Ecological Silviculture for Oak-dominated Ecosystems of the Central Hardwoods Region

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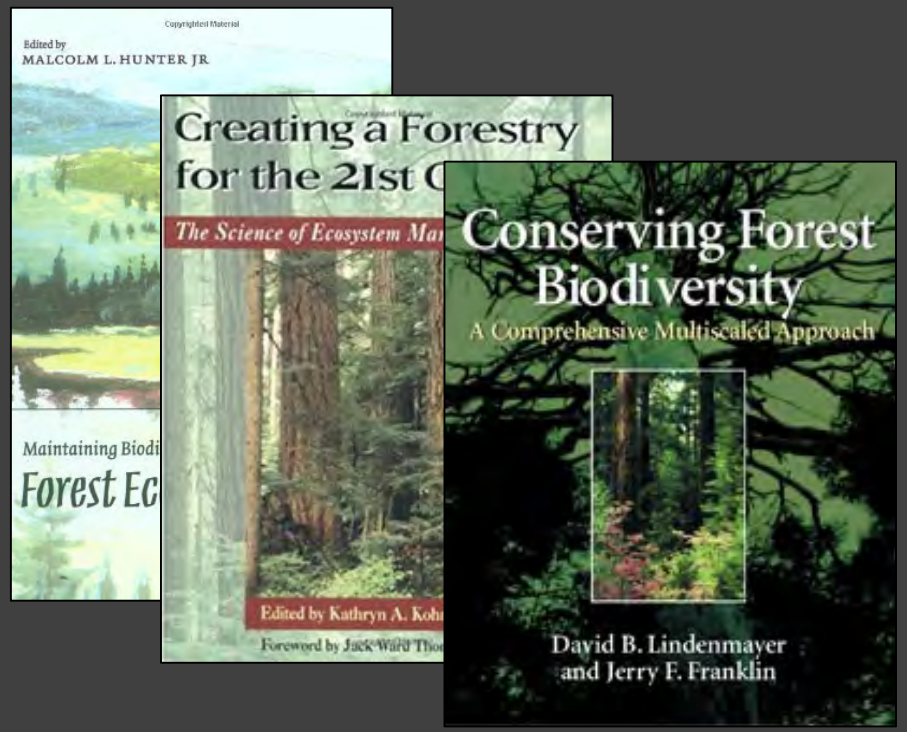
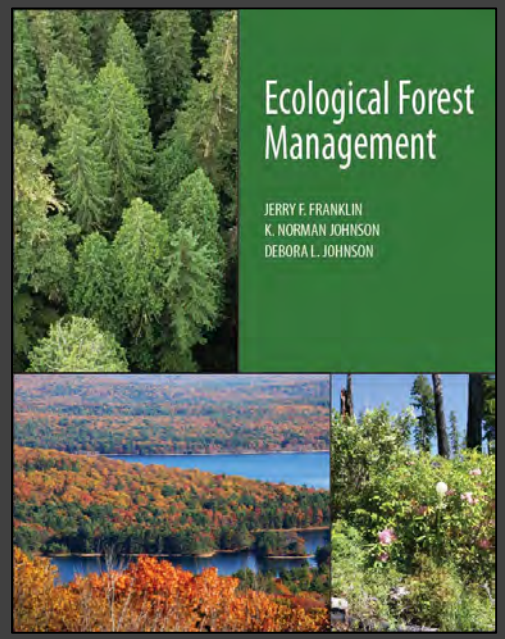
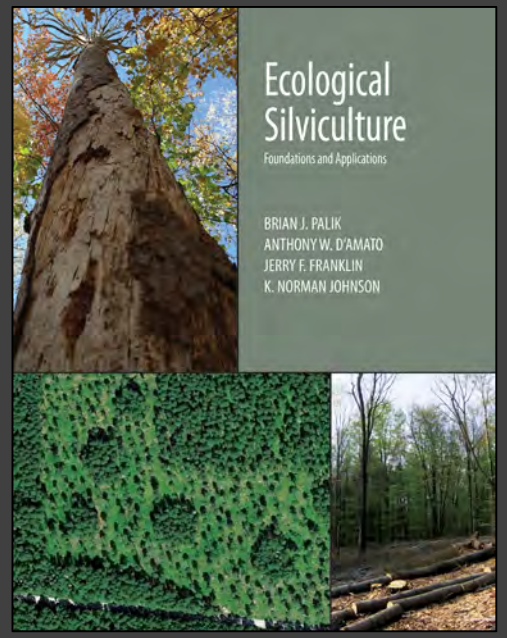
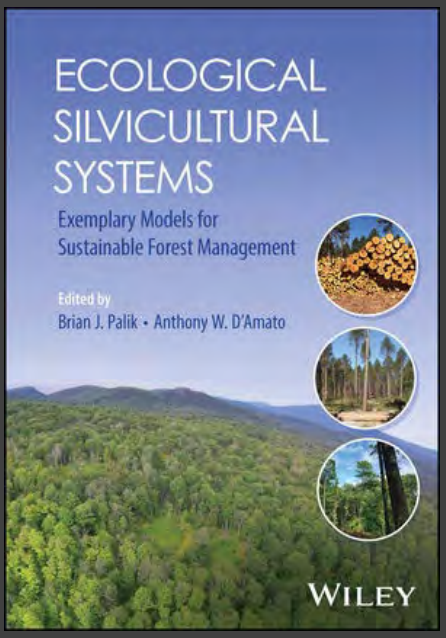
ECOLOGICAL SILVICULTURE is “…an approach for managing forests, including trees, associated organisms, and ecological functions, based on emulation of natural models of development”. (Palik and D’Amato 2024)

Principles: 1) continuity, 2) complexity and diversity, 3) timing, and 4) context

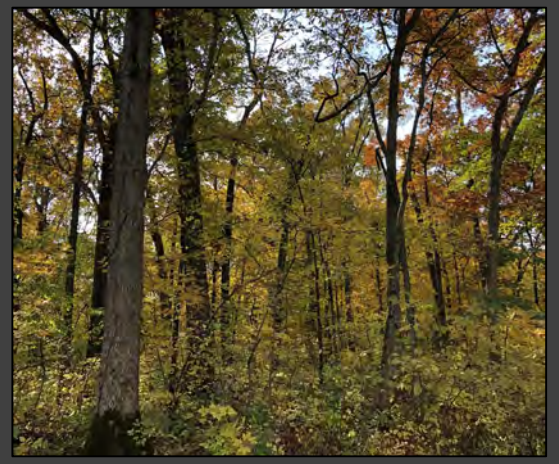






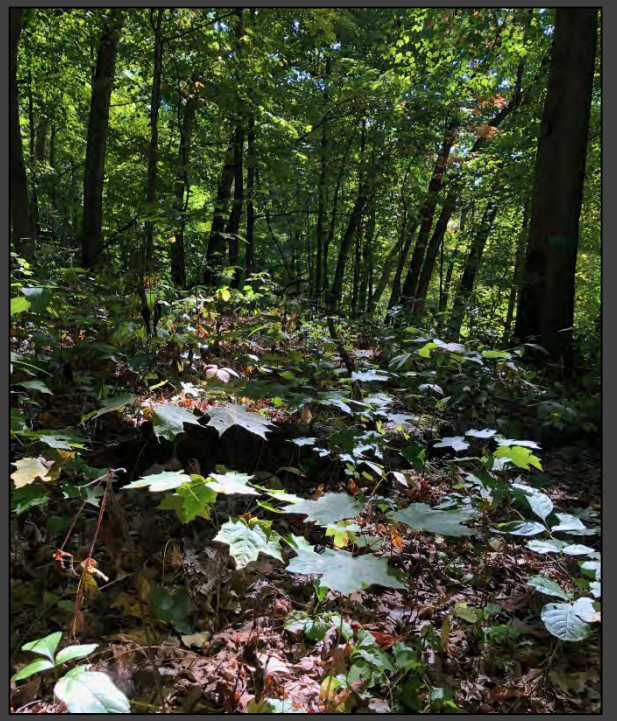


The Central Hardwoods Region extends across the eastern United States, including 5 ecoregion provinces.

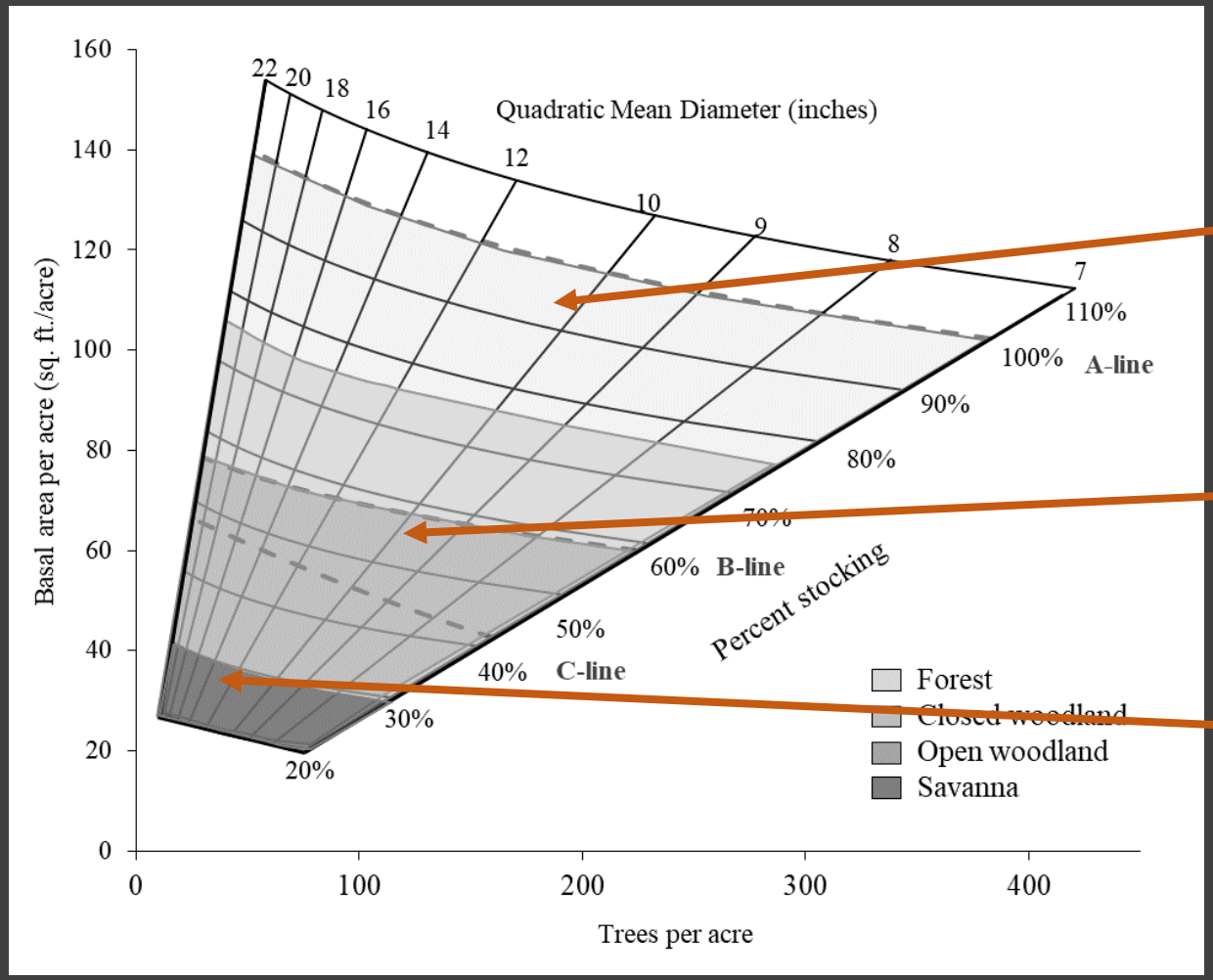


Ownership greatly impacts forest and woodland management and is largely private across the CH region.

- Many properties are small and getting smaller.
- Forests and woodlands are highly fragmented.
- The forest landscape is heavily influenced by agriculture, development, invasive species, and fire suppression and exclusion.



Oak species characterize forests and woodlands across much of the Central Hardwoods Region.



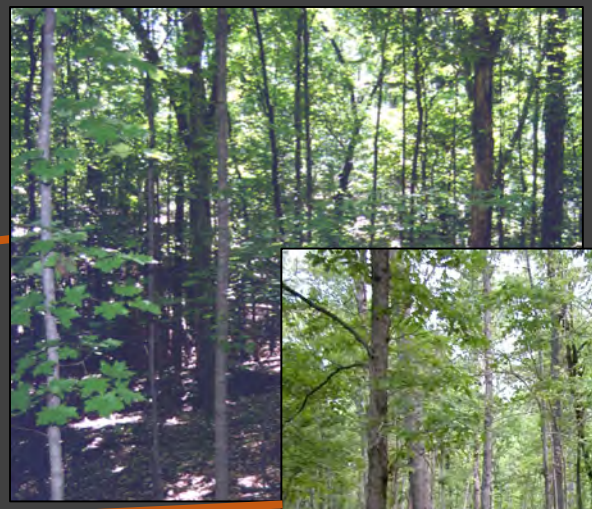


Photo: D. Dey

Key Point: Open forest ecosystems are important components of the Central Hardwoods Region, both culturally and ecologically, having been maintained largely through prescribed fires applied by indigenous peoples. They should be managed accordingly with greater focus on ground flora than tree recruitment.

Common tree species and silvical characteristics

Species	Mast frequency (years)	Max longevity (years)	Shade tolerance	Drought tolerance (1-5)	Adaptability
Red maple (*Acer rubrum*)	1-2	150	tolerant	1.84	**8.5**
Bitternut hickory (*Carya cordiformis*)	3-5	200	intolerant (to intermediate in bottomlands)	4	**5.6**
Pignut hickory (*C. glabra*)	1-2	325	intolerant (Northeast) to tolerant (Southeast)	4	**4.7**
Shagbark hickory (*C. ovata*)	1-3	350	intermediate	3	**4.4**
Mockernut hickory (*C. tomentosa*)	2-3	300	intolerant (but varies)	3	**5.4**
Black cherry (*Prunus serotina*)	1-5	250	intolerant	3	**3**
White oak (*Q. alba*)	4-10	600	intermediate	3.6	**6.1**
Scarlet oak (*Q. coccinea*)	3-5	250	very intolerant	4	**4.6**
Bur oak (*Q. macrocarpa*)	2-3	400	intermediate	3.9	**6.4**
Chestnut oak (*Q. prinus*)	4-5	400	intermediate	3.5	**6.1**
Northern red oak (*Q. rubra*)	2-5	400	intermediate	2.88	**5.4**
Post oak (*Q. stellata*)	2-3	400	intolerant	4.5	**5.7**
Black oak (*Q. velutina*)	2-3	250	intermediate	3	**4.9**

Across a highly variable region, soil quality and disturbance regimes drive species composition.

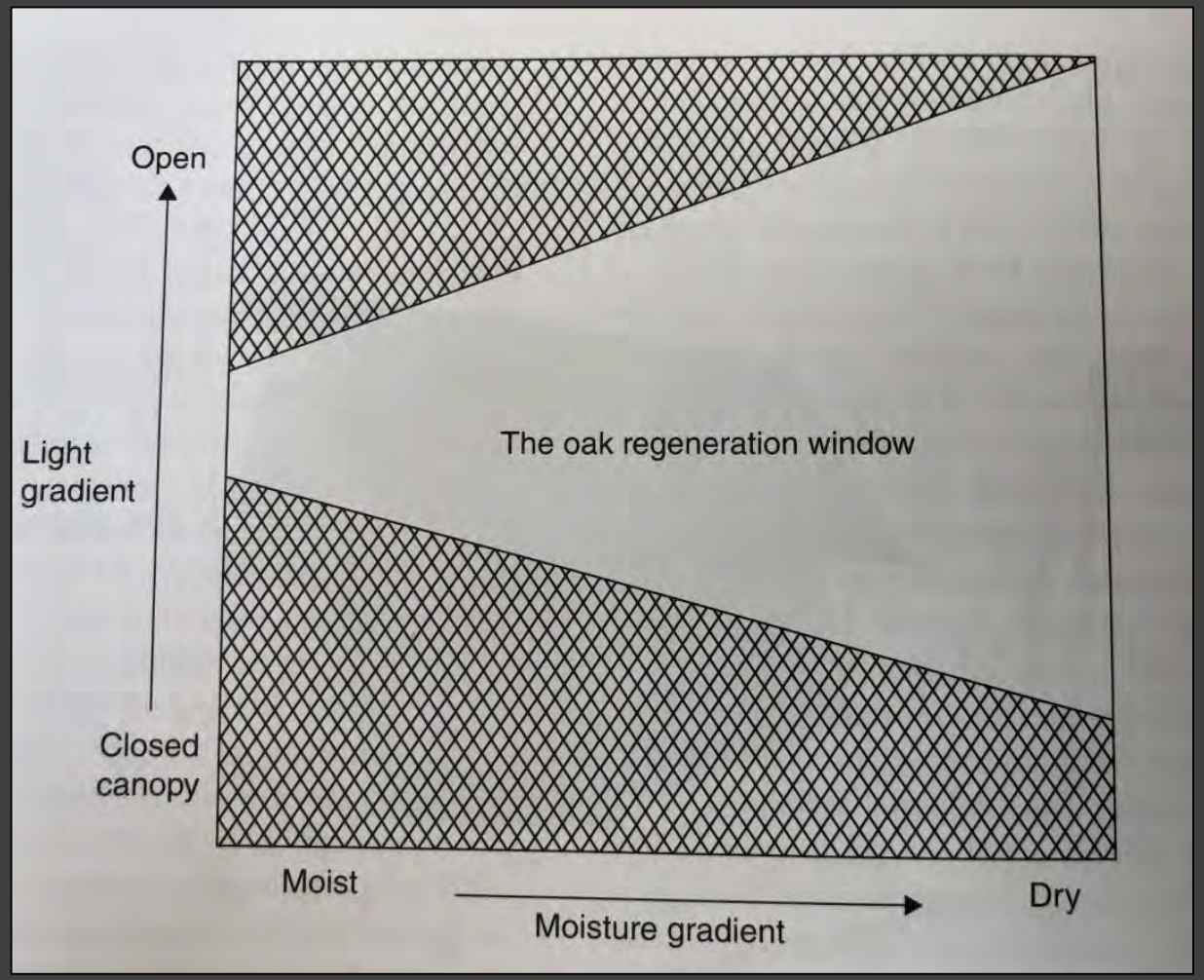
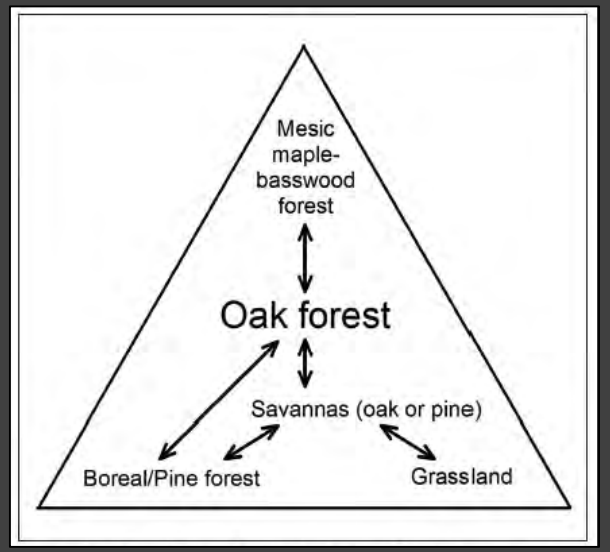
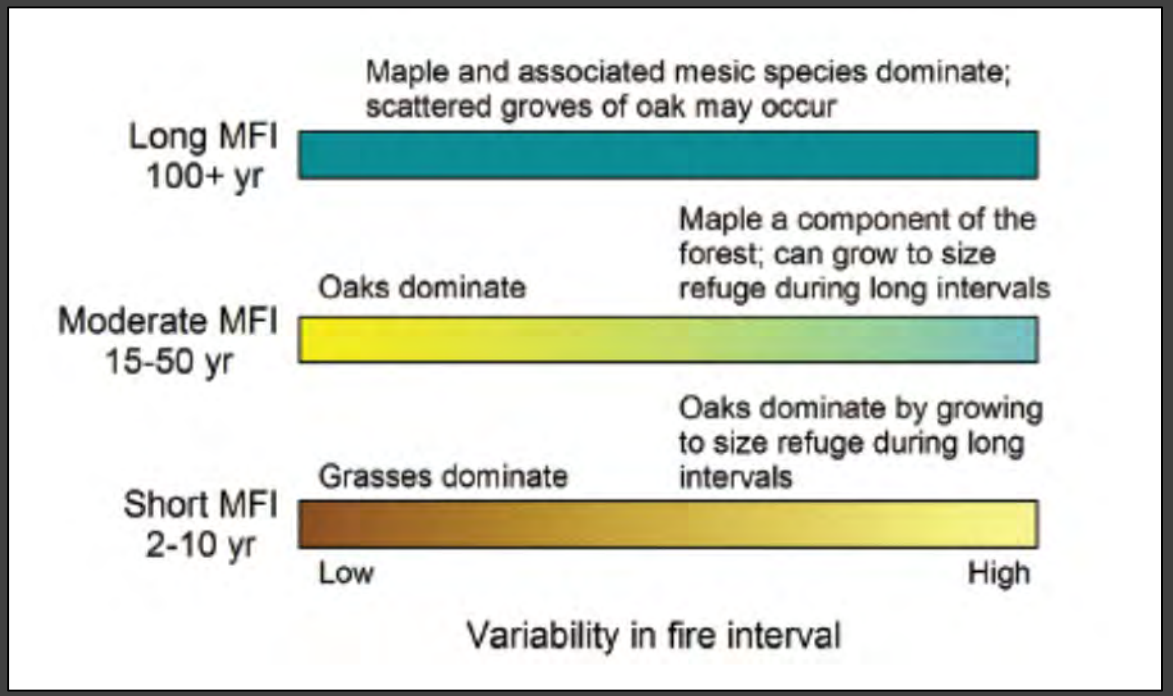


Figure from Johnson et al. 2019



Figures from Frelich et al. 2015 (PNW-GTR-914)



Wind, insects and disease also influence oak ecosystem dynamics.

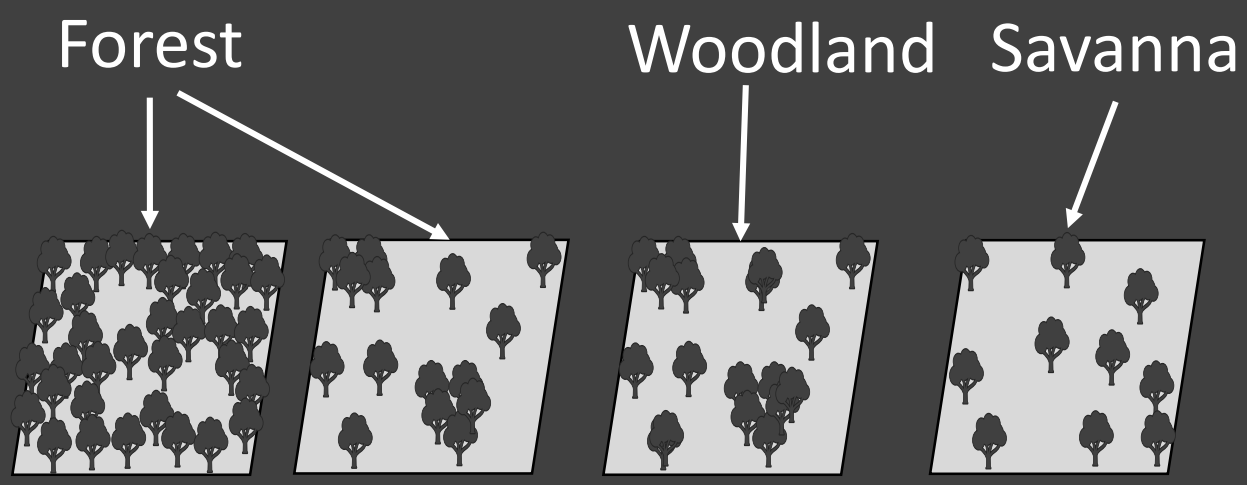
Mature white oak-dominated stand in central Iowa

The same stand following the 2020 derecho, subsequent decline, and harvest.

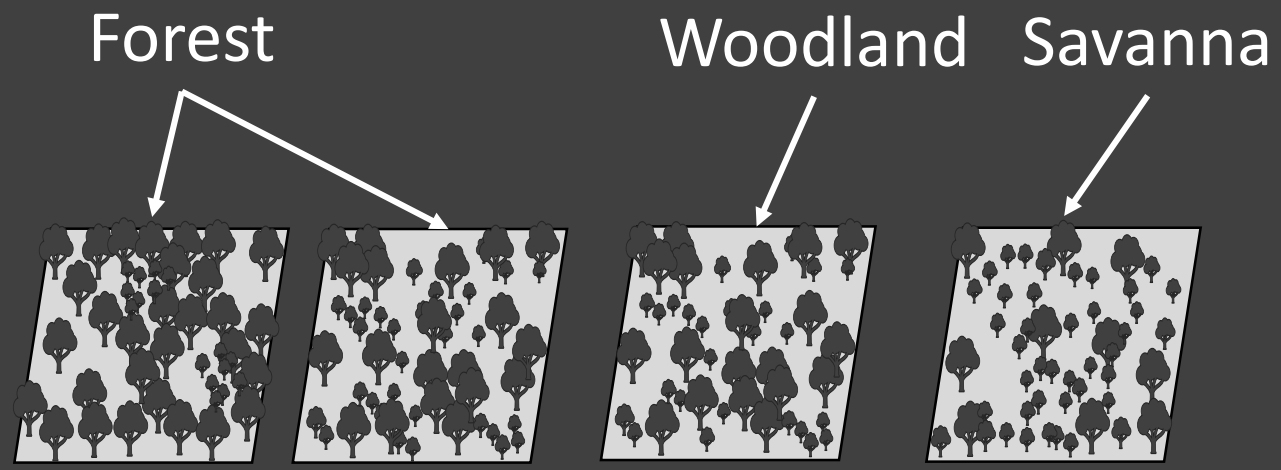
Where silviculture is applied, clearcutting and conventional shelterwood are the most common regeneration methods.

Key point: Regeneration harvesting should prioritize biological legacies and the maintenance of a healthy and diverse understory, creating structures that reflect the dynamic and disturbance-dependent nature of these ecosystems.

In the **DISTURBANCE AND LEGACY CREATION** stage, near stand-replacing to partial canopy disturbance leaves live tree and deadwood legacies.



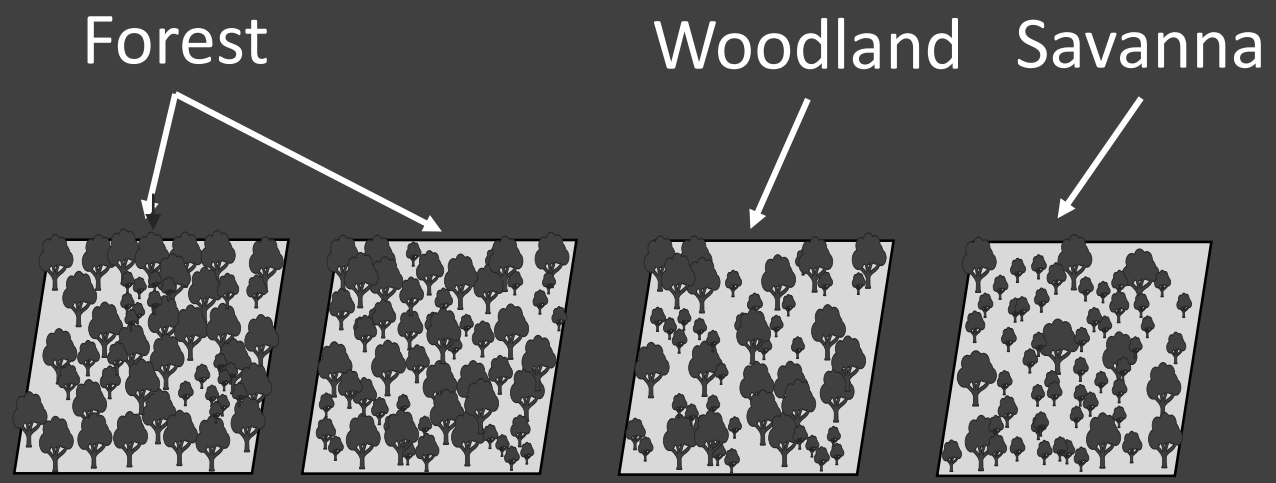
In the **PRE-FOREST** stage, oak and hickory sprouts dominate forests and woodlands alongside a significant herbaceous component.



Hardwood sprouts shorten the length of this stage when abundant.

Key point: The pre-forest stage provides valuable early-successional habitat that can be enriched and encouraged through fire while also encouraging desired oak and hickory regeneration. In woodlands and savannas, characteristics of this stage are maintained throughout development.

In the YOUNG stage, oak sprouts recruit to the canopy and thinning results from recurring fire (savanna, woodland) or self-thinning (forest).



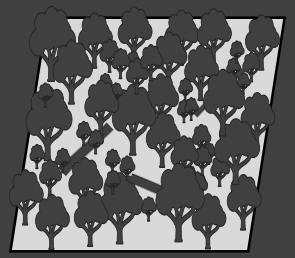
During the **MATURE** stage, oaks with wide crowns dominate the overstory; deadwood abundance and plant species diversity increase in the understory and ground layer (savanna, woodland) or in the seedling layer (forest).

During the **OLD-GROWTH** stage, overstory structure becomes more complex as individual trees die, new cohorts recruit, and deadwood accumulates.

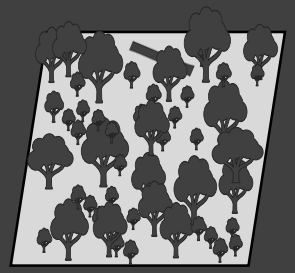
Low-intensity fire continues to facilitate establishment and early growth of oak stump sprouts in savanna and woodlands.

More shade tolerant tree species establish in lower strata in the absence of frequent fire in forests.

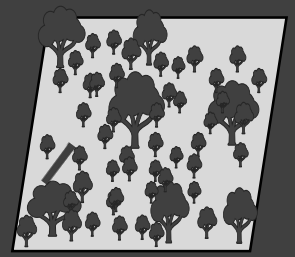
Forest



Woodland



Savanna



Wegener Woods, MO (photo: NPS)

Key point: Application of treatments should reflect the best available knowledge of the natural and historic disturbance regime:

- Recovery periods (e.g. between prescribed fires and/or harvest entries)
- Severity (e.g. severity of surface fire, proportion of canopy removed, abundance of dead wood created).

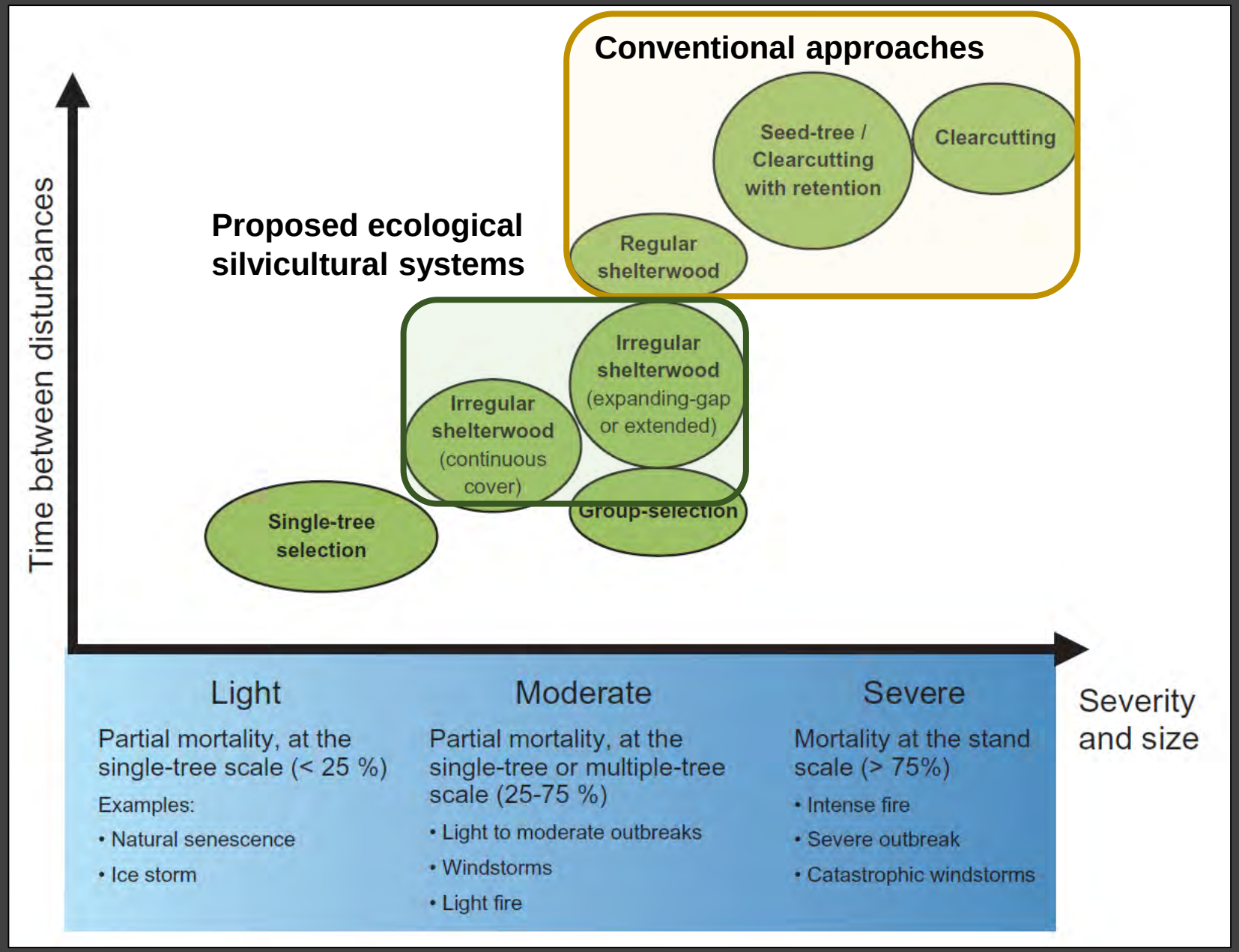


Figure 2 from Kern et al. 2016

Desired future conditions in oak-dominated ecosystems of the CHR include:

- Uneven-aged/multi-cohort age structure (some two-cohort)
- Vertical and horizontal structural complexity
- Standing and down dead wood
- Structure and species composition in the understory and midstory reflective of the natural disturbance regime

An effective ecological silviculture system for this region must be dynamic.

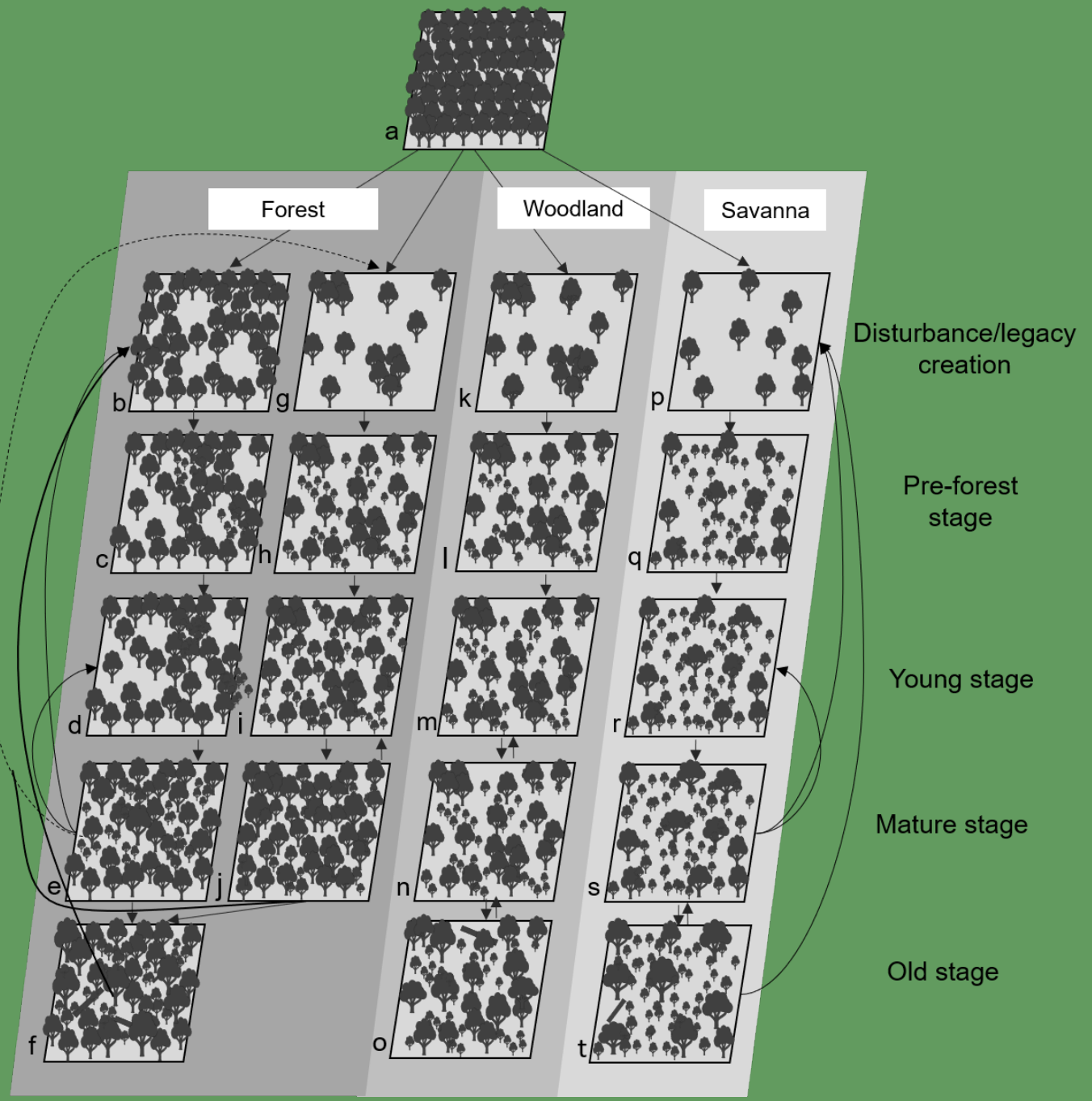
Options include irregular shelterwood (e.g. continuous cover, expanding gap) methods for forests and variable retention harvest for woodlands and savannas.

Raymond et al. 2009. Journal of Forestry.

silviculture

The Irregular Shelterwood System: Review, Classification, and Potential Application to Forests Affected by Partial Disturbances

Patricia Raymond, Steve Bédard, Vincent Roy, Catherine Larouche, and Stéphane Tremblay



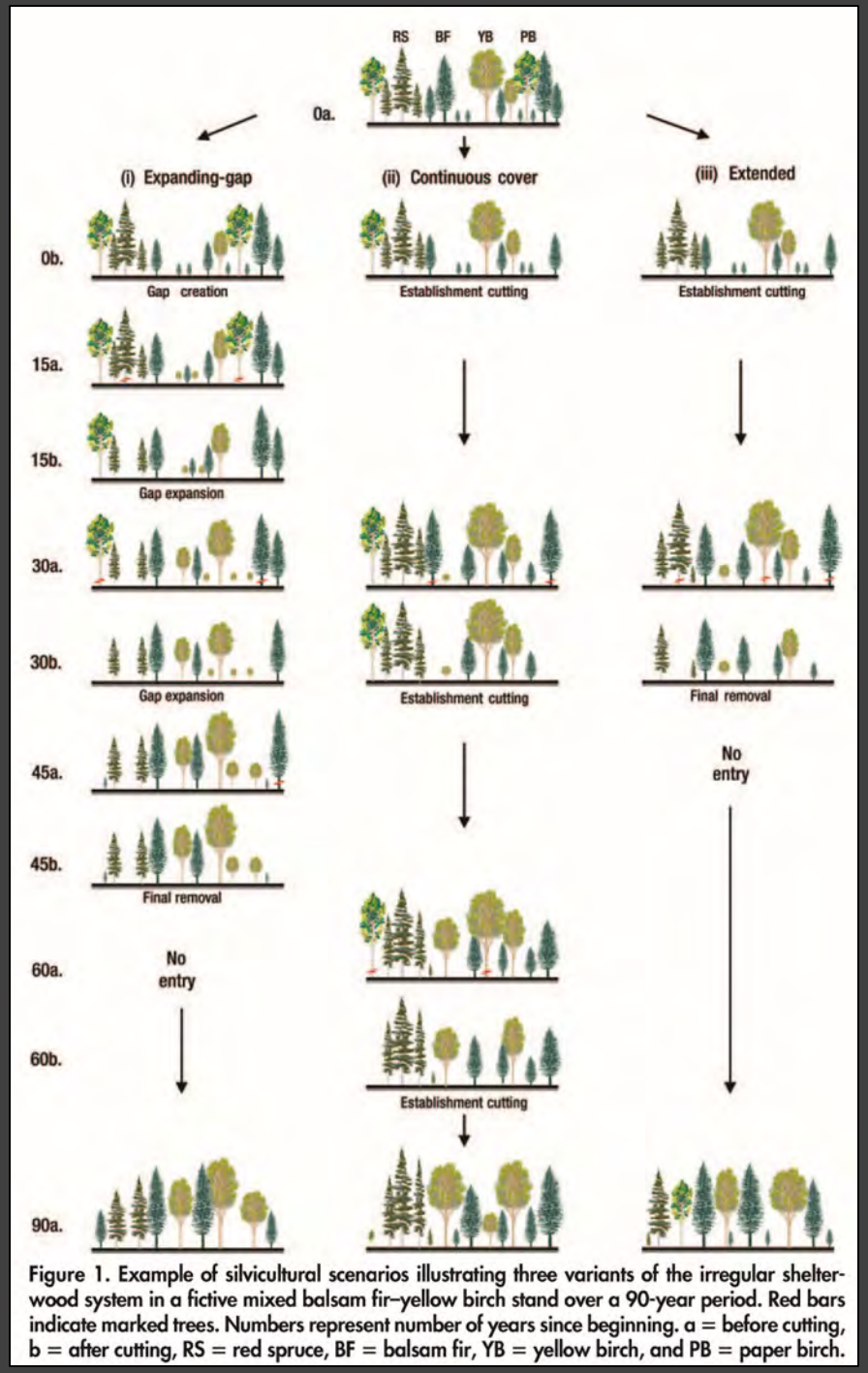


Figure 1. Example of silvicultural scenarios illustrating three variants of the irregular shelterwood system in a fictive mixed balsam fir–yellow birch stand over a 90-year period. Red bars indicate marked trees. Numbers represent number of years since beginning. a = before cutting, b = after cutting, RS = red spruce, BF = balsam fir, YB = yellow birch, and PB = paper birch.

Continuous cover irregular shelterwood

- Age structure: multi-cohort
- Harvesting pattern: varied (single tree and group)
- No final removal
- Vertical structure: irregular, layers
- Horizontal structure: irregular, mix of cohorts

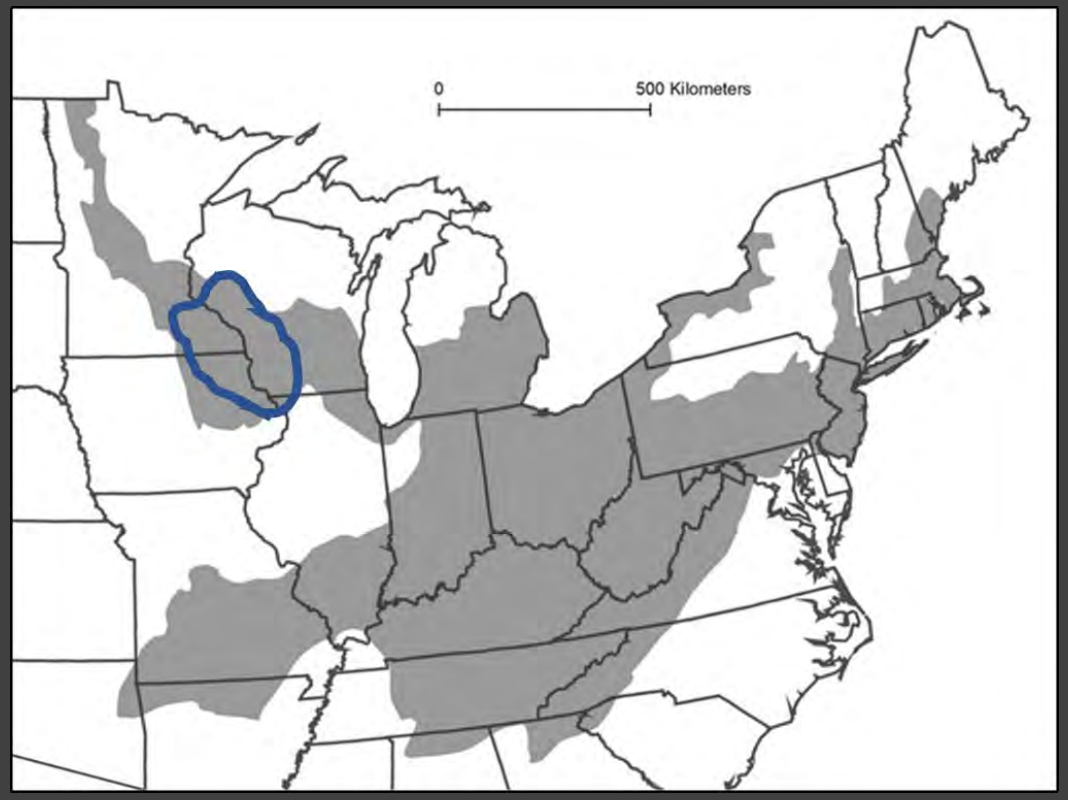
Raymond et al. 2009. The irregular shelterwood system: review classification, and potential application to forests affected by partial disturbances. Journal of Forestry. 107(8): 405-413.

Key point: Diversity and variability in structure, timing (e.g. recovery periods), and community composition in the understory (if not trees) are prioritized in these ecological silvicultural systems to promote native biodiversity and maintain adaptive capacity.

Question Break

The Driftless Area Region

"…But it is the ice that floats, not you, secured to bedrock in the Driftless Land." – Kevin Koch



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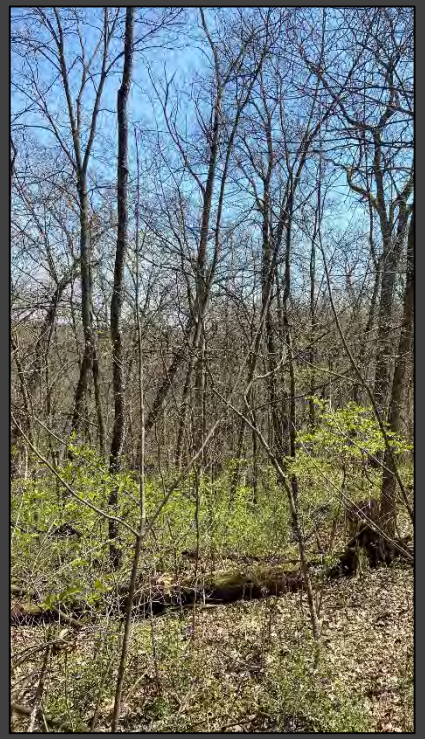


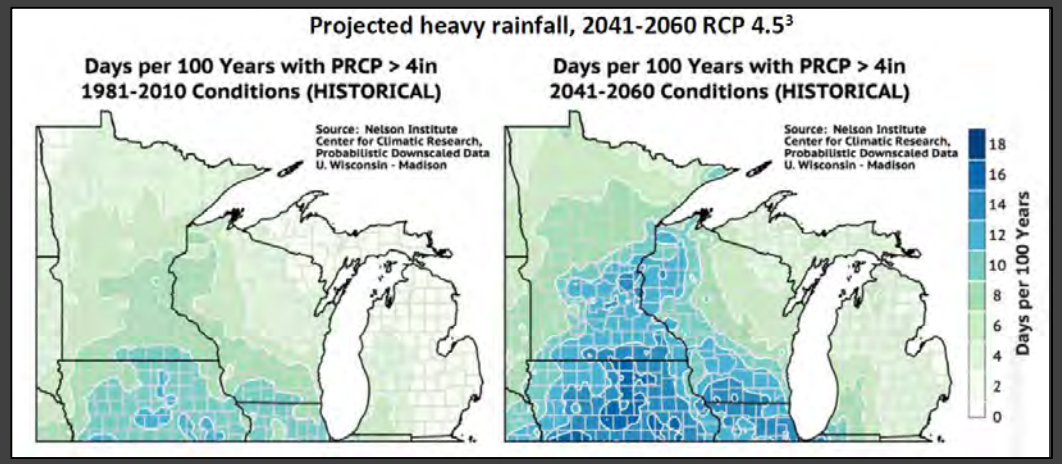
Photo credit: Brad Hutnik

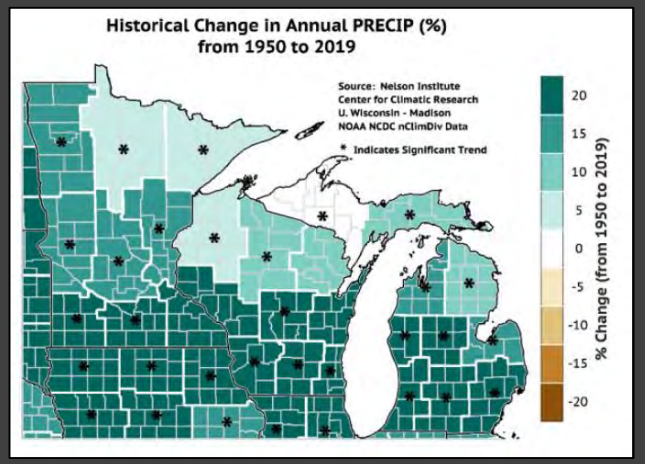
Yellow River State Forest, IA

Photo credit: David Mark

Recent changes to climate in the Driftless Area are expected to continue.

- Average annual temperature has increased 2-3 degrees F across the region since 1950; average winter temperatures +3-5 degrees F.
- Average winter minimum temperature has increased 4-7 degrees F.
- The Driftless Area has received more than 20% more annual precipitation since 1950.
- Heavy precipitation events have occurred more frequently in recent decades.
- The frost-free growing season has already increased by almost two weeks across much of the Driftless Area and is expected to increase by ~ 20 additional days by 2050.





ASCC Network Locations

Core Sites

Affiliate Sites

John Prince Research Forest, BC, Canada
Sub-boreal spruce

Cutfoot Experimental Forest, MN
Dry-mesic mixed woodland

Petawawa Research Forest, ON, Canada
White pine-mixed wood

Second College Grant, NH
Northern hardwoods

Southern New England, CT, RI
Exurban oak-hickory

Flathead National Forest, MT
Western larch/mixed-conifer

Driftless Area, IA, MN, WI
Southern dry-mesic hardwoods

Ohio Hills, OH
Dry/mesic oak

Colorado State Forest, CO
High-elevation spruce-fir

San Juan National Forest, CO
Warm, dry mixed-conifer

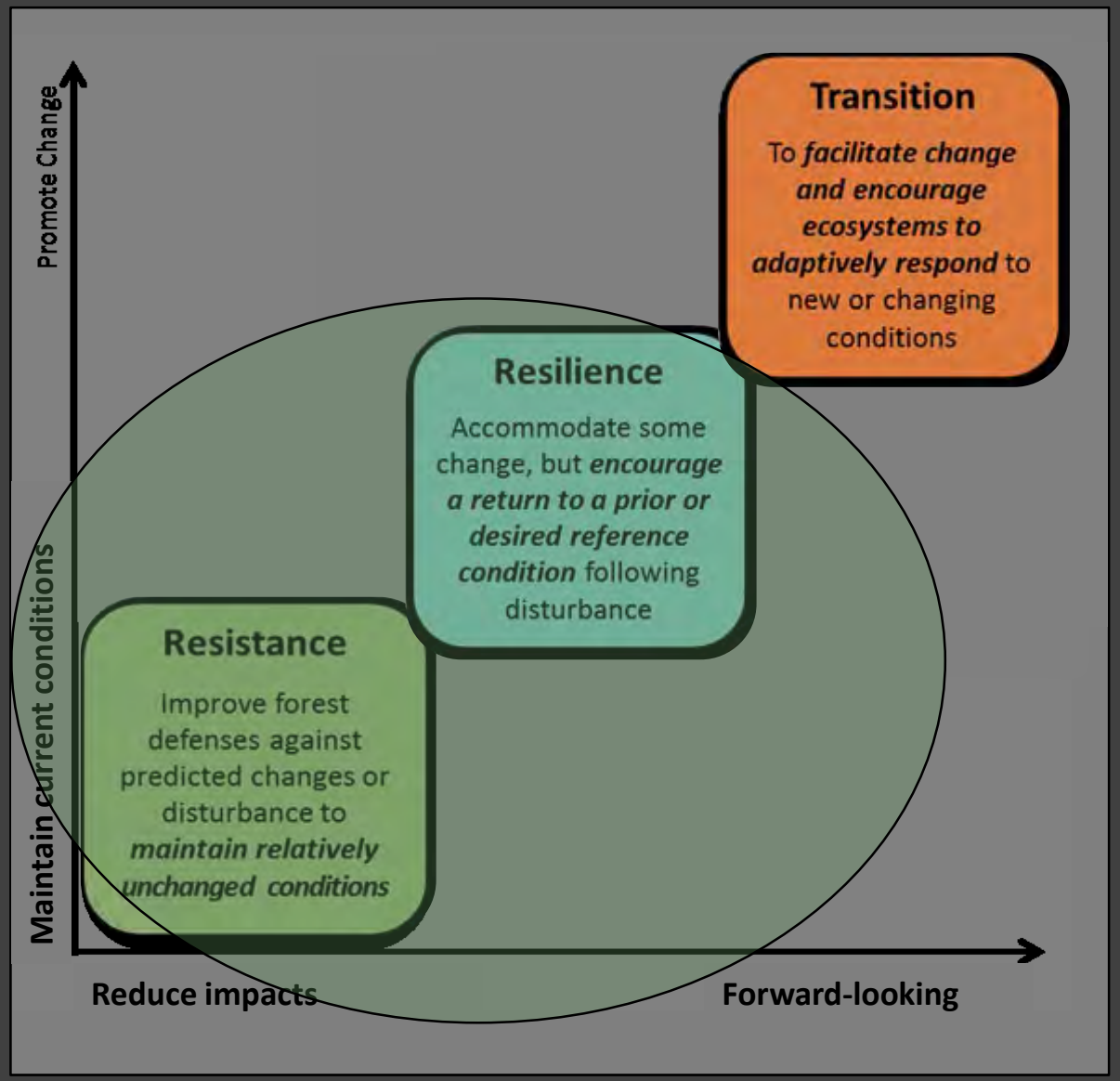
Taylor Park, CO
High elevation Lodgepole pine

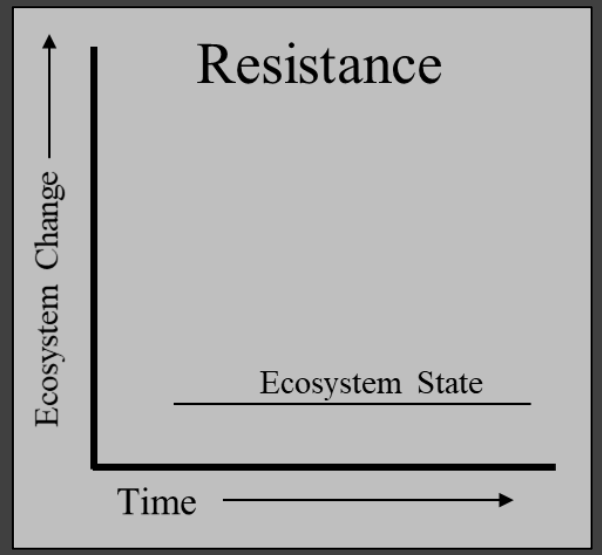
Crosby Farm, MN
Urban floodplain forest dominated by ash-elm

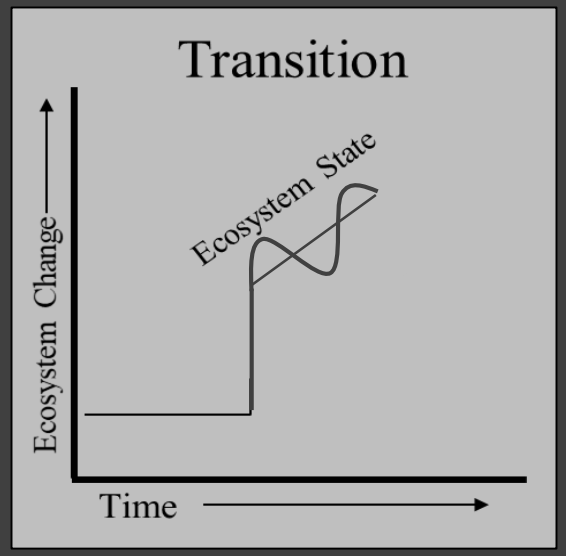
The Jones Center at Ichauway, GA
Longleaf pine-hardwood

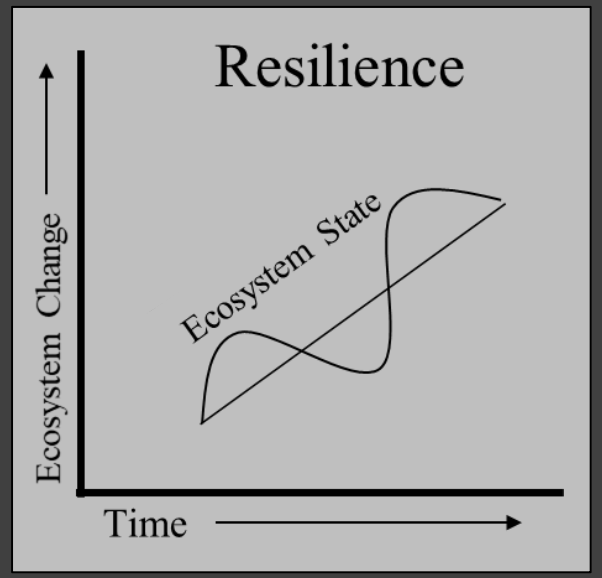
Robinson Forest, KY
Appalachian mixed mesophytic

Treatments









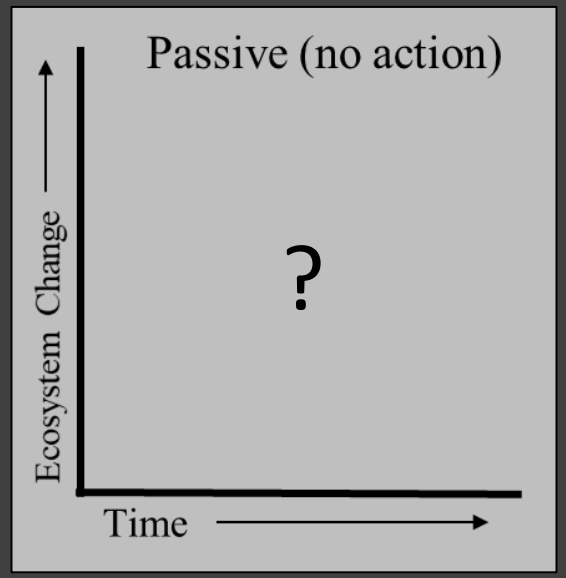


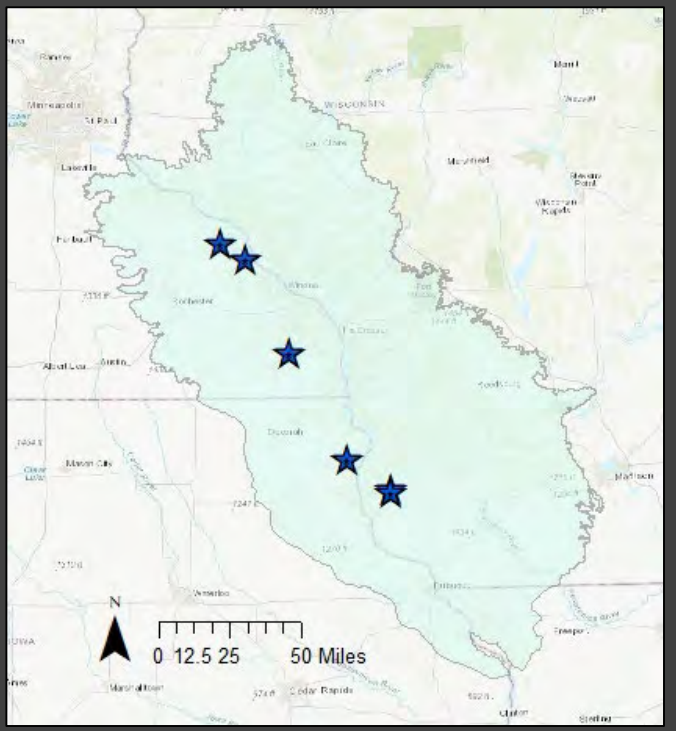
Figure adapted from Nagel et al. 2017

Driftless Area Sites and Study Design

- Eight blocks across three states
- Dry-mesic oak-dominated forests
- Even-aged stands ~85-110 years old
- Silt-loam textured soils
- Each block consists of 40+ acres divided into 4 treatment stands.

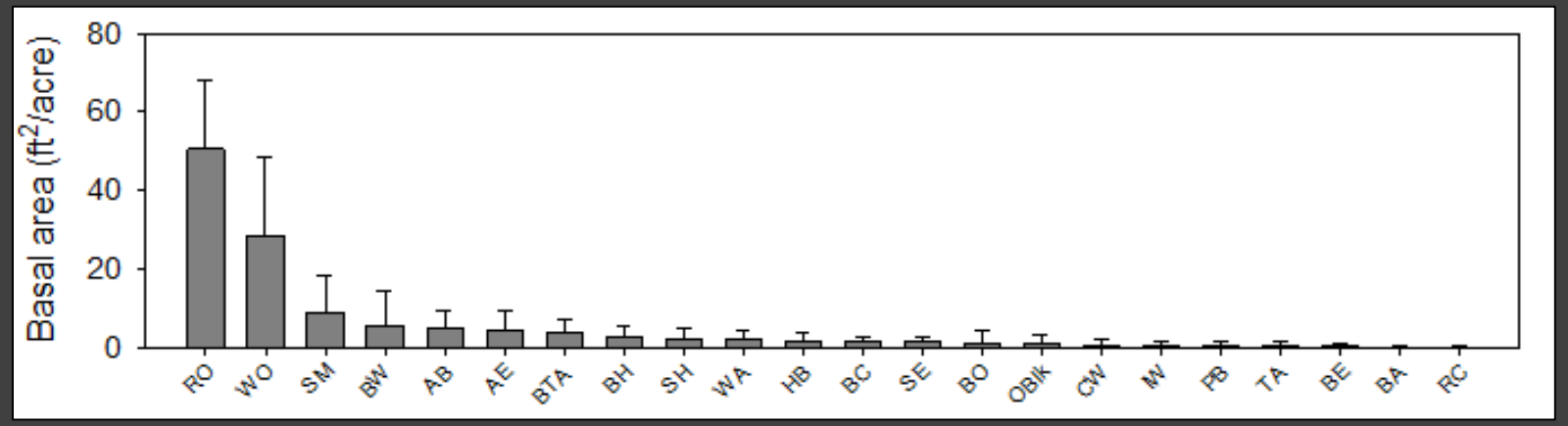
Bridle Trail Unit, Wisconsin DNR

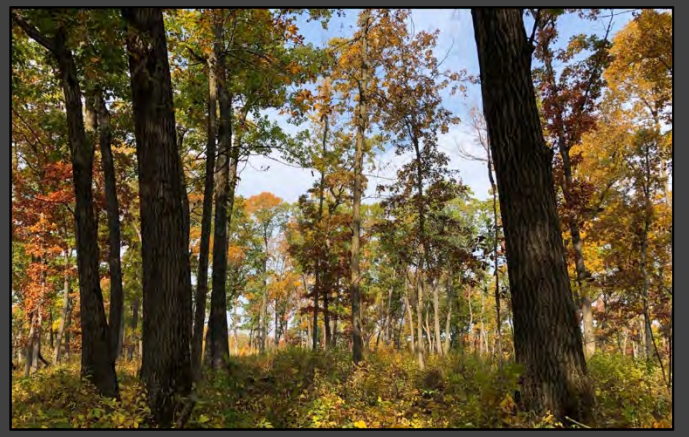
Weaver Ridge, Minnesota DNR

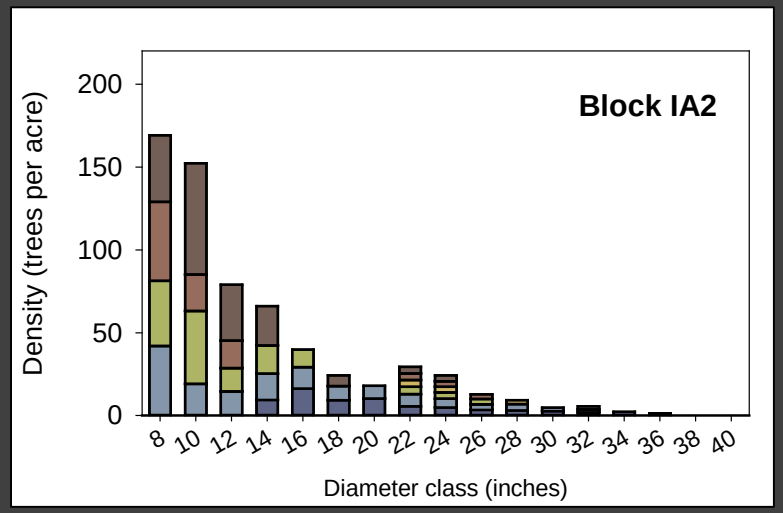


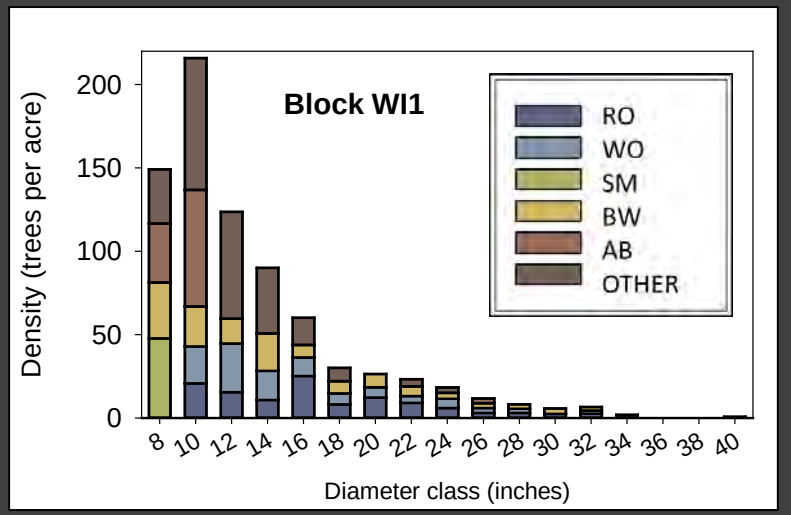
Yellow River State Forest, IA DNR

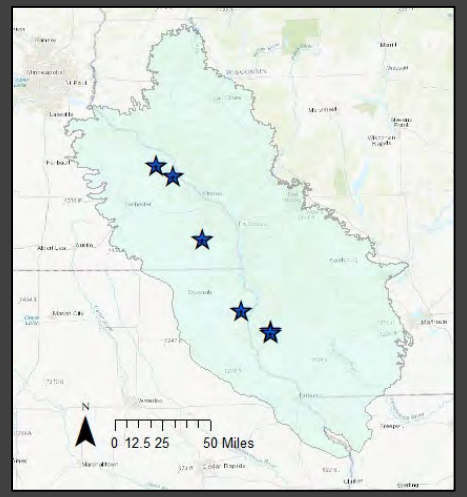
Northern red oak and white oak dominate forest stands study-wide.











AB, American basswood; AE, American elm; BH, bitternut hickory; BA, black ash; BC, black cherry; BE, boxelder; BN, butternut; BO, bur oak; BTA, bigtooth aspen; BW, black walnut; CW, cottonwood; HB, hackberry; IW, ironwood; OBlk, black oak; MW, musclewood (American hornbeam); PB, paper birch; RC, eastern red cedar; RE, rock elm; RO, northern red oak; SE, slippery elm; SM, sugar maple; SH, shagbark hickory; TA, trembling aspen; WO, white oak.

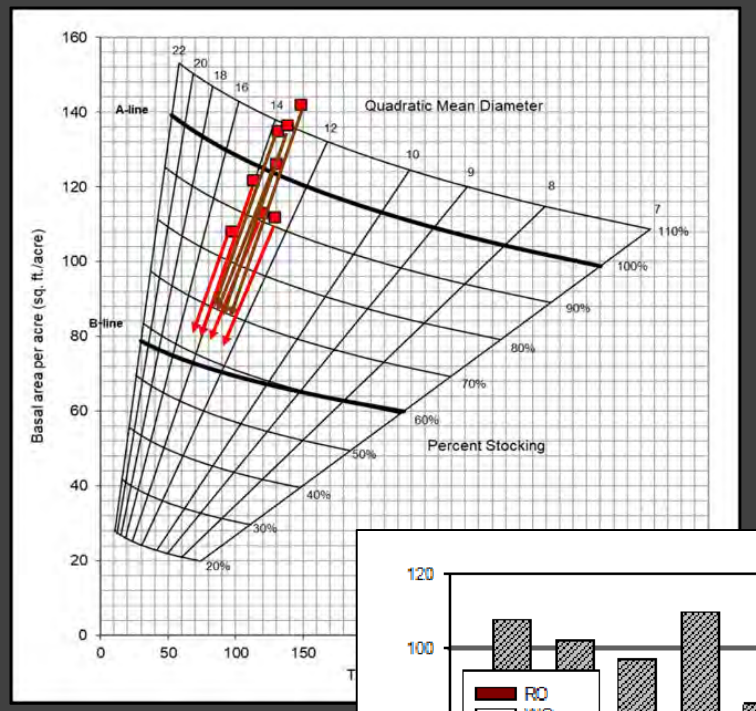
Regeneration (e.g. sugar maple) does not reflect overstory composition (northern red oak and white oak).

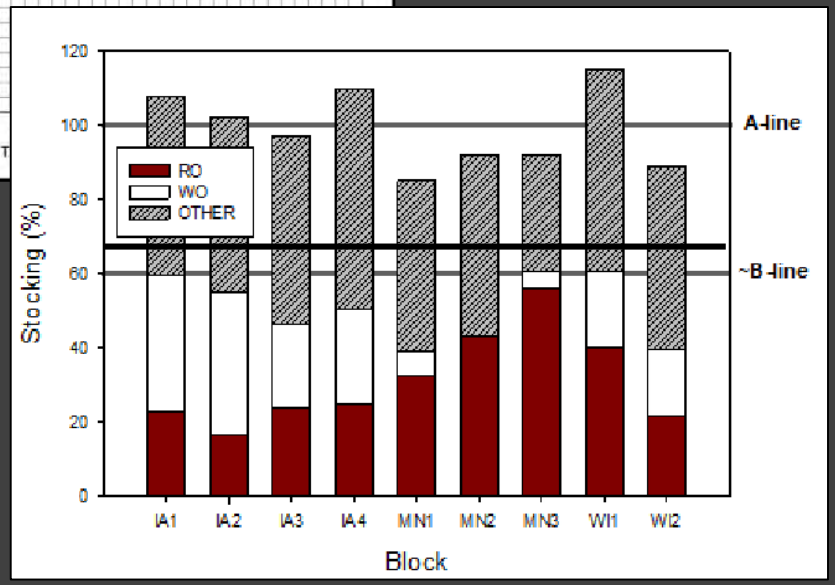
Driftless Area, IA, MN, & WI, USA

RESISTANCE Maintain relatively unchanged conditions over time

<u>DFC/Goal (near-term)</u>

- Northern red oak and white oak > 50% basal area
- Stocking maintained around 70%
- Native and sparse midstory (sugar maple, basswood)
- Maintain *potential* for future natural regeneration





Driftless Area, IA, MN, & WI, USA

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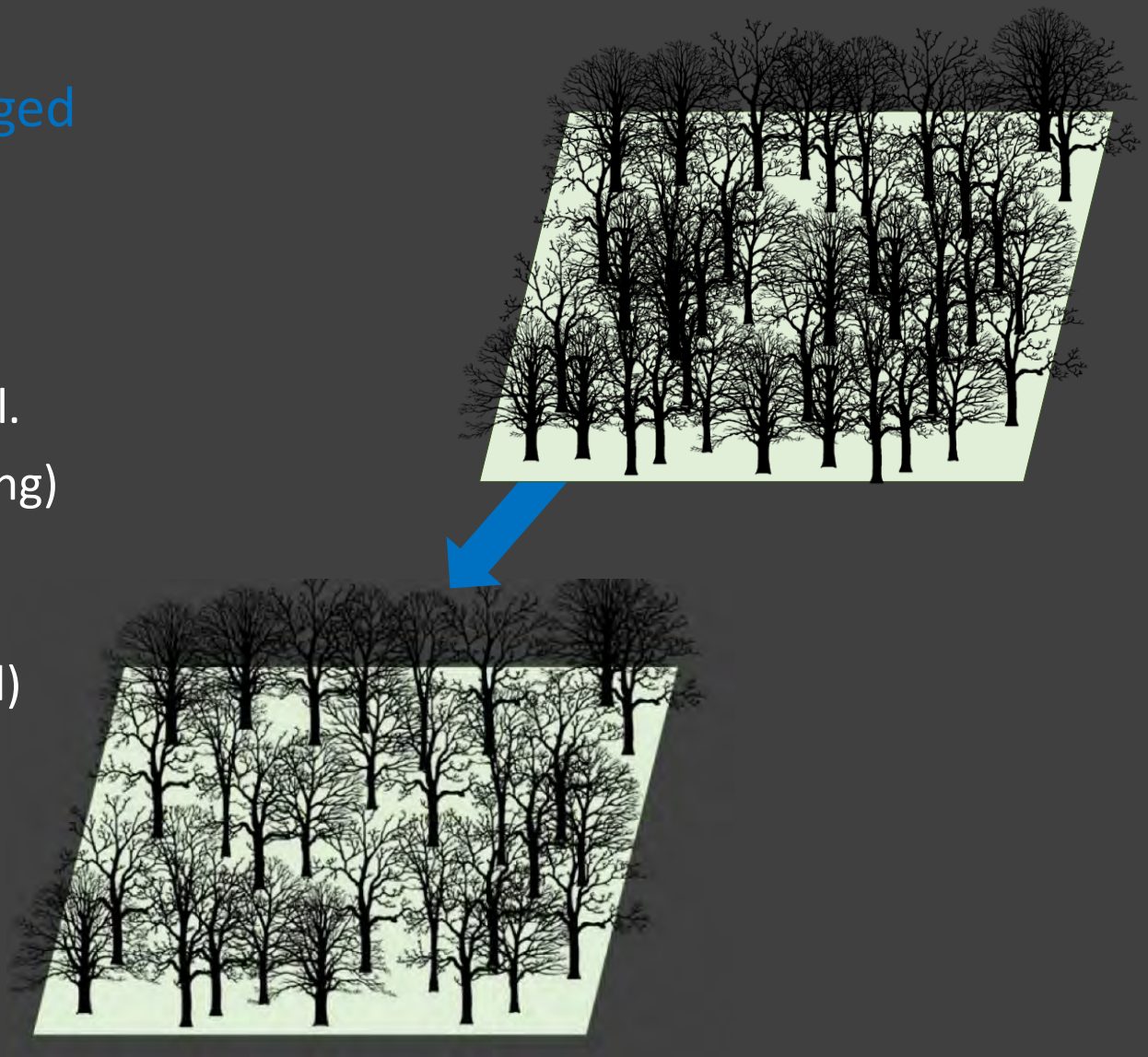
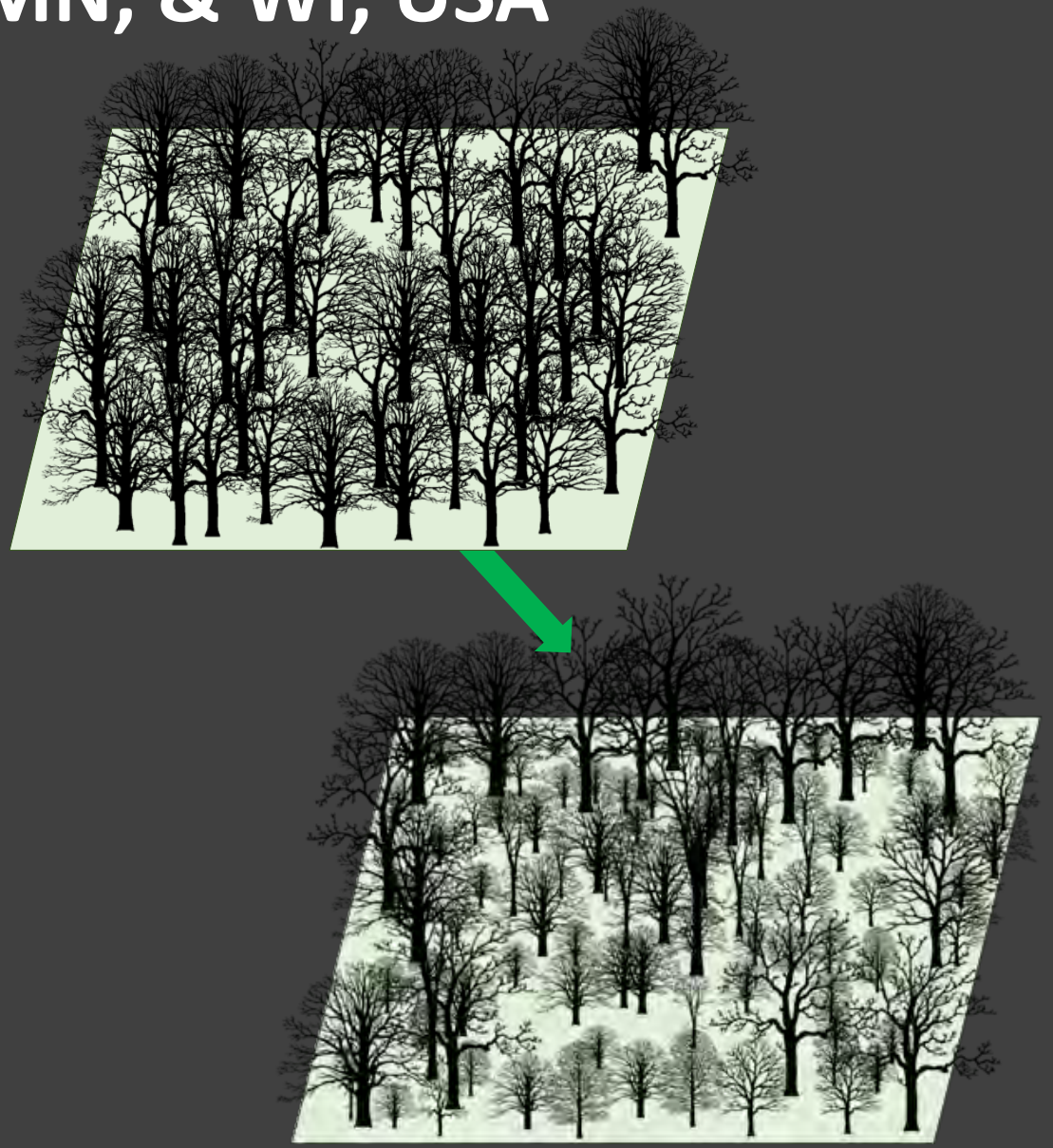


Tactics

- Invasive shrub treatment and midstory removal.
- Free thinning to just above B-line (70% stocking)
  - Prioritize species to release as follows:
    1) white oak
    2) other oak species (mostly northern red)
    3) black walnut
- Repeat thinning in future years to maintain full stocking around 70%

Driftless Area, IA, MN, & WI, USA

Resilience Allow some change in current conditions, but encourage an eventual return to reference conditions



DFC/Goal

- Two-cohort (ultimately multi-cohort) stand with greater stand-scale species, genetic, and structural diversity than current (2021) conditions
- Composition should include mast-producers that are drought, fire, frost, disease, and wind tolerant

Driftless Area, IA, MN, & WI, USA

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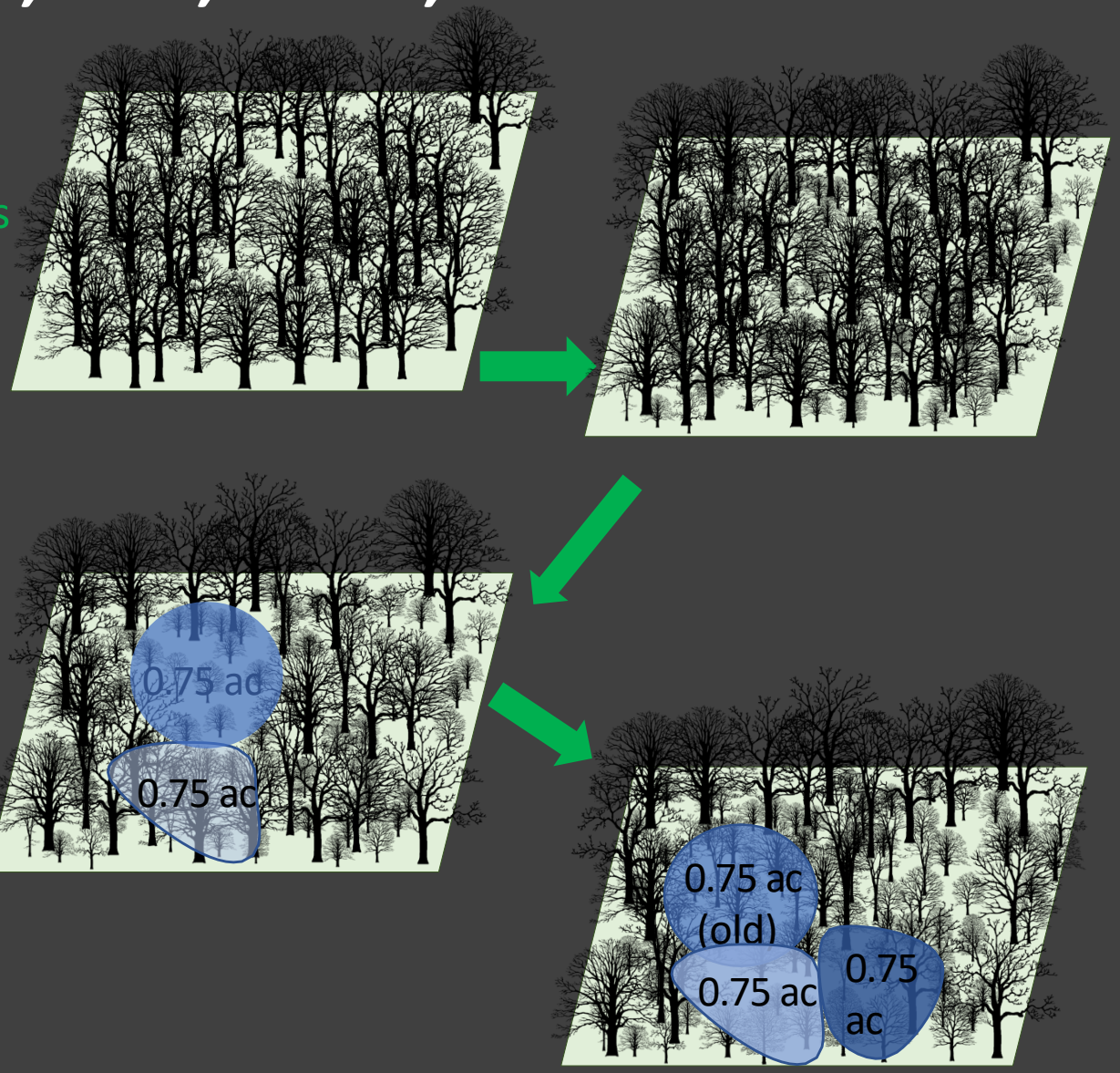


Tactics:

Continuous cover irregular shelterwood silvicultural system

- Invasive shrub treatment and midstory removal
- Prescribed fire or other site prep
- Underplant *native* intermediate, fire-adapted species
- Establishment cutting: Create three 0.75-acre openings
  - Retain 1 tree in each gap
  - Plant additional native seedlings, including shade intolerants in gaps
- Remove overstory (with retention) in patches where overstory cover was reduced to 40- 50% in initial harvest entry. Create new gaps to release advance regeneration.

Driftless Area, IA, MN, & WI, USA

Resilience

Treatment suummary

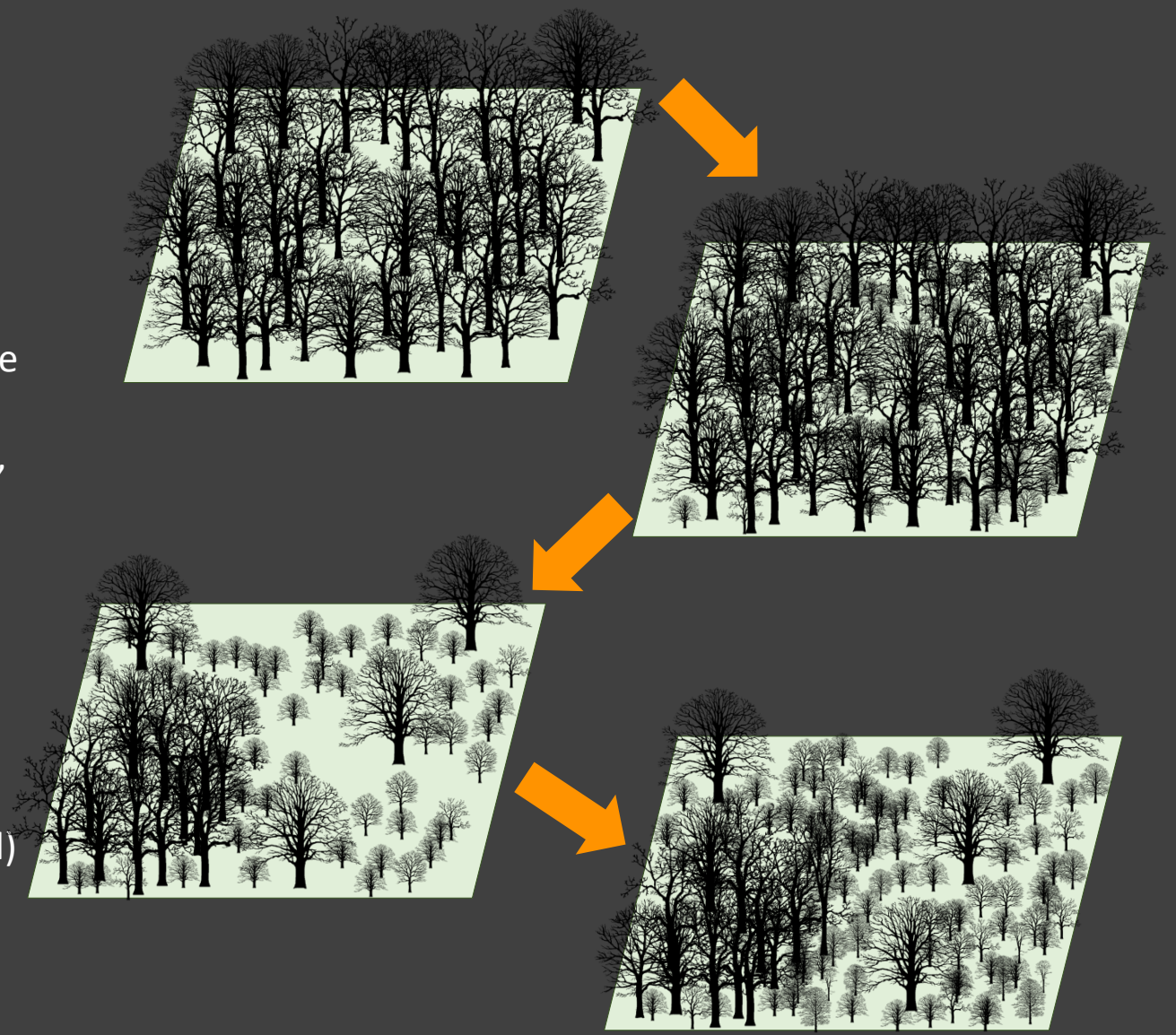
Continuous cover irregular shelterwood with

- 0.75 ac gaps (with 1 tree/gap retained),
- 0.75 ac patches with 40-50% cover
- Free thin matrix to ~70% stocking
- Plant drought, frost, & fire tolerant, disease- & wind-resistant species

Resilience species	Underplanted 2023
- Chinkapin oak	- Bur oak*
- White oak*	- Shagbark hickory
- Northern red oak*	- Black oak
- Black walnut*	- Black cherry

Driftless Area, IA, MN, & WI, USA

Transition Actively facilitate change to encourage adaptive responses



DFC/Goal

- Two-cohort stand with future-adapted species that are projected to have future habitat suitability in the Driftless Area
- Tree species should have greater drought tolerance, heat tolerance, disease resistance, and fire adaptability than other treatments
- Invasive species absent or minimal

Tactics

Clearcut with reserves silvicultural system

- Invasive shrub treatment and midstory removal
- Underplant with future-adapted species
- Retain 20% overstory (2 acres in each 10 acre stand) in clumps (0.25-0.5 acre)
- Plant future-adapted species after harvest

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