



# Northern Oak Ecosystems: A Natural History

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Hardwood tree genera in the literature of science:  
a search of the *Biological Abstracts* data base  
(1969-2009)

Search terms	No. of hits
Oak + <i>Quercus</i>	8,045
Birch + <i>Betula</i>	3,812
Beech + <i>Fagus</i>	3,117
Maple + <i>Acer</i>	2,948
Poplar + <i>Populus</i>	2,844
Aspen + <i>Populus</i>	2,299
Ash + <i>Fraxinus</i>	1,309
Walnut + <i>Juglans</i>	991


# Caveats

- Generalizations do not cover all cases; exceptions may always be found
- An oak is not an oak...each species-habitat combination is ecologically unique
- Some data I present are from outside northern Michigan and may or may not be transferable
- I will avoid the silvicultural management of stands (covered in other talks)




# Today's Topics


- Michigan's northern oaks



*Quercus*—World  
400+ trees & shrubs in  
2 subgenera & 5 sections

A topographic map of the United States, showing terrain elevation in shades of green and brown. The map includes state boundaries and major water bodies like the Great Lakes and the Gulf of Mexico. The text is centered over the eastern half of the continent.

*Quercus*—USA  
70+ trees and shrubs  
in 3 sections

A satellite-style map of Michigan and its surrounding regions, including parts of Wisconsin, Indiana, and Ohio. The map shows the state's outline and major water bodies like Lake Superior, Lake Michigan, and Lake St. Clair. A black line outlines the state of Michigan. Overlaid on the map is the text: 

*Quercus*—Michigan  
12 trees and 1 shrub  
in 2 sections

# Michigan's 13 Native Oaks

(Barnes & Wagner 2004)

- Red oaks

(section *Erythrobalanus*)

- Northern red
- Black
- Pin
- Northern pin
- Scarlet
- Shumard ?
- Shingle

- White oaks

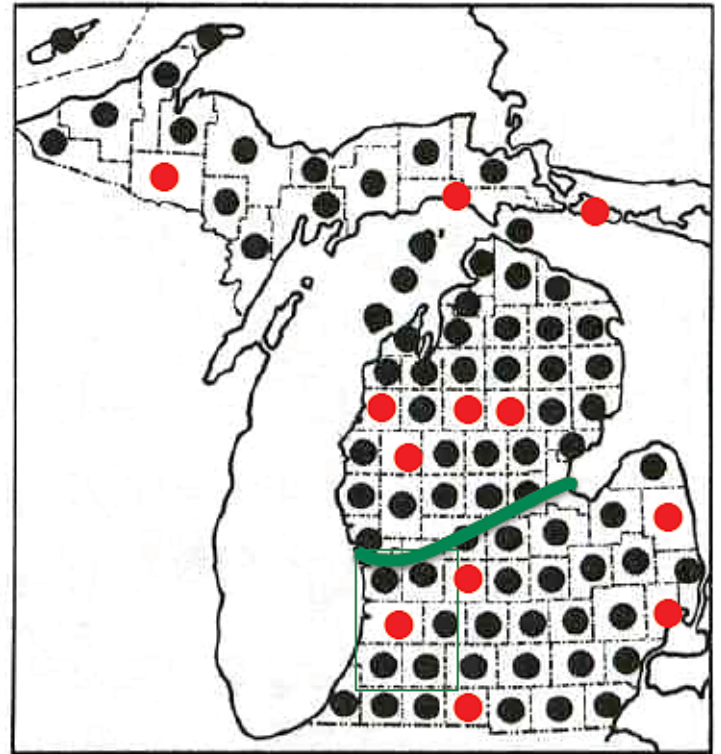
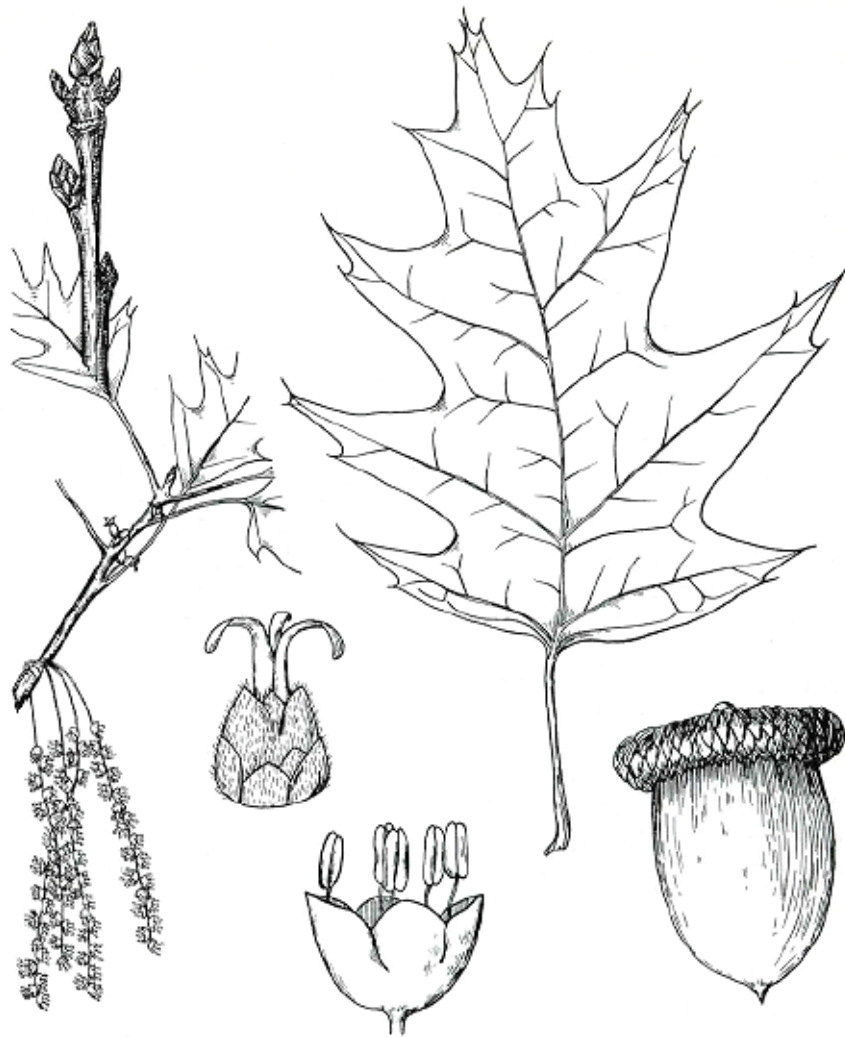
(section *Quercus*)

- White
- Bur
- Swamp white
- Chinkapin
- Chestnut ?
- Dwarf chinkapin  
(shrub)



# Michigan's 5 Northern Oaks

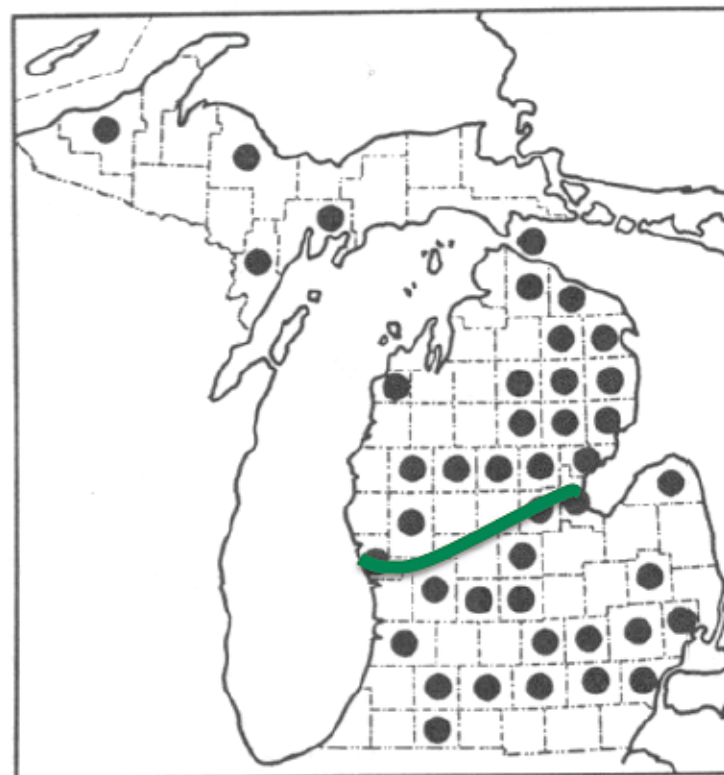
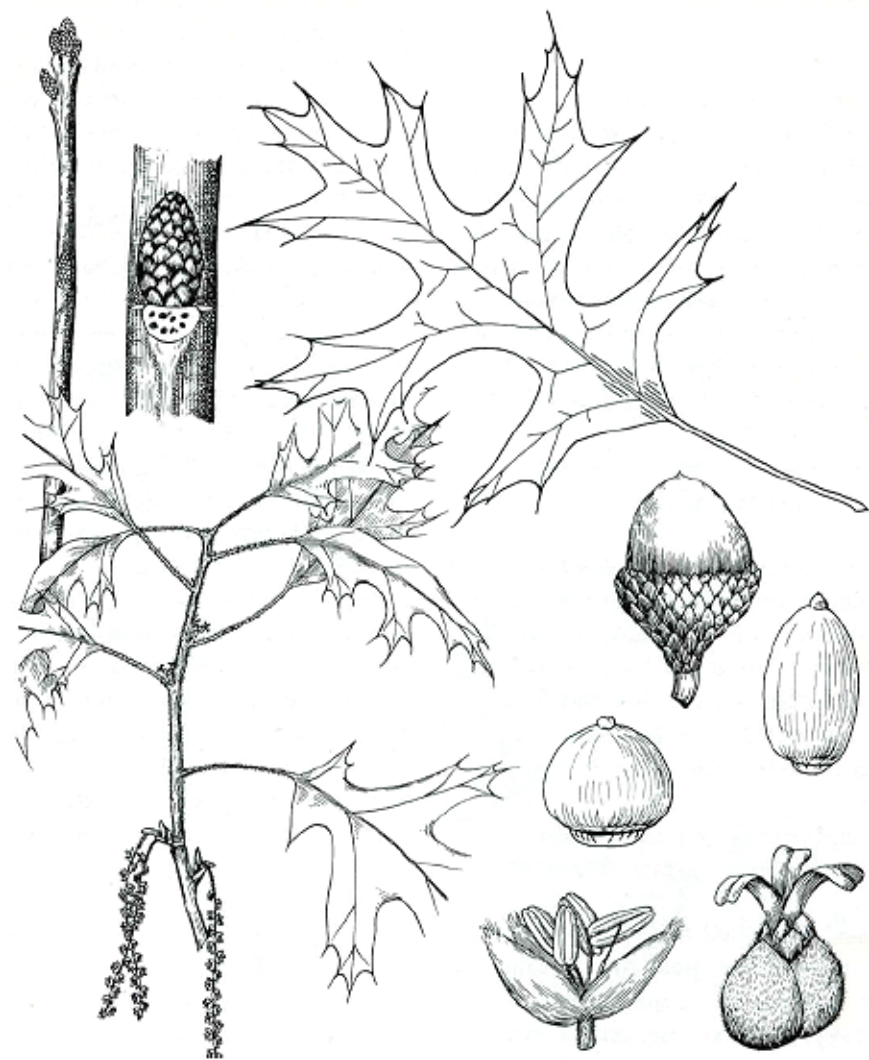
- Red oaks
  - Northern red
  - Black
  - Northern pin
- White oaks
  - White
  - Bur



From Voss *Michigan Flora* (red dots by Dickmann)

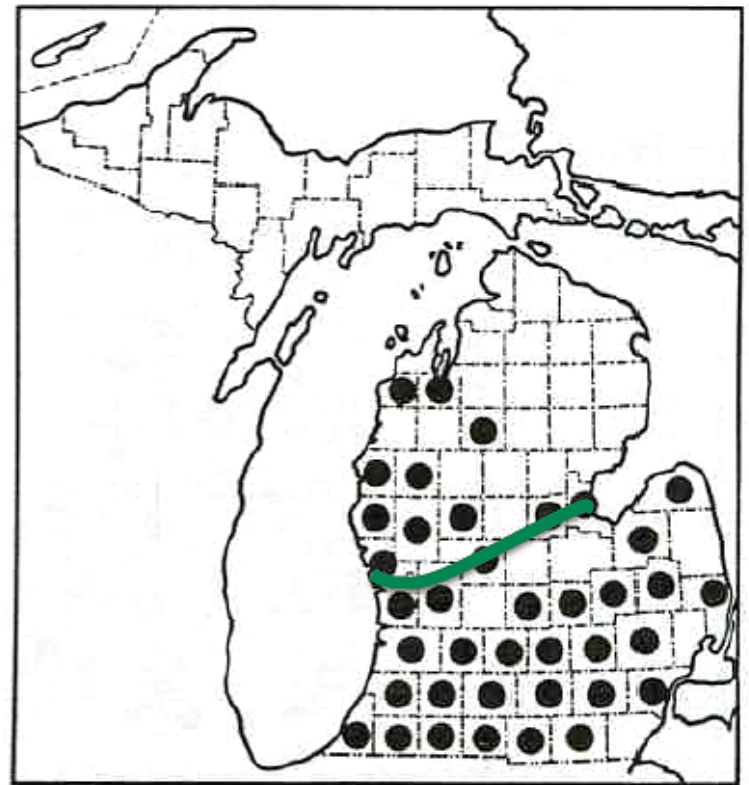
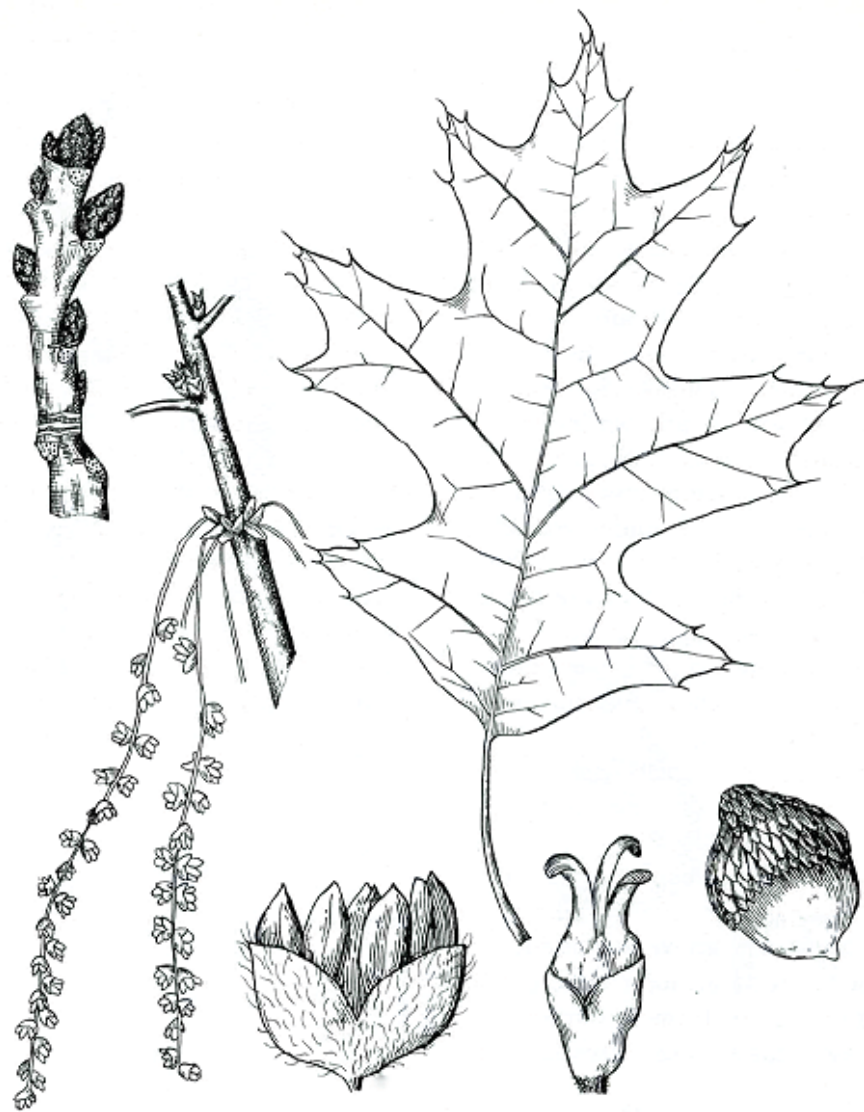
# Northern red oak

*Quercus rubra*



From Voss *Michigan Flora*

**Northern pin (Hill's) oak**  
*Quercus ellipsoidalis* (a.k.a. *Q. coccinea*)



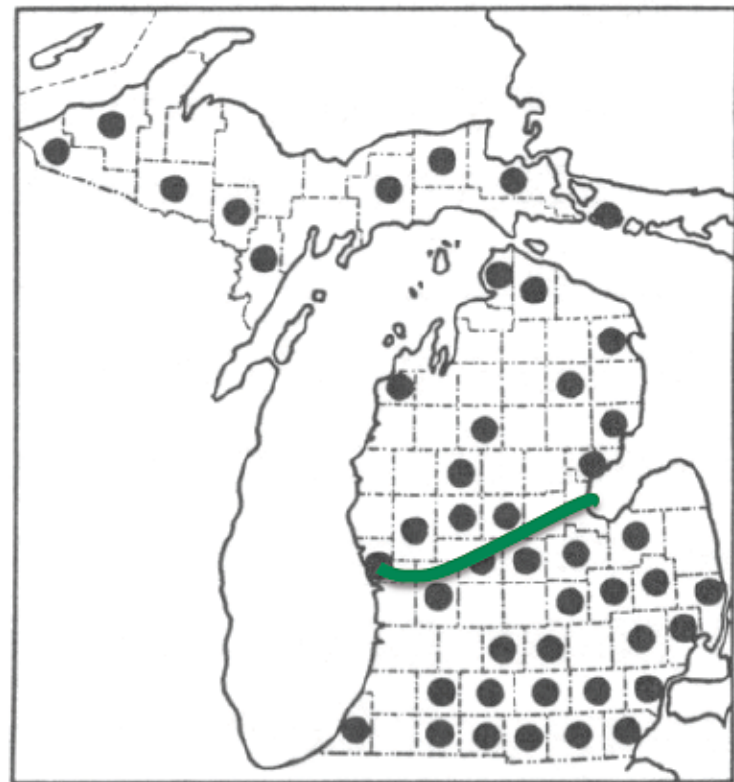
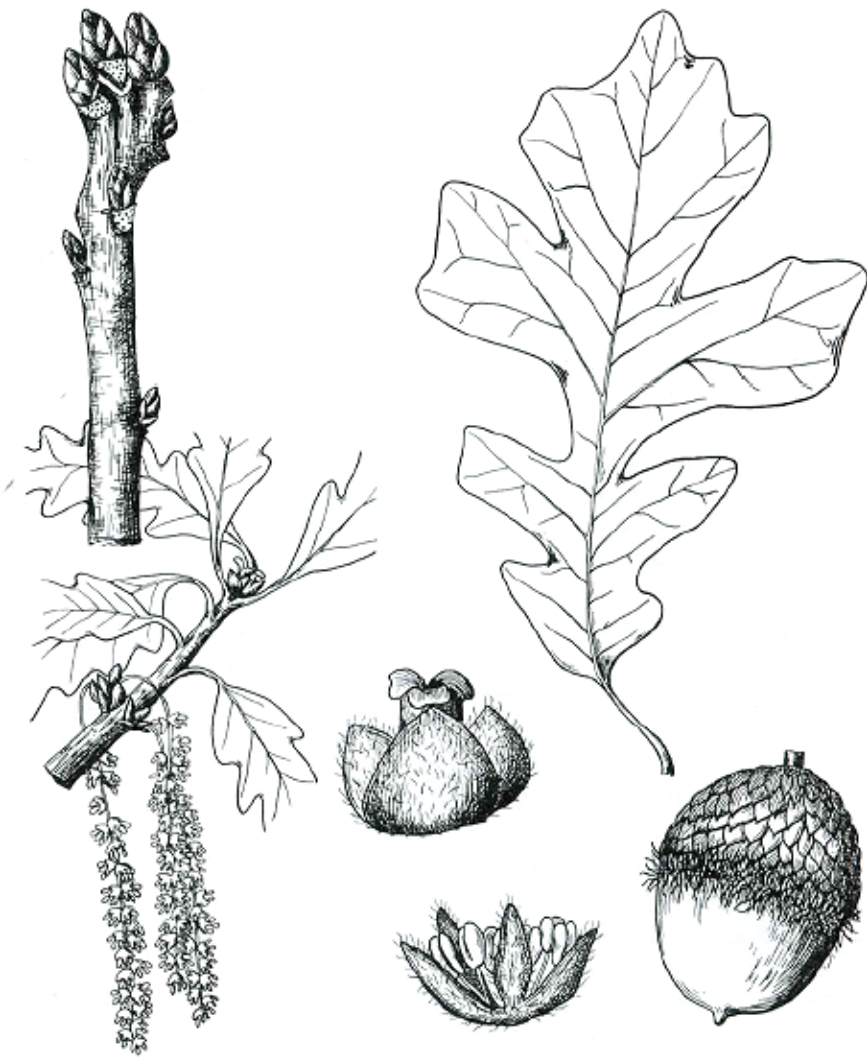
From Voss *Michigan Flora*

**Black oak**  
*Quercus velutina*



From Voss *Michigan Flora*

**White oak**  
*Quercus alba*



From Voss *Michigan Flora*

**Bur oak**  
*Quercus macrocarpa*

Within a section oaks readily hybridize;  
e.g.



×

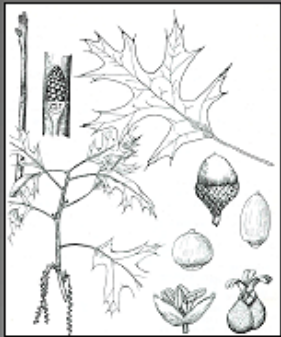


*Q. ×hawkinsiae*

Hybrids can backcross to either parent species

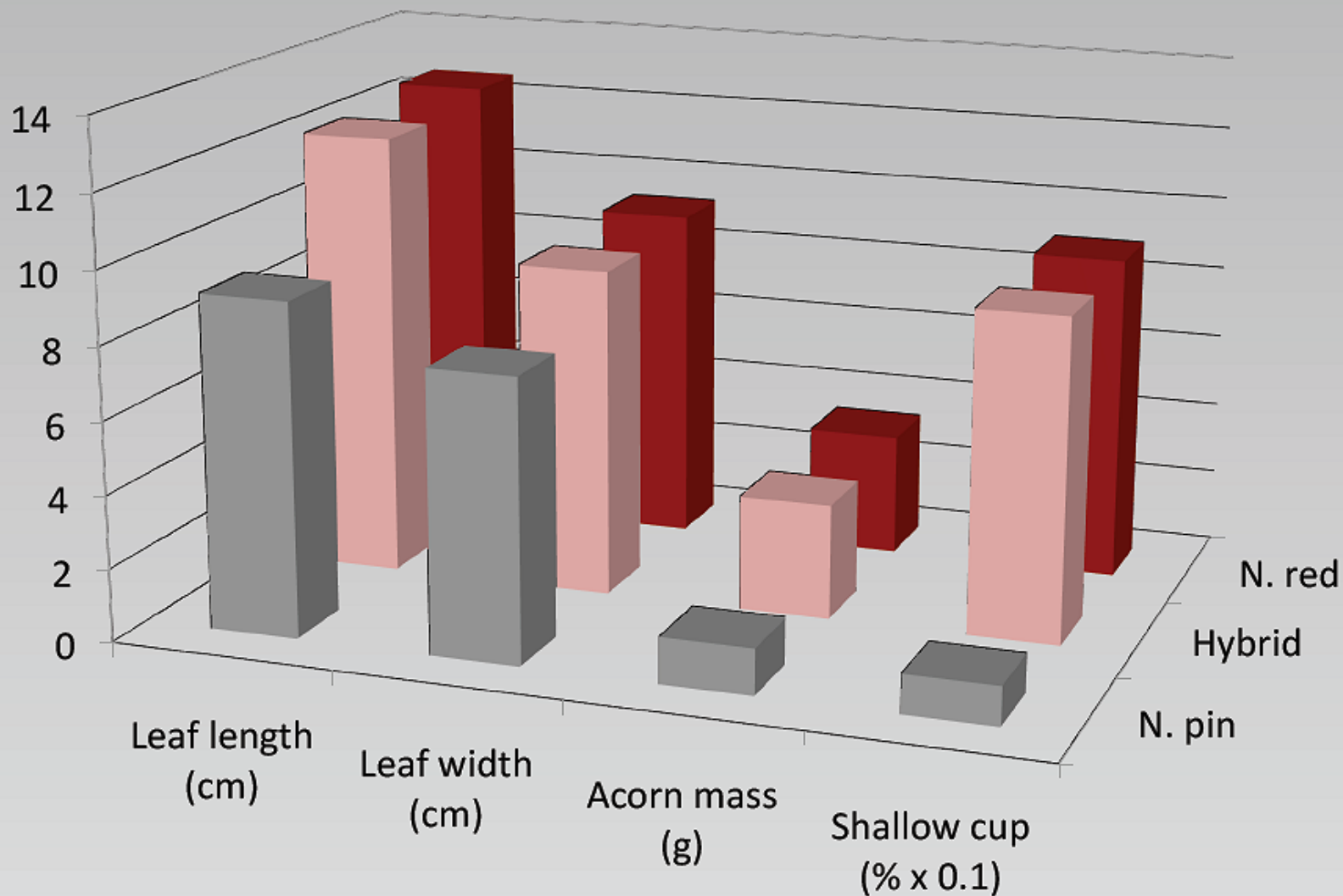
# A species ?

A group of actually or potentially interbreeding populations that produces fertile offspring, is distinct morphologically, and (normally) does not interbreed with related species populations.





## Comparison of characters for oak mother trees



From Tomlinson, Jensen, & Hancock (2000)



# Take-home:

Collect seed from stands containing only one oak species in a section when possible to *minimize* the hybrid effect.

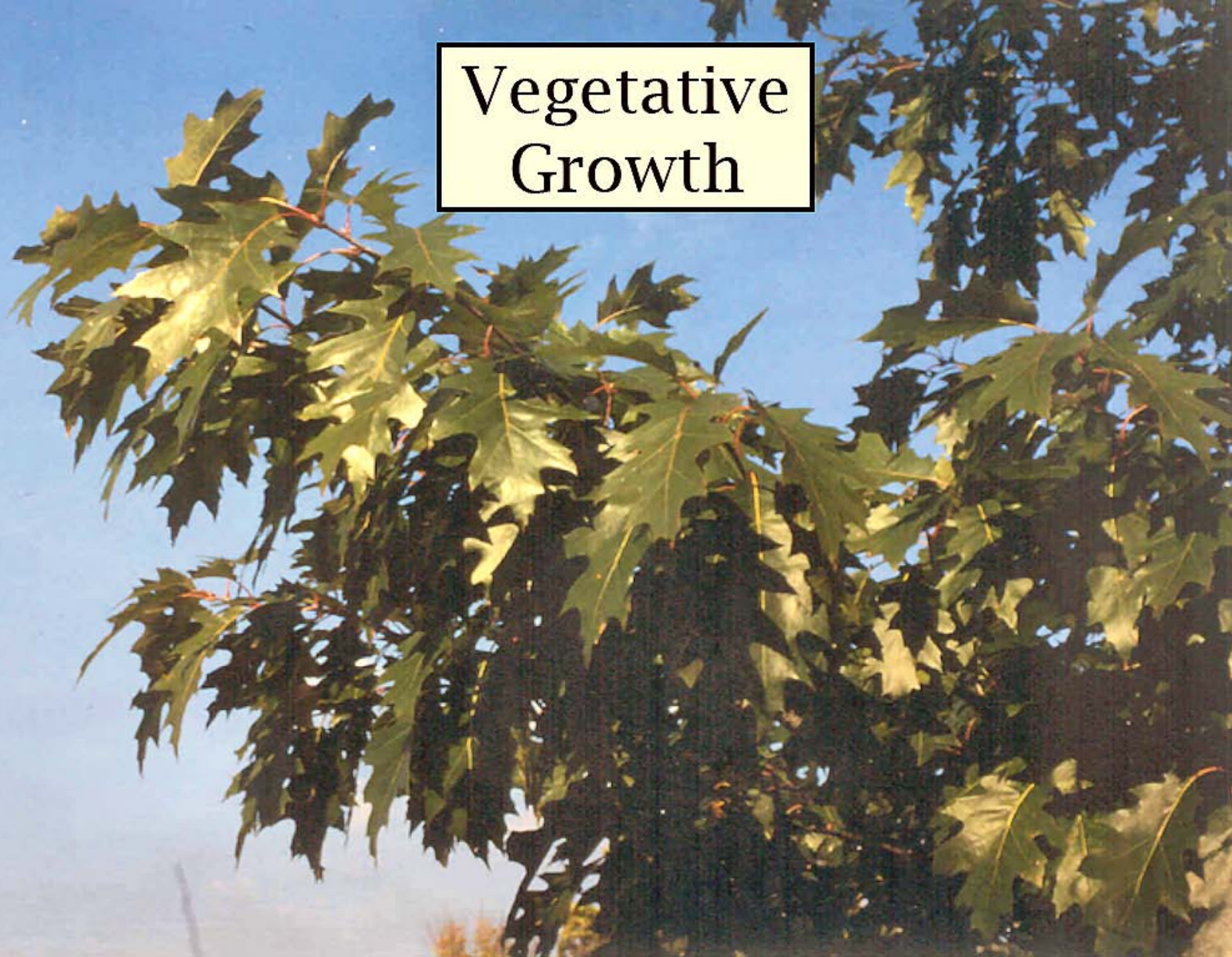




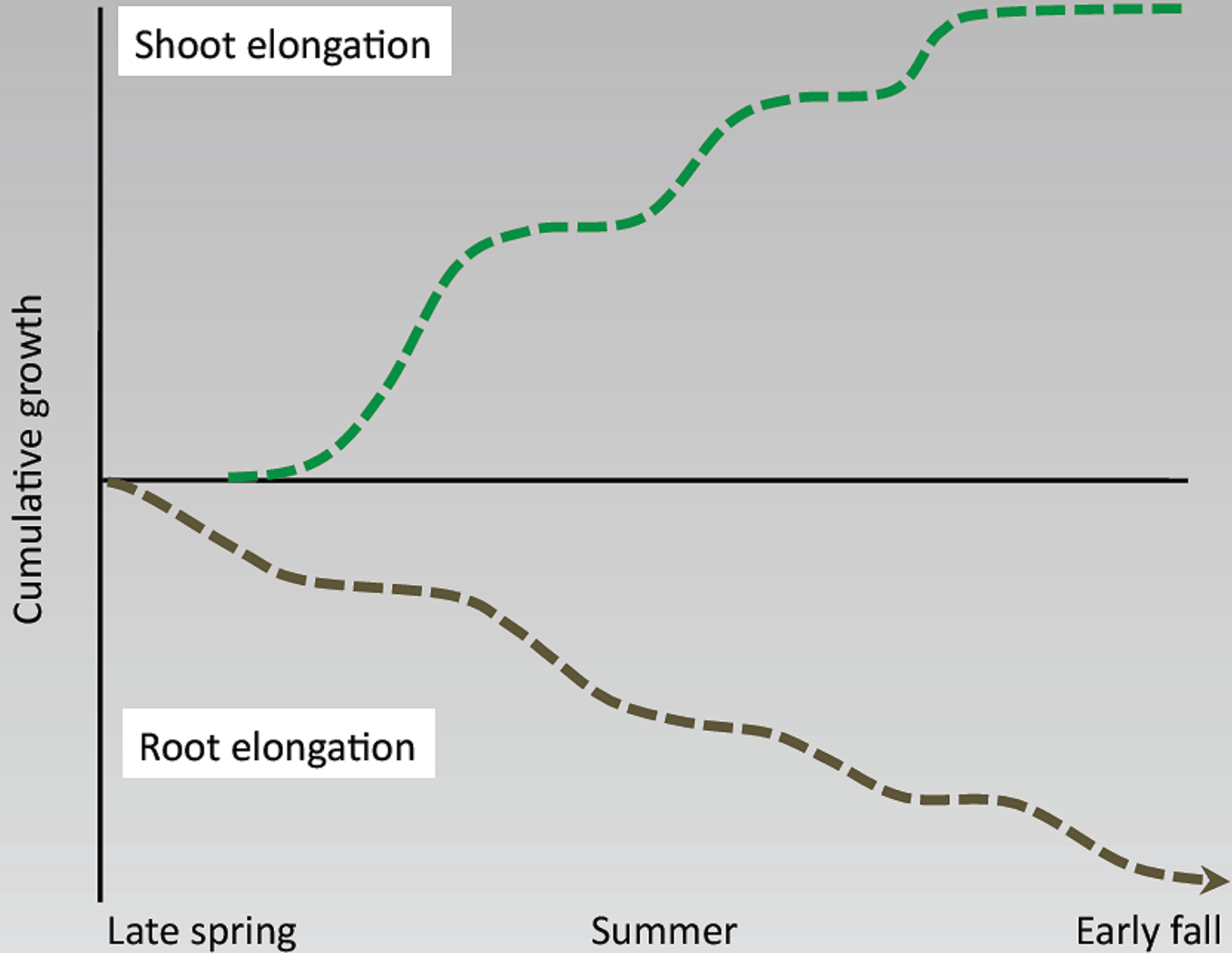
# Today's Topics

- Michigan's northern oaks
- Physiological ecology of oaks

# Vegetative Growth



# Growth of young, high-vigor oak trees

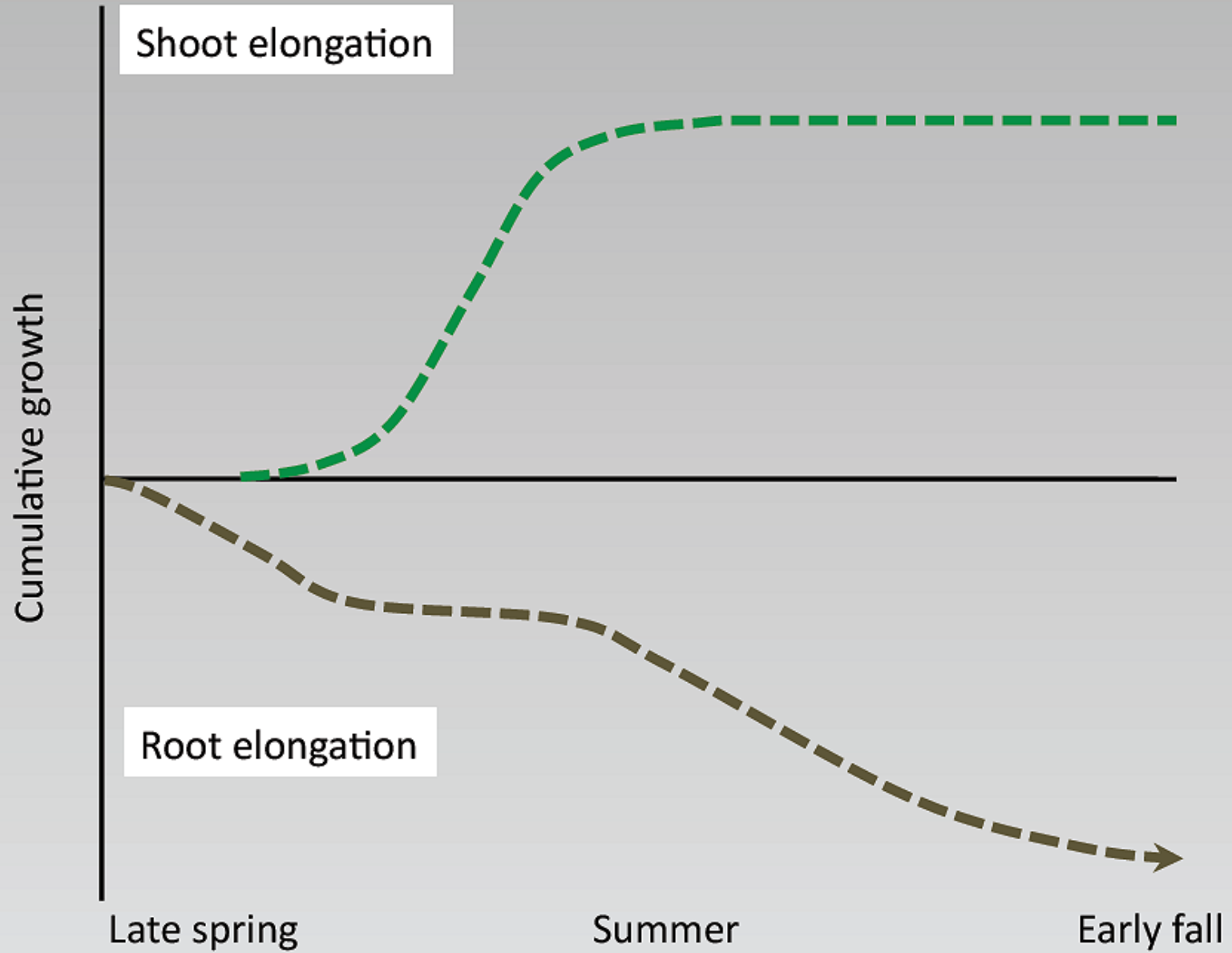


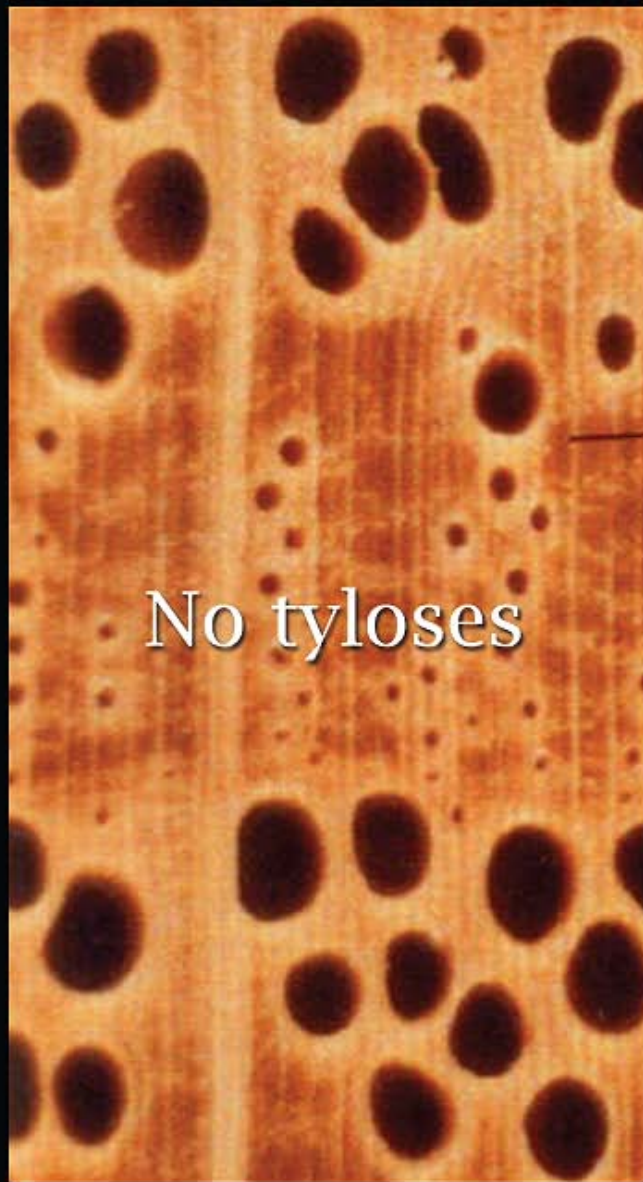


2<sup>nd</sup> flush

1<sup>st</sup> flush

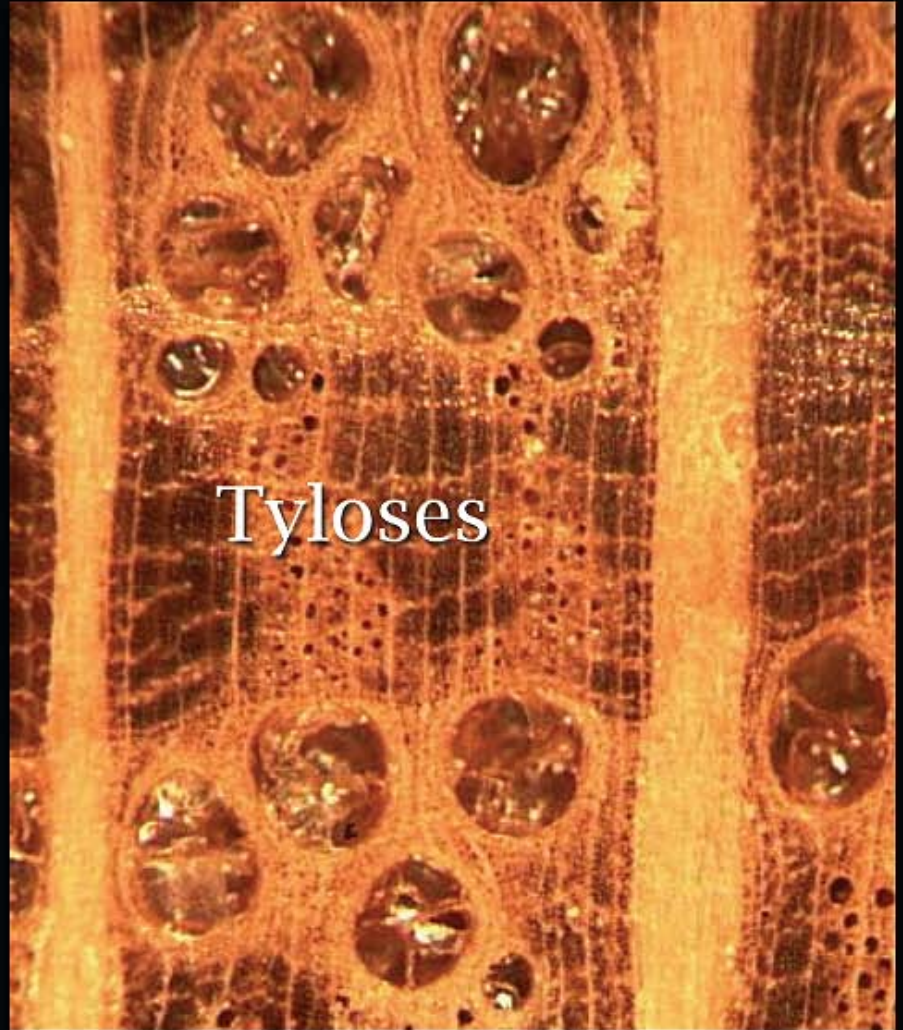
# Growth of older or low-vigor oak trees





No tyloses

Red oak



Tyloses

White oak



# Reproduction



# Stages of acorn development: white oaks

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Flower bud formation



***GROWING  
SEASON 1***



Flowering



Pollination



**Fertilization**



Acorn development



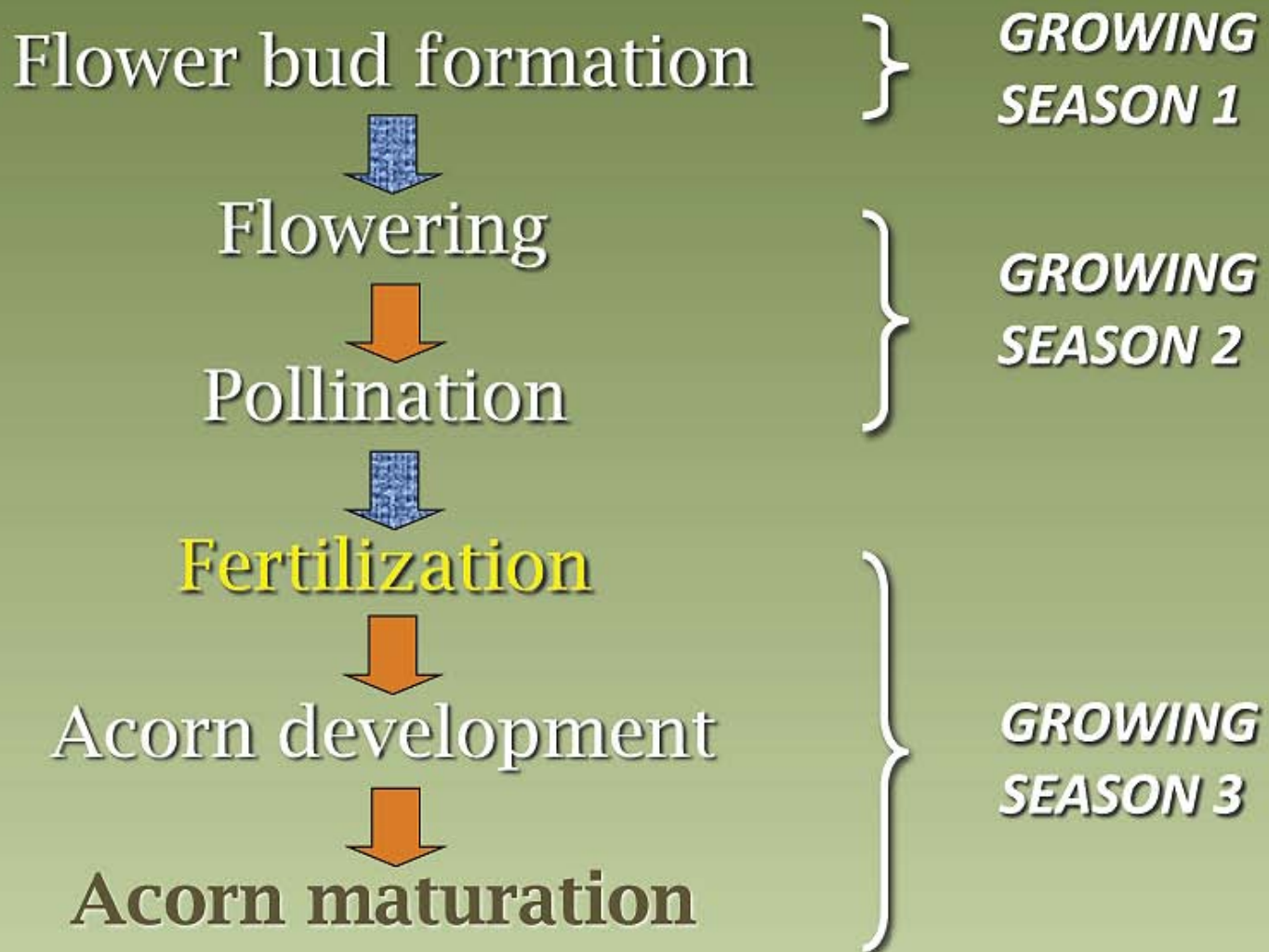
**Acorn maturation**




***GROWING  
SEASON 2***

# Stages of acorn development: red oaks

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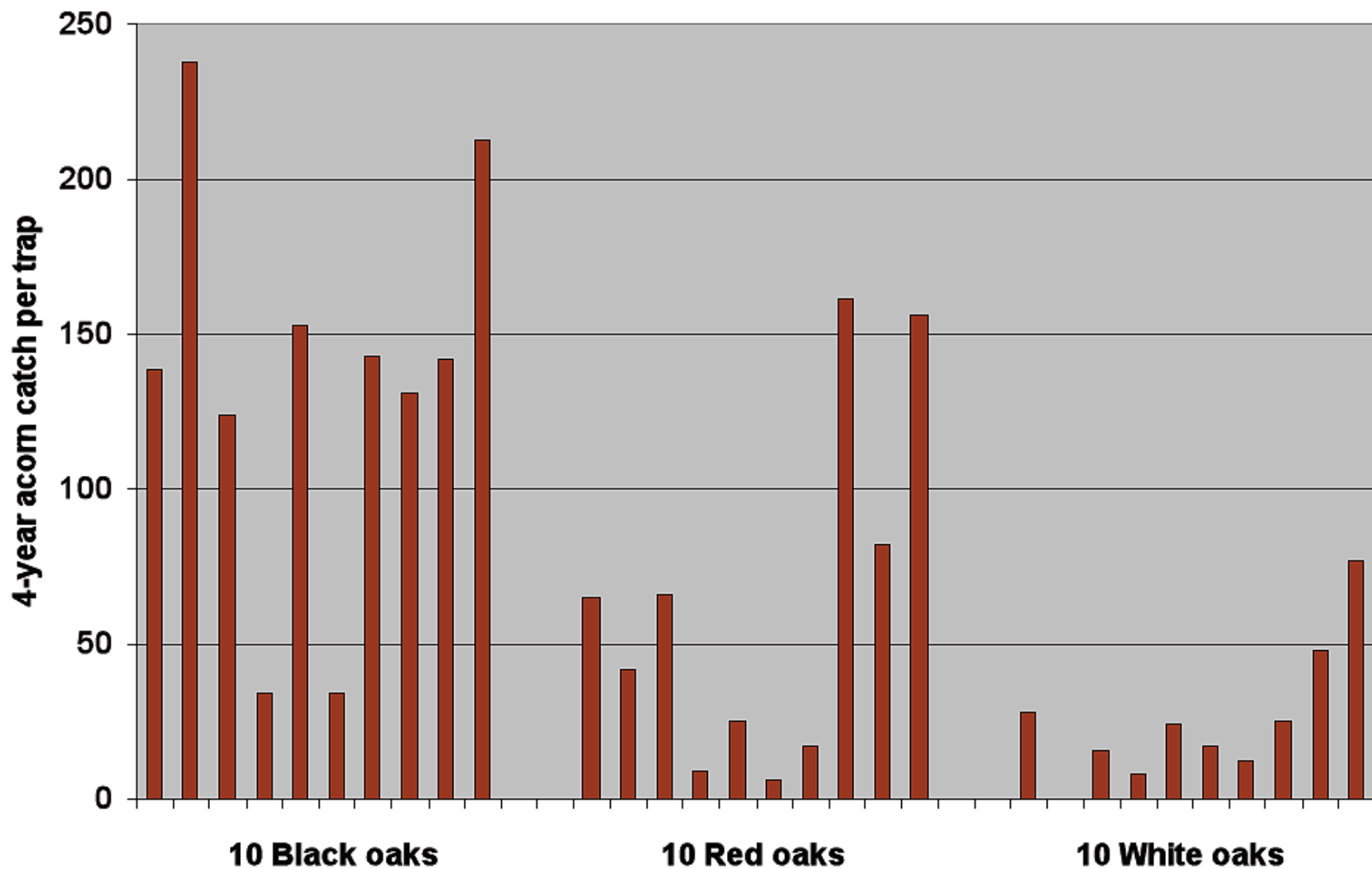


A close-up photograph of an oak branch. The branch is brown and has several green, lobed leaves with prominent veins. Some leaves show signs of being eaten, with holes visible. On the left side of the branch, there are small, reddish-brown acornlets. On the right side, there are several larger, brown acorns with their caps. Three red arrows point to the acornlets. The background is a soft, out-of-focus light color.

First-year acornlets

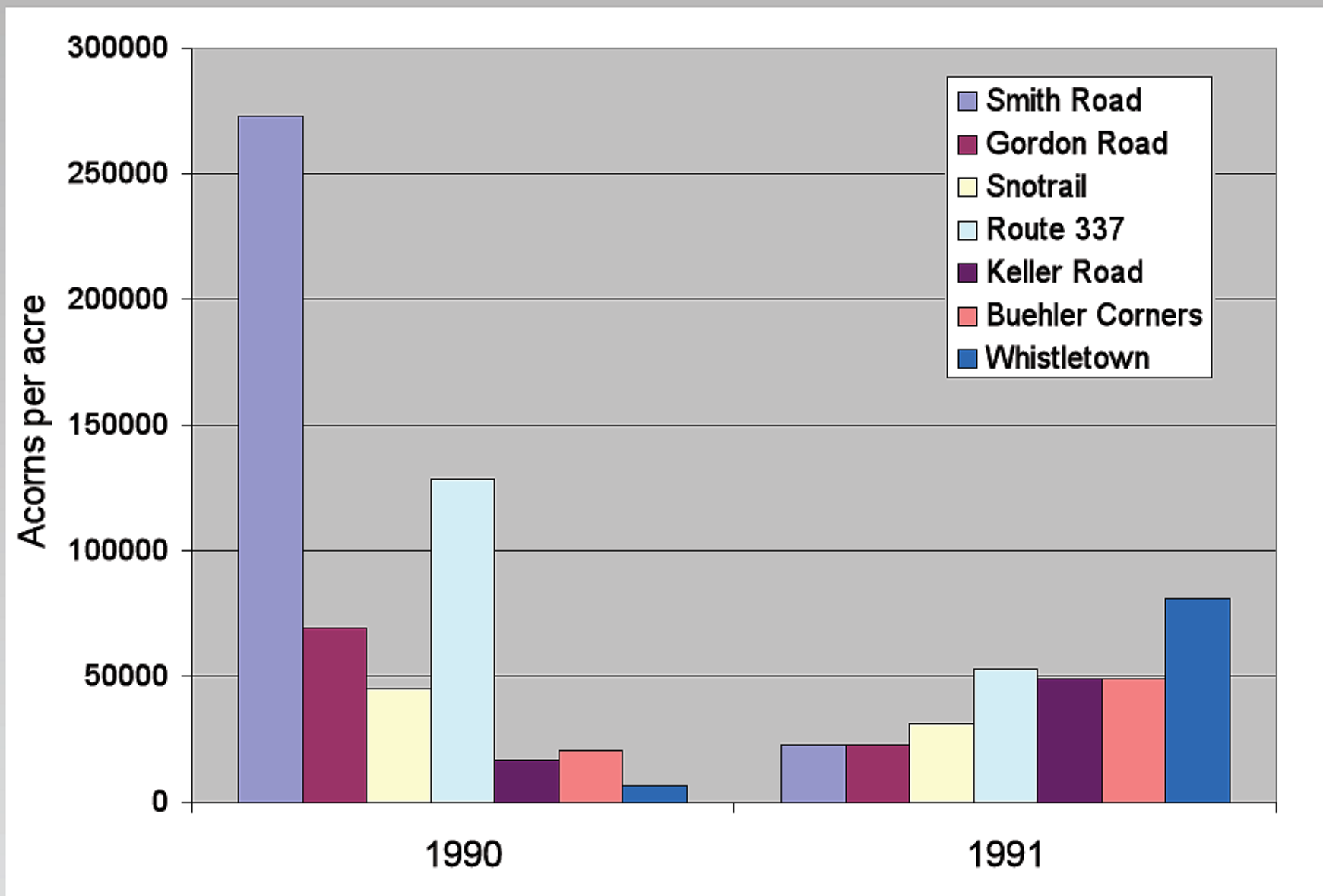
Second-year acorns

# Tree to tree mast production in Michigan



From Gysel (1956)

# Mast production in red oak stands in Pennsylvania



From Auchmoody, Smith & Walters (1993)



Sprouting



Young sprouts





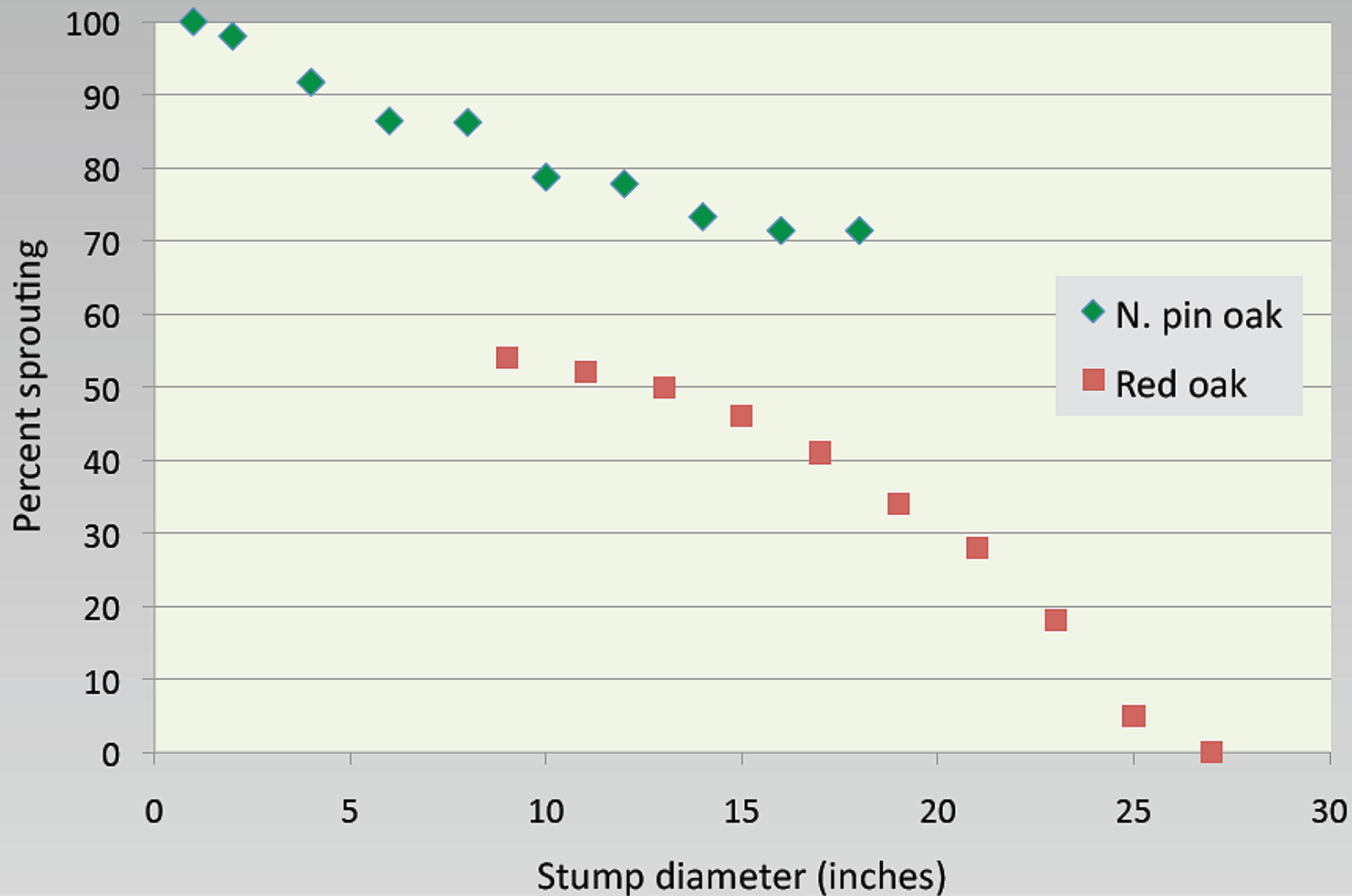
Old sprouts



## Big root systems fuel sprouting

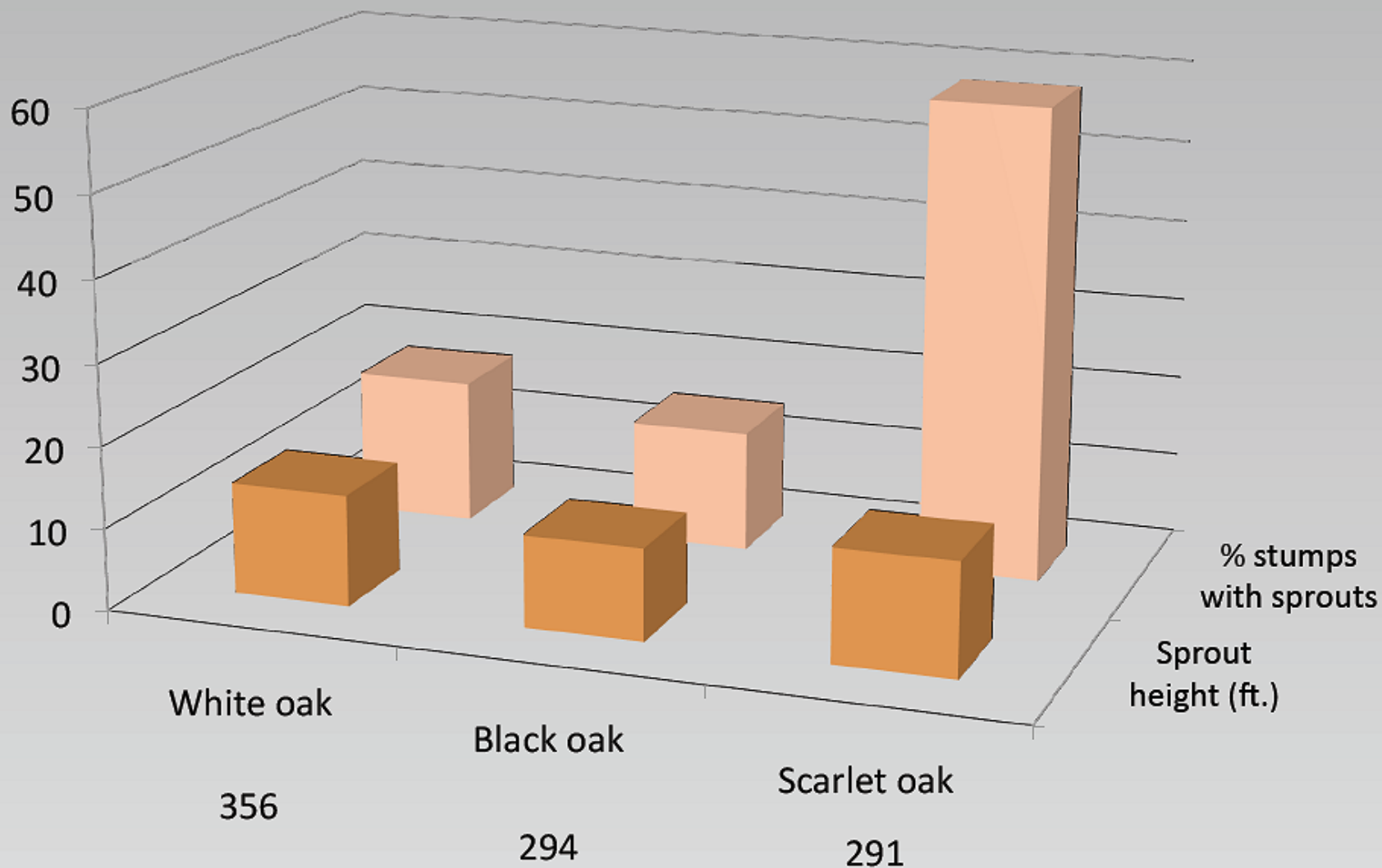
Photos: US Forest Service (above); Plants Beautiful Nursery (left)

# Northern pin & red oak stump sprouting in the North Central Region



N. pin: Mujuri & Demchik (2009)  
Red: Johnson (1975)

# Oak stump sprouting in Missouri 5 years after cutting



From Johnson (1977)

A photograph of a forest with many bare, thin tree trunks, likely oaks, standing in a field of green ferns. The sky is visible through the branches. The text "Oak Pests" is overlaid in a white box with a black border at the bottom center.

# Oak Pests

# Gypsy moth



# Two-lined chestnut borer



# Oak wilt





# Deer browsing





# Today's Topics

- Michigan's northern oaks
- Physiological ecology of oaks
- Oaks and fire



Oaks are tolerant of fire



## Functional role of fire in the ecology of oak regeneration

- Prepares seedbeds
- Encourages caching of acorns by jays and rodents
- Discourages acorn & seedling predators

## Estimated mortality of red oak acorns in Pennsylvania

Location	Acorns (thousands per acre)	Acorns destroyed (thousands per acre)	
		By fire	By insects
Moshannon State Forest (1989)	105.1	42.4 (40%)	13.9 (13%)
Allegheny National Forest (1990)	45.6	18.4 (40%)	3.5 (8%)

From Auchmoody & Smith (1993)



## Functional role of fire in the ecology of oak regeneration

- Prepares seedbeds
- Encourages caching of acorns by jays and rodents
- Discourages acorn & seedling predators
- Mortality in the overstory opens up understory
- Reduces fire-intolerant competitors

## Abundance of seedlings or clonal stems before and a year after a single surface fire in a northern pin oak-dominated stand

Species	No. per ha	
	Pre-burn	Post-burn
Red maple	10,600	2,850
Quaking aspen	450	1,300
Black cherry	28,250	18,500
White oak	550	450
N. pin oak	2,300	2,450

From Reich et al. (1990)

## Effect of 31 years of prescribed fire on sapling\* density in oak savannas & woodlands in central Minnesota

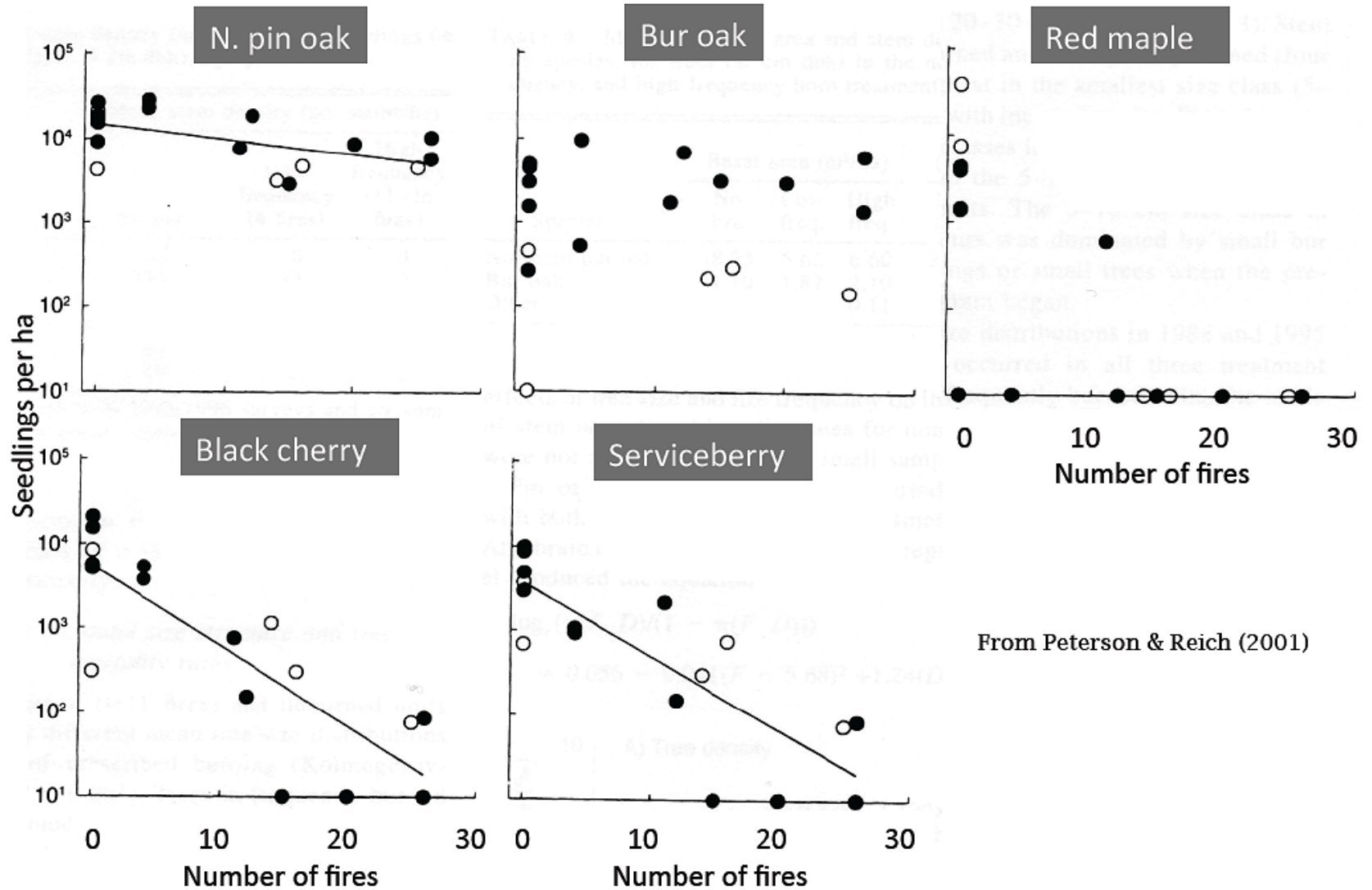
Species	No. per ha		
	Unburned	4 fires	11-26 fires
Red maple	62	0	0
Serviceberry	255	33	0
Black cherry	124	1,840	0
Bur oak	89	215	2
N. pin oak	319	7,709	19

\*  $\geq 1.5$  cm tall &  $< 5$  cm dbh)

From Peterson & Reich (2001)



# Effects of prescribed fire frequency on seedling densities in oak savannas & woodlands in central Minnesota



From Peterson & Reich (2001)



## Functional role of fire in the ecology of oak regeneration

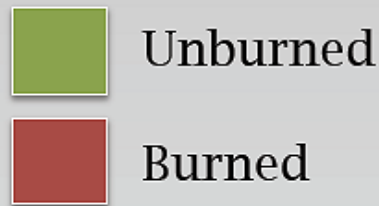
- Prepares seedbeds
- Encourages caching of acorns by jays and rodents
- Discourages acorn & seedling predators
- Mortality in the overstory opens up understory
- Reduces fire-intolerant competitors
- Increases vigor of sprouts

## Growth of white oak seedlings in the second year following prescribed burning in eastern Kentucky

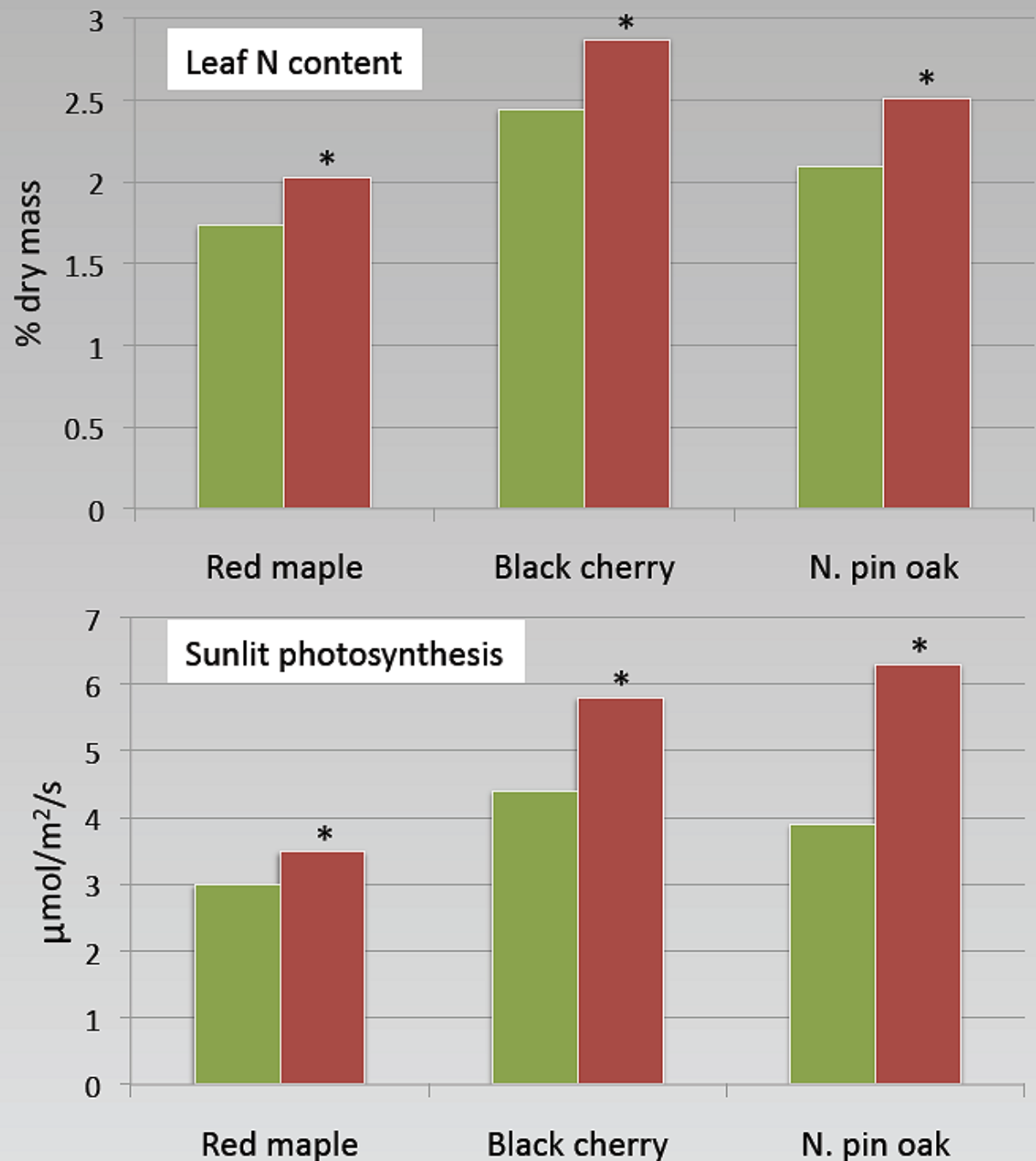
Seedling character	1 burn	2 burns	Unburned
Relative shoot elongation rate (cm/day)	<b>0.17</b>	0.15	<b>0.13</b>
Specific leaf mass (g/cm <sup>2</sup> )	<b>45.5</b>	41.8	<b>37.4</b>

From Adams & Rieske (2001)

# Effects of a single prescribed fire on the physiology of advance regeneration in a northern pin oak-dominated stand in central Wisconsin



From Reich et al. (1990)





## Functional role of fire in the ecology of oak regeneration

- Prepares seedbeds
- Encourages caching of acorns by jays and rodents
- Discourages acorn & seedling predators
- Mortality in the overstory opens up understory
- Reduces fire-intolerant competitors
- Increases vigor of sprouts
- Xerifies sites

# “Xeriphication”



Reduces or  
eliminates forest  
floor



Consumes organic  
matter in mineral soil



Greater solar  
radiation at  
soil surface

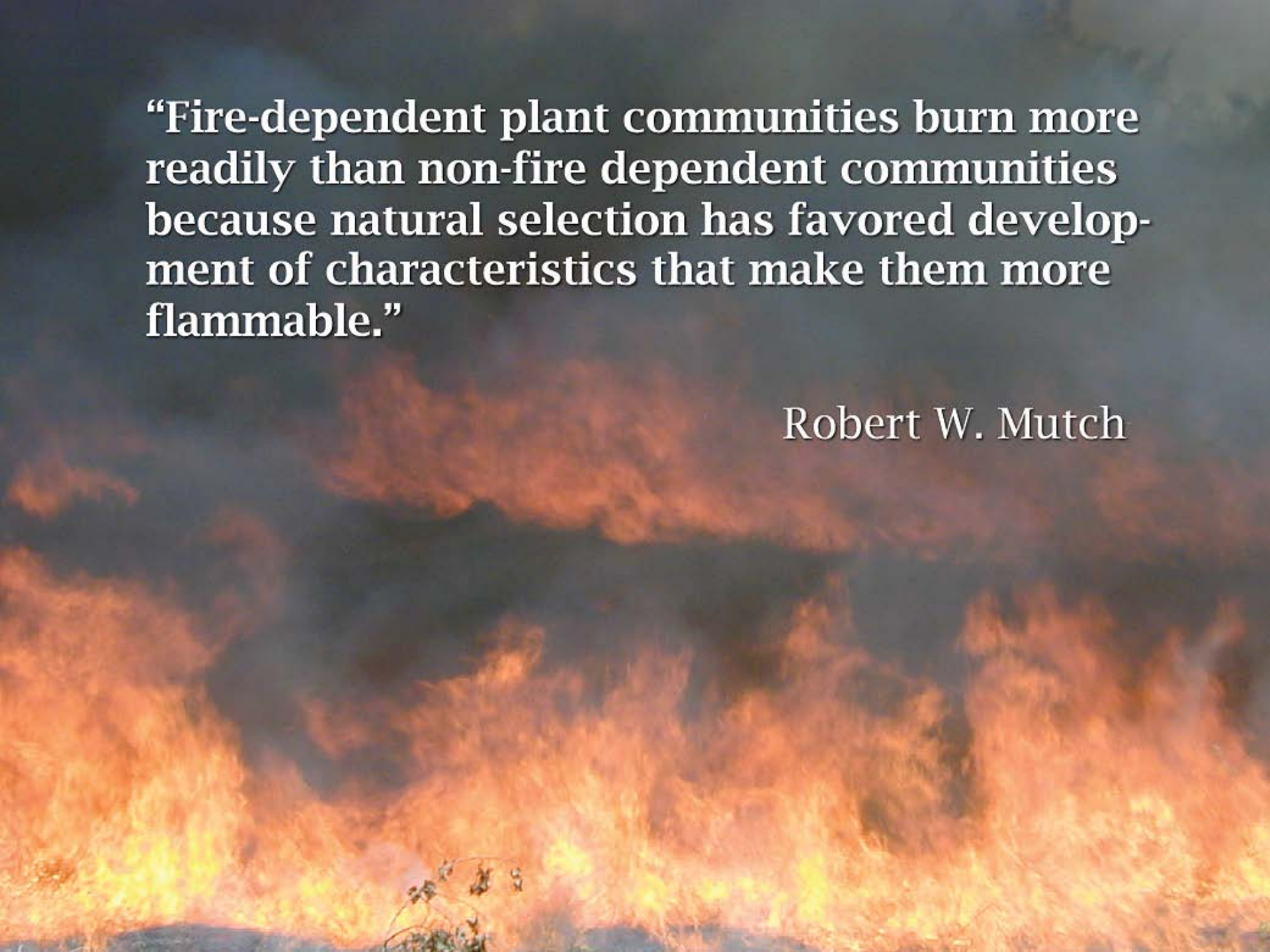


## Functional role of fire in the ecology of oak regeneration

- Prepares seedbeds
- Encourages caching of acorns by jays and rodents
- Discourages acorn & seedling predators
- Mortality in the overstory opens up understory
- Reduces fire-intolerant competitors
- Increases vigor of sprouts
- Xerifies sites
- Increases community flammability

**“Fire-dependent plant communities burn more readily than non-fire dependent communities because natural selection has favored development of characteristics that make them more flammable.”**

Robert W. Mutch







## Functional role of fire in the ecology of oak regeneration

- Prepares seedbeds
- Encourages caching of acorns by jays and rodents
- Discourages acorn & seedling predators
- Mortality in the overstory opens up understory
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- Increases community flammability

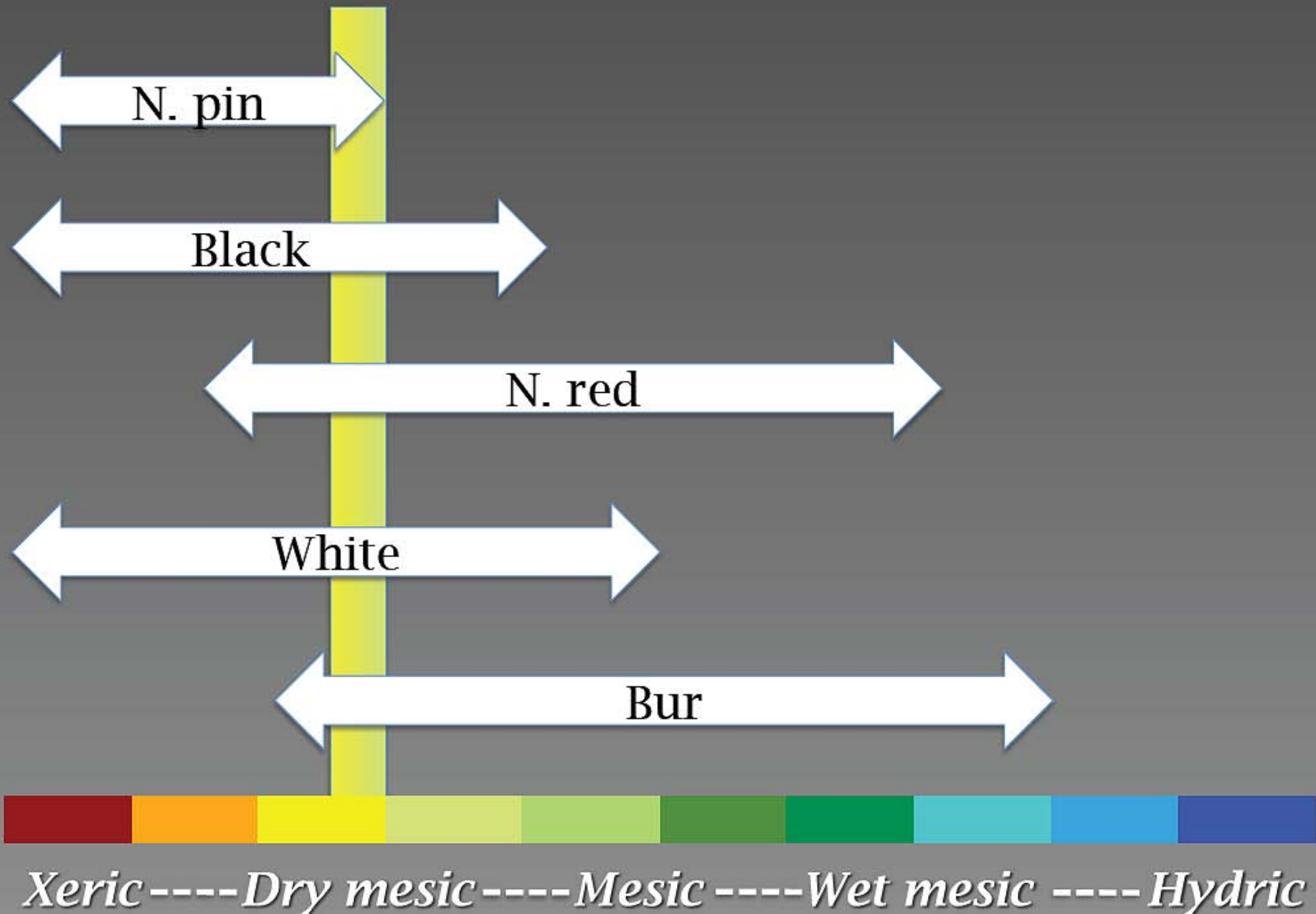


Allows oaks to dominate advance regeneration

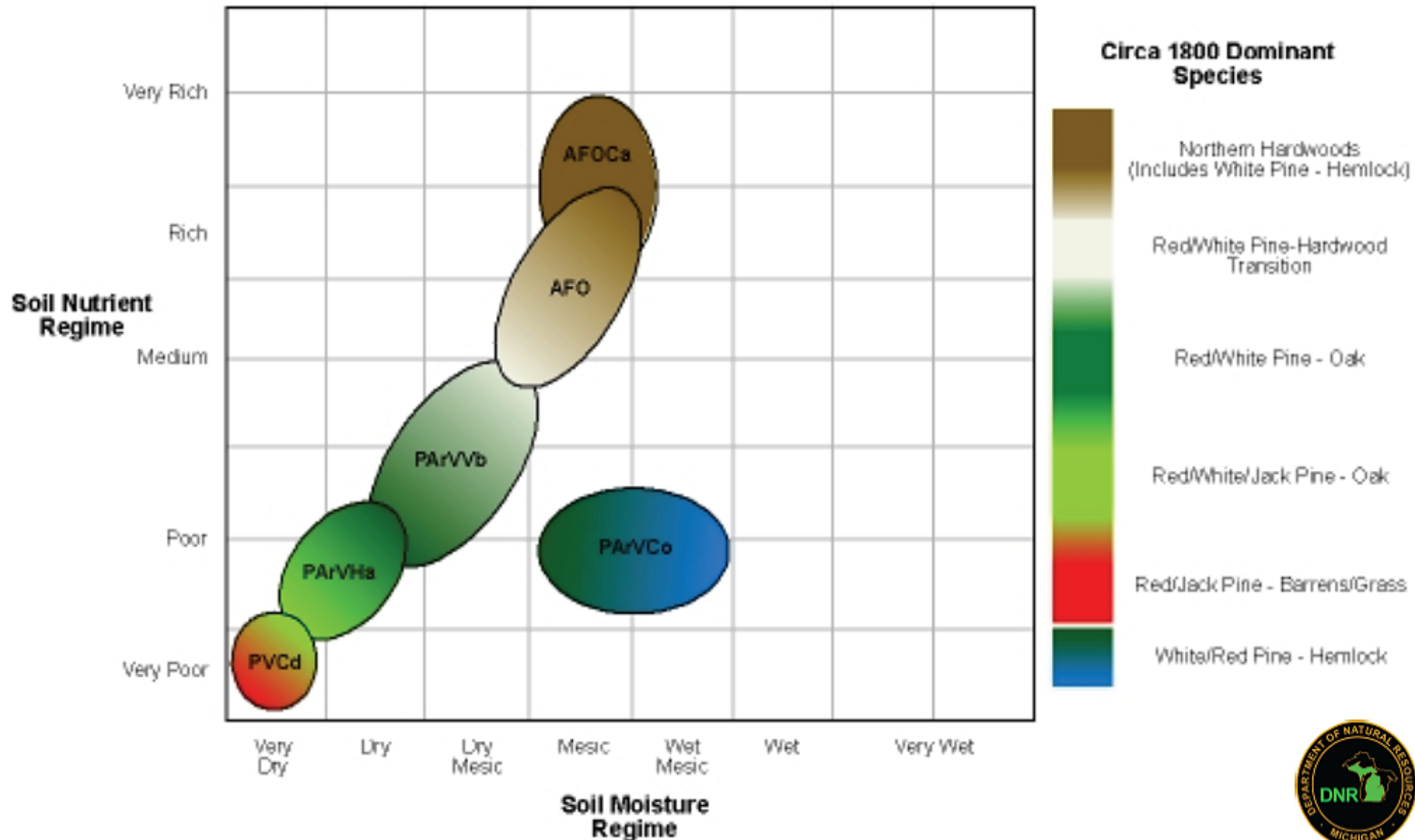


# Today's Topics

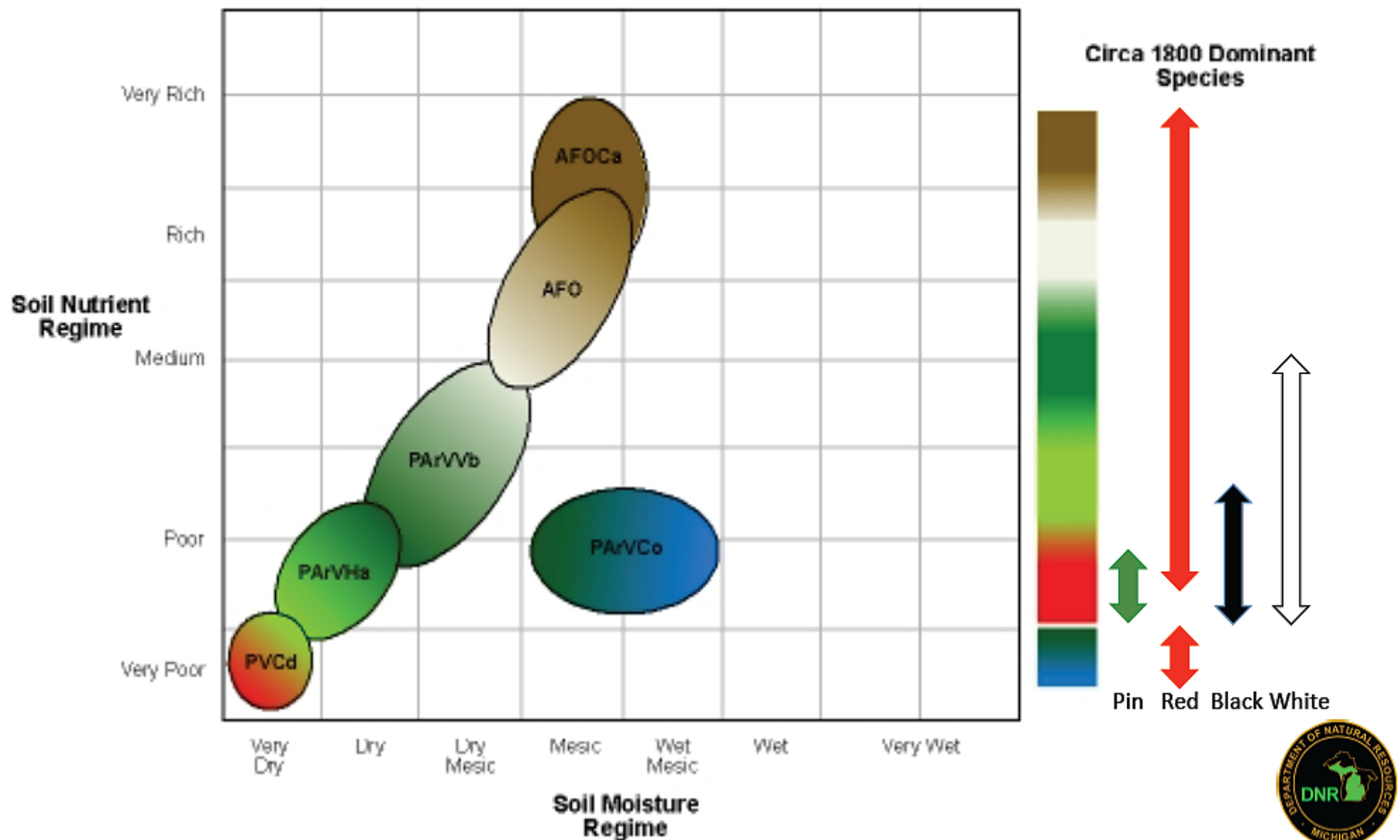
- Michigan's northern oaks
- Physiological ecology of oaks
- Fire and oaks
- Oaks across the landscape: then and now



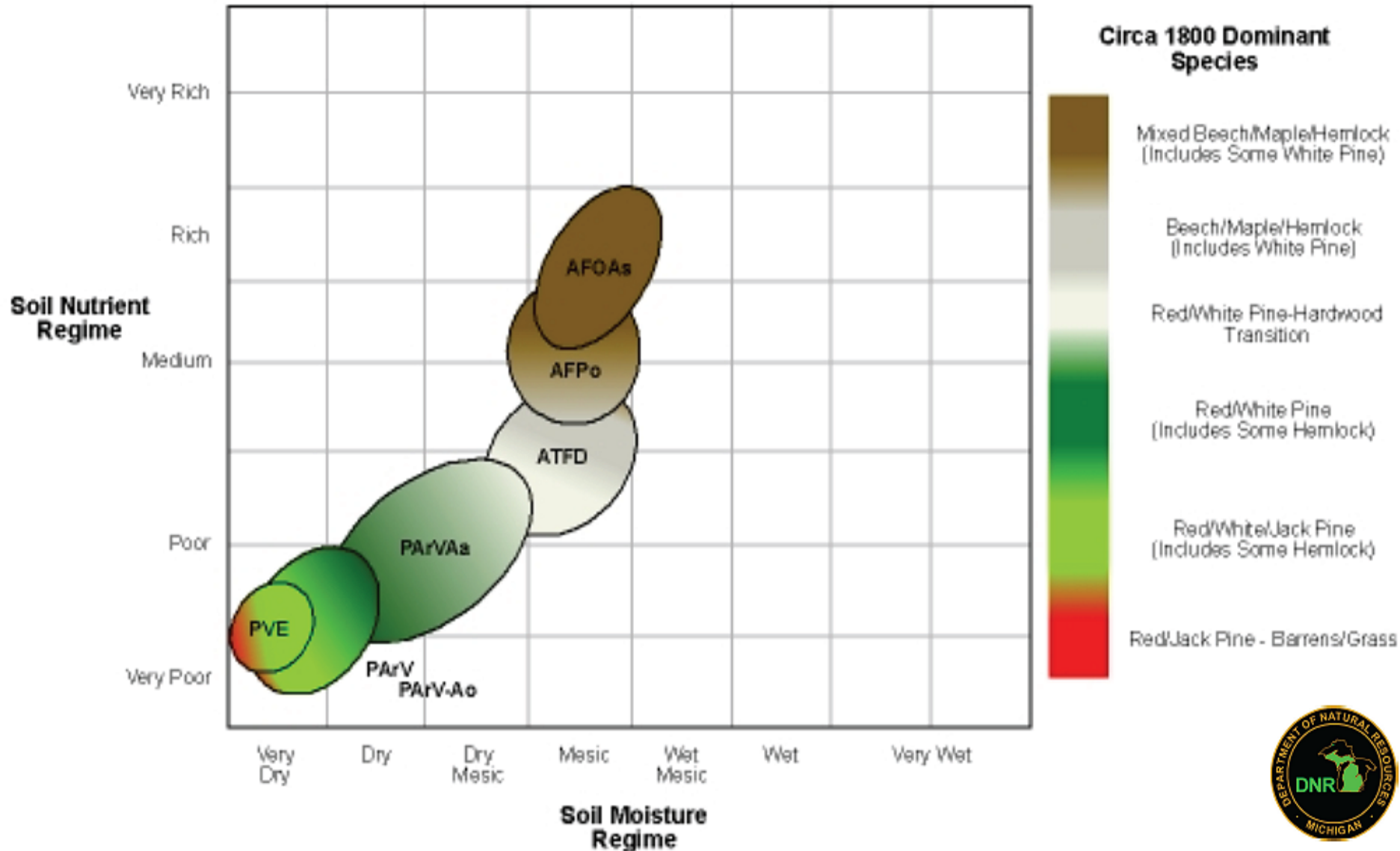
# Northern Lower Peninsula forest habitat types (Burger and Kotar)



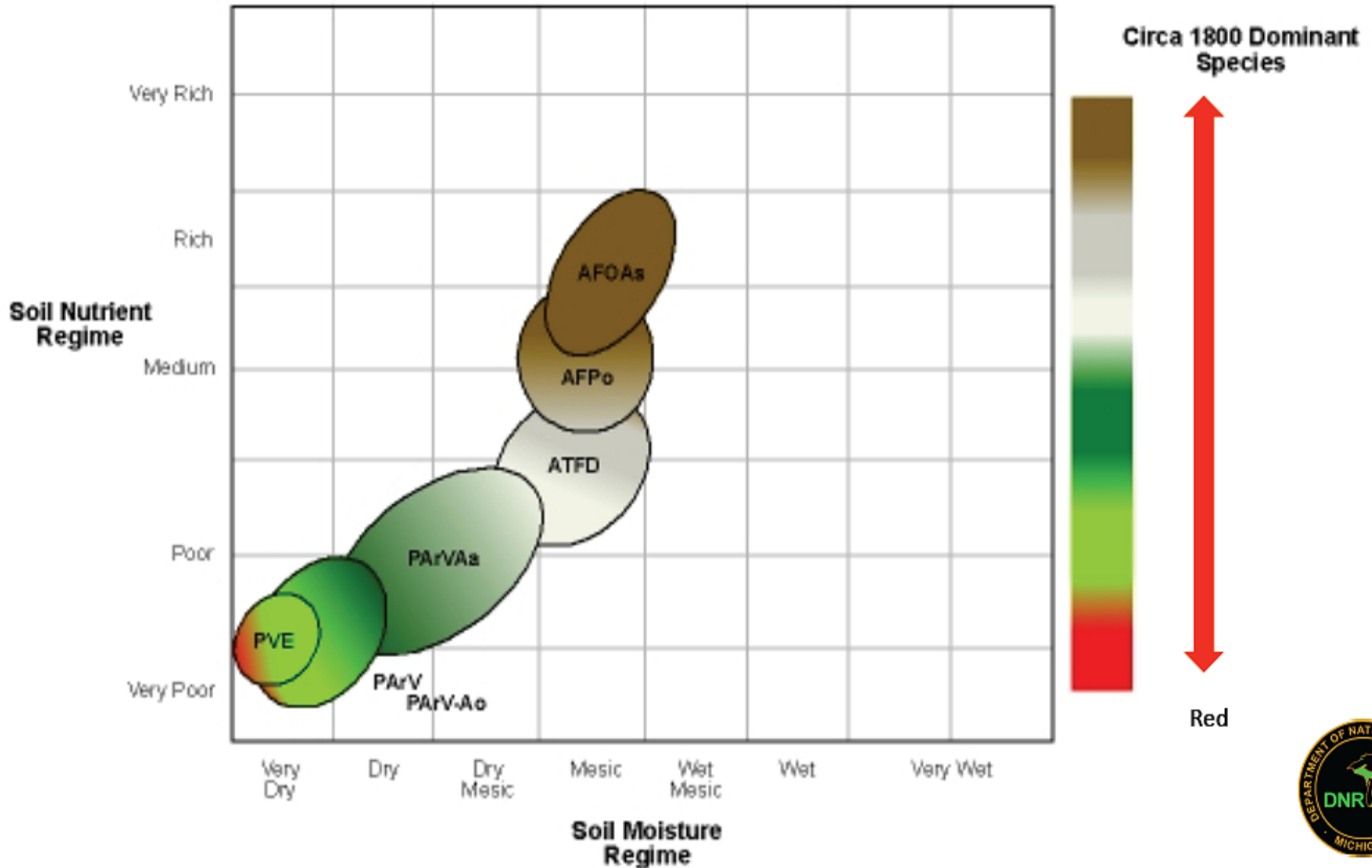
# Northern Lower Peninsula forest habitat types—where oaks fit in



# Eastern Upper Peninsula forest habitat types (Burger and Kotar)



# Eastern Upper Peninsula forest habitat types—where oaks fit in



# Ecological land & forest classification—Huron-Manistee National Forest

ELT	ELTP	Description
Outwash plains	1	N. pin oak/white oak— <i>Deschampsia</i>
	10-12	Black oak/white oak— <i>Vaccinium</i>
Dry ice-contact & sand hills	20-25	Mixed oak/red maple— <i>Trientalis</i>
Mesic ice-contact & sand hills	32-35	N. red oak/red maple— <i>Viburnum</i>
	37	N. red oak/red maple— <i>Desmodium</i>
Herb-poor moraines	40-43	Sugar maple/beech/red oak— <i>Maianthemum</i>
Herb-rich moraines	44-45	Sugar maple/white ash— <i>Osmorhiza</i>
	47	Sugar maple/white ash— <i>Caulophyllum</i>
Somewhat poorly drained uplands	62	Mixed oak/red maple— <i>Vaccinium</i>
	63	Red oak/red maple/paper birch— <i>Maianthemum</i>
	64	White ash/basswood— <i>Viola</i>

↑ ↑ ↑  
↓ ↓ ↓  
 Pin Black  
 Red White

From Cleland et al. (1993)



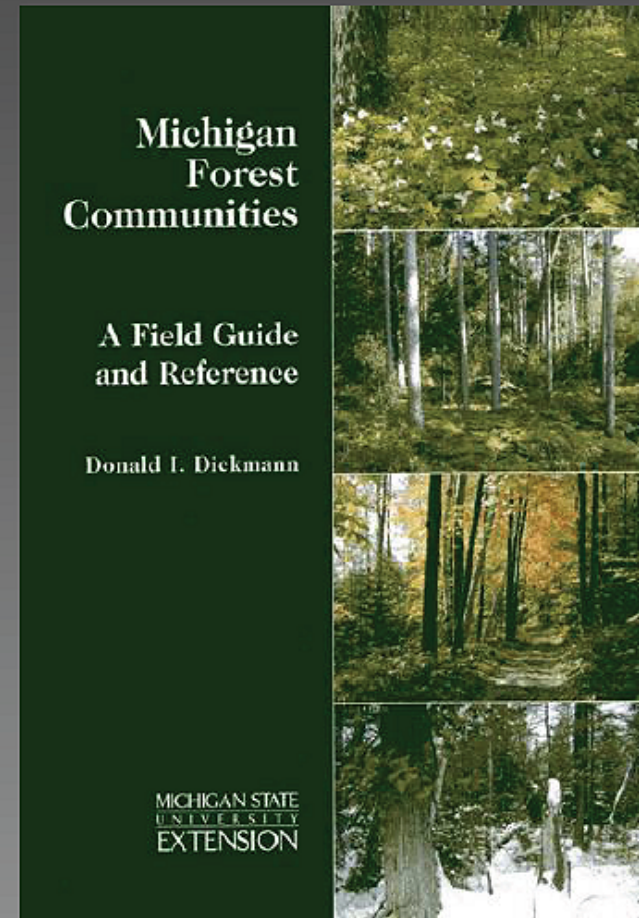
# Northern Michigan forest communities with an oak component

## Closed-canopy upland forest communities

- 9 Northern mesic hardwood (hemlock-hardwood) forests  
(AF-AT habitat types; ELTPs 40+)
- 10 Northern dry-mesic oak forests  
(PA habitat types; ELTPs 20-37)
- 11 Northern dry-mesic pine forests  
(PA habitat types; ELTPs 20-37)
- 12 Northern dry pine-oak forests  
(PV habitat types; ELTPs 1-12)
- 14 Dune forest-swale complexes
- 16 Plantations

## Open-canopy upland forest communities

- 19 Northern pine and oak barrens
- 21 Northern balds, cliffs, and bedrock glades





**Dry (xeric) oak  
communities**

Historically maintained by  
fire





Maintained by fire and harvesting today

A photograph of a forest with many tall, thin trees and a ground covered in ferns and fallen leaves. The trees are mostly deciduous with green foliage. The ground is covered with a mix of green ferns and brown, fallen leaves. The lighting is bright, suggesting a sunny day.

**Dry-mesic oak  
communities**

Historically oaks were mostly  
in pine understories



10003

Historic logging & fires took  
out the pines





## N. Lower Peninsula dry-mesic oak

Circa 1800 (MNFI):  
2.21 thousand acres

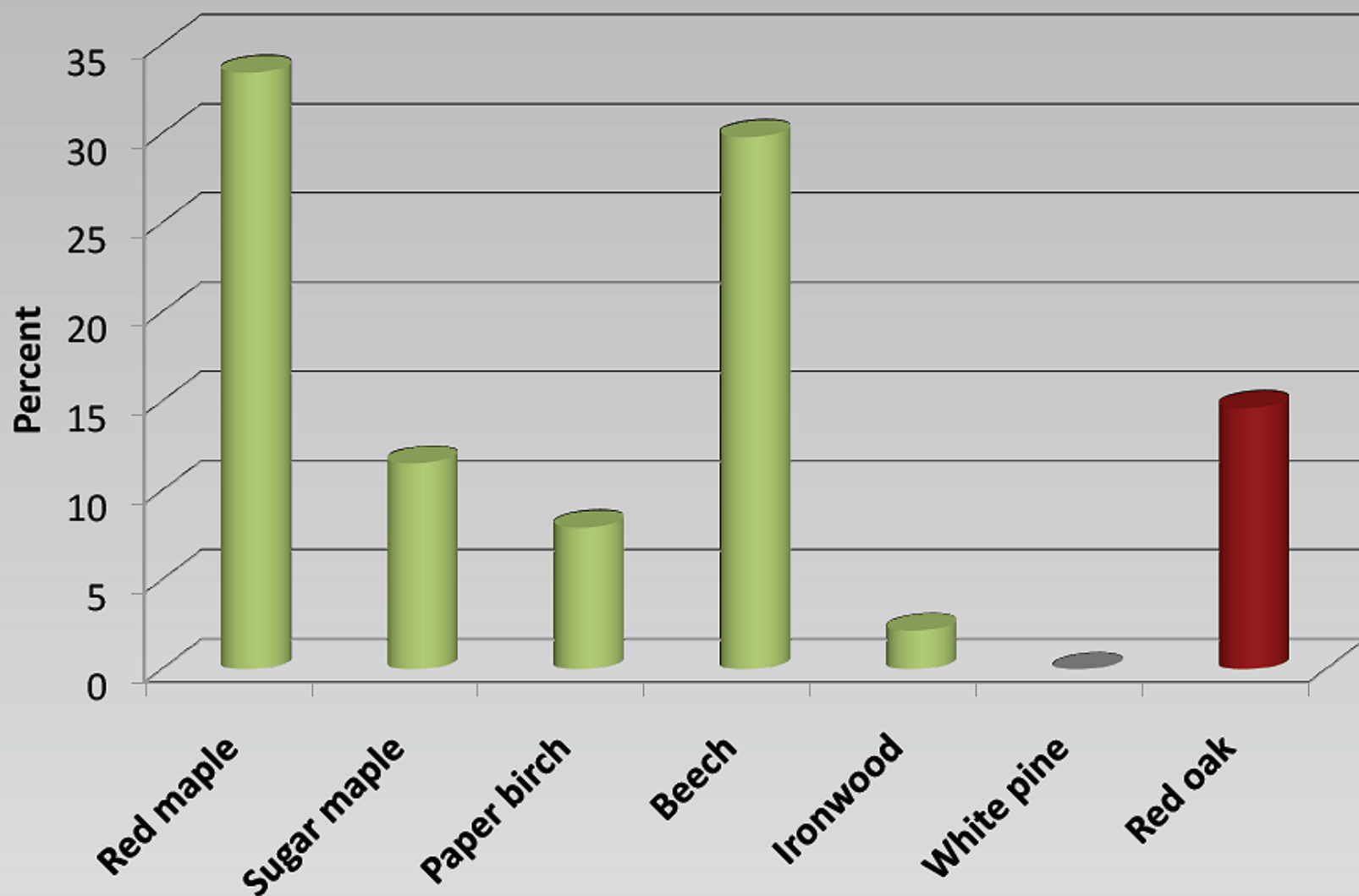
Today (FIA):  
1.17 *million* acres





**Mesic oak  
communities**

## Relative dominance (basal area) of overstory trees in northern hardwood stands at Colonial Point (Burt Lake)



From Albert (1987)

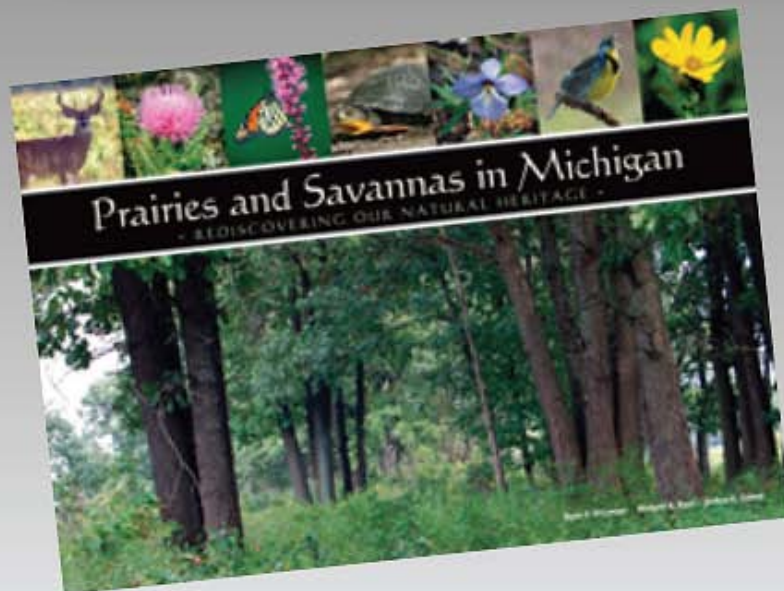
**Oak/oak-pine  
barrens**



# Historic (c. 1800) northern Michigan oak barrens (acres)

Region	Oak barrens	Oak/pine barrens
N. Lower Peninsula	10,507	79,205
Upper Peninsula	0	955

From Michigan Natural Features Inventory



# Today? <1%



Restoration is occurring



Fire is required to maintain restorations



# Today's Topics

- Michigan's northern oaks
- Physiological ecology of oaks
- Fire and oaks
- Oaks across the landscape: then and now
- Succession of oak types: what's their future?



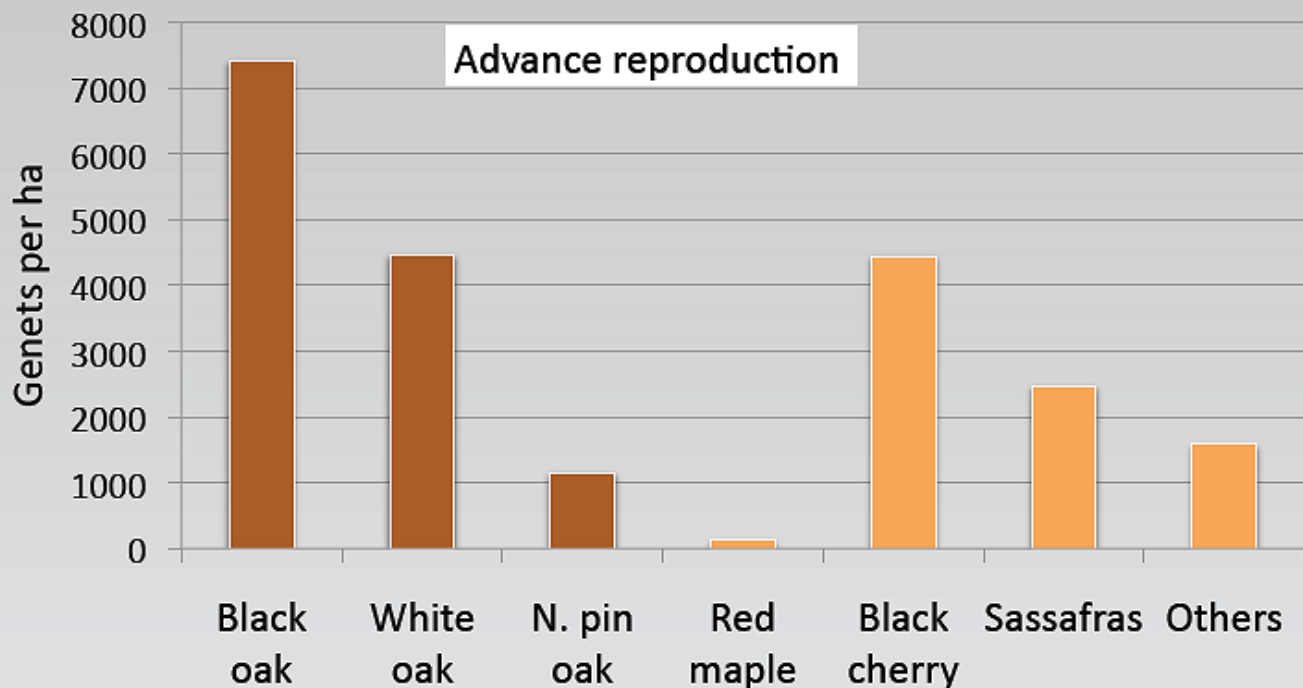
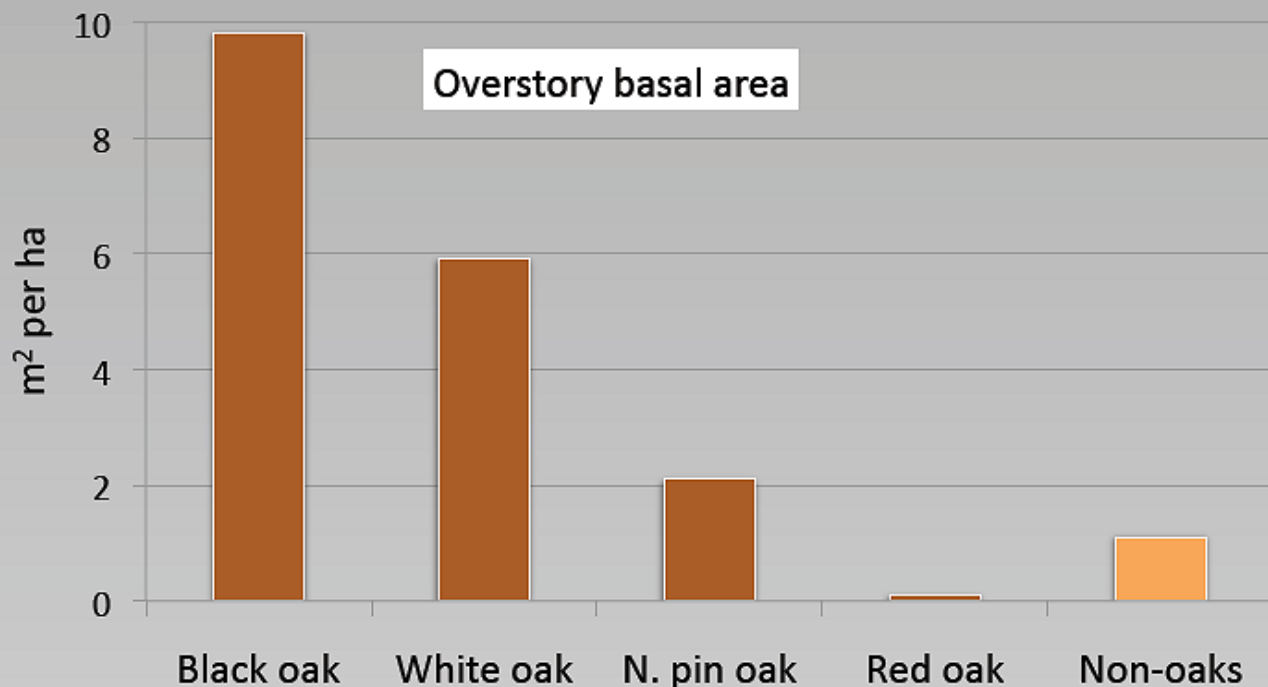
Xeric oak systems will persist



**Stand characteristics of a highly xeric oak ecosystem\* in the Newaygo District of Michigan**

**N. pin oak-black oak/*Deschampsia* (ELTP 1)  
SI 15.5 m (51 ft)**

From Johnson (1992)



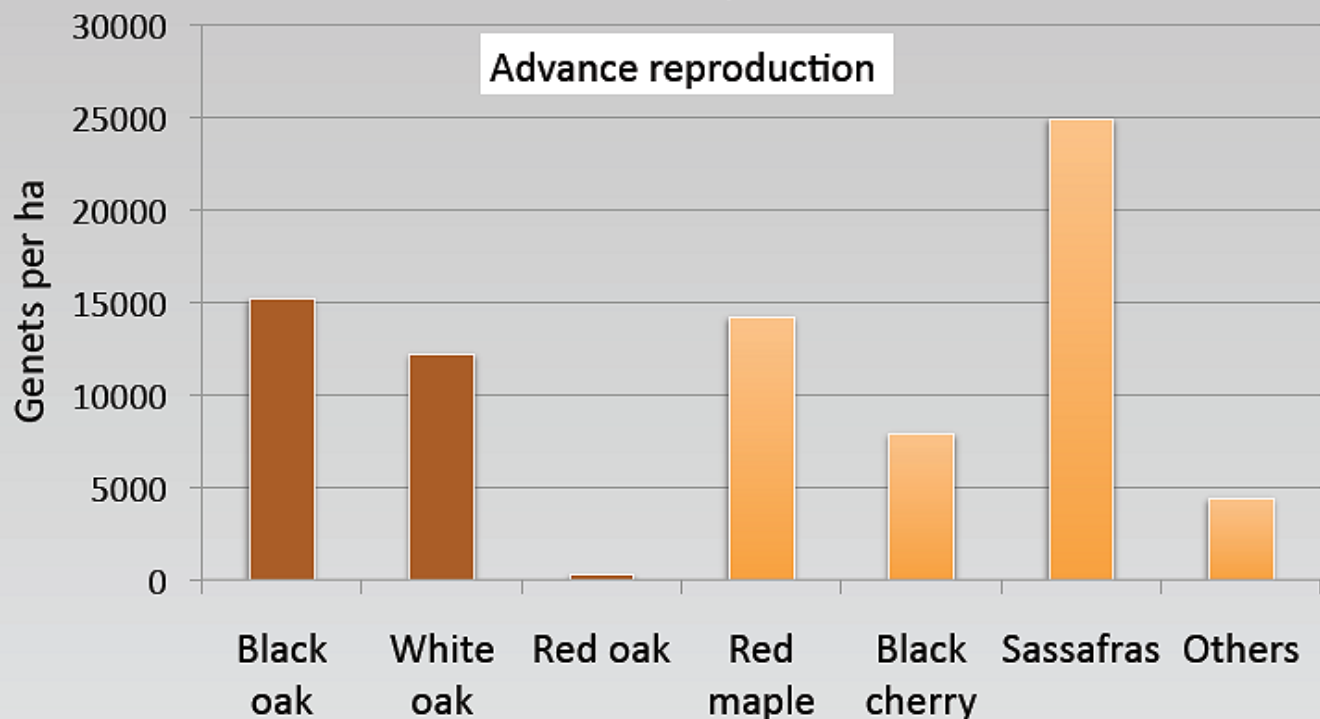
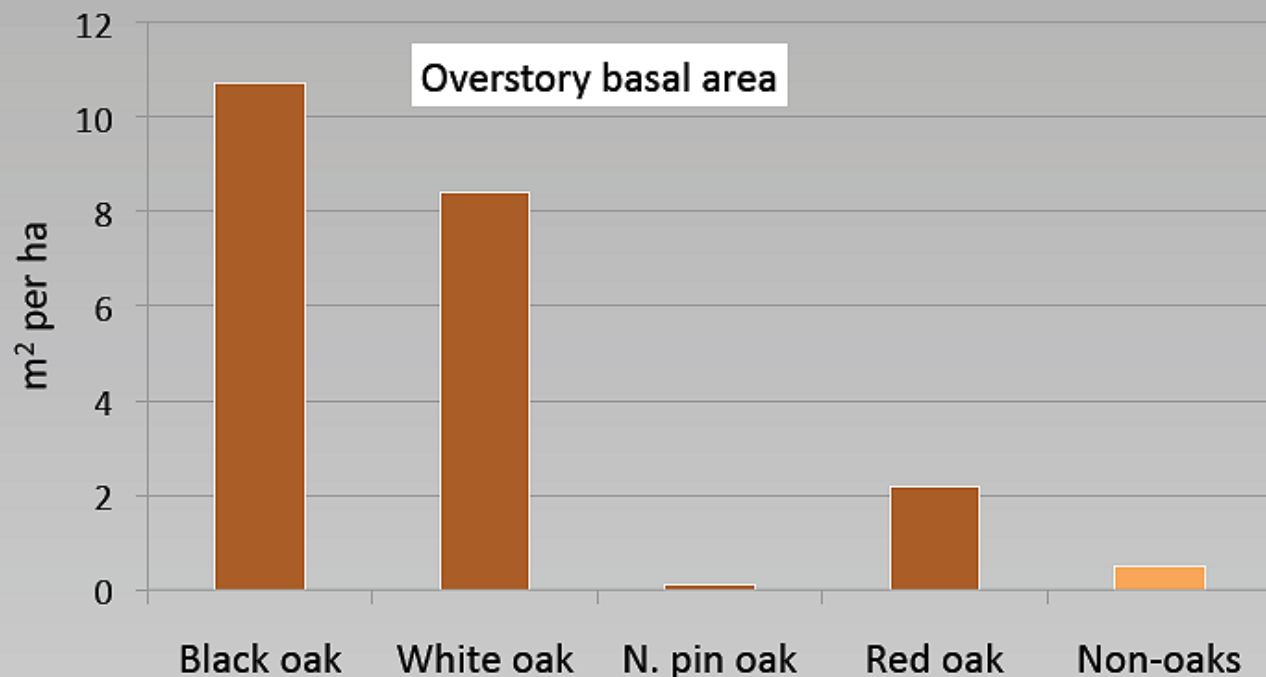
Oaks can persist on dry end of dry mesic sites,  
but silvicultural intervention may be required




**Stand characteristics of a xeric oak ecosystem\* in the Newaygo District of Michigan**

**Black oak-white oak/*Vaccinium* (ELTP 10)  
SI 16.5 m (54 ft)**

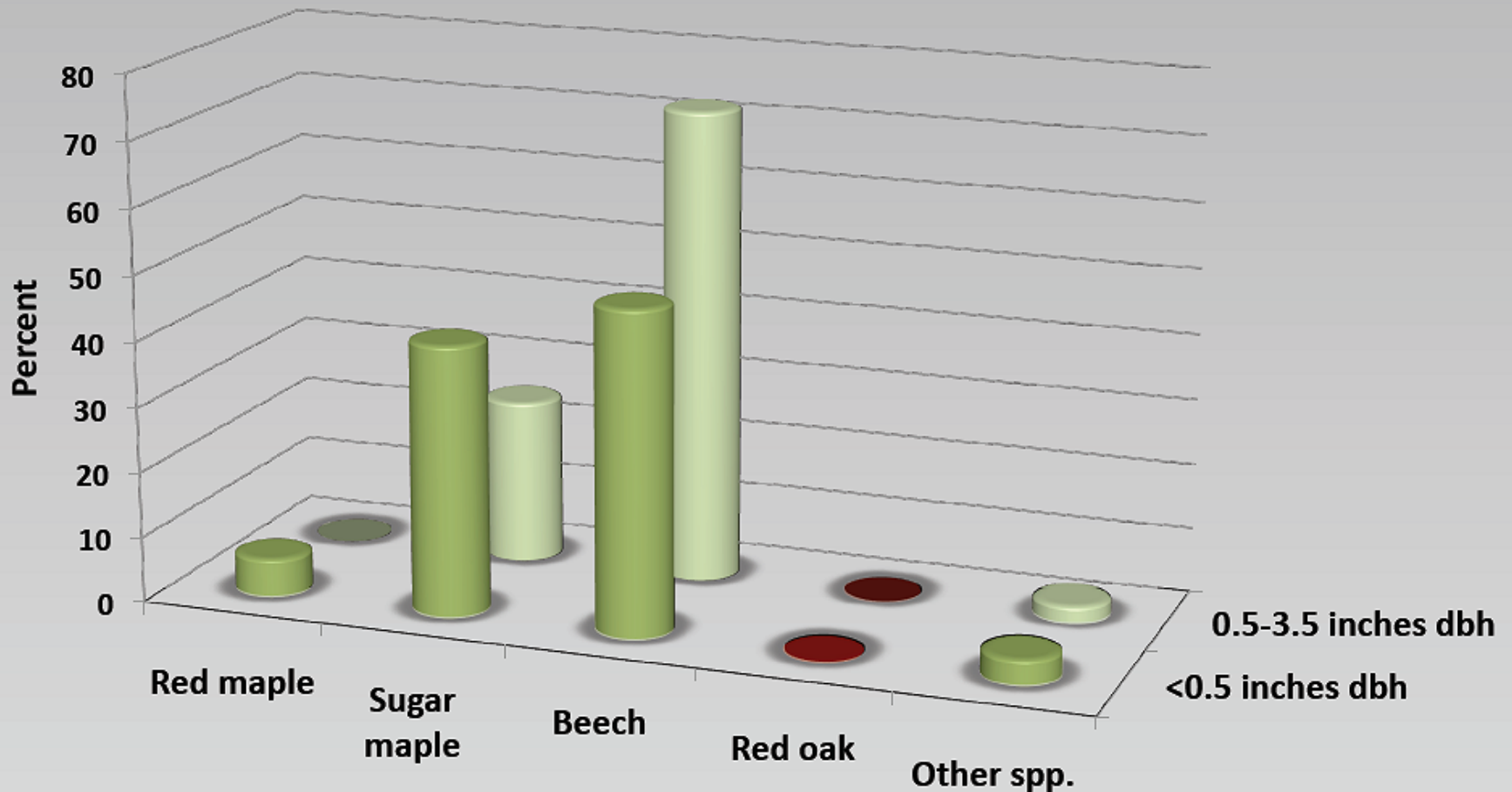
From Johnson (1992)



A photograph of a forest during autumn. The trees have yellow and green leaves, and the ground is covered in fallen leaves. The text is overlaid on the bottom right of the image.

On wet end of dry mesic & mesic sites oaks will disappear without silvicultural intervention

# Relative density of advanced regeneration in northern hardwood stands at Colonial Point (Burt Lake)



From Albert (1987)



## “Mesophication”

(Nowacki & Abrams 2008)...  
the successional  
disappearance of  
oaks on mesic sites



# Today's Topics

- Michigan's northern oaks
- Physiological ecology of oaks
- Fire and oaks
- Oaks across the landscape: then and now
- Succession of oak types: what's their future?
- Oaks and northern society



Mast & habitat  
for wildlife &  
game





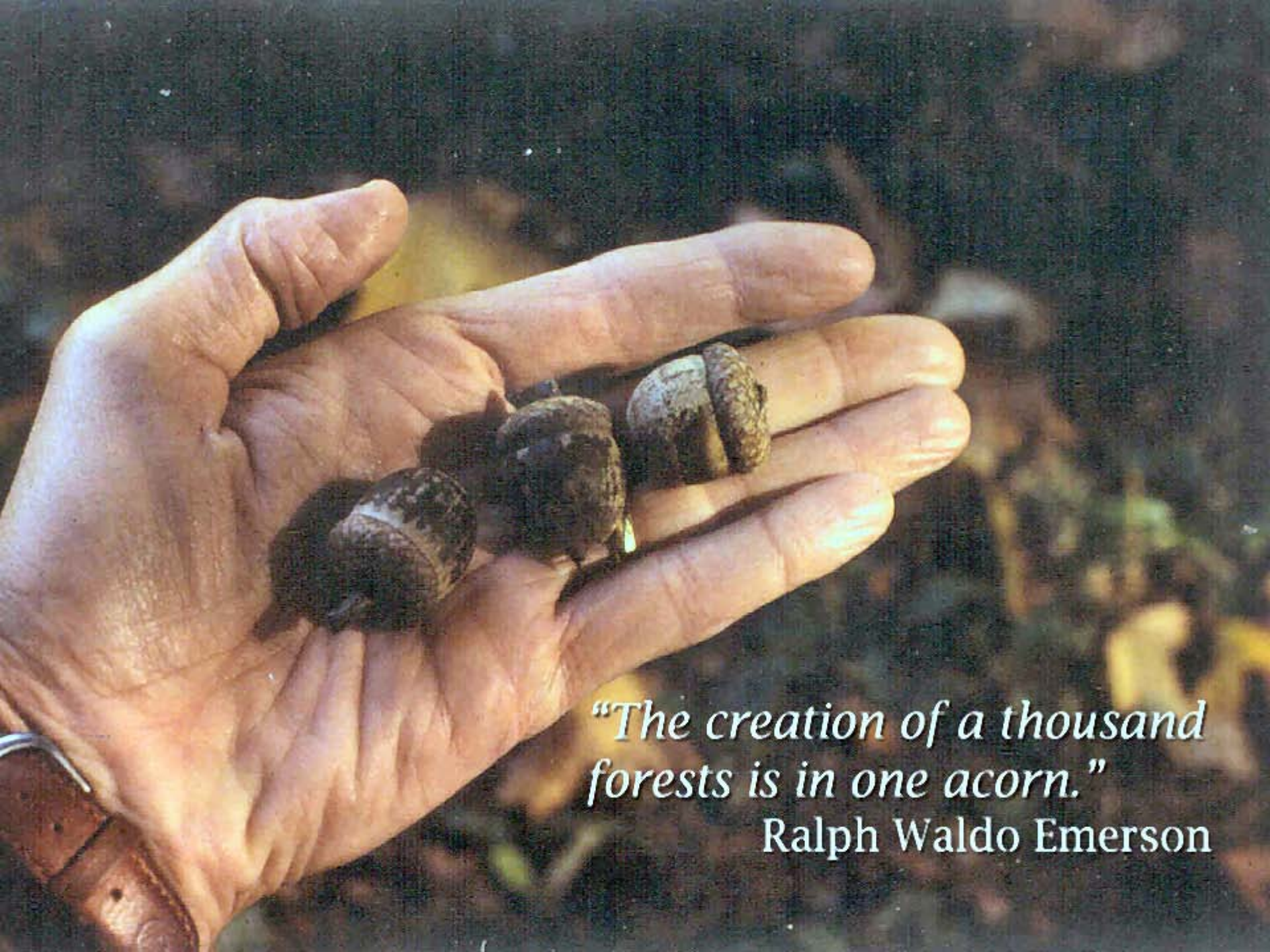


## Industrial wood products





Firewood



*“The creation of a thousand  
forests is in one acorn.”*

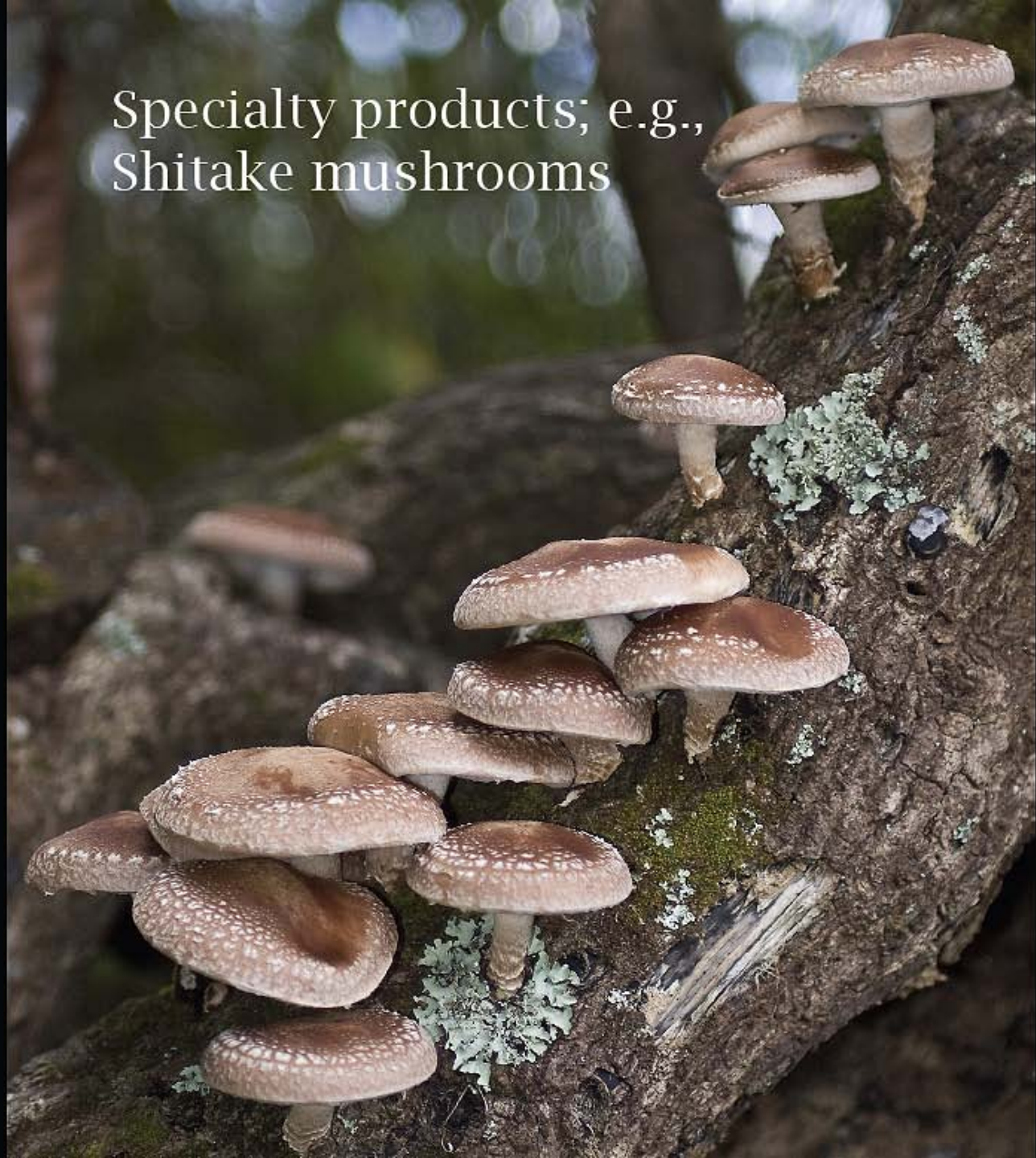
Ralph Waldo Emerson



Autumn color



Specialty products; e.g.,  
Shitake mushrooms



# Herbal uses of oaks, based on Native traditions

Oak species	Herbal uses
Red	Inner bark an astringent for diarrhea, bronchial infections, gonorrhea, & blood or heart trouble; a powerful antiseptic. Bark makes a brownish-red dye & used for tanning leather
Black	Bark makes a reddish-yellow dye & dye set
White	Inner bark used for diarrhea
Bur	Inner bark an astringent & for treating cramps, heart trouble or broken bones. Inner bark makes a black dye & dye set



**Michigan**  
**Society of American Foresters**

*Growing better all the time*