# Repeated Prescribed Fires Favor Oak Regeneration in Canopy Gaps

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Northern
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WAYNE
National Forest
75th ANNIVERSARY
1935 - 2010

# Collaborators

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- Robert Long, USFS, NRS
- Joanne Rebbeck, USFS, NRS
- Daniel Yaussy, USFS, NRS

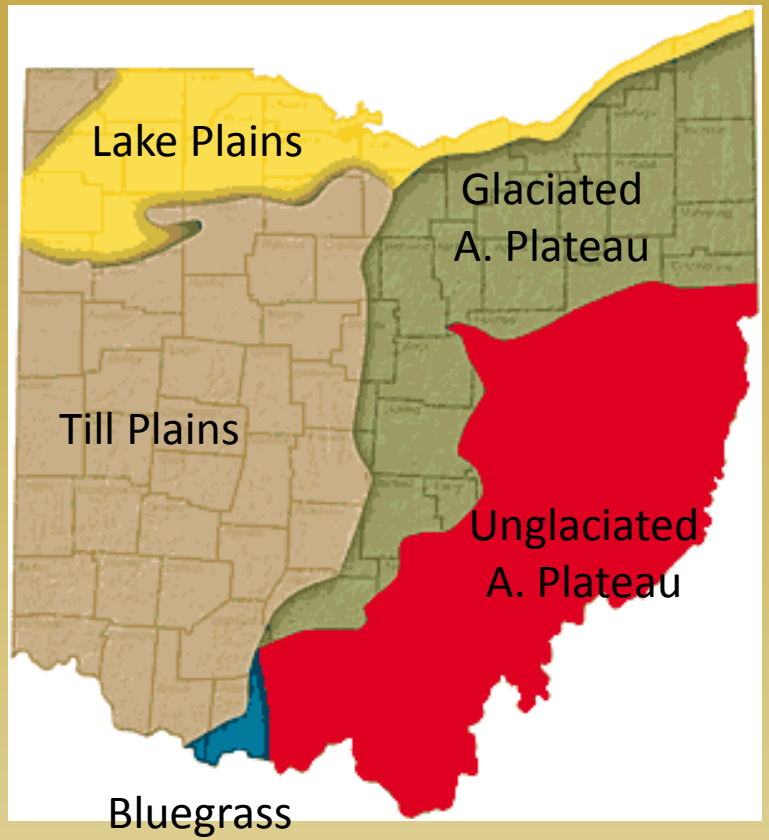

Field crew, circa 1995

# Oak regeneration across the landscape

- Intrinsic accumulation
  - Low moisture/nutrient availability
  - Upper slopes, S-aspect
  - Site index <60
- Recalcitrant accumulation
  - High moisture/nutrient availability
  - Middle-lower slopes, N-aspect
  - Site index >70

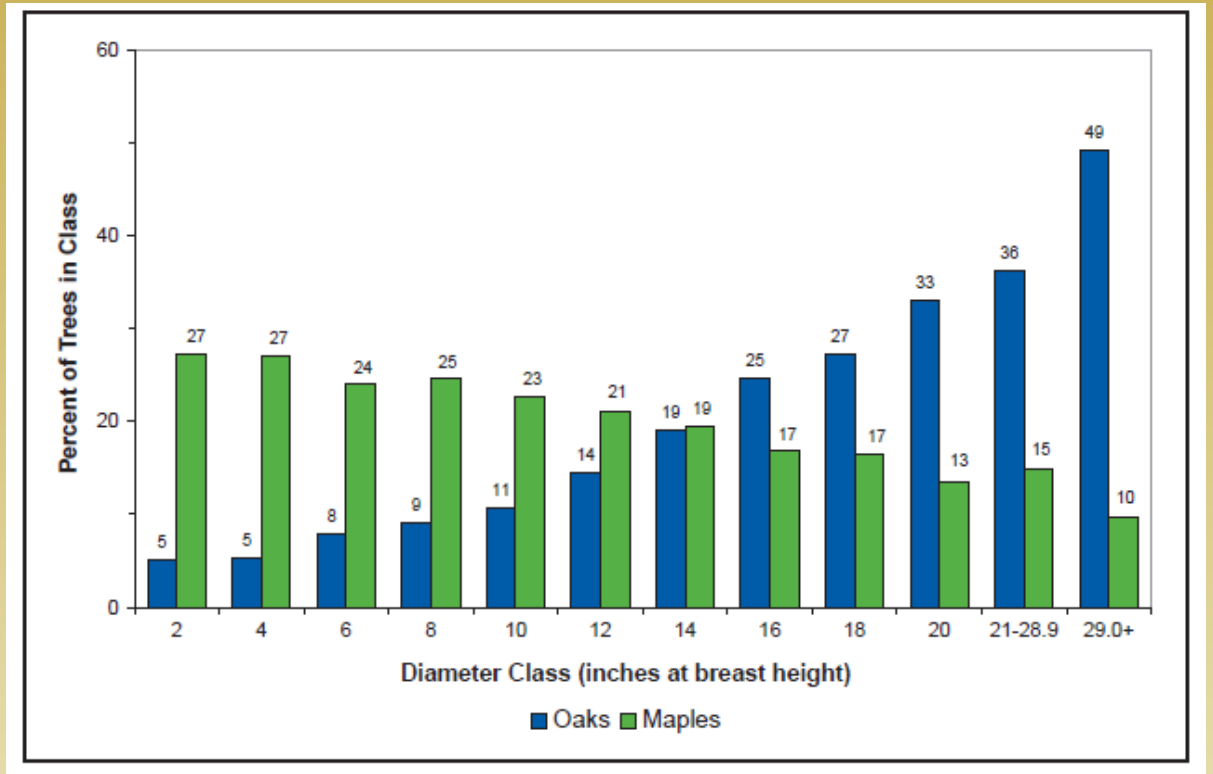
Johnson et al. 2009. Ecology and Silviculture of Oaks

## Ohio Physiographic Regions




## Ohio Forest Cover, 1994

# The Oak Regeneration Problem, Ohio




Ohio, FIA 2006

Widmann et al. 2009

# Southern Ohio Forests, ca. 1800

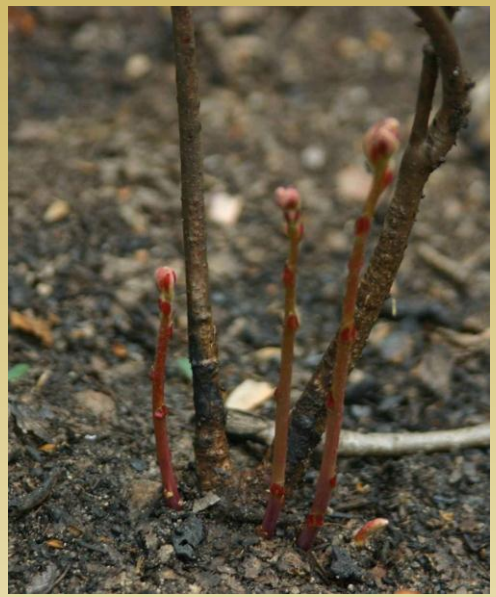
| Survey name | Scientific.name | Witness trees | Diameter (in) | Distance (ft) |
|---|---|---|---|---|
| White oak | *Quercus alba* | 1878 (33%) | 18 (3 – 60) | 22 |
| Hickory | *Carya spp.* | 779 (14%) | 12 (1 – 36) | 23 |
| Black oak | *Quercus velutina + coccinea* | 658 (12%) | 18 (2 - 96) | 25 |
| Beech | *Fagus grandifolia* | 572 (10%) | 12 (3 - 50) | 20 |
| Sugartree | *Acer saccharum* | 254 (4%) | 12 (3 – 32) | 20 |
| Gum | *Nyssa sylvatica* | 197 (3%) | 10 (3 – 30) | 17 |
| Maple | *Acer rubrum* | 193 (3%) | 12 (4 – 24) | 19 |
| Poplar | *Liriodendron tulipifera* | 158 (3%) | 14 (5 – 48) | 18 |
| Dogwood | *Cornus florida* | 149 (3%) | 5 (2 – 12) | 15 |
| Elm | *Ulmus spp.* | 111 (2%) | 12 (3 – 48) | 20 |
| Chestnut | *Castanea dentata* | 106 (2%) | 18 (3 – 60) | 29 |
| Chestnut oak | *Quercus prinus* | 89 (2%) | 14 (3 – 36) | 21 |
| | | | | |

Witness trees, five counties (*n* = 5696)

# Ecosystem Management Study, 1995

# Oak (and hickory) fire adaptations

- Trees
  - Thick bark
  - Wound compartmentalization
- Seedlings
  - Root-centered growth
  - Location of dormant buds
  - Re-sprouting capacity



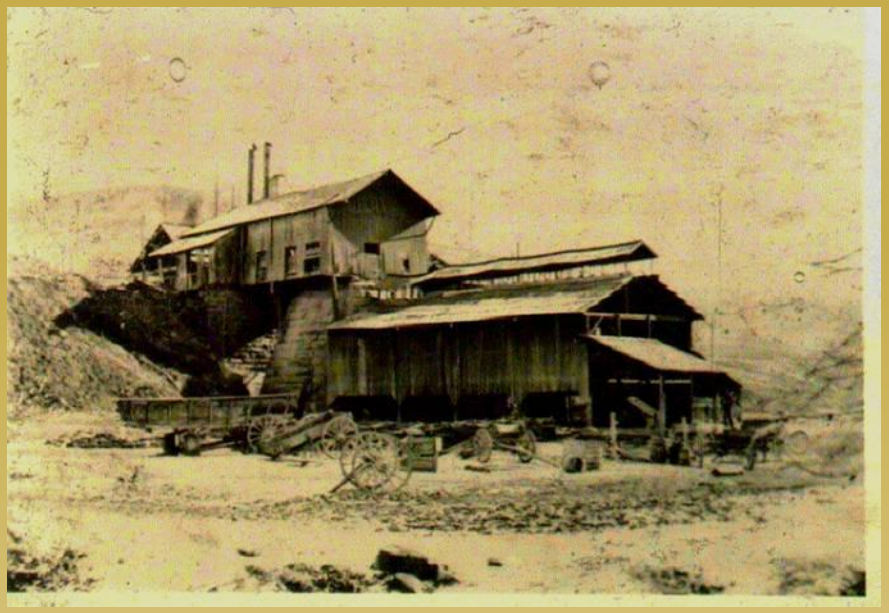
# Hypotheses: Forest Structure and Tree Regeneration

Repeated low-intensity fires will:

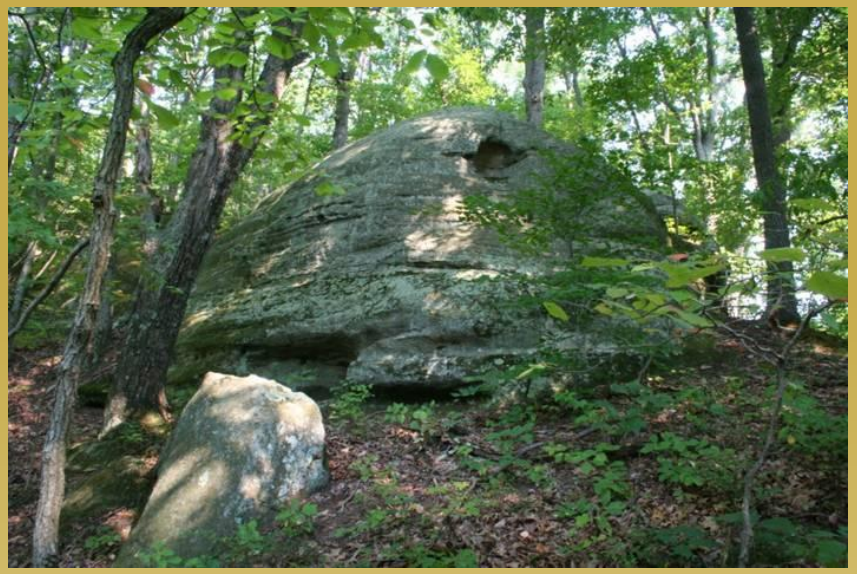
1. Reduce the density of midstory and understory trees, which are predominately non-oaks

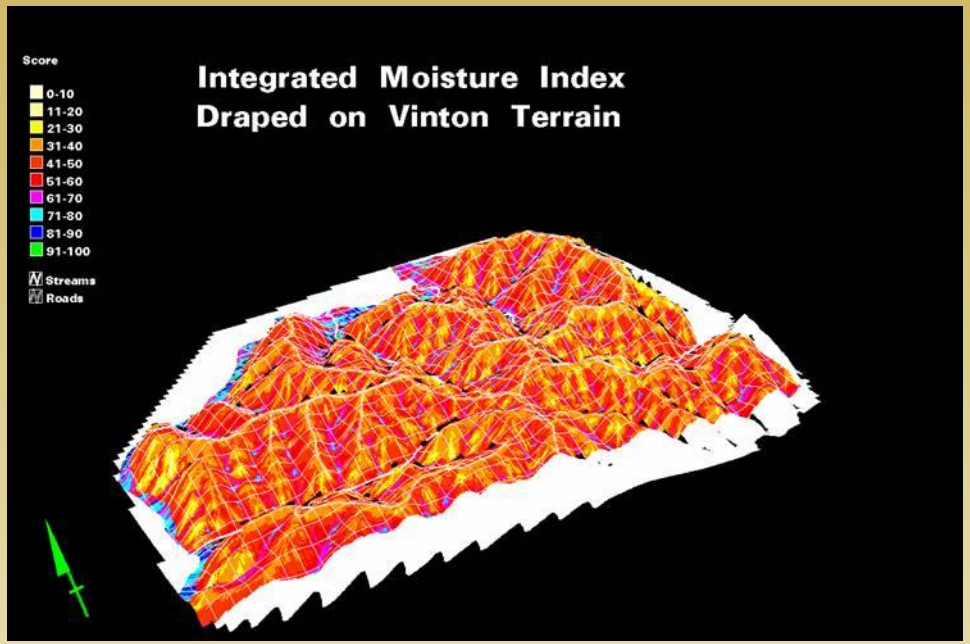
2. Increase the competitive status of oak regeneration due to their sprouting capacity and increased light to the forest floor

# Study Site: Vinton Furnace State Experimental Forest (VFSEF)



# Study site:  VFSEF






# Fire History, Vinton Furnace Exp. Forest



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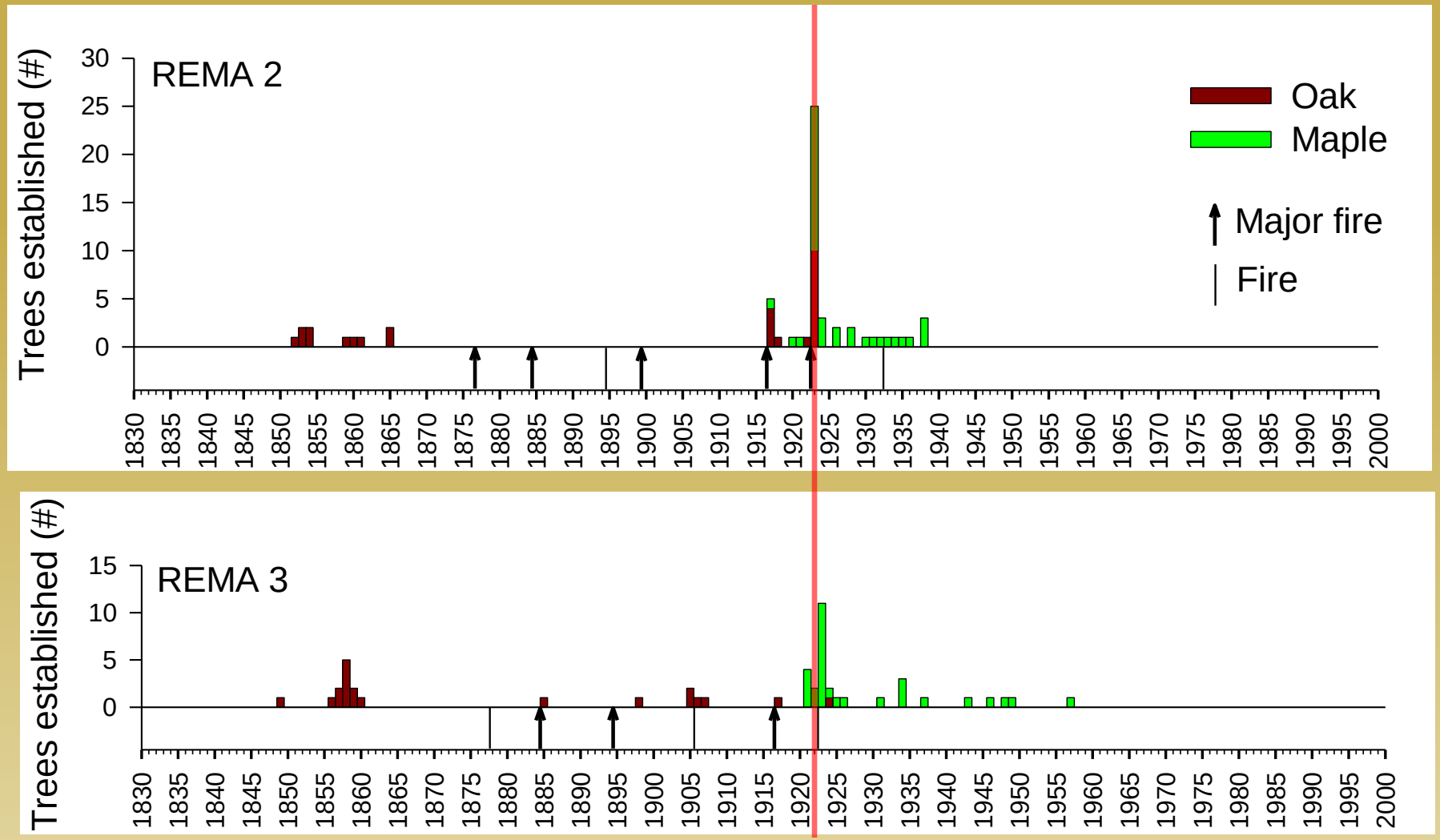
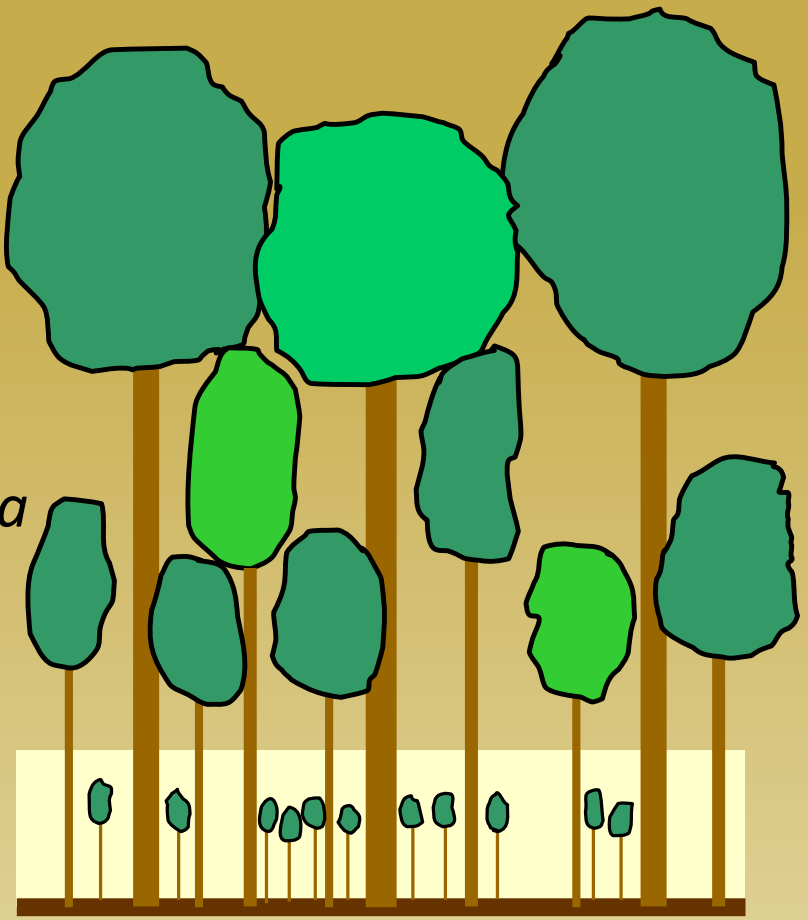


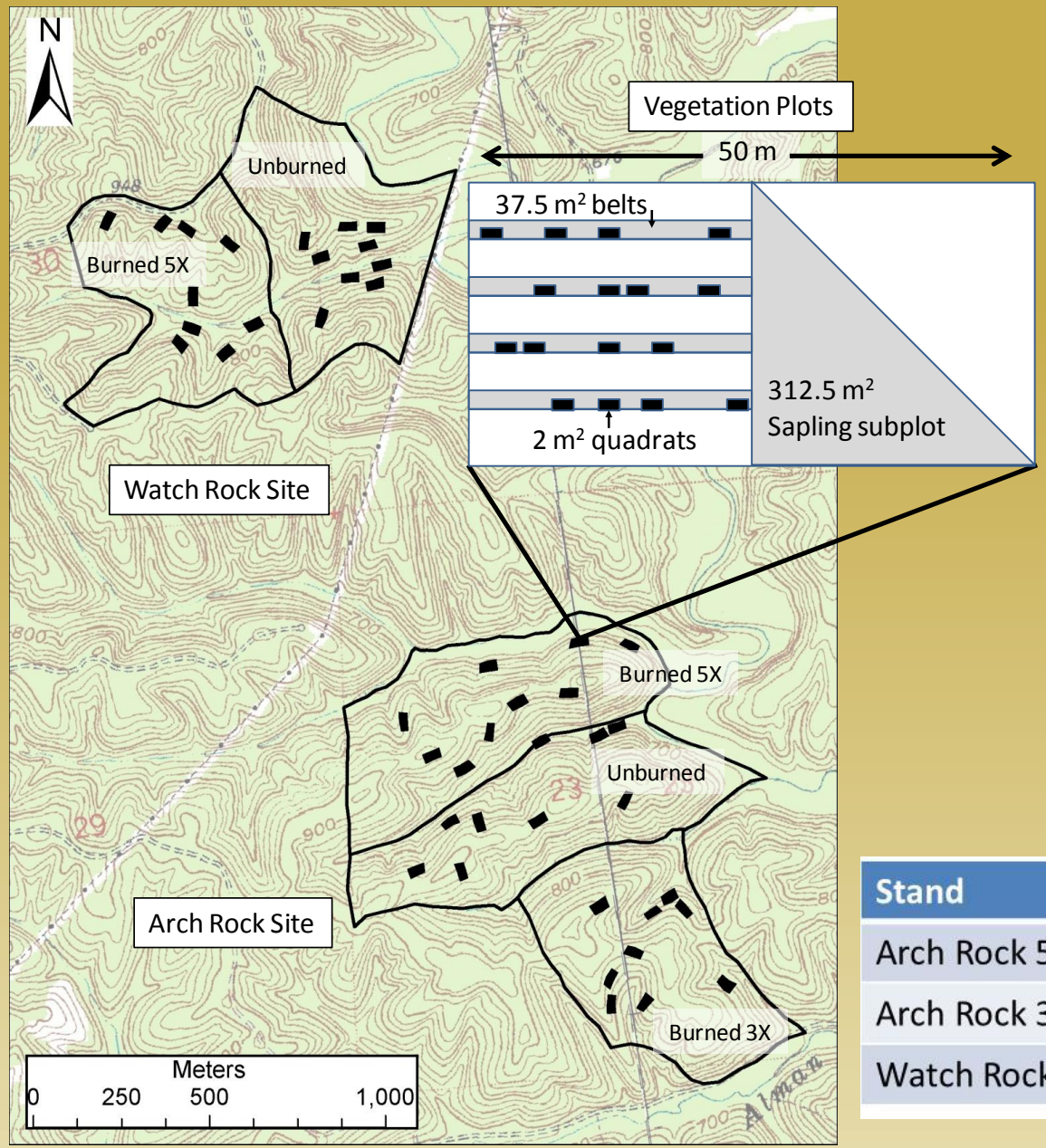

Hutchinson et al. *Can. J. For. Res*. 2008

# Forest Composition

- Overstory
  - White oak, *Quercus alba*
  - Chestnut oak, *Quercus montana*
  - Black oak, *Quercus velutina*
  - Hickories, *Carya* spp.
  - Scarlet oak, *Quercus coccinea*
  - Yellow poplar, *Liriodendron tulipifera*
- Understory
  - Red maple, *Acer rubrum*
  - Sugar maple, *Acer saccharum*
  - Blackgum, *Nyssa sylvatica*
  - Beech, *Fagus grandifolia*
  - Sourwood, *Oxydendrum arboreum*



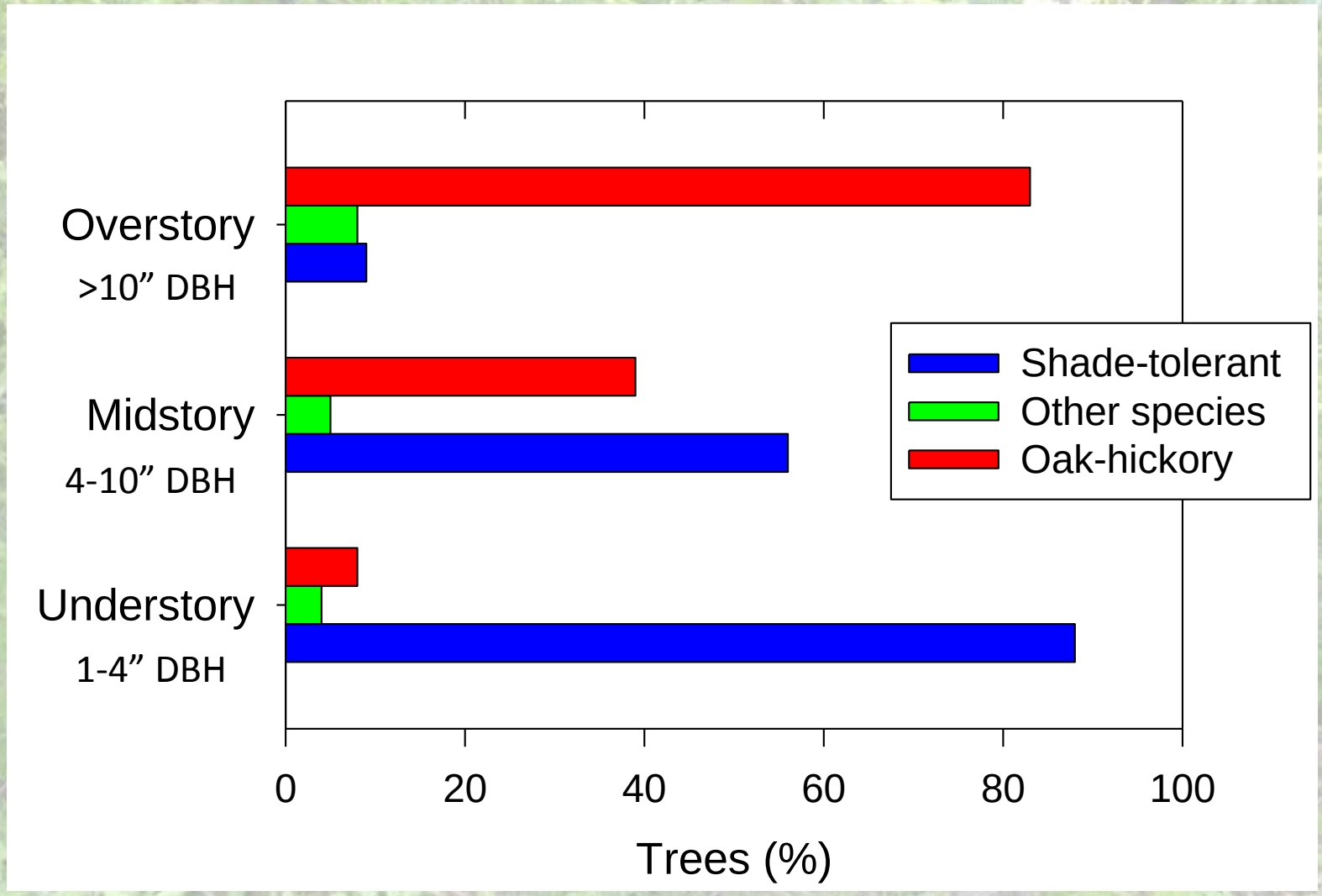
# Study Design




## Prescribed fires

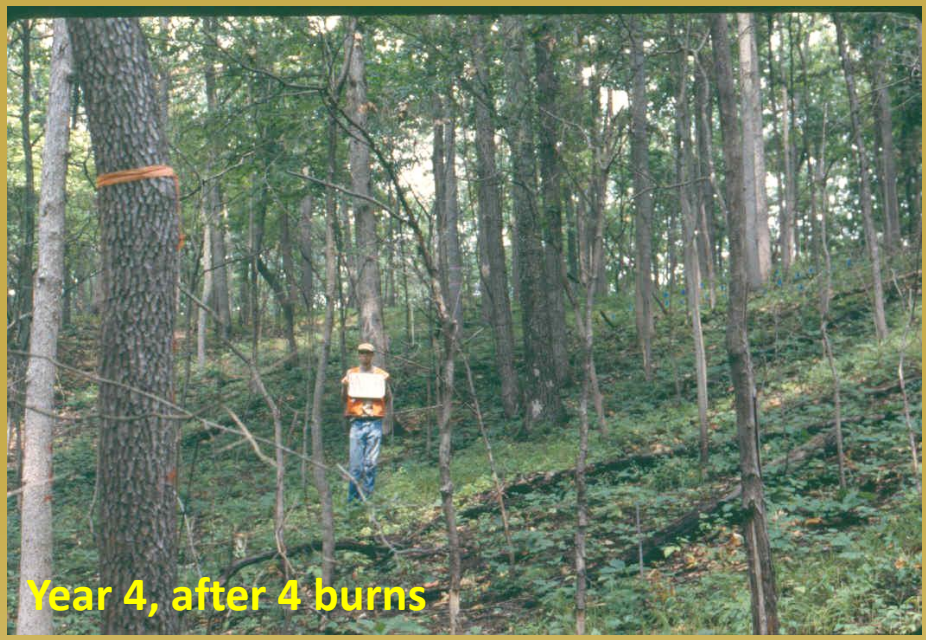
| Stand | yr1 | yr2 | yr3 | yr4 | yr9 | yr10 |
|---|---|---|---|---|---|---|
| Arch Rock 5X | 4/19 | 4/2 | 4/6 | 3/26 | 4/17 | |
| Arch Rock 3X | 4/18 | | | 3/26 | | 4/15 |
| Watch Rock 5X | 4/21 | 4/3 | 4/6 | 3/27 | 11/9 | |

# Forest Composition, year 0




This was another study……


Year 0, pre-burn


Year 4, after 4 burns


Year 13, after 5 burns


Year 0, pre-burn


Year 4, after 2 burns

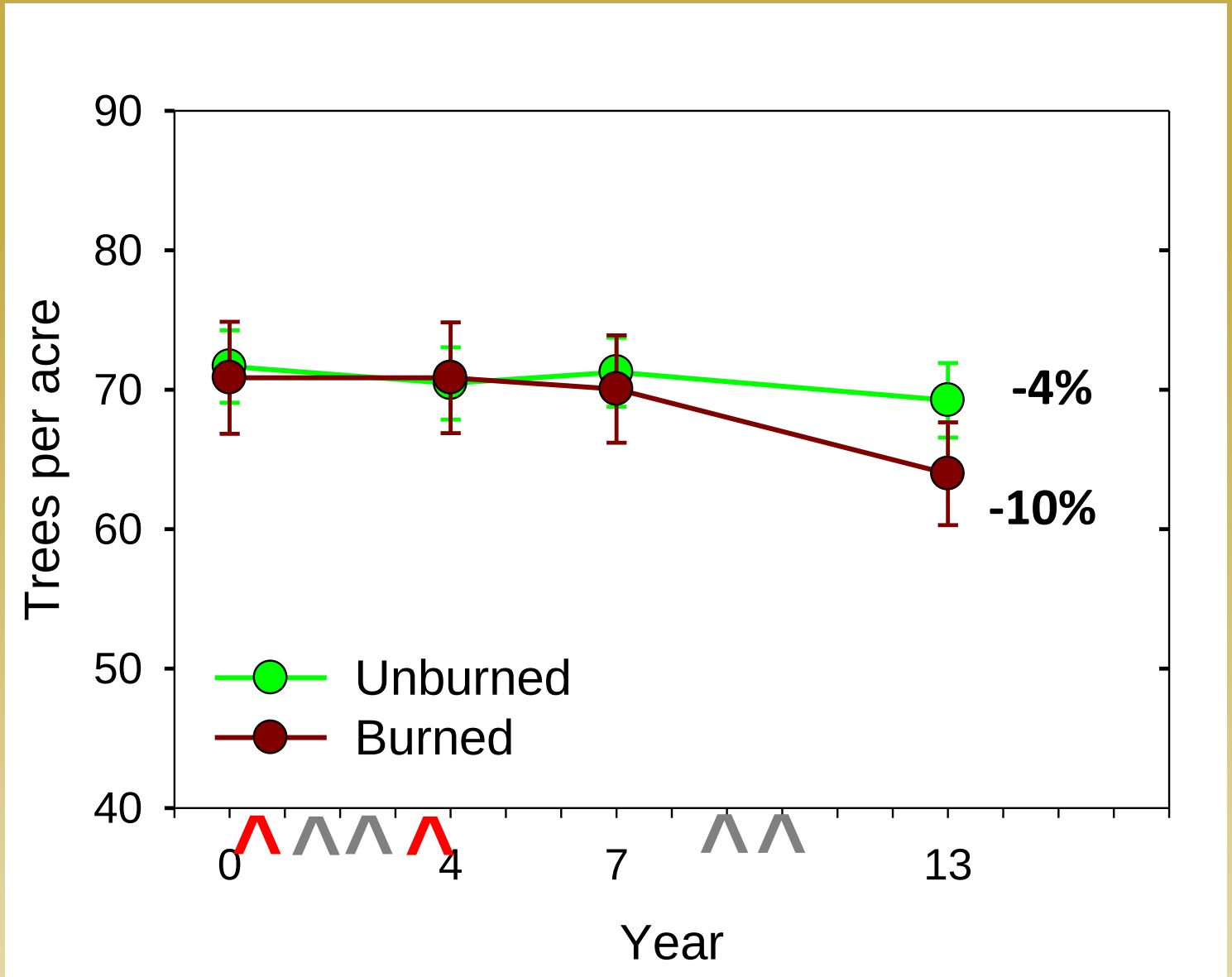

Year 13, after 3 burns


Year 0, pre-burn

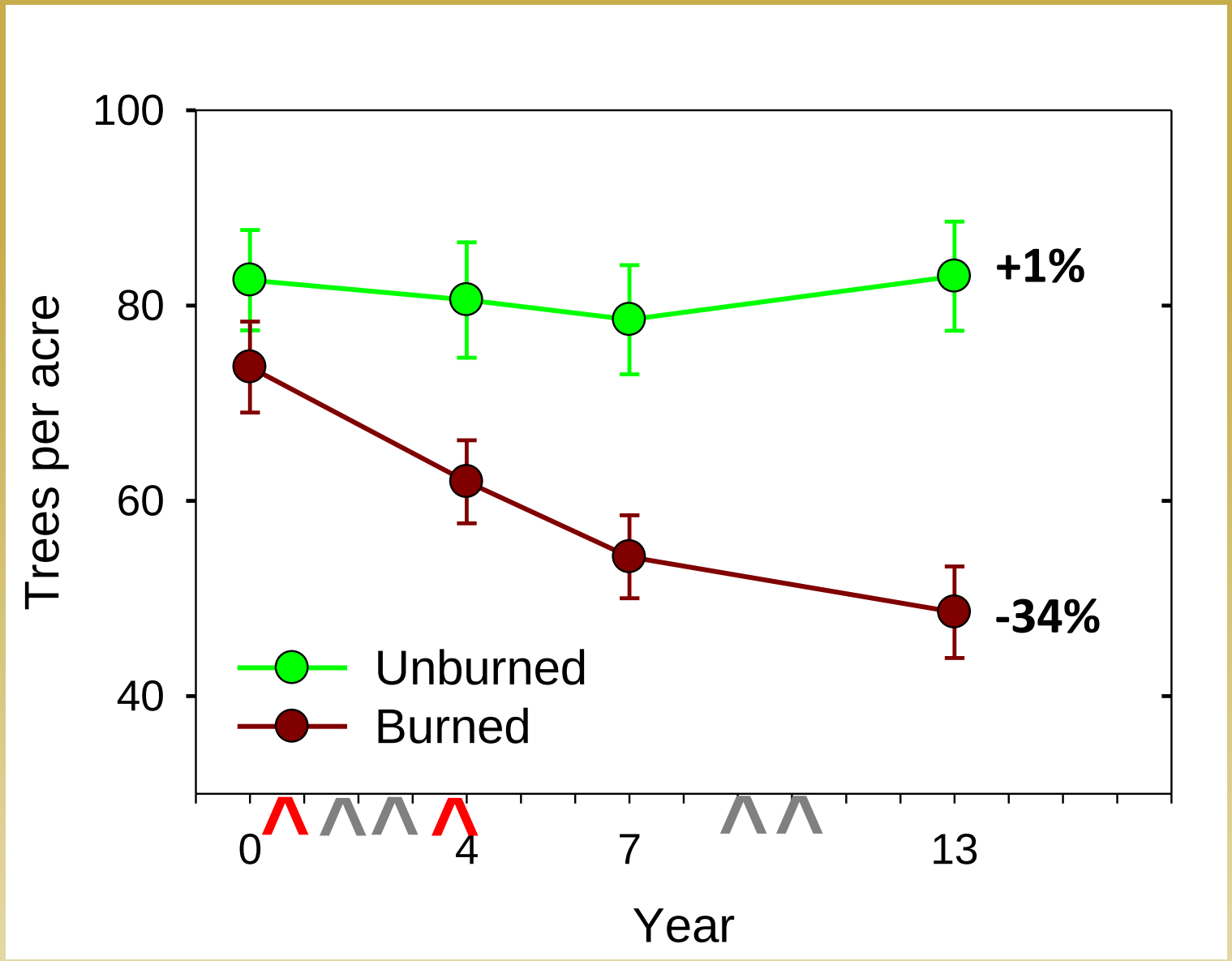

Year 4, after 4 burns


Year 13, after 5 burns

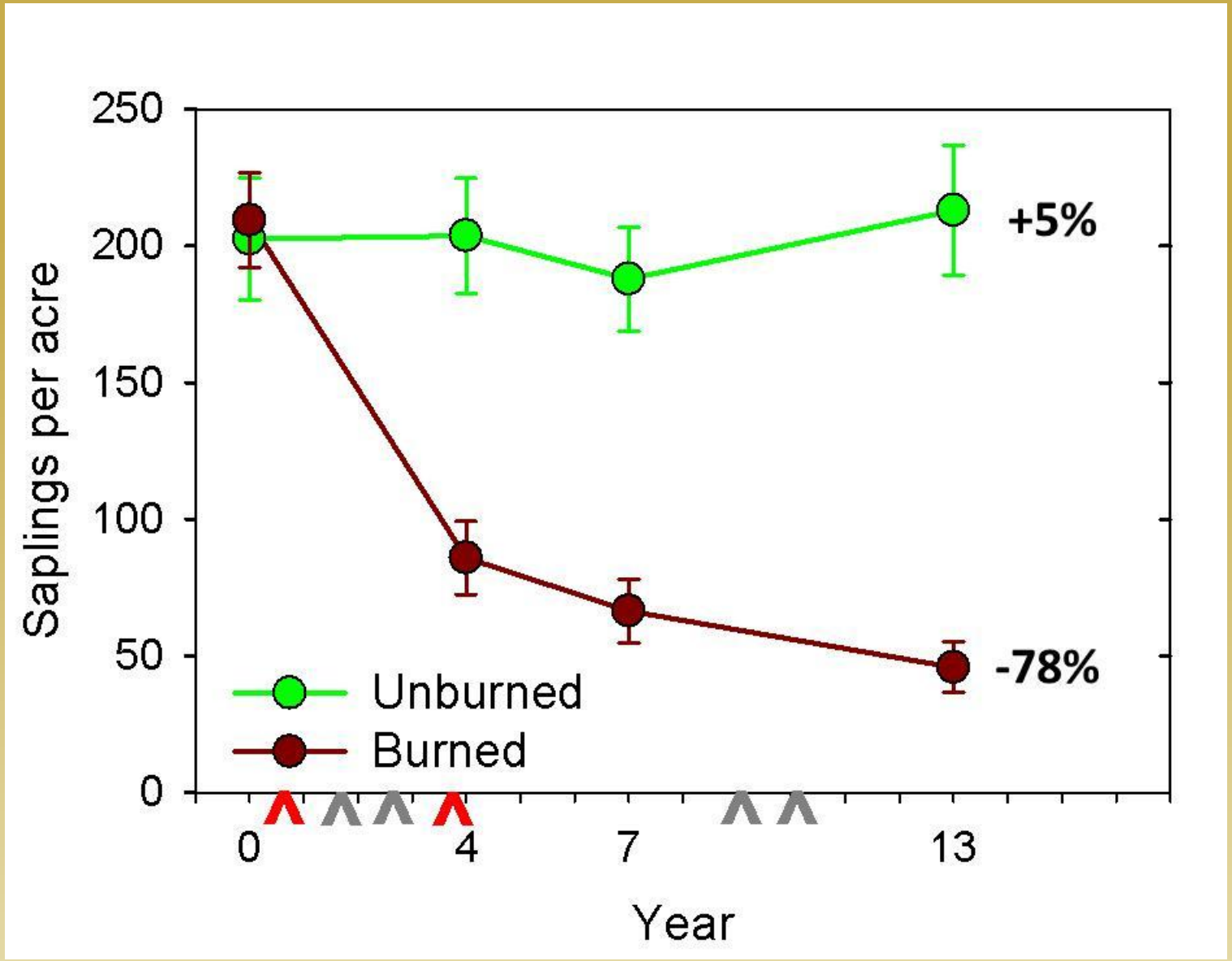
# Overstory trees >10” DBH



# Midstory trees 4-10” DBH



# Saplings 1-4” DBH

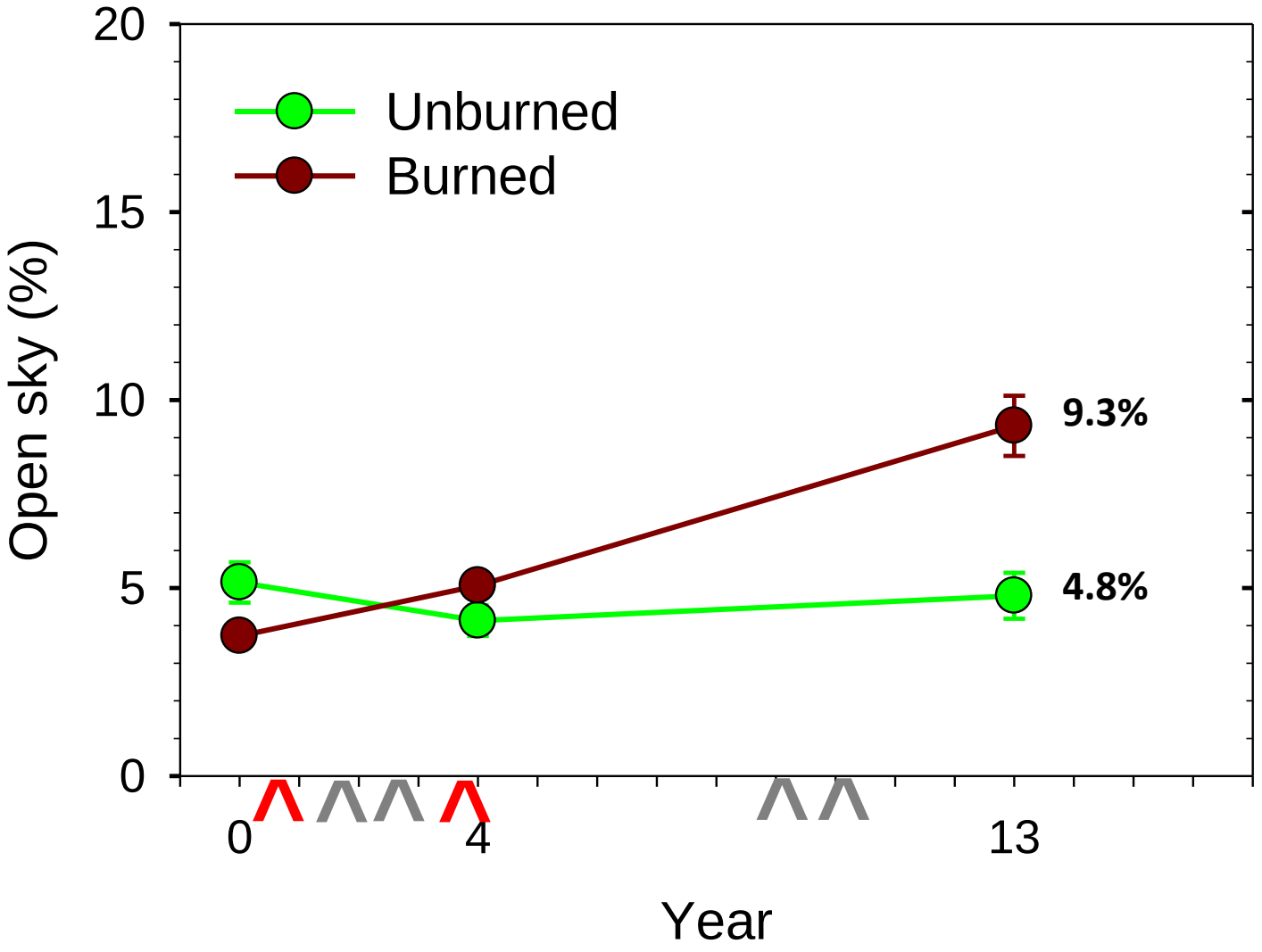


# Midstory mortality, year 13
# Trees 4 – 10” DBH

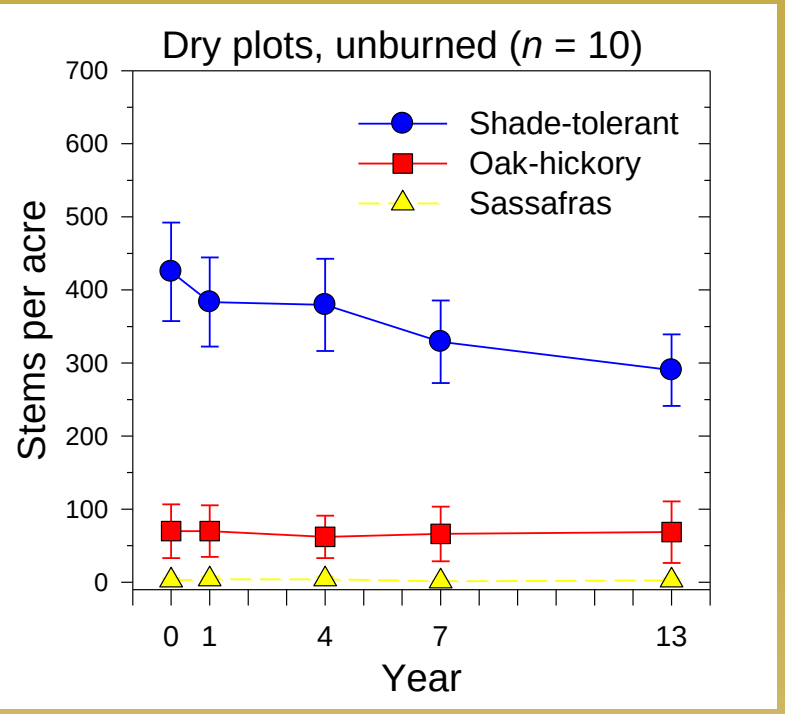
| Species | “Fire” mortality. | |
|---|---|---|
| Red maple | 43% | (49 - 6) |
| White oak | 21% | (67 - 46) |
| Hickory | 17% | (26 - 9) |
| Yellow poplar | 7% | (23 - 16) |
| Blackgum | 6% | ( 9 - 3) |
| Chestnut oak | 2% | (15 – 13) |

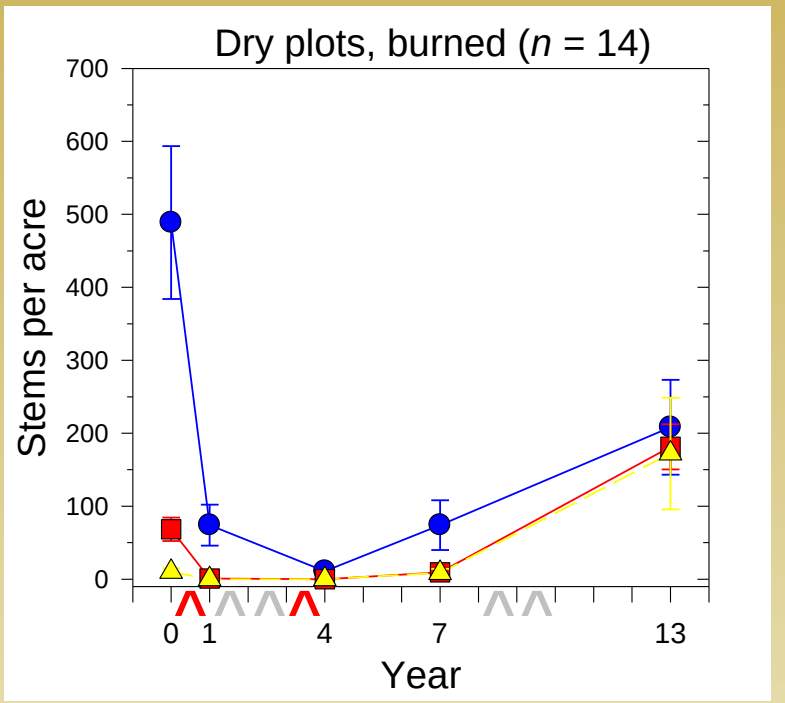

Year 13
3 burns

# Canopy Openness



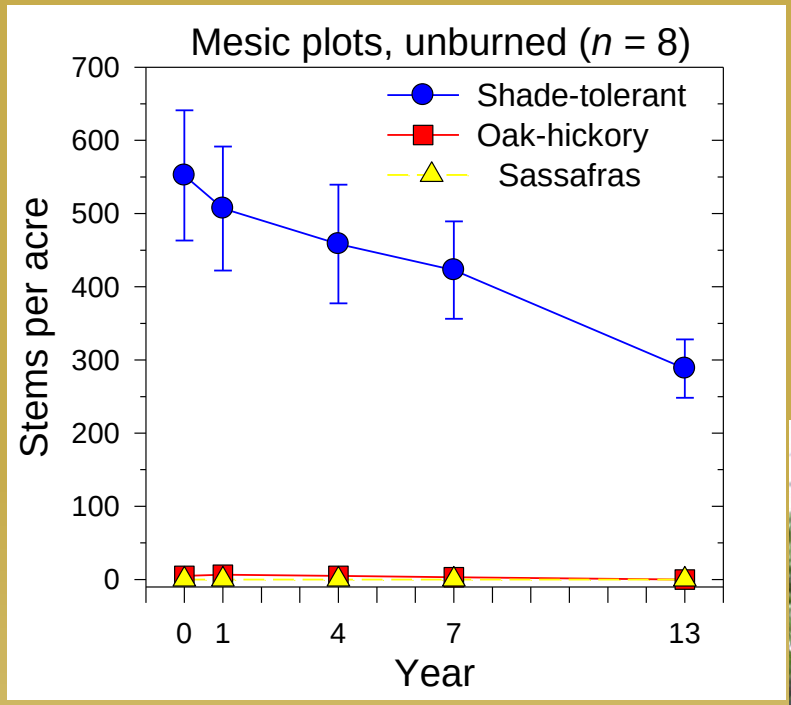
# Small saplings (4.5’ tall to 1” DBH) Dry sites

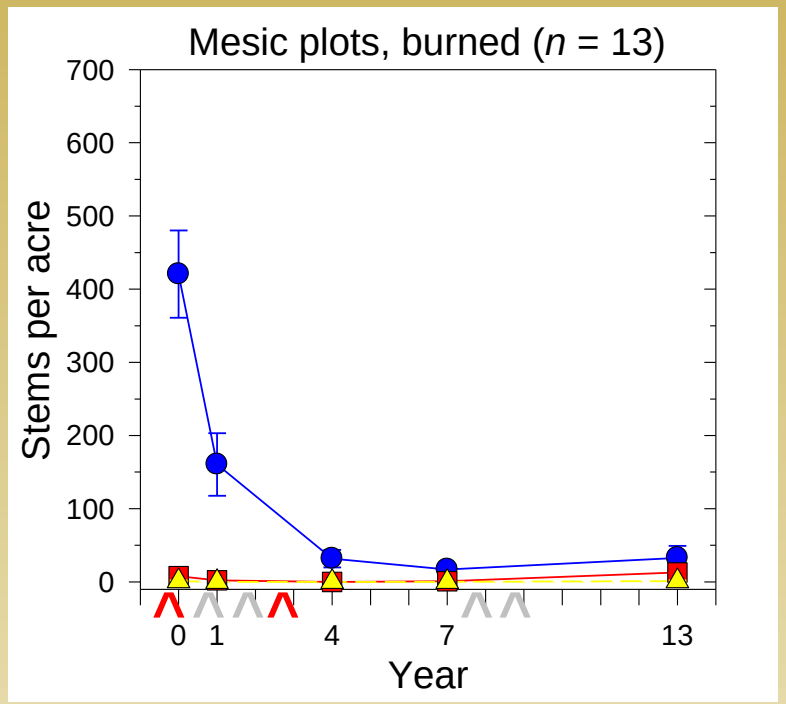


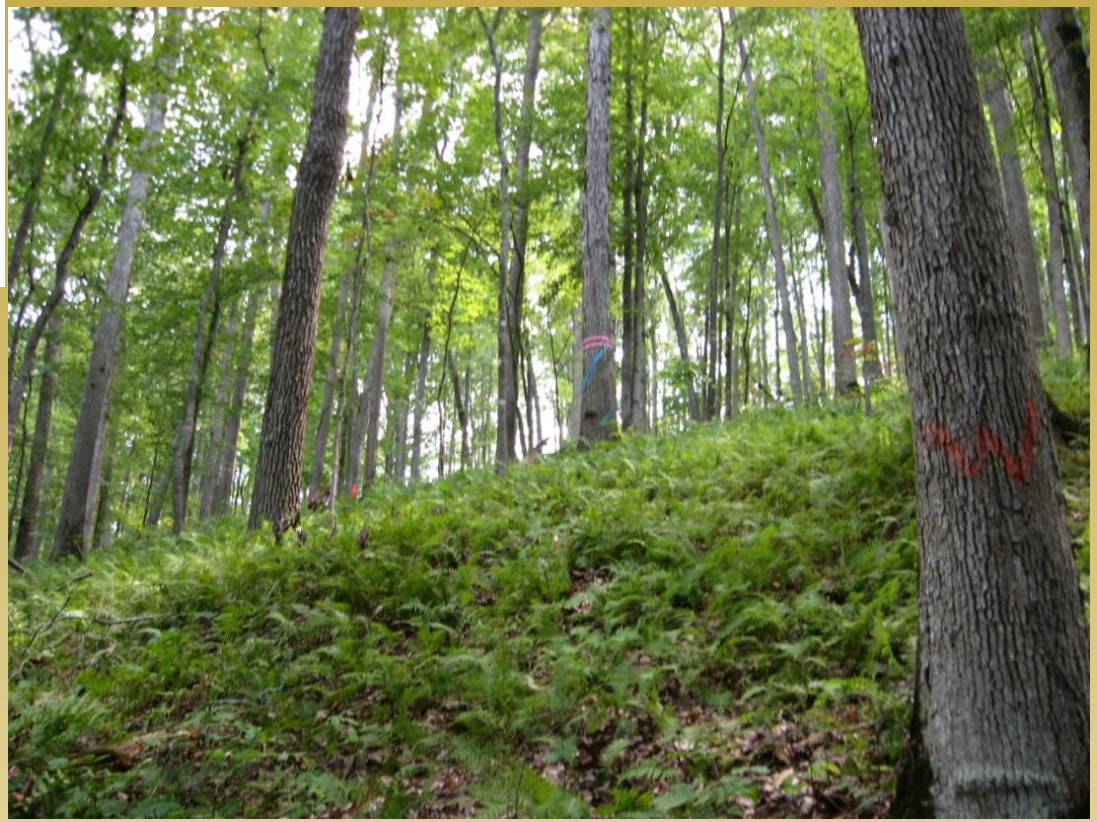




Year 13, 5 burns

# Small saplings (4.5’ tall to 1” DBH) Mesic sites

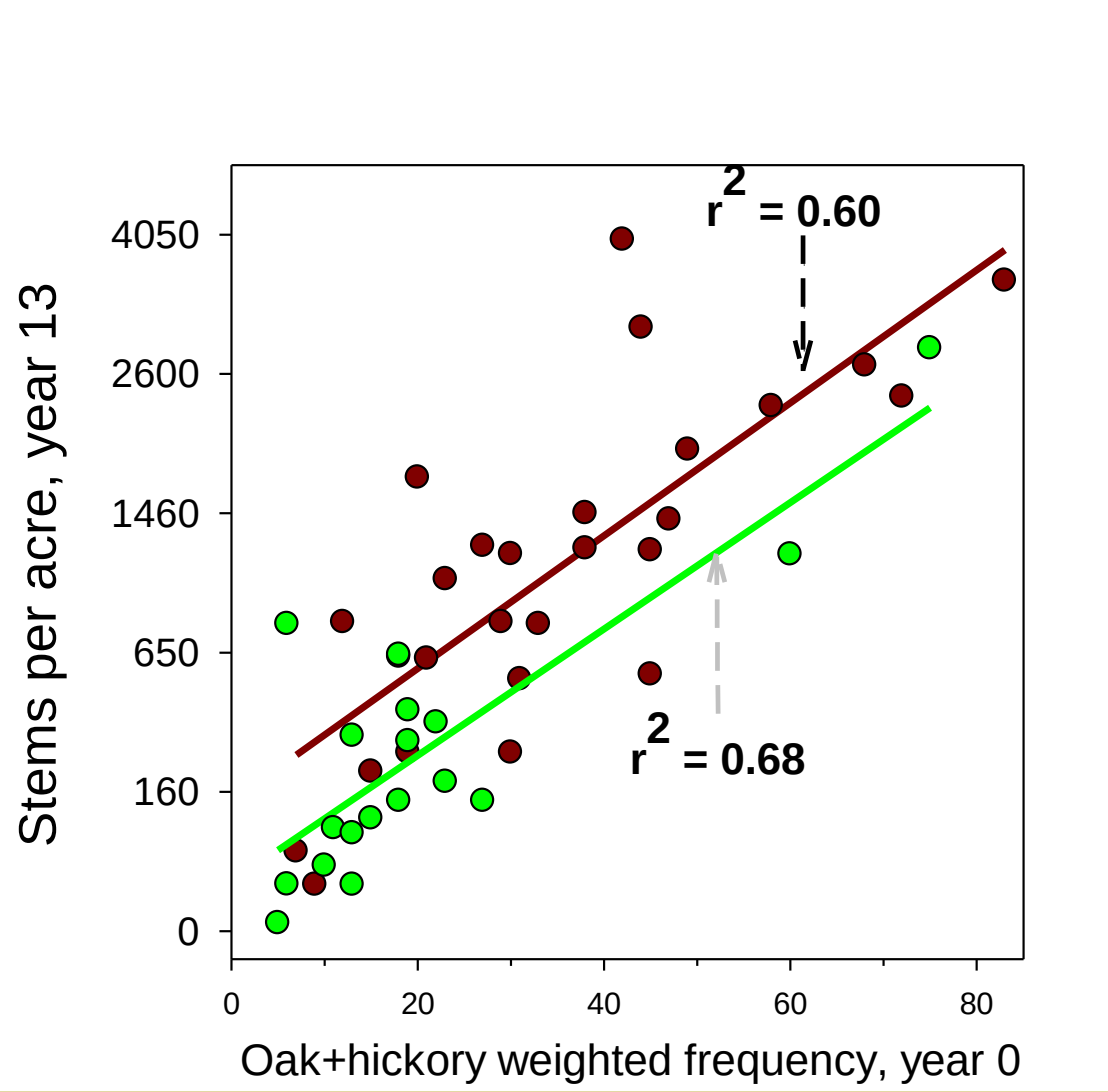


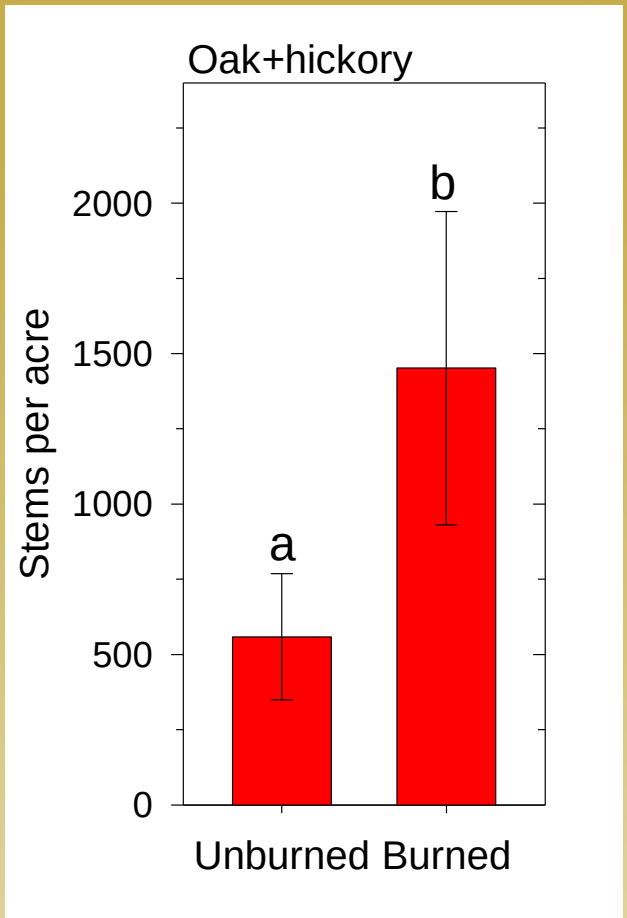
Year 13, 5 burns

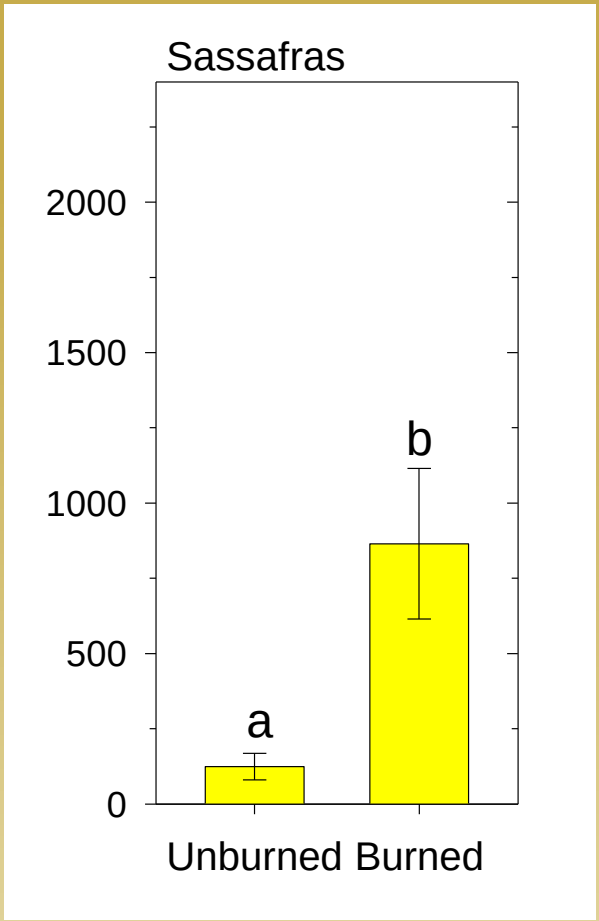
# Oak-hickory advance regeneration, Year 13, Stems 1’ tall to 1” DBH

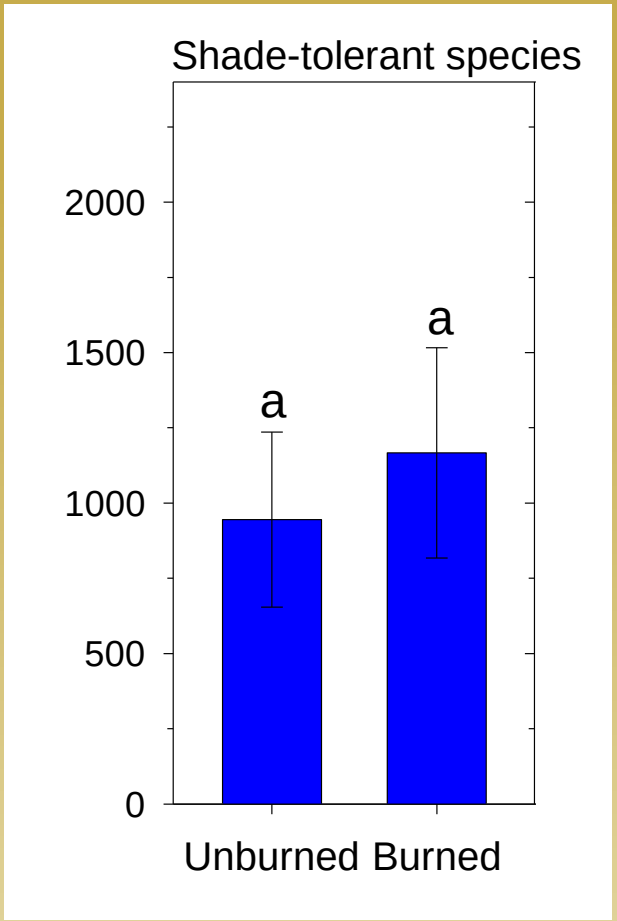



Unburned
Burned

# Advance regeneration, Year 13
# Stems 1’ tall to 1” DBH





*Sassafras albidum*

# Conclusions, Permanent Plots, Year 13

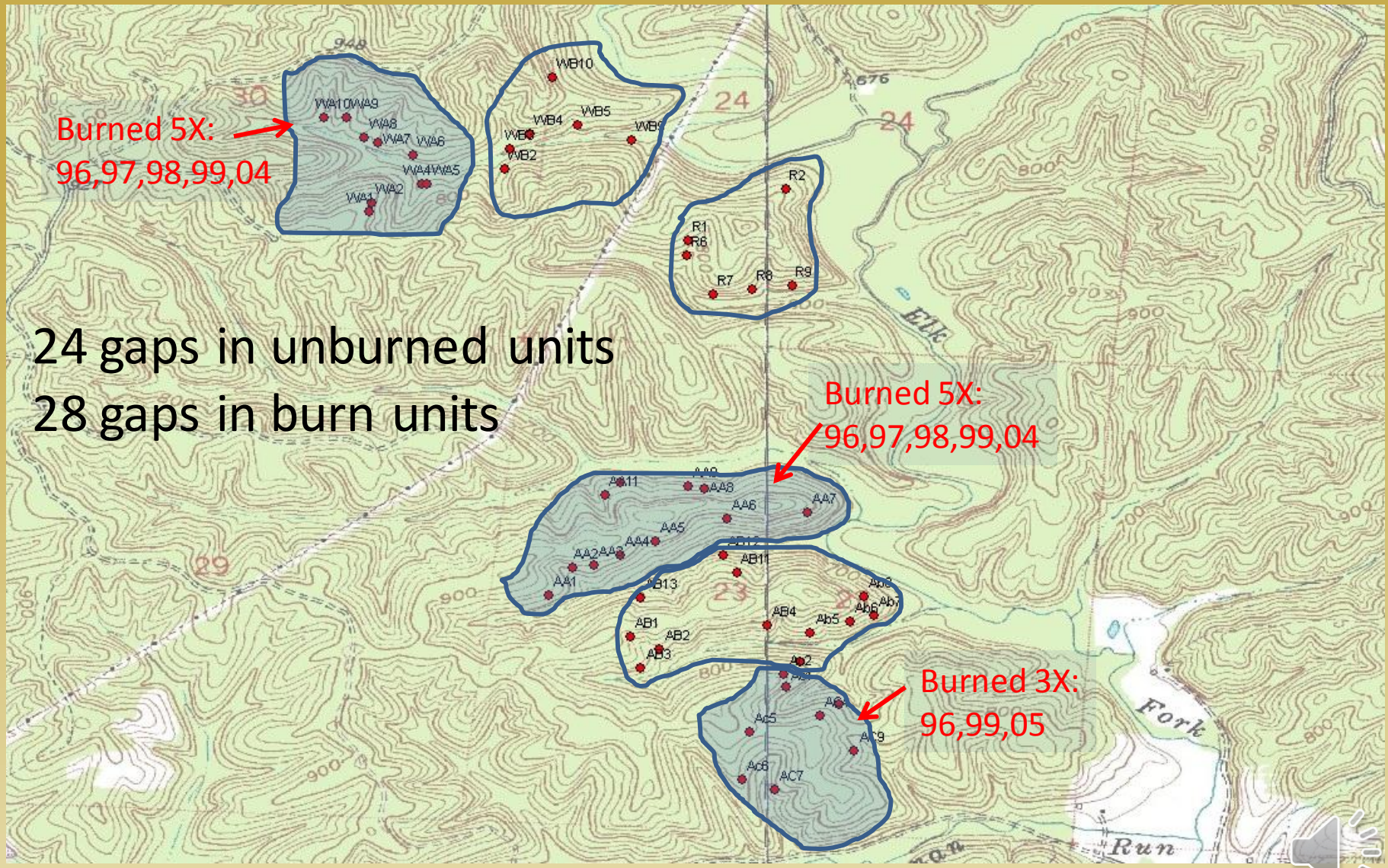
- Fire effects on stand structure:
  - Understory > Midstory > Overstory
- Fire changed the species composition of the small saplings on dry plots:
  - Shade-tolerant –
  - Oak-hickory +
  - Sassafras +
- Oak-hickory advance regeneration (>1’ tall) was more abundant on burned sites
  - Highly variable across landscape
  - Dependent on the ABUNDANCE and SIZE of oak-hickory seedlings present initially

# Years 8-10: White oak decline
# Formation of canopy gaps

# 3 years since gap formed (year 11)

2 years after the last of five fires

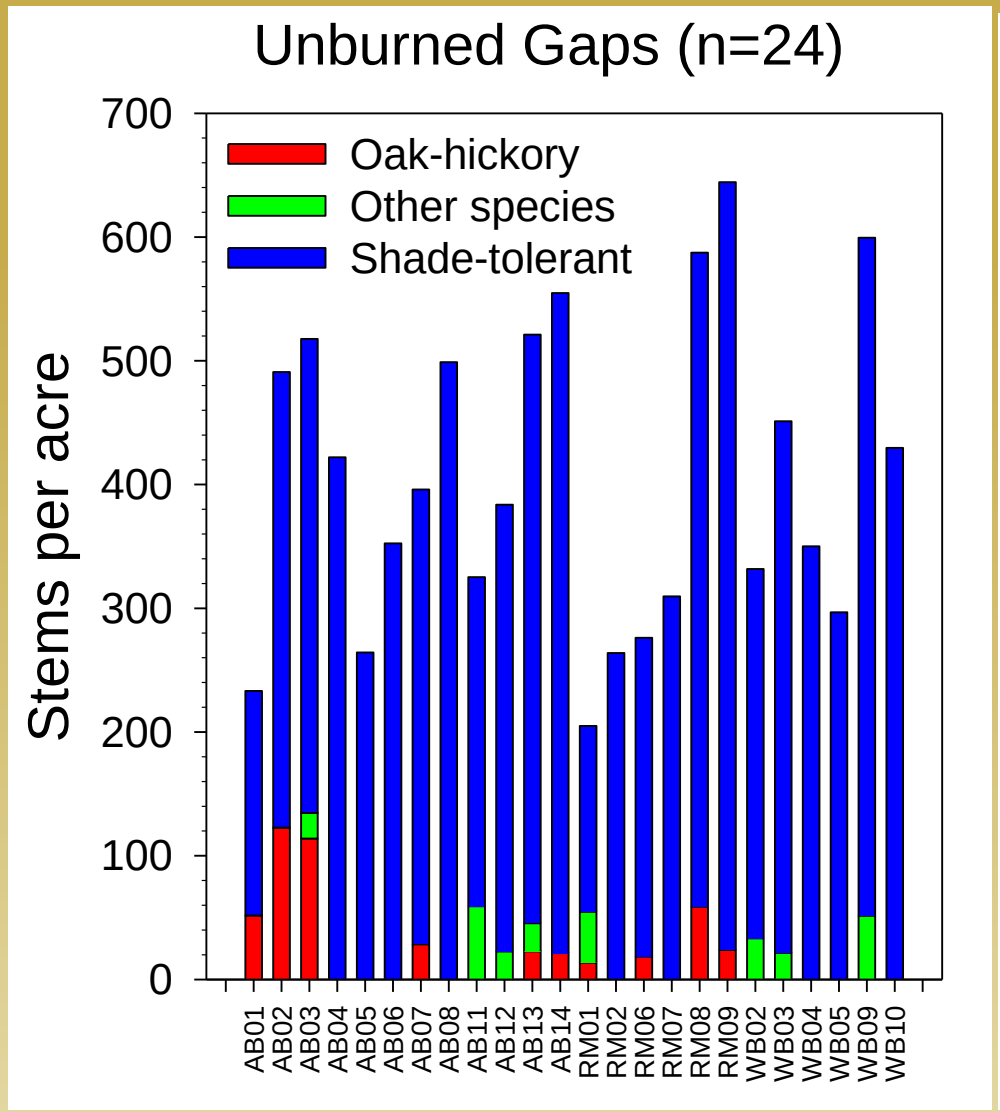
# Tree regeneration in burned and unburned canopy gaps, year 13

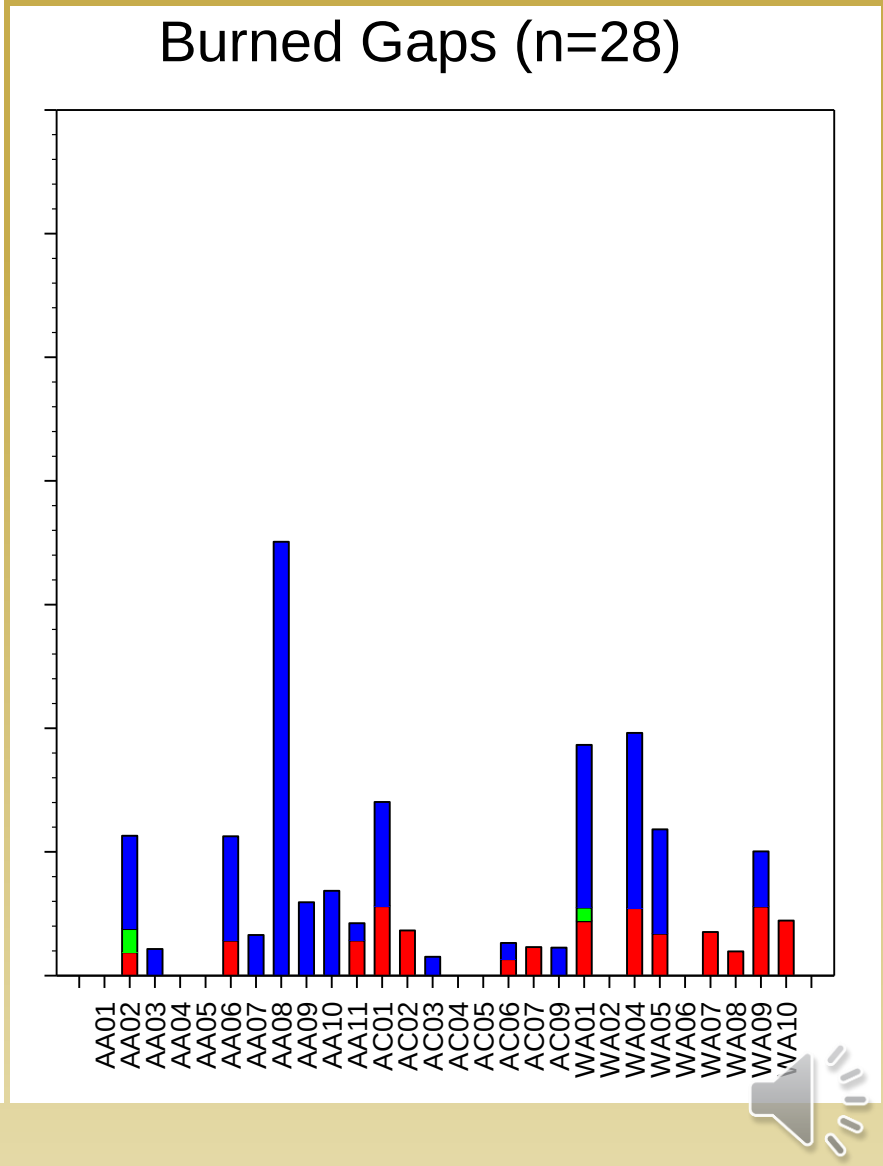


# Attributes of gaps, year 13

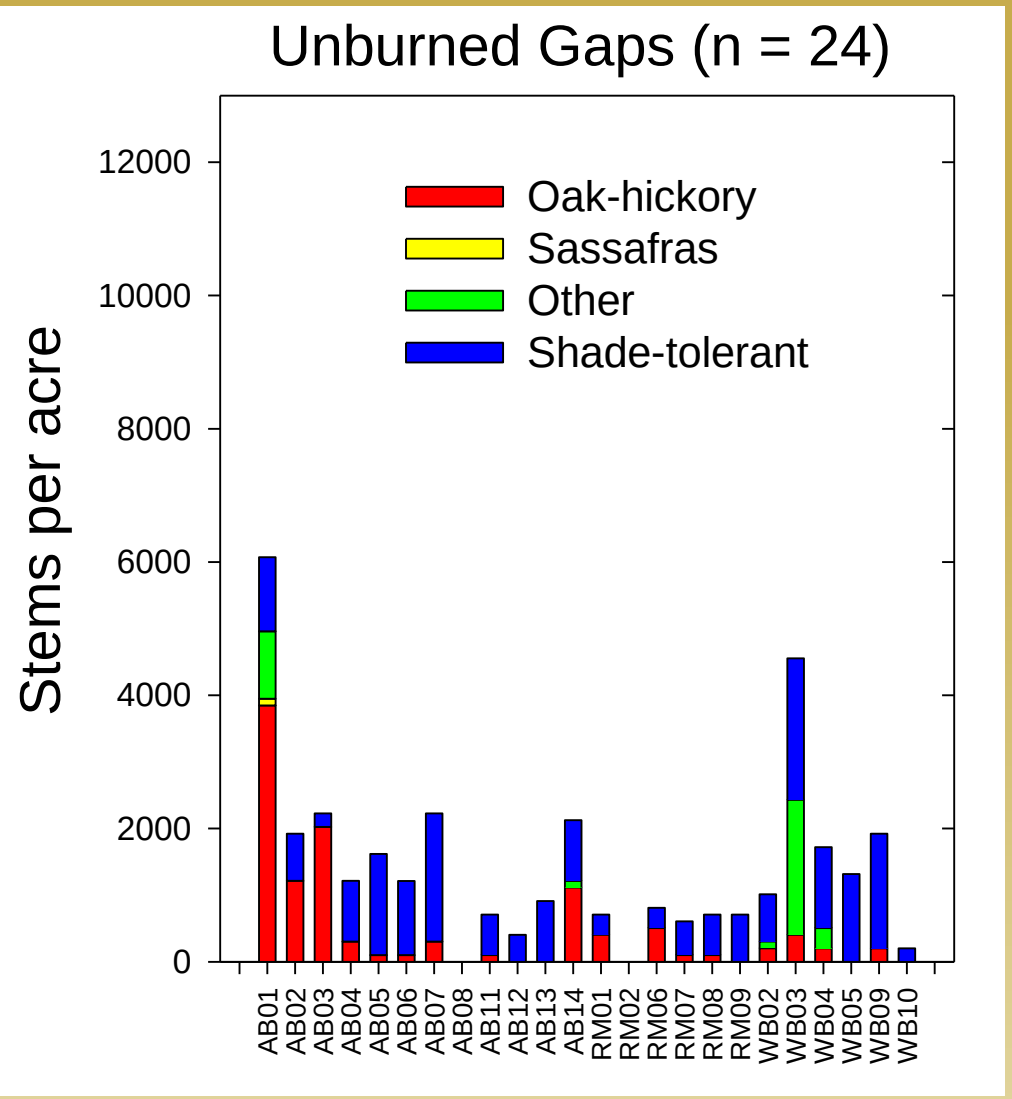
| Attribute | Average Unburned gaps (n = 24) | Average Burned gaps (n = 28) |
|---|---|---|
| Dead canopy trees | 3.8 trees | 4.1 trees |
| Area | 0.05 acres | 0.06 acres |
| Saplings/poles | 331 per acre | 37 per acre |
| % Full Sunlight | 8% | 18% |

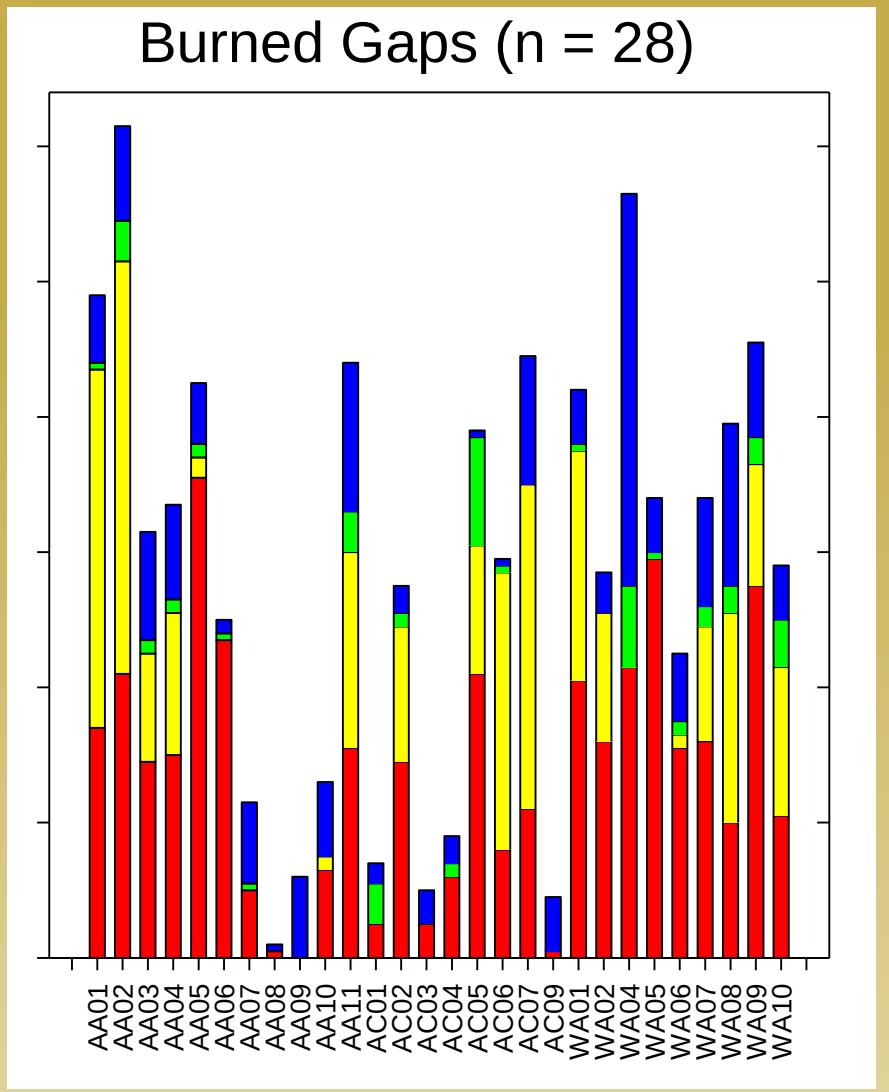
# Saplings and poles, 1 to 8” DBH, year 13



# Large advance regeneration (>2’ tall), year 13

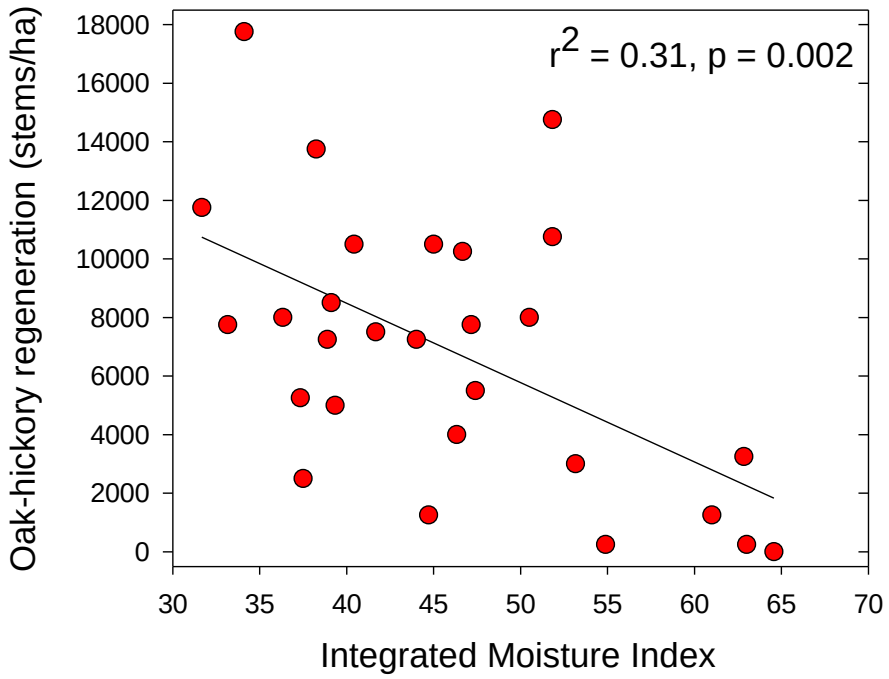


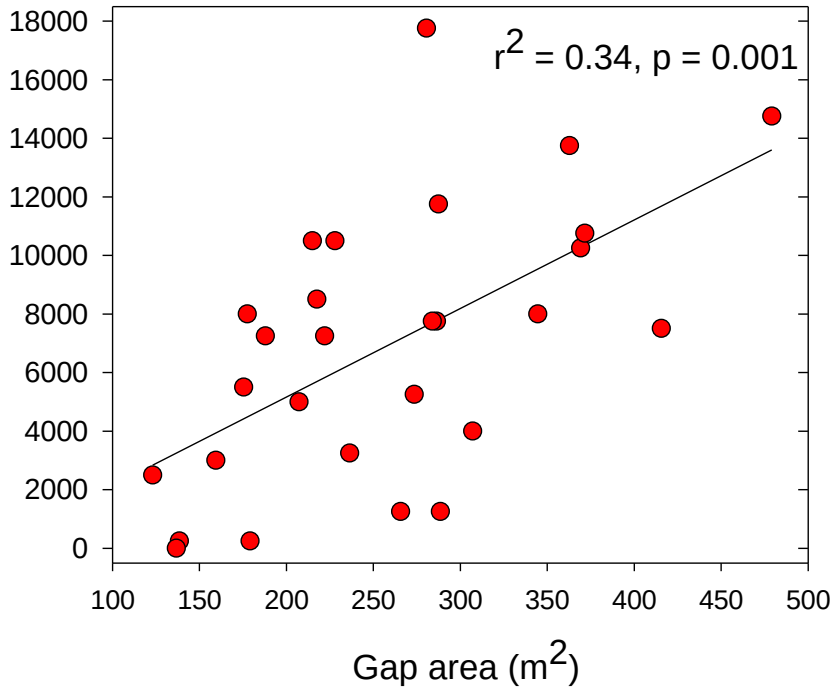




Oak-hickory, mean: 468 per acre

Oak-hickory mean: 2798 per acre

# Large oak-hickory advance regeneration (>2’ tall) in burned gaps



# Species composition of oak advance regeneration (>30 cm tall) in burned gaps

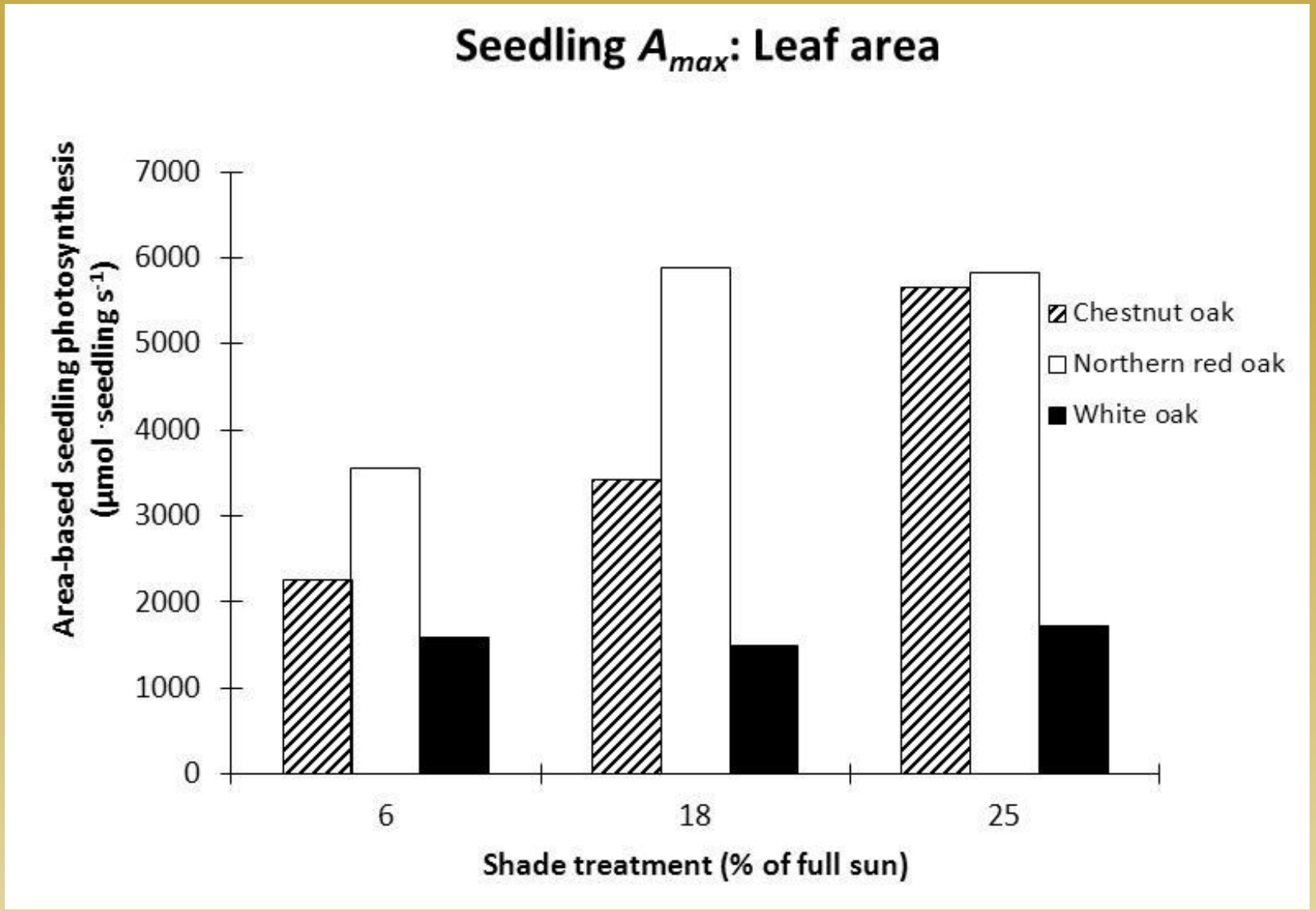
- White oak (*Quercus alba*) 67%
- Black oak (*Q. velutina*) 17%
- Chestnut oak (*Q. montana*) 7%
- Scarlet oak (*Q. coccinea*) 6%
- Northern red oak (*Q. rubra*) 4%

# Oak seedling shading study

- White, chestnut, and red oak
- 25%, 18%, and 6% of full sunlight
- 2 years of growth and physiology measurements

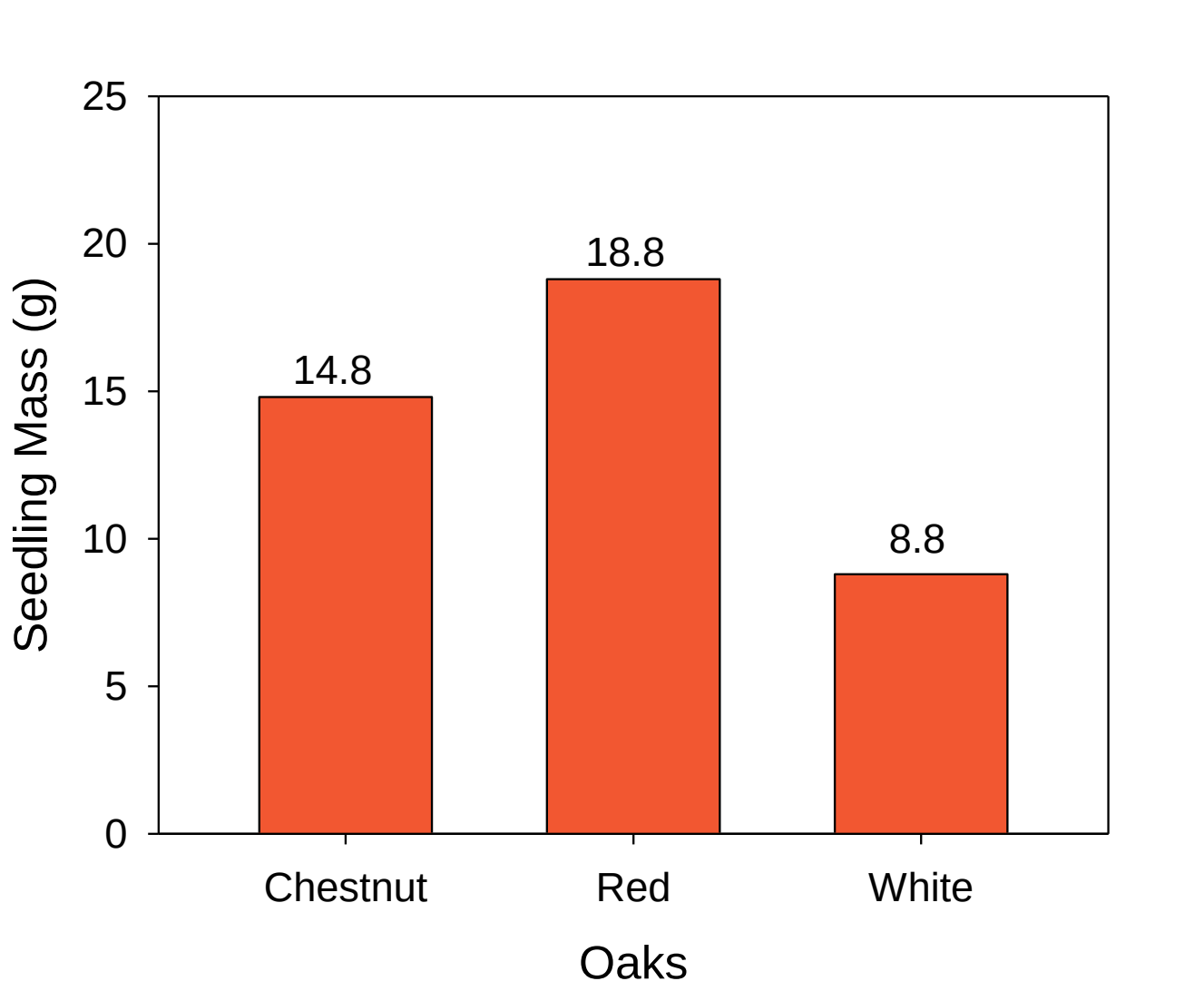
Rebbeck et al. 2011. *Can J. For. Res*.
Rebbeck et al. 2012. *Can J. For. Res*.

# Oak seedling shading study



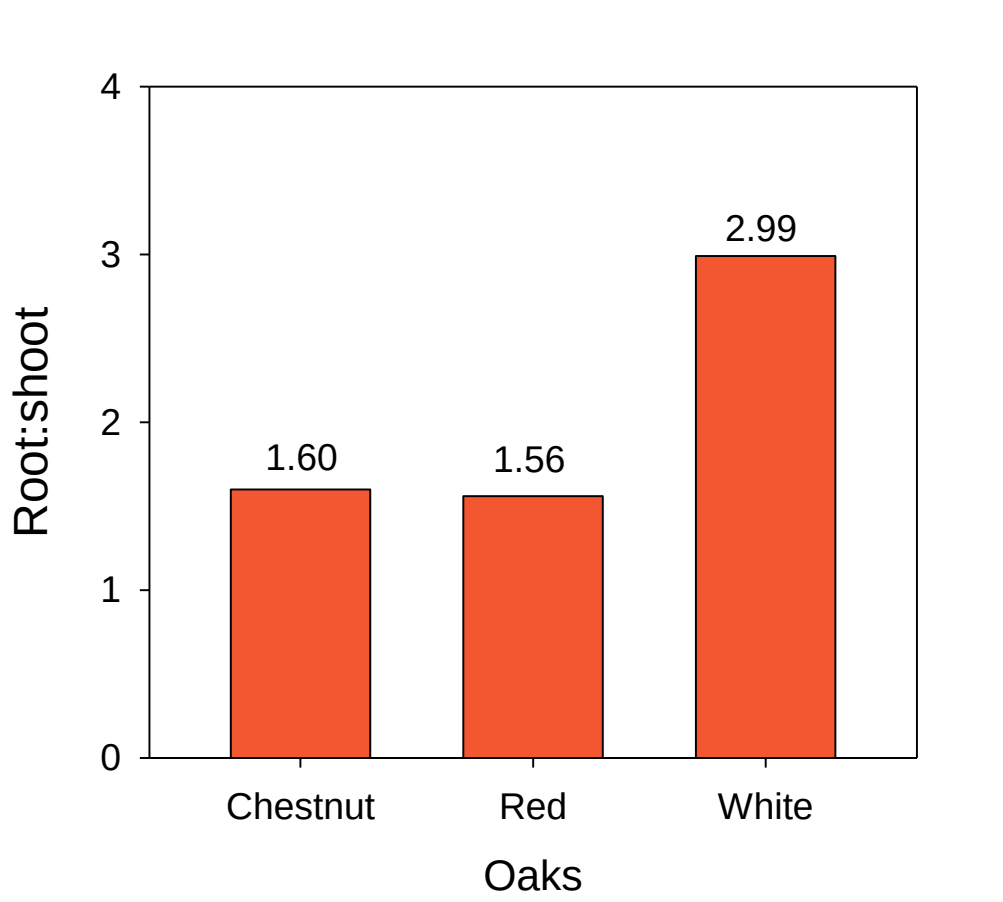

Rebbeck et al. 2012

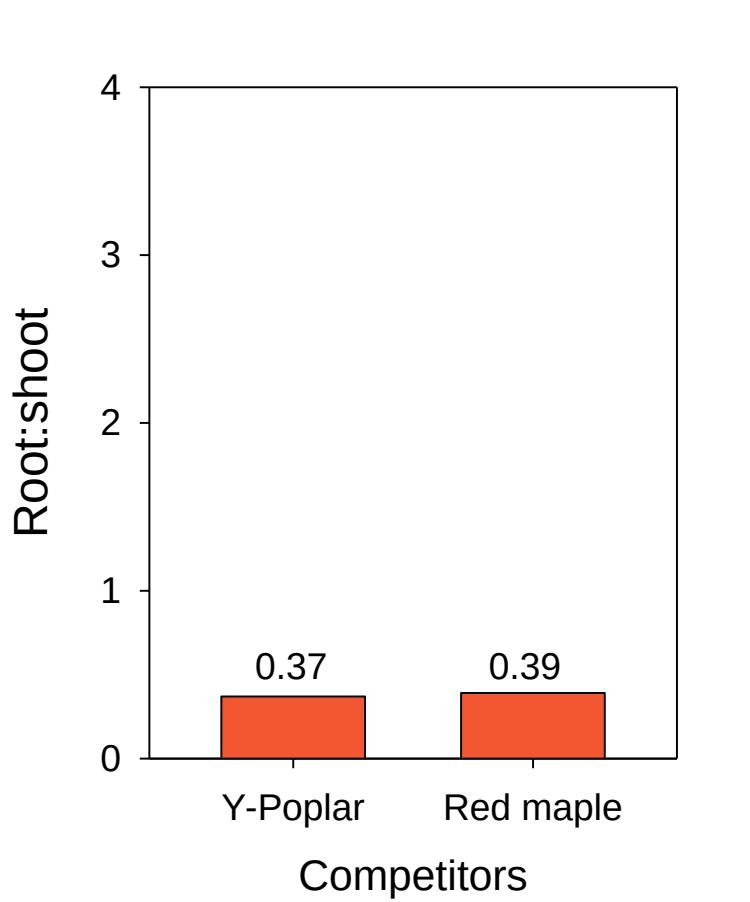
# Seedling mass at 2-years




Rebbeck et al. 2011

# Root:shoot at 2-years




Rebbeck et al. 2011

# When topkilled by fire…

- Red maple and yellow-poplar
  - 60% of seedling mass is destroyed
- Chestnut oak and northern red oak
  - 40% of seedling mass is destroyed
- White oak
  - 25% of seedling mass is destroyed

# Conclusions, Gap Study, Year 13

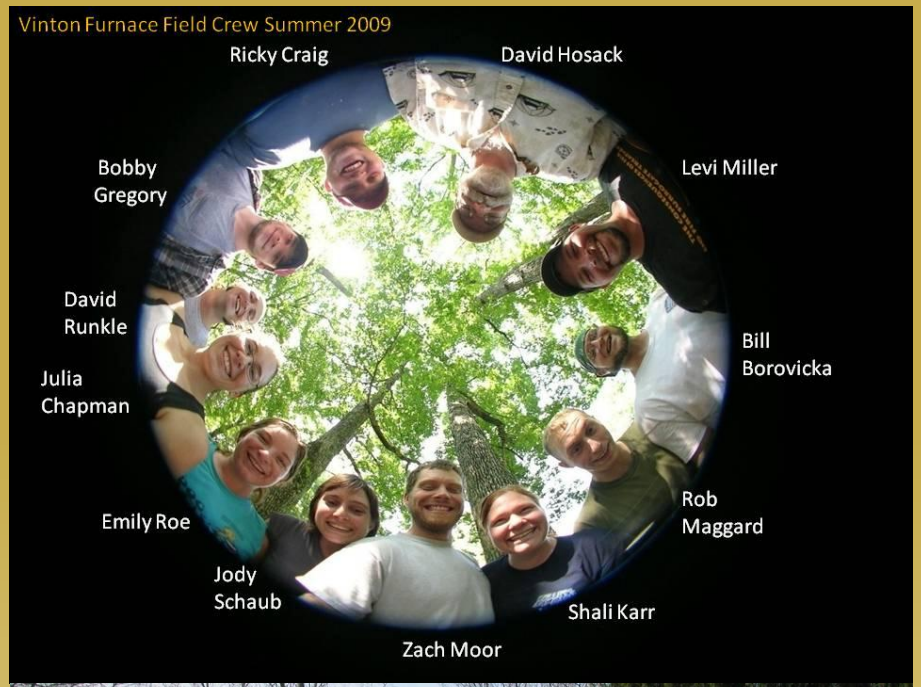
- Unburned gaps:  Filled by shade-tolerant saplings and poles
- Burned gaps:  Saplings and poles were largely eliminated
- Oak-hickory regeneration was dominant in gaps within burned stands
- White oak (*Q. alba*) regeneration may benefit most from repeated low-intensity burns – the "slow approach"

# Publications from this work..


- Hutchinson, T.F., E.K. Sutherland, and D.A. Yaussy. 2005. Effects of repeated fires on the structure, composition and regeneration of mixed-oak forests in Ohio. *For. Ecol. Manag*.
- Hutchinson, T.F., Sutherland, S., Sutherland, E.K., Ortt, M., and L.R. Iverson. 2005. Prescribed fire effects on the herbaceous layer of mixed-oak forests. *Can. J. For. Res*.
- Hutchinson, T.F., R.P. Long, J. Rebbeck, E.K. Sutherland, and D.A. Yaussy. 2012. Repeated fires alter gap-phase regeneration in mixed-oak forests. *Can. J. For. Res*.
- Hutchinson, T.F., D.A. Yaussy, R.P. Long, J. Rebbeck, E.K. Sutherland. *In press*. Long-term (13-year) effects of repeated prescribed fires on stand structure and regeneration in mixed-oak forests. *For. Ecol. Manag*.


# Key papers on fire effects in oak forests

- Brose, P.B., Van Lear, D.H. 1998. **Responses of hardwood advance regeneration to seasonal prescribed fires in oak-dominated shelterwood stands**. *Can. J. of For. Res*.
- Brose, P.B. et al. 2005. **Responses of oak and other hardwood regeneration to prescribed fire: what we know as of 2005**. In Proceedings, Fire in Eastern Oak Forests: Delivering Science to Managers. Edited by M.B. Dickinson. USDA For. Serv. Gen. Tech. Rep. NRS-P-1.
- Dey, D.C. and Z. Fan. 2009. **A review of fire and oak regeneration and overstory recruitment**. *In* Proceedings of the 3rd Fire in Eastern Oak Forests Conference. *Edited by* T.F. Hutchinson. USDA For. Serv. Gen. Tech. Rep. NRS-P-46.
- Arthur, M.A. et al. 2012. **Refining the oak-fire hypothesis for management of oak-dominated forests in the eastern U.S.** *Journal of Forestry*.




# Acknowledgements


- VFSEF crew
  - David Hosack
  - Bill Borovicka
  - Levi Miller
- ODNR Division of Forestry
- Wayne National Forest
- Funding: USDA Forest Service
- Technical support: Tim Fox, Joan Jolliff

Year 13, after 5 fires