Silvicuture & Fire in Piedmont Hardwood Forests

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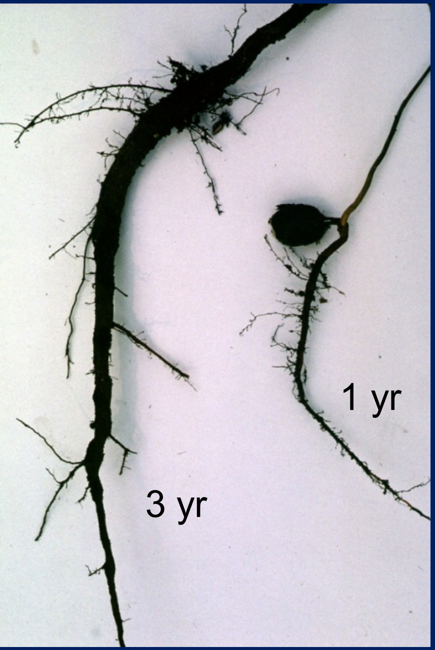
Piedmont Forests:
31 million acres: 87% private, 10% fed & state
52% upland hardwoods: oak-hickory, oak-pine, oak-mixed hardwood
Young forest: 55% ≤ 40 yrs, hardwoods a bit older
Mgmt level low on public lands: 5,000 ac thinning & 1,000 ac regen on NF
Prescribed fire:
fuels mgmt.
ecological benefits:

- biodiversity conservation
- wildlife habitat T&E, conservation, game spp
- restore fire dependent ecosystems – oak-pine forest, woodland, savanna
- increase forest resilience – favor fire/drought adapted spp; vary structure
- forest regeneration of desired spp

Sources of Oak Regeneration



Seedlings

Slow juvenile shoot growth

Preferential allocation of biomass to roots

Seedling Sprouts

Exponential increase in sprouting capacity with increasing diameter – root size

Stump Sprouts

Faster growing oak repro
Not all stumps sprout
50-75% of dominate oak from sprouts

The Key to Sustaining Oak Stocking is Adequate Large Advance Reproduction

Oak seedings have good growth
30 to 50% of full sunlight
Maximum growth occurs between
50 to 100% full sunlight

White oak → **Scarlet oak**

Intermediate

Intolerant

The most common starting situation is a closed canopy mature forest

forests cut in the 1900s grew up savannas & woodlands became forests with fire suppression

Oak advance reproduction does not accumulate and grow in the understory due primarily to insufficient light

Ground flora diversity decreases and shifts to shade tolerant, forbs and woody species

Habitat favors wildlife species associated with complex forest structure

Oak Fire-Regen Ecology

- A leaf covering helps maintain acorn moisture content
- Leaf litter > 2" deep is a barrier to acorn germination
- Equilibrium in leaf litter accumulation in 12-14 yrs
- Leaf litter recovers to 75% of equilibrium in 4 yrs after fire

- Fire before acorn drop

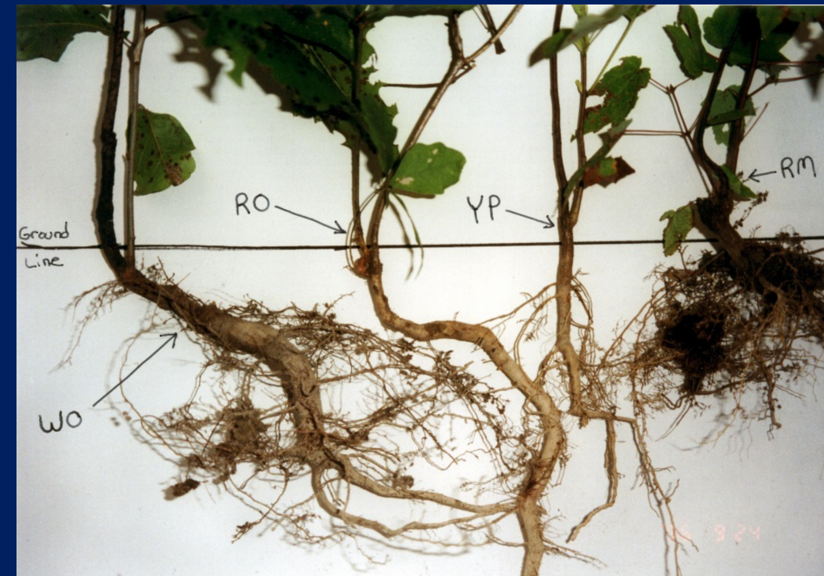
- Fire after acorn drop

Fire kills 70% of acorns in Pennsylvania
Auchmoody & Smith 1993
58% mortality in 1-yr-old northern red oak
Johnson 1974

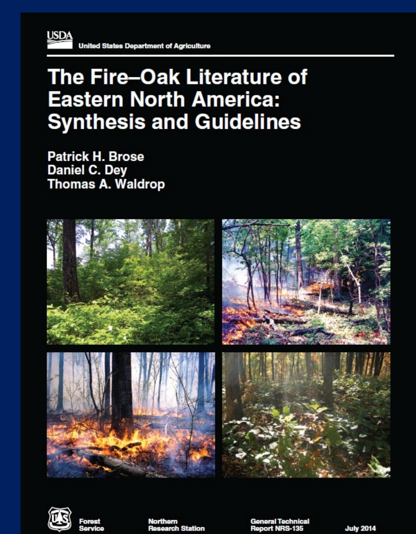
Oak Fire-Regen Ecology

183 to 698 ºF @ 10 “

41 to 45 ºF @ 0.5 “



Brose et al. 2014


USDA United States Department of Agriculture

The Fire–Oak Literature of Eastern North America: Synthesis and Guidelines

Patrick H. Brose
Daniel C. Dey
Thomas A. Waldrop

Forest Service | Northern Research Station | General Technical Report NRS-135 | July 2014

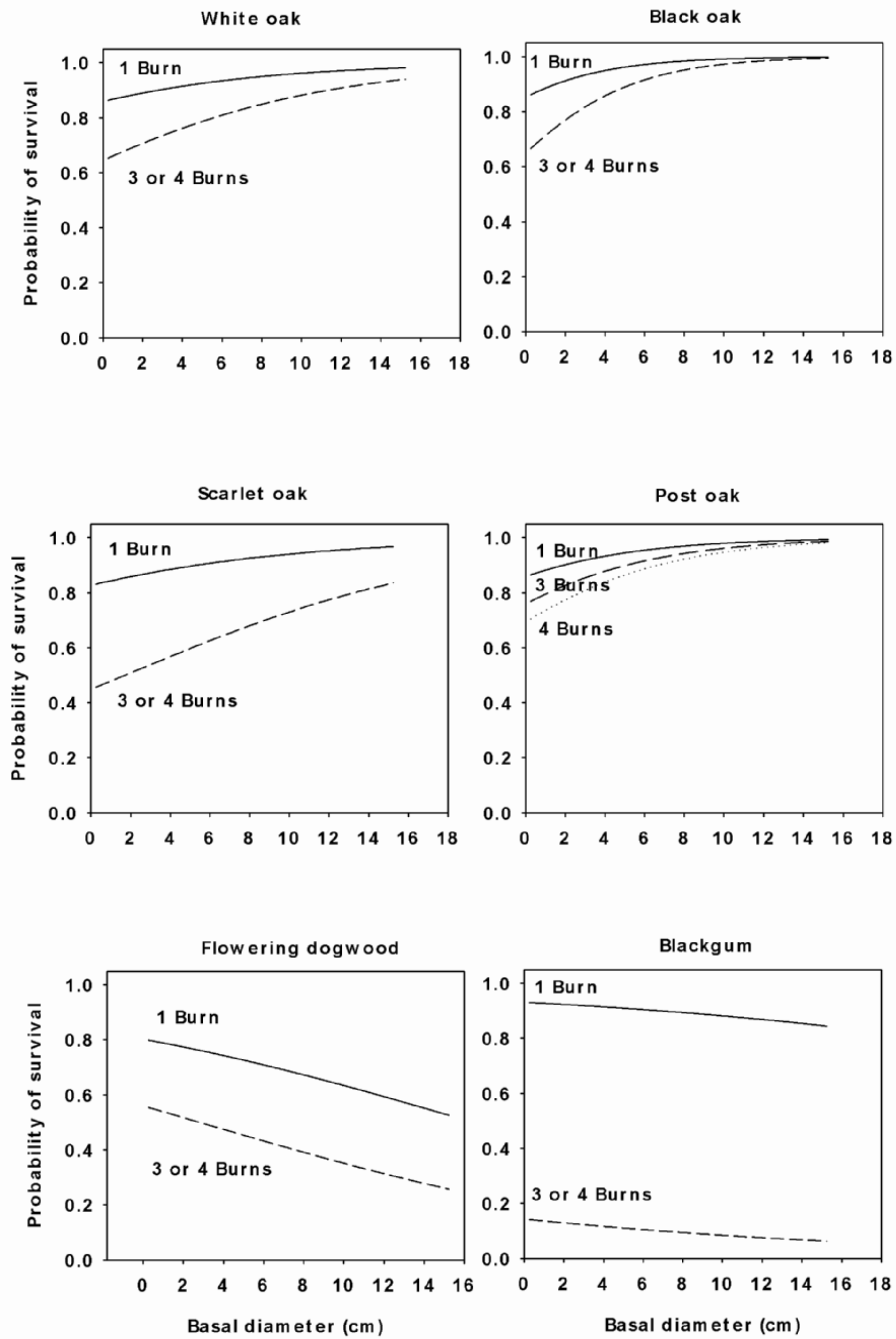
1. Oaks are masting species
2. Acorns are buried in soil by animals
   - Seed moisture
   - Soil poor conductor of heat
   - Location of root collar buds
3. Oaks preferentially store carbohydrates in roots

Oak seedlings & saplings have increasing capacity to sprout after fire topkill

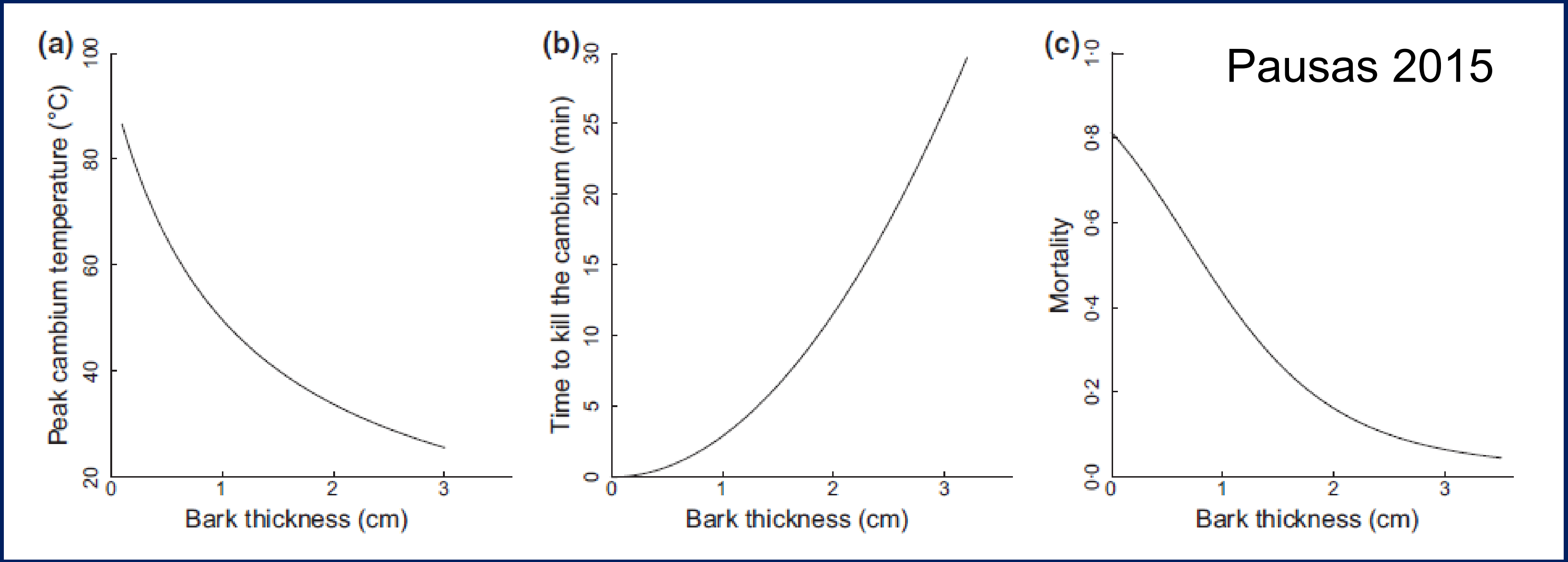
Low intensity fires can reliably topkill trees up to 4” dbh

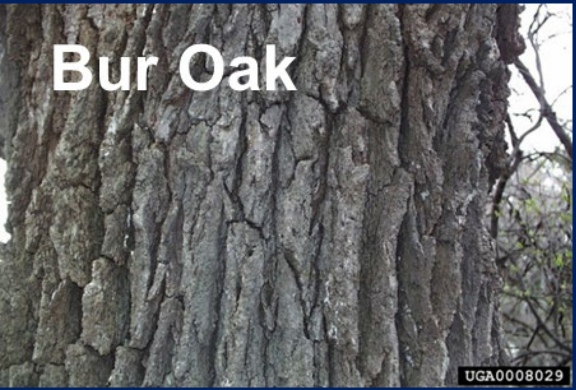
Oaks are favored by frequent burning

Dey and Hartman 2005
Brose et al. 2013, 2014



Bark protects trees from heat





5% reduction in overstory basal area upland oak-hickory forests

Hutchinson et al. 2005, Fan and Dey 2014, Knapp et al. 2015

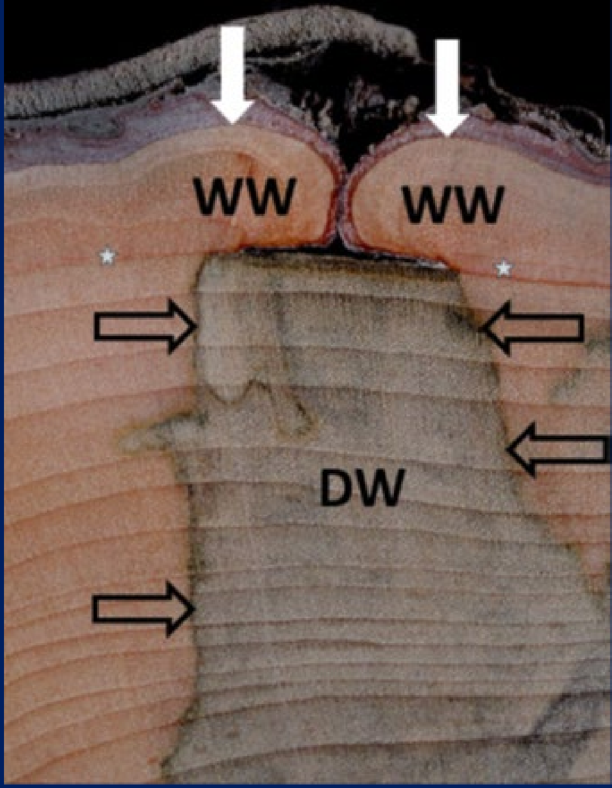
Brose & Van Lear 1999
Hanberry et al. 2014

Compartmentalization
a boundary setting process
a response to wounding

Oaks are better than many species

FPL 1967

Resistant or very resistant	Moderately resistant	Slightly or nonresistant
Bur oak	Swamp chestnut oak	Hickories
Chestnut oak	Baldcypress (young growth)	Maples
Post oak	Honey locust	Red & black oak
White oak	Longleaf pine	Other pines
Osage-orange	Slash pine	Yellow-poplar
Black locust		Sweetgum
Sassafras		Cottonwood



Scenario #1: Mature forest no oak advance repro

It may take 10 to 30 yrs to get a good acorn crop and develop large oak advance repro

Site preparation burning to :

reduce leaf litter, reduce competing advance repro & midstory, destroy seed in forest floor, and xerify the seedbed to inhibit mesic species germination

Probably talking about multiple fires to reduce fuel loading, leaf litter, control invasive/undesired woody germination & establishment

That is enough time for advanced decay to develop, but larger trees are more resistant to scarring in low intensity burns

Low intensity Rx fire
Stand structure & understory composition

Fire frequency:

Annual to biennial to reduce density of sensitive species, woody veg, invasives

Periodic for woody-oak retention

Low intensity fires good for removing hardwood stems <4-6 inches dbh

Midstory removal can increase understory light to 10 to 15 % full sunlight

Low intensity fires have little effect on overstory mortality

Low light inhibits height growth of understory

Scenario #2: Mature forest with abundant small oak advance repro

Shelterwood harvest removing 50% basal area or to B-level stocking

Release burning with low intensity dormant season burn in ±3 years

Remove shelterwood, post harvest burn in ≤ 3 years

If oak seedlings ≥ 0.75” basal diameter consider moderate to higher intensity fire in late spring – early leaf out

Risks advance decay in any overstory trees that will be retained for the long-term, especially with higher intensity burns in logging slash

Keep slash at least 3’ away from residual overstory trees

Scenario #3: After final shelterwood removal, or clearcutting

Before crown closure and stem exclusion stage of stand development

If competing stems are <4 to 5” dbh, especially with low intensity fires

Release burning with low to high intensity fires every 3-5 years as needed to develop competitive oaks

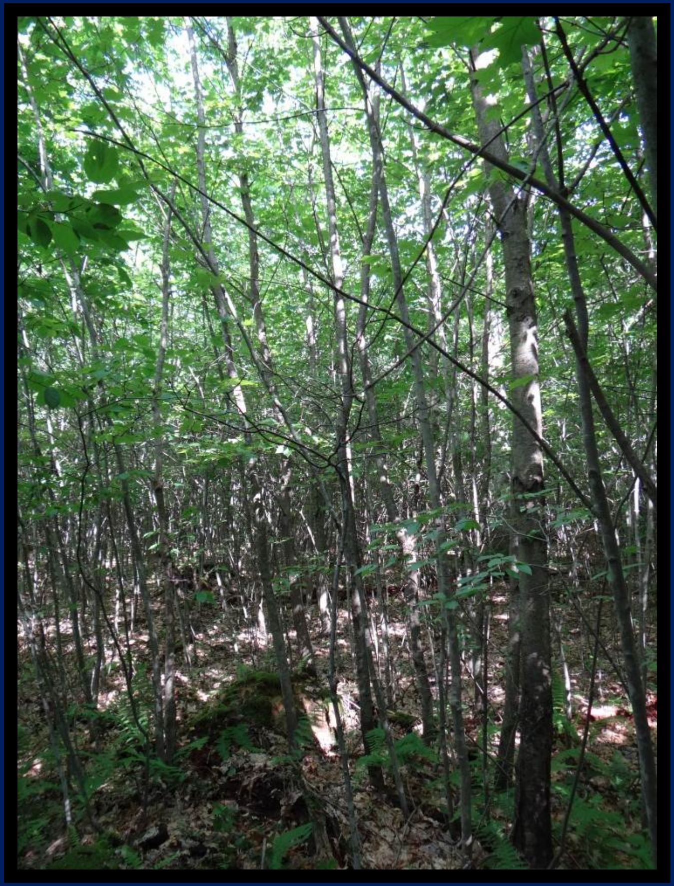
If oak reproduction is large enough (e.g., 0.75” basal diameter) go with higher intensity burns in early leaf out to summer season

Scenario #4: Crown closure, stem exclusion stage

Release burning inhibits continued recruitment into the overstory and is a clumsy, indiscriminant way to control stand density and composition

Risk of bole wounding and advanced decay in sapling & polewood crop trees is high

Mechanical/chemical release is a better alternative



Scenario #5: Uneven-aged management

Not appropriate for oaks on mesic & hydric sites

Regeneration and overstory recruitment occur simultaneously

Fire would set back to seedling stage stems meant for overstory recruitment

Midstory stems are dominated by shade tolerant, fire sensitive species

Risk of bole wounding and advanced decay in sapling, polewood and small sawtimber trees is high

Hard to burn small group openings in a matrix of uncut or single-tree harvest

Scenario #6: Savanna & woodland management

To reduce density in a mature forest requires moderate to high intensity fires that would cause large bole wounds to residual trees; an indiscriminant tool

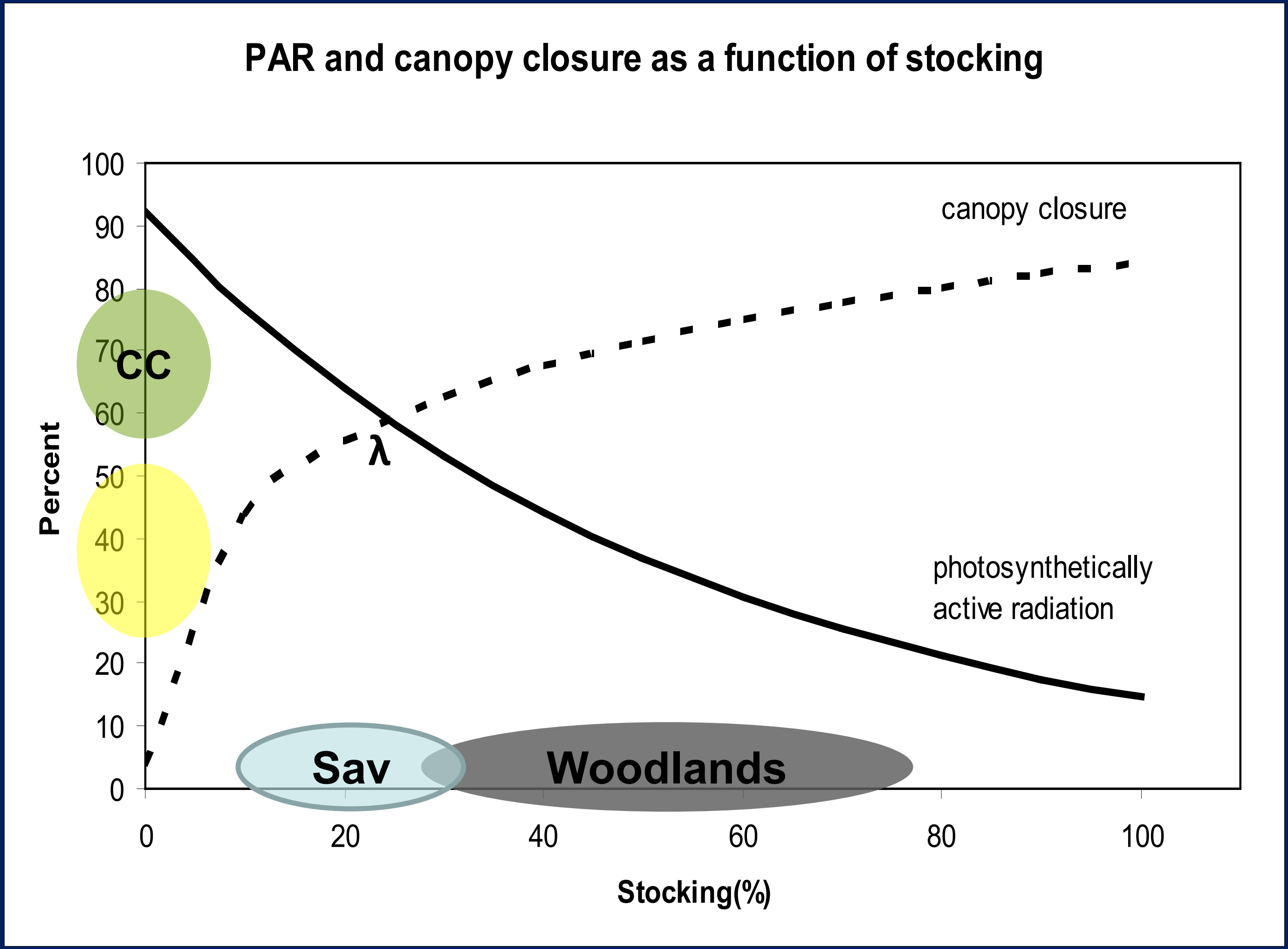
The longevity of wounded and decayed trees is reduced due to windthrow and stem breakage

It would be better to harvest the overstory to desired stand stocking & use low intensity fires to achieve other ecological objectives and control small hardwood sprouts

Rx fire use is driven by managing stand structure, ground flora, invasives

Role varies through restoration & maintenance, & recruitment phases

Managing light is important for promoting desired ground flora

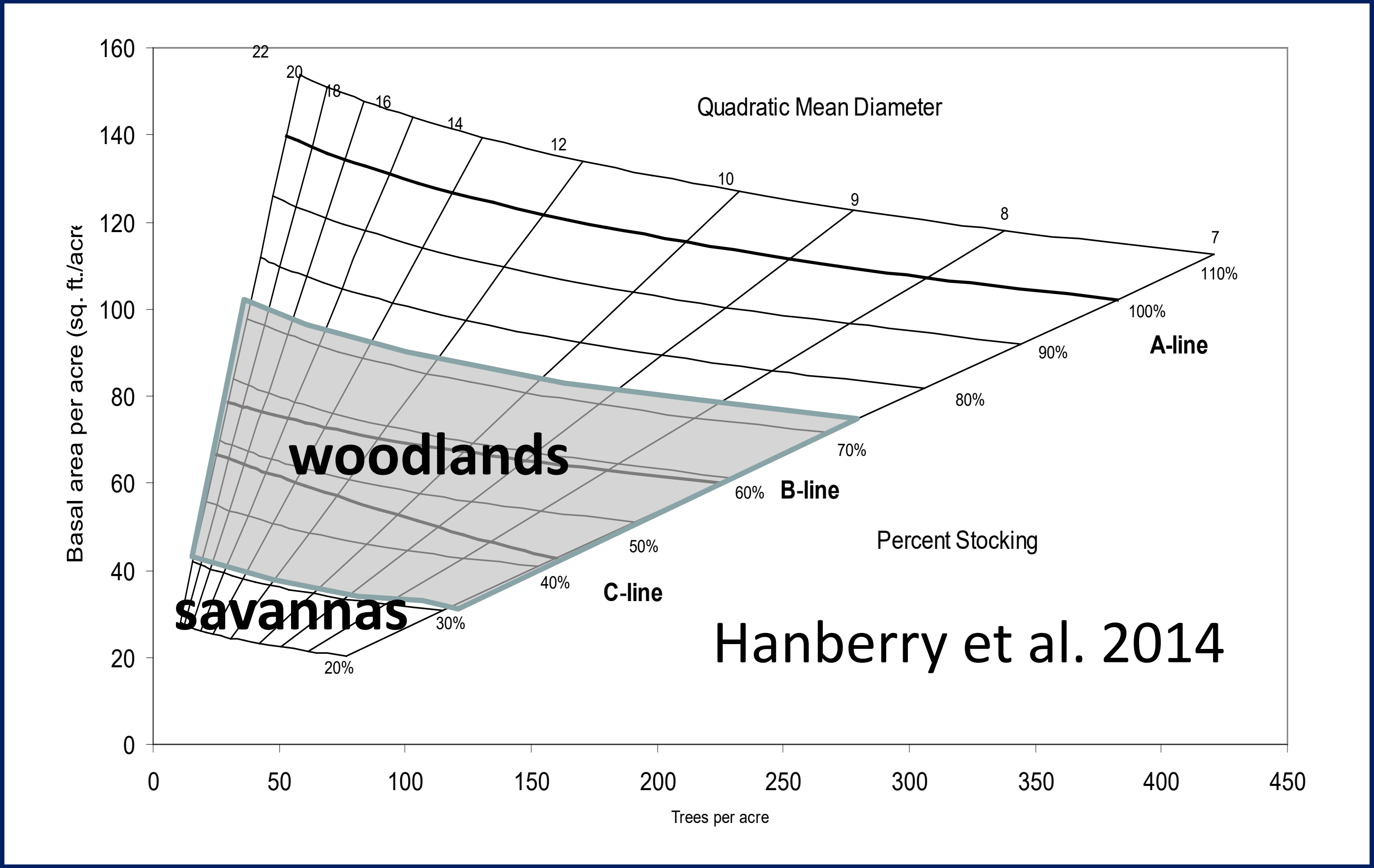


Open to Closed Woodlands have between 25 to 50% of full sunlight

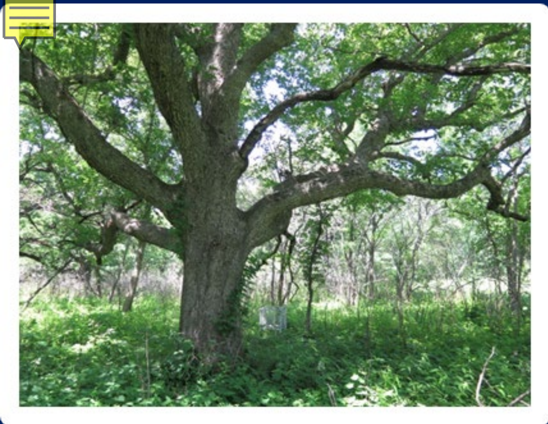
This is sufficient to maintain vigorous oak advance reproduction

Grass dominance occurs < 50% tree crown cover

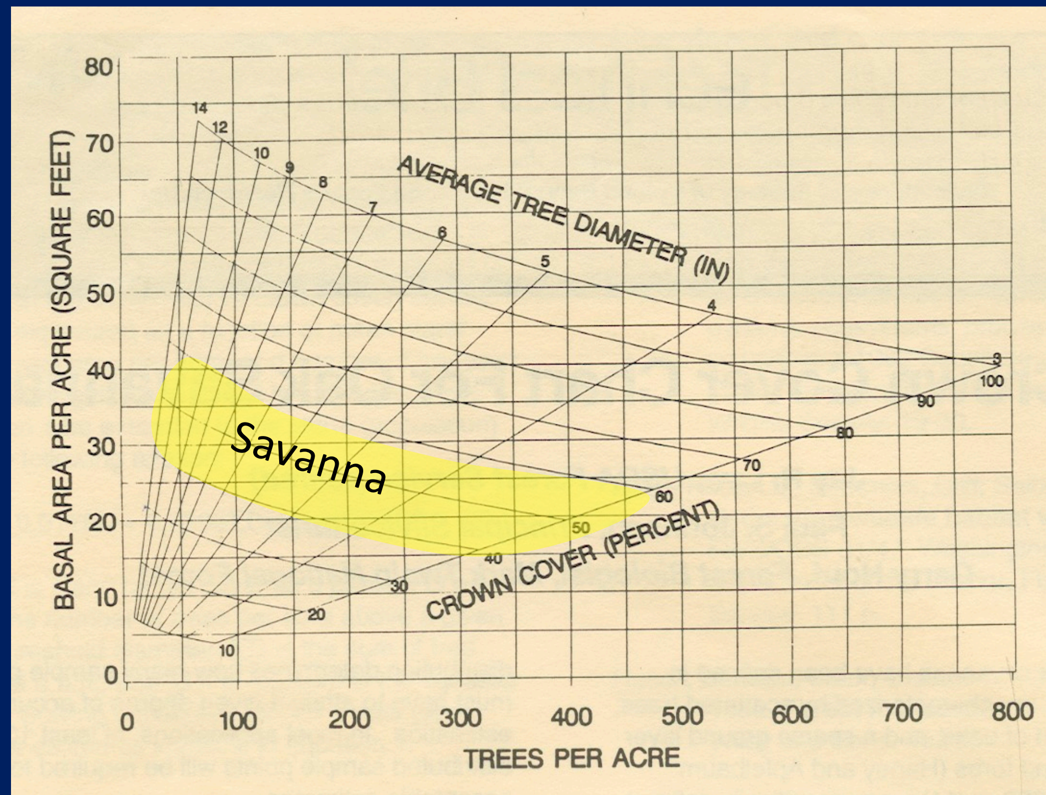
Stocking in Savannas & Woodlands



Savanna	**< 30% stocking**
Open Oak Woodland	**< 55% stocking**
Closed Oak Woodland	**<75% stocking**



Determining Crown Cover in stands of open-grown trees



Trees that have developed most of their lives below B-level stocking

Law et al. 1994

Managing Ground Flora

Overstory Density

- needs to be in range of that required by desired or indicator species
- can be used to suppress growth of shade intolerant species
- < 50% crown cover to promote dominance by grasses

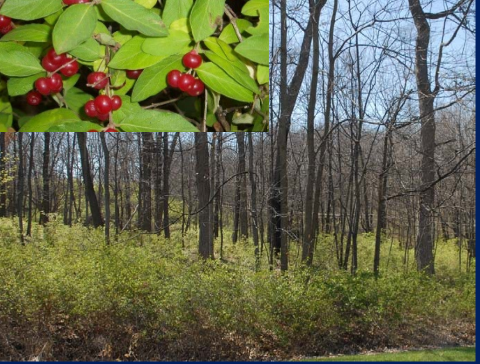
Fire

- **Frequency & season has differential effects on plant functional groups**

Fire	Grasses	Forbs	Woodies
Annual	√		
Biennial		√	
Less Frequent			√
Spring, dormant	√ C_4		√
Summer		√	

Grazing

- Can be used to shift competitive relations among species, e.g., early summer grazing by bison decreases C_4 grass dominance and increases total species richness



Bush Honeysuckle

Japanese Stiltgrass

Sericea Lespedeza

Dealing with Invasive Species

Restoration or regeneration creates environments that promote many invasive spp

Survey and control source populations before initiating canopy disturbance

Monitor

Invest in aggressive control – don't let it get a foothold

Control methods vary considerably depending on:
- species
- modes of reproduction –
  - seed (current or seedbank)/vegetative
  - repro structures above or belowground

Success may be eradication, or sustained control

Establish vigorous native ground cover

A combination of consecutive treatments – fire, herb, mechanical

Oak overstory recruitment:

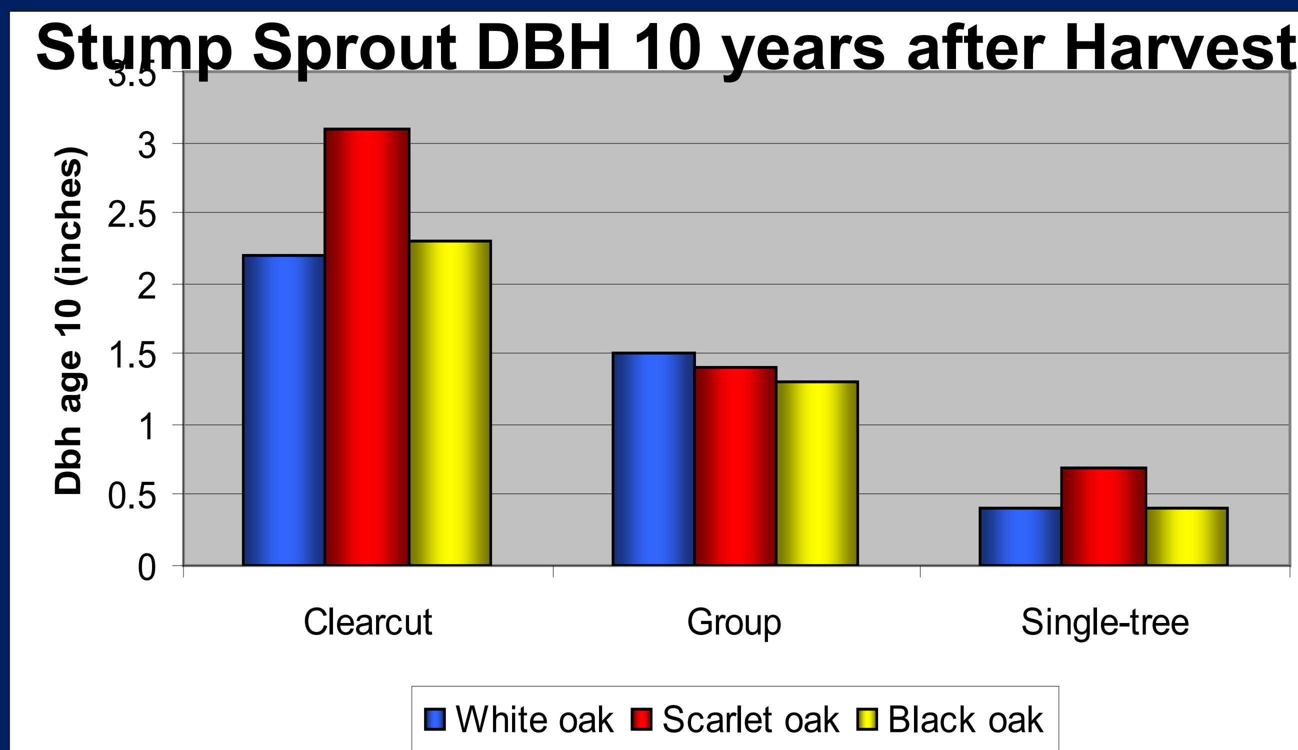
Requires a fire-free period
Approaches vary by mgmt. scale

Vigorous oak saplings –

- **grow 1.6 in in dbh in 10 years**
- **site index 65 ft in Missouri**

Oak stump sprouts grow initially faster

- **in the open**



Recruitment to Dominance needs to be managed

Hilt 1985
Morrissey et al. 2008
Zenner et al. 2012
Ward and Stephens 1994
Ward 2009

Only dominant oaks remained at end of stem exclusion

Those were largely stump sprouts

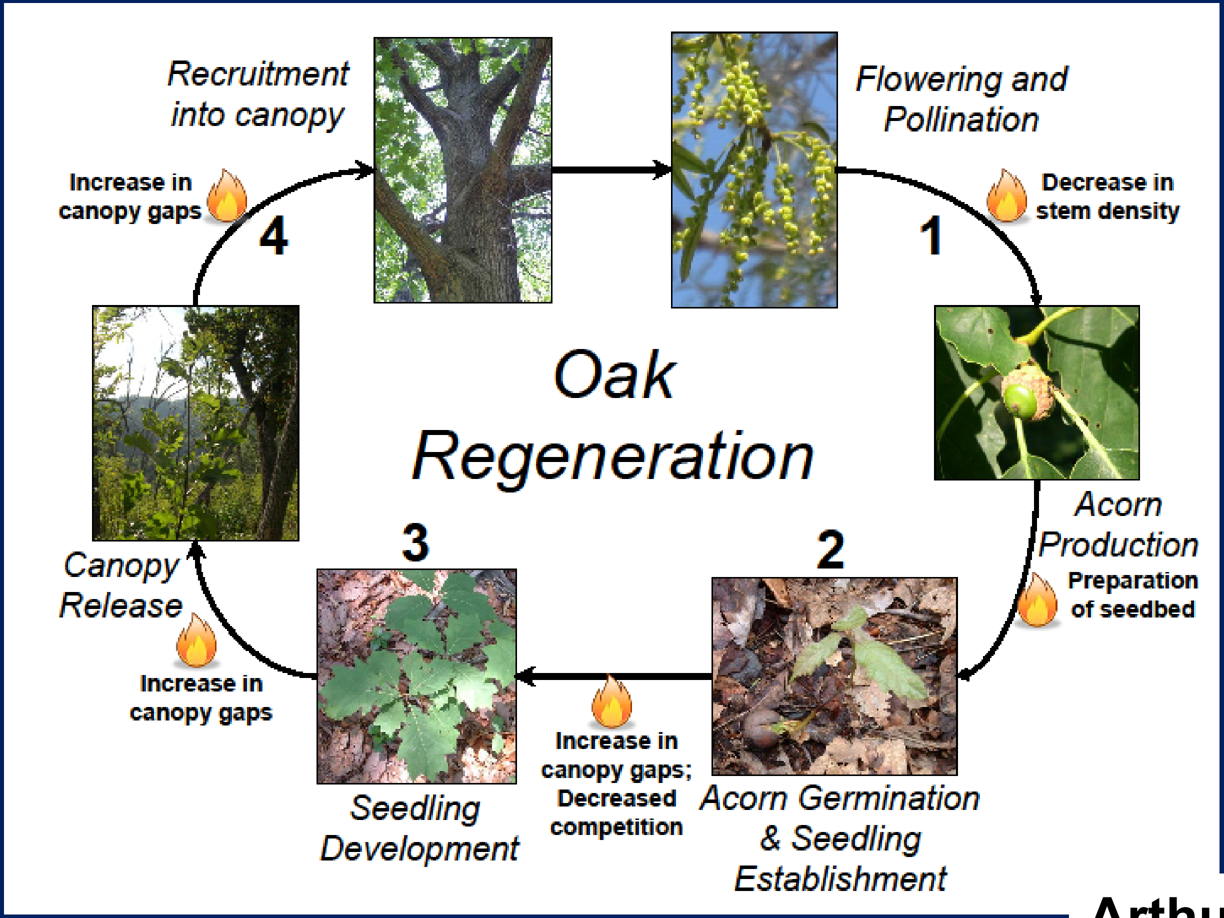
Oaks were more competitive on xeric & lower quality sites

Recommend oak release thinning at crown closure

Only oaks that are dominant at end of crown closure are likely to remain dominant/codominant at maturity

Role of Fire in Managing Oak

Depends on stage in life cycle of oak
Management Objectives –
forest, woodland, or savanna
Usually combined with mechanical or chemical treatments
Oak-pine mgmt. requires sequence of treatments over time =
long-term planning & committment



Arthur et al. 2012

Effects of Prescribed Fire on Oak Timber at different scales

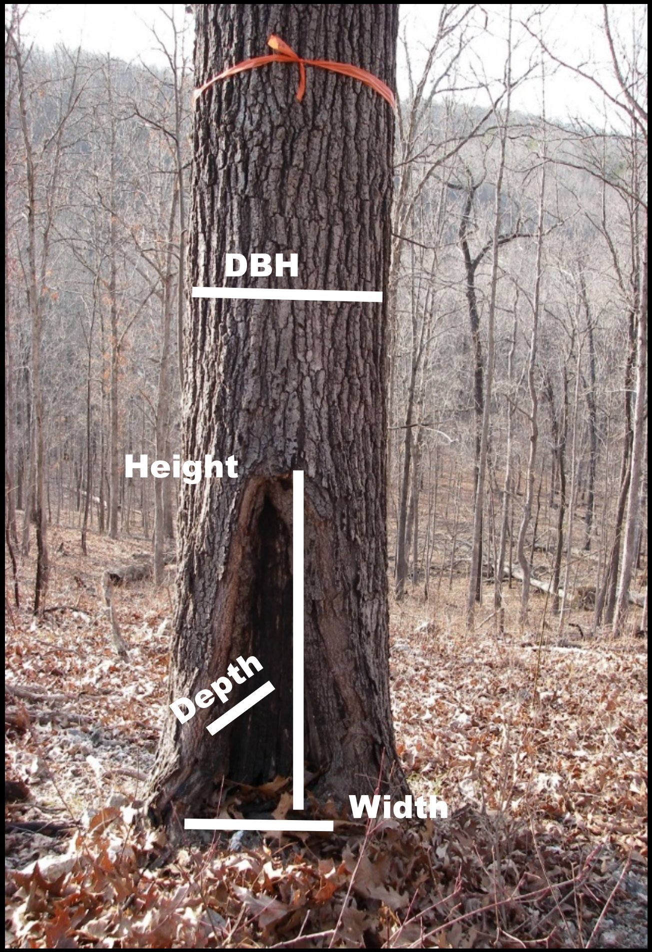
Tree volume & value

Tree lumber volume & value

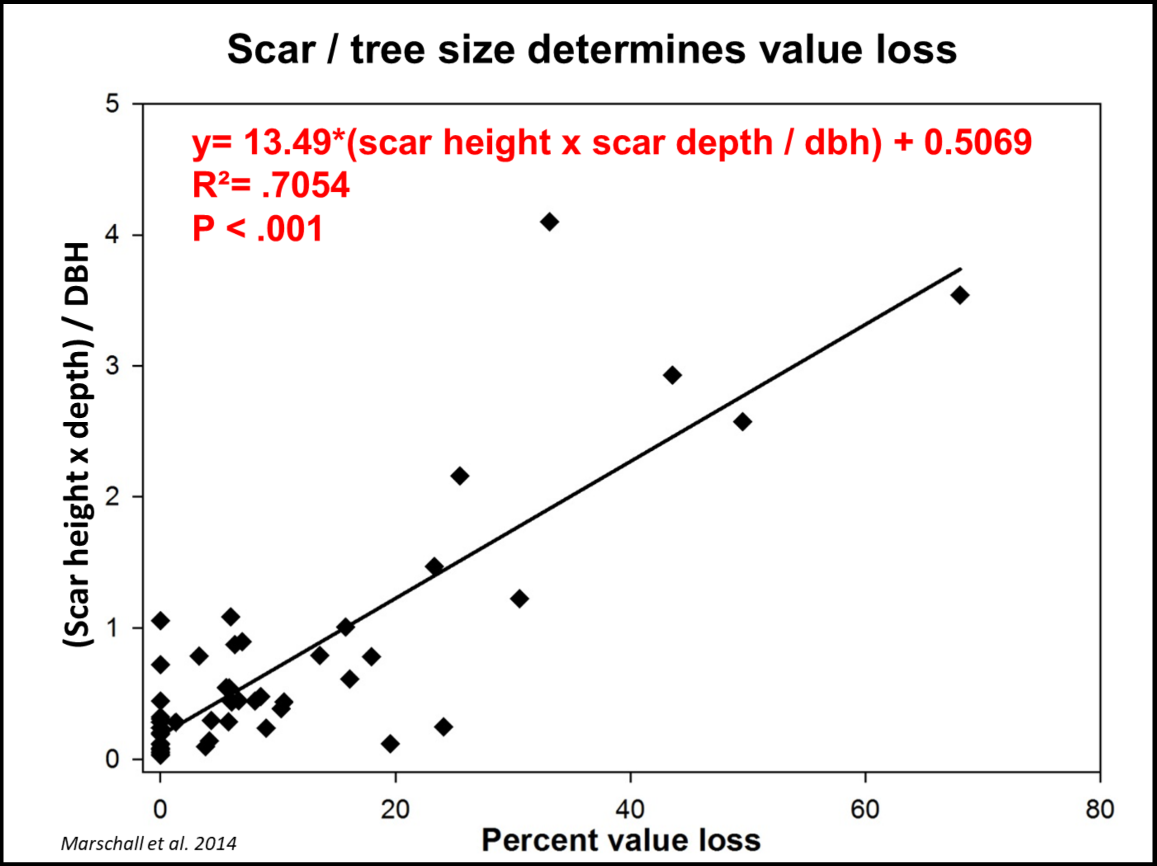
Stand volume and value

Tree growth – wood properties & scar closure

Individual Trees - Marschall et al. 2014



- Missouri Ozark
- Scarlet, black, northern red oaks
- 90 butt logs
- Burned 3-4 times in <15 yrs



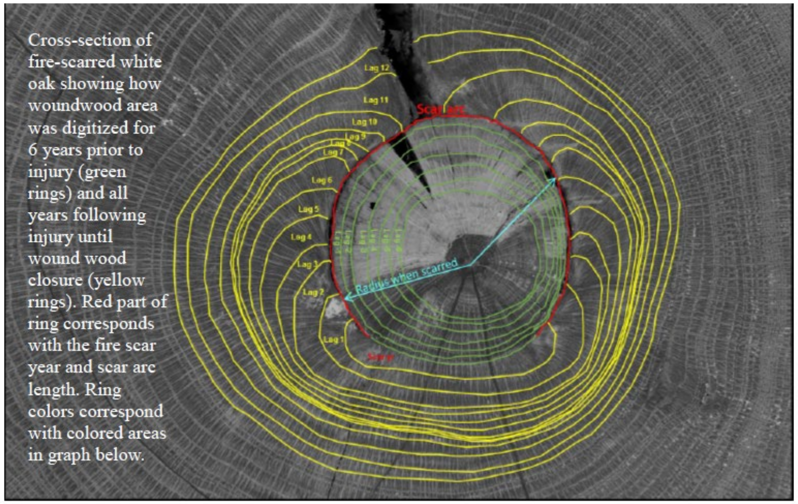
Avg value loss 9.4%
Avg volume loss 2.4%

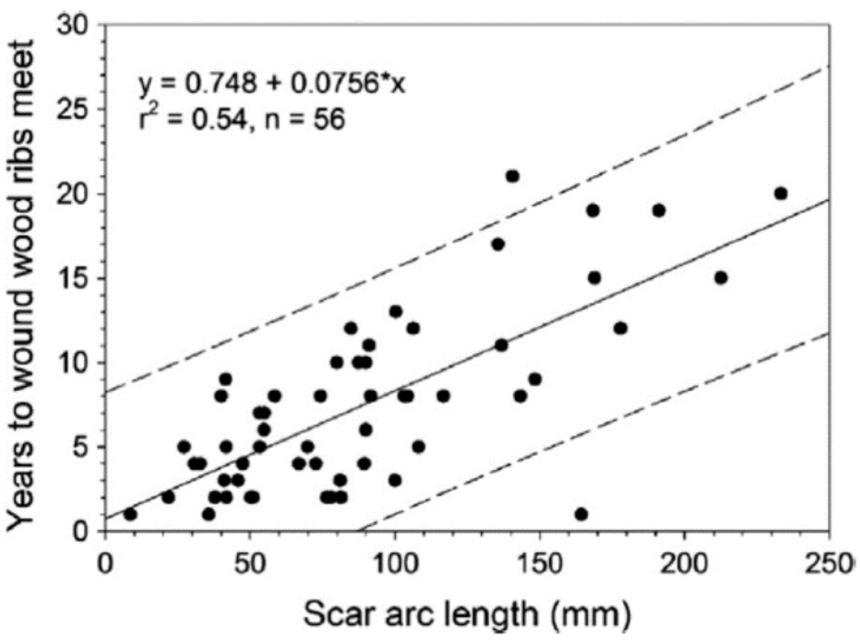
Initially, defect is outside scaling cylinder

Value loss due largely to lumber grade reduction resulting from a loss of clear cuttings

Individual tree radial growth – Stambaugh et al. 2017

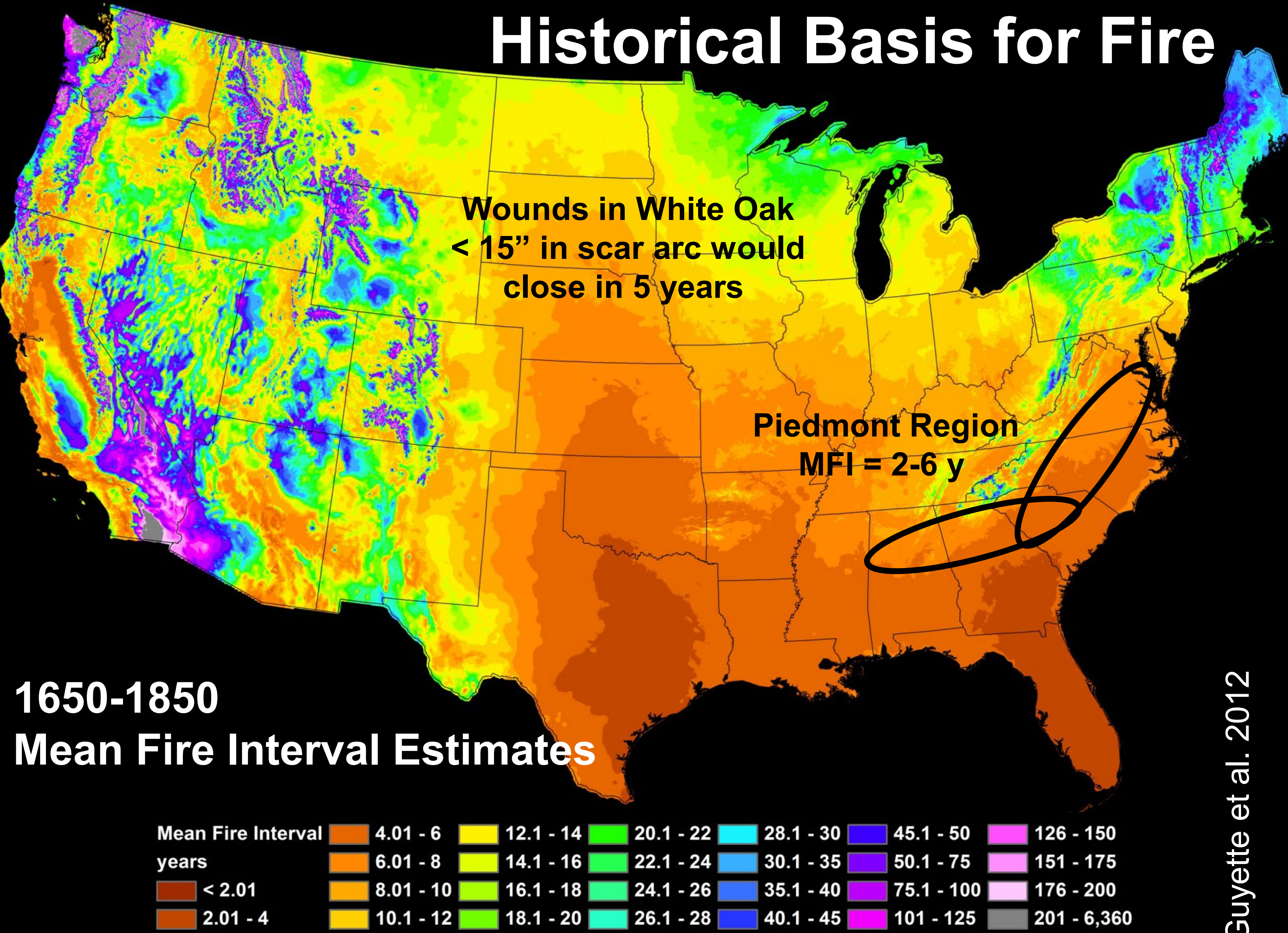
Tree growth following fire scarring (Stambaugh, Smith)





- History of frequent fire in upland oak forest in central Missouri since 1850s
- Diameter growth in white oaks was measured by digitizing tree rings
- Low % trees scarred
- White oak radial tree growth not affected by repeated fires
- Fire scar closure time is related to scar size
- Most wounds closed in 10 yrs

Historical Basis for Fire



Guyette et al. 2012

Stand level impacts – Knapp et al. 2015, 2017; Stanis et al. 2019; Mann et al. 2020

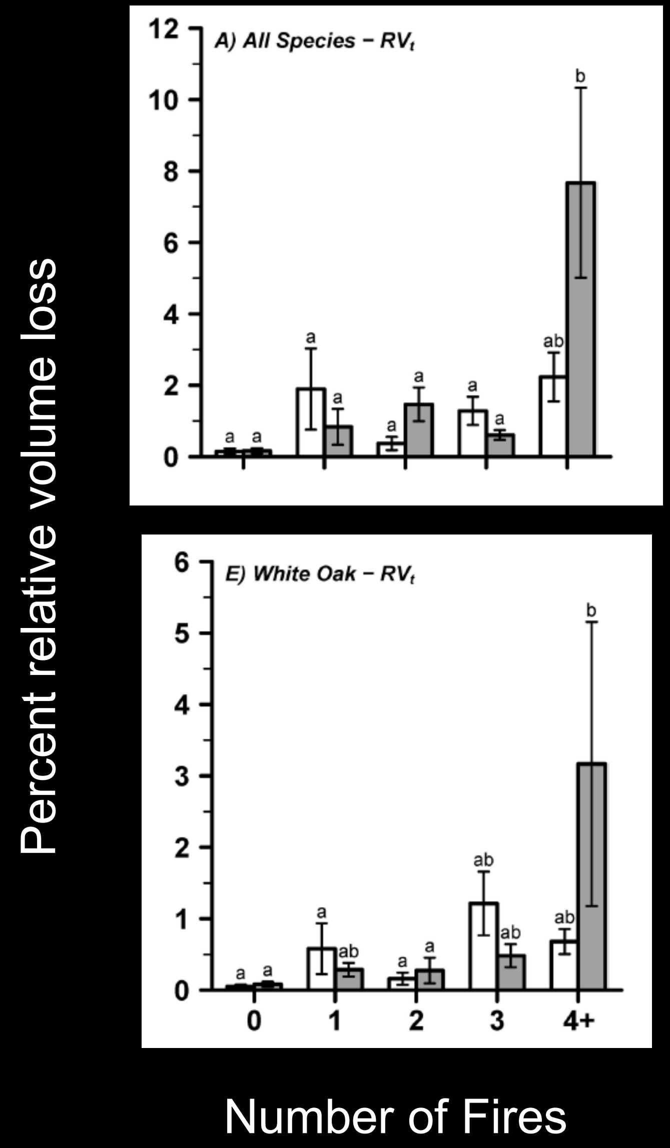
- Stumpage values applied to standing volume data

- Value loss to fire-scarred residuals estimated using Marschall (2014) equation

- 60+ years prescribed fire - annual, periodic (4 years) & control
- Missouri Ozarks, upland oak site
- Long-term, frequent burning affects stand-level values primarily through changes in species composition (shift to post oak from red oak)
- 29 to 34% reduction in stand stumpage value from annual or periodic burning, respectively
- Periodic burning scarred 55% of overstory trees, compared to 6% in annually burned
- Stand value loss due directly to fire damage was 0.5% in annual and 2% in periodic burns

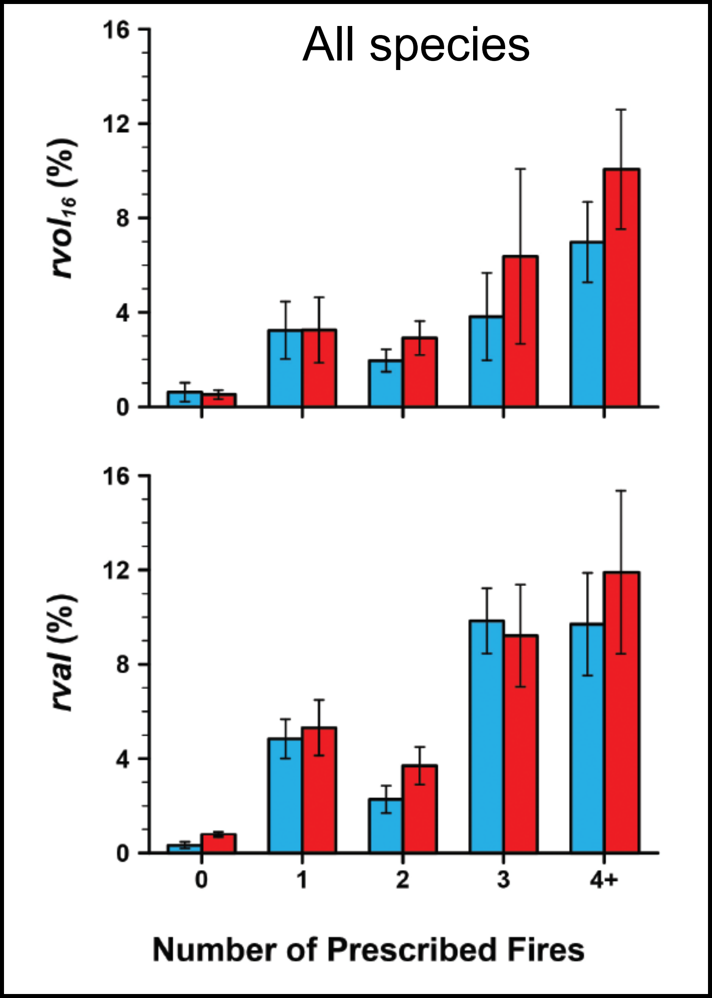
Stand level loss in volume - Stanis et al. 2019

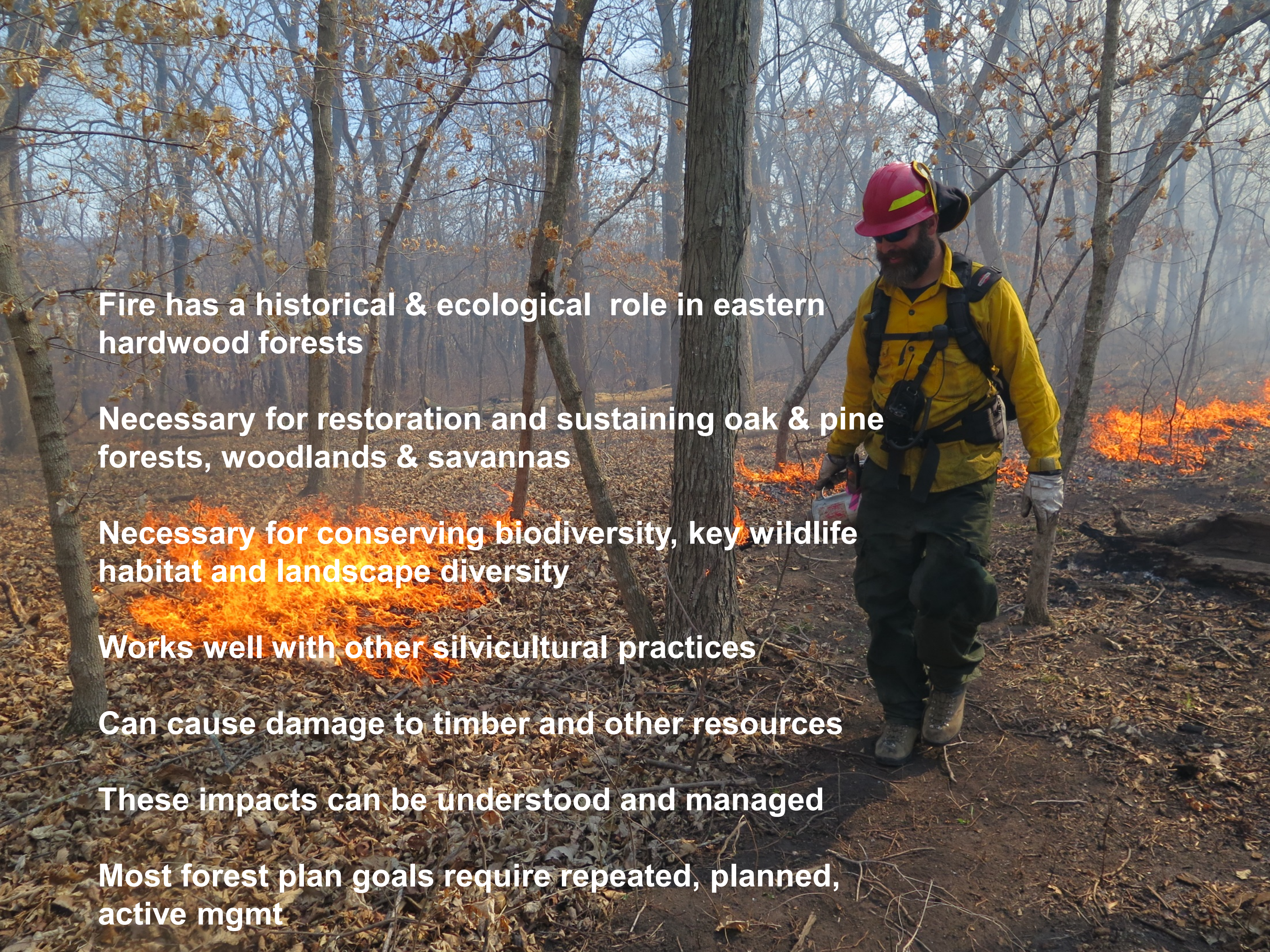
- 24 years prescribed fire
  - 1 - 4+ rx burns
- Hoosier National Forest (s. Indiana) – 54 oak stands
- 49% of trees wounded after 3+ fires
- Avg wound height 27”
- 3% trees had decline in tree grade
- 5-10% decrease in standing sawtimber volume



Stand level loss in volume - Mann et al. 2020

- 139 oak stands on 4 National Forests
- (Daniel Boone, Wayne, Hoosier, Mark Twain)
- 25 years of prescribed fire and up to 6 fires
- 31% of trees with wounds
- 7% of trees had decrease in tree grade
- < 3% volume & value loss on more mesic forests
- > 10% volume & value loss on Mark Twain
- White oak had lowest volume and value loss at 2% and 4.5% vs red oak at 13% vs sugar maple at 10%; yellow-poplar was similar to white oak




Fire has a historical & ecological role in eastern hardwood forests
Necessary for restoration and sustaining oak & pine forests, woodlands & savannas
Necessary for conserving biodiversity, key wildlife habitat and landscape diversity
Works well with other silvicultural practices
Can cause damage to timber and other resources
These impacts can be understood and managed
Most forest plan goals require repeated, planned, active mgmt