Managing Forest Landscapes Before and After the Inevitable Wildfire

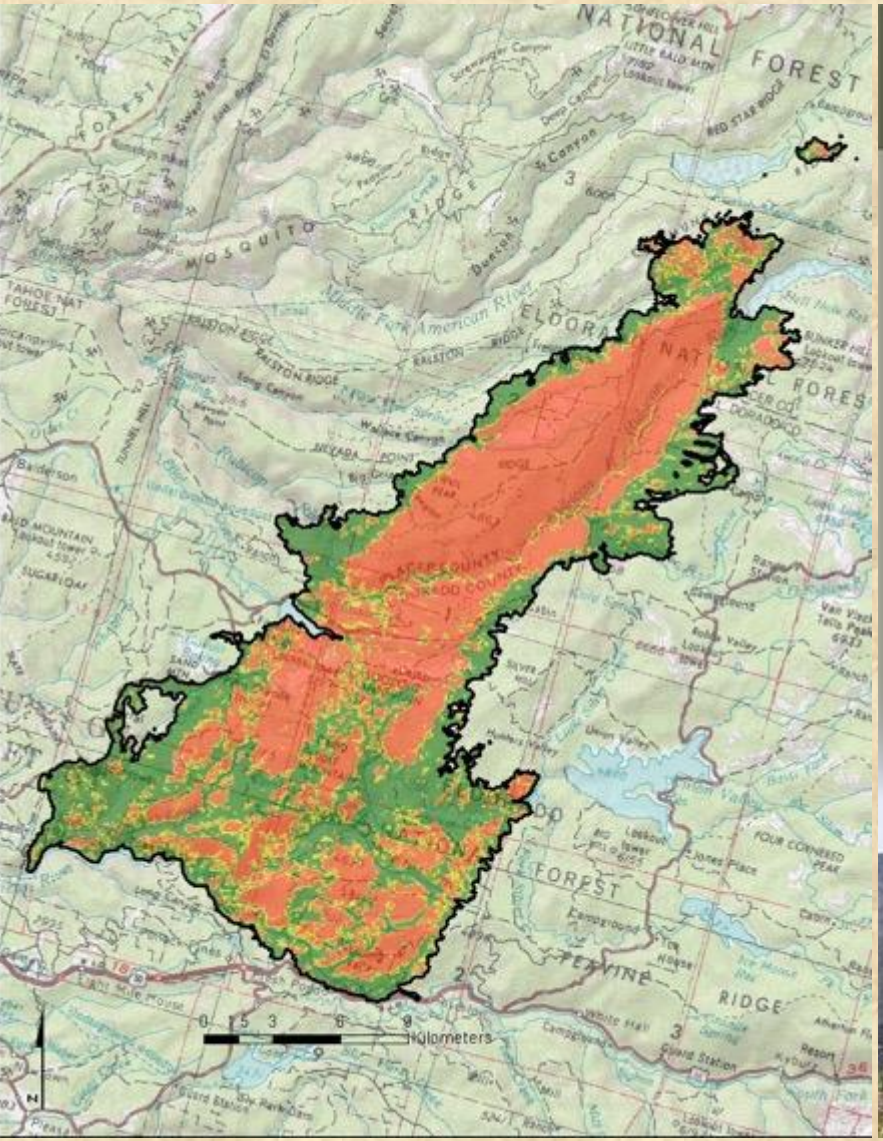
After the Fire:

- Using NRV as a guide for restoration
- Reforestation: do planting patterns matter?

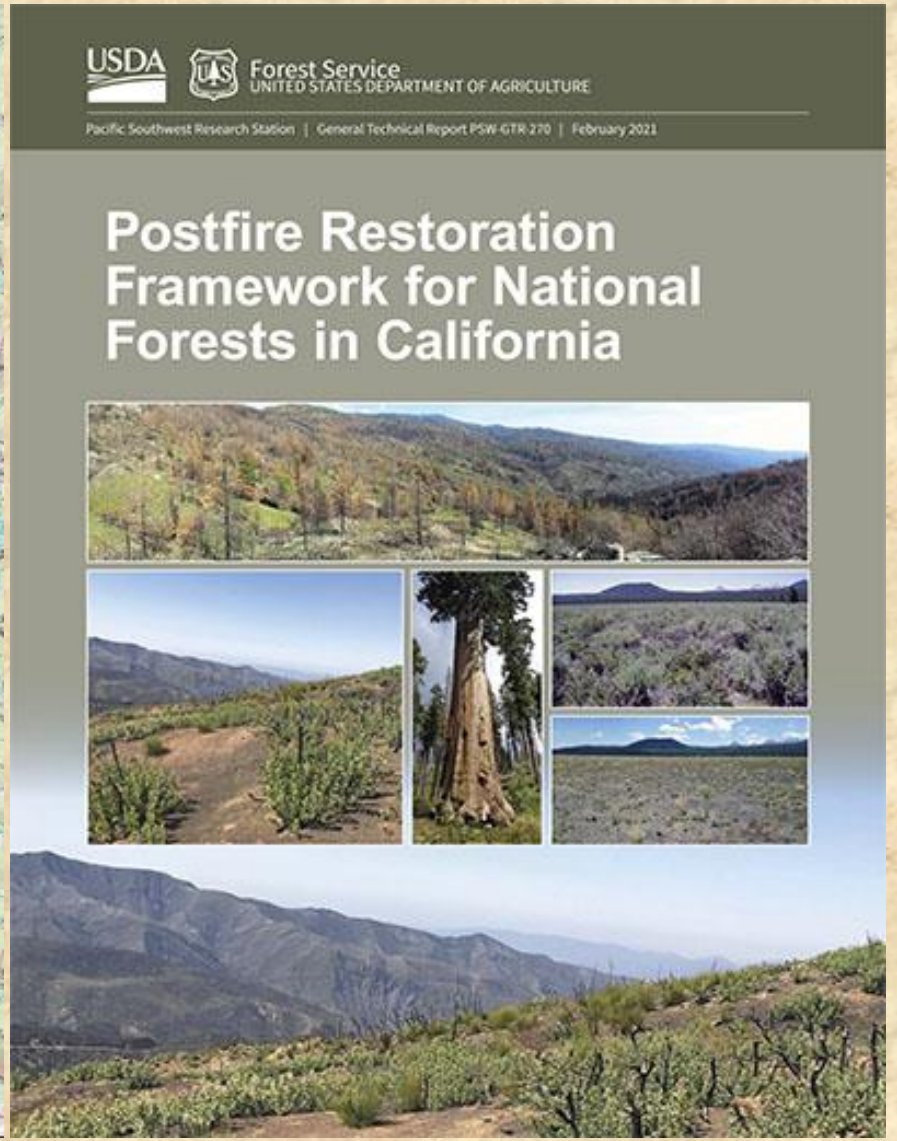
Before the Fire:

- Pyrosilviculture: Maximizing the tools we have
- Beyond fuels treatment, what is resilience?

What To Do After a Large Wildfire?



Current Wildfires: 2014 King Fire: >50% high severity [red patches]



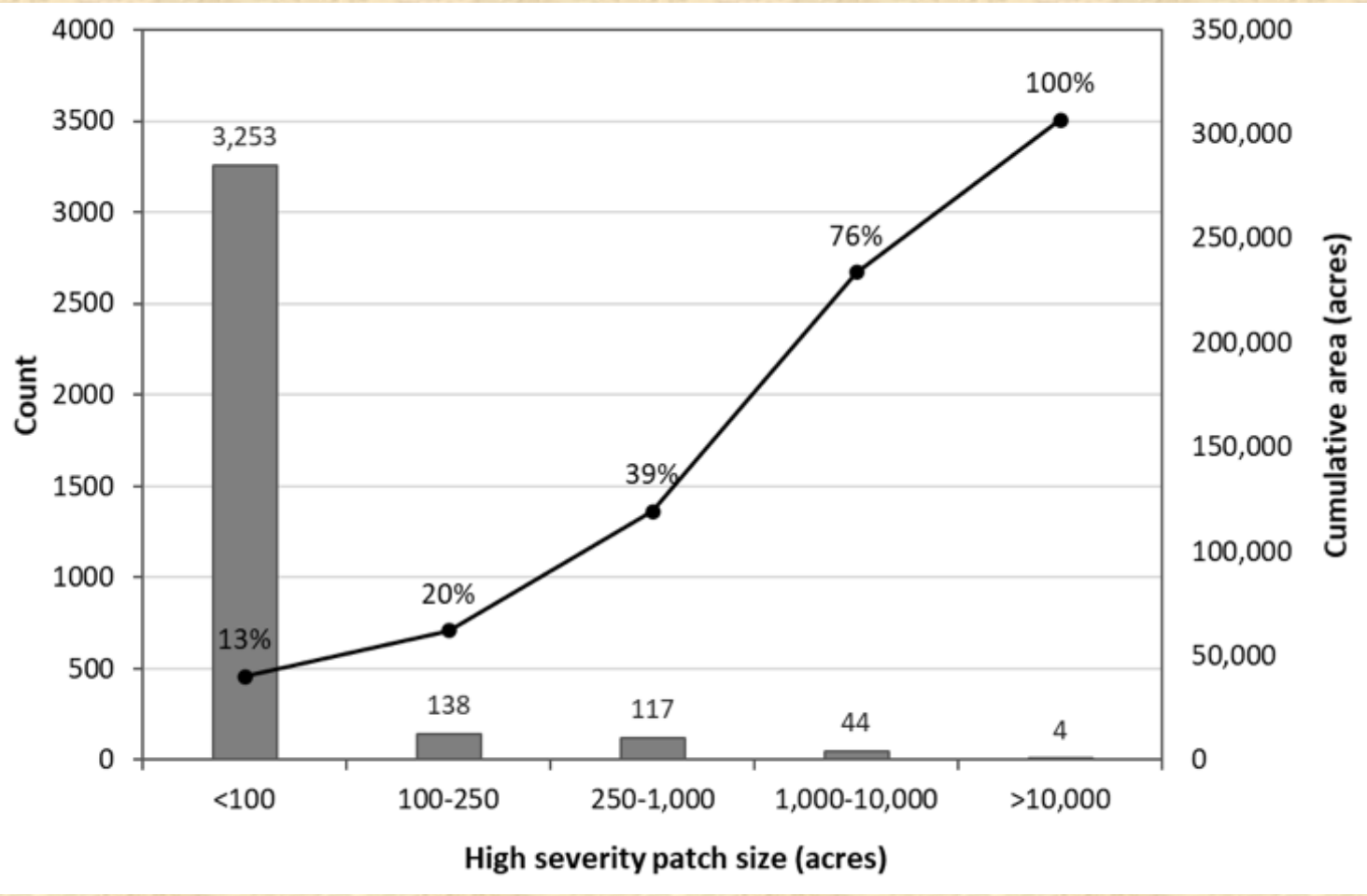
M.D. Meyer, J.W. Long, and H.D. Safford (eds.) Postfire restoration framework for National Forests in California. USDA Forest Service, PSW-GTR-270. 204 pp.

Moving Beyond Triage:

6 Science-Based Guiding Principles:

- Restore key ecological processes
- Consider landscape context
- Promote regional native biodiversity
- Sustain diverse ecosystem services
- Establish a prioritization approach for management interventions
- Incorporate adaptation to agents of change

What is the Natural Range of Variation (NRV) and Why is it Important



Distribution of High-Severity Patch size by Count and Cumulative Area

Numerically small (<100 ac) patches dominate (3,253)

But 87% of the high-severity area was in patches >100 ac

When high-severity patches are large:

No historical or ecological analog

Little to no natural recruitment (live tree seed sources beyond wind dispersal distance)

Homogenous microclimate, habitat and substrate

Loss of Heterogeneity → Hysteresis

After the fire: How are burned forests replanted?
Often with pine seedlings planted at a regular, gridded spacing

After wildfire

Planting in parallel lines

Young pine plantation

Rapid growth

Simplified forest

Maximizes tree crop

Objectives:

- Bypass uncertain natural seeding & vulnerable seedling stage
- Widely spaced =Rapid growth
- Crowns soon interlock controlling light resources
- Shades out shrubs

Why the focus on tree regeneration quickly gaining site control?

Most western fire-dependent forests have 'aggressive' shrubs, both re-sprouters and with long-lived seed, that rapidly recolonize burns, outcompete conifers for near soil surface moisture, and kill or reduce growth of tree regeneration. High severity fire often produces ≈85+% shrub cover

Shrub cover almost 100% 8 years after Angora Fire

This has led to high density planting to shade out shrubs

Forest Service

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

Current stocking is 3-5 times historic densities:

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

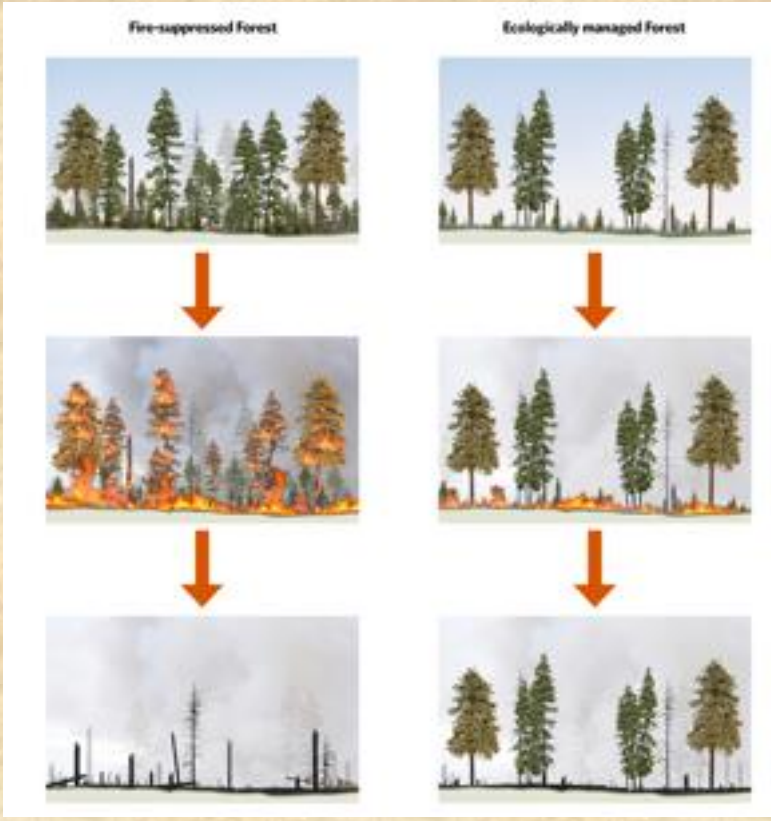
Red fir: 65 tpa (range 48-84 tpa)

Mixed conifer 64 tpa (range 24-133 tpa)

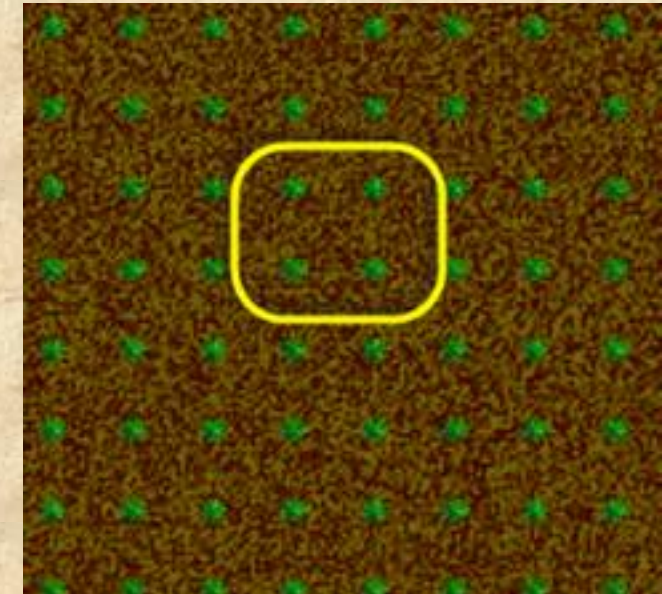
But Rapid Growth May ≠ Resilient Forest
Problem: Uniform Spacing

Incinerated plantation

- Wildfire: when burned often leads to 100% incineration (foliage close to ground, crowns interlocked)



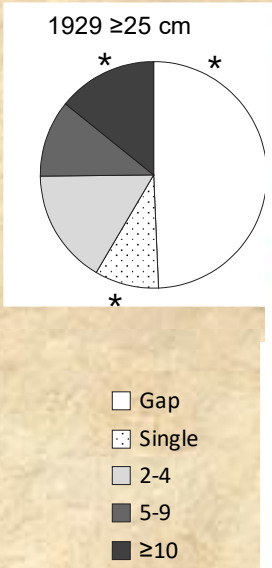
- To drought: With uniform density/competition, there is no variability in the competitive/ resource capture area
('all your eggs are in one basket')



There is no natural analog for 'pines in lines': Historical all active-fire forests had an ICO Pattern* (**I**ndividual trees, **C**lumps of trees, **O**penings)

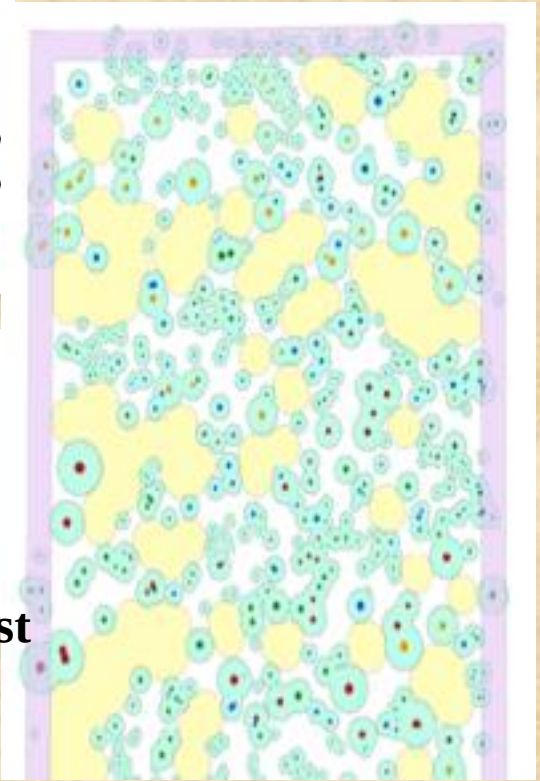
ICO pattern in fire-restored forest, Yosemite

Tree Groupings:



50% of forest was in gaps (yellow)

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

*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.

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.

Influence of Tree Spatial Patterns on Fire Severity

Why does variable tree spacing have lower fire intensity?

The openings have little surface fuel (the driver of fire severity) so fire drops out of the tree canopy and stays on the forest floor

Koontz, M.J., M.P. North, C.M. Werner, S.E. Rick and A.M. Latimer. 2020. Local forest structure variability increases resilience to wildfire in dry western U.S. coniferous forests. Ecology Letters.

Is Variable Tree Spacing Also Ecologically Important? Yes!

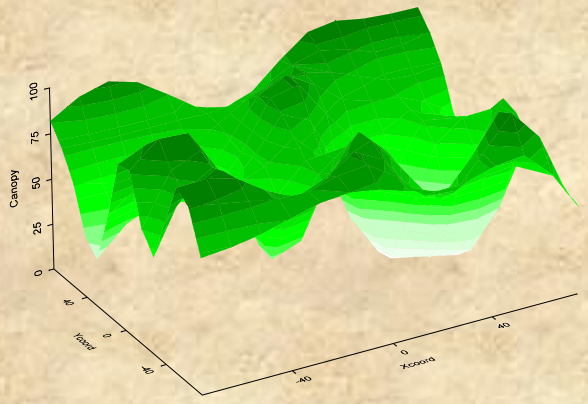
Spatial Variability of Forest Structure is Tightly Linked to Ecosystem Processes

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

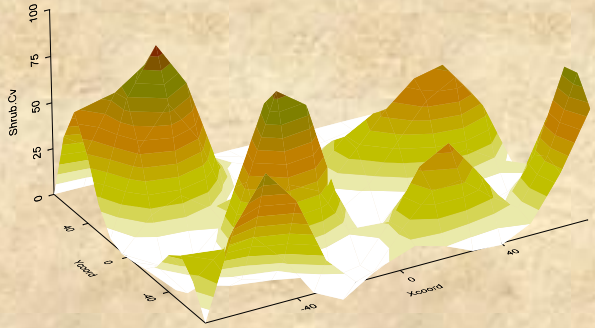
Vege Structure:

Ecosystem Process:

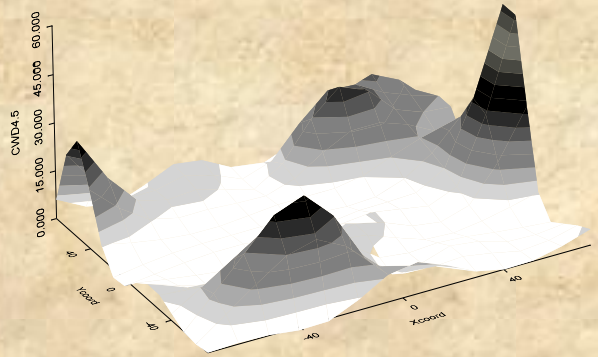
Forest Canopy Gaps



Ceanothus Cover

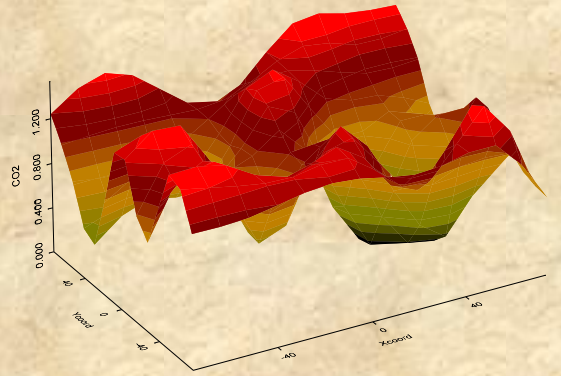


Litter Depth

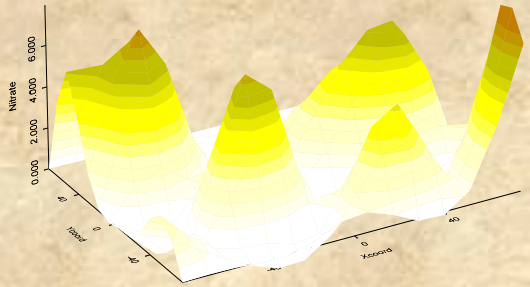


4 ha fully mapped plots

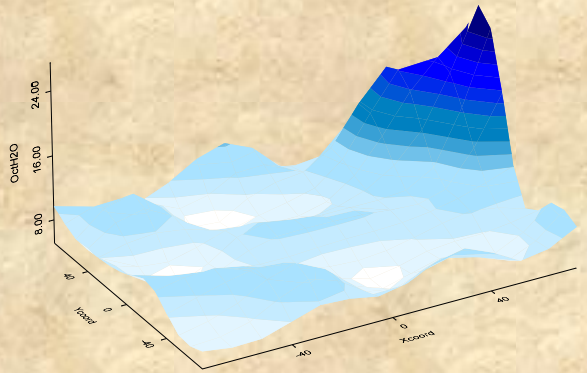
PAR



Available Nitrogen



Soil Moisture



The forest's heterogeneity supports it's biodiversity

Before the Fire: How do we increase treatment pace and scale?

- Diagnosis the problem: What's impacting most of the landscape? What's limiting the scale of current management practices?

Report Card

Area: There are 13 M ac of Forest Service Ownership in the Sierra Nevada

Fuels Treatment Target: Before European arrival, every year 622,000 ac burned reducing fuels

Current Treatment Rate: (2011-2020) FS averaged 63,357 ac/yr treated or 11% of historic rate

Most impactful: Wildfire burns almost 300,000 ac/yr; drought & beetles: 150 M dead trees

- So what needs to change, is it practical, and how do you pay for it?

Pyrosilviculture: directly increase fire use in dry western conifer forests by coordinating and consolidating prescribed burns, managed wildfire, and modified mechanical treatments to reduce fuels and tree density at **large scales**

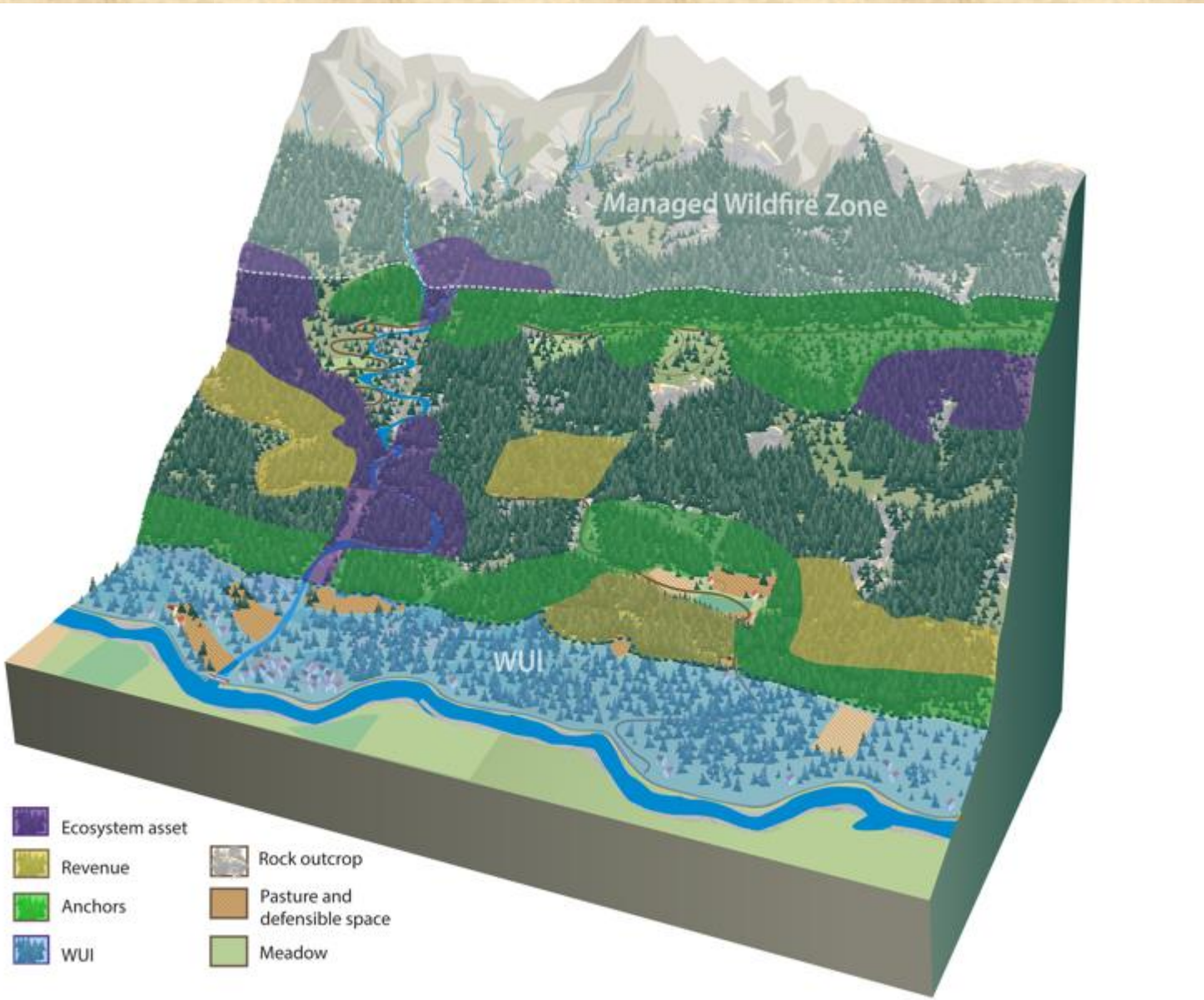
North, M.P., R.A. York, B.M. Collins, M.D. Hurteau, G.M. Jones, E.E. Knapp, L. Kobziar, H. McCann, M.D. Meyer, S.L. Stephens, R.E. Tompkins, and C.L. Tubbesing. 2021. Pyrosilviculture needed for landscape resilience of dry western U.S. forests. Journal of Forestry 119: 520-544.

Thin and Burn treatments are too small (36-40 ac) and dispersed (4500' between) to increase fire use or modify burn severity beyond the treated unit

- Following WDSS protocol which use roads, ridges, and natural features to set boundaries

- Fuels treatments are coordinated to form a large-scale (>5,000 ac) box for applying fire.

Landscape schematic of how 3 proposed forest treatments; anchors, ecosystem assets, and revenue might be placed to provide a boundary 'box'.

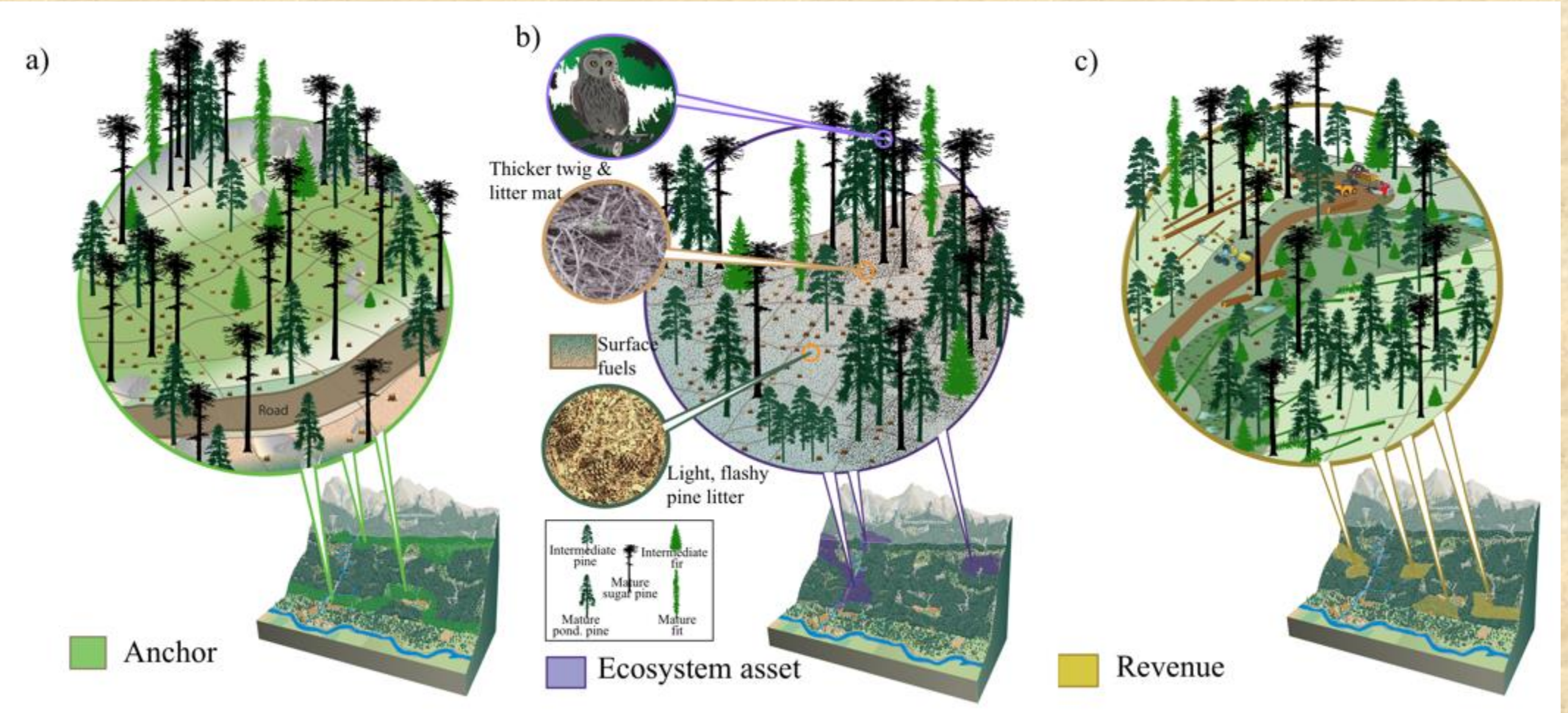


Stand-level schematics of three proposed thinning treatments:

a) Anchor: Near a road, a backstop (heavy fuels reduction leaving only large, spatially separated pines) grading into a more mixed-species forest with a fire resistant spatial pattern (i.e., individual trees, clumps of trees and openings [ICO]) where the fire leaves the anchor;

b) Ecosystem Asset: thinned trees are ladder fuel size, an ICO pattern is created, and pine litter is dispersed in openings to facilitate fire spread

c) Revenue: thinning where intermediate and larger fire-sensitive fir are removed for saw log processing.



Are these different from current fuels treatments?

All are focused on getting fire into the forest, scaling up its footprint, and financing it

Pyrosilviculture Benefits

- Mechanical thinning often limited in scale and long review period, as Rx fire can be scaled up with programmatic burn plan for entire N.F.
- Fire reintroduces a key process and may provide better forest adaptability/resilience than targeted thinning prescriptions
- Maintenance of areas with reduced fuels needs a large-scale, repeatable treatment.

But, some changes are needed

- Will need a western US prescribed fire training center to develop crews dedicated to using fire for resource benefit and to coordinate equipment and resources across agencies
- Will need longer duration permits to carry out large burns
- Could employ a push/pull Yosemite strategy: under poor weather and smoke dispersal, fire is pushed into low fuel areas and then pulled across the landscape when conditions are favorable

Drought/Beetles/Climate Change:
What happens when the larger, overstory trees die

- Fire suppression has left too many ‘straws in the ground’ and a 2012-2016 CA drought and bark beetle outbreak resulted in >150 M dead trees in the Sierra Nevada

- This produced such high fuel loads, that the 2020 Creek Fire burning in these heavy fuels had fire behavior similar to WW2 fire bombing (i.e., Tokyo and Dresden)

- This compounding of disturbances is likely to increase with climate change and more severe wildfires

2020 Creek Fire: >55,000 ft tall pyrocumulonimbus cloud

Forests need to be **resilient** to multiple stresses
They were in the past. What's changed?

Historically most western forests were open and dominated by large trees

Forest appears 'understocked'

1902 timber survey of the northern Sierra Nevada by Leiberg: "Suppression of the young growth has always been one of the serious results of fires…The land does not carry more than **35 per cent** of the quantity of timber it is capable of supporting"

North, M.P., R.E. Tompkins, A.A. Bernal, B.M. Collins, S.L. Stephens, and R.A. York. 2022. Operational resilience in western US frequent-fire forests. Forest Ecology and Management 507: 120004.

Historically western frequent-fire forests survived fire & droughts

What's different now?

Without fire, live tree density and biomass ⬆
competition for growth resources ⬆
tree vigor ⬇

Inter-tree competition creates **chronic** growth reductions ➔
increased tree susceptibility to stress and mortality

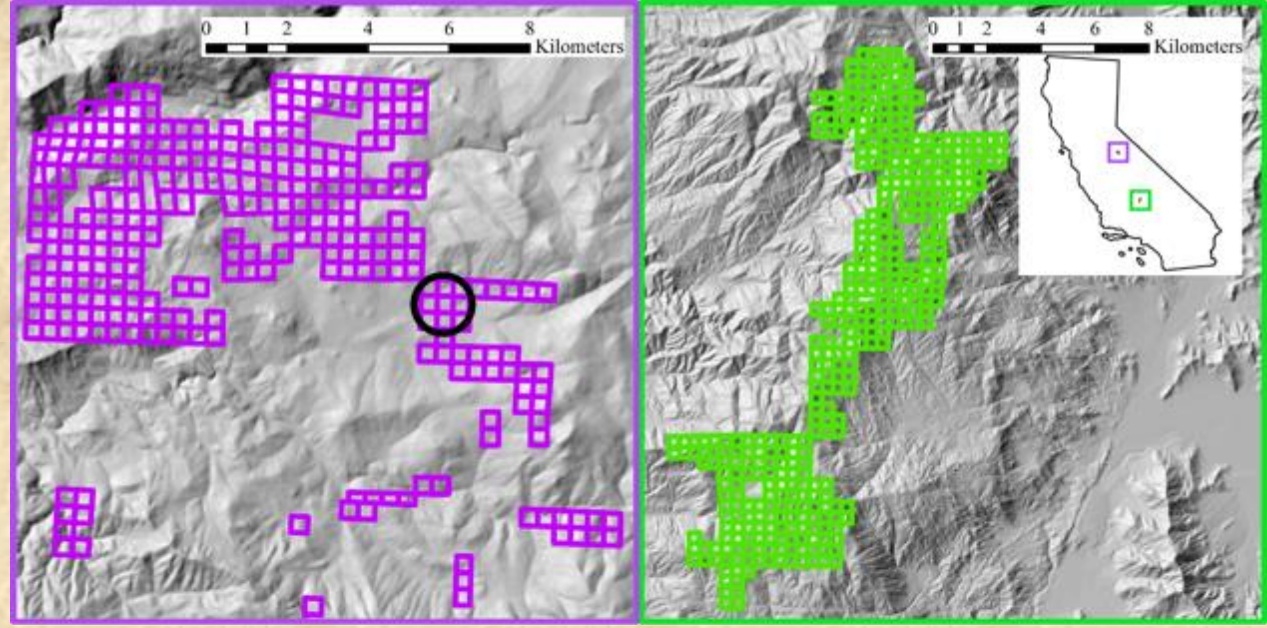
Competition reduces radial growth

FF forests can resist stress 'pulses' (fire, pests), but
are not adapted to stress 'presses' such as competition

Foresters already have a good measure of competition
Relative SDI = how a local stand compares to the maximum biomass that can be supported for a particular forest type

Testing of this Resilience Concept with Historical Data

1911 timber inventories in the Stanislaus (left) and Sequoia (right) N.F.s
(Collins et al. 2015 & Stephens et al. 2015)



Total of 644, Quarter-Quarter sections covering over **24,000 acres**

Belt transects 1-2 chains x 20 chains

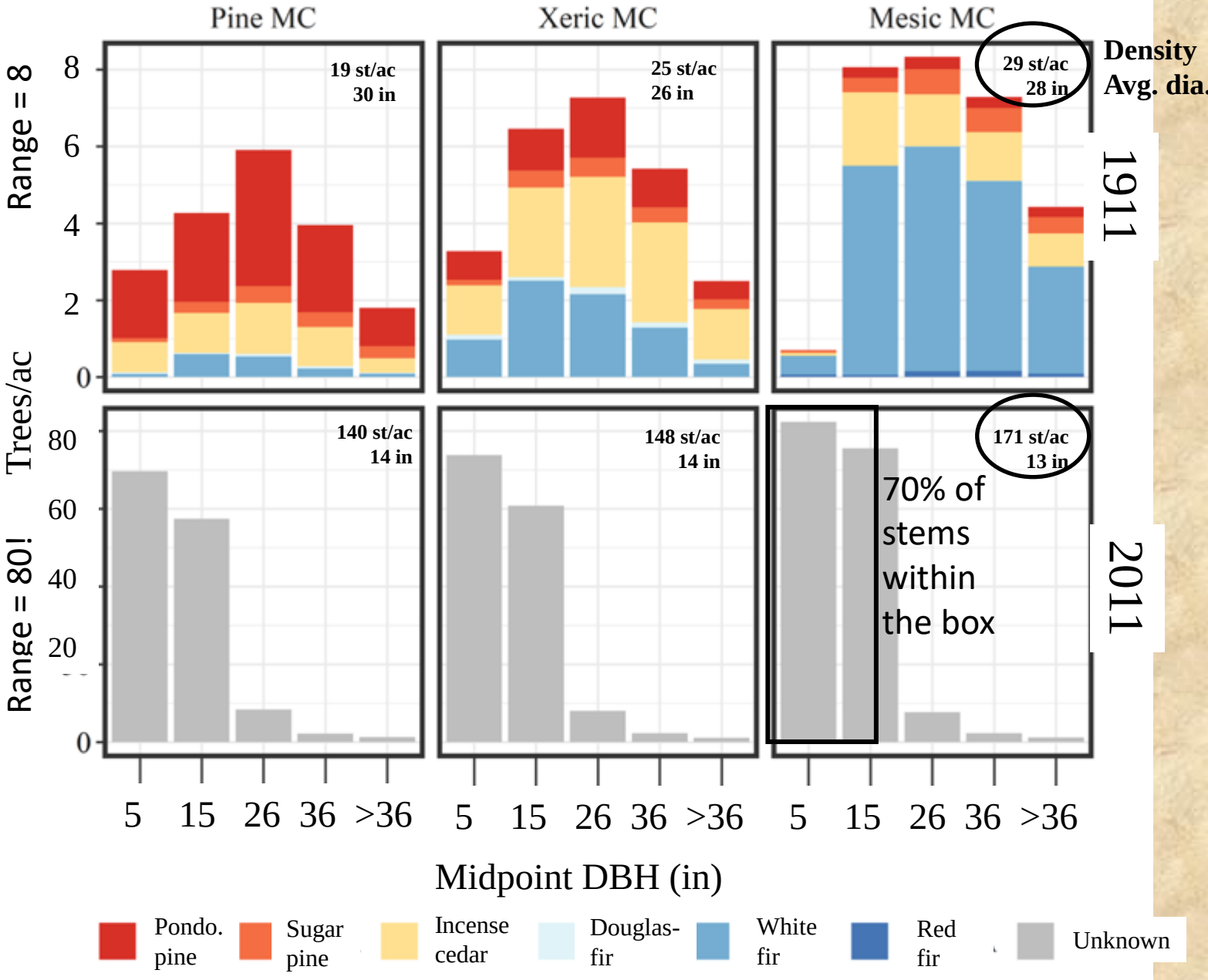
5-10% sample intensity

All conifer trees > 6.0 inches

2011 forest conditions assessed with USFS F3 data: FIA, FVS, & FastEmap. (Huang 2018)

Change in Forest Conditions from 1911 to 2011:

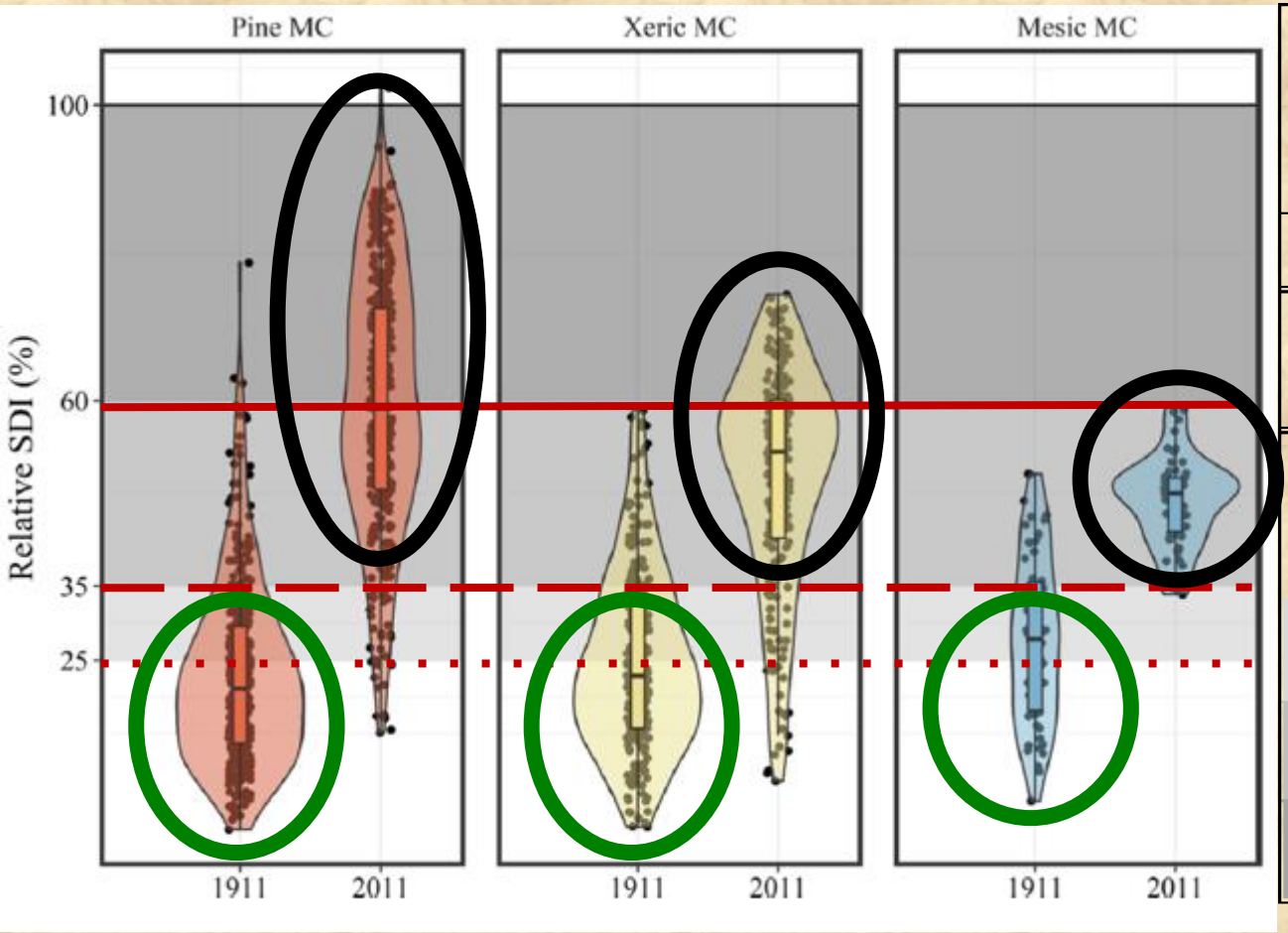
Forest density increased by 6 fold; average tree diameter dropped 50%



Bear Creek R.S., Plumas NF

SHIFTS IN THE COMPETITIVE ENVIRONMENT

RELATIVE DENSITY AS A RESILIENCE METRIC



	Pine MC		Xeric MC		Mesic MC	
A) Absolute SDI						
	1911	2011	1911	2011	1911	2011
SDI_{metric}	206 (123-267)	535 (433-655)	275 (175-370)	551 (462-668)	378 (247-483)	632 (575-674)
$SDI_{english}$	83 (50-108)	216 (174-265)	111 (71-150)	223 (187-270)	153 (100-196)	256 (233-273)
B) Relative SDI (% of SDI_{max})						
Mean (Range)	23 (14-30)	59 (48-73)	25 (16-33)	50 (42-60)	28 (18-36)	46 (42-50)
C) % of Relative SDI Observations In Each Competitive Benchmark						
Free (<25% SDI_{max})	64	4	58	9	44	0
Partial (25-34% SDI_{max})	21	6	21	9	29	5
Full (35-59% SDI_{max})	14	42	20	57	27	95
IM (≥60% SDI_{max})	<1	48	0	25	0	0

In historic forests (1911): 73-85% of stands were below full occupancy (free of competition or partial competition)

In contemporary forests (2011): 82-95% of stands are in full competition or in the zone of imminent mortality

SO WHAT? MANAGEMENT & POLICY IMPLICATIONS:

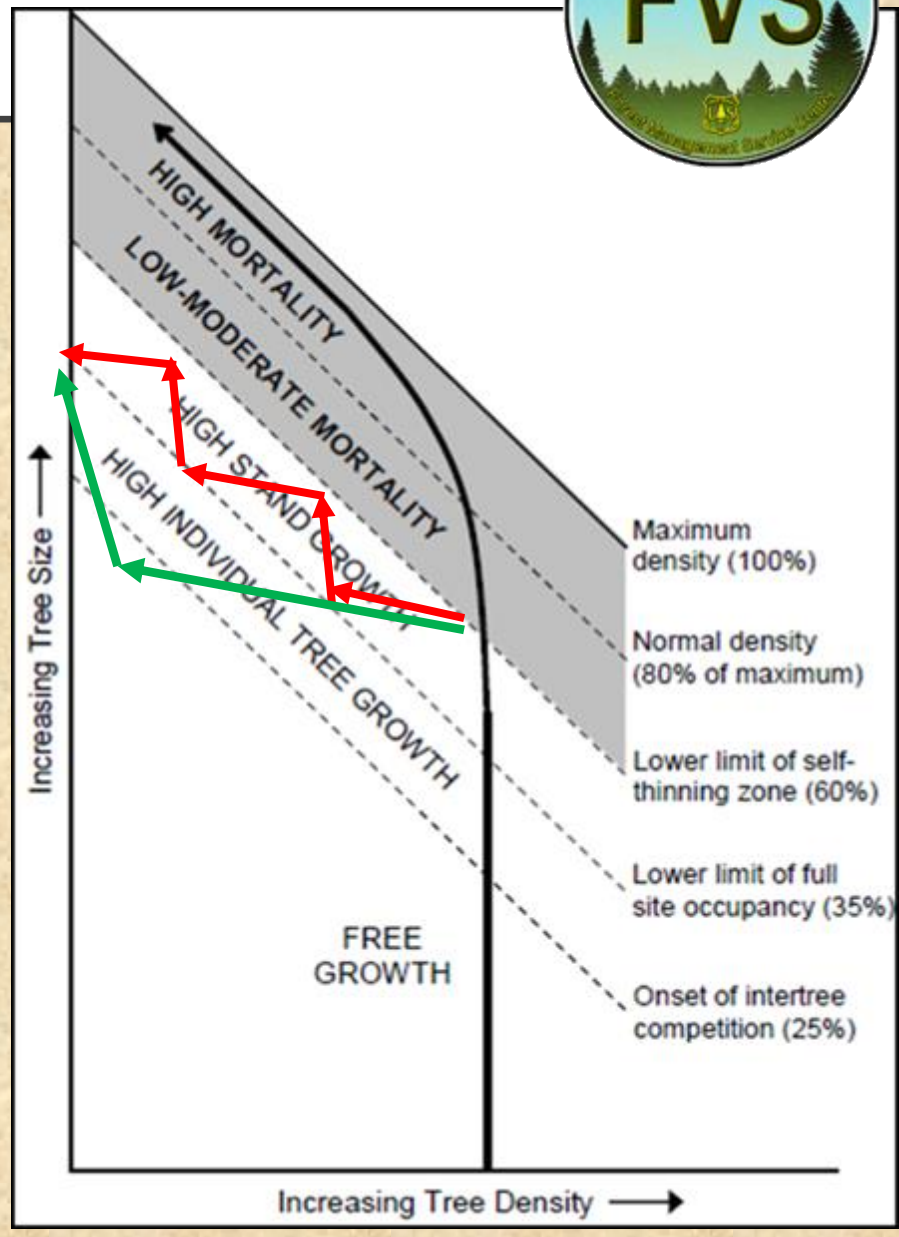
Competition is the driver of how forest stands are currently managed, when thinning occurs, and which trees are favored due to their size

Implications:

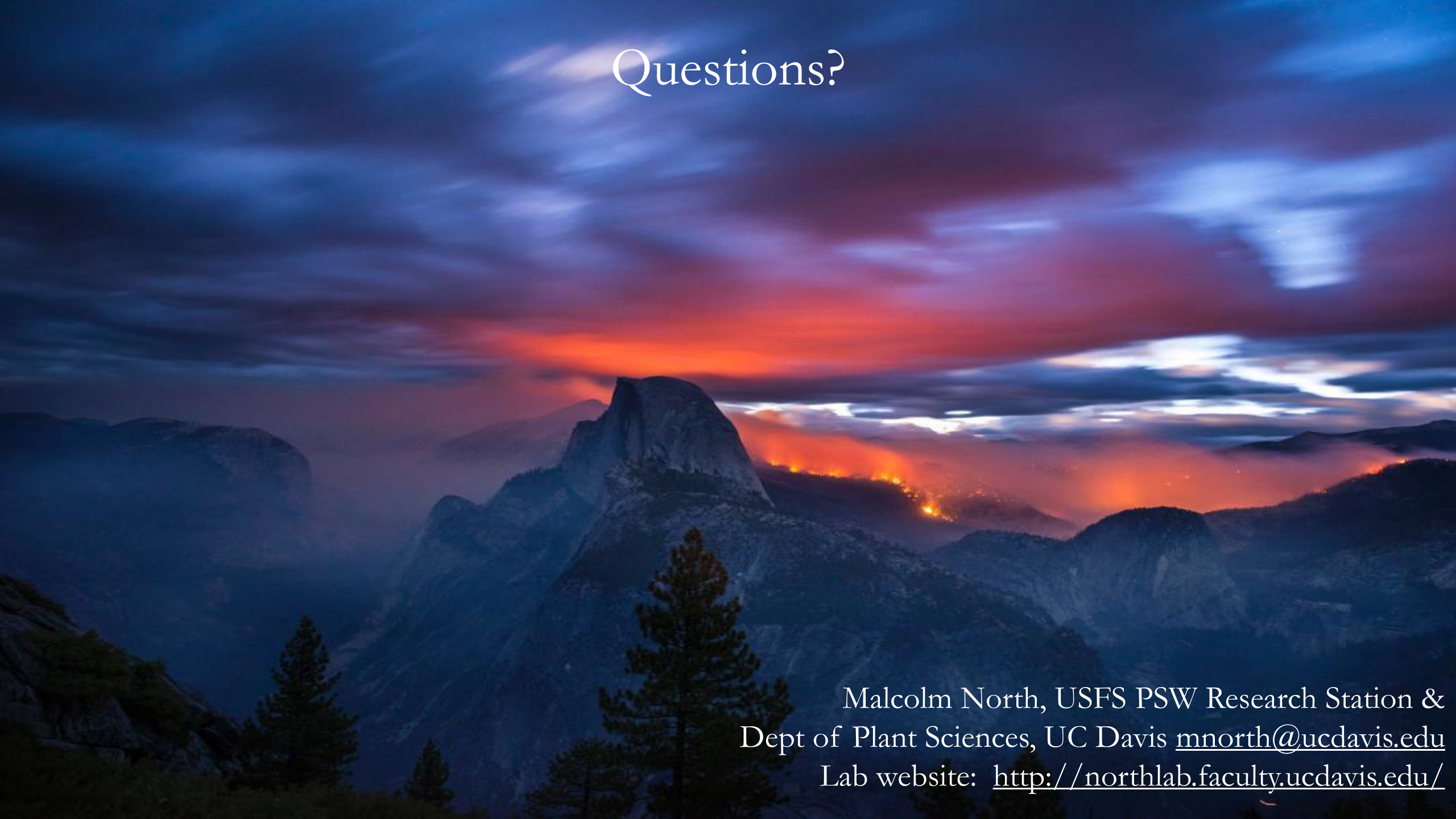
Relative SDI of 35% should be a ***maximum not a minimum***

Using relative SDI_{max} ≥60%, Region 5 would **treat only** 48%, 25% and 0% of our contemporary pine, xeric &mesic mixed-conifer types.

Treatments to minimize competition would be much more extensive: 96%, 91% and 100% of the three forest types.



Questions?



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