Oak, Fire & Mesophication

Past, current and future trends of oak in the eastern United States

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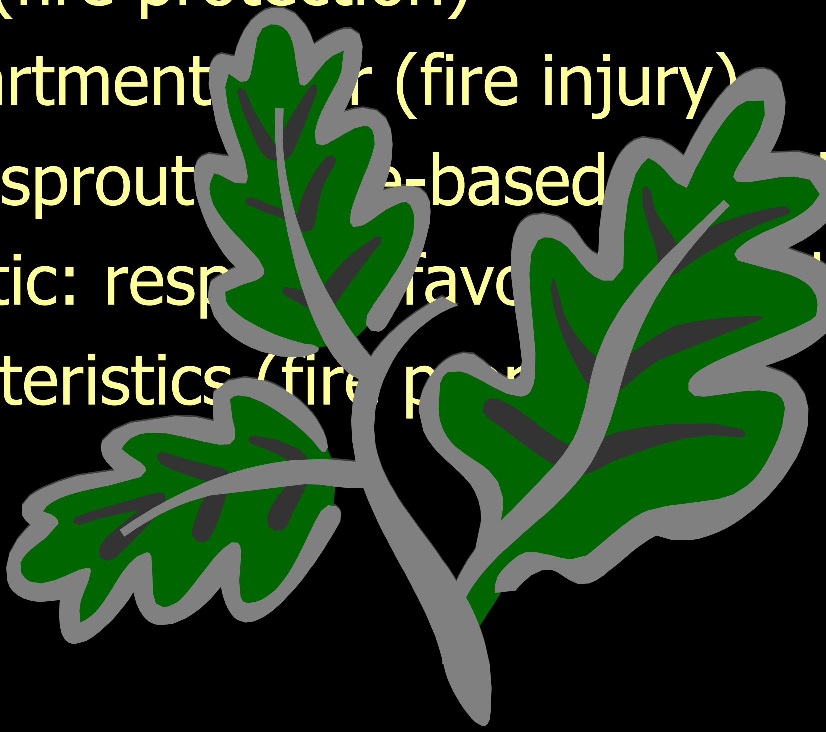
Oak is a fire-dependent, drought-tolerant genus that possess various adaptations…

- Thick bark (fire protection)
- Able compartment[illegible]r (fire injury)
- Aggressive sprout[illegible]e-based [illegible]uctive strategy)
- Opportunistic: resp[illegible] favo[illegible] disturbance
- Fuel characteristics (fire p[illegible]




Coarse Woody Debris Decay Rates
Oak = Hickory < Beech < Maple
Slow
Fast

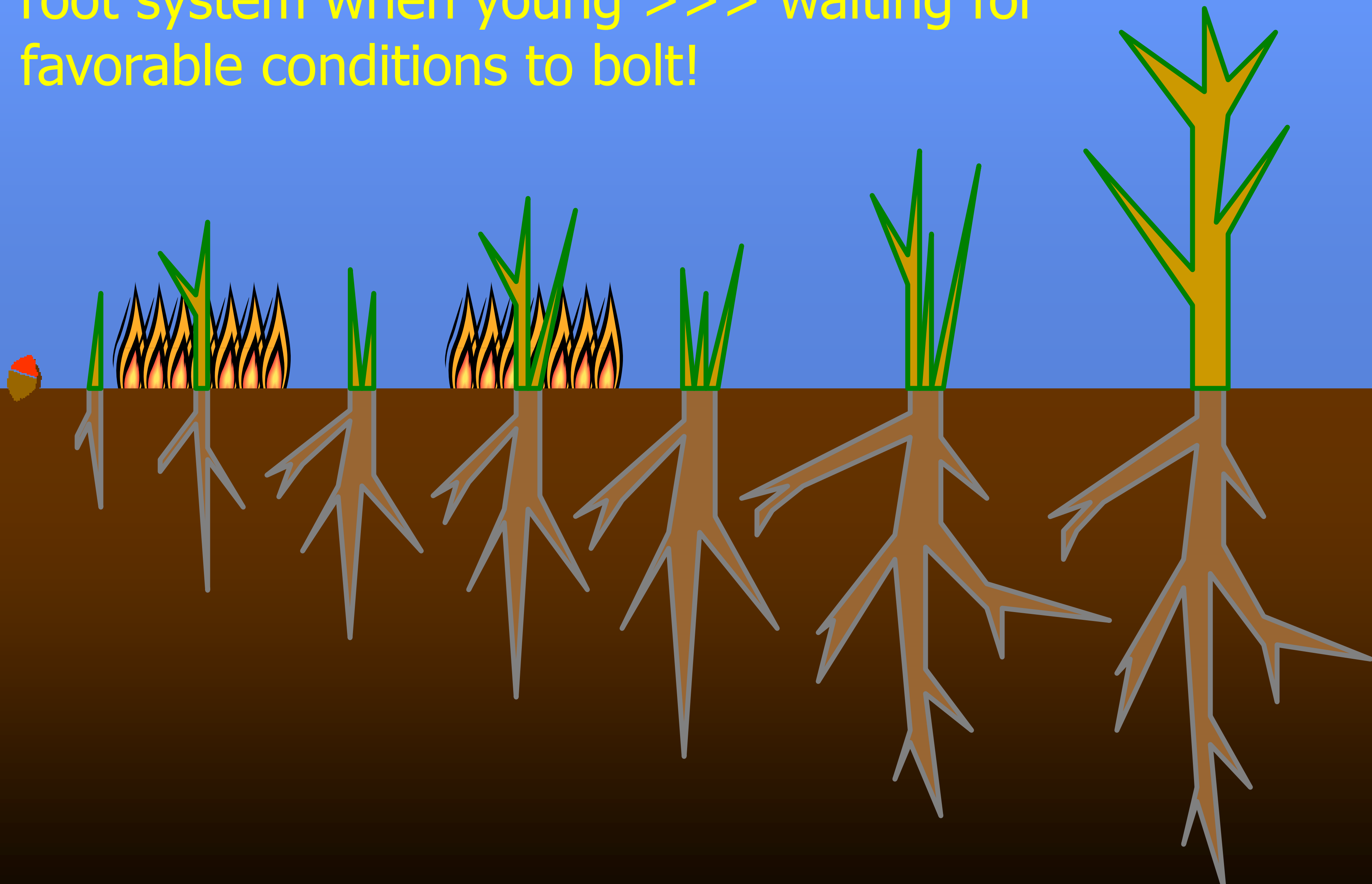
Leaf Differences

Oak-Hickory vs. Mesophytes

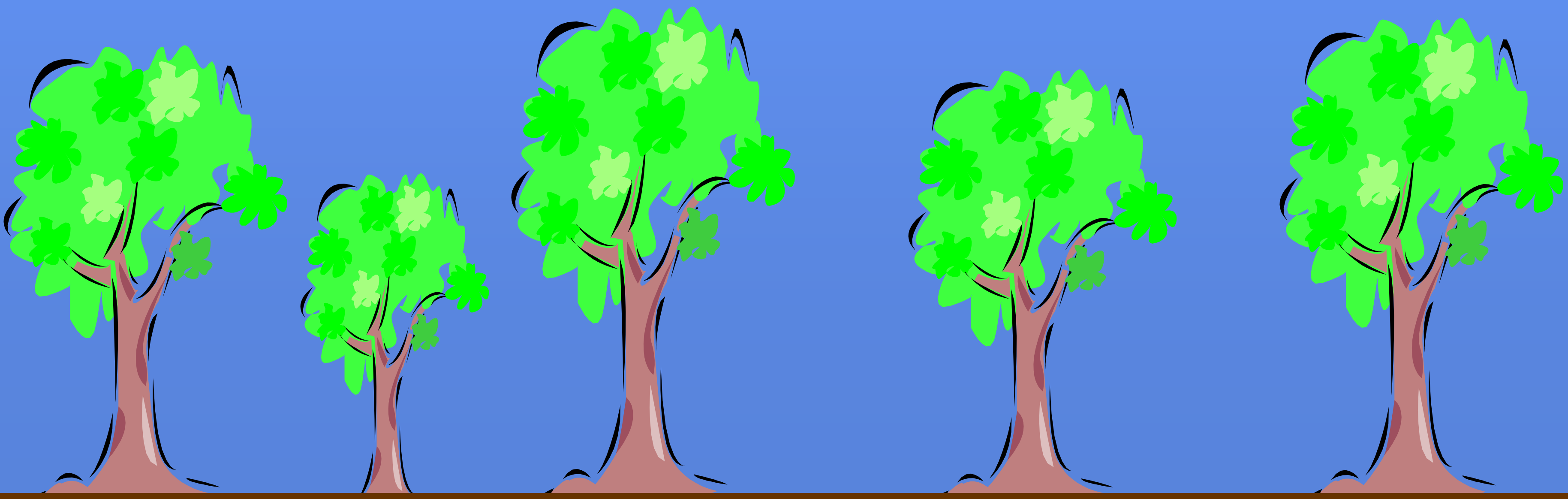
Oak is a fire-dependent, drought-tolerant genus that possess various adaptations…

- Thick bark (fire protection)
- Able compartmentalizer (fire injury)
- Aggressive sprouter (fire-based reproductive strategy)
- Opportunistic: responds favorably to disturbance
- Fuel characteristics (fire promotion)
- Water efficient (drought resistance)
  - tap roots exploit deep H_2O sources
  - osmotic adjustment: extract H_2O from dry soils
  - xeromorphic leaves minimizes H_2O loss

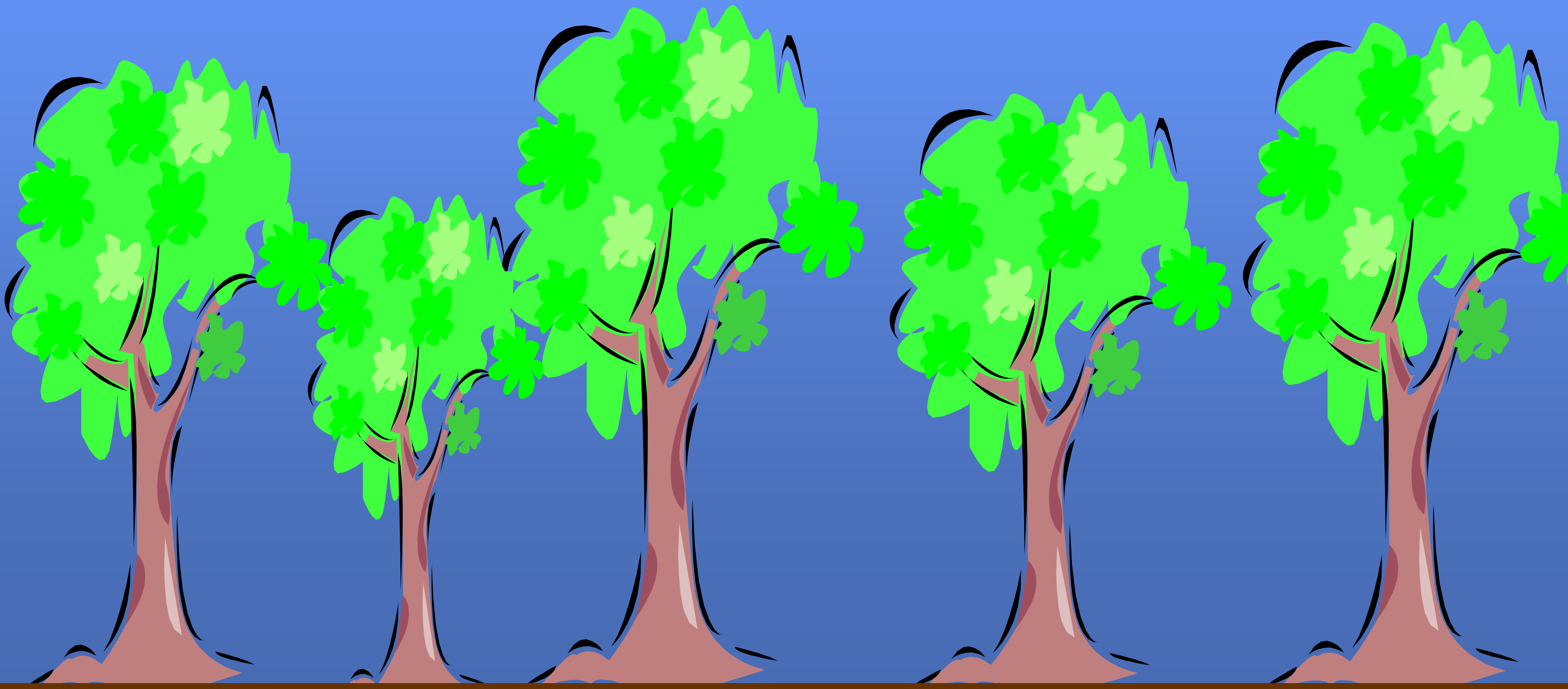
Oak Survival Strategy: heavy investment in root system when young >>> waiting for favorable conditions to bolt!



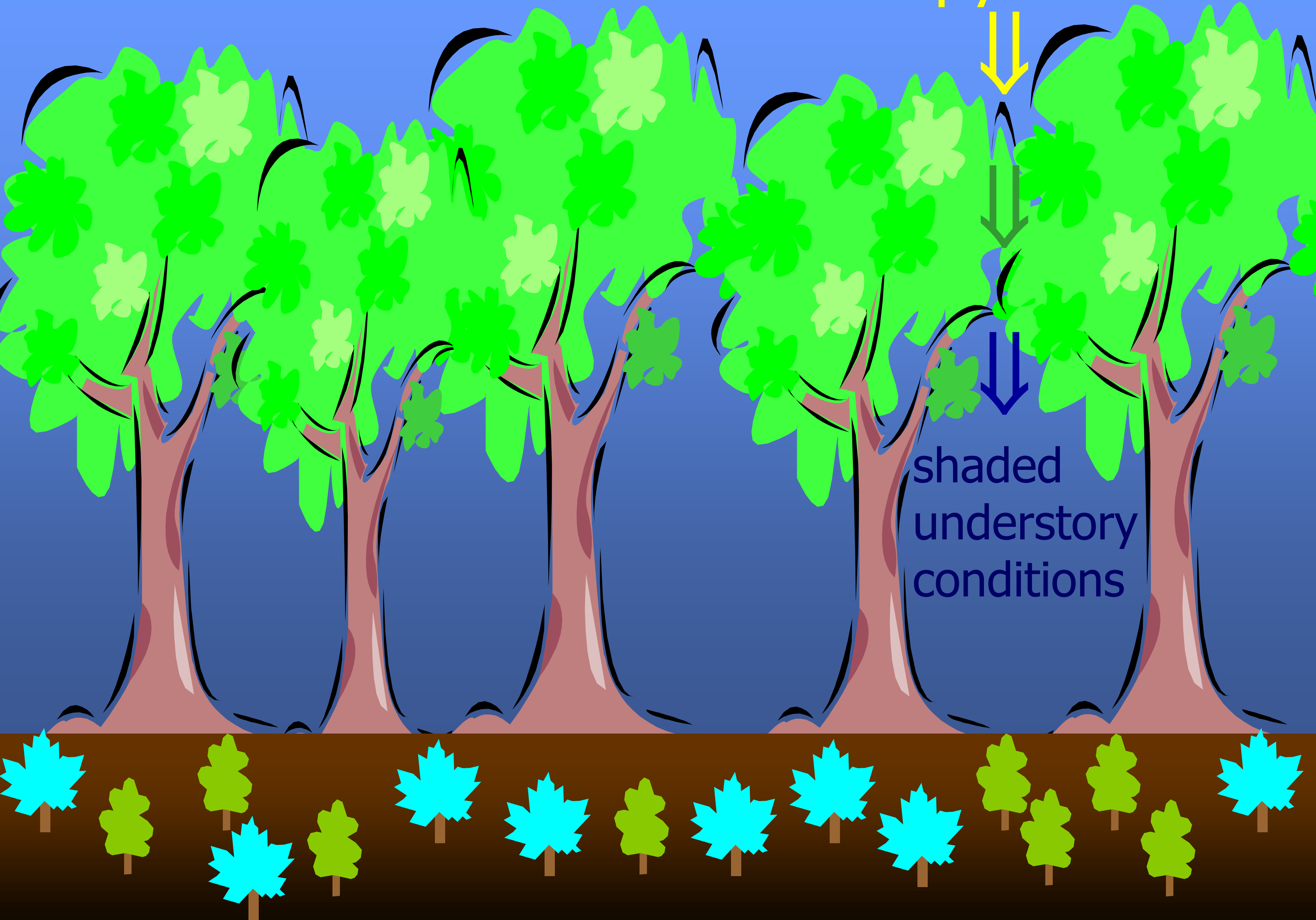
In the absence of fire



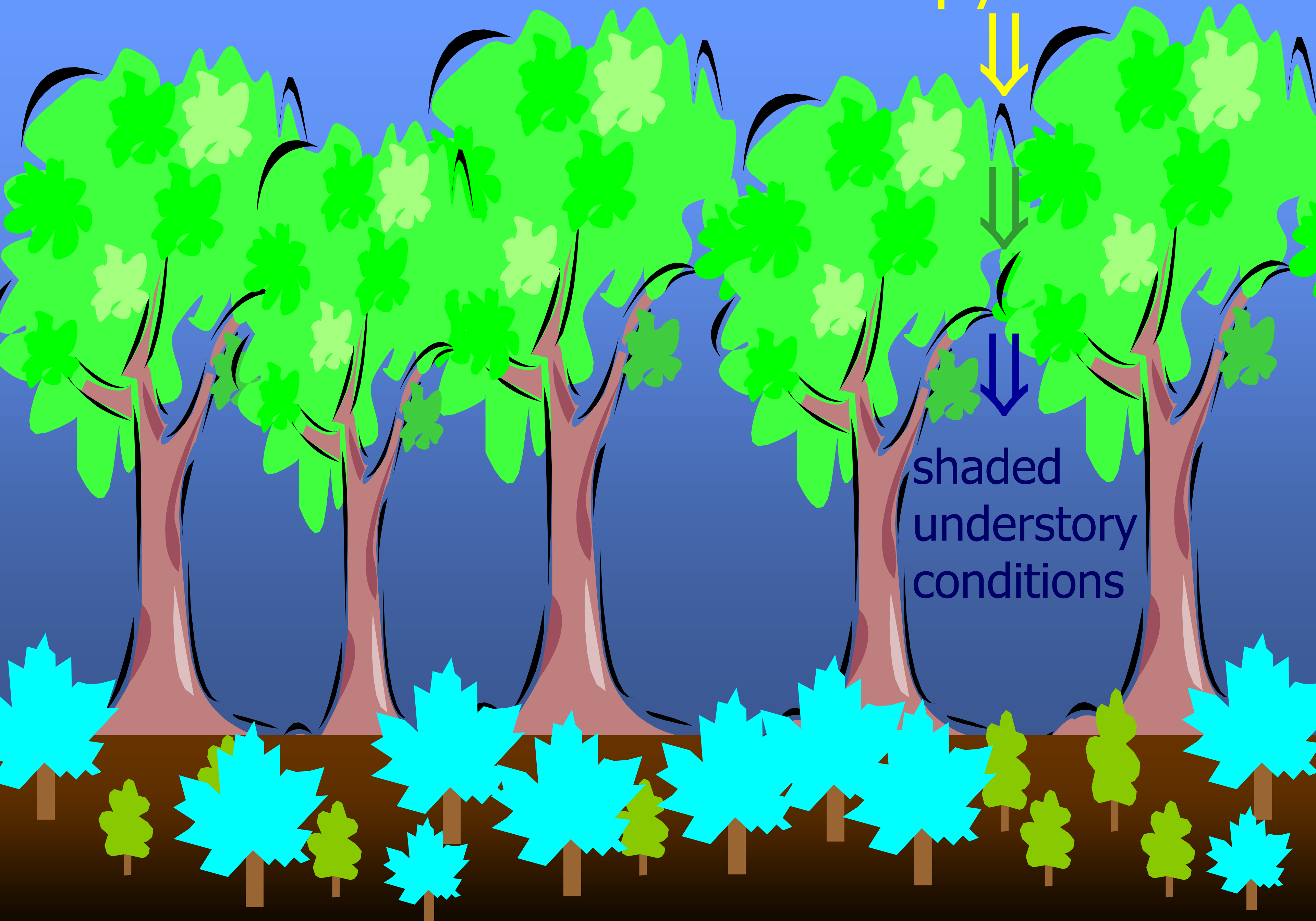
In the absence of fire ⇒



In the absence of fire ⇒ canopy closure



In the absence of fire ⇒ canopy closure




In the absence of fire ⇒ canopy closure
shaded understory conditions
The sapling bottleneck

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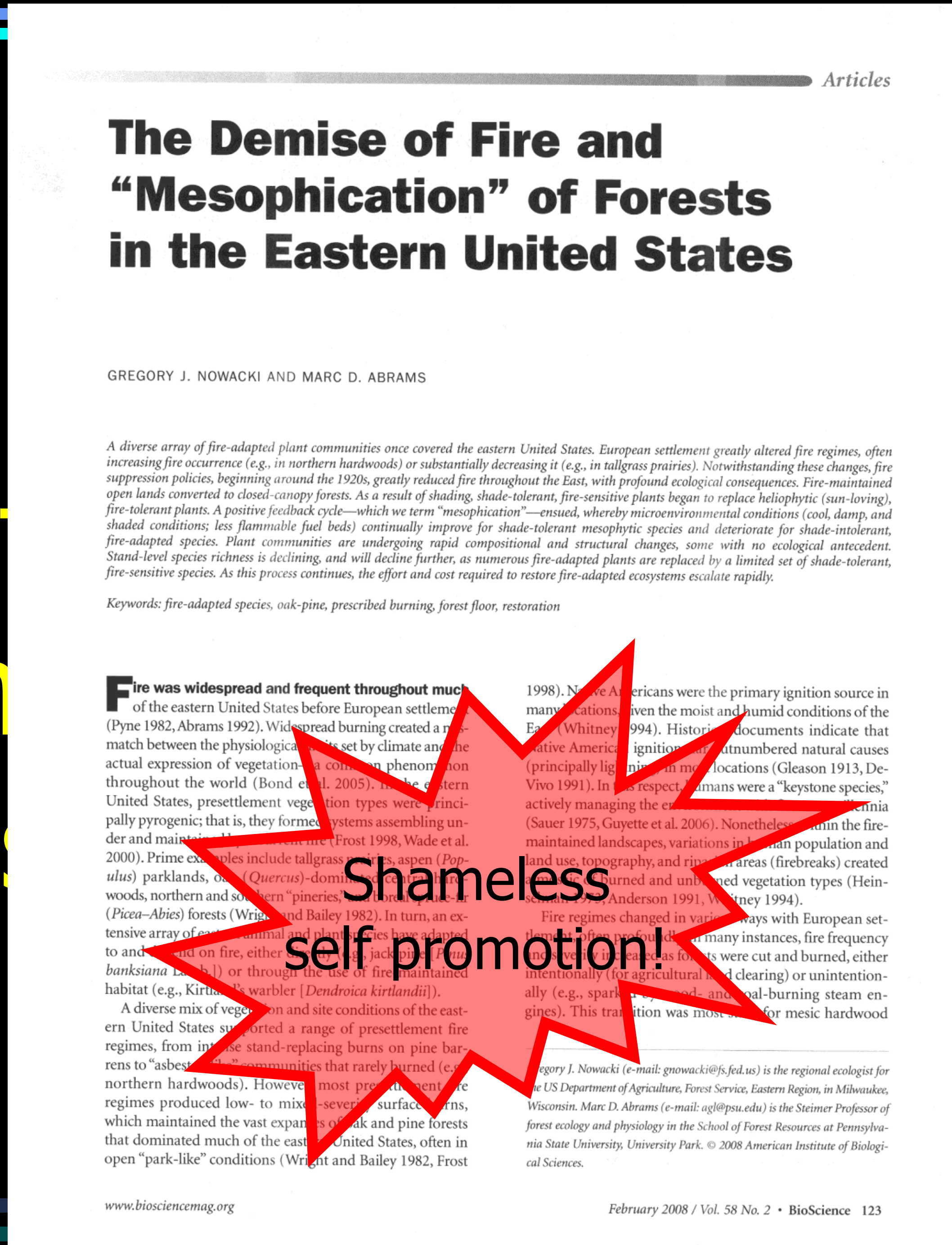

The Demise of Fire and “Mesophication” of Forests in the Eastern United States

GREGORY J. NOWACKI AND MARC D. ABRAMS

A diverse array of fire-adapted plant communities once covered the eastern United States. European settlement greatly altered fire regimes, often increasing fire occurrence (e.g., in northern hardwoods) or substantially decreasing it (e.g., in tallgrass prairies). Notwithstanding these changes, fire suppression policies, beginning around the 1920s, greatly reduced fire throughout the East, with profound ecological consequences. Fire-maintained open lands converted to closed-canopy forests. As a result of shading, shade-tolerant, fire-sensitive plants began to replace heliophytic (sun-loving), fire-tolerant plants. A positive feedback cycle—which we term “mesophication”—ensued, whereby microenvironmental conditions (cool, damp, and shaded conditions; less flammable fuel beds) continually improve for shade-tolerant mesophytic species and deteriorate for shade-intolerant, fire-adapted species. Plant communities are undergoing rapid compositional and structural changes, some with no ecological antecedent. Stand-level species richness is declining, and will decline further, as numerous fire-adapted plants are replaced by a limited set of shade-tolerant, fire-sensitive species. As this process continues, the effort and cost required to restore fire-adapted ecosystems escalate rapidly.

Keywords: fire-adapted species, oak-pine, prescribed burning, forest floor, restoration

Fire was widespread and frequent throughout much of the eastern United States before European settleme[illegible] (Pyne 1982, Abrams 1992). Widespread burning created a m[illegible]s-match between the physiologica[illegible] set by climate an[illegible] the actual expression of vegetation[illegible] a com[illegible] phenom[illegible] throughout the world (Bond et [illegible]l. 2005). [illegible] e[illegible]stern United States, presettlement vege[illegible]tion types were [illegible]princi-pally pyrogenic; that is, they forme[illegible] systems assembling un-der and main[illegible] fire (Frost 1998, Wade et al. 2000). Prime ex[illegible]ples include tallgrass [illegible]ies, aspen (*Pop-ulus*) parklands, o[illegible] (*Quercus*)-domi[illegible] woods, northern and so[illegible]ern “pineries,” [illegible] (*Picea–Abies*) forests (Wrig[illegible] and Bailey 1982). In turn, an ex-tensive array of [illegible] and plant [illegible] have adapted to and [illegible] on fire, either [illegible] jack pi[illegible] [*Pinus banksiana* L[illegible]]) or through the use of fire-maintained habitat (e.g., Kirtl[illegible]’s warbler [*Dendroica kirtlandii*]).

A diverse mix of vege[illegible]on and site conditions of the east-ern United States su[illegible]ported a range of presettlement fire regimes, from int[illegible]se stand-replacing burns on pine bar-rens to “asbest[illegible] communities that rarely burned (e.g., northern hardwoods). Howeve[illegible] most pre[illegible] regimes produced low- to mix[illegible]-severi[illegible] surface [illegible]rns, which maintained the vast expan[illegible]es of [illegible]ak and pine forests that dominated much of the east[illegible] United States, often in open “park-like” conditions (Wri[illegible]ht and Bailey 1982, Frost 1998). N[illegible] A[illegible]ericans were the primary ignition source in many [illegible]cations, [illegible]iven the moist and humid conditions of the Ea[illegible] (Whitney [illegible]994). Histori[illegible] documents indicate that [illegible]ative America[illegible] ignition[illegible] [illegible]utnumbered natural causes (principally lig[illegible] in mo[illegible] locations (Gleason 1913, De-Vivo 1991). In [illegible] respect, [illegible]mans were a “keystone species,” actively managing the e[illegible]ennia (Sauer 1975, Guyette et al. 2006). Nonethele[illegible]in the fire-maintained landscapes, variations in [illegible]an population and land use, topography, and ri[illegible] areas (firebreaks) created a [illegible] burned and unb[illegible]ned vegetation types (Hein-selman [illegible], Anderson 1991, W[illegible]itney 1994).

Fire regimes changed in vari[illegible]ways with European set-tlement, often profound[illegible] many instances, fire frequency and severity increased as fo[illegible]ts were cut and burned, either intentionally (for agricultural [illegible]d clearing) or unintention-ally (e.g., spark[illegible] and [illegible]oal-burning steam en-gines). This tra[illegible]ition was most [illegible] for mesic hardwood

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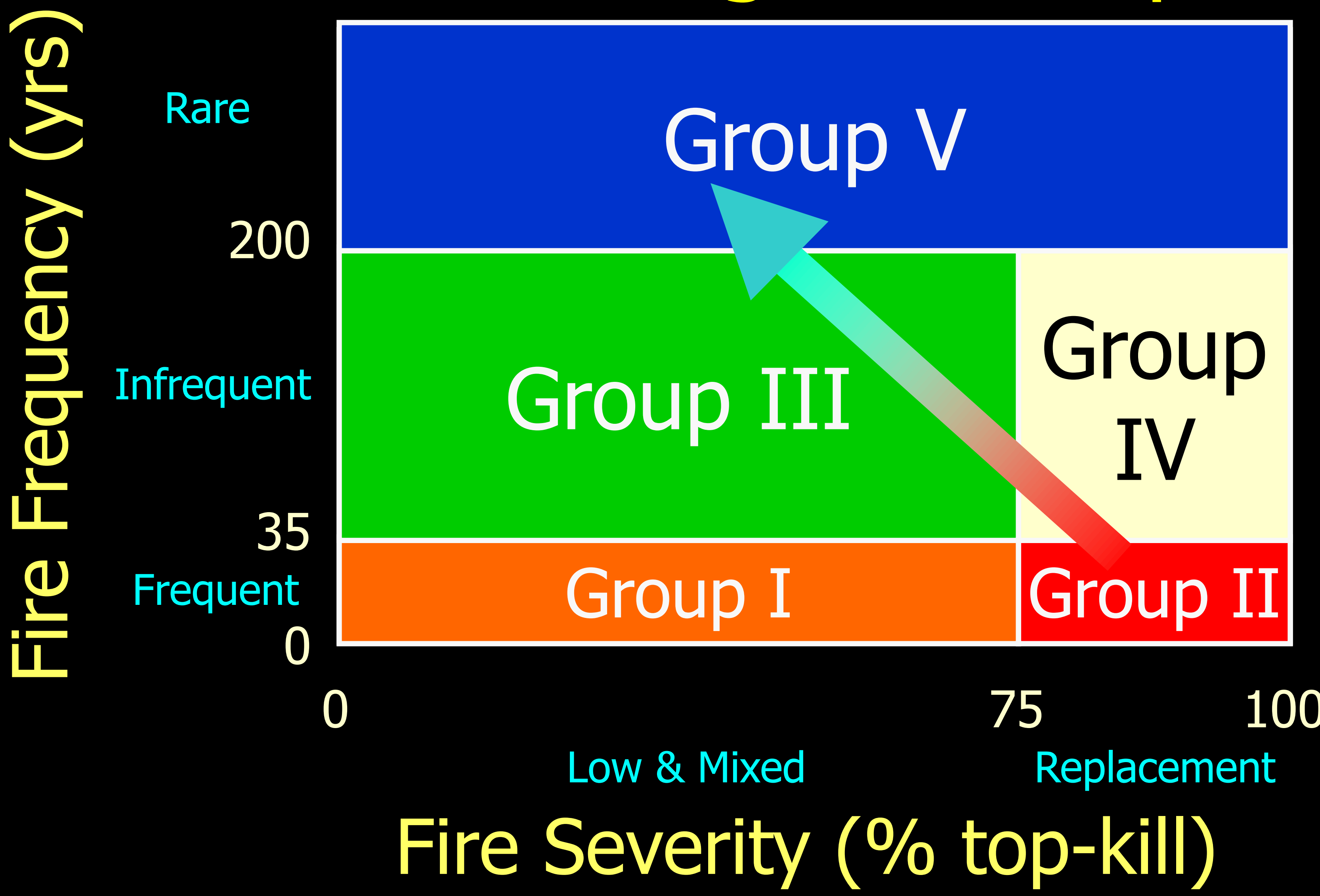
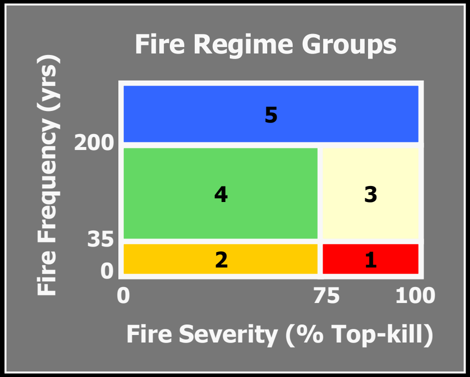
Fire Regime Group



Potential Natural Vegetation map

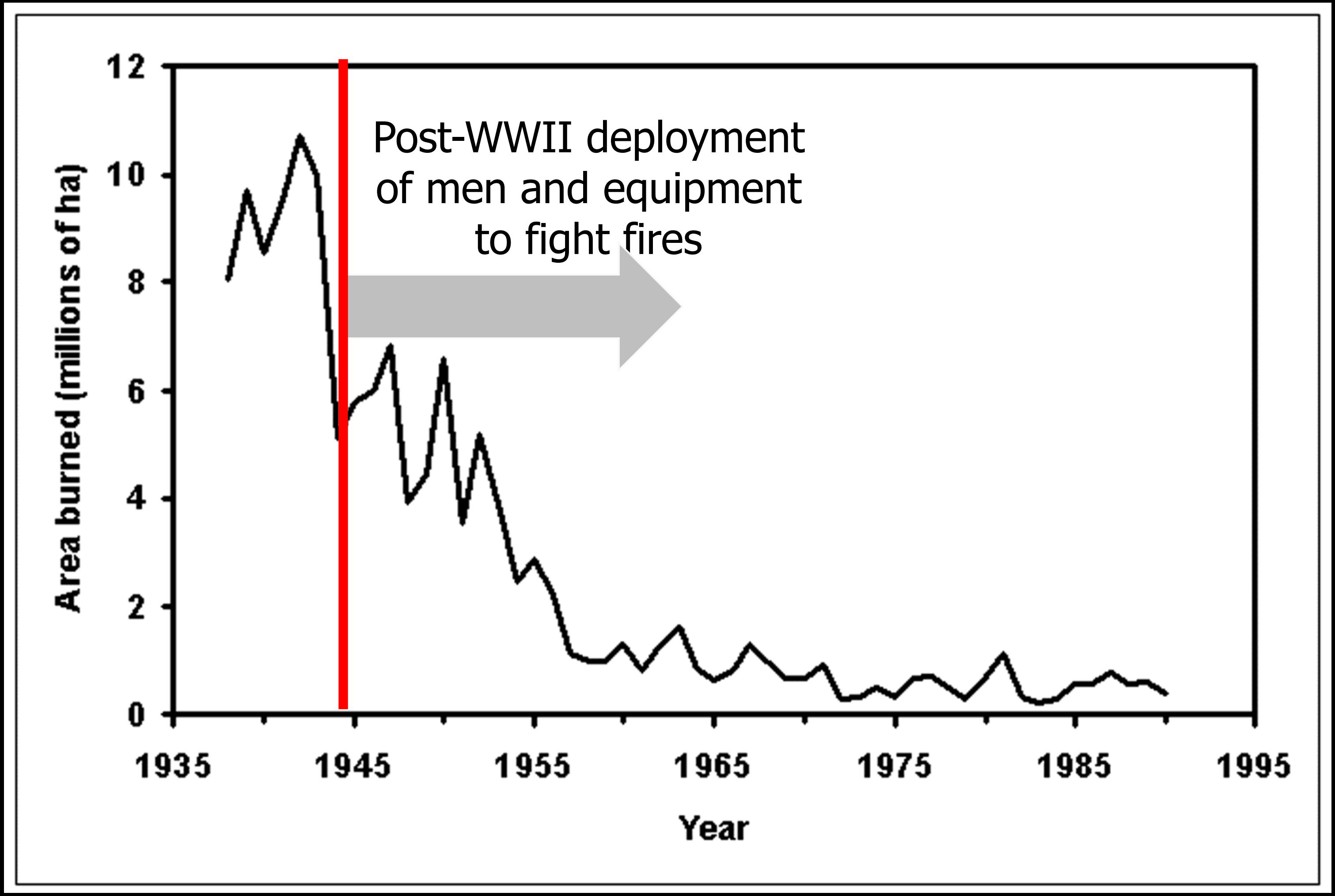
PNV-FRG – NLCD-FRG "Change" map

(1 km^2 pixels)



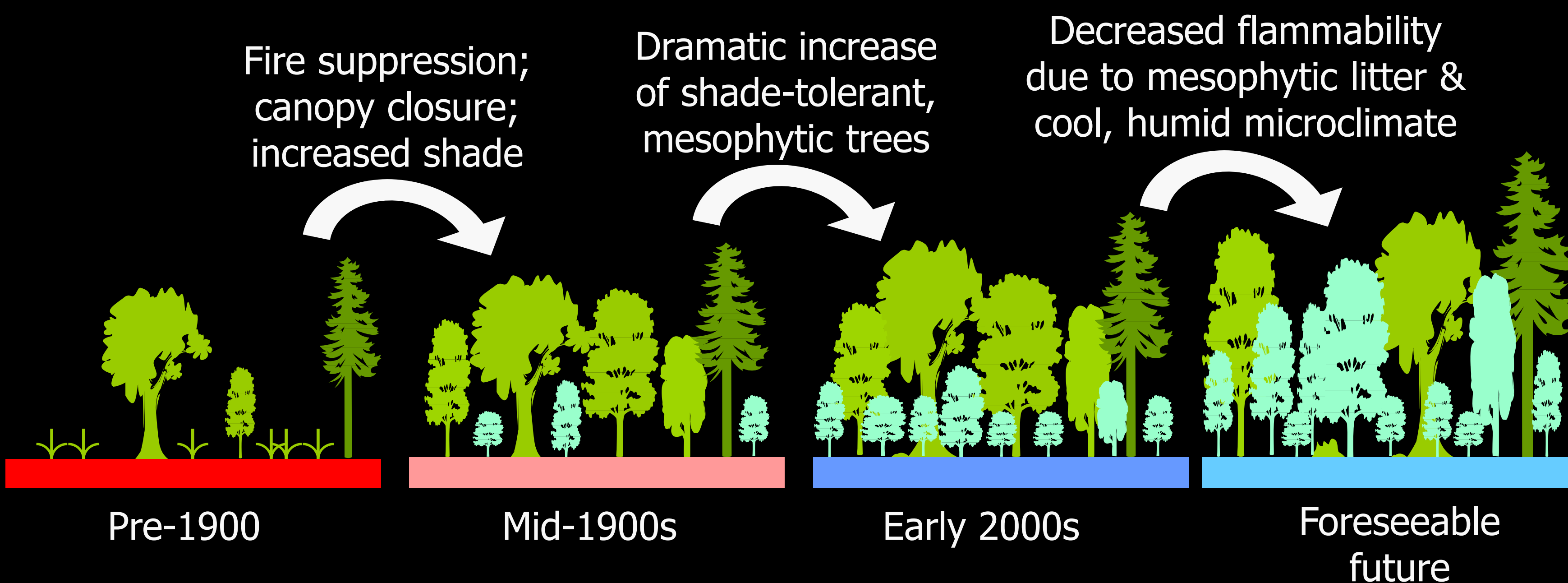
Fire Regime Change = Past FR – Current FR

Area burned in the eastern U.S.*



* States from Minnesota to Louisiana eastward.

Fire Importance



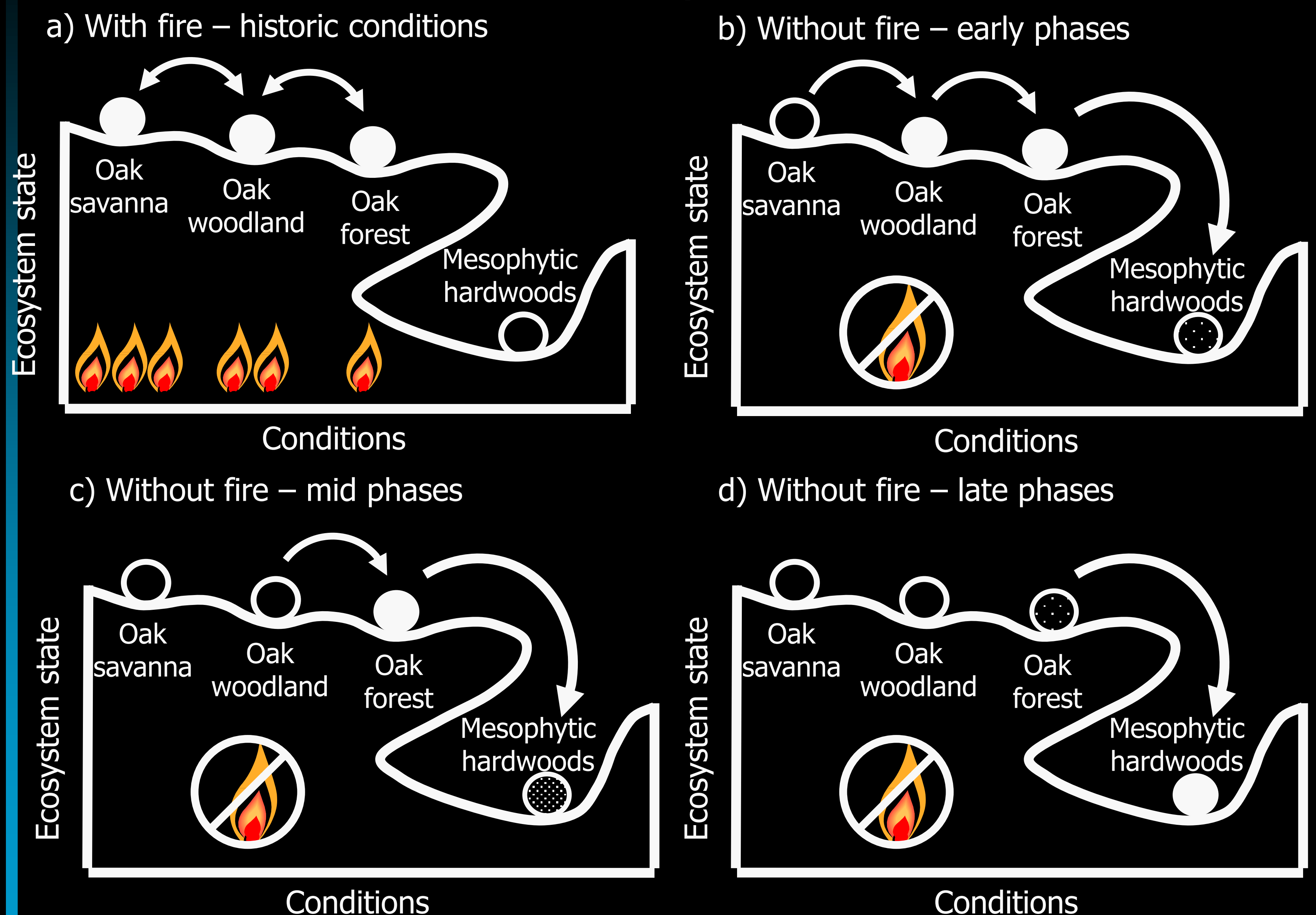
Mesophication

Structural Changes: Presettlement (1806-07) to Modern (1970s)

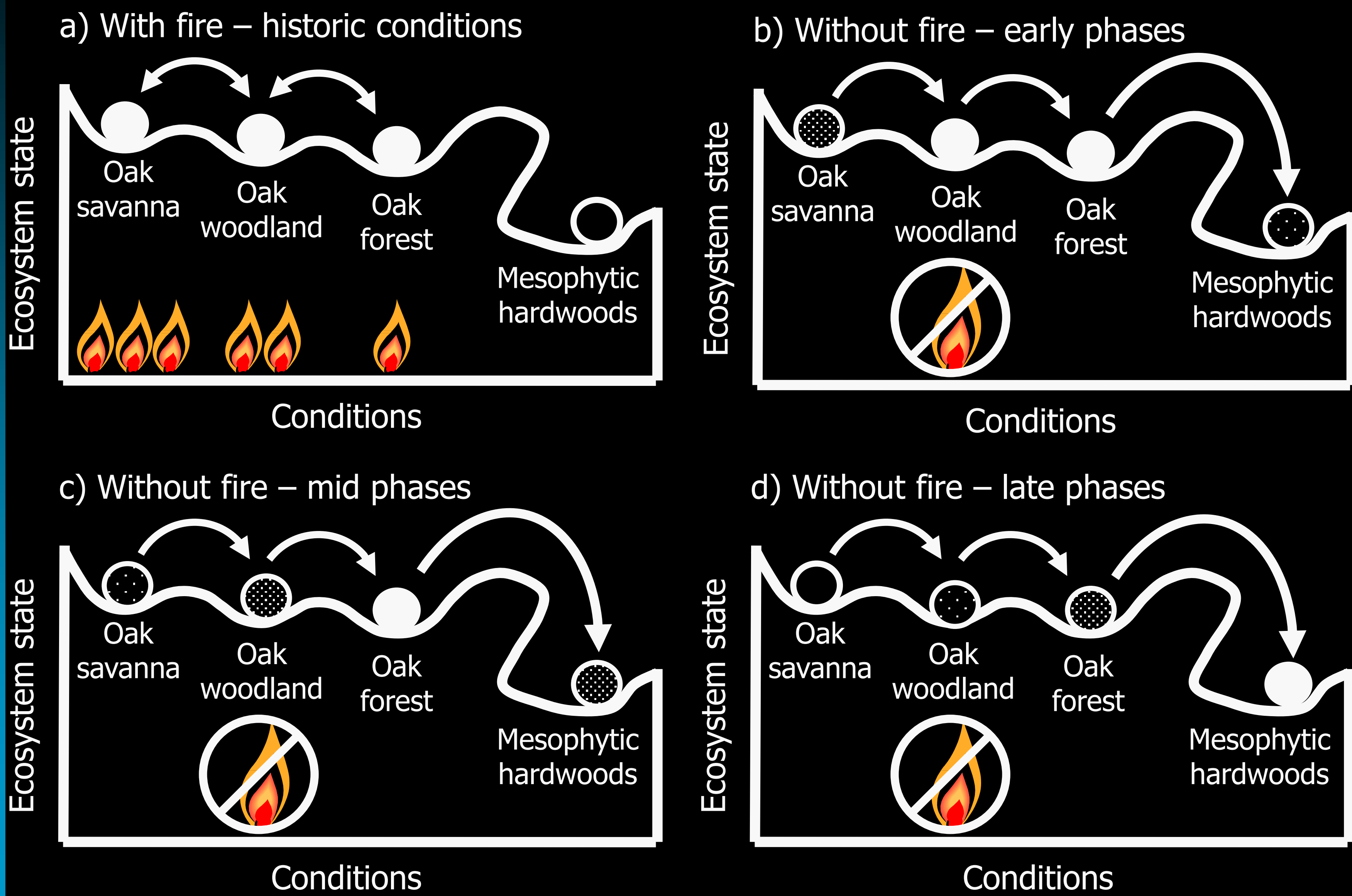
Fralish et al. 1991

Vegetation Type/Site	Presettlement Structure	Modern Structure	Change
Oak-hardwoods (terrace)	Density = 155 trees/ha QMD = 42 cm BA = 22 sq m/ha	Density = 457, 311 trees/ha QMD = 23, 35 cm BA = 20, 30 sq m/ha	▲ tree density ▼ mean diameter
Oak forest (low north slope)	Density = 146 trees/ha QMD = 36 cm BA = 15 sq m/ha	Density = 438, 345 trees/ha QMD = 26, 32 cm BA = 24, 28 sq m/ha	▲ tree density ▼ mean diameter ▲ basal area
Oak forest (high north slope)	Density = 144 trees/ha QMD = 36 cm BA = 14 sq m/ha	Density = 425, 377 trees/ha QMD = 25, 30 cm BA = 20, 26 sq m/ha	▲ tree density ▼ mean diameter ▲ basal area
Oak forest (ridgetop)	Density = 127 trees/ha QMD = 38 cm BA = 14 sq m/ha	Density = 487, NG trees/ha QMD = 25, NG cm BA = 24, 20 sq m/ha	▲ tree density ▼ mean diameter ▲ basal area
Oak forest (rocky south slope)	Density = 125 trees/ha QMD = 30 cm BA = 9 sq m/ha	Density = 650, 393 trees/ha QMD = 17, 22 cm BA = 15, 15 sq m/ha	▲ tree density ▼ mean diameter ▲ basal area
Oak forest (south slope)	Density = 144 trees/ha QMD = 36 cm BA = 16 sq m/ha	Density = 506, 415 trees/ha QMD = 22, 25 cm BA = 16, 21 sq m/ha	▲ tree density ▼ mean diameter ▲ basal area

Mesic uplands

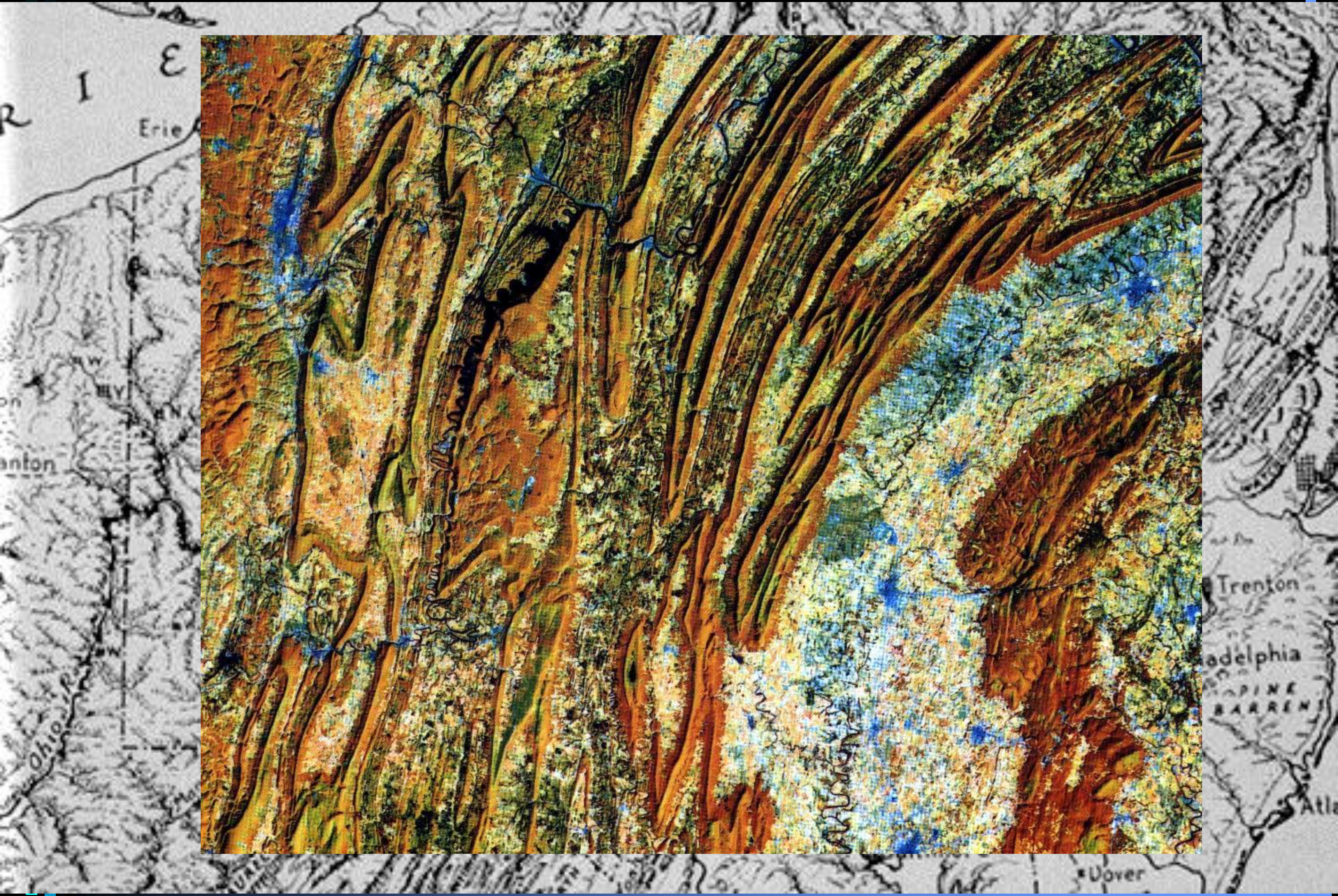


Xeric uplands

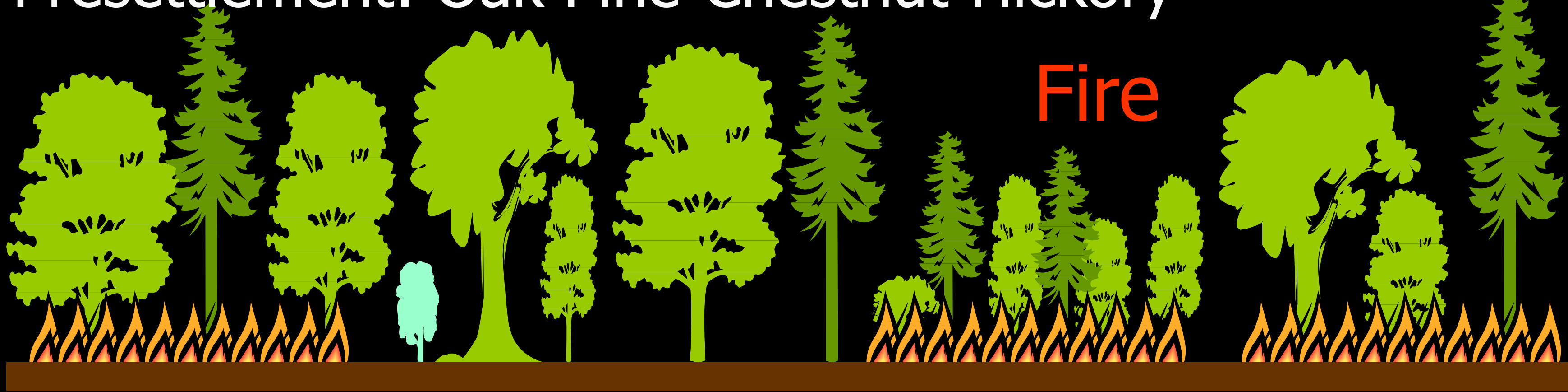


The demise of fire has been ubiquitous over the eastern U.S. leading to dire ecological problems in most locations.

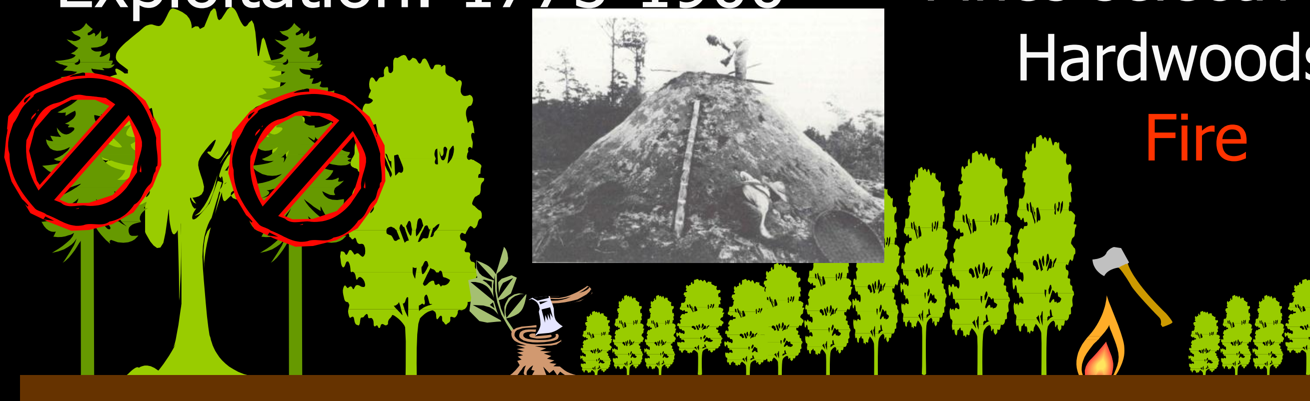
Example


Erie
Ohio
Trenton
adelphia
PINE BARRENS
Dover

Presettlement: Oak-Pine-Chestnut-Hickory



Exploitation: 1775-1900



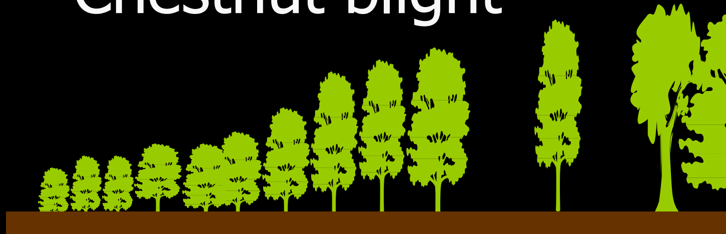
Pines selectively removed

Hardwoods coppicing

Fire

Modern: 1900-today

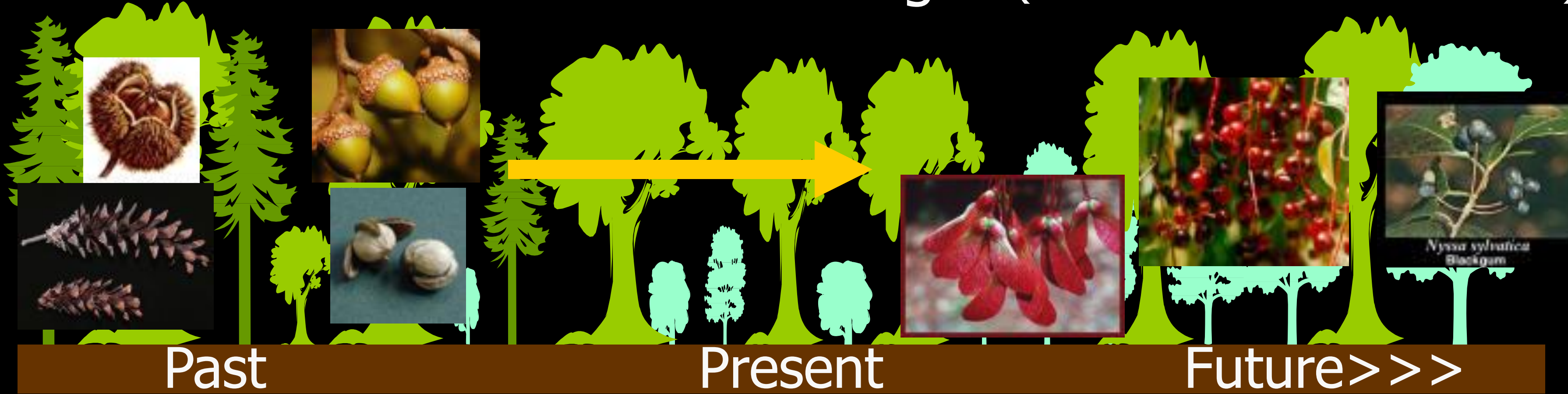
Chestnut blight



Pennsylvania Fires

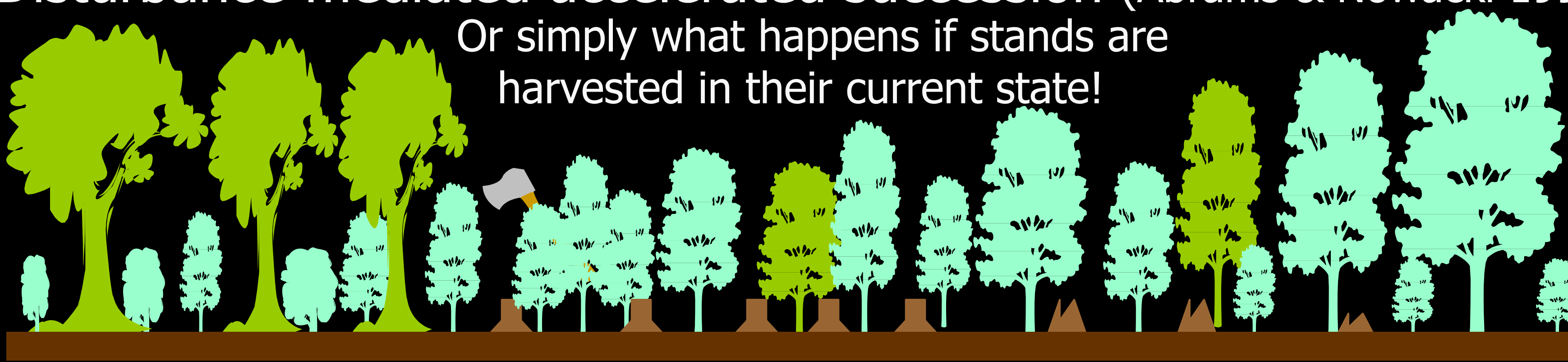
Year	Acres
1908	407,700
1913-19	108,155
1920-29	72,378
1930-39	42,049
1940-49	21,158
1950-59	12,784
1960-69	8,634
1970-79	3,240
1980-89	3,388

Oak succession and habitat changes (Rodewald & Abrams 2002)

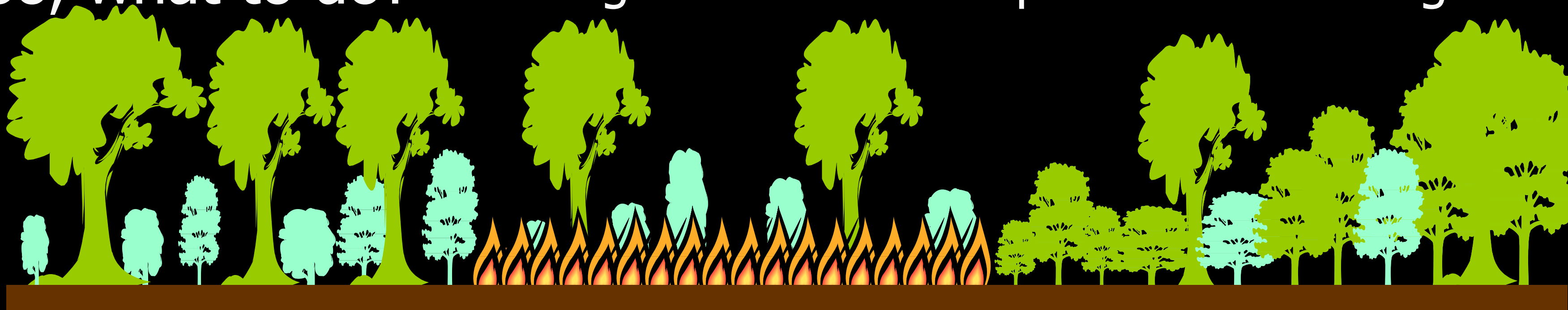


Disturbance-mediated accelerated succession (Abrams & Nowacki 1992)

Or simply what happens if stands are harvested in their current state!



So, what to do? Thinning treatments and prescribed burning



Western Star Oak Flatwoods
Houston/Rolla RD, Mark Twain NF

Untreated	Thinned, burned

Typical present-day conditions:

- Continuous canopy; high density
- Shaded understory
- Depauperate ground flora
- Deep leaf litter

Restored (thin & 5 burns over 15 yrs):

- Open canopy; historic density
- High-light conditions
- Robust & diverse ground flora
- Negligible leaf litter

Conclusions

- Oak is a pyrogenic (fire-dependent) genus based on tree life histories and physiological characteristics.
- Fire formerly played a significant role throughout the East!
- Fire suppression efforts over the last century have been extremely effective — to the detriment of fire-dependent plant communities.

Conclusions (cont.)

- Fire suppression has had cascading effects, changing openlands to closed forests and allowing fire-sensitive, shade-tolerant species to prosper (esp. maples) at the expense of oaks.
- Prescribed burning and thinning is needed in order to maintain oak communities (including attendant ground flora!).
- Opportunities for restoring pyrogenic ecosystems are rapidly waning…