Fire in Oak Silviculture

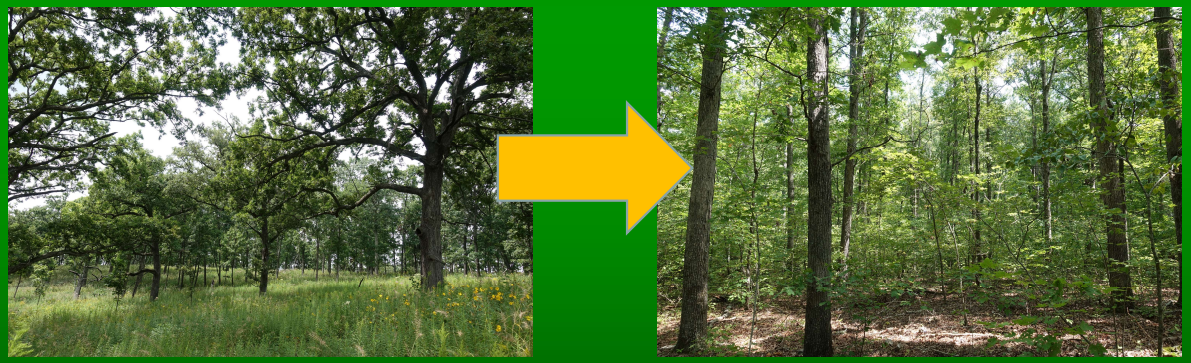
Dan Dey
Assistant Director Research
Northern Research Station

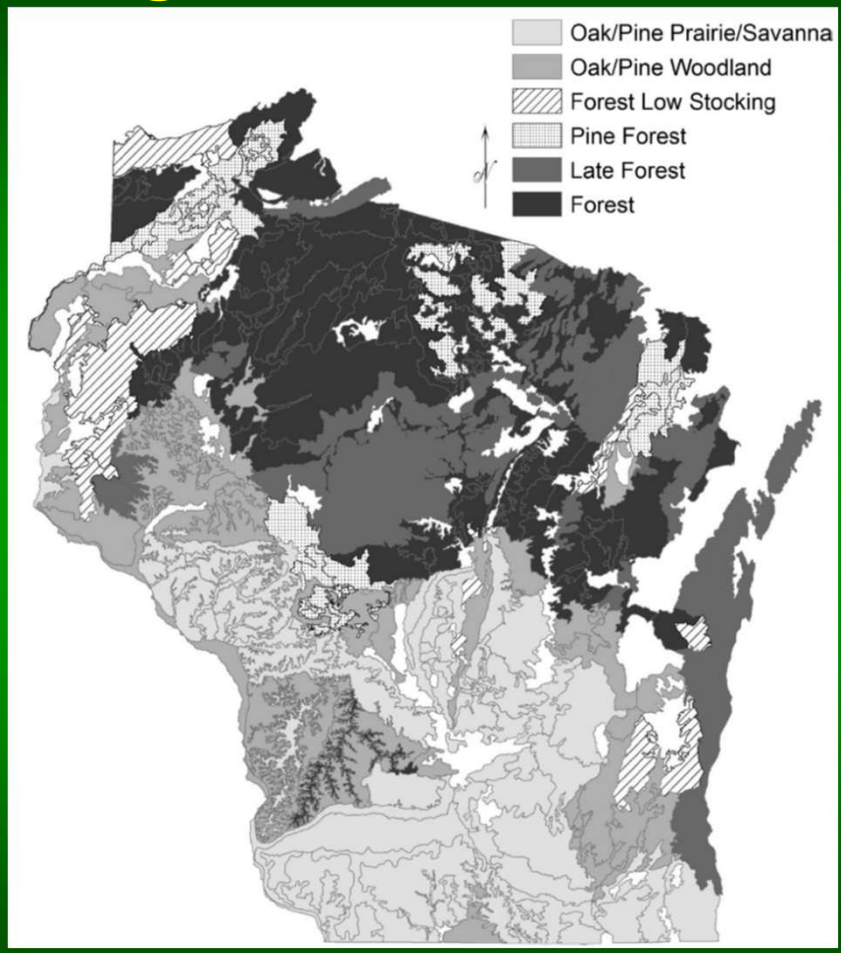
Historical Vegetation Conditions & Change

Oak composition: 65% to 23% from 1830 to 2009

Oak savannas & woodlands once 46% of Wisconsin

Loss of open forest ecosystems: increased tree density 2.2 times





Fire suppression → Mesophication

Oak woodland → Oak forest → Maple forest

Hanberry and Dey 2019

A Common Status of Oak Forests

- Closed canopy, complex vertical structure
- Dominance of shade tolerant species in mid/understory
- Low light in the understory <5% f.s.
- Little to no oak advance reproduction, or common but small
- Decades of fire suppression & canopy gap type disturbances

Key to Oak Regeneration Success: Develop Adequate Large Oak Advance Reproduction

Not all oak stumps sprout
&
New oak seedlings are not competitive

Vigorous Oak Sprouts
Missouri Ozarks

Oak Success in Dodgeville, WI

Barriers to Oak Regeneration

White oak <45%
Red oak <35%
acorn moisture content
poor germination

- Deep litter (>2” deep) inhibits oak seedling est.
  – acorns and new germinants dessicate
- Low survival of oak seedlings in mature, dense forests (<5% fs)
- Dominance of shade tolerant competitors
- Accumulation of competitor seed (cherry, yellow-poplar, Rhubus) in seed bank

Shelterwood method initially recommended to get light to oak
releases oak reproduction in short-term
but releases competing vegetation
without further management the oak is lost

The Role of Fire in Oak Silviculture – Rx fire alone

Rx fire reduces deep leaf litter

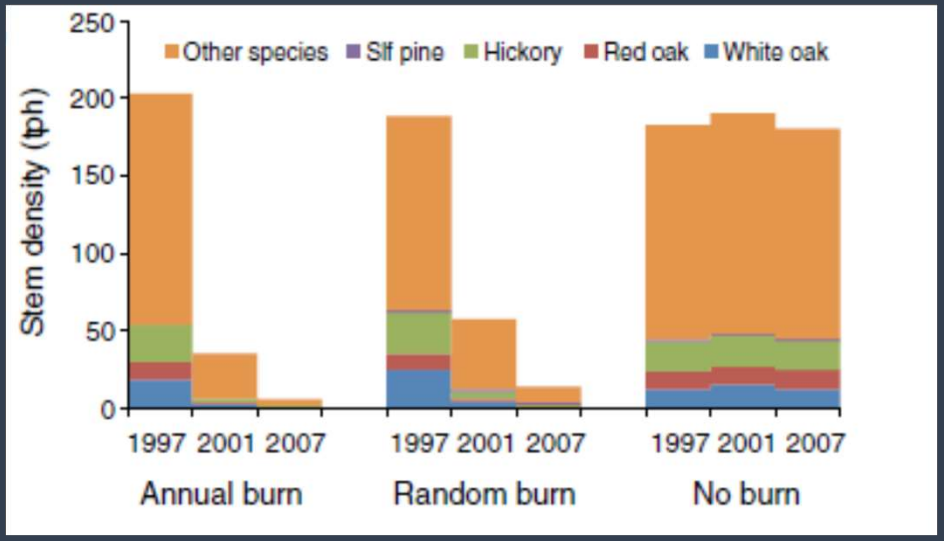
Consumes seed in seed bank

Can increase understory light to 10-20% full sunlight

<5% loss of overstory basal area with dormant season burns

Topkills woody competition, sprouts grow slowly under closed canopy

Frequent repeated fire 1-3 years reduces understory woody competition



Hutchinson et al. 2005
Fan & Dey 2014
Knapp et al. 2015

Fire- Oak Establishment

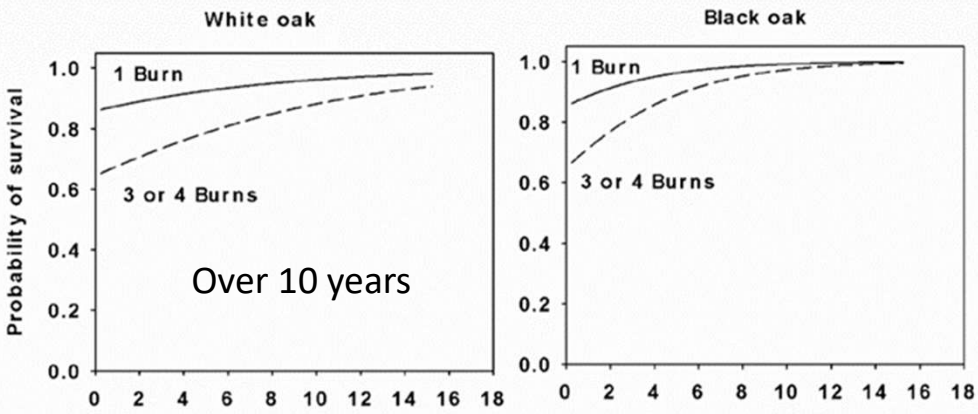
- **Leaf litter recovers to 75% of equilibrium in 4 yrs after fire**
- **Fire after acorn drop – can kill >70% of acorn crop**

Can persist & grow through recurring Rx fire for decades with adequate light

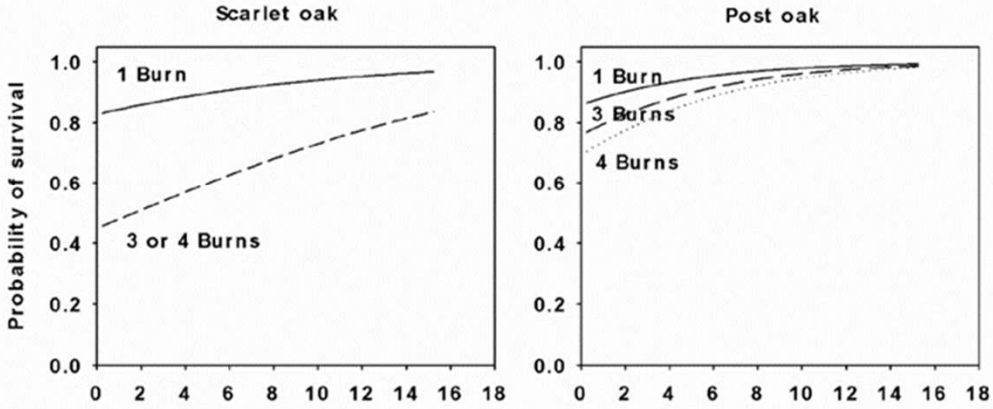
Auchmoody & Smith 1993
Johnson 1974
Dee et al. 2022

One spring burn
70% mortality of oak seedlings
less than 3-years-old

Not all oak species respond the same to fire

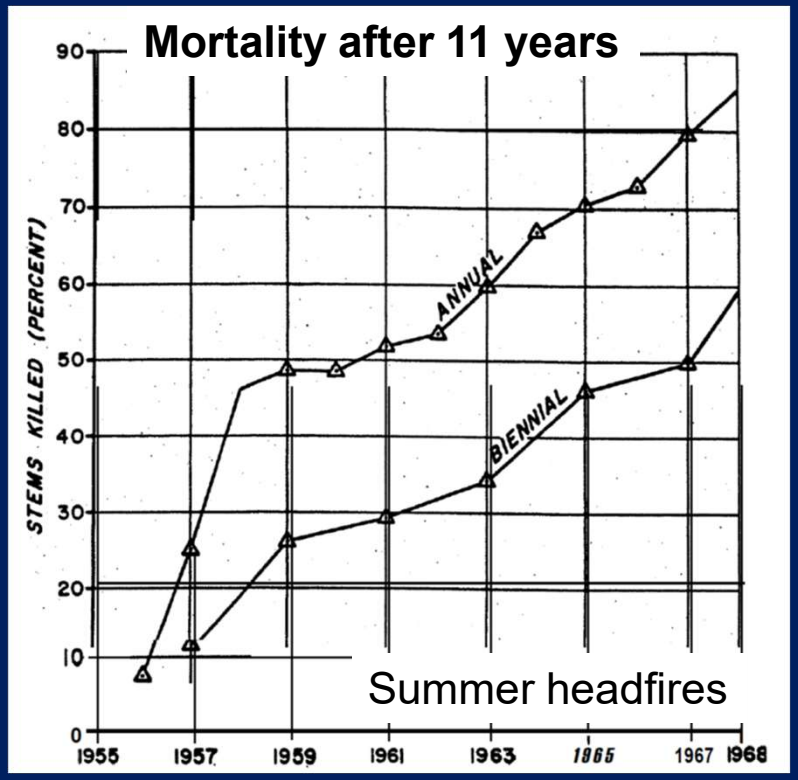


Spring burns under mature oak forests – Missouri Ozarks



The Role of Fire in Stand Management
The Understory & Midstory

Grano 1970

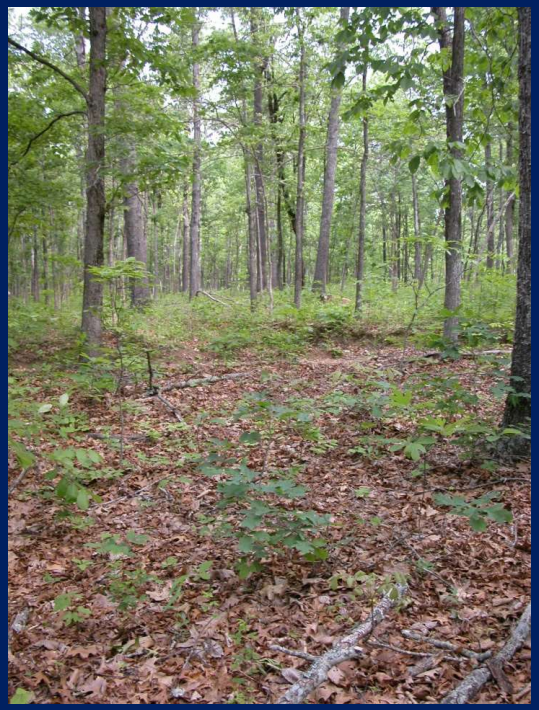


Hardwood stems <6” basal diameter
Southern pine forest in Ashley Co, Arkansas

Hack n spray herbicides effective on larger saplings and pole-sized trees

Stand Density & Oak Growth

60 ft^2 per acre or more:



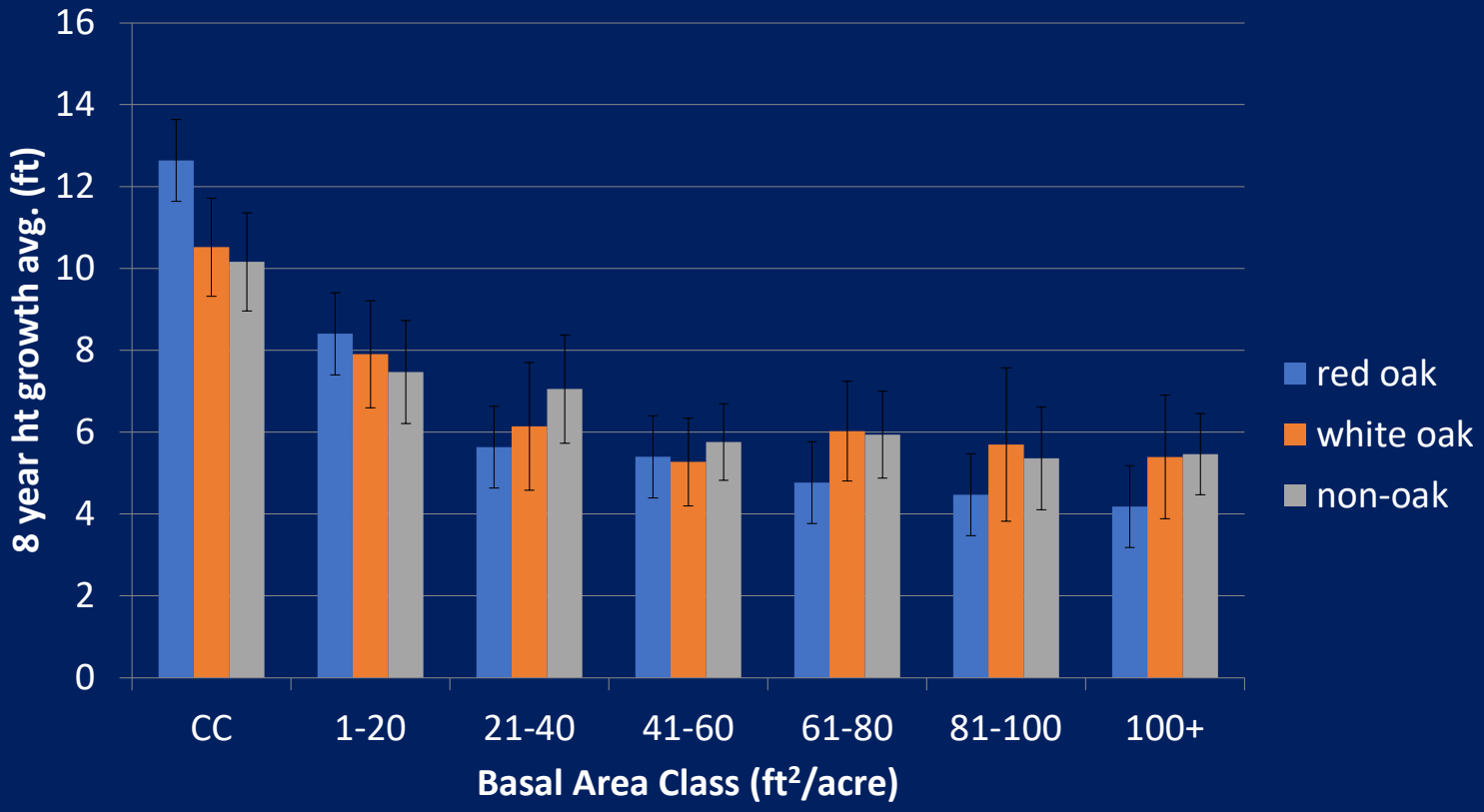
reduces survival of oak stumps
reduces growth of oak stump sprouts
Dey et al. 2008

reduces oak advance reproduction growth and survival, and hence, density of large oak seedlings
Larsen et al. 1997
Green 2008
Kabrick et al. 2008

discriminates against red oak species causing shifts to white oaks or other shade tolerant species
Kabrick et al. 2008
Arthur et al. 1998
Groninger and Long 2008

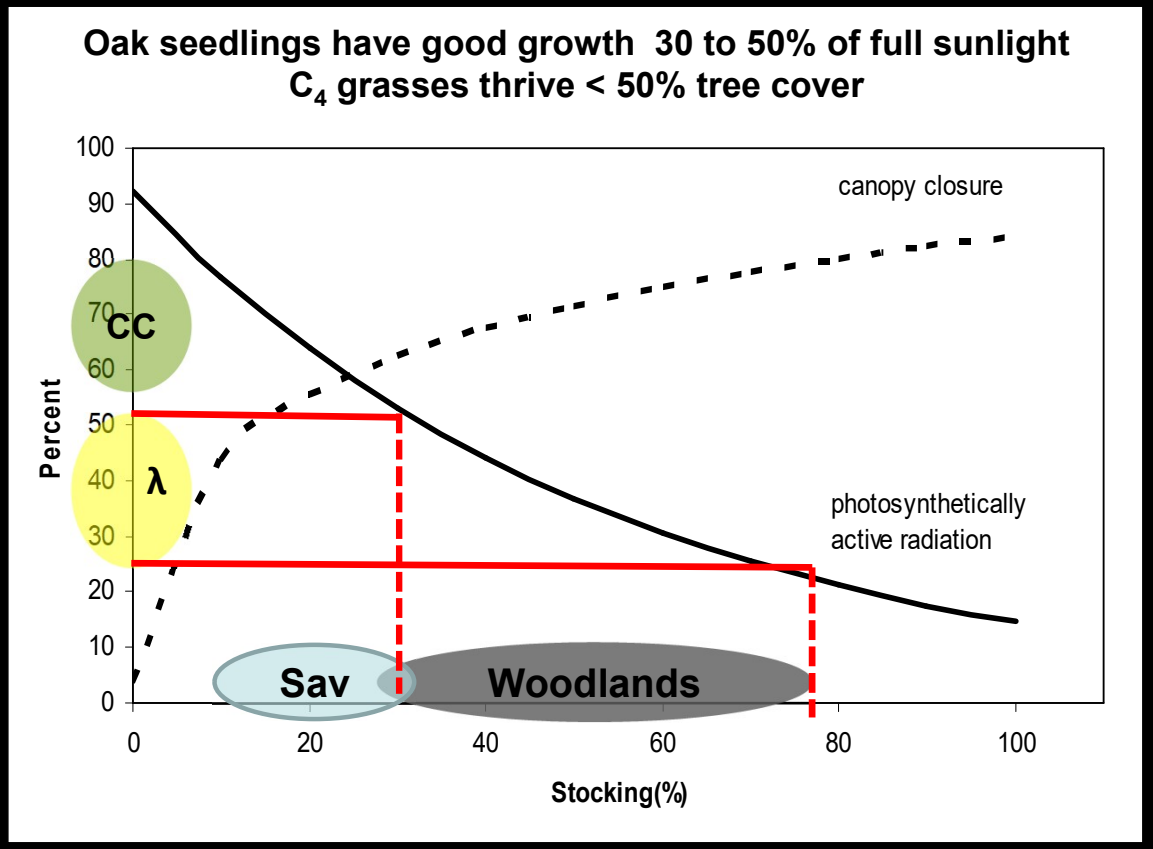
Oaks need 30 to 50% f.s. but competitors must be controlled

Height growth red oak vs. white oak vs. non-oak with increasing overstory density



Green 2008

Tree Density & Biological Diversity, Ecosystem and Landscape Integrity & Resilience



Savannas and Open Woodlands have the highest plant diversity, and this supports Ecosystem diversity, health, productivity, resilience

Blizzard et al. 2013
Dey et al. 2017
Hanberry et al. 2014

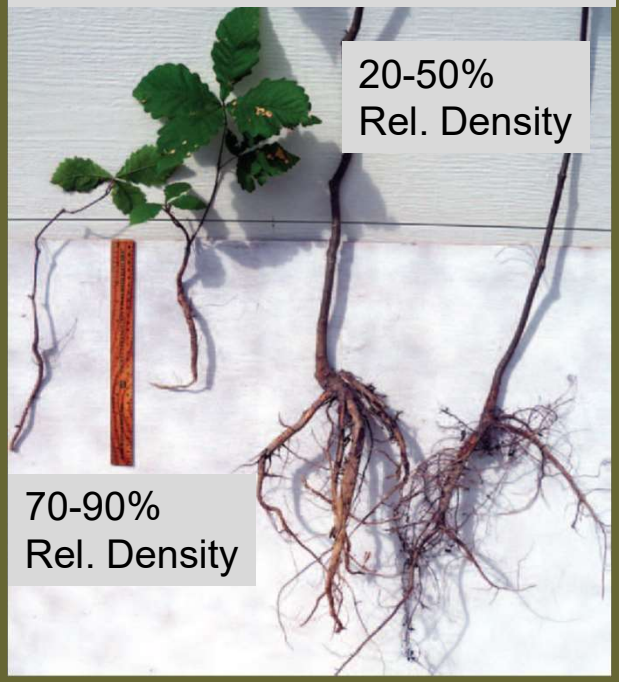
Combining Fire with Harvesting can Promote Oak Regeneration
shelterwood (uniform, irregular) & group selection methods

3 or 5 fires begun 7 years before gap formation
and ending 1 to 2 years after –

promoted the development of large white oak advance repro

Fire after Final Overstory Removal – shelterwood method

8 yr planted oak seedling growth under various overstory density

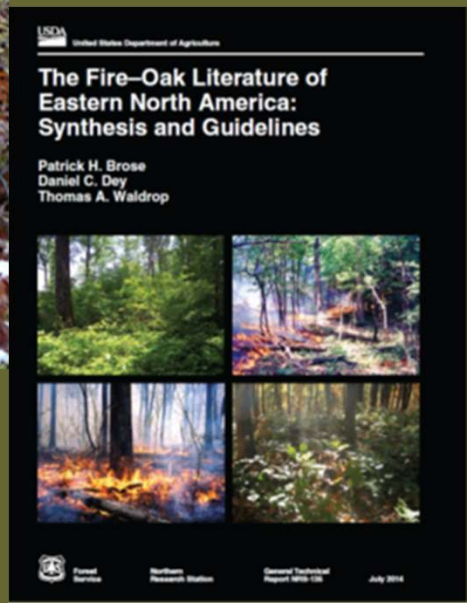


Cease fire to allow for Recruitment

Consider tending?

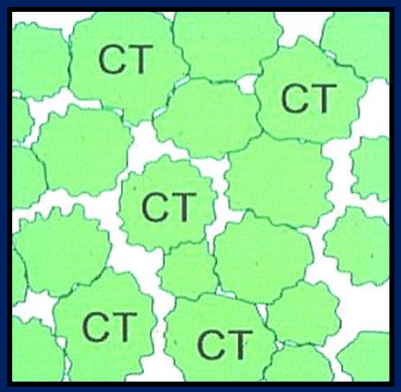
When oak repro > 0.5” basal diameter burn later in spring early summer with increased fire intensities

Brose et al. 2014

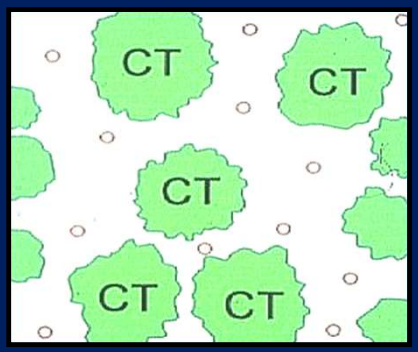


Stand Development
Canopy Closure
Crop Tree Release

Stand age 10 to 20 years
Canopy closure



4-sided crown touching method



50 to 75 crop trees per acre at maturity

Fire is not useful at this stage

Fire in the Life Cycle of Oak

Arthur et al. 2012 Journal of Forestry

Refining the Oak–Fire Hypothesis for Management of Oak-Dominated Forests of the Eastern United States

Mary A. Arthur, Heather D. Alexander, Daniel C. Dey, Callie J. Schweitzer, and David L. Loftis

ABSTRACT

Prescribed fires are increasingly implemented throughout eastern deciduous forests to accomplish various management objectives, including maintenance of oak-dominated (*Quercus* spp.) forests. Despite a regional research-based understanding of prehistoric and historic fire regimes, a parallel understanding of contemporary fire use to preserve oak forests is only emerging, and with somewhat inconsistent results. For prescribed fires to be effective, they must positively influence oak regeneration at one or more critical life stages: pollination, flowering, seed set, germination, establishment, seedling development, and release into the canopy. We posit that a simplistic view of the relationship between fire and oak forests has led to a departure from an ecologically based management approach with prescribed fire. Here, we call for a refinement in our thinking to improve the match between management tools and objectives and provide some guidelines for thinking more ecologically about when and where to apply fire on the landscape to sustain oak-dominated forests.

Keywords: oak-fire hypothesis, oak regeneration, forest management, oak ecology, prescribed fire

Forest managers working in oak-dominated forests throughout the eastern deciduous forest biome increasingly embrace prescribed fire among the silvicultural and restoration tools available for addressing a variety of management objectives. This growing acceptance and use of fire stems from a rapidly expanding research-based knowledge of prehistoric (Clark et al. 1996) and historic fire regimes in the region (Guyette et al. 2002, McEwan et al. 2007). This is coupled with mounting concerns

agement plans throughout the region call for increased acreages burned (USDA Forest Service Daniel Boone National Forest 2005, USDA Forest Service Mark Twain National Forest 2005, USDA Forest Service Ozark-St. Francis National Forests 2005). Despite these trends, however, fire use as a forest management tool has often preceded research-based evidence for its effectiveness in accomplishing specific silvicultural and ecological objectives across the many ecological settings where oaks are dominant or prominent.

As public agencies and forest managers increase their burn acreage targets and personnel to accomplish more burning across the oak-dominated forest landscape, we think this is a good time to explore the physiological and ecological basis for using pre-

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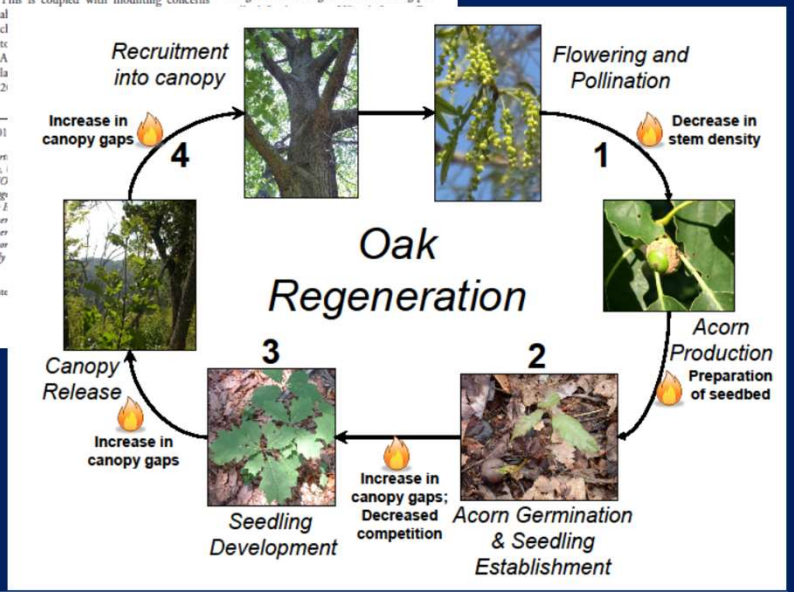
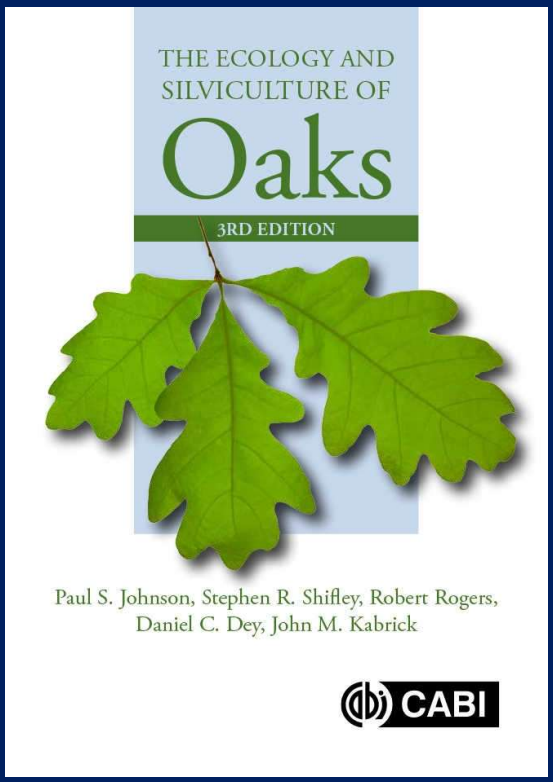
Mary A. Arthur (marthur@uky.edu) is professor, Depart... Alexander (hdalexander@wfl.edu) is postdoctoral fellow, ... Research Station, 202 ABNR Building, Columbia, MO ... Research Station, Upland Hardwood Ecology and Manag... Forest Service Southern Research Station, Bent Creek E... M. Arthur's article, "Prescribed fire and oak regener... Lexington, KY, Oct. 3–4, 2007. The idea was further ... 20–22, 2008. The authors appreciate the editorial wor... 3-year conversation among the coauthors. This study ... approved by the Director.





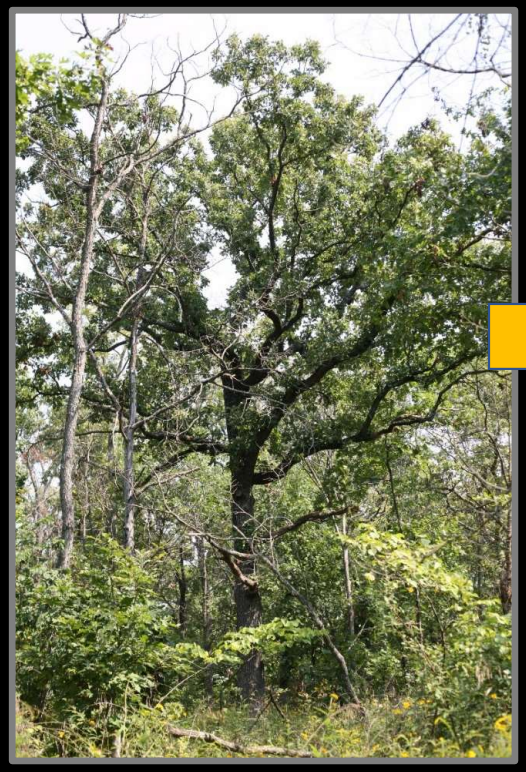
Fire has another Role in Oak Woodlands & Savannas

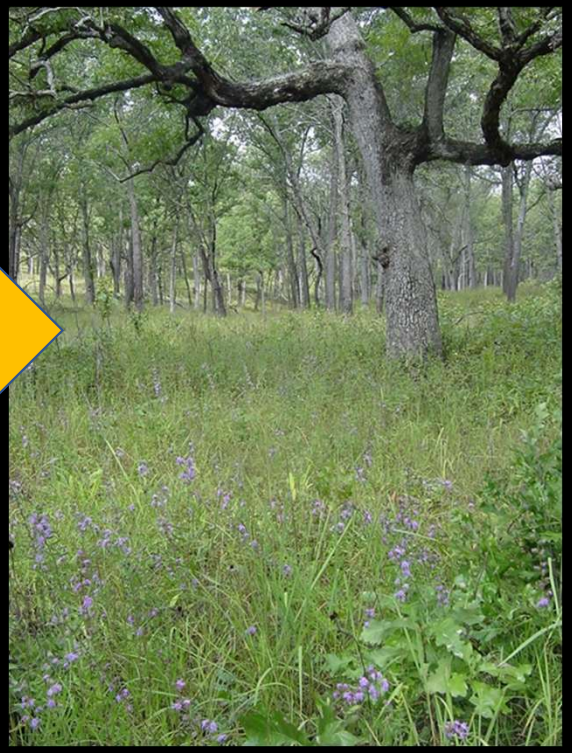

Big brown bat


Eastern red bat


Evening bat


Tri-colored bat






Prairie warbler


Summer tanager


Blue-winged warbler


Eastern wood-peewee

Fire Effects on Timber: Highlights

Marschall et al. 2014, Stambaugh et al. 2017
Stanis et al. 2019, Mann et al. 2020
Saunders et al. 2023)

Individual Trees:

2.4% volume, 9% value loss in red oaks after 14 years following Rx fires
Minimize loss if harvest within 5 yrs and if scars <20" in height in mature trees
Pole-sized trees most vulnerable

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

Stand Level:

3-7 % trees had decline in tree grade over 25 years and 6 Rx fires
3-10% decrease in standing sawtimber volume and value, varied by species; white oaks least effected (2-3%)

Silviculture Studies:

Initial dormant season low intensity fire is good for reducing decades of fine fuel accumulation

Annual burns cause less injury to trees than periodic burns

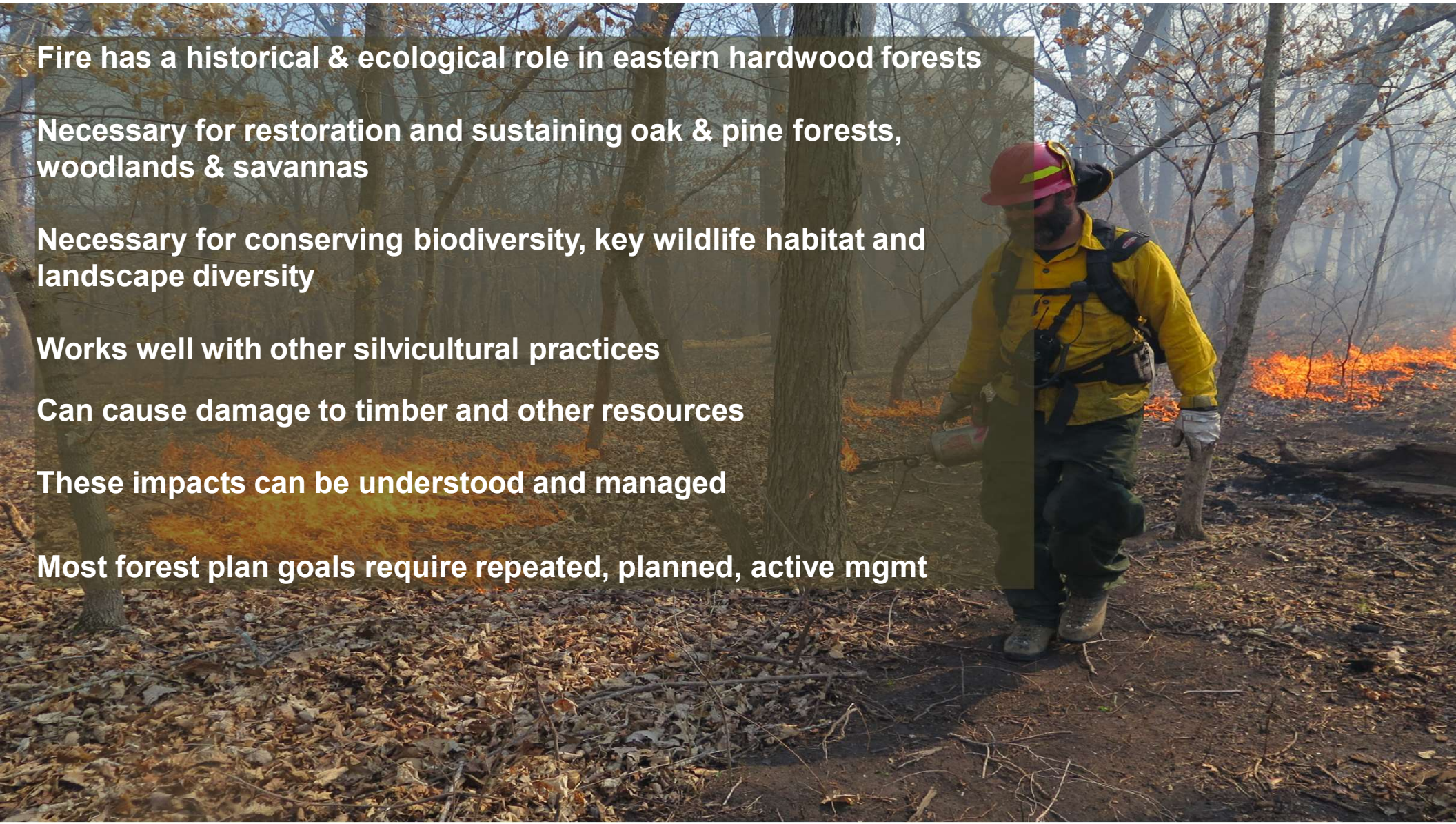
Removal of heavy fuels from 3' around trees substantially reduces chance of injury

To Minimize Fire Damage
Timing is important!

Small trees have small wounds and if vigorous heal quickly Compartmentalizing the defect in a central core area

Large mature trees are harder to scar
Time to harvest may be close at hand
Scars in the sapwood are outside the scaling cylinder

Pole to small sawtimber trees are in greatest risk of sustaining large scars and remaining in the stand long enough to develop substantial decay


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

Burn to Learn

Don’t wait until you know everything before you do something – burn to learn

These are fire dependent species and communities