

# Historical Development of Oak-Dominated Forests



# Historical Development of Oak Forests

- For past 10,000 years, *Quercus* dominant genus throughout North America
- Oak distribution has shifted in response to changes in:
  - Climate
  - Disturbance regime
  - Human population and culture



# Historical Development of Oak Forests

*pre-1900*

Indigenous Peoples  
Burning and other land-uses



European settlement  
Land clearing and conversion



Iron Furnaces



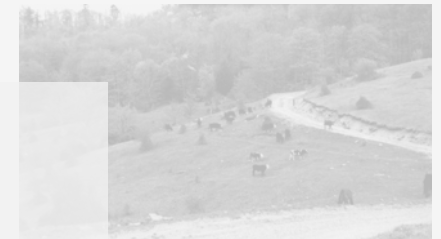
Subsistence Agriculture



Indiscriminate Logging  
Intense Wildfire



Wood Utilization  
Subsistence



Domestic Grazing



# Historical Development of Oak Forests

- Periodic disturbances maintained oak-dominated forests prior to European settlement
  - Increasing Native Americans population linked to increased fire occurrence since at least the middle Holocene (*c.*6000 years bp)
  - Human-set fires largely determined fire regimes as Native Americans settled North America
    - Fire in agriculture and horticulture to manage native animals, plants and trees (including oaks) and domesticated crop species (squash, beans and maize)
    - Fire to maintain prairies and savannahs for grazing herds of native ungulates
  - Relationship between increasing oak dominance and historical human land use, including fire, is strong throughout the latter Holocene before European immigration

# Historical Development of Oak Forests

- After European arrival, European diseases spread rapidly and decimated Native American populations
- In regions where native populations declined precipitously, fire occurrence often decreased, and extended fire-free periods (e.g. 50–100 years) have been observed in several eastern fire histories
- With European settlement, fire regimes became more consistent, frequent and ubiquitous on the eastern US landscape from about the 1850s to the 1930s

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# Historical Development of Oak Forests

*post-1900*



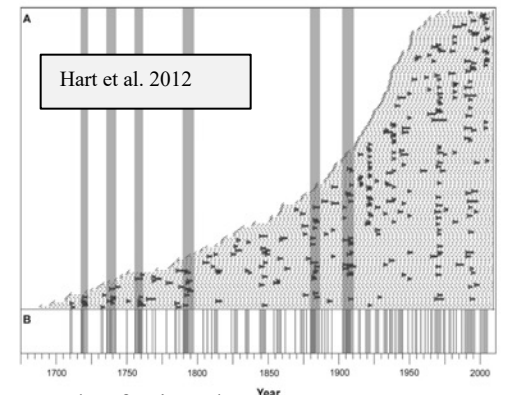
Land Abandonment



Fire Suppression



Loss of Keystone Species  
Chestnut Blight



Lack of Disturbance

# Historical Development of Oak Forests

- Fire suppression efforts in the early to mid 20th century essentially removed fire as a disturbance mechanism in oak dominated forests
- Due to shifts in disturbance patterns, dense midstory canopies of shade tolerant species such as sugar maple, red maple, and American beech have invaded many eastern hardwood forests
- This alteration of stand structure and the resulting understory environmental conditions has led to a decline in oak seedling development

# Historical Development of Oak Forests

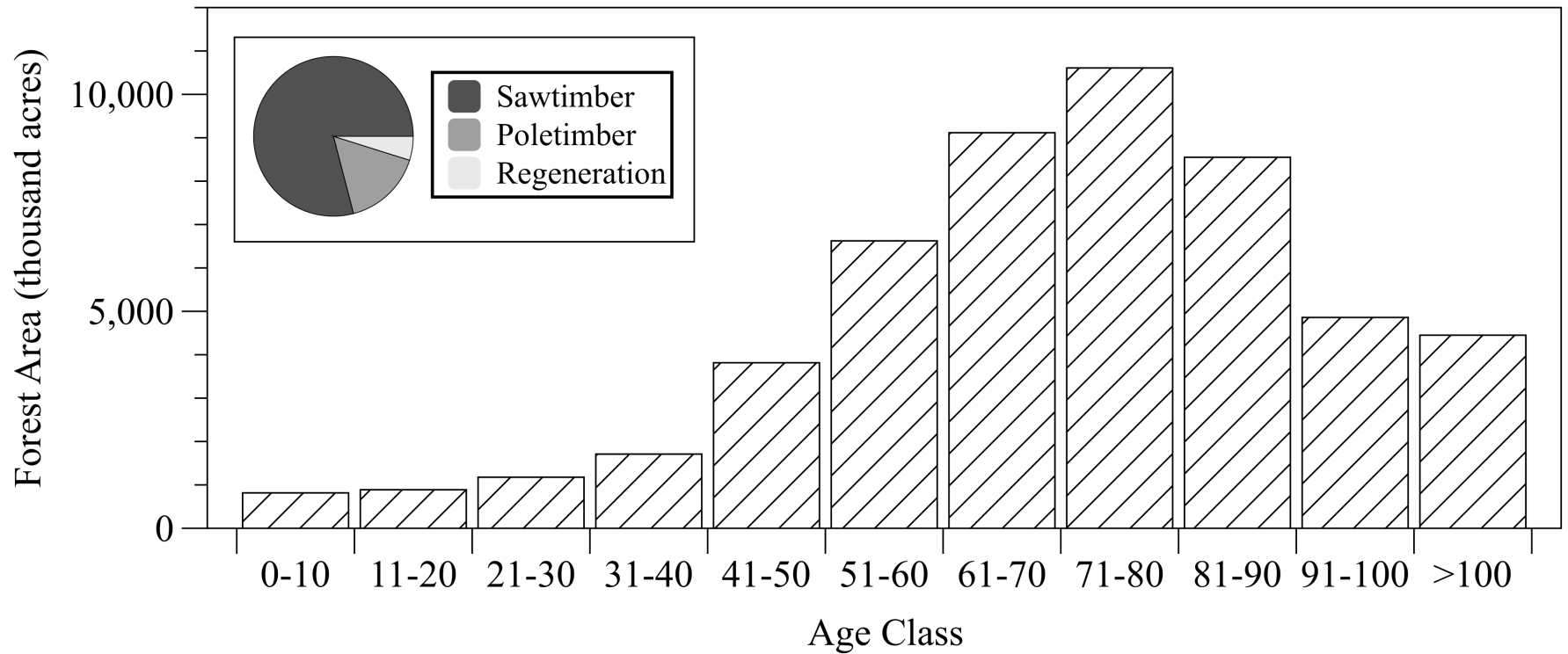


Origin of many of today's mature oak forests is from forest disturbances operating during the period of dramatic changes due to settlement

# Historical Development of Oak Forests

- The large decrease in oak recruitment over the last 50 to 100 years could have a substantial impact on the perpetuation of oak dominated systems.
  - Presence of advance reproduction and stems capable of stump sprouting is generally required to successfully regenerate oak forests.
- If current stand development trends remain, shade tolerant, mesophytic species would replace oak as the dominant canopy species in many stands.

# Oak Sustainability “Bottleneck” – Regional Scale

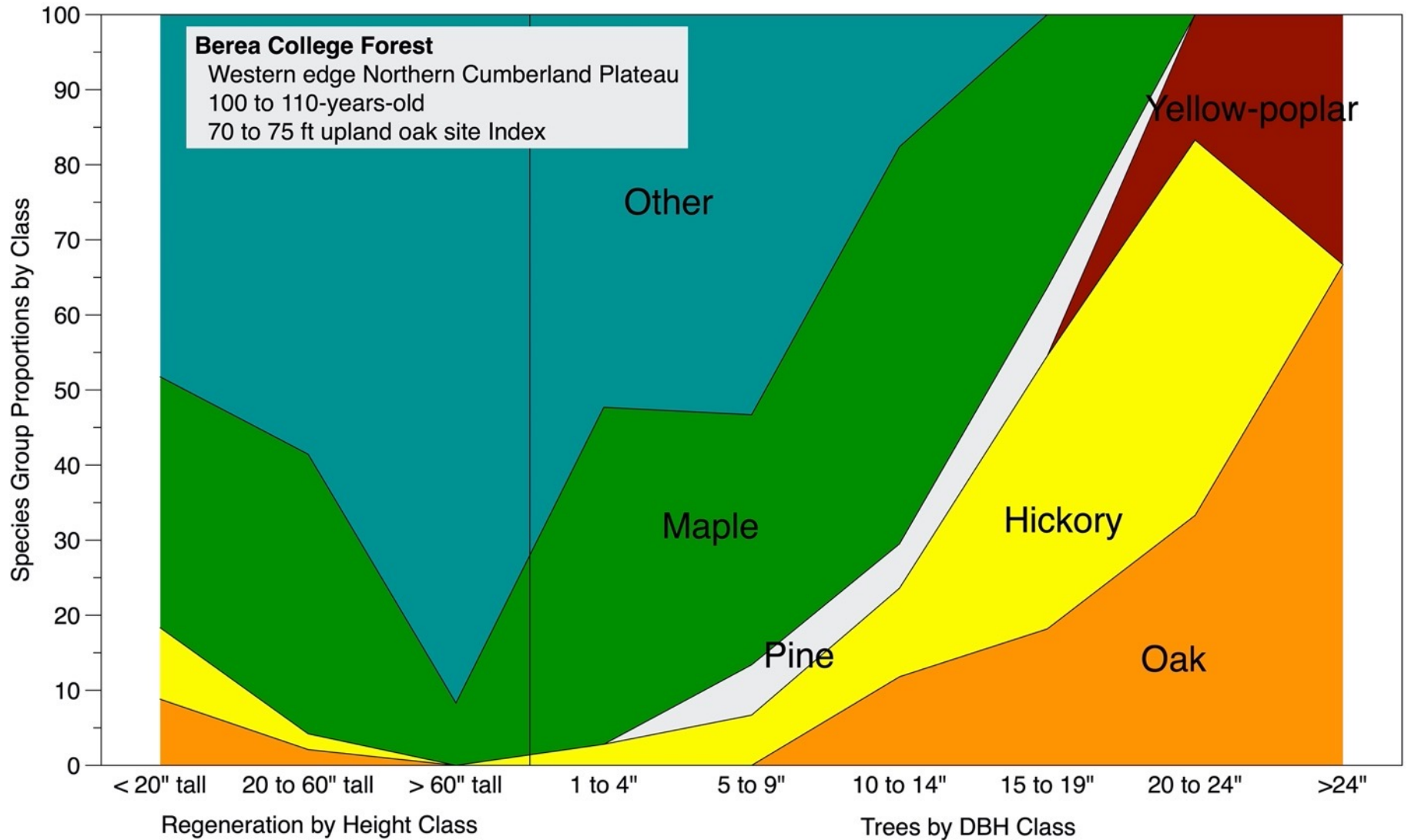


Forest Inventory and Analysis plot network within AL, AR, DE, GA, IL, IN, IA, KY, MA, MI, MN, MO, MS, NC, NJ, OH, PA, SC, TN, VA, WI, WV (USDA Forest Service - Forest Inventory and Analysis Program 2019)

# Oak Resource Trends

- More than four decades of decline in oak forest regeneration
  - Moser et al. 2006, Miller and McGill 2019, Vickers et al. 2019
- According to Luppold and Bumgardner 2018 ...
  - Total volume growth has also flattened
  - Net accumulation in small size classes has reached a negative growth rate

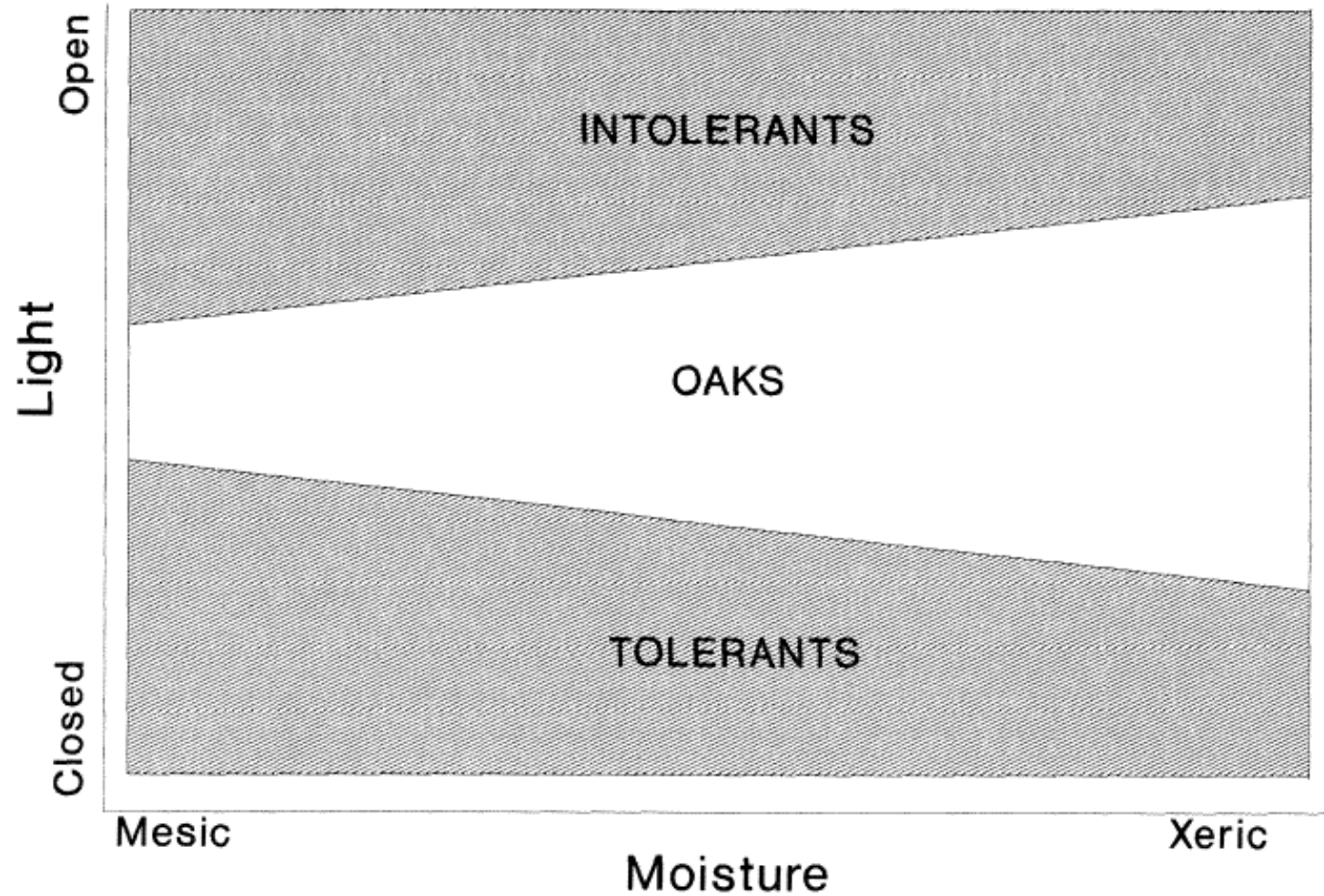
# Oak Sustainable “Bottleneck” – Stand Scale



# Ecological Basis for Oak Silviculture

- Inability of oak reproduction to compete with large shade tolerant advance reproduction or aggressive pioneer species is the fundamental cause of problems in oak regeneration and sustainability.
- Oak regeneration problems and reductions in oak stocking are most likely on higher-quality mesic sites (site index > 65 feet).
- Oaks appear to be successional most stable on xeric sites.
  - Increased competition from shade-tolerant trees and shrubs may influence oak regeneration potential even on xeric sites.

# The Oak Regeneration Window



# Current Oak Regeneration Situation



Low Productivity Sites – Oak Reproduction Generally Abundant

# Current Oak Regeneration Situation



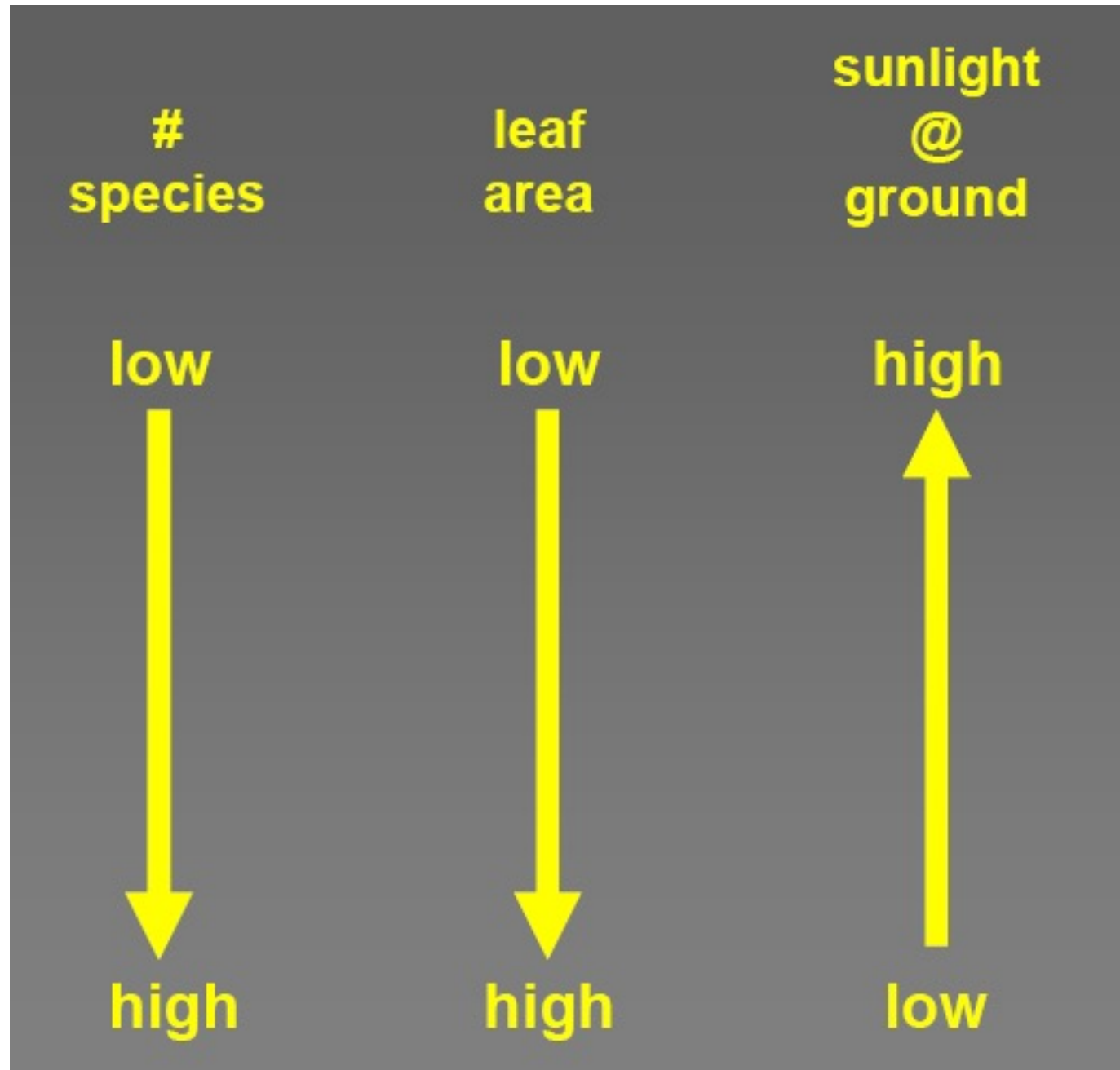
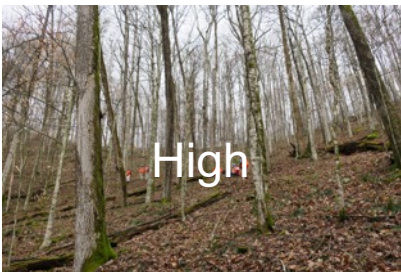
Medium Productivity Sites – Oak Reproduction Intermediate Abundance with High Variation

# Current Oak Regeneration Situation

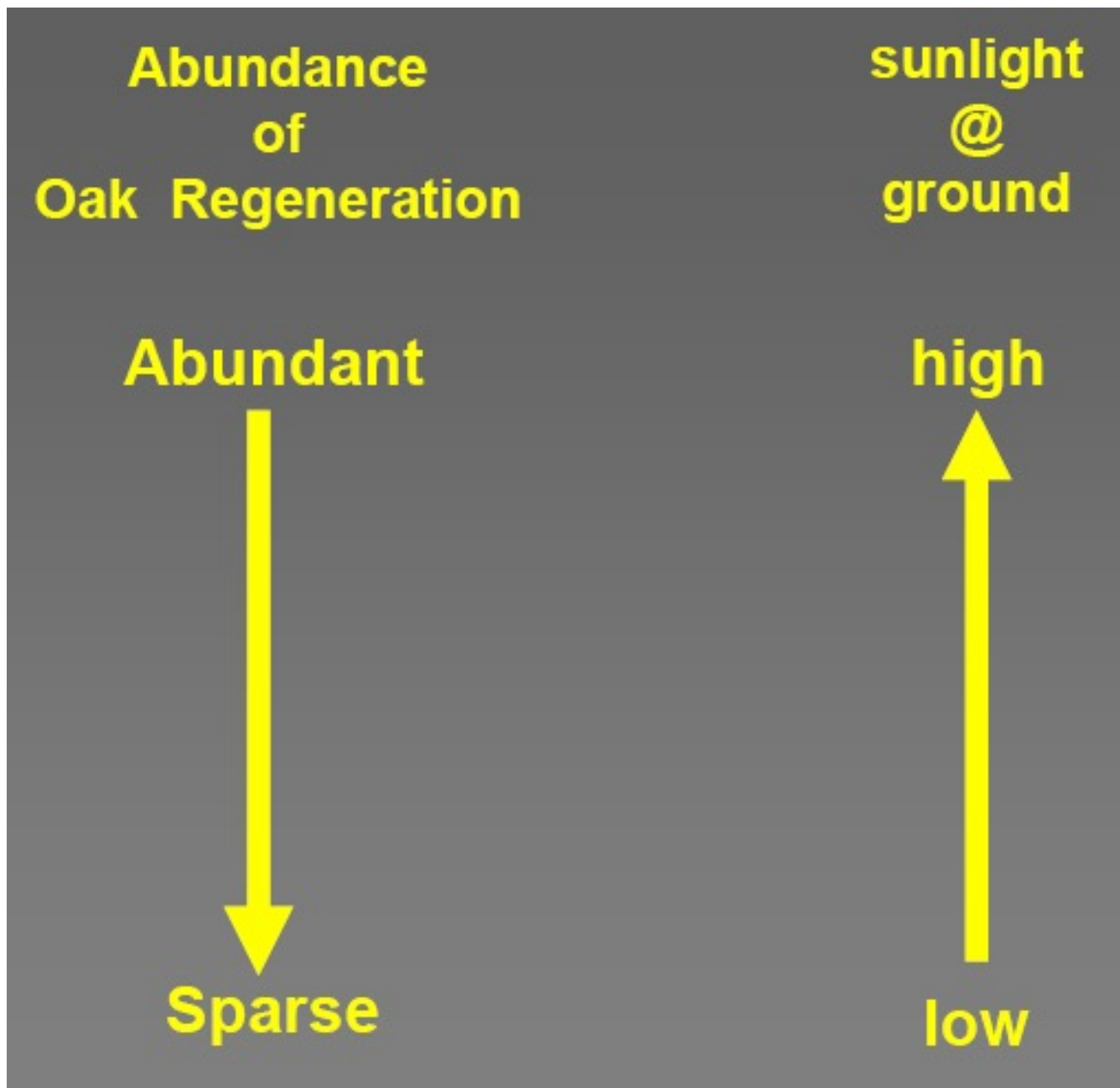
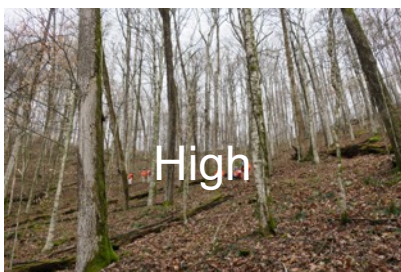
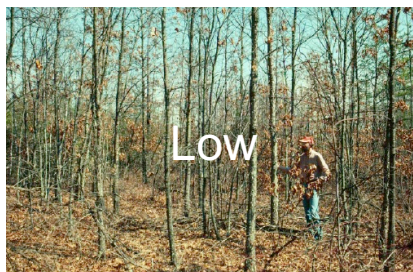


High Productivity Sites – Oak Reproduction Absent

# Oak Productivity Gradient



# Oak Productivity Gradient



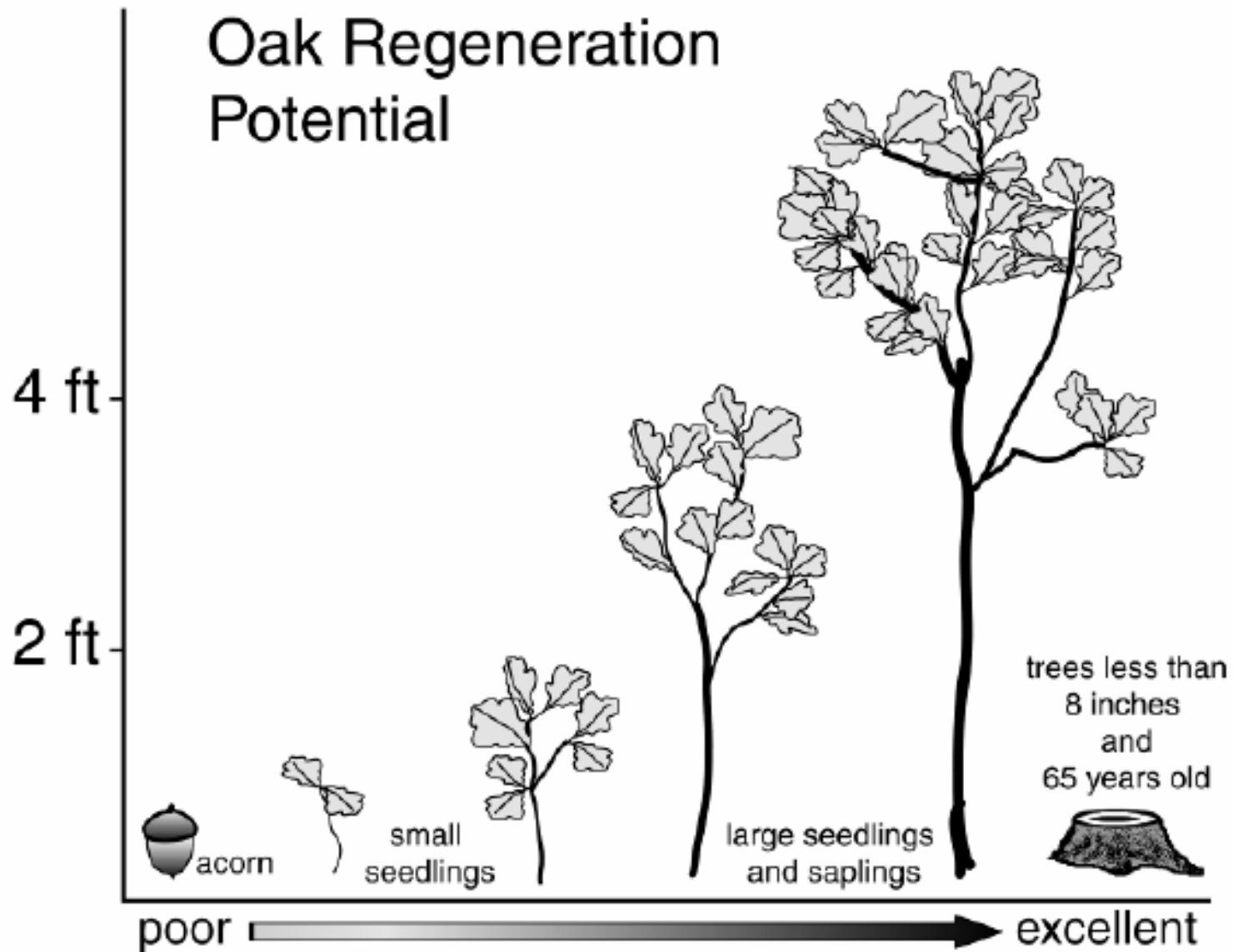
# Oak Productivity Gradient



- abundant diffuse light
- large oak advance regeneration
- limited competitors

- limited diffuse light
- oak seedlings short lived
- small advance regeneration
- high number of competitors

# Oak Regeneration Potential



Typical mature, undisturbed upland oak stand in the Central Hardwood Forest Region, overstory dominated by oak and dense midstory canopy of shade tolerant species



An another example...



So how does oak regeneration develop in these stands?

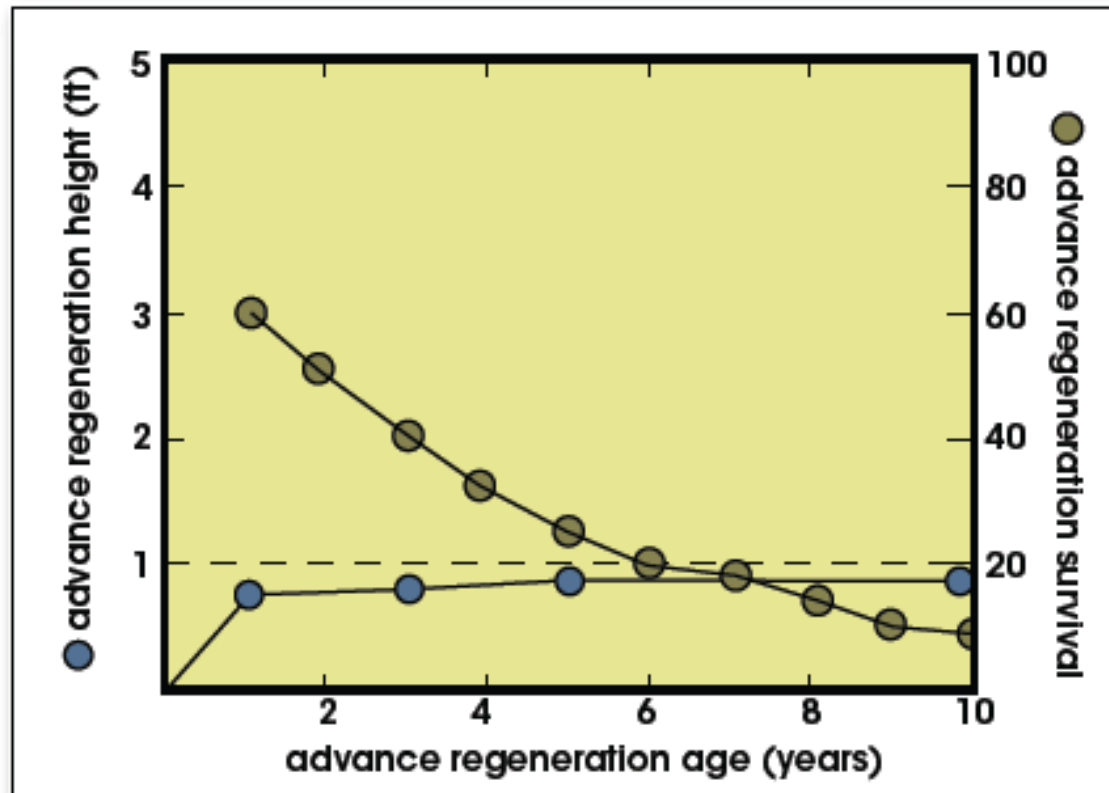


Figure 2. Northern red oak advance regeneration cohort height growth and survival under a typical mid-story on a mesic site.

# Summary of Oak Regeneration Cycle on Intermediate to High Quality Sites with Undisturbed Canopy

- Bumper acorn crop
- Seedling establishment
- Slow loss of seedling cohort
- Minimal height growth
  - Gradual loss of seedling vigor
- Ultimate loss of seedling cohort

# Pillars of Oak Silviculture

- Regeneration
  - Establishing oak through regeneration practices to meet desired levels of stocking to meet management goals
- Recruitment
  - Ascension of oak reproduction into the overstory (i.e., they successfully reach the dominant and codominant crown classes)
  - Maintenance of oak in the overstory crown classes during the stem exclusion stage

# “Laws” of the Oak Regeneration Pillar

- 1) The presence of competitive sources of oak regeneration
  - Successful oak regeneration after harvest will come from advance reproduction that exists in the current stand and stump sprouts from trees that are harvested from the current stand
  
- 2) Timely, sufficient release of these oak regeneration sources
  - Concerns the timing and pattern of tree removal from the existing stand to ensure the regeneration sources develop, ultimately, into overstory trees

# Timing of Regeneration Treatments in Oak Dominated Stands

- "If you go into a 10-year-old hardwood stand and wonder what you might do to change the species composition, you may be at least 20 years too late."
  - Dr. Don Beck, US Forest Service (received from Dr. David Loftis, US Forest Service)