Managing for Species Migration Due to Climate Change: Myth or Reality?

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United States Department of Agriculture

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Outline

- Overall theme: is this a question of general approach?
- Review historical ecological forestry approaches
- Alternatives/complements to assisted migration
  - Timing
  - Stand structure
  - Species mix
- Assisted migration: moving species vs. seeds
- Application to uneven-aged management

Overview of climate change impacts in California forests

Insect outbreaks

Elliot Ranch Levels of Growing Stock Study in 2022, Tahoe National Forest

Severe wildfires

Unthinned stand post-Antelope Fire, Goosenest Adaptive Management Area

Drought

Multiple plantings into Bald Fire, Lassen National Forest

Two approaches to climate change adaptation

Ecological forestry

Chippewa NF ASCC, Minnesota. Most silviculture for climate change research is an outgrowth of ecological forestry

Intensive forest management

Whitmore, CA second rotation Garden of Eden study site

Ecological Forestry

Timing

"High Diversity" treatment, Blacks Mountain Ecological Research Project

Continuity

Retained fir seed trees, Swain Mountain Experimental forest

Complexity

Variable density thinning study, Stanislaus-Tuolumne Experimental Forest

Ecological forestry for climate change

Promote change

Facilitate change to future-adapted condition

Transition

Variable density thin/ Irregular shelterwood. Image Credit: Peter Clark, UVM

Return to initial state following disturbance

Resilience

Single tree selection plus group selection. Image Credit: Tony D'Amato

Resist change

Resistance

Single tree selection. Image Credit: Tony D'Amato

Adapted from Nagel et al. (2017)

Ecological forestry for climate change: limitations

- May not consider economics
- Longer rotations
- More reliant on assisted migration
- Uneven-aged management
- Less likely to apply all the tools

Adaptive Silviculture for Climate Change "Transition" treatment, Chippewa NF, Minnesota

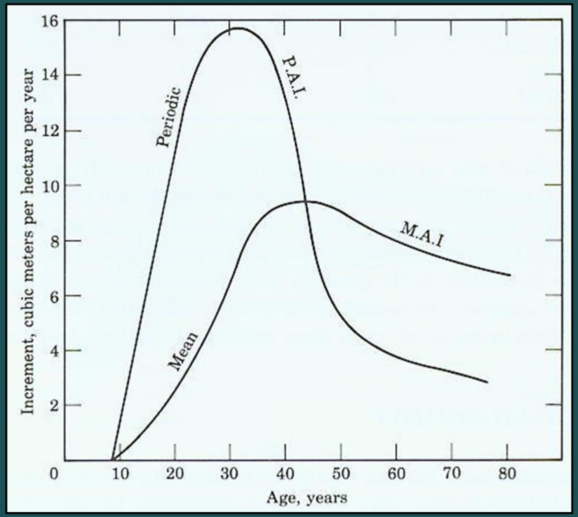
Climate change adaptation: what is it made of?

Assisted migration

United States Department of Agriculture

Climate change adaptation: what is it made of?

Assisted migration



Timing

Structure

Species mix

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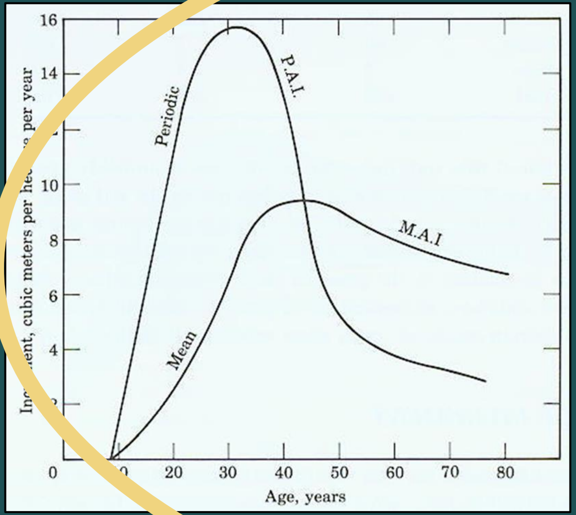
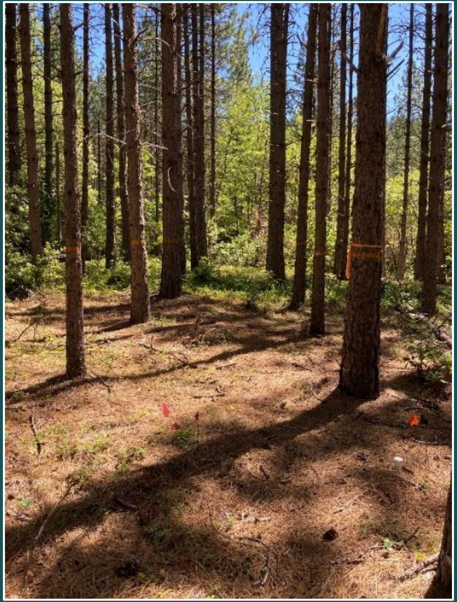
Climate change adaptation: what is it made of?

Assisted migration



Timing

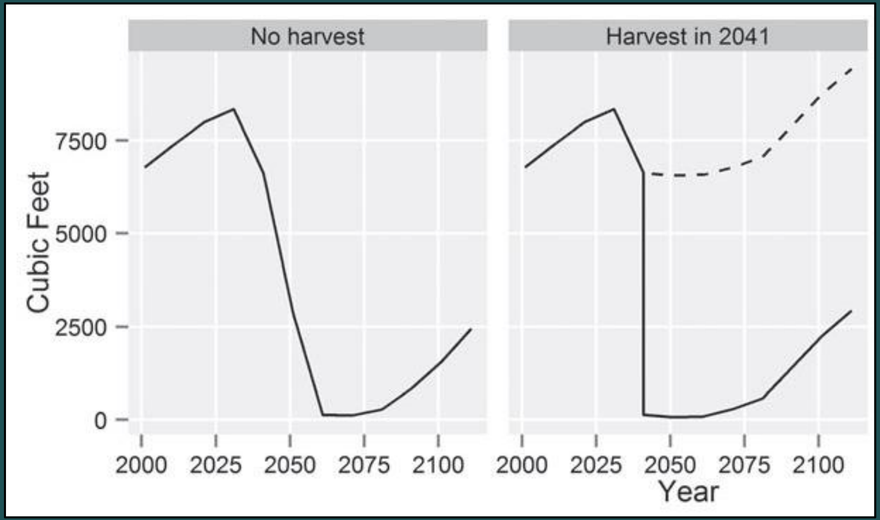


Structure

Species mix

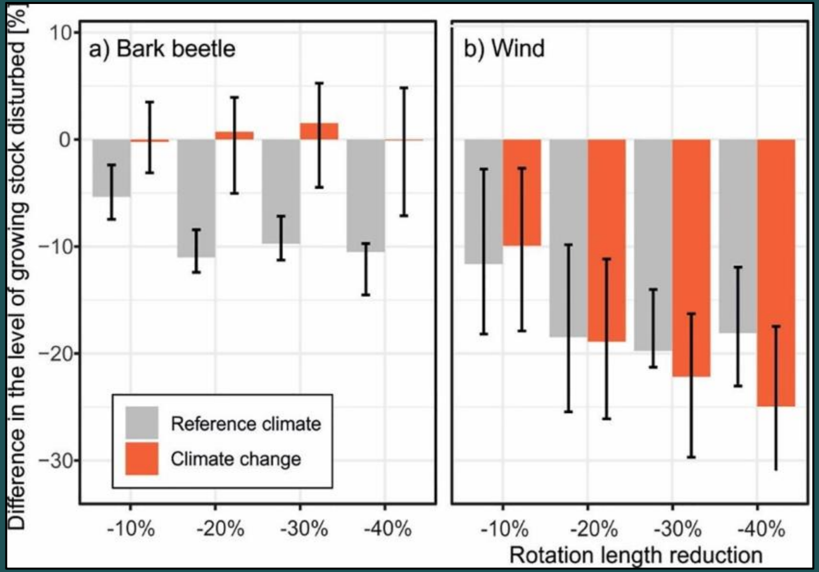
Intensive management: an alternative approach to climate change?

Harvesting and replanting with adapted stock could avoid mortality



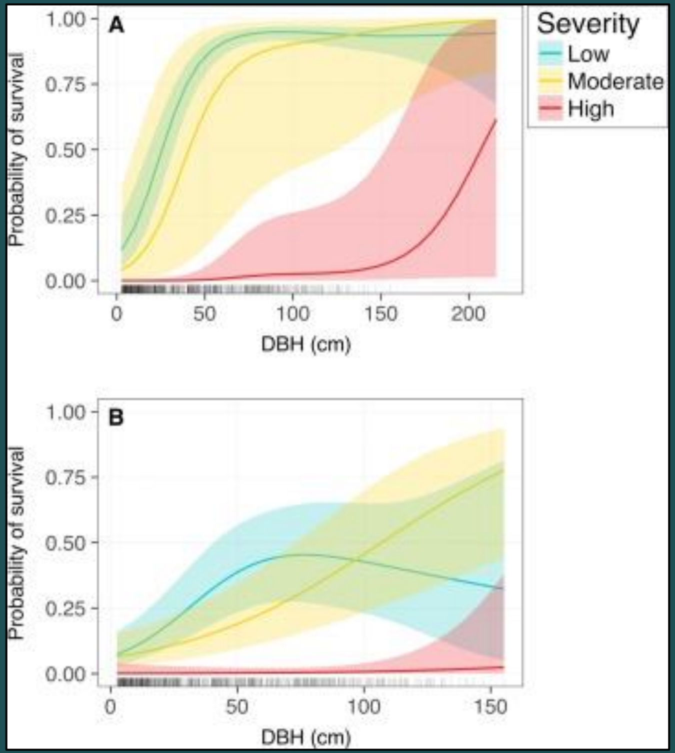
Climate-FVS simulations of unmanaged (left) of managed (right) vs. live volume under changing site quality. From Crookston, 2014.

Earlier rotations could reduce risk



From Zimova et al., 2020. Shortening rotations could mitigate disturbances

California context: grow trees fast for fire resistance



Tree survival increases with DBH
For intolerants (top) and tolerants (bottom). From Johnston et al. 2019

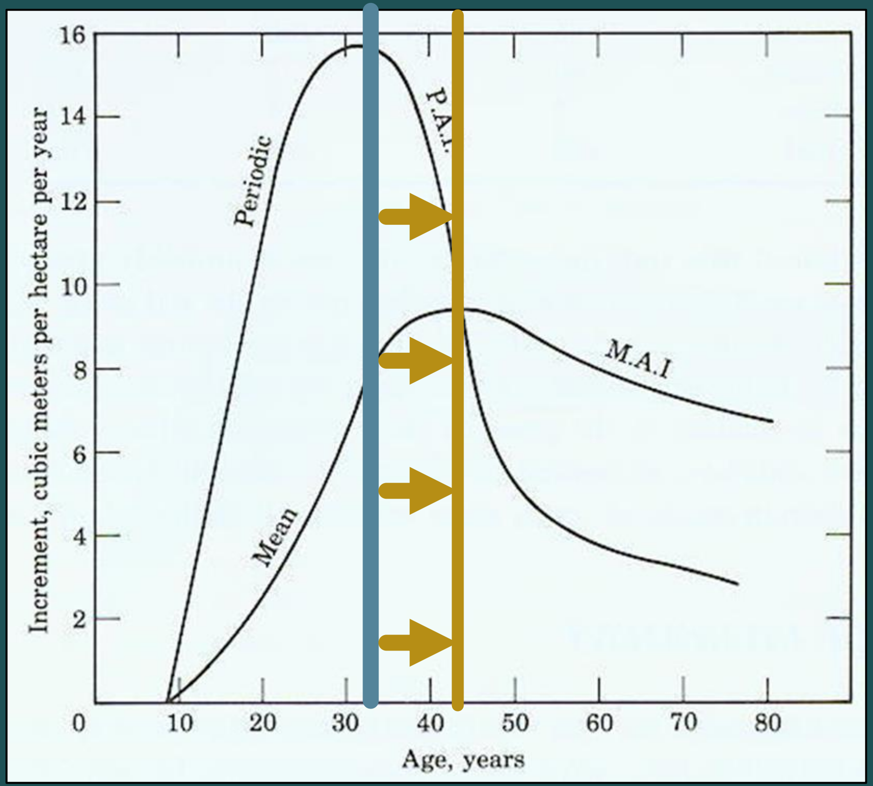
Managing for higher mean tree size might reduce landscape fire risk

Thinned red/white fir group selection stand survived Dixie Fire, Swain Mountain Experimental Forest

California context: grow trees fast for fire resistance

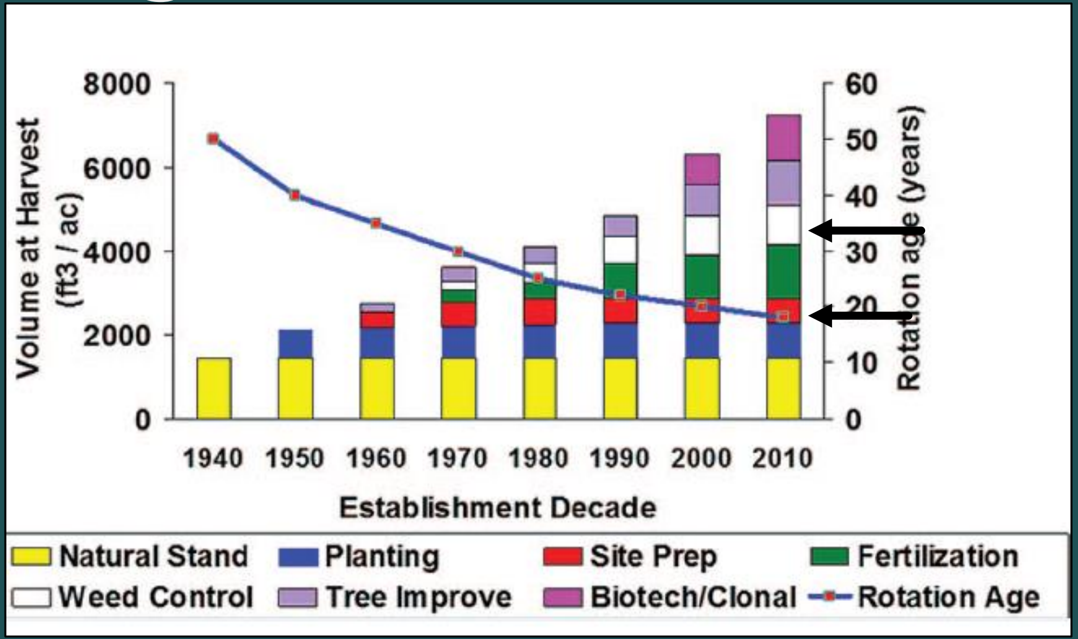
Instead of reducing rotation ages, consider:

- Could we improve growth and yield but maintain rotation age?
- Rotate at biological maturity?



Stand-level volume increment over age

Accelerating forest recovery: competing vegetation control



Site prep and vegetation control have driven major reductions in rotation age. From D'Amato et al. 2018

Herbicide (left) vs. site prep only, (right), Pondosa, CA

Competing vegetation control: benefits under climate change

Reduce fuels

1960s brushfield conversion study burned in 2021 Dixie Fire, Swain Mountain Experimental Forest

Promote survival under drought

Second rotation Garden of Eden experiment minimizing shrub competition Feather Falls, CA

Planting spacing

New opportunities and challenges

Challenge Initial Spacing Study

Wide spacings and poor vegetation control…

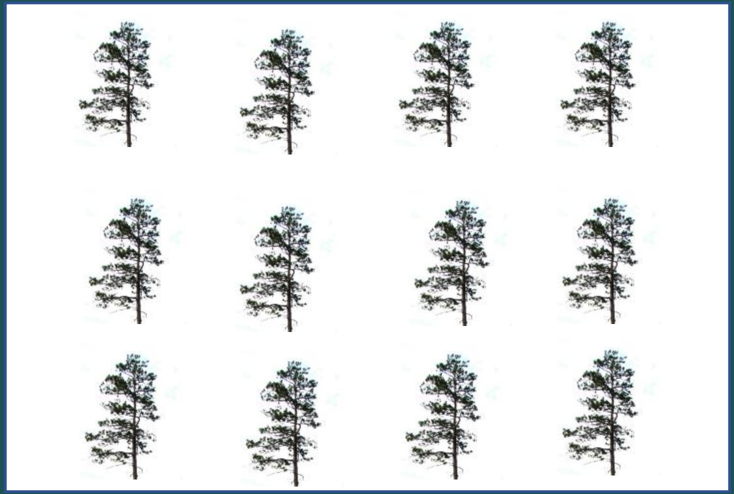
Herbicide demonstration site, CA

Planting arrangement

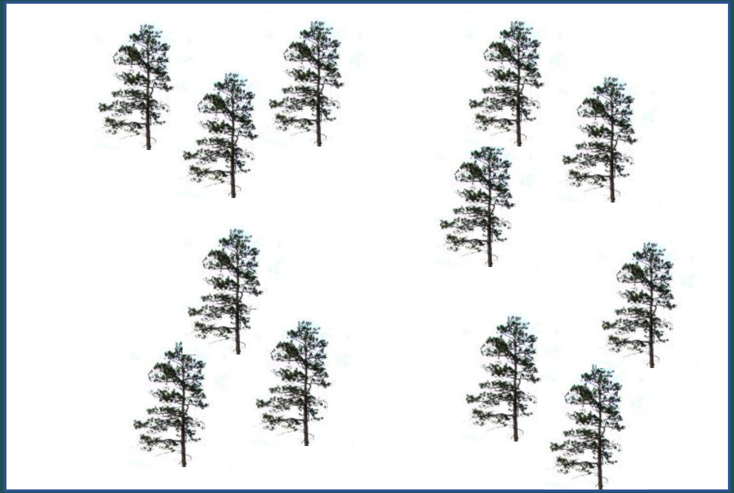
Cluster planting

Eiler Fire scar, Lassen NF

Traditional planting



Cluster planting

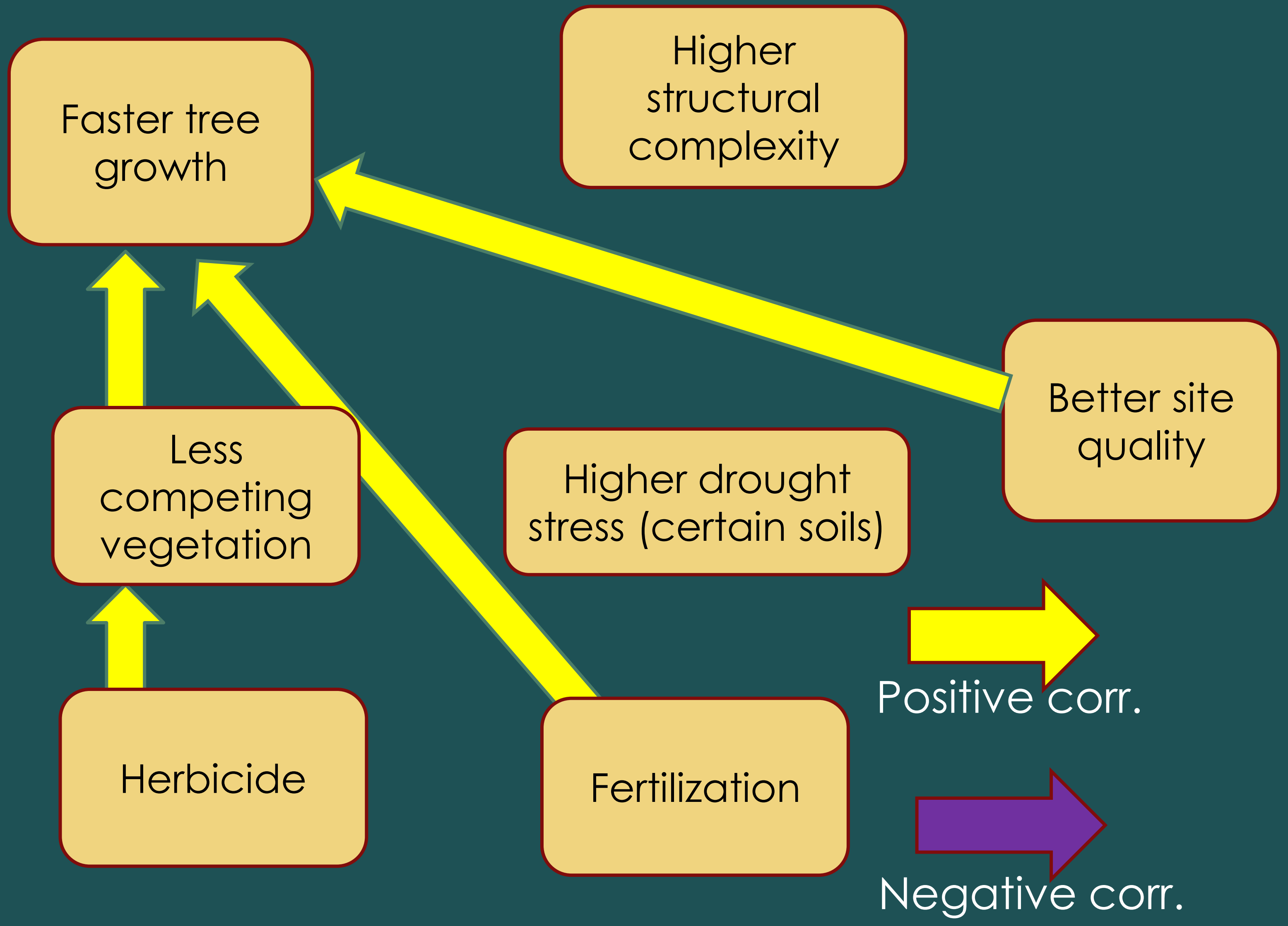


Garden of Eden study

- Established by Bob Powers in 1985-1987
- Examined herbicide, fertilization, herbicide + fertilization effects
- Replicated over broad range of soil types

Experimental replicate
H=herbicide, F=fertilization, C=control

Structural complexity during planting: probably not a great idea



Adapted from Looney and Zhang (2022)

Structural complexity during planting: probably not a great idea

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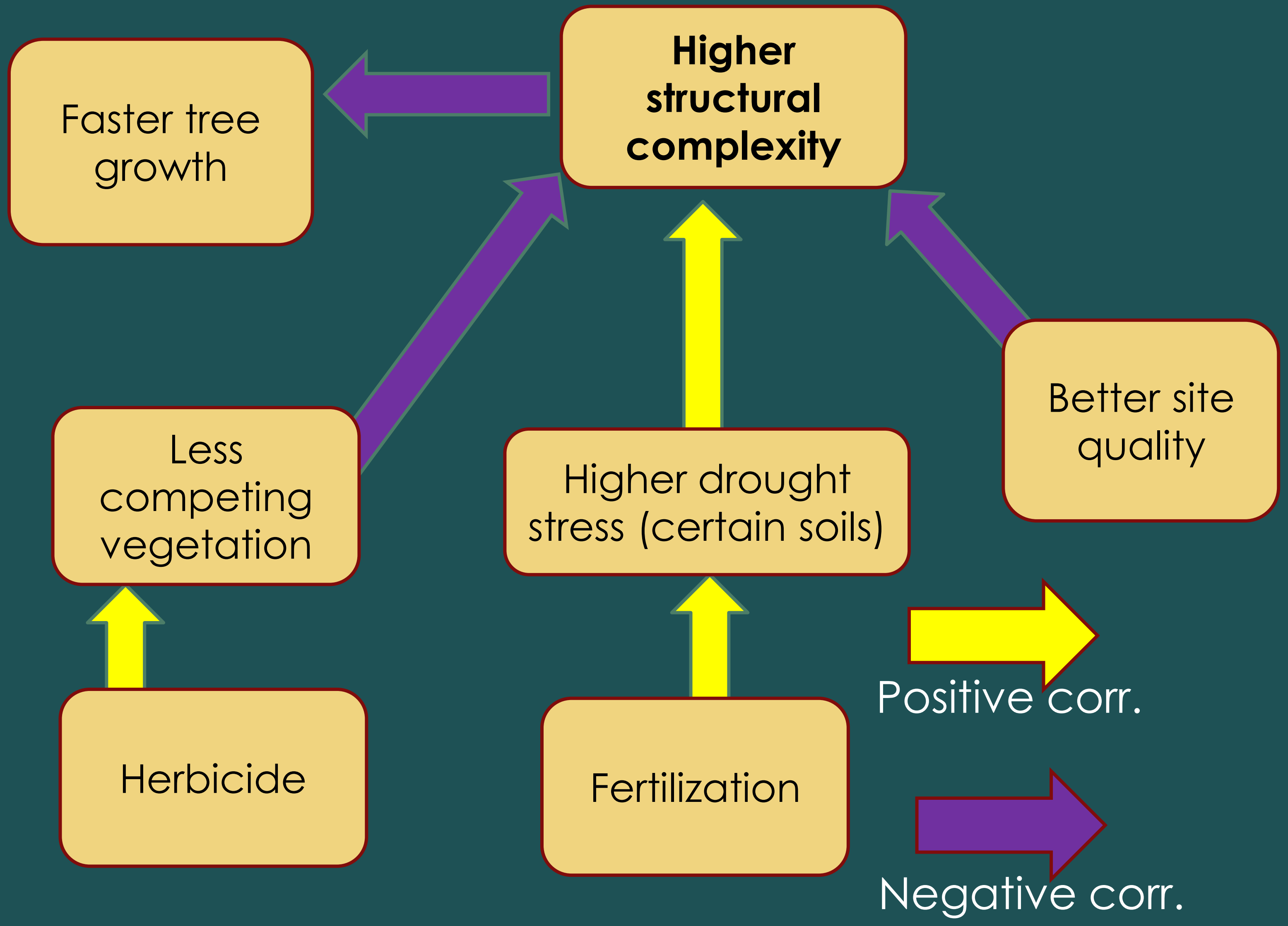
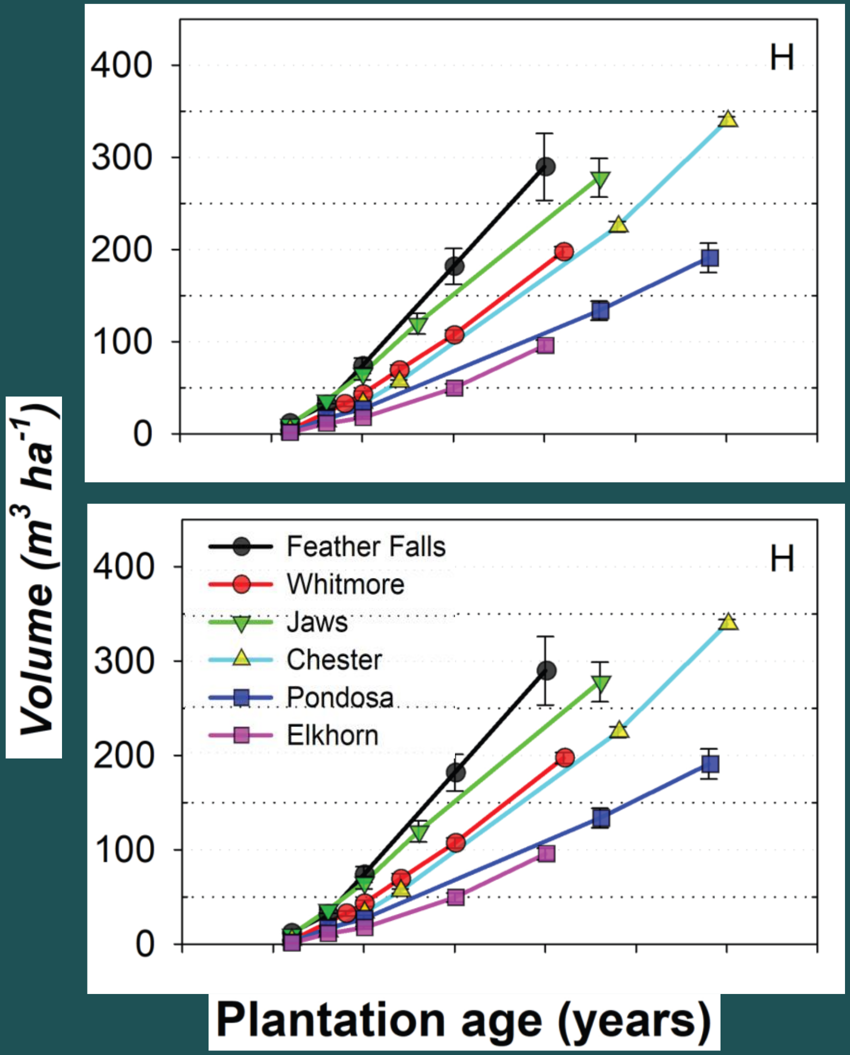


Early rotation fertilization



Garden of Eden study:
Fertilizer + herbicide

…vs. herbicide-only

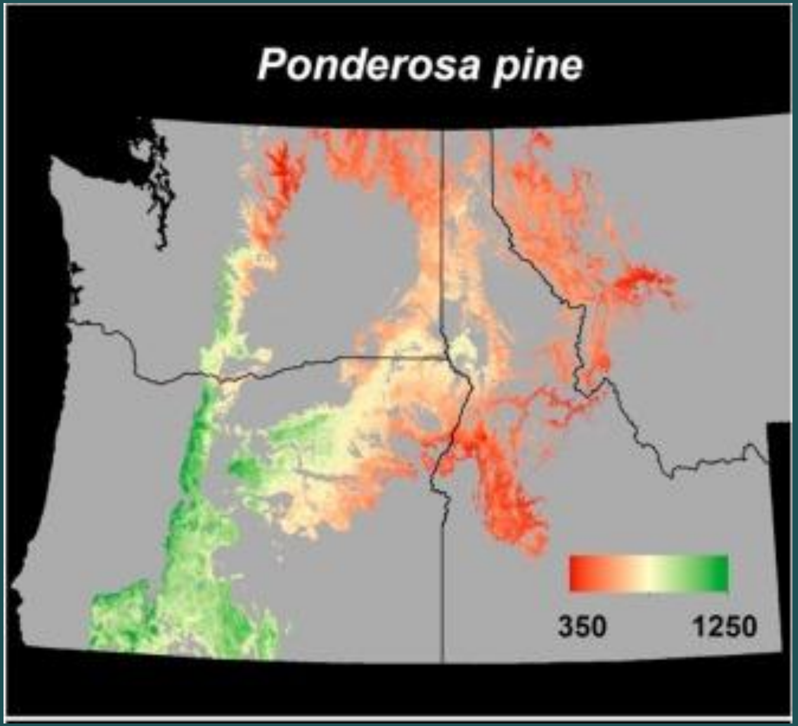
From Zhang et al.,
2022

Challenge Initial Spacing Study

Lower planting densities: has the time for early rotation fertilization arrived?

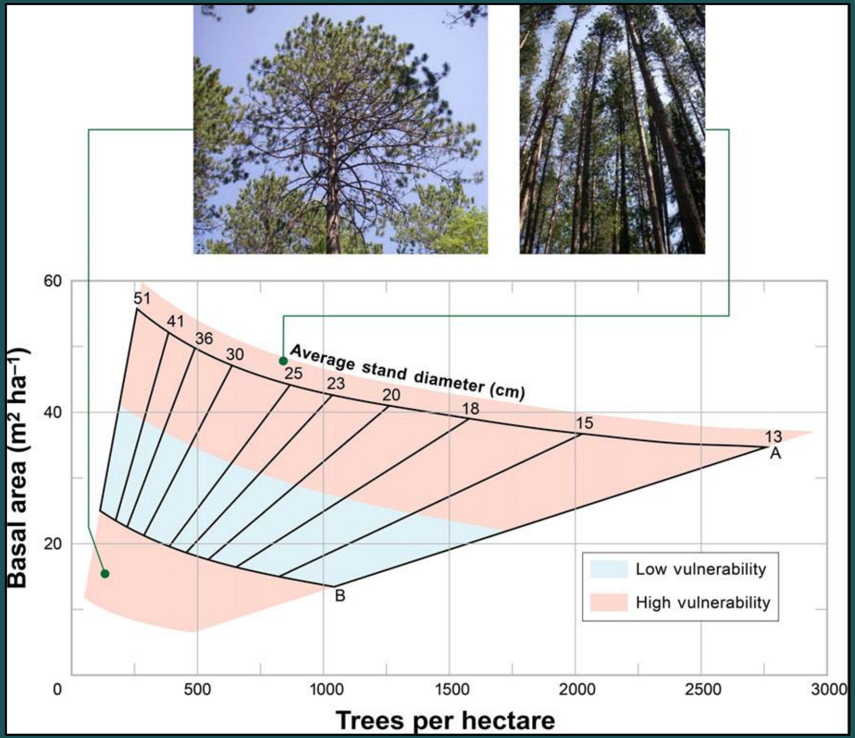
Stocking under climate change

Max SDI may change with climate



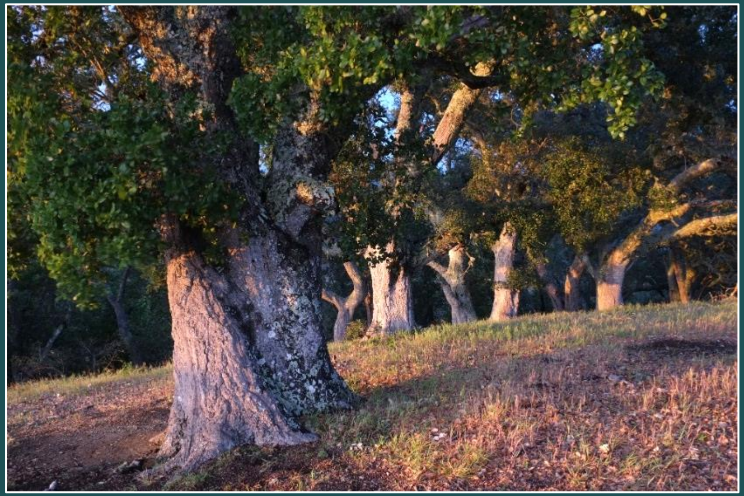
From Kimsey et al. 2019. Max SDI varies for ponderosa pine in PNW

Both low and high stocking may be risky



From Clark et al. (2016). Gingrich chart showing hypothesized low-risk zone

Mixed-species stands: benefits for sustaining productivity?



Facilitation

Oak species may sustain neighbors through hydraulic lift

Competition Reduction

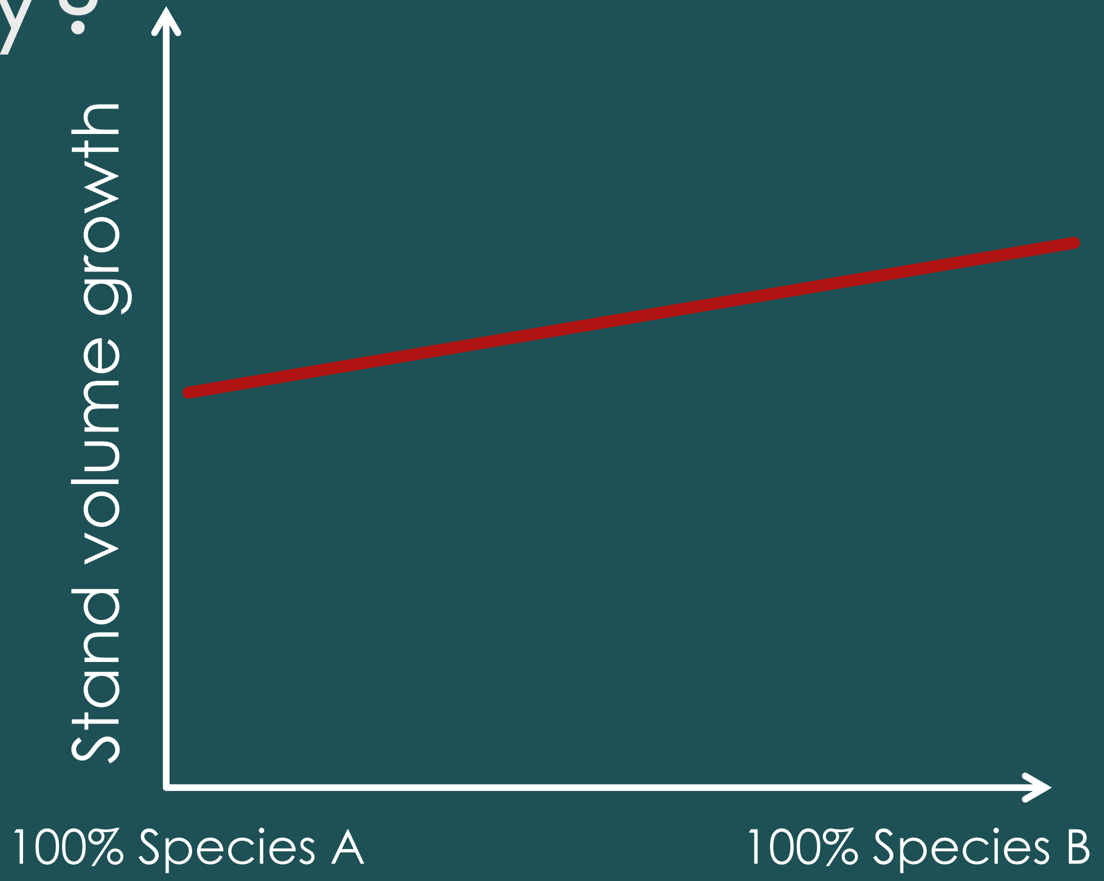
Mixed crown shapes: promote efficient light use

Reduced disease problems

Near-total loss of ponderosa overstory to beetles

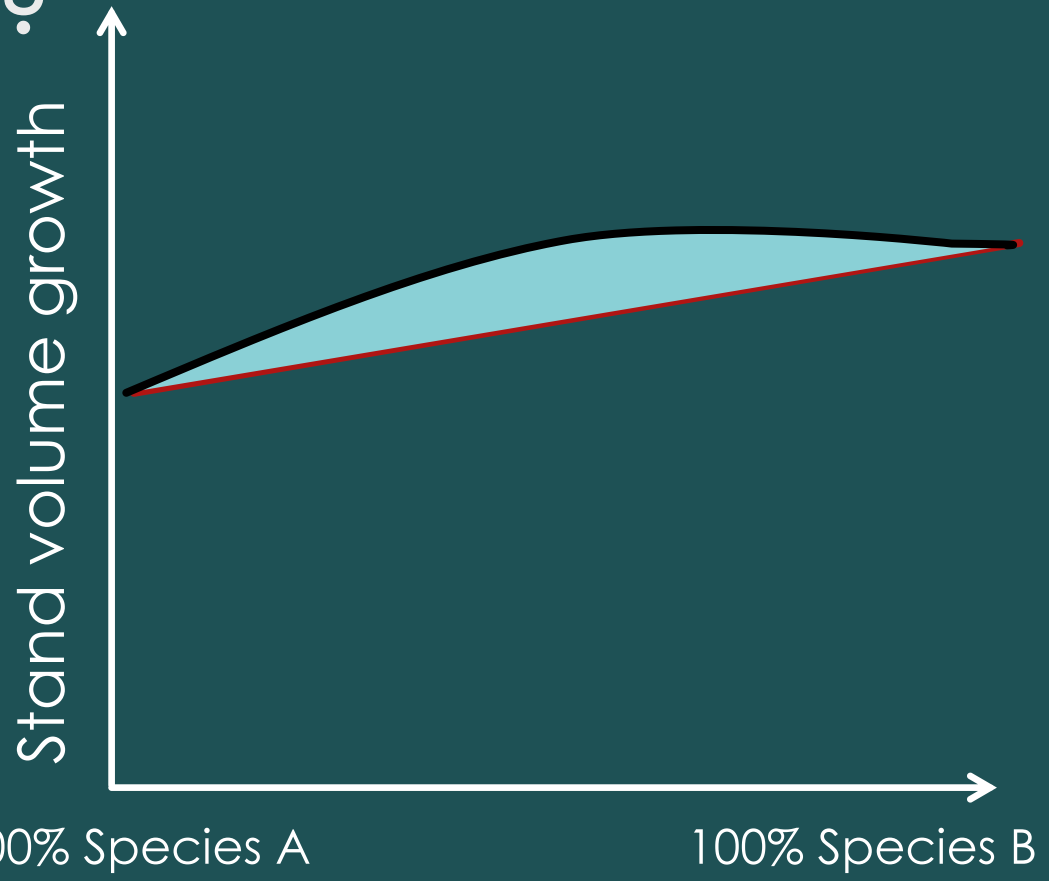
Mixed-species stands: benefits for sustaining productivity?

Mixed crown shapes use space, light more efficiently. Kakabeka Falls, Ontario



Mixed-species stands: benefits for sustaining productivity?

Mixed crown shapes use space, light more efficiently. Kakabeka Falls, Ontario



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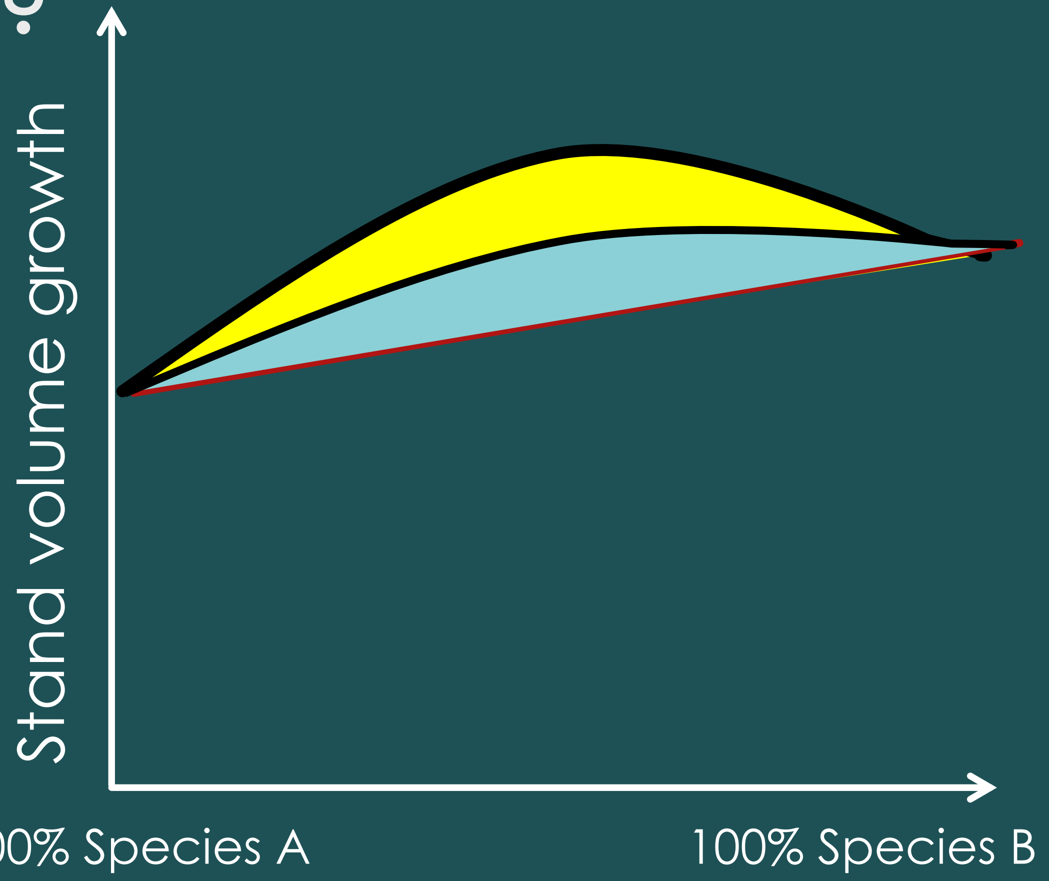

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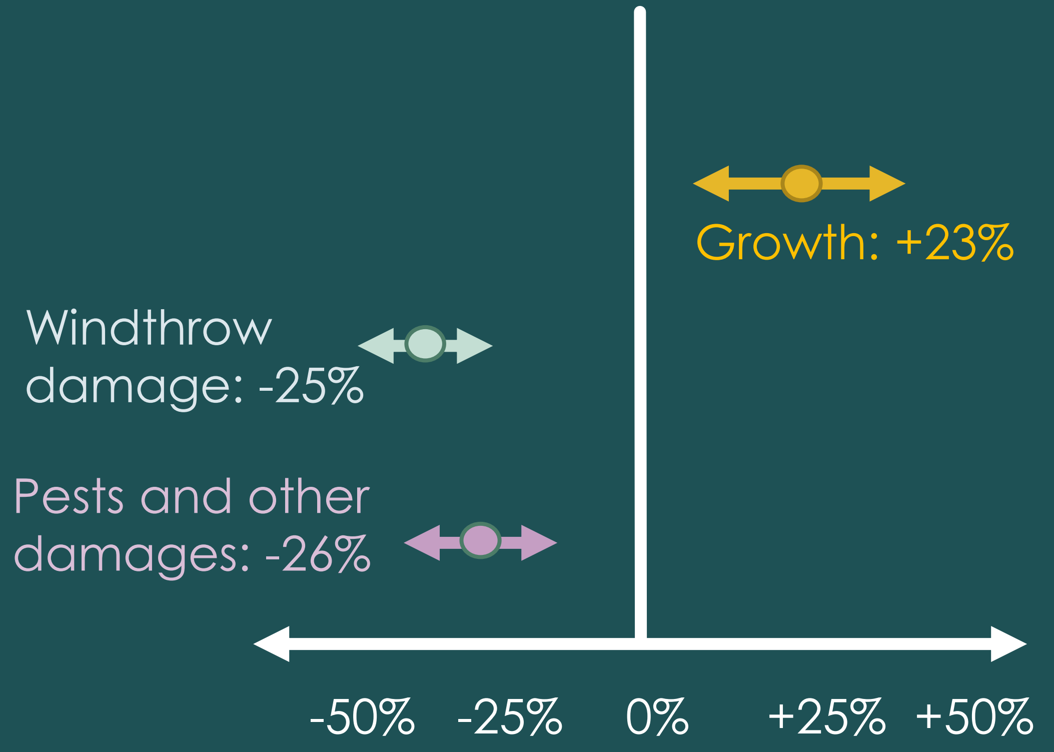
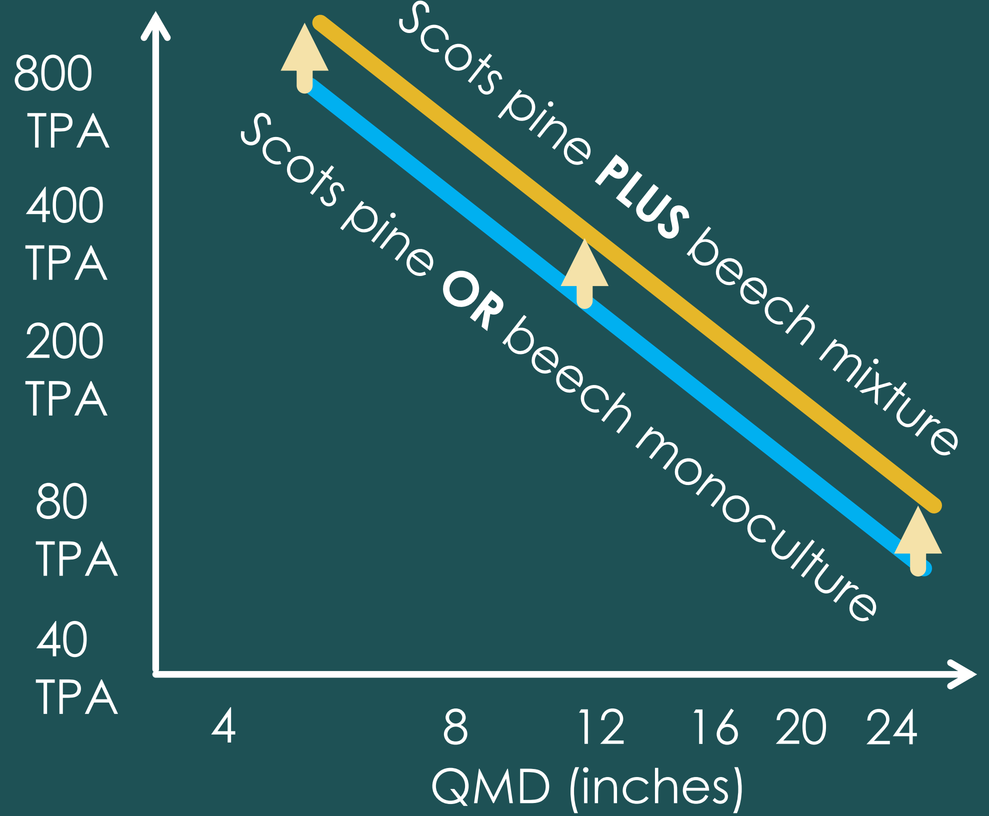
Mixed-species stands: benefits for sustaining productivity?



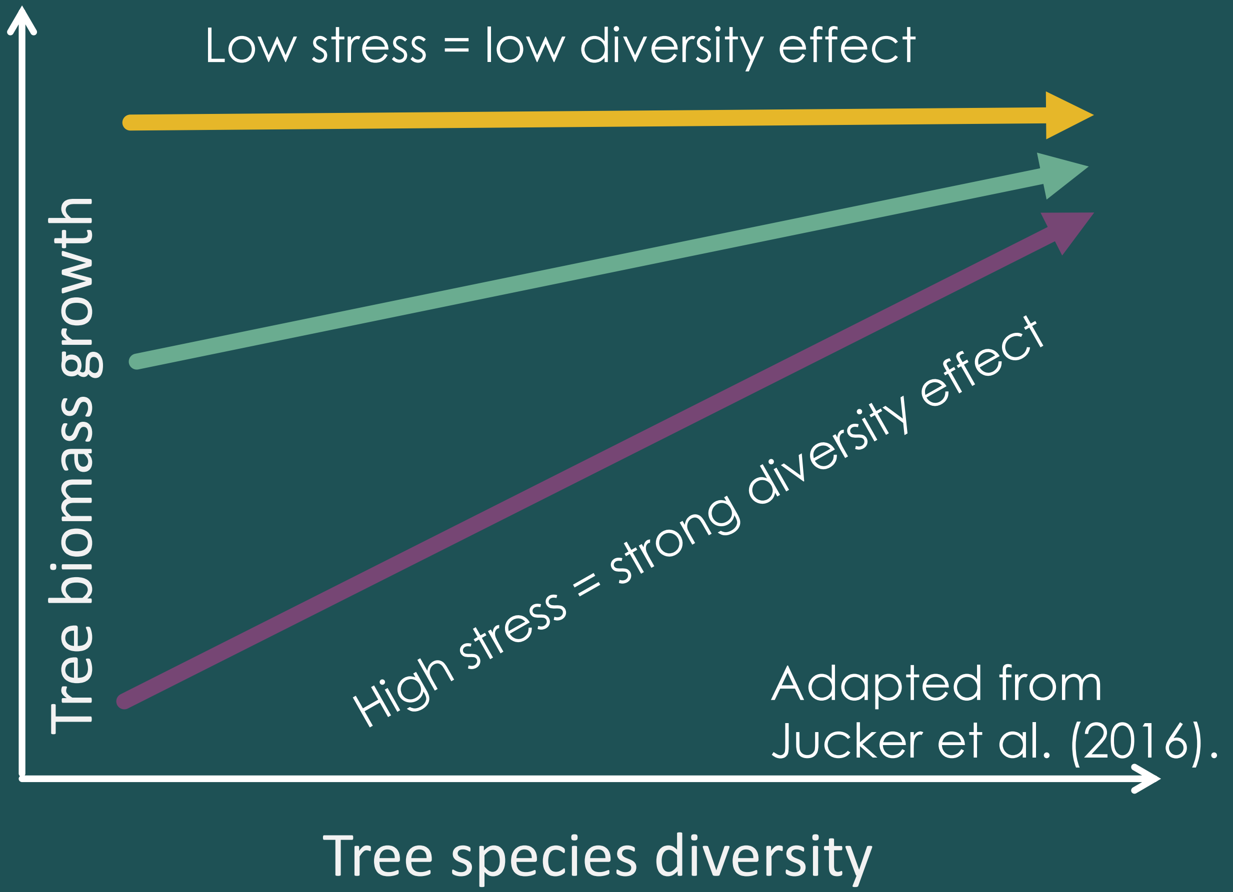
Adapted from Griess and Knoke, 2011



Adapted from Pretzsch et al., 2019

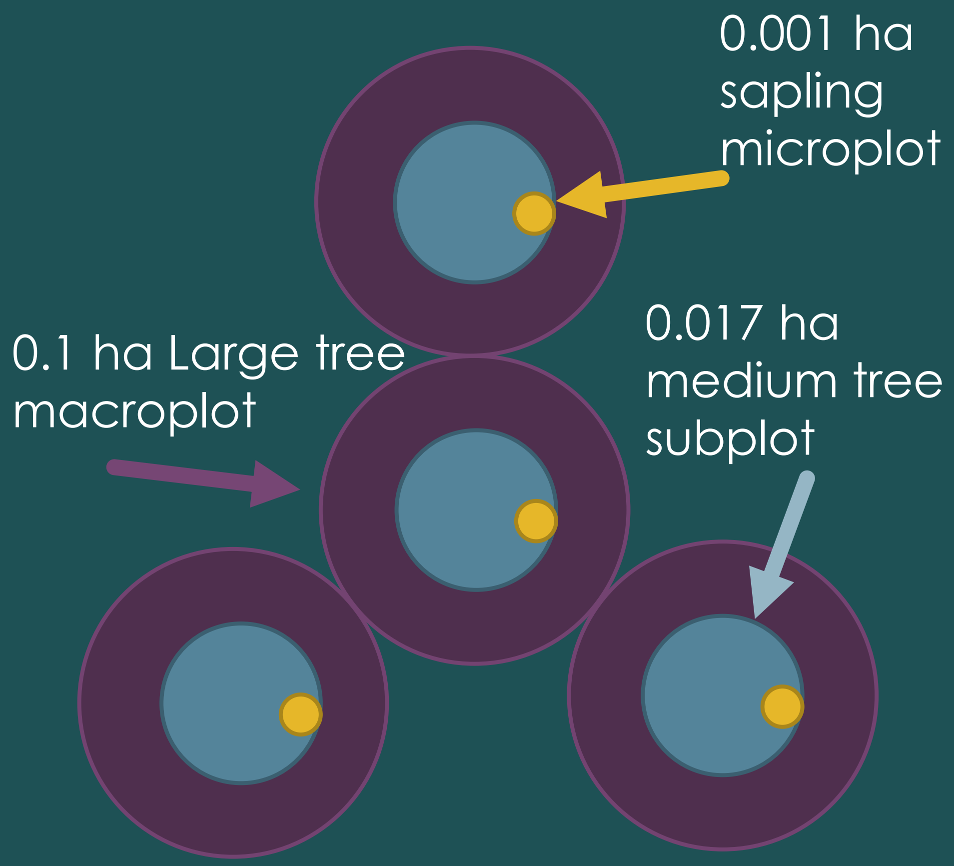
Mixed-species stands: benefits for sustaining productivity?

Differences in snow interception, rooting depth could help during droughts

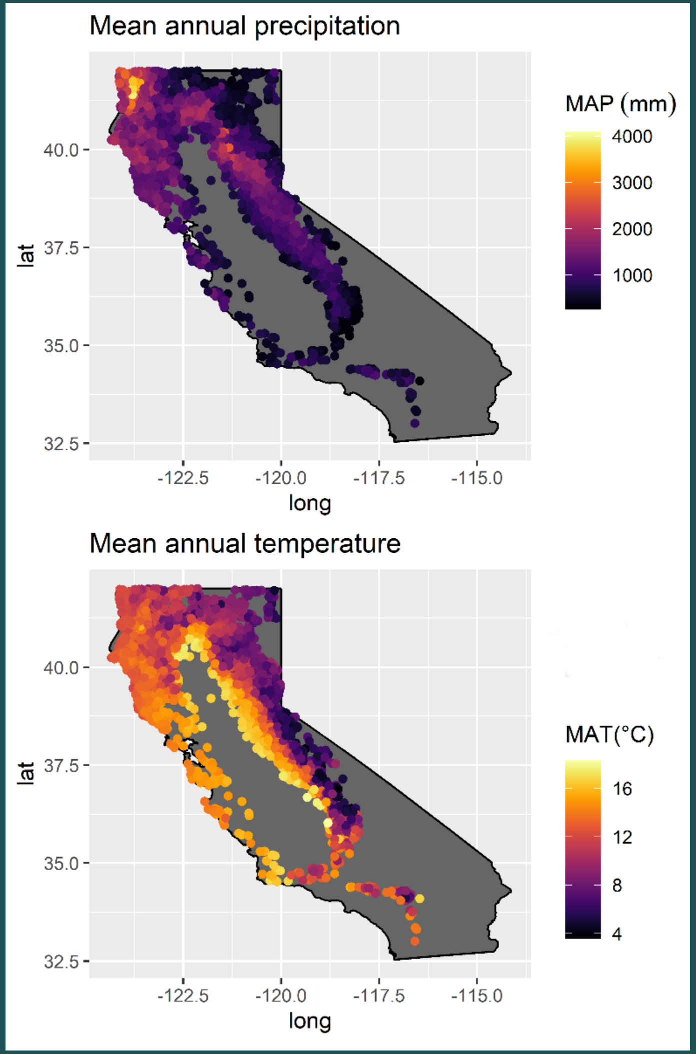


Adapted from Jucker et al. (2016).

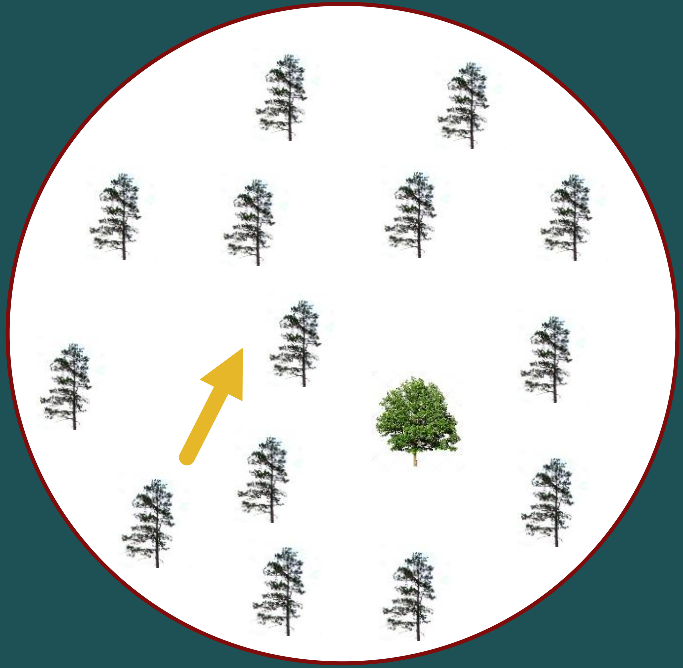
Preliminary results from FIA data



FIA nested subplot design
Adapted from Bechtold and Peterson (2005)



Quantifying diversity



Subplot/macroplot with 100% low dissimilarity

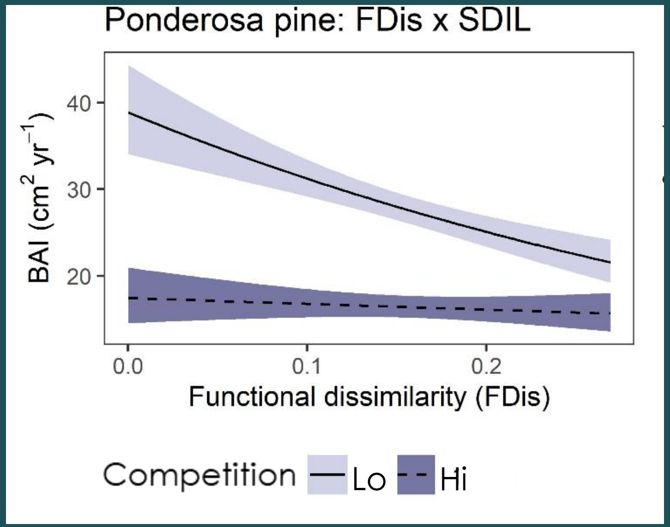
Subplot/macroplot with high dissimilarity

Trait	Category
Fire strategy	Disturbance ecology
20yr height	Disturbance ecology
Bark thickness	Disturbance ecology
Mature height	Competitiveness
Wood spec. gravity	Life strategy
Crown shape	Effect on light environment
Evergreen status	Effect on light environment
Shade tolerance	Stress tolerance
Fertility req.	Stress tolerance
Drought tolerance	Stress tolerance
Mycorrhizae type	Effect on soil resources

Mixed-species stands: early results from FIA data across California

Ponderosa pine

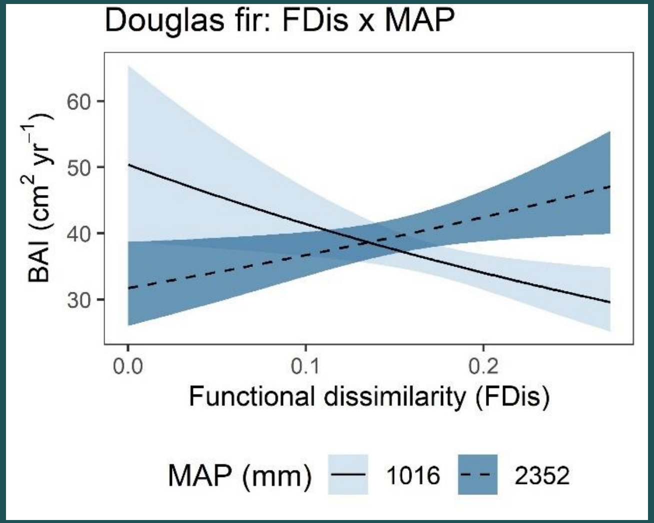
Basal area increment



Less diverse more diverse

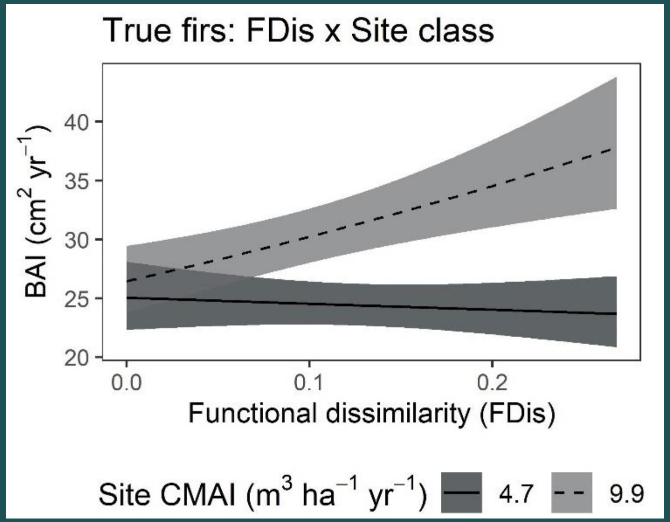
Growth poorer in diverse stands under more open conditions

Douglas-fir



Growth better in diverse stands only on moist sites

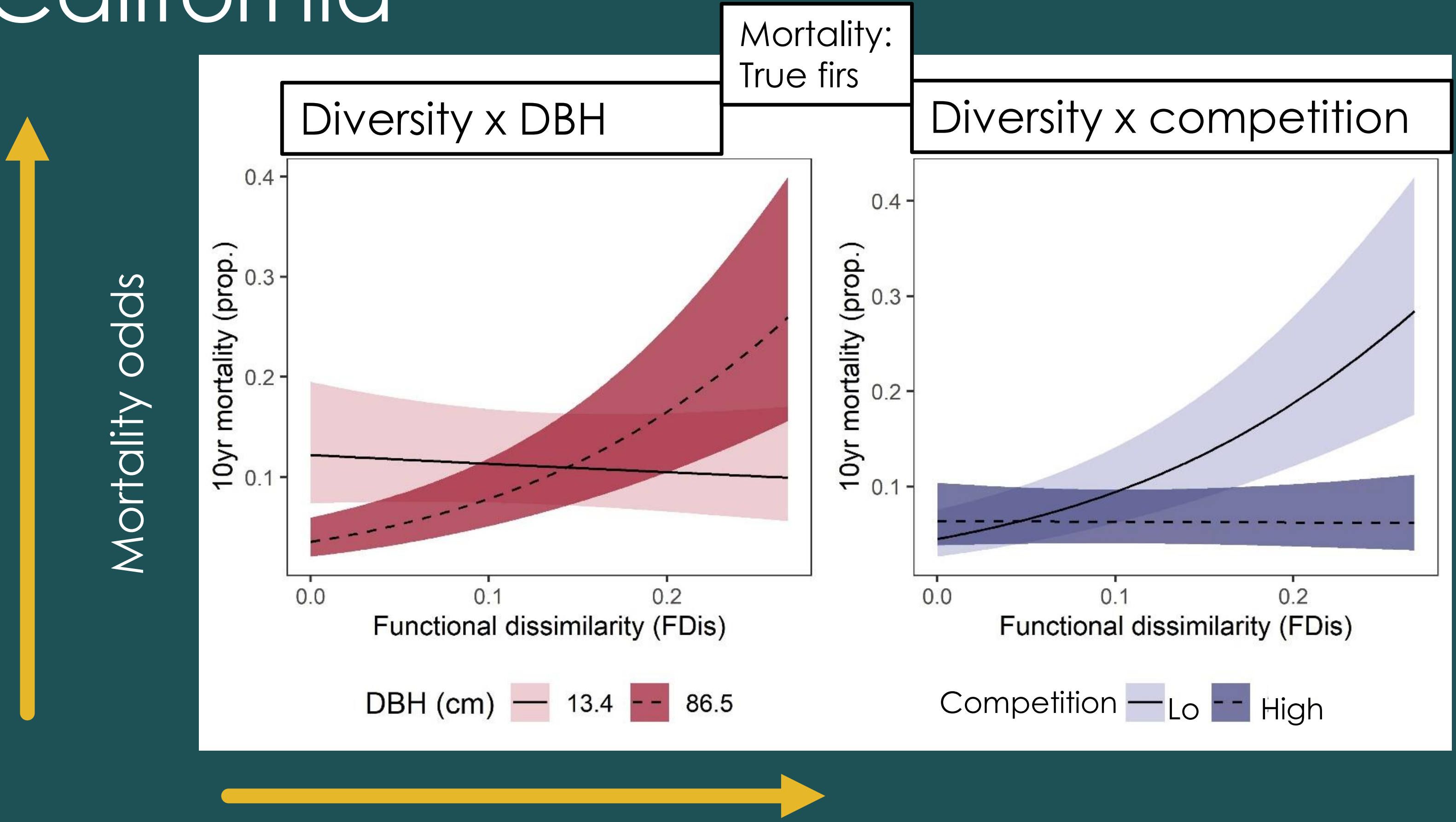
True firs



Growth better in diverse stands only on high site class sites

Mixed-species stands: early results from FIA data across California

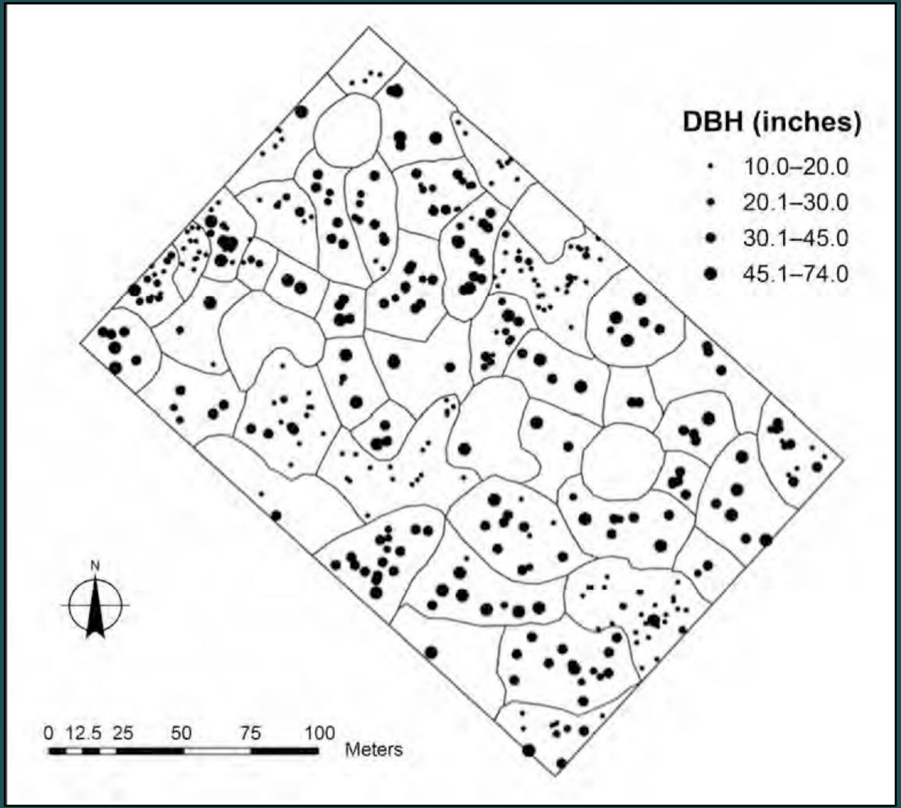
- Less evidence of effect on mortality
- Only for true firs
- Faster stand development?



Mixed-species stands: early results from FIA data across California

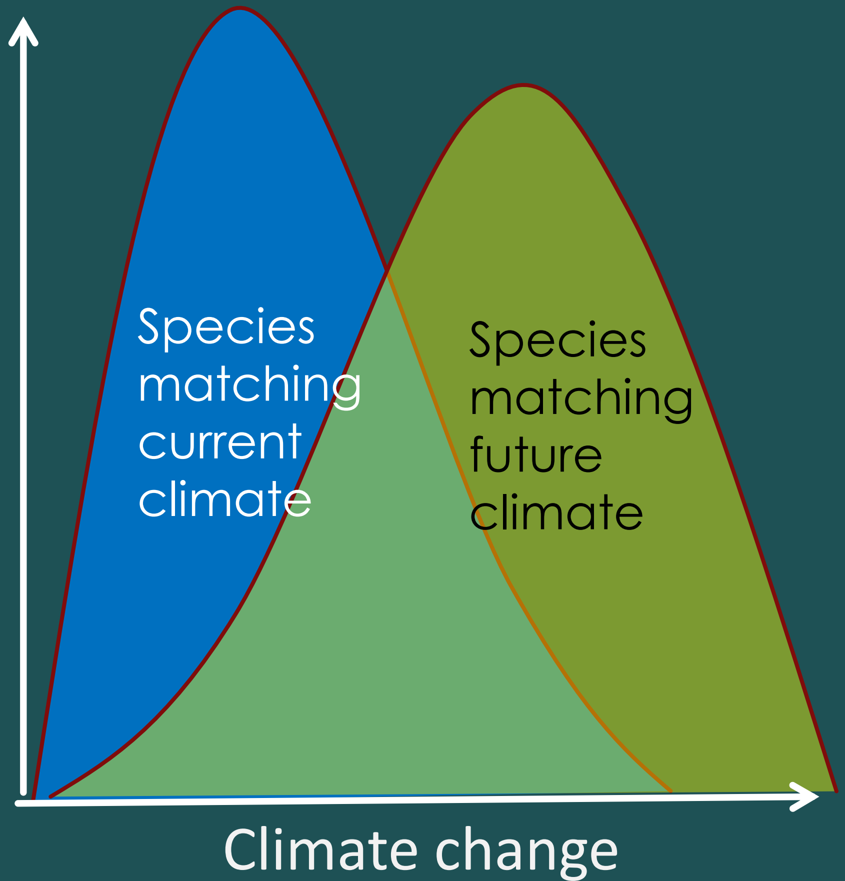
- May be hard to balance species
- Need to consider both composition and density in thinning
- Positive effects may weaken under climate change

Mixed-species stands: early results from FIA data across California



From Knapp et al. (2012). Methods of Cutting
Stem map showing 1929 reference conditions

Assisted migration of species



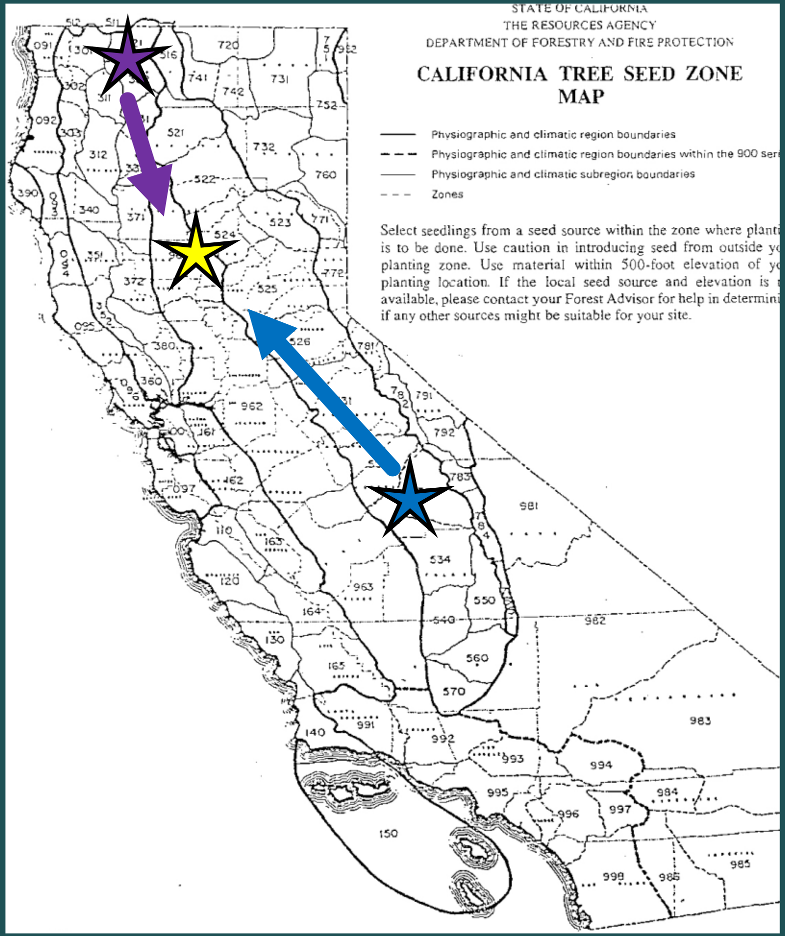
Adapted from Brown et al. (2019)

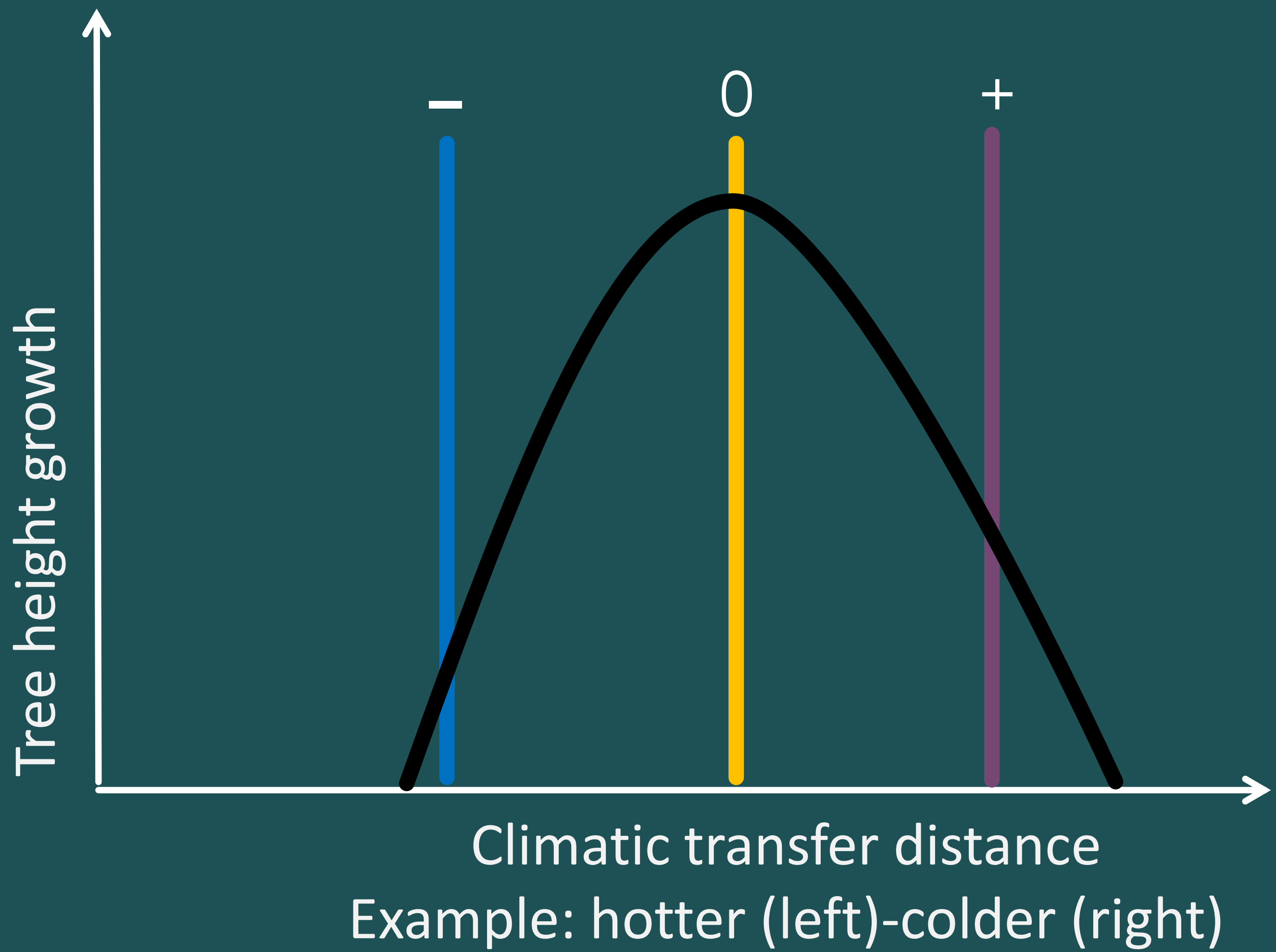
Assisted migration, Chippewa NF, Minnesota

58 year old KMX pine plantation, Trinity Alps, 2022. A prime example of poor acclimation

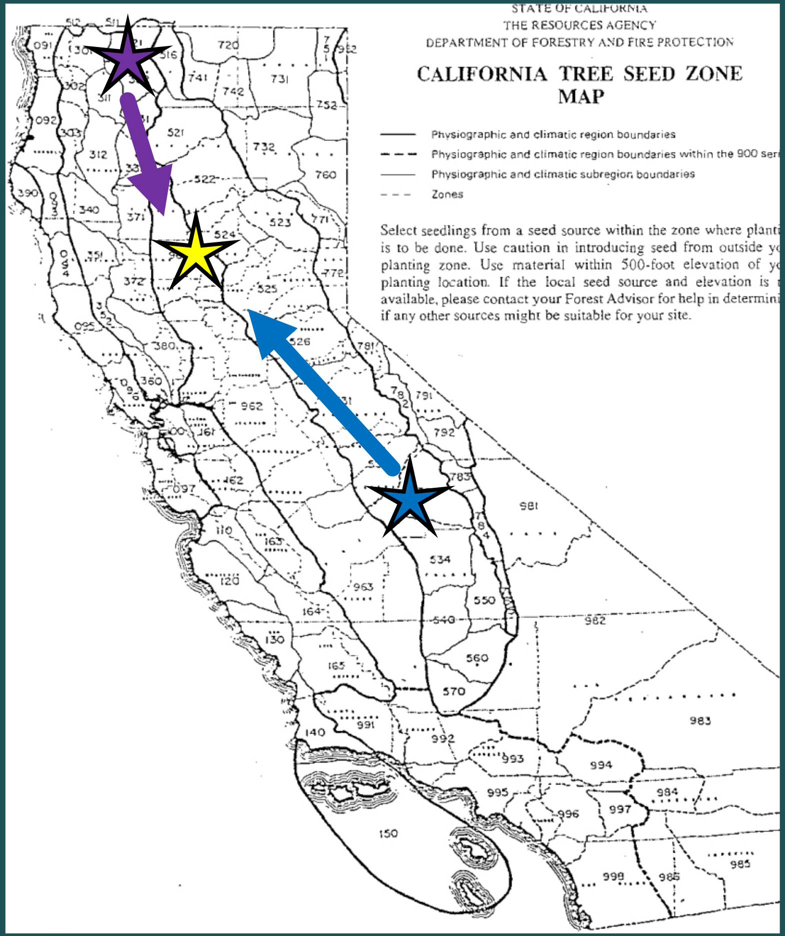
United States Department of Agriculture

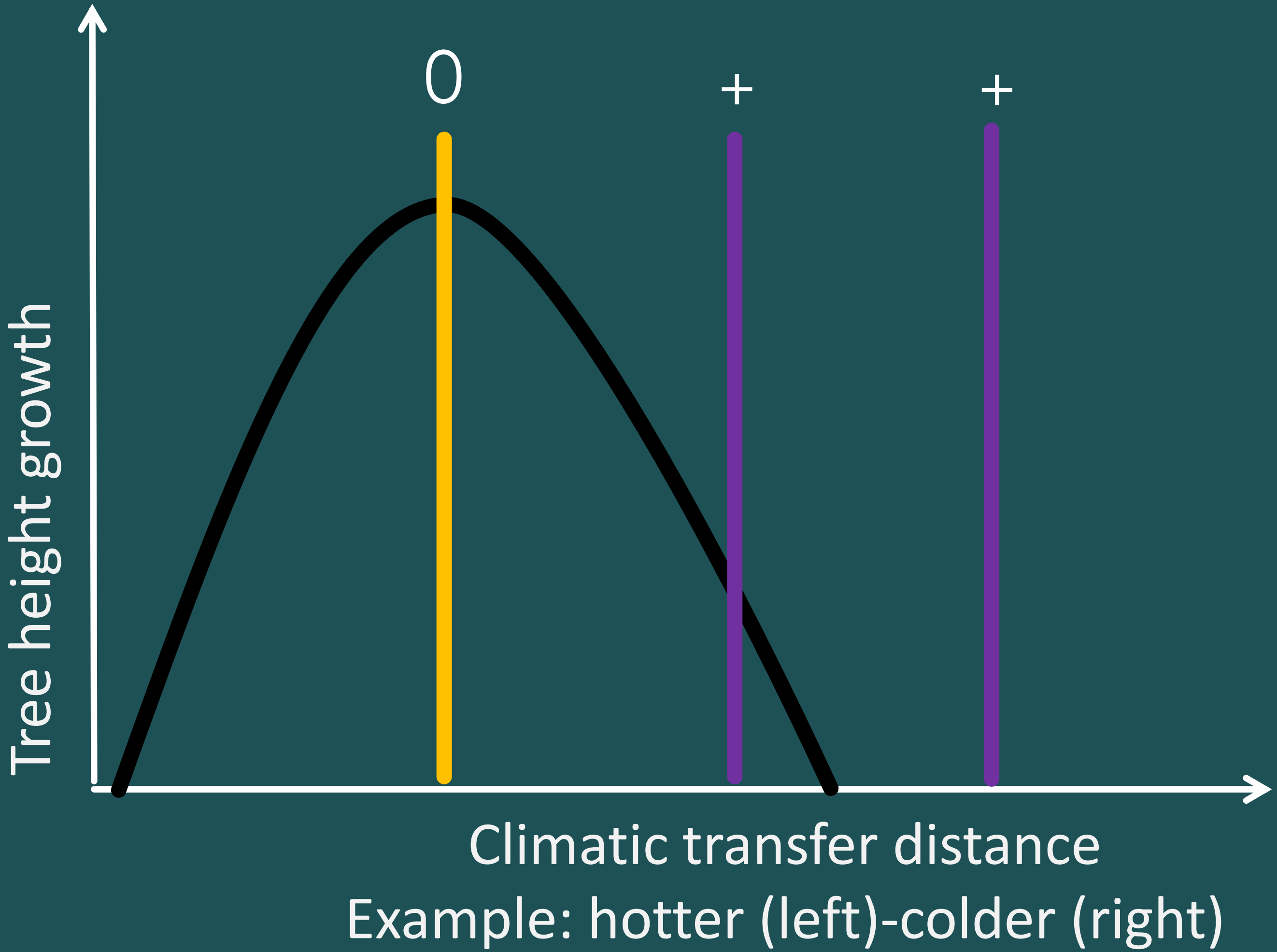
Moving seeds of local species to match future climate



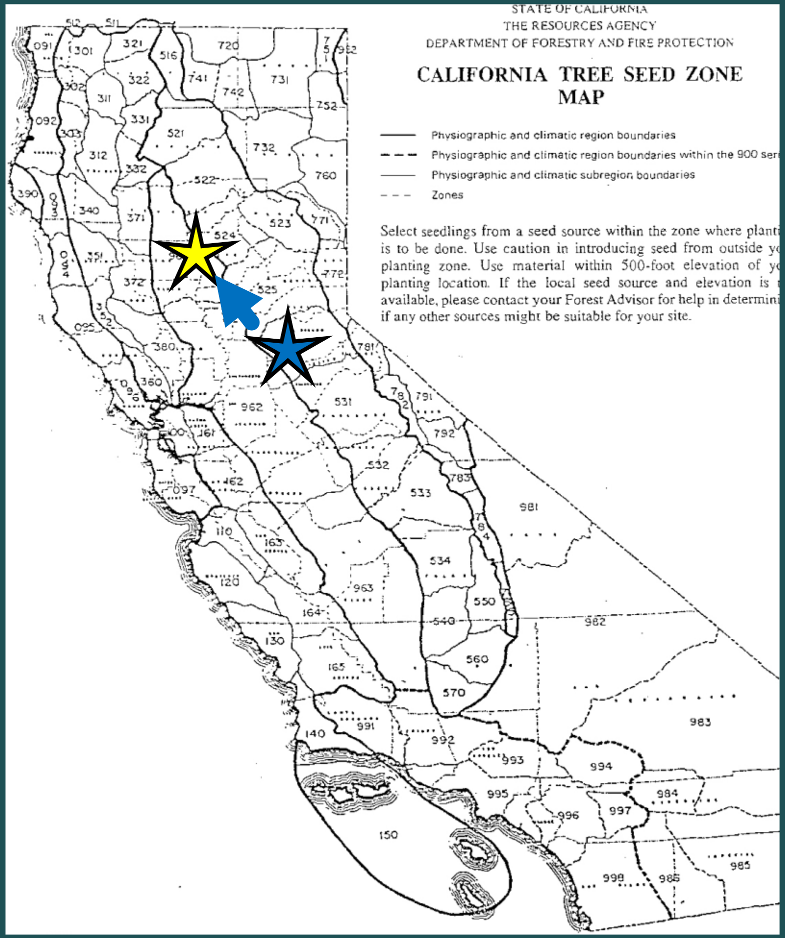


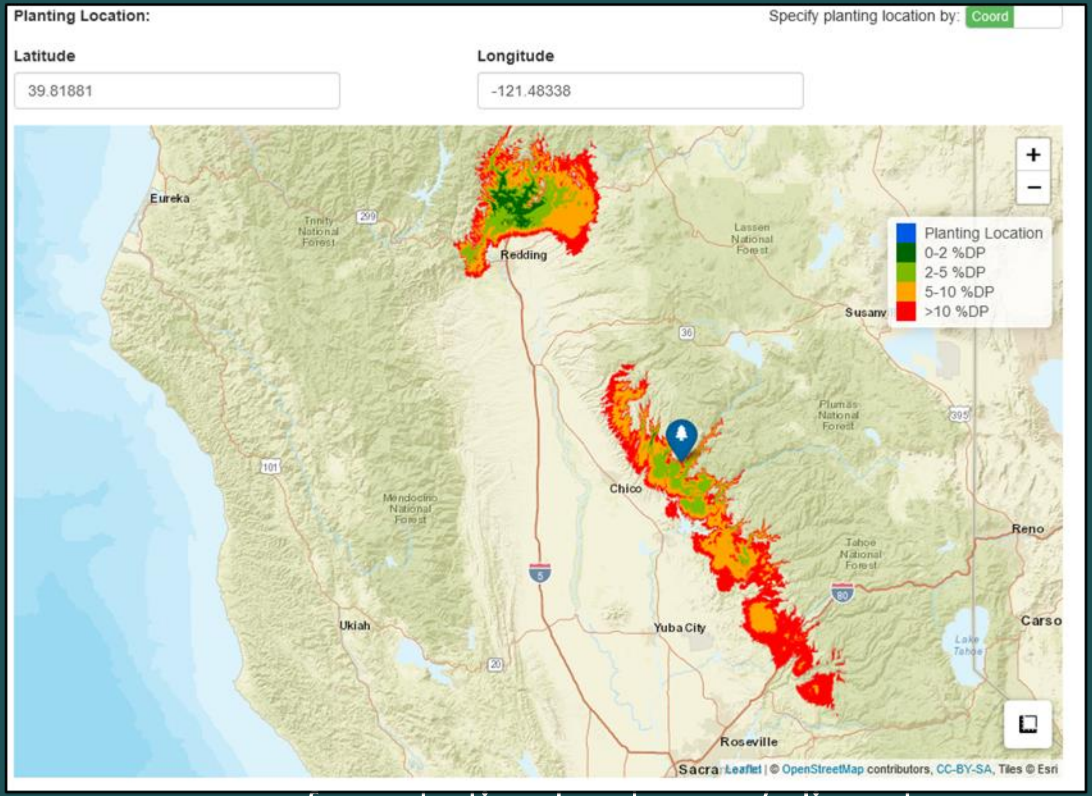
Seed selection of local species to match future climate: end of rotation





Seed selection of local species to match future climate: tools

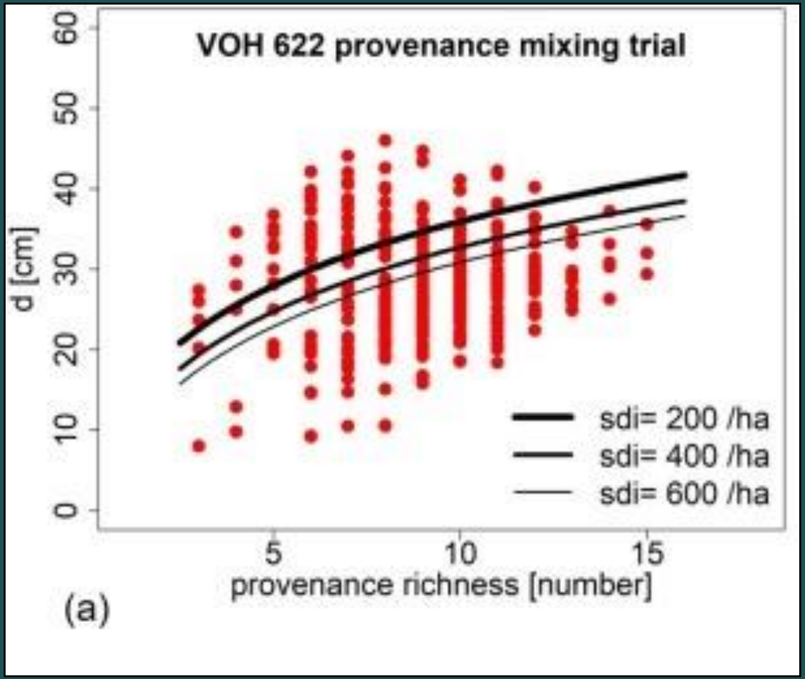




www.reforestationtools.org/climate-adapted-seed-tool/

Mixed-provenance plantings: similar benefits for sustaining productivity?

Mixed crown shapes use space, light more efficiently. Kakabeka Falls, Ontario



From Pretzsch (2021). Provenance richness enhances Norway spruce (*Picea abies*) tree and stand-level growth

The Griffin KMX pine provenance trial

Knobcone pine near Stonyford, Mendocino NF

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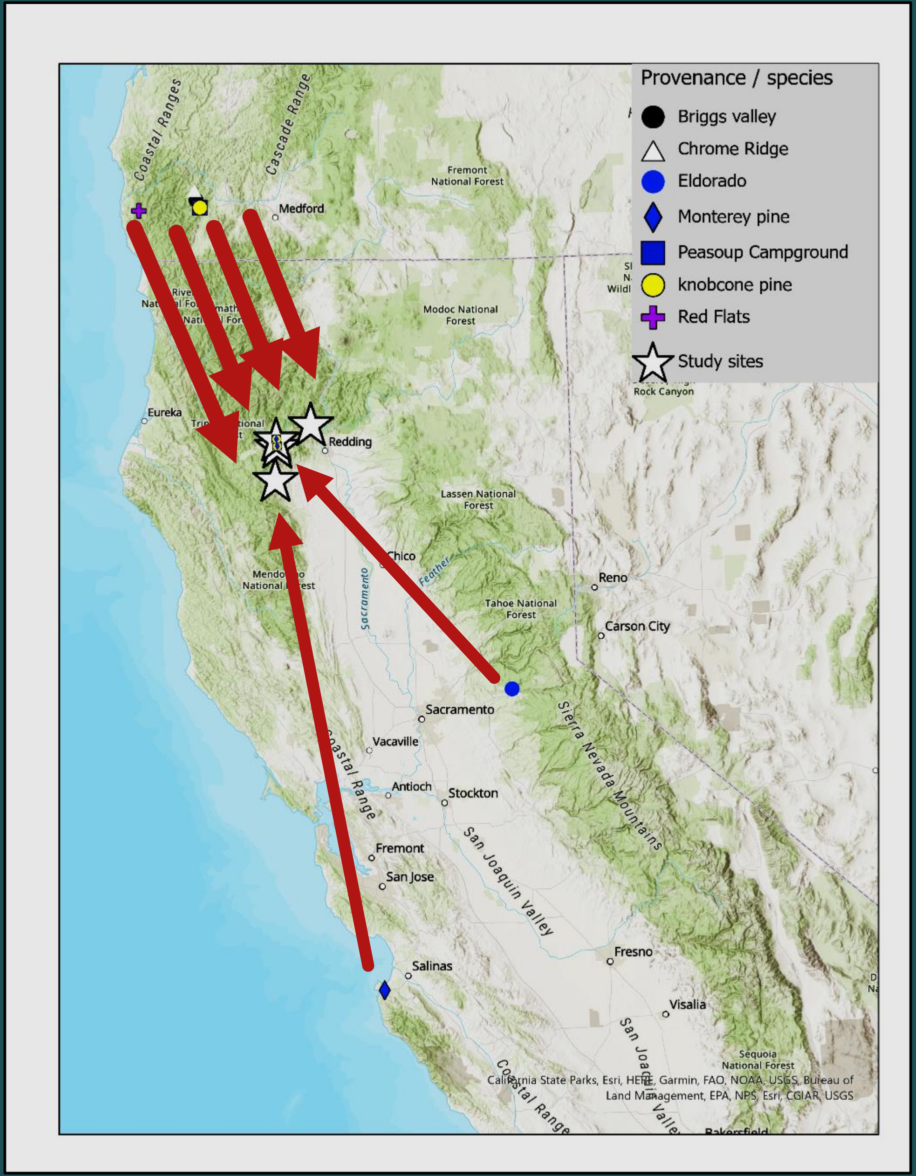
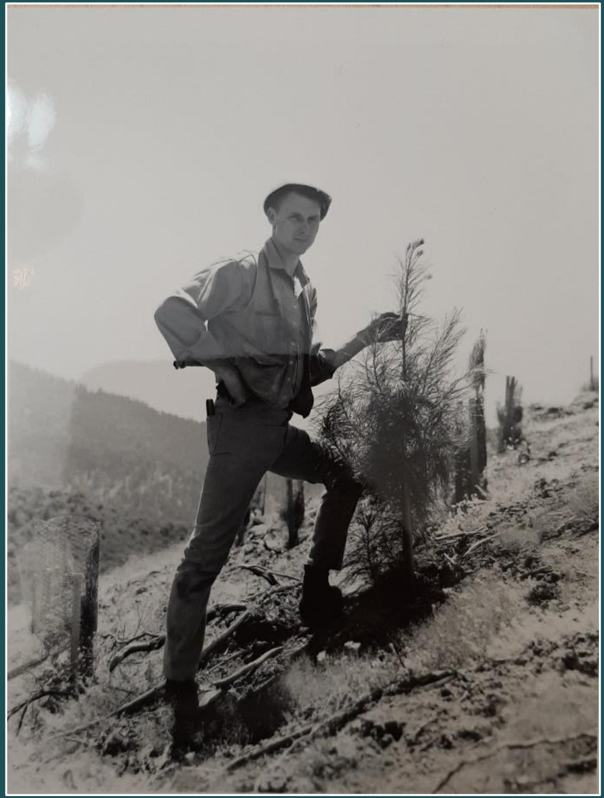
Monterey pine, Huckleberry Hill Forest Preserve, Monterey

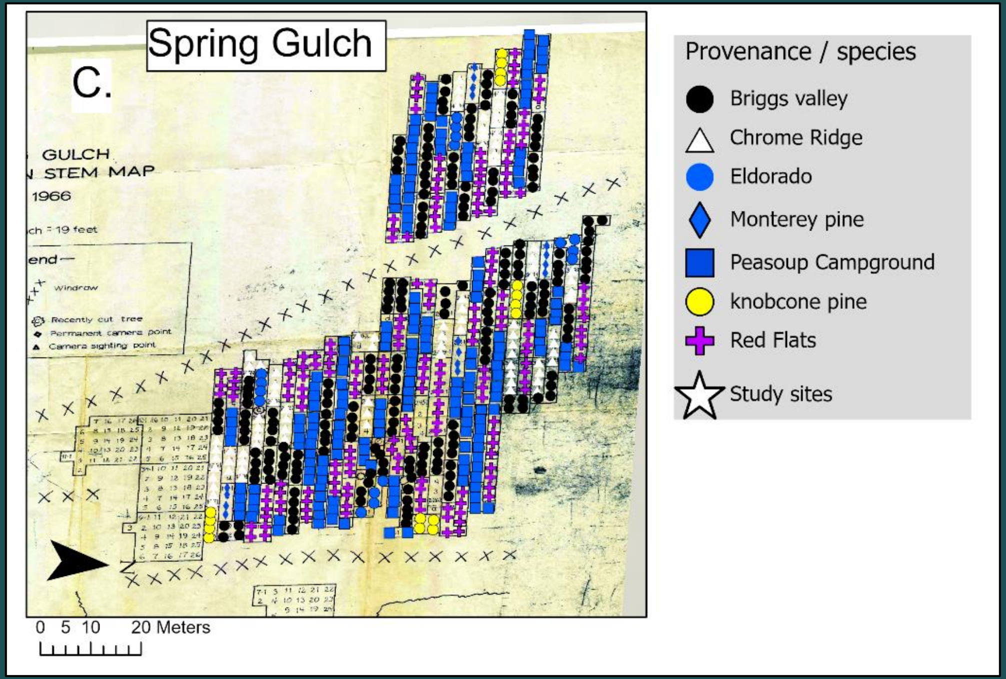


Revisiting the provenance trial



Bob Powers
at Spring Gulch, 1965

Spring Gulch, 2022



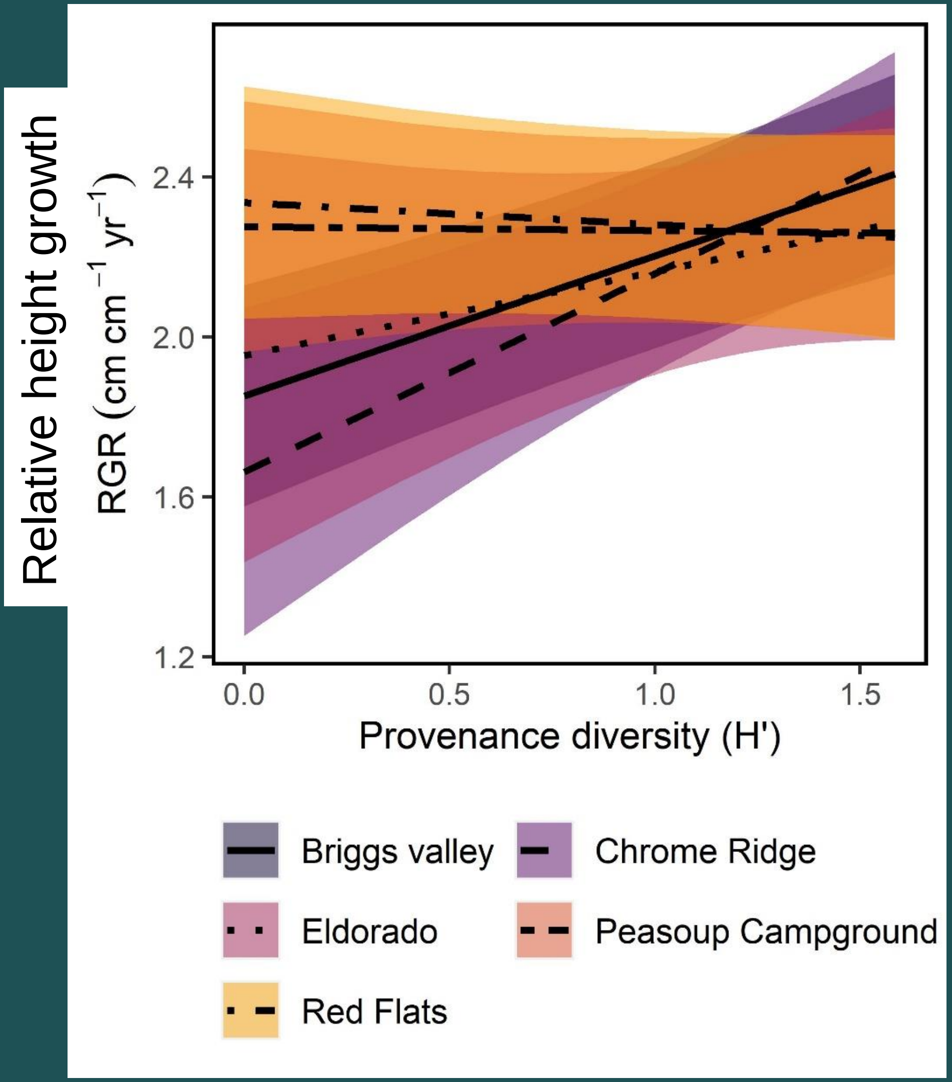
Geo-registered stem map with
survivor trees as of 1966

United States Department of Agriculture

Trees grow better with diverse neighbors, but seed source matters

Seed parents from snowy or serpentine sites

Seed parents from milder winters



Two approaches to climate change adaptation

Ecological forestry

- Builds on “last big thing” in research
- Need to plan much farther ahead
- More drastic assisted migration
- Might do better under “hands-off” managment
- Uneven-aged management

Two approaches to climate change adaptation

Intensive forest management

- Draws on established research and practices
- Shorter planning horizons
- Less uncertainty
- Milder assisted migration
- Need to keep active role of management

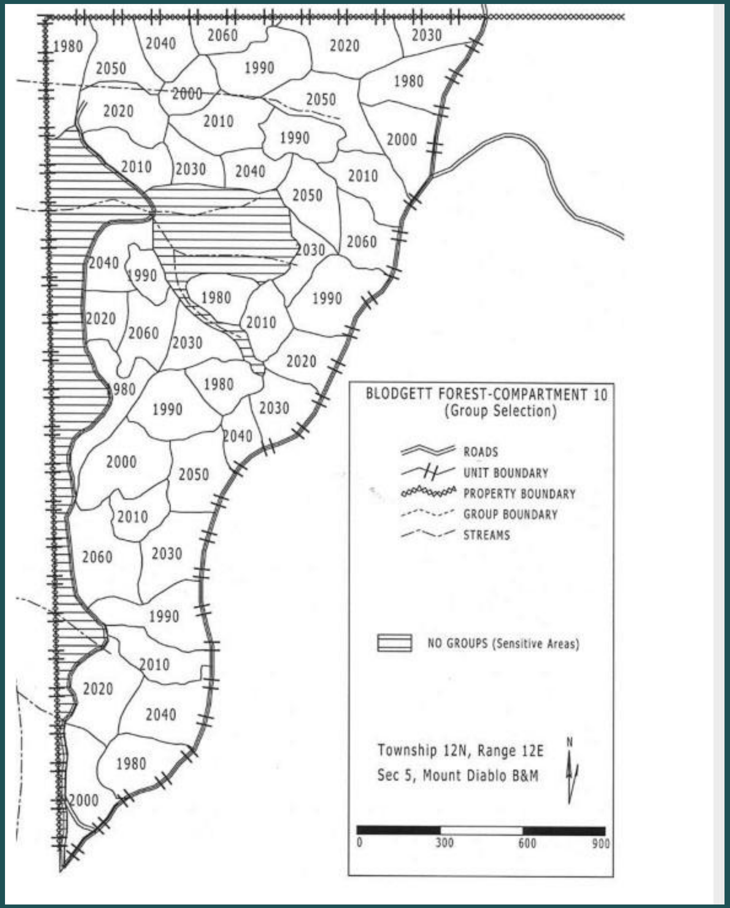
Applications to uneven-aged management

Seedling production
- Nursery practices
- Species and genotype

Establishment
- Site prep
- Planting
- Protection
- CVC

Tending
- Thinning
- Pruning
- Fertilization
- Pest control

Regeneration harvest
- Even-aged
- Uneven-aged



From O'Hara et al. (2014). Planned selection groups, Blodgett Experimental Forest

Applications to uneven-aged management: group selection

Apply ICO/VDT to matrix

+

Manage groups as true plantations

Benefits of intensifying group selection

Group selection with planting, minimal site prep, advanced fir regen. Tahoe NF

Group selection with ripping, burning, planting, PCT. Goosenest Adaptive Management Area, Klamath NF

Summary: A vision for incremental climate change adaptation

- Proper site prep, manage competing vegetation
- Seek ways to accelerate fire resistance
- Anticipate changes in max stocking
- Mixed species, mixed-genetics, uneven-aged management for risk reduction
- Focus on stock adapted to near-term, update each rotation as needed

Questions?

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