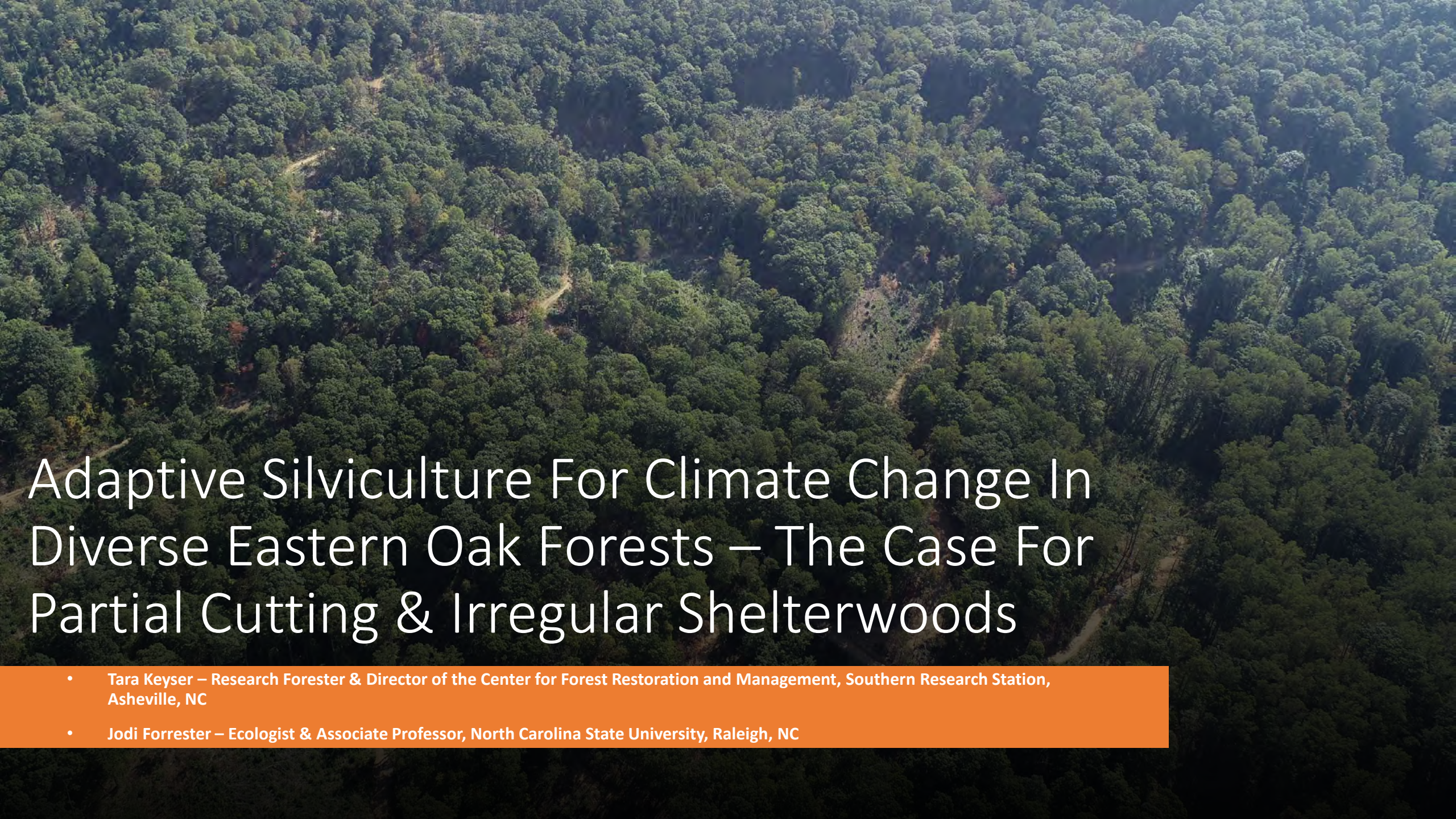


Adaptive Silviculture For Climate Change In Diverse Eastern Oak Forests – The Case For Partial Cutting & Irregular Shelterwoods

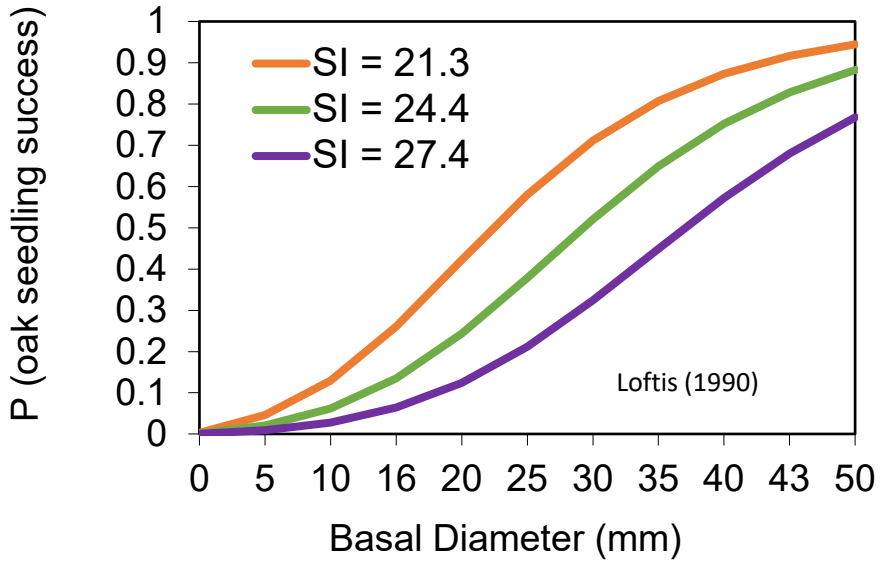
- **Tara Keyser – Research Forester & Director of the Center for Forest Restoration and Management, Southern Research Station, Asheville, NC**
- **Jodi Forrester – Ecologist & Associate Professor, North Carolina State University, Raleigh, NC**

Roadmap

- Sustainability of oak is dependent on disturbance
- The case for partial cutting and irregular shelterwoods
- Femelschlag (expanding gap version) in oak forests: prescription, implementation, constraints, and goals

Oaks – adapted to frequent disturbance

- Oaks, hickories, and many other species that are mid-tolerant of shade have a persistence strategy when it comes to regeneration
- Successful oak and hickory regeneration and recruitment is dependent sprouting from mature trees (*problematic*) after disturbance **AND** the existence of oak/hickory saplings (defined here as stems ~>1.4 m tall)
- W/o disturbance, oak seedlings tend to be abundant and small, while advance reproduction of competitors is abundant and large(er)
- When severe, punctuated disturbance occurs w/o large advance oak reproduction, seedlings of shade-tolerant species OR seed-origin shade-intolerant species (YP, SB, BC) outcompete small oak seedlings



Oak regeneration potential

ZERO

LOW

BETTER

EVEN BETTER (stump sprout)

Stems ~≥1.4 M - BEST!!!!

Probability of successful regeneration

Contemporary oak forests are a legacy of past land use

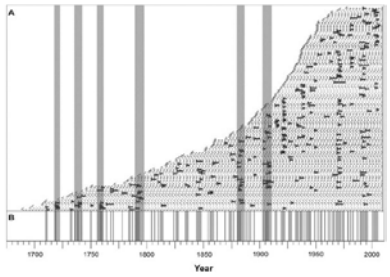
Functional extirpation of keystone species, *C. dentata*

Indigenous Peoples – burning & other land uses

Early European settlement pasture, agriculture, girdling & fire

Domestic grazing

20% pasture
25% cultivated
45% forest



Lack of disturbance (Hart et al. 2012)

Fire suppression

Land abandonment

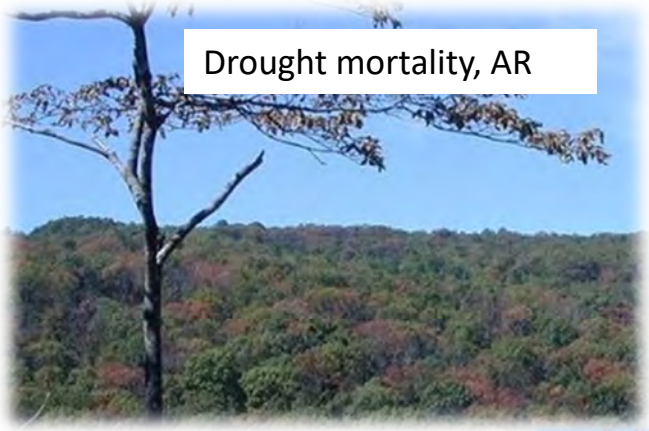
Exploitive logging/wildfires

50% forestland owned by large companies; 86% was cleared, burned, or both

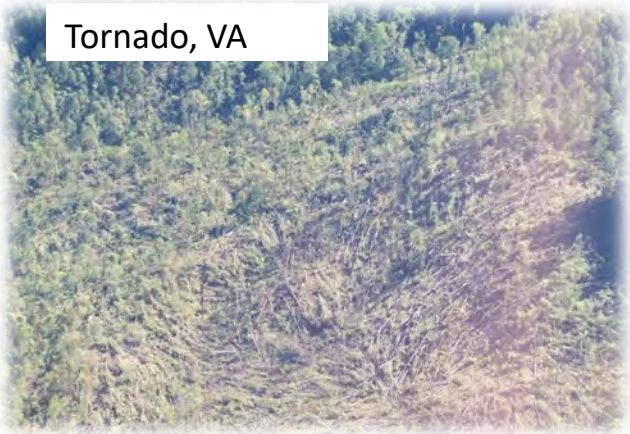
Wood utilization - subsistence agriculture

Industrialization


Tropical storm/wind, NC


Drought mortality, AR


Oak decline, VA


Tornado, VA

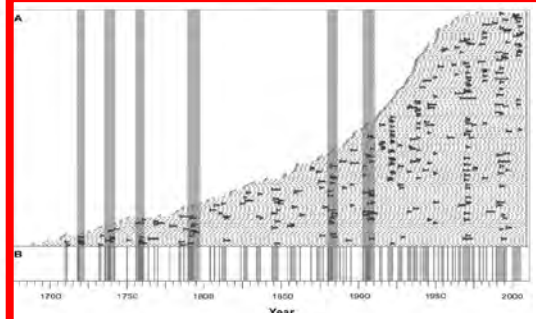

Tropical storm/wind, NC


Ice storm, NC


Background gap/phase


Ice damage, NC

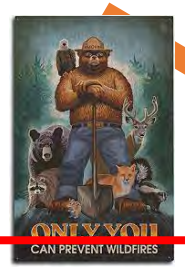

Wildfire, NC

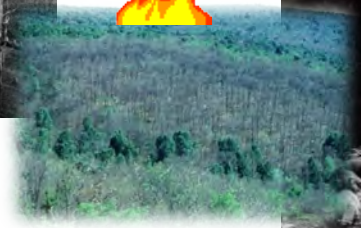


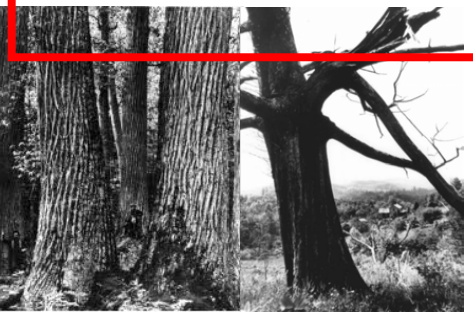
Lack of disturbance (Hart et al. 2012)

Punctuated disturbance (clearcutting; high-grading; other natural disturbance

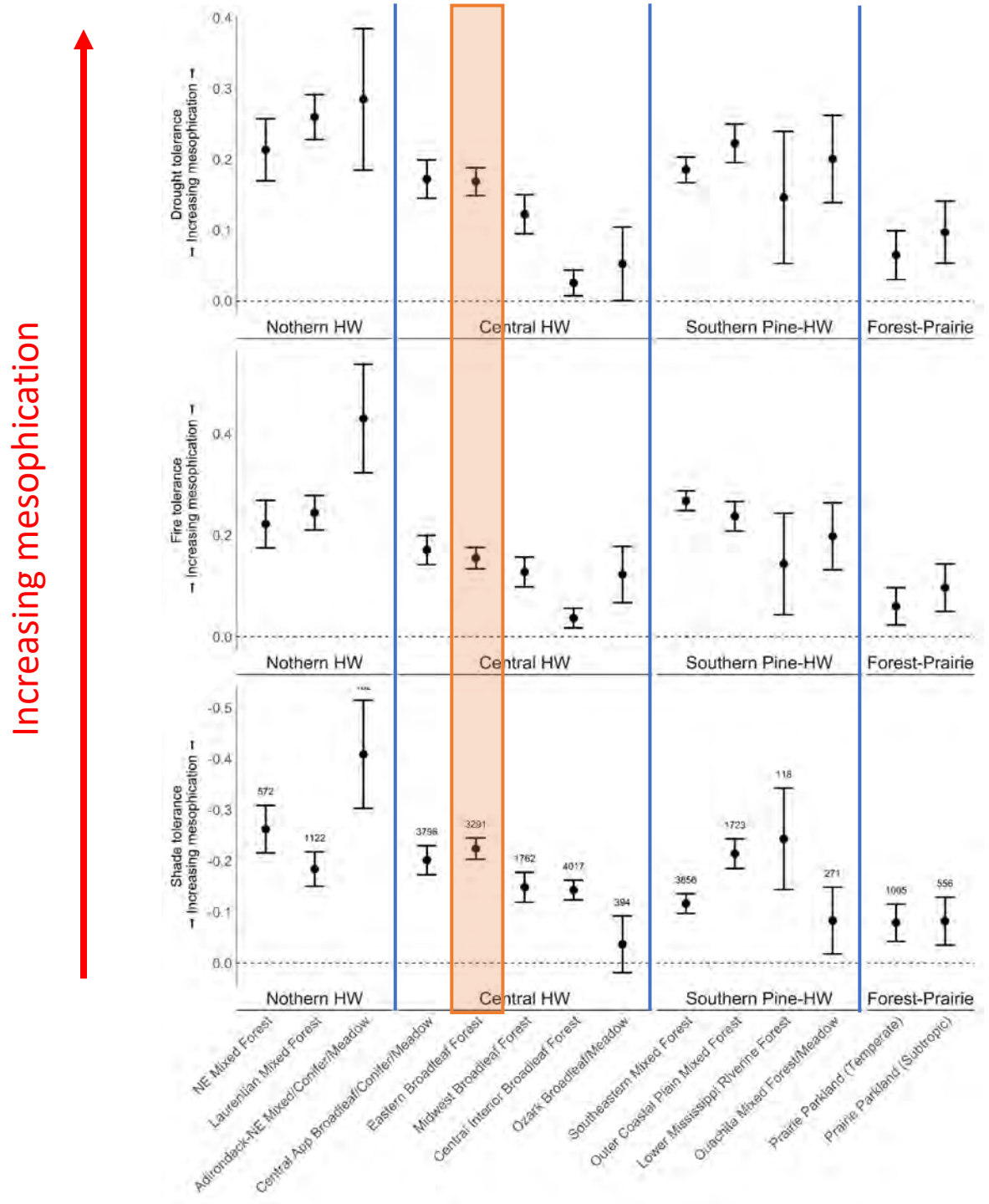
Indigenous Peoples – burning & other land uses



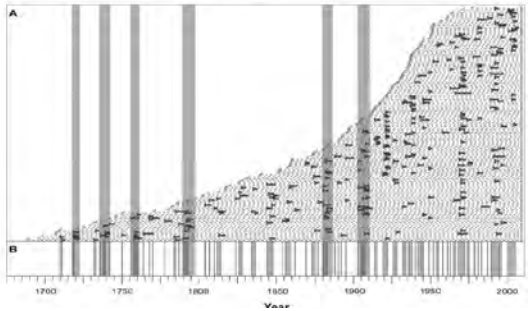




Mesophication of oak/hickory forests – a regional issue



Woodbridge, Keyser, Oswalt, *in prep*



Lack of disturbance (Hart et al. 2012)

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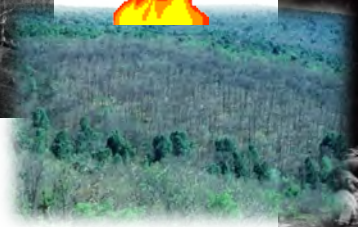


SILVICULTURAL APPROACH & RX

Partial disturbance

- Disturbance regime that has perpetuated oak/hickory (across space & time) forests is based on frequent, low-severity disturbances (FIRE), punctuated by intermediate disturbances/release events
- These intermediate severity/frequency disturbances rarely cause complete overstory removal
  - Ecological memory & legacy
- 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

Multi-aged forest created using group selection harvesting – all three age classes are dominated by dominant/co-dominant yellow-poplar. Photo: David Schnake

Partial cutting ~ continuous cover silvicultural methods

Group selection

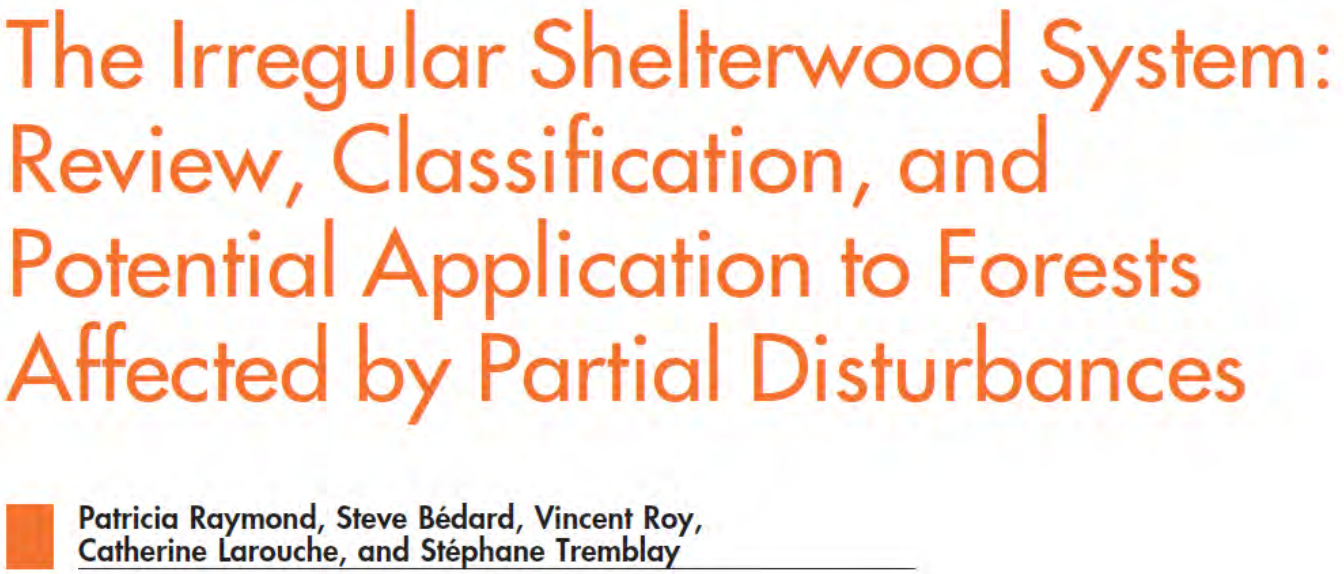
- Studies from the CHR indicate group selection can create an uneven-aged structure
- However, it does *not* effectively regenerate oak/hickory
- Even on dry-mesic sites, group openings (up to 23 years) are dominated by shade-intolerant yellow-poplar (Jenkins & Parker 1998; Weigel & Parker 1997; McNab & Oprean 2021)

Single-tree selection

- Long-term studies demonstrate STS is not an appropriate method to regenerate mid-tolerant oak species in more mesic forests of the eastern US
- Results in a decrease in species diversity and importance of hard mast species, while increases the importance of shade-tolerant species (Schuler et al. 2017)
- Only in the extreme western portion of the CHR has STS been effective at sustaining oak/hickory**

Irregular shelterwood system

- Regeneration period extends for decades due to multiple partial harvests (as opposed to more traditional even-aged shelterwood methods)
- Relies on advance reproduction
- Suitable for mixed-species stands comprised of shade intolerant to shade tolerant species


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

1. **Expanding-gap (Bavarian Femelschlag)**
2. Continuous (Swiss Femelschlag)
3. Extended (two-aged)

Expanding gap (Bavarian) Femelschlag

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

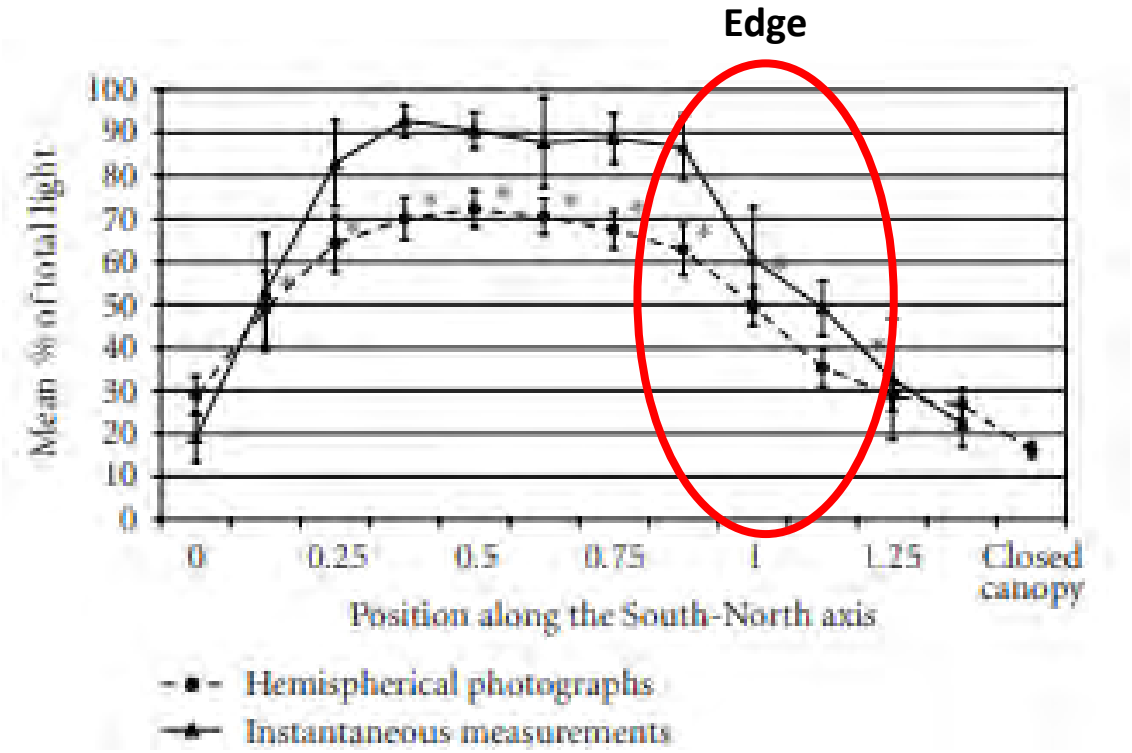
WHY? - LIVING ON THE EDGE

Support for implementing ‘expanding gap’ Femelschlag in upland oak forests

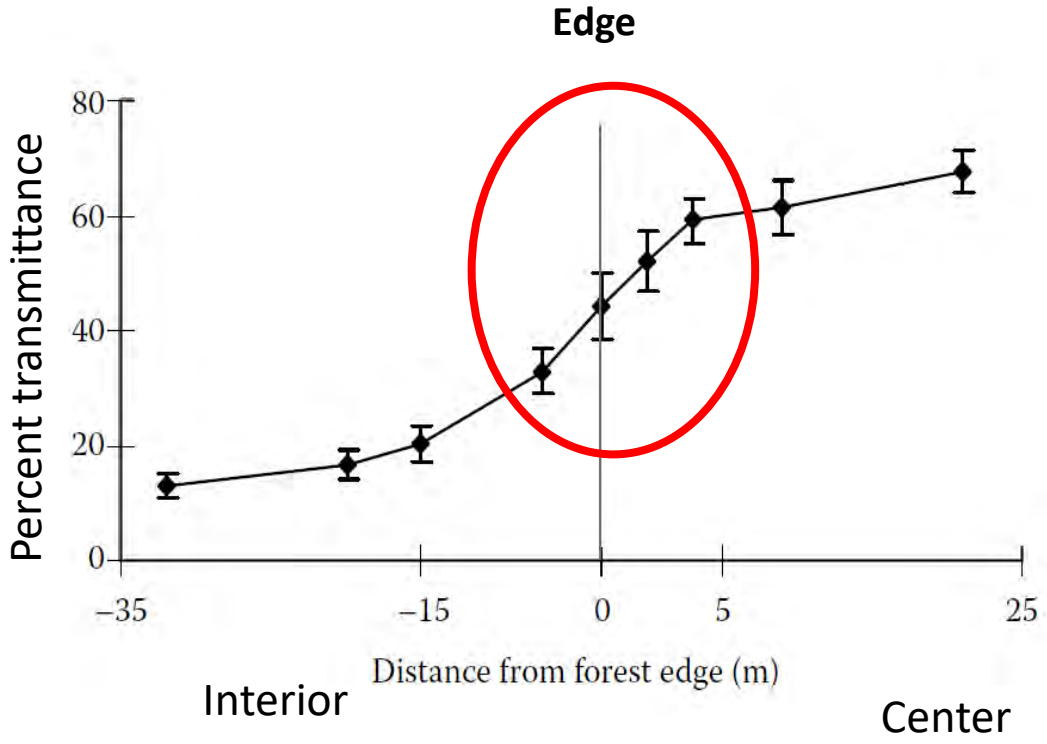
2021 Forest Stewards Guild tour participants view a 0.25-acre gap in the Appalachian Femelschlag, Asheville, NC

Support for ‘expanding gap’ Femelschlag: Light dynamics around openings

Intensity & duration may be key attributes of that edge environment

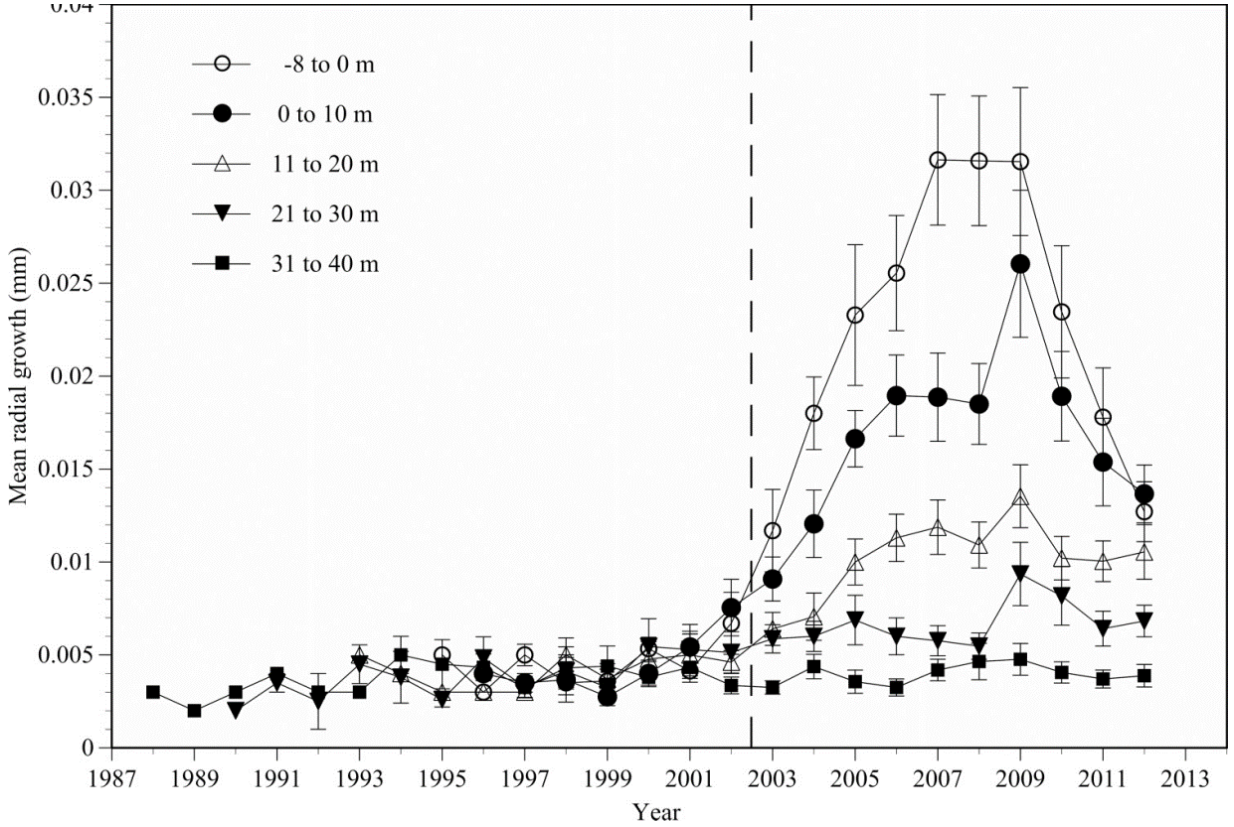


Gendreau-Berthiaume & Kneeshaw (2009)



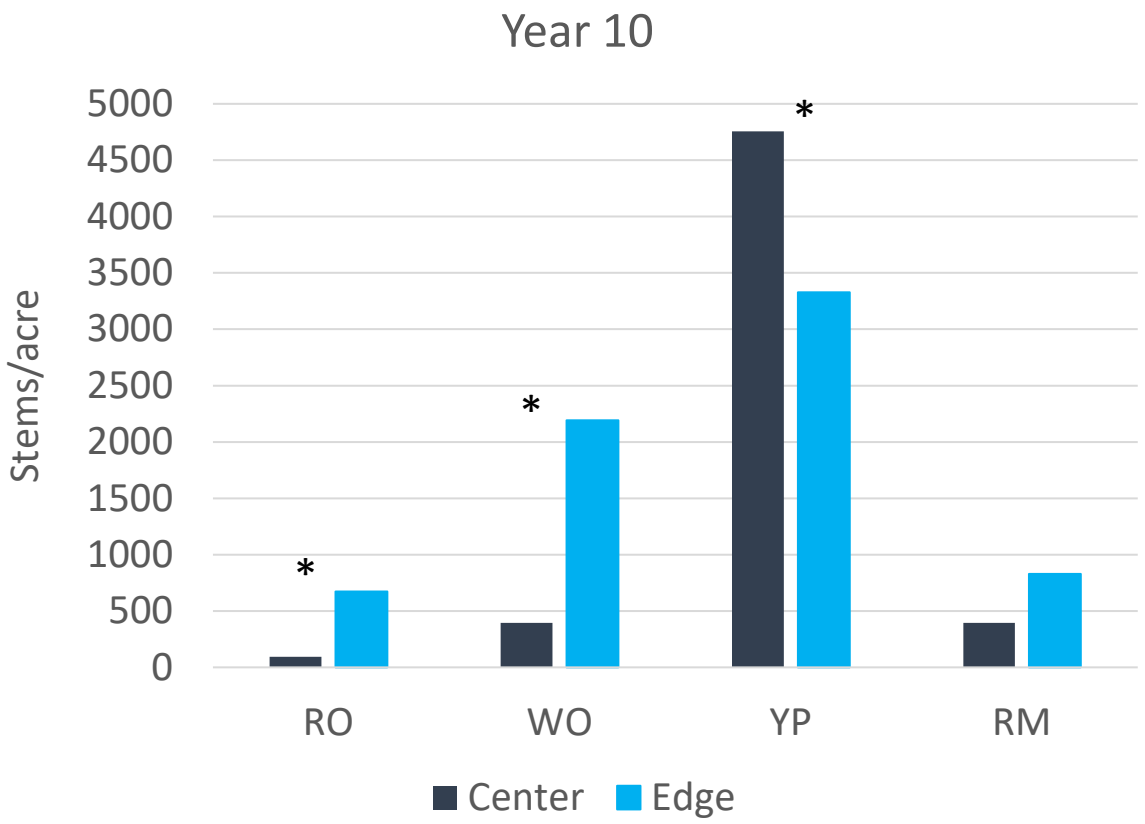
Schmid et al. (2005)

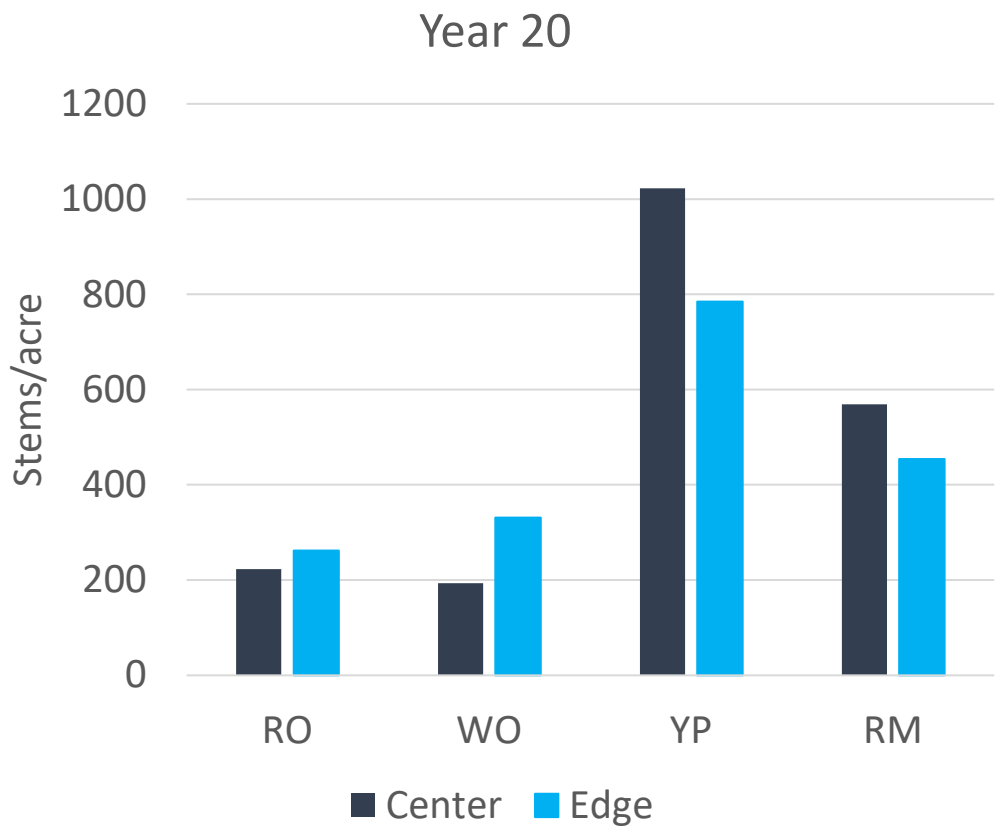
Support for ‘expanding gap’ Femelschlag: Advance oak reproduction dynamics surrounding clearcuts



Lhotka and Stringer 2013

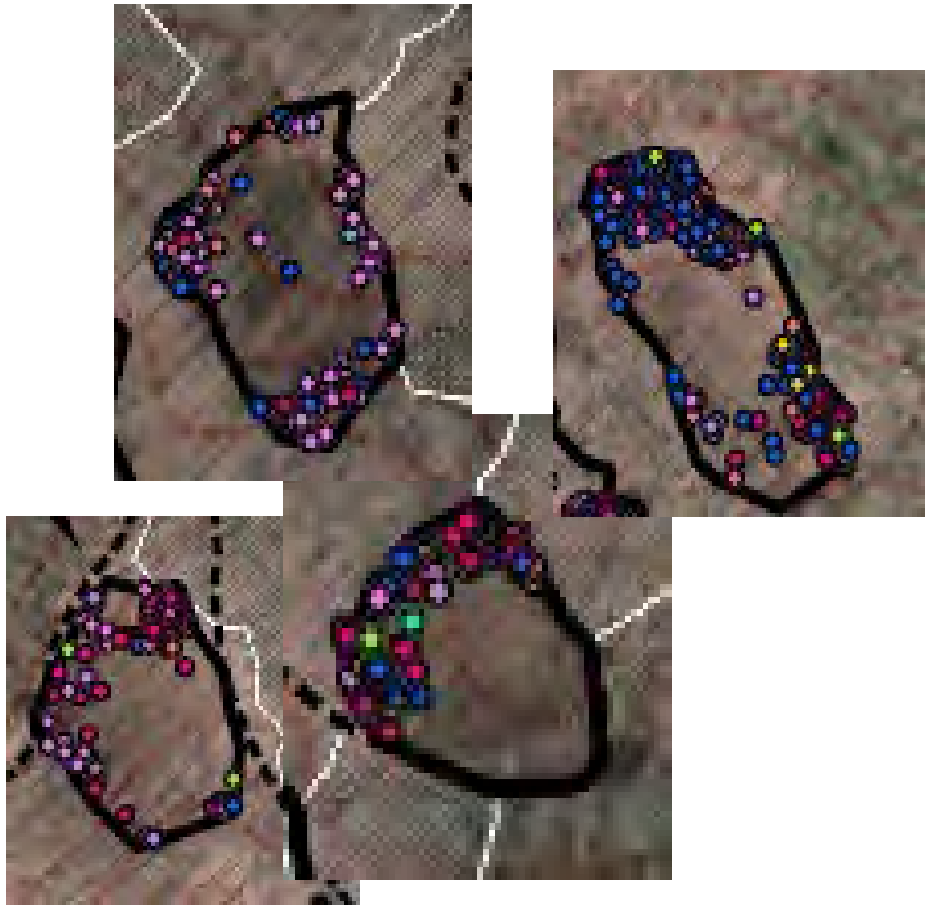
Support for ‘expanding gap’ Femelschlag: Differential response of species to location within opening

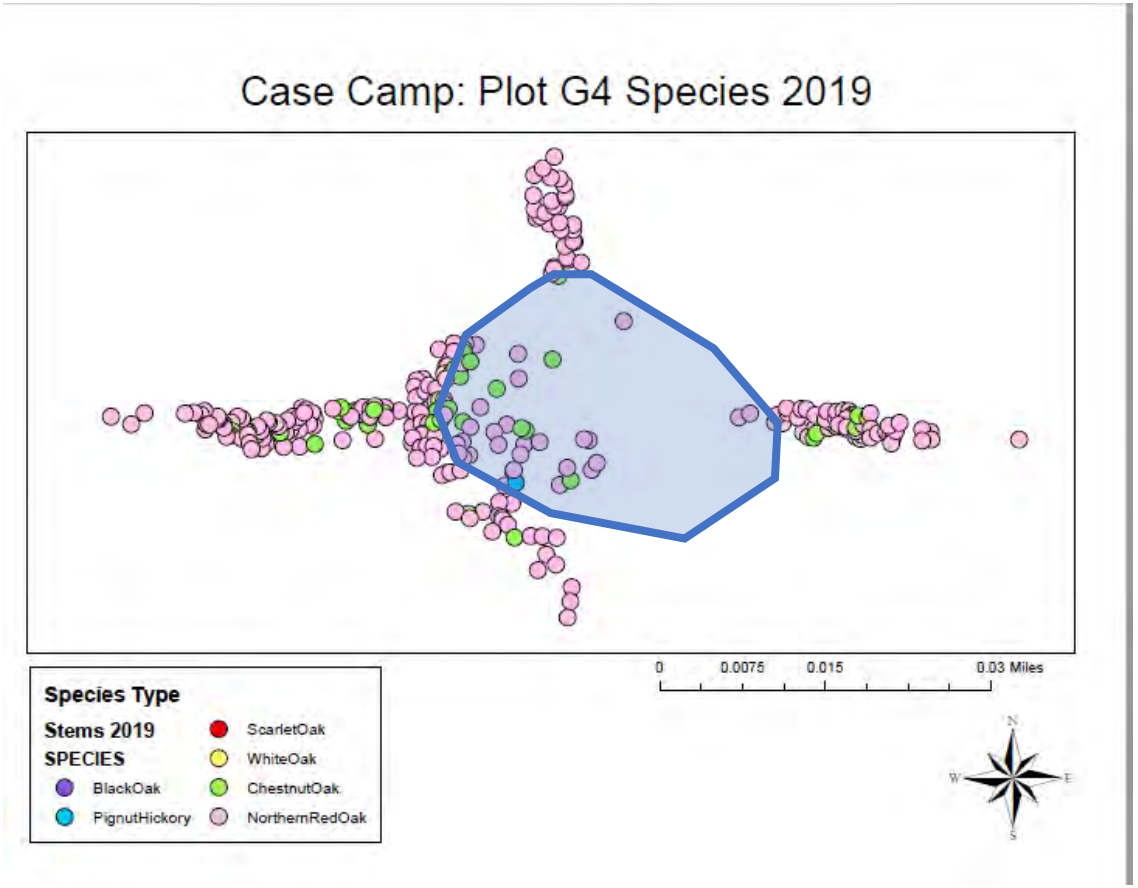




McNab and Oprean (2021)

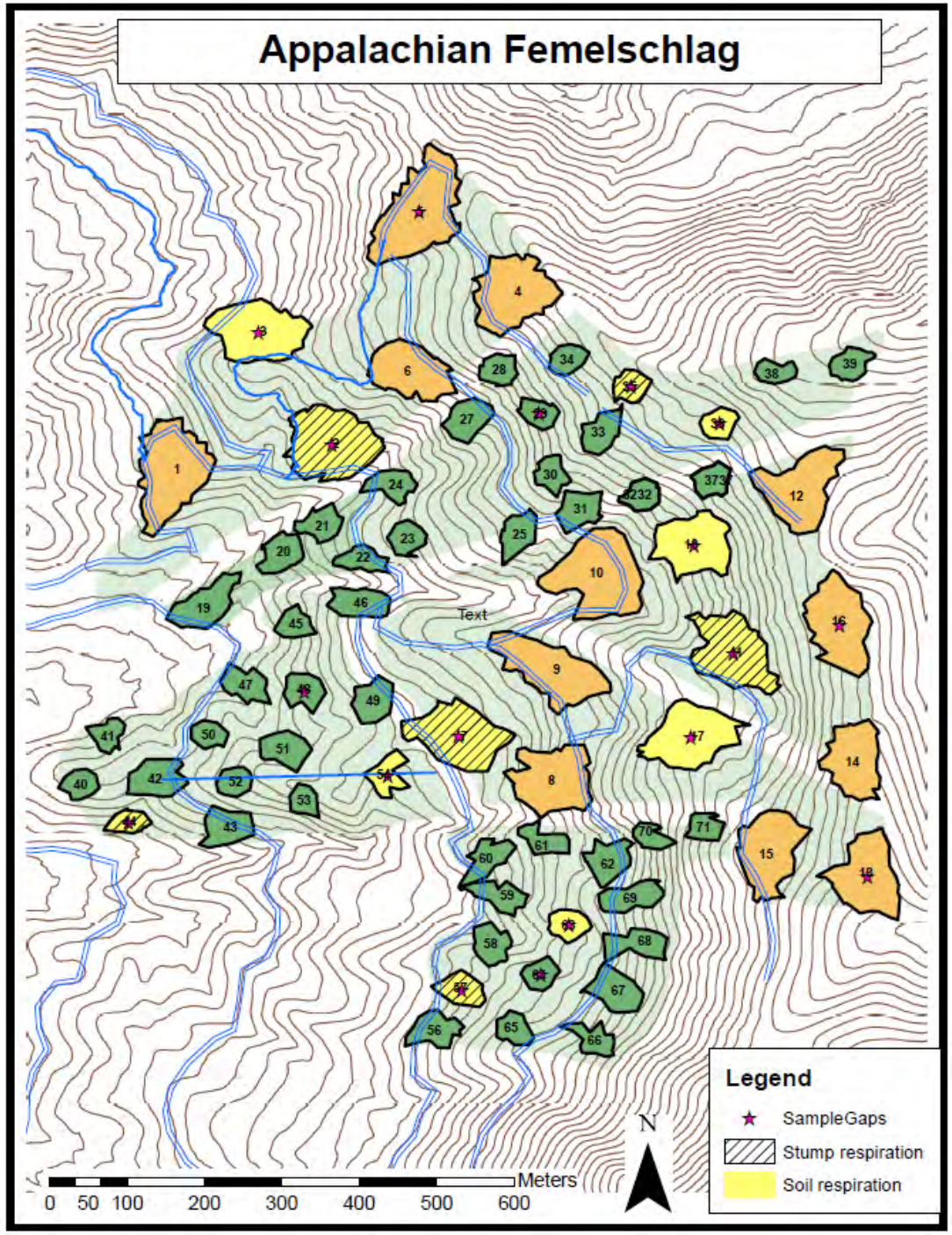
Support for ‘expanding gap’ Femelschlag: Stem-mapped data (dom/co-dom/intermediate oak and hickory) in & around group openings in western NC *(unpublished data from Schnake, Forrester, & Keyser)*





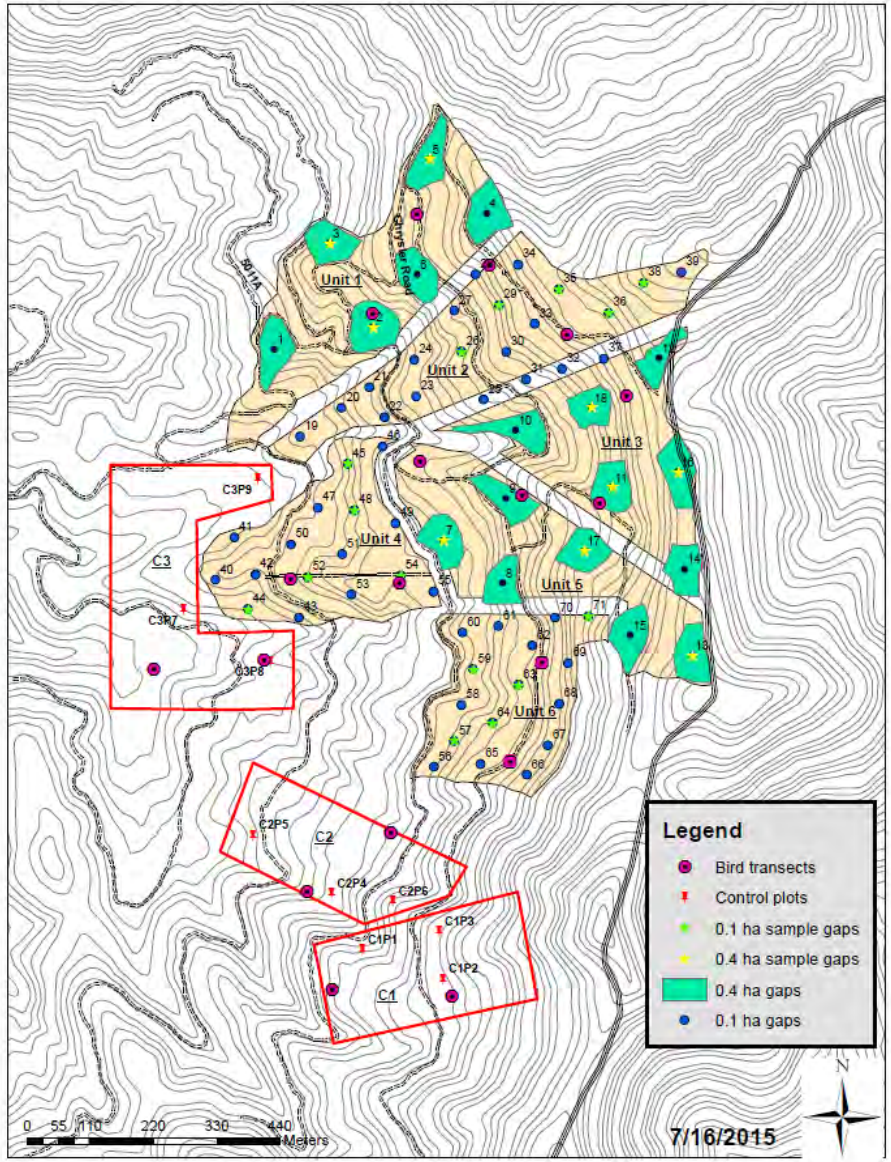
Appalachian Femelschlag

In partnership with National Forests of North Carolina (Pisgah NF)



Appalachian Femelschlag: Design

- Informed by the observed success of oak/hickory at the edges of natural and silvicultural openings
- 150-acre stand oak/hickory/yellow-poplar stand on the Pisgah National Forest divided into six stands b/t ~18 and 27 acres (SI: ~85 ft)
  - ~47% of the BA oak/hickory; 25% yellow-poplar; 14% red maple
- Two treatments (3 reps/treatment)
  - Small gap: 25% of the stand regenerated in 0.25-acre gaps during 1st entry
  - Large gap: 25% of the stand regenerated in 1-acre gaps during 1st entry
- Midstory removal (hack 'n squirt herbicide treatment) conducted throughout the matrix of the 150 acres
  - Stems 2 – 8" injected (Yellow-poplar, silverbell, striped maple, red maple, sugar maple, blackgum, sweet birch, beech, sourwood, paulownia, tree-of-heaven, rhodo, laurel)
- Site-prep within gaps: slash down of all stems <8" dbh (oaks, hickories, other soft mass trees not slashed)
- Plan called for 71 total gaps: 53 small & 18 large



Appalachian Femelschlag: Implementation

- Logging complete May 2019
- 70 gaps total: one small gap less than planned due to logging safety issue (steep as heck)
- Gaps larger than planned: tree size & topography
  - Small gaps: 0.4 – 0.6 acres
  - Large gaps: 1.7 – 2.5 acres
- Hand felled (skidder & forwarder)
- 43.5 CCF/acre sawtimber removed
- 0.74 CCF/acre pulpwood removed

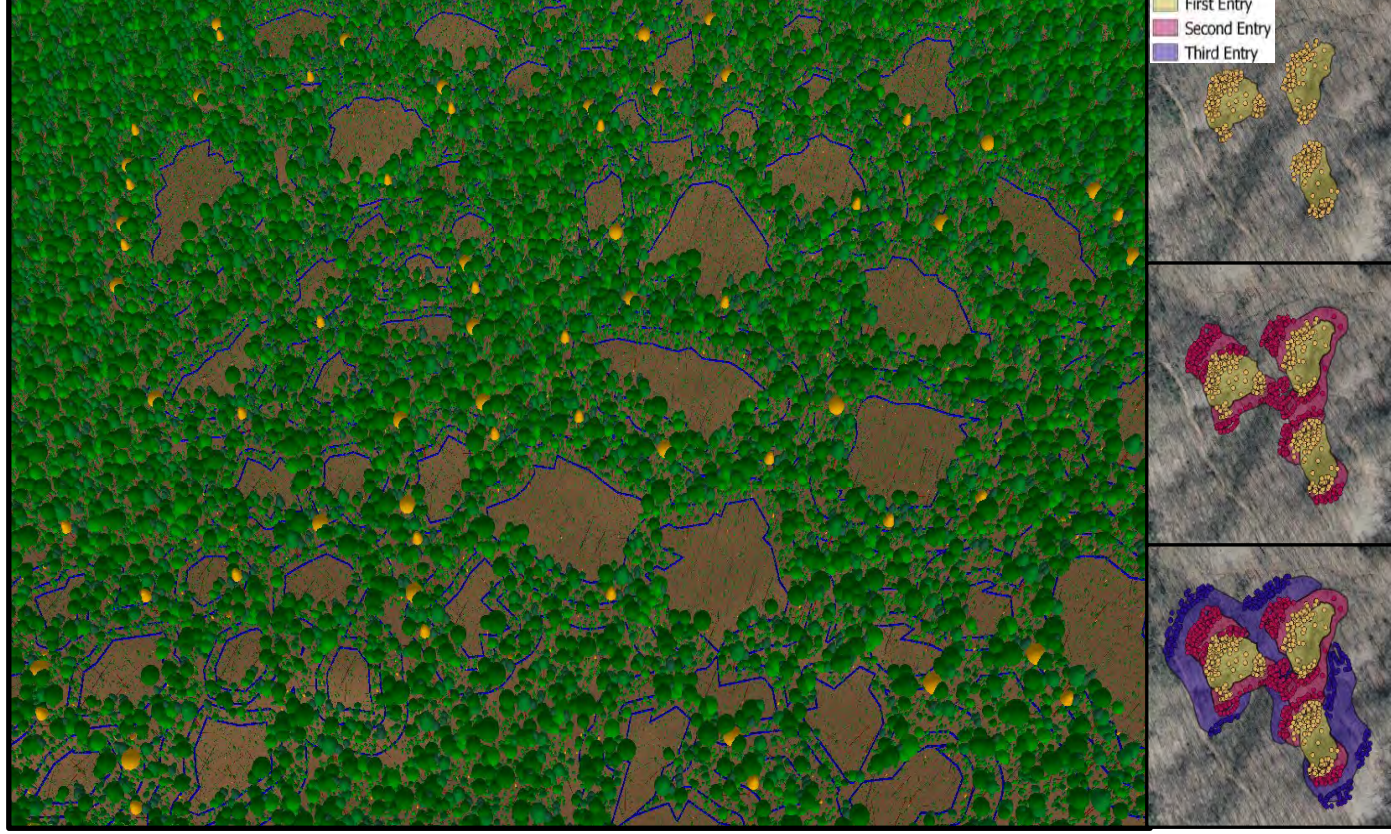




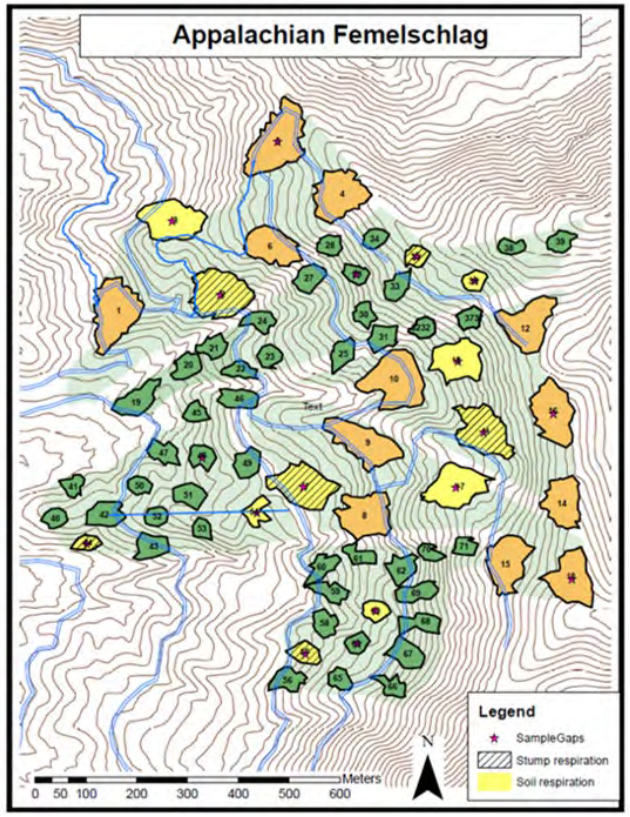



Future entries

- Gaps will be expanded irregularly around each opening in ~***2029***, 2039, and possibly 2049* at which time the stand will be regenerated and intermediate treatments conducted
  - Realistically, a maximum of four age classes will be present; oldest age class represented by legacies in inoperable areas and riparian areas
- The amount of area regenerated in future entries will be dictated by the response of the regeneration
  - Expansions will follow the development of competitive oak/hickory advance reproduction around the openings
- Release treatments (sprout control, crown-touch release throughout stand development) will be necessary
- Burning?? This is a rich and mesic site

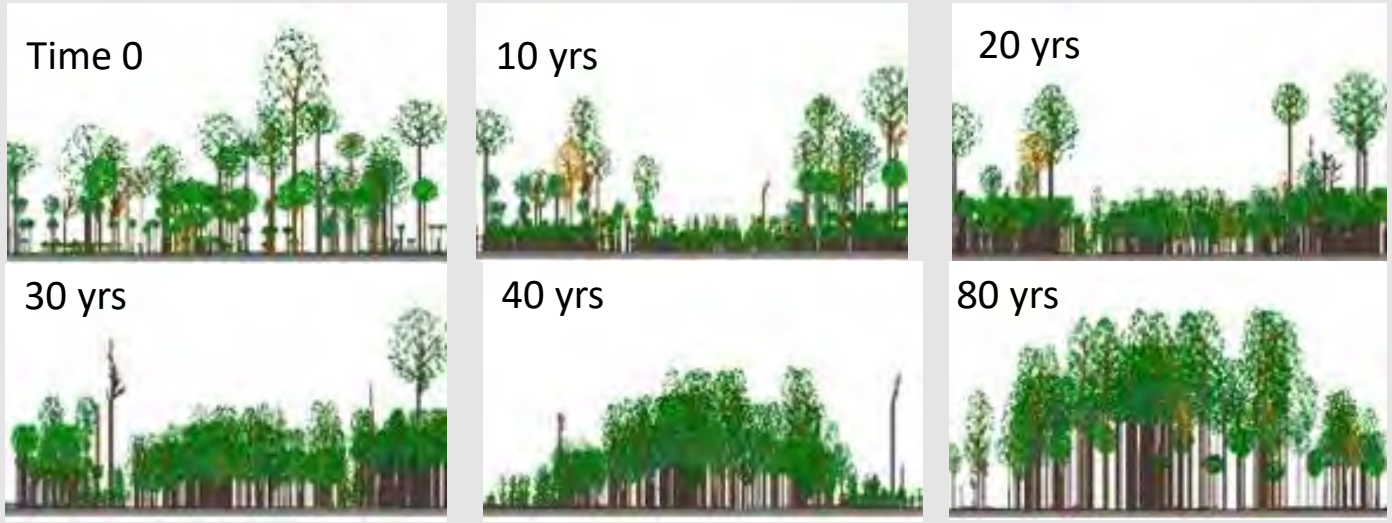


Lessons learned



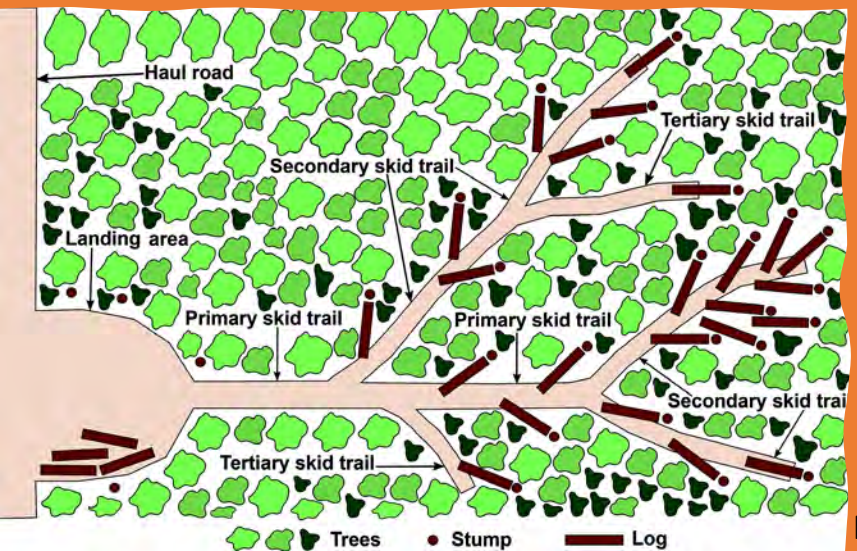
- Communication throughout the planning and implementation process among silviculturist, TMA, and, if you are lucky enough to have one, logging engineer is key
- The time spent on planning on the front end of implementation is key to making re-entry (relatively) seamless
- Go to the woods as a team (silviculturist, timber management assistant, timber contracting officer, logging/roads engineer) and ask questions

Goals



- Regenerate and conserve diversity associated with the suite of species characteristic of productive stands in the southern Appalachians
  - Maintain an oak component* – *VERY DIFFICULT ON THIS TYPE OF SITE*
- Develop within-stand structural diversity that will lead to:
  - Age class diversity & an increase in response diversity
  - Horizontal and vertical heterogeneity of ‘desired’ species
  - A shifting mosaic of stand development stages and resultant wildlife habitats

Interest & education



Challenges and considerations

- As with any partial harvesting system, damage to residual overstory & the developing advance reproduction is possible
  - Likely less than a traditional shelterwood, as re-entry uses the existing skid and road network and harvesting is around regeneration gaps
- Growth of regeneration is slower than would be under an even-aged system
  - May ameliorate the advantage of enhanced increment of overstory trees
  - **Who cares?** Balance was never the goal
- Topography - limited to ground-based systems (<40% slope)
- Requires the preparation of a long-term logging plan
  - Road & skid network
- **Not the end-all-be-all, but another tool in our oak silvicultural toolbox**

Figure: DeArmond et al. 2021

Northern red oak - living on the edge

Benefits

- Flexible, adaptive system that can be adapted to local conditions and modified as conditions change
- Regenerate and recruit species across the shade-tolerant spectrum
  - Increasing (or 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
- Periodic entry = periodic source of revenue – relevant to private landowners
- Aesthetically more acceptable than even-aged practices – relevant to private landowners

Research objectives

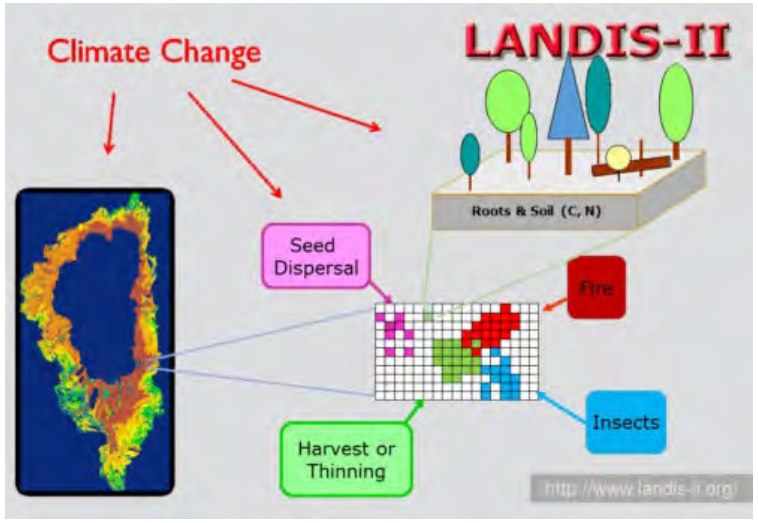
1. Modify hardwood management practices to increase oak and hickory regeneration within the southern Appalachian mixed oak forests
   - Quantify spatial arrangement of regenerating tree and groundlary species and identify relationships between successful regeneration and micro-environment

2. Assess the interactions among forest structure, composition, regeneration, and ecosystem processes
   - Interactions between moisture & light on oak and non-oak sprout performance
   - Ecophysiological traits of oak and non-oak competitors in relation to resource availability
   - Ecosystem level carbon (CO_2 and CH_4) dynamics (sources and sinks; above and belowground)
   - **Changes in water use of mature trees as affected by gap size, gap position, and species **Is the edge more conducive to oak because residual canopy trees use more water and 'dry' out the edge making it less favorable to YP?**

3. Assess how gap size, matrix conditions, and structural diversity influence species richness & occupancy, including effects on breeding bird communities

Research objectives

4. Forecast (LANDIS-II) effects of disturbance and drought on long-term, landscape-level patterns of wood-production, carbon storage, and biodiversity under alternative versus existing management practices
    - Creating a 10 m-pixel light submodel to parameterize LANDIS-II and better model sub-stand spatial dynamics
5. Assess effects of harvesting practices and residual structure on future timber quality (Jan Wiedenbeck – *does anyone in NRS want to take it over*?)
    - Harvest damage of overstory trees surrounding gaps
    - Epicormic sprouting of overstory trees surrounding gaps
6. Response of planted white oak, eastern and Carolina hemlock
7. Pollinator response (Auburn University)



Questions