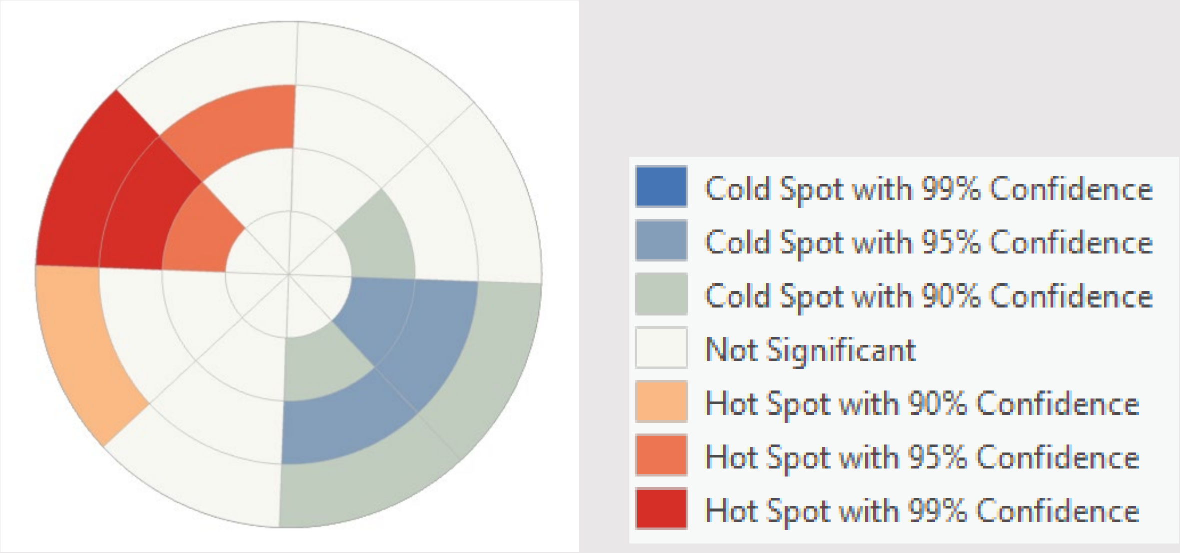
Red Oaks (1079 mapped points)



Hickories (130 mapped points)



White Oaks (1030 mapped points)

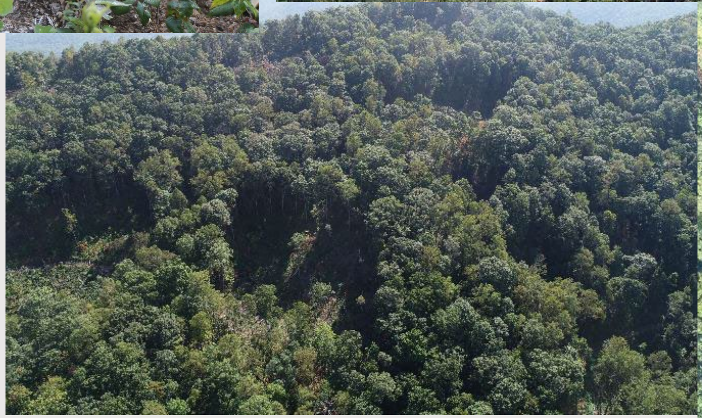


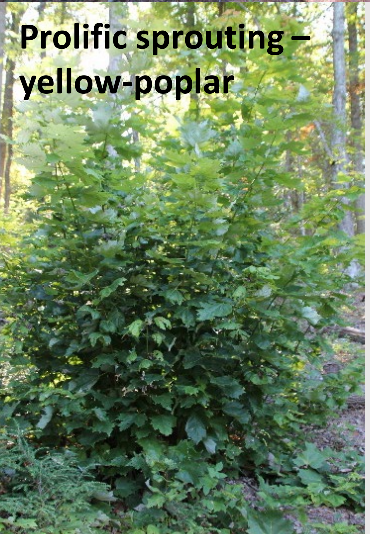
Appalachian Femelschlag

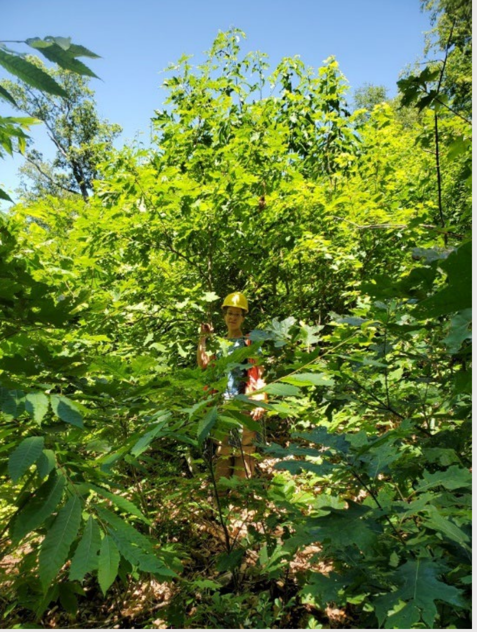
- Informed by the observed success of oak/hickory at the edges of natural and silvicultural openings
- 150-acre oak/hickory stand on the Pisgah National Forest (SI: ~85 ft)
    - ~47% of the BA oak/hickory; 25% yellow-poplar; 14% red maple
- Two treatments (3 reps/treatment)
    - **<u>Small gap</u>:** 25% of the stand regenerated in 0.25-acre gaps during 1st entry *(upper limit of gaps created during 'natural' gap-phase dynamics in mesic eastern hardwood forests – Runkle 1982)*
    - *53 total small gaps*
    - **<u>Large gap</u>:** 25% of the stand regenerated in 1-acre gaps during 1st entry (*~median gap size created during Hurricane Opal in western NC; McNab et al. 2004)*
    - *18 total large gaps*
- Site-prep within gaps: slash down of all stems <8" dbh <u>*except for* oaks, hickories, other soft mass trees</u>
- Midstory removal (hack 'n squirt herbicide) conducted throughout the non-gap matrix
    - Stems 2 – 8" injected (yellow-poplar, silverbell, striped & red maple, blackgum, sweet birch, beech, sourwood, paulownia, tree-of-heaven, rhodo, mtn laurel)

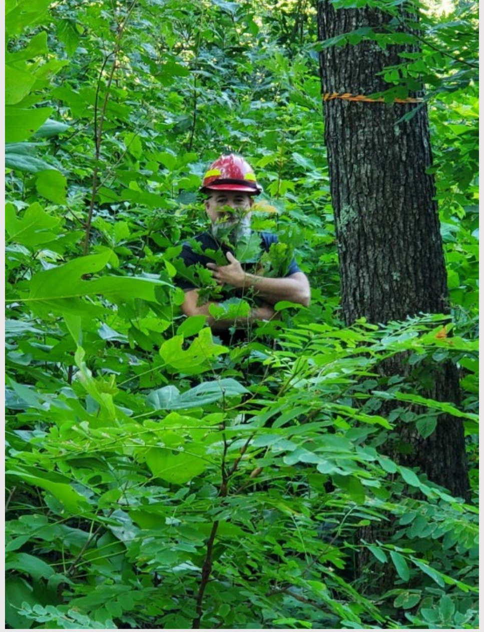
Appalachian Femelschlag: 3 months post-harvest

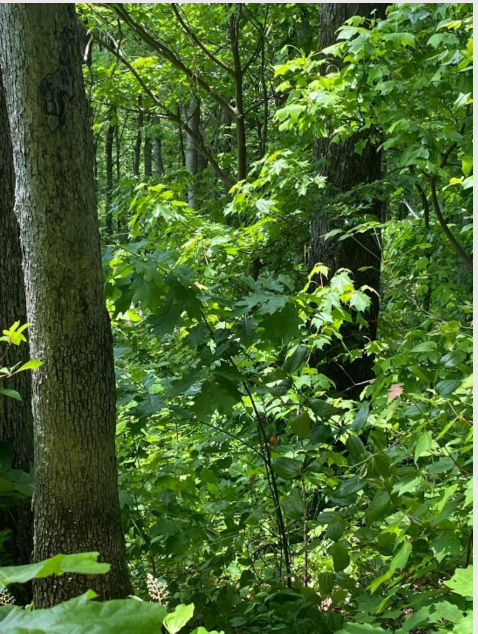
Dying red maple from midstory removal trt

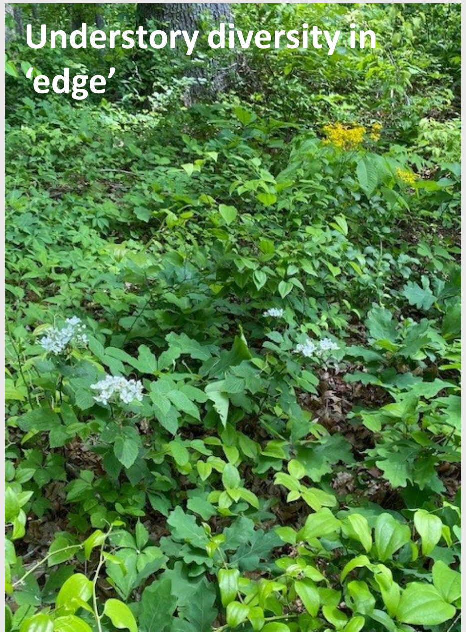










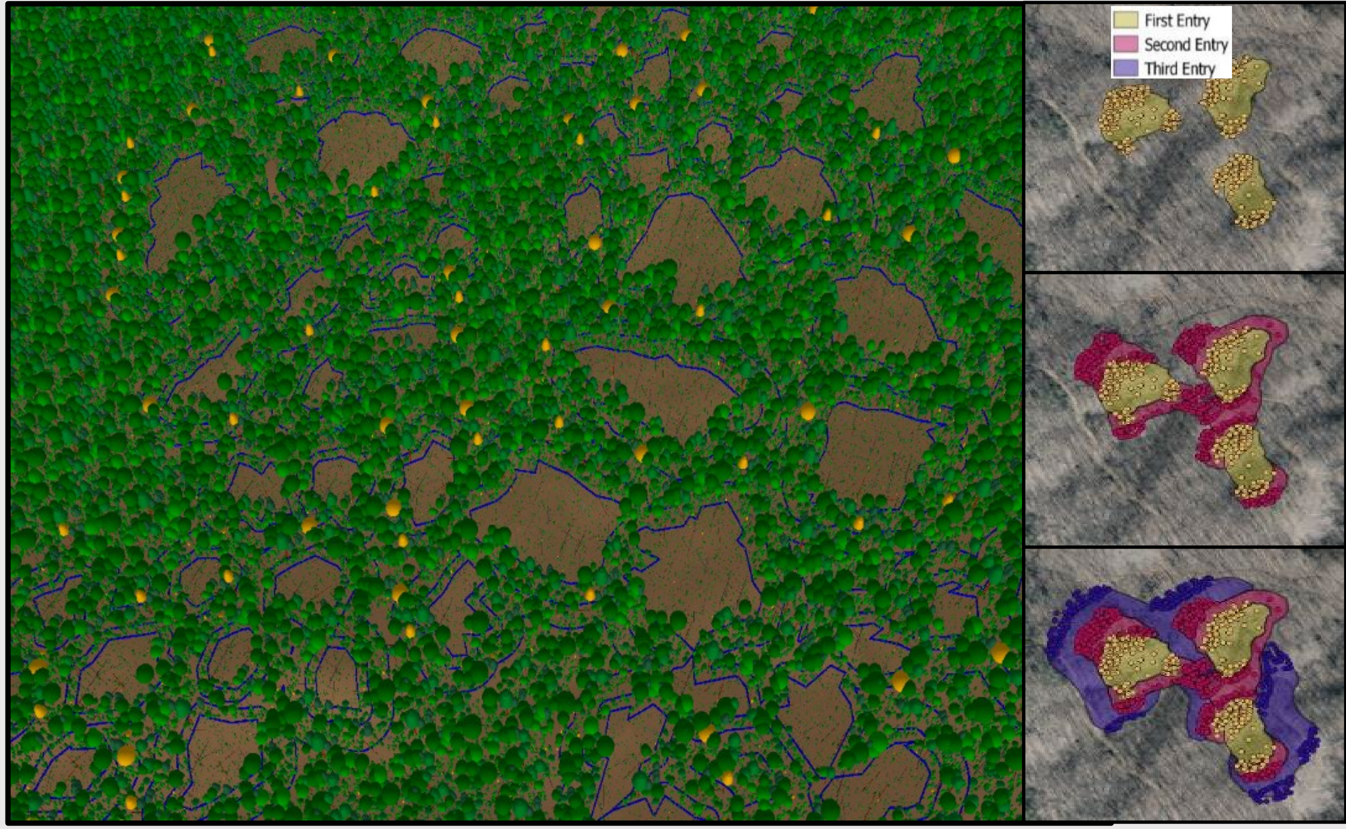


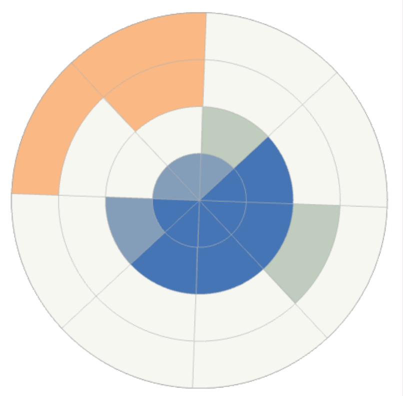
Understory diversity in ‘edge’

Femelshclag in white pine plantations; DuPont State Forest, NC

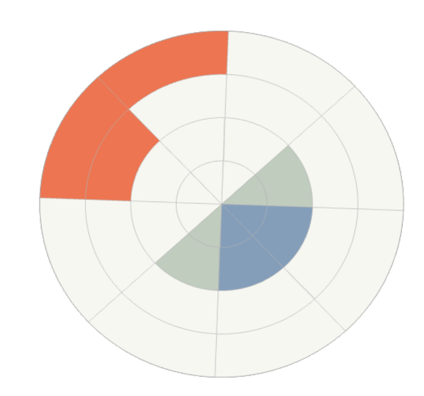
Future entries

- Gaps will be expanded irregularly around each opening in ~***2027*** and 2037
  - Gap expansion is a natural phenomenon, continuing the use of 'natural' disturbance as an ingredient in the recipe for managing oak/ hickory forests (Worrall et al. 2005; Vepakomma et al. 2012; Foster & Reiners 1986)
  - If conducted over time, the stand will contain four age classes; oldest age class represented by legacies in inoperable areas and riparian areas
- The area regenerated in future entries will be dictated by the response of the regeneration adjacent to openings
  - Adaptive and guided by site conditions: expansions will follow and release the newly development competitive oak/hickory around the openings
- Release treatments (sprout control, crown-touch release, and treatment of invasive species throughout stand development) will be necessary
- Prescribed fire??

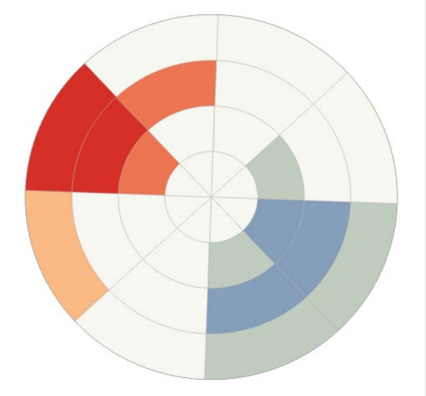




Hickory species



Red oaks



White oaks

Schnake et al., unpublished data

Potential benefits

Flexible system that can be adapted to local conditions and modified as conditions change

Regenerate and recruit species across the shade-tolerant spectrum: Increasing/maintaining diversity **= increased response diversity and resilience to disturbance and environmental change**

Shifting mosaic of structural stages and associated wildlife habitat: Age class/structural diversity (especially of 'desired' species) **= increased resilience to disturbance and environmental change**

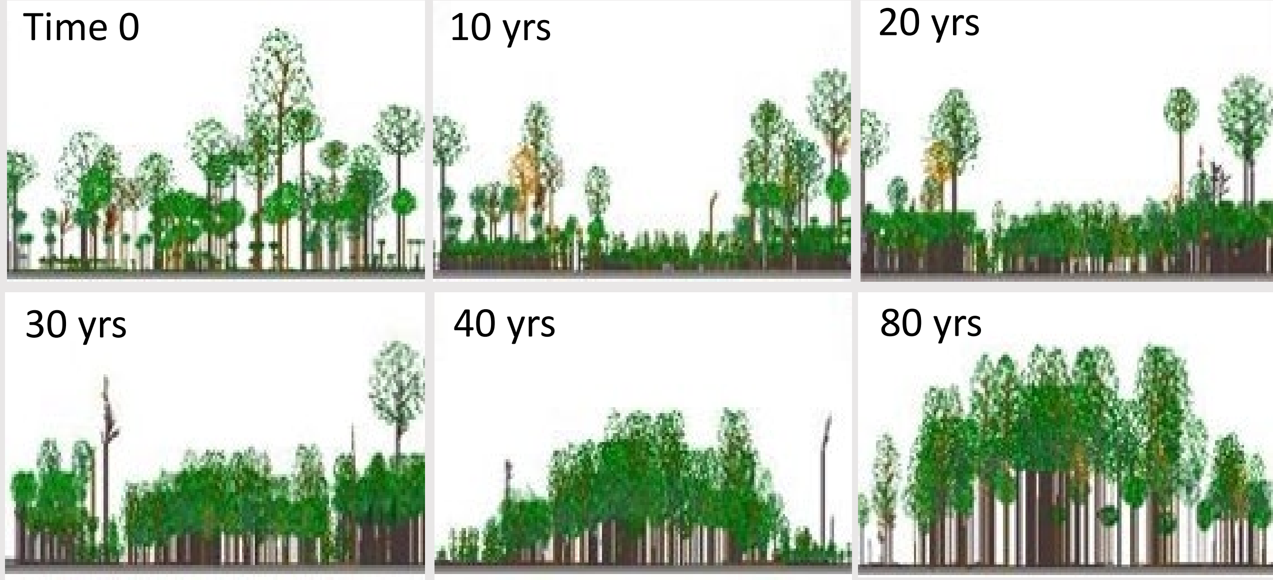
Less soil disturbance by re-using the same skid/road system

Periodic entry = periodic source of revenue – *relevant to private landowners*

Aesthetically more acceptable than even-aged practices

Not the end-all-be-all solution to our oak regeneration issues, but another tool in our limited oak silvicultural toolbox

Oaks - living on the edge



Challenges & considerations

As with any partial harvesting system, damage to residual overstory & the developing advance reproduction is possible

Growth of regeneration is slower than would be under an even-aged system

- **Who cares?** Balance isn't the goal

Topography - limited to ground-based systems (<40% slope)

Requires the preparation of a long-term logging plan

- Attention to road and skid road networks

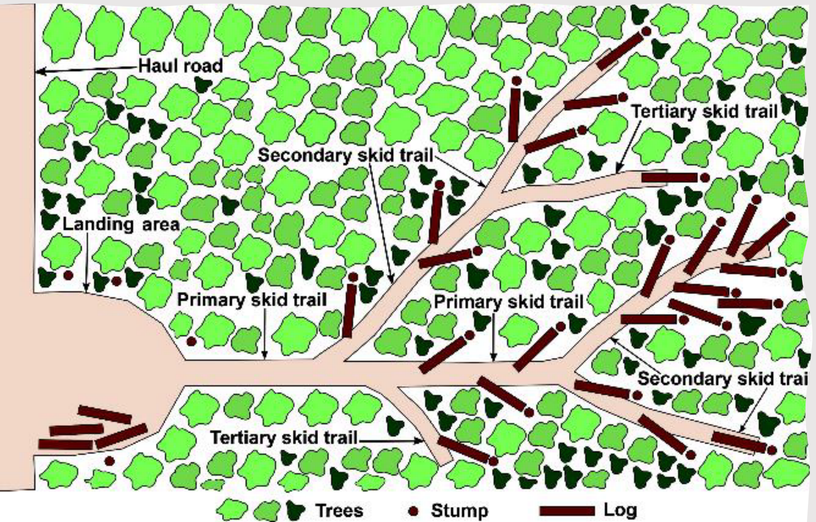
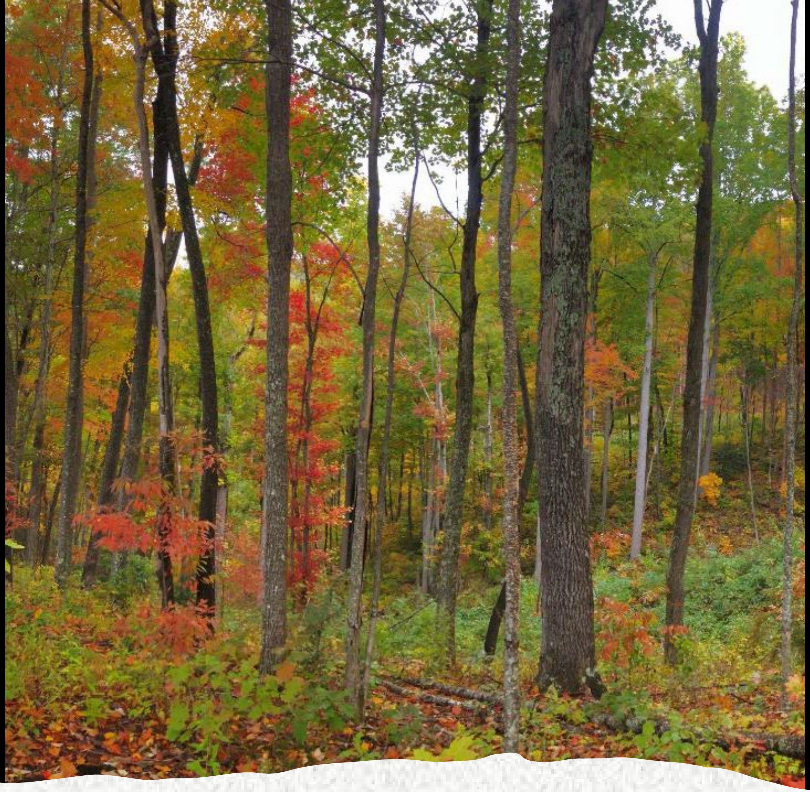


Figure: DeArmond et al. 2021




QUESTIONS