New reforestation practices for post-disturbance landscapes: building early resilience


Tamm Review: Reforestation for resilience in dry western U.S. forests

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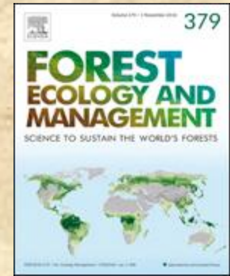
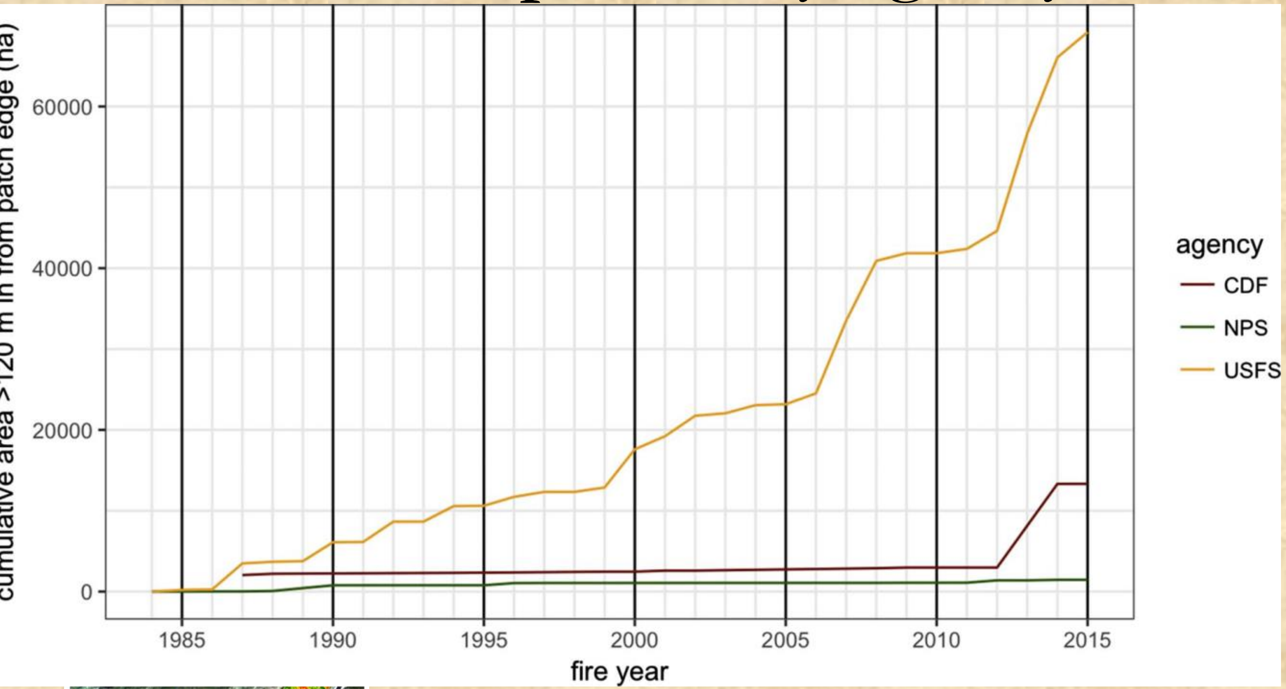
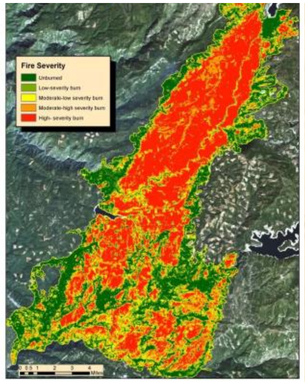


Ecological Impact of Modern Wildfire: Effect of changes in the amount and size of high-severity patches on reforestation

Increase in high-severity area beyond conifer seed dispersal, by agency*





* Stevens et al. 2017. Changing spatial patterns of stand-replacing fire in California conifer forests. FEM 406: 28-36.

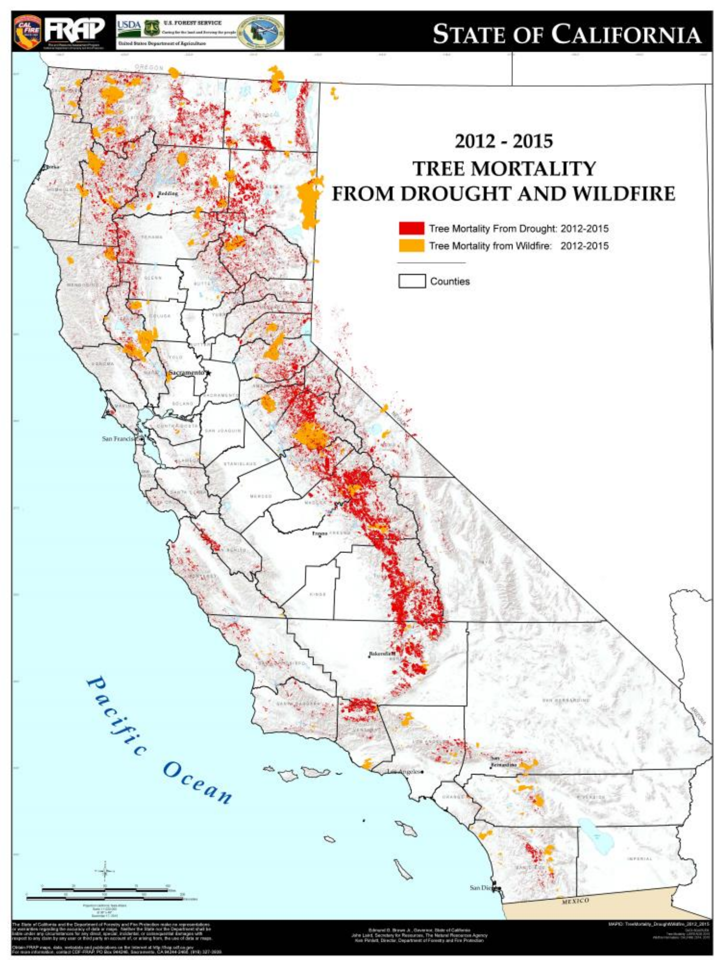
Current Fire Behavior:

- ❖ High severity often averages >35% (historic 4-12%)
- ❖ Patches >400 ha are common (historic rarely >4 ha)
- ❖ Interior of these high-severity patches is well beyond conifer seed dispersal

Implications:

- ❖ The pattern you plant is what you get
- ❖ Large increase in seedlings needed and planter costs
- ❖ Without planting many of these areas may become long-term shrub fields

Overly dense forests are not only a fire problem, they also create water stress: there are too many 'straws in the ground'



- 2012-2016: Most severe drought in last 1000 years
- In California's Sierra Nevada >150,000,000 dead trees
- Mortality correlated with climatic water deficit and stand basal area (Young et al. 2017)
- Beetle mortality is particularly accelerating the **loss of large, old-growth (>400 yrs) trees**

Are current reforestation practices, grids of mostly pine, well adapted to these increasingly common stressors?



Objectives:

- Bypass uncertain natural seeding & vulnerable seedling stage
- Crowns soon interlock controlling light resources
- Rapid initial height and diameter growth for ≈ 20 yrs



The focus on high density is often to shade out competing shrubs

Reduction in tree sapling height growth with no to heavy brush cover

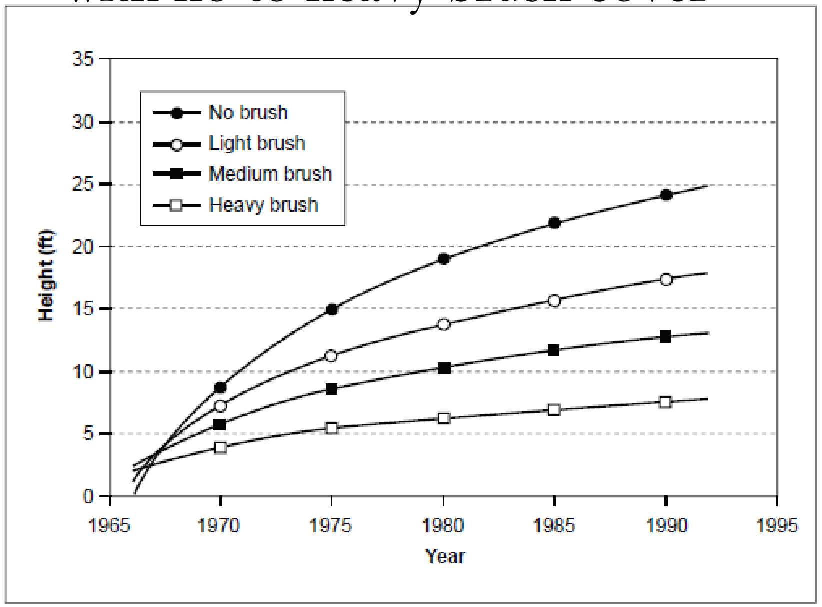


Figure 9—Relationship of ponderosa pine height to shrub density category, Mount Shasta brushfields, 1966–1992.

Current R5 stocking guidelines by species and site class compared (below) to historic densities

USDA

United States Department of Agriculture

Minimum Recommended and Acceptable Stocking Levels			
Forest Type	R5 Site Class	Recommended TPA	Minimum TPA
Ponderosa & Jeffrey Pine	0 and 1	200	150
	2	200	125
	3	150	100
	4 and 5	125	75
Red/White Fir	All	300	200
Douglas-fir	All	225	125
Mixed Conifer	All	200	150

Pacific Southwest Region

Historic densities*:

Pondo pine: 51 tpa (range 29-64 tpa)

Red fir: 65 tpa (range 48-84 tpa)

Mixed conifer 64 tpa (range 24-133 tpa)

* (Taylor 2010, Meyer and North 2019, Safford and Stevens 2017)

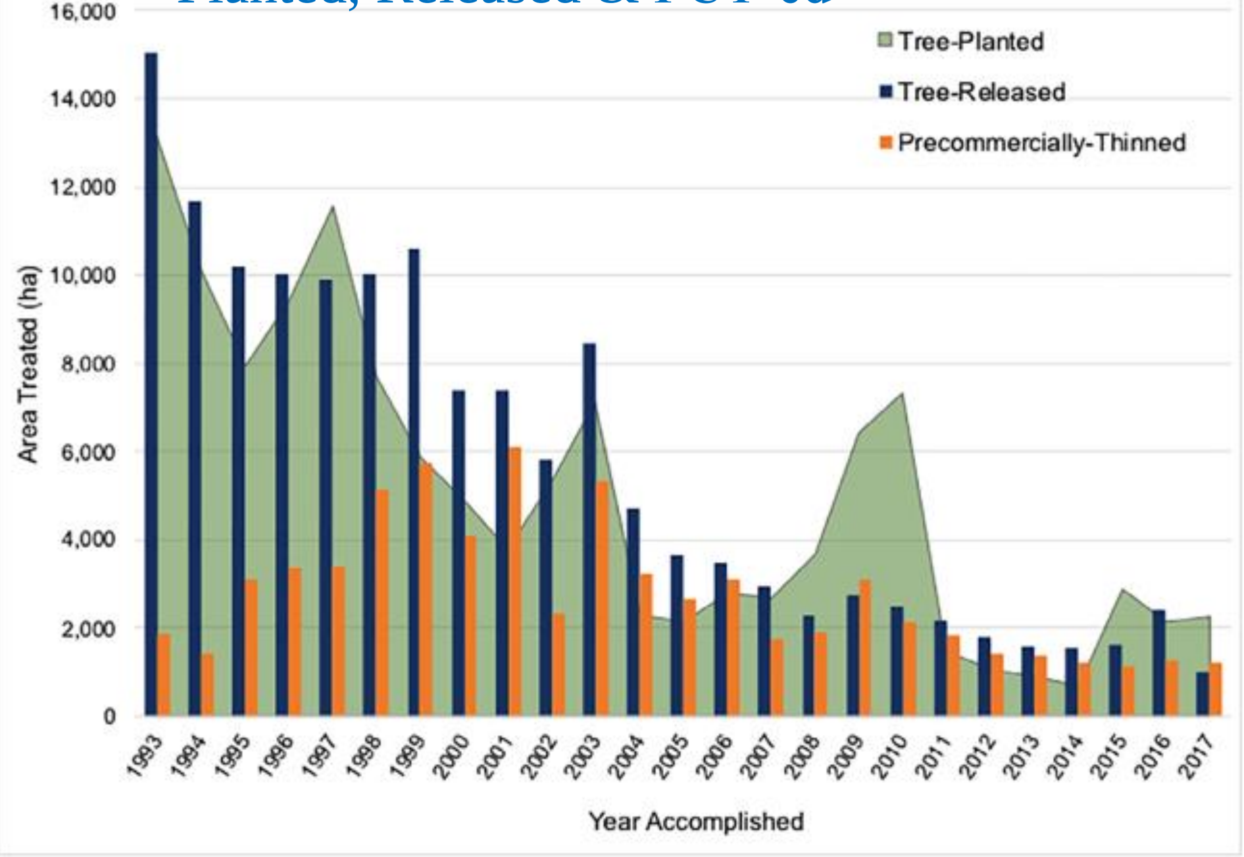
Problems with high-density gridded reforestation

- Method is heavily dependent on costly ‘course correction’:
- PCT often needed to reduce density, change composition, and spatial pattern
- Reduce shrubs with manual herbicide or labor intensive grubbing
- Yet there’s been a 40% decline in acreage released in USFS Regions 1-6

“pines in lines”

without ‘course correction’
50 years later

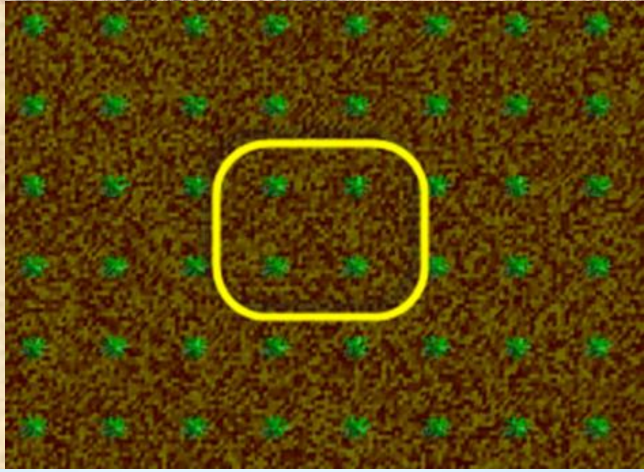
Declining Acres of Sierra Nevada NF Ownership
Planted, Released & PCT’ed



High density plantations lack resilience

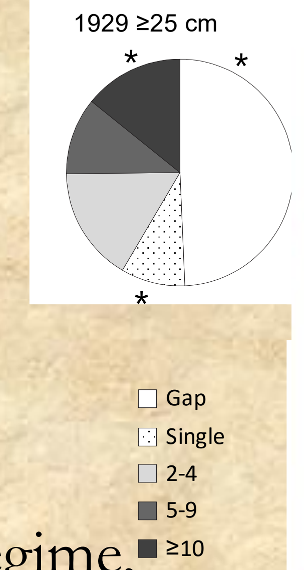
- To fire: when burned often leads to 100% incineration due to interlocked crowns and near ground foliage
- To drought: 'All eggs in one basket'
  - There is no variability in the competitive/resource capture area
  - Single species lack hydraulic diversity associated with drought resilience (Anderegg et al. 2018. Hydraulic diversity of forests regulates ecosystem resilience during drought. Nature 561: 538-541)

- Regular spacing is a crop production strategy for maximizing growth not necessarily resilience



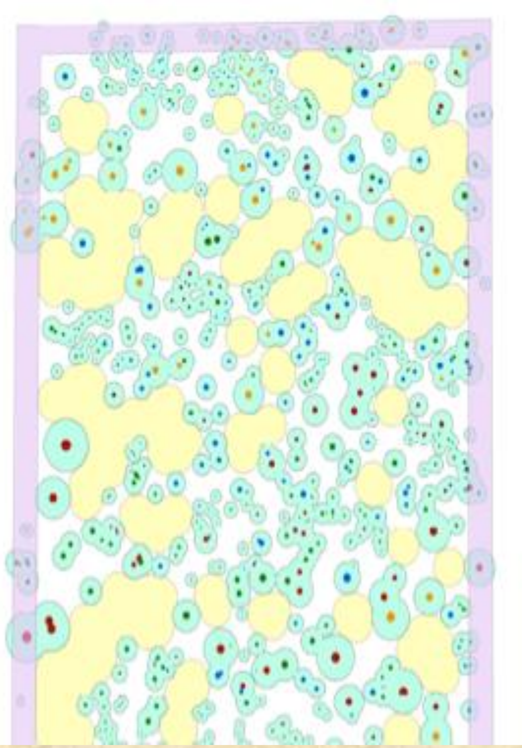
In Many Dry Conifer Forests, Resilience is Associated with Fine-Scale Heterogeneity
ICO Pattern (**I**ndividual trees, **C**lumps of trees, **O**penings)

Tree Groupings:



Larson, A.J. and D. Churchill. 2012. Tree spatial patterns in fire-frequent forests of western North America, including mechanisms of pattern formation and implications for designing fuel reduction and restoration treatments. Forest Ecology and Management 267:74–92.

Map and table of mixed conifer conditions before fire-suppression



Trees/ clump	#/ha	% of all trees
Single	15	13
2-4 tree	13	30
5-9 tree	5	24
≥10 tr	4	33

ICO pattern produced by active fire regime, Yosemite

Lydersen, J.M., M.P. North, E.E. Knapp, and B.M. Collins. 2013. Quantifying spatial patterns of tree groups and gaps in mixed-conifer forests: reference conditions and long-term changes following fire suppression and logging. Forest Ecology and Management 304: 370-382.

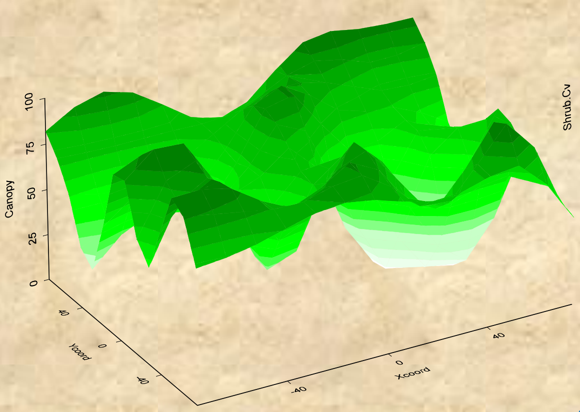
Why Does This Heterogeneity Matter?

Spatial Variability of Forest Structure is Tightly Linked to Ecosystem Processes

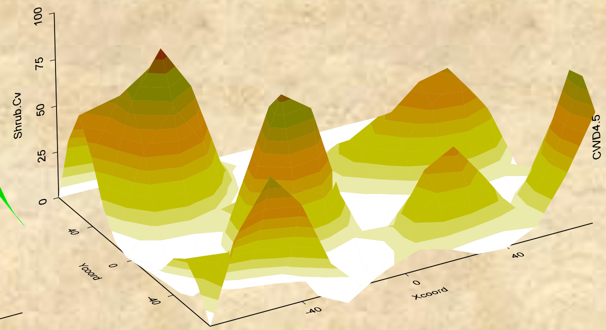
Kriged maps of structure and process variability in 4ha mapped mixed conifer at Teakettle Exp. Forest

Vegetation Structure:

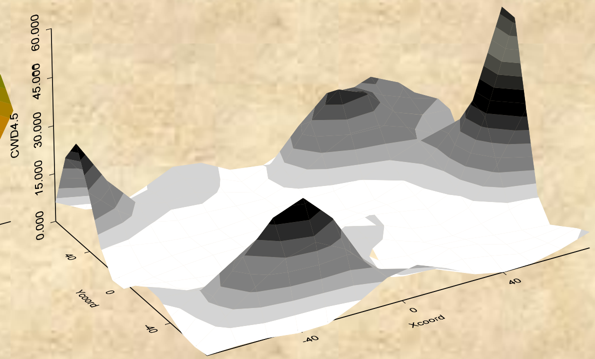
Forest Canopy Gaps



Ceanothus Cover



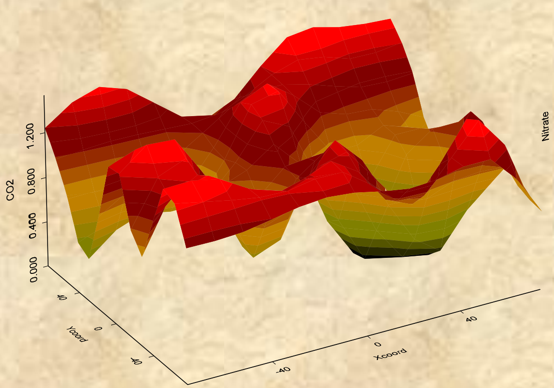
Litter Depth



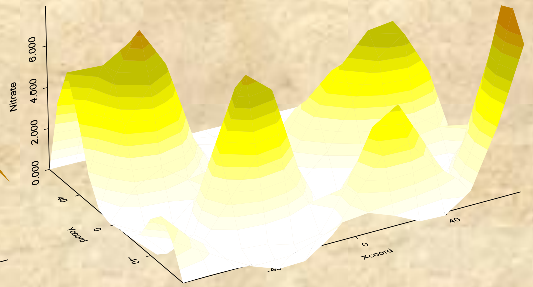
4 ha fully mapped plots

Ecosystem Process:

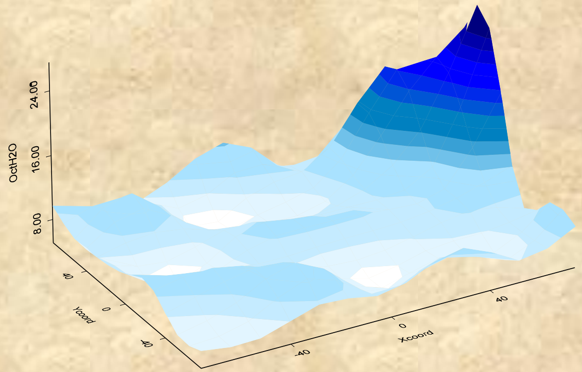
PAR



Available Nitrogen

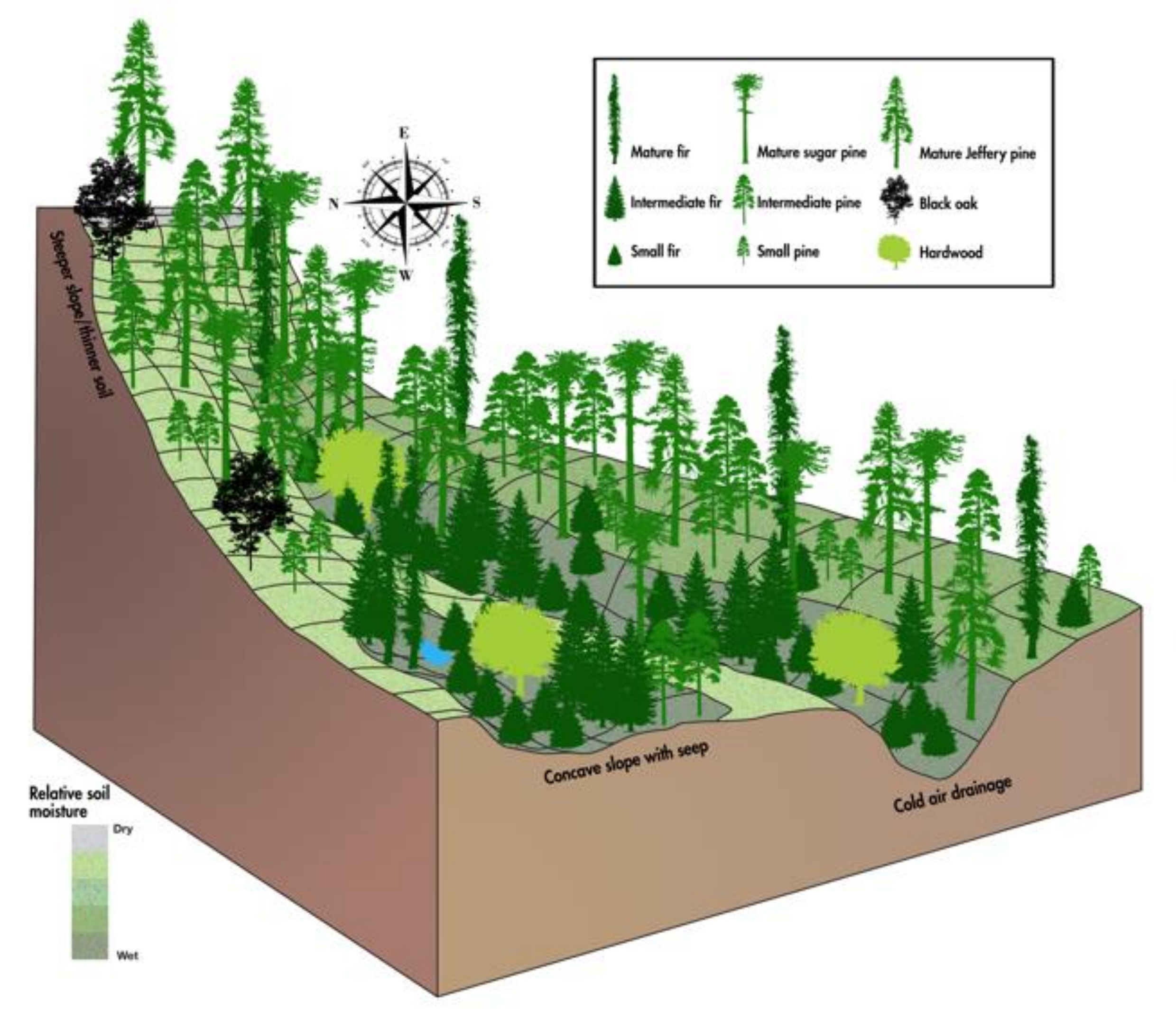


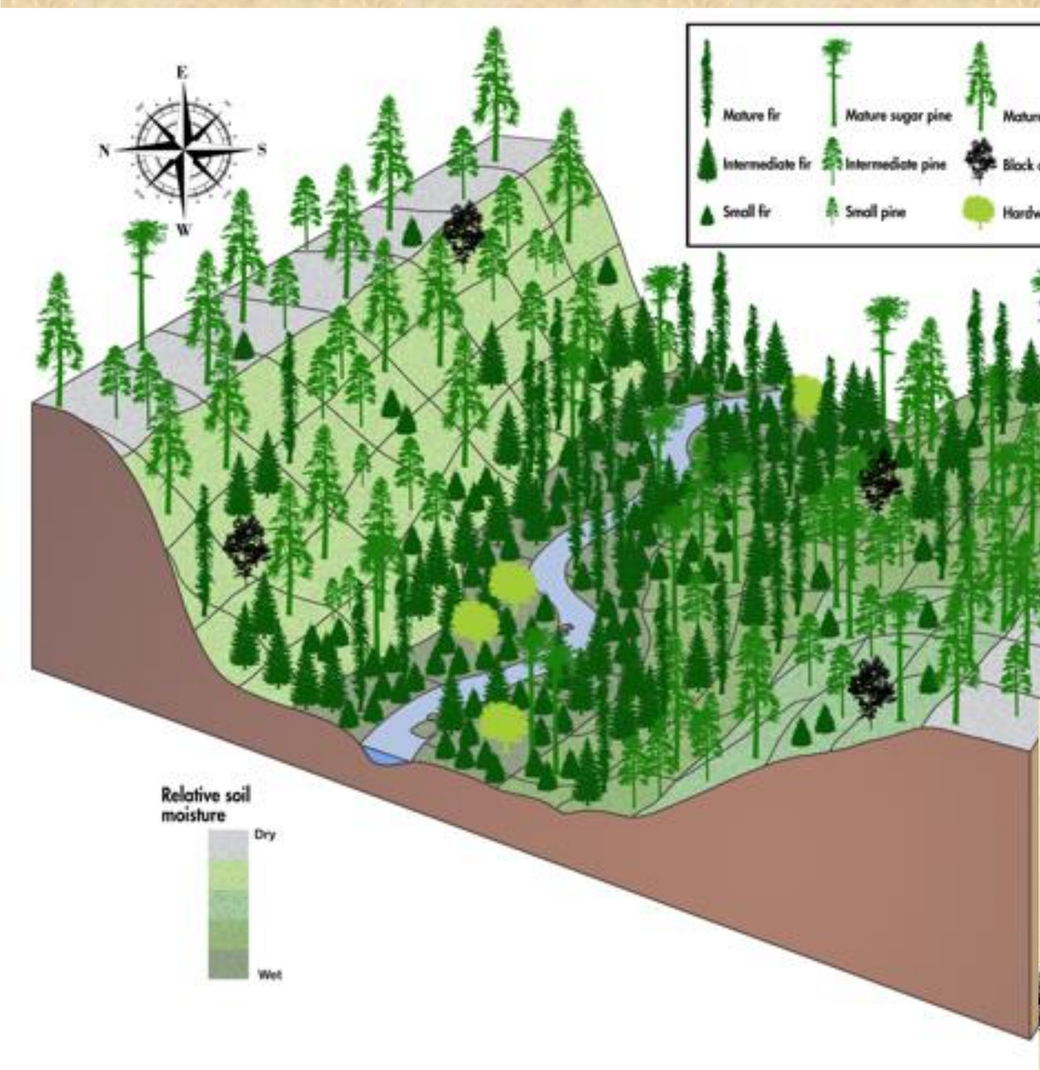
Soil Moisture

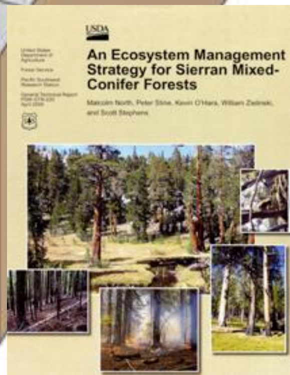


Suggests forest heterogeneity supports biodiversity and ecosystem resilience

In active-fire forests, local density, composition, and structure are often **congruent with how topography influence water availability and fire intensity**







Reforestation For Resilience:
3 main objectives

1) Divide reforestation area into zones by potential seeding and access/costs
2) Composition, density, and pattern should vary and be aligned with microsite water and fire patterns
3) Build young forest resilience with the use of early, frequent prescribed fire

Stand structure and pattern of an active-fire forest, Sierra San Pedro del Martir, Baja

#1) Zones With Different Strategies

Z1: Interplant as needed within seed dispersal distance of green trees

Z2: Cluster/regular planting in accessible (for salvage and planting) areas beyond seed dispersal

Z3: Plant founder stands in remote, inaccessible areas with cost and safety challenges

A partially salvaged area two years after the 2014 Eiler Fire in Northern California

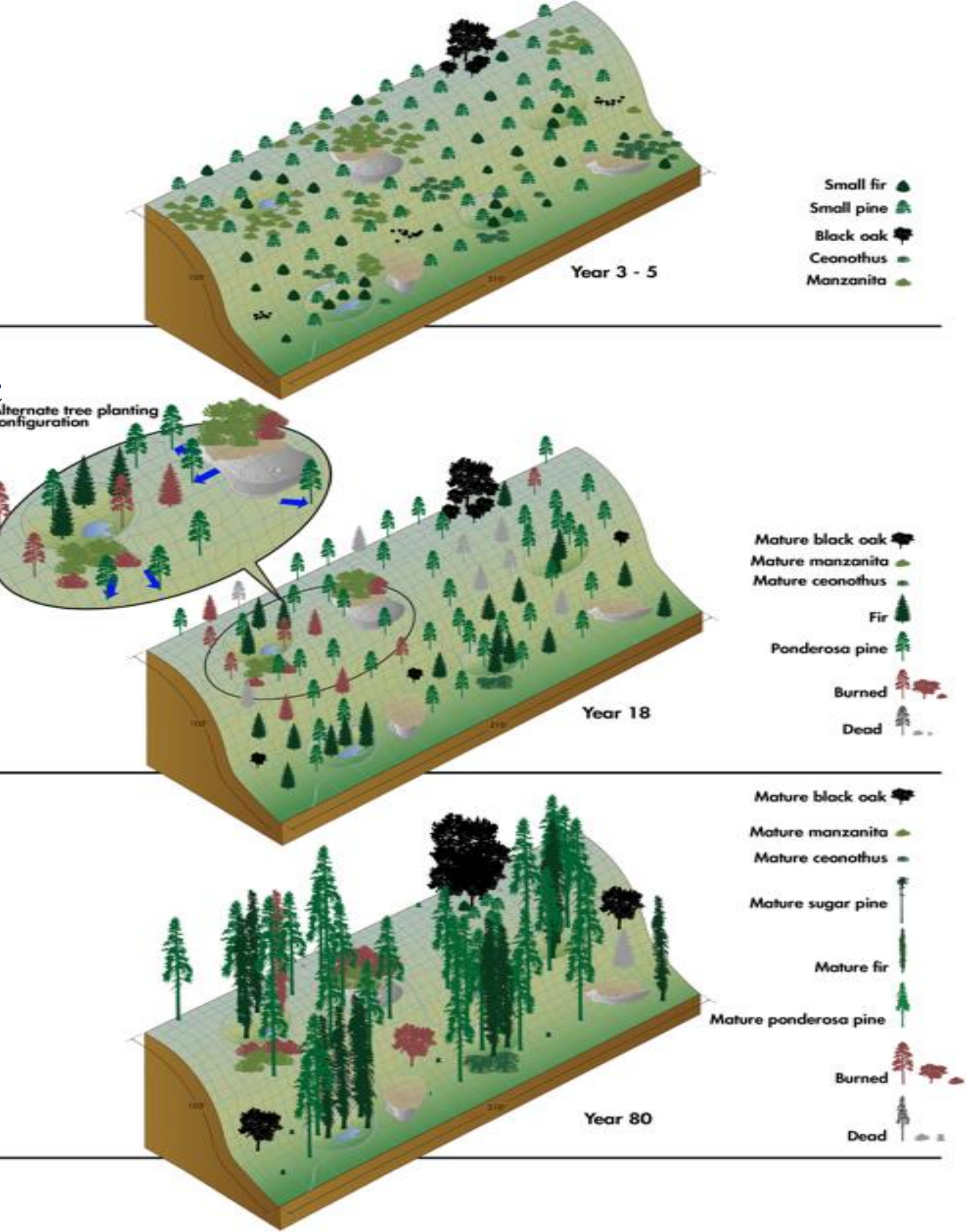
#2 Proposed Planting:

Schematic of the initial planting & subsequent stand development for a 0.5 ac (105 X 210ft) slope of forest.

Clusters of seedlings planted where there is more water (concavities), species varies with local projected fire intensity, and low density of regularly spaced seedlings planted between clusters.

'Martir' Baja forest structure resilient to drought and fire

Spatial Pattern in the Beaver Creek Pinery

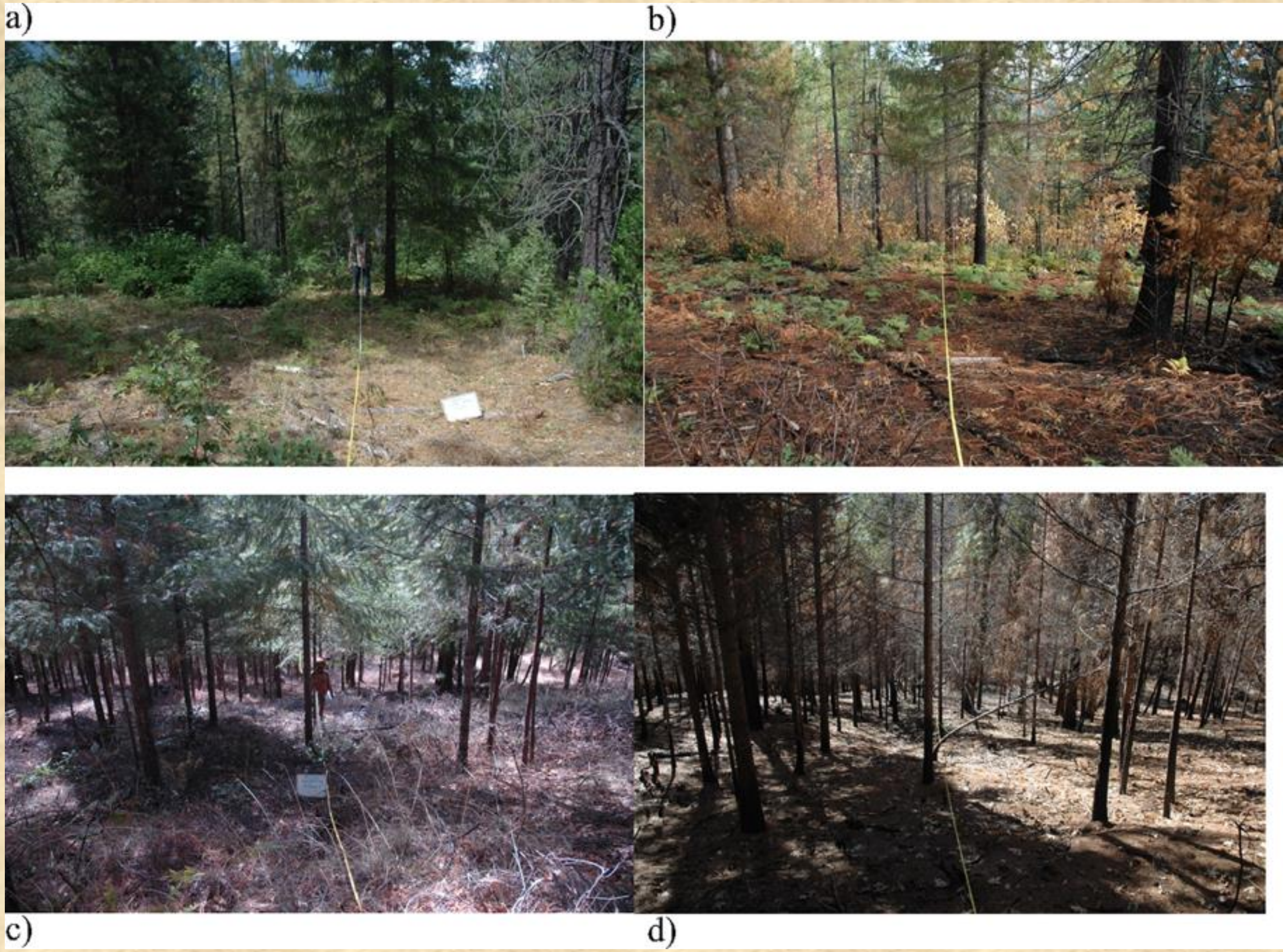


#3: Build early resilience and genetic selection for fire tolerance with prescribed fire

Before and after examples of young stand Rx burns on the Shasta-Trinity National Forest.

The upper pair, a) and b), show a mixed-conifer plantation that was spring burned 33 years after planting. Surface fuels were reduced, as was density by killing smaller trees.

The lower pair, c) and d), showing how the burn in a 25 yr old stand acted like a cost effective pre-commercial thin reducing natural recruitment density.



Rx fire re-establishes selective mortality favoring phenotypes with thicker bark and early branch abscission

For modern reforestation practices to become more resilient, they should consider using ecological principles that emphasize the importance of spatial arrangement

- Varying the density and pattern of planting with water and burn behavior will increase variability in resource competition, fuel loads, and wildlife habitat conditions.

- Work with shrubs…they will be reduced in tree clusters through shading and more extensively throughout the stand with cost-effective prescribed burning that builds fire resilience.

- Initial planting pattern and frequent burning foster resilient stand development and spatial patterns without depending on costly future treatments or hoped for commercial thinning to adjust the developing forest.

Questions?

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