

OPERATIONAL RESILIENCE IN WESTERN US FREQUENT-FIRE FORESTS: WHAT IS FOREST RESILIENCE & HOW DO WE RESTORE IT?



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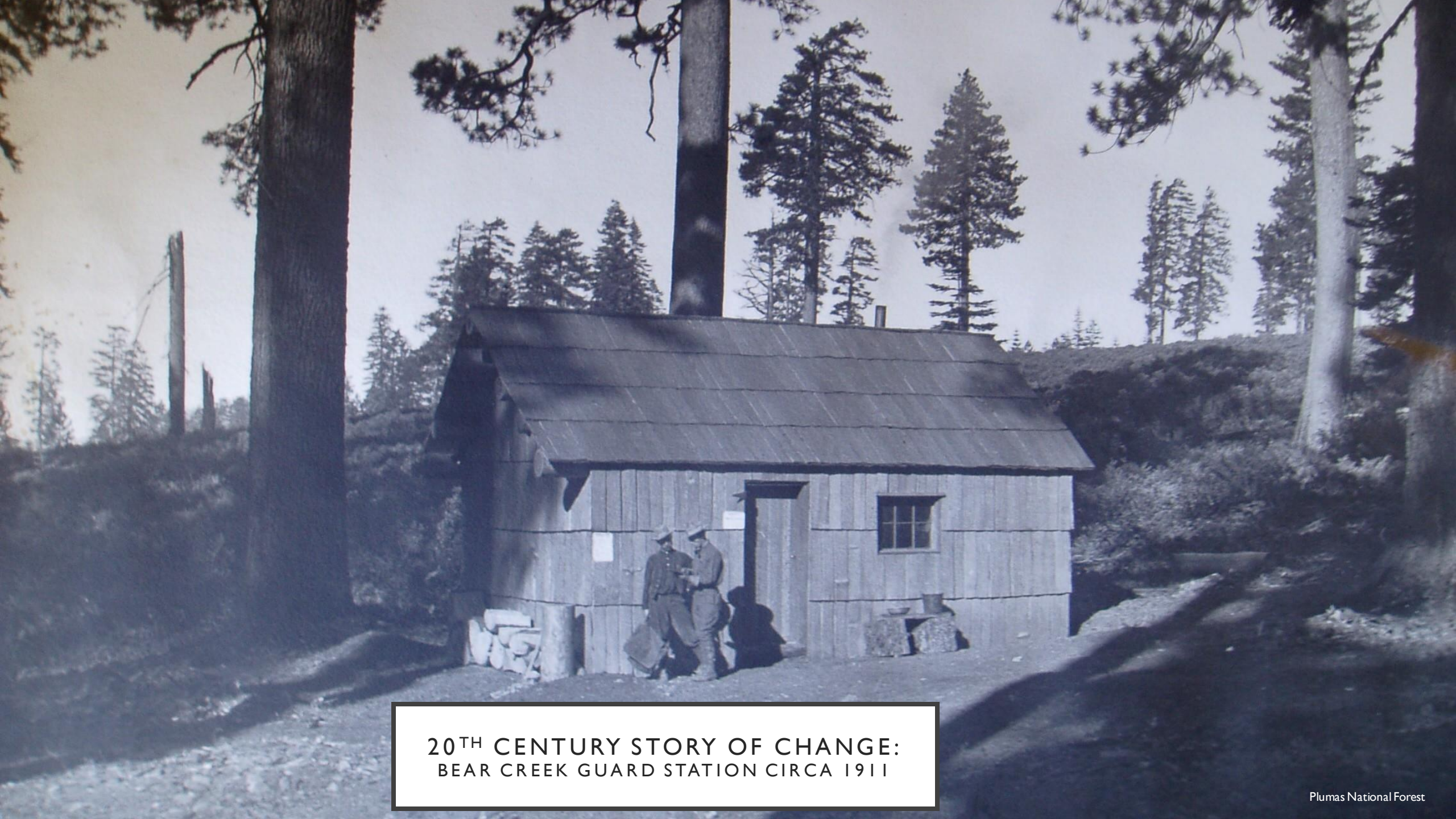
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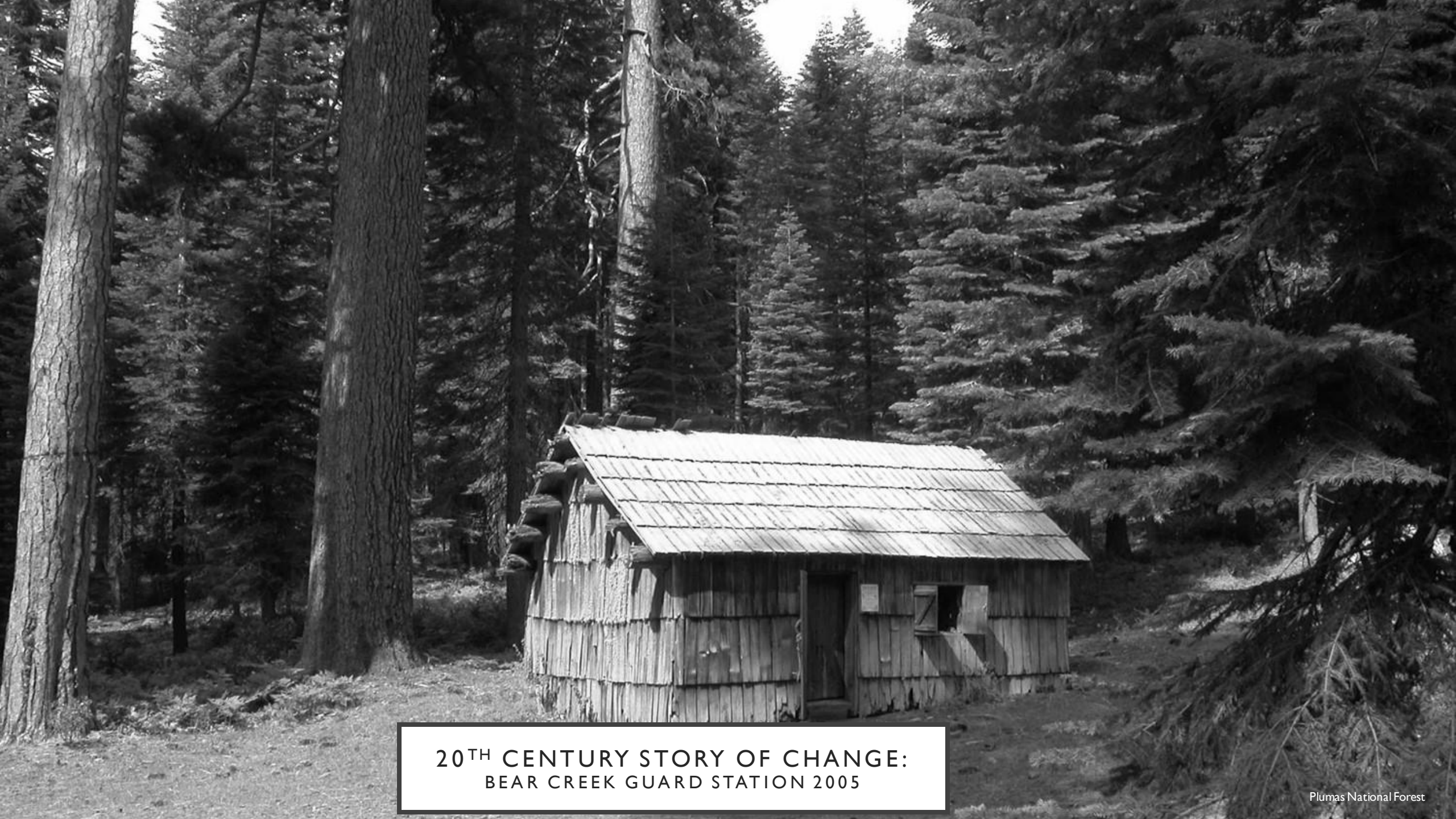
North, M.P., Tompkins, R.E., Bernal, A.A., Collins, B.M., Stephens, S.L. and York, R.A., 2022. Operational resilience in western US frequent-fire forests. *Forest Ecology and Management*, 507, p. 120004.

“SUPPRESSION OF THE YOUNG GROWTH HAS ALWAYS BEEN ONE OF THE SERIOUS RESULTS OF FIRES...THE LAND DOES NOT CARRY MORE THAN 35 PERCENT OF THE QUANTITY OF TIMBER IT IS CAPABLE OF SUPPORTING” (LEIBERG 1902)





20TH CENTURY STORY OF CHANGE:
BEAR CREEK GUARD STATION CIRCA 1911



20TH CENTURY STORY OF CHANGE:
BEAR CREEK GUARD STATION 2005



Photo: Plumas County Search and Rescue/KRCR

21ST CENTURY SHIFTS IN DISTURBANCE REGIMES:
ALIGNMENT OF DROUGHT WITH LANDSCAPE LEVEL FOREST DENSITY & FUELS

FOUNDATIONAL ECOLOGICAL CONCEPTS:

RESISTANCE vs. RESILIENCE

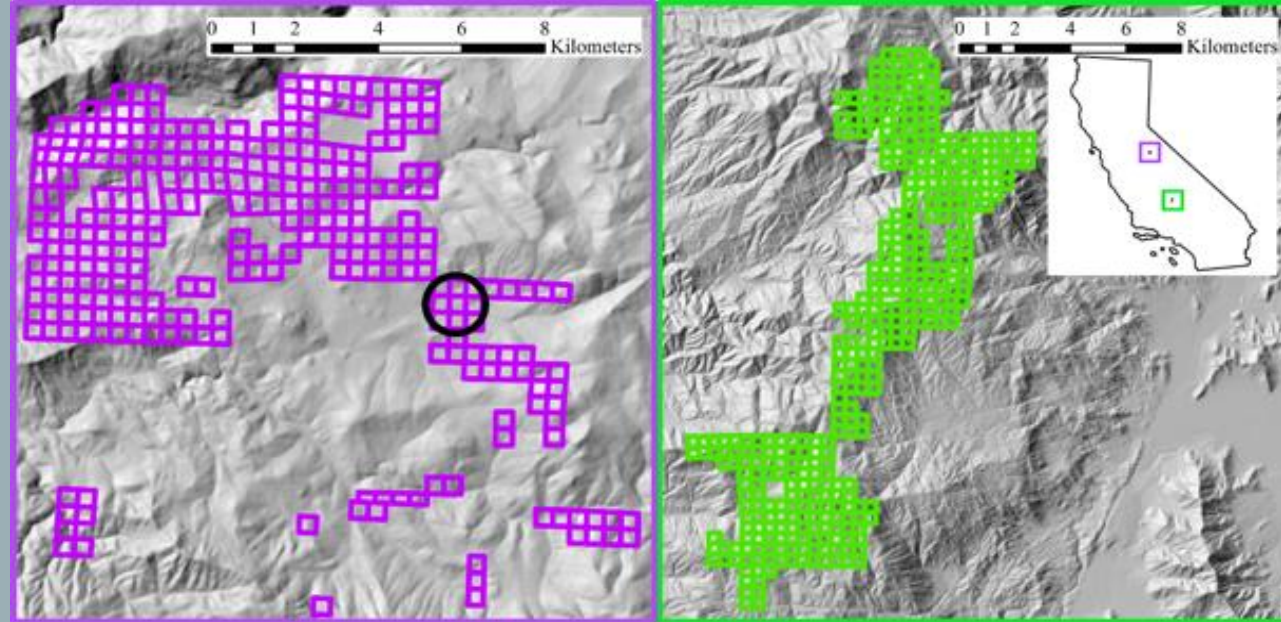
Resistance: Measure of persistence, focuses on minimizing change to a specific stress

Resilience: Measure of adaptability, focuses on retaining an ecosystem's essential structure and composition to a range of stresses or complex of disturbance interactions

RESILIENCE STUDY DESIGN

Utilized 1911 Forest Inventory data from Stanislaus & Sequoia National Forests (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
- Trees > 6.0 inches
- Canopy Covers 12-28% for forested stands



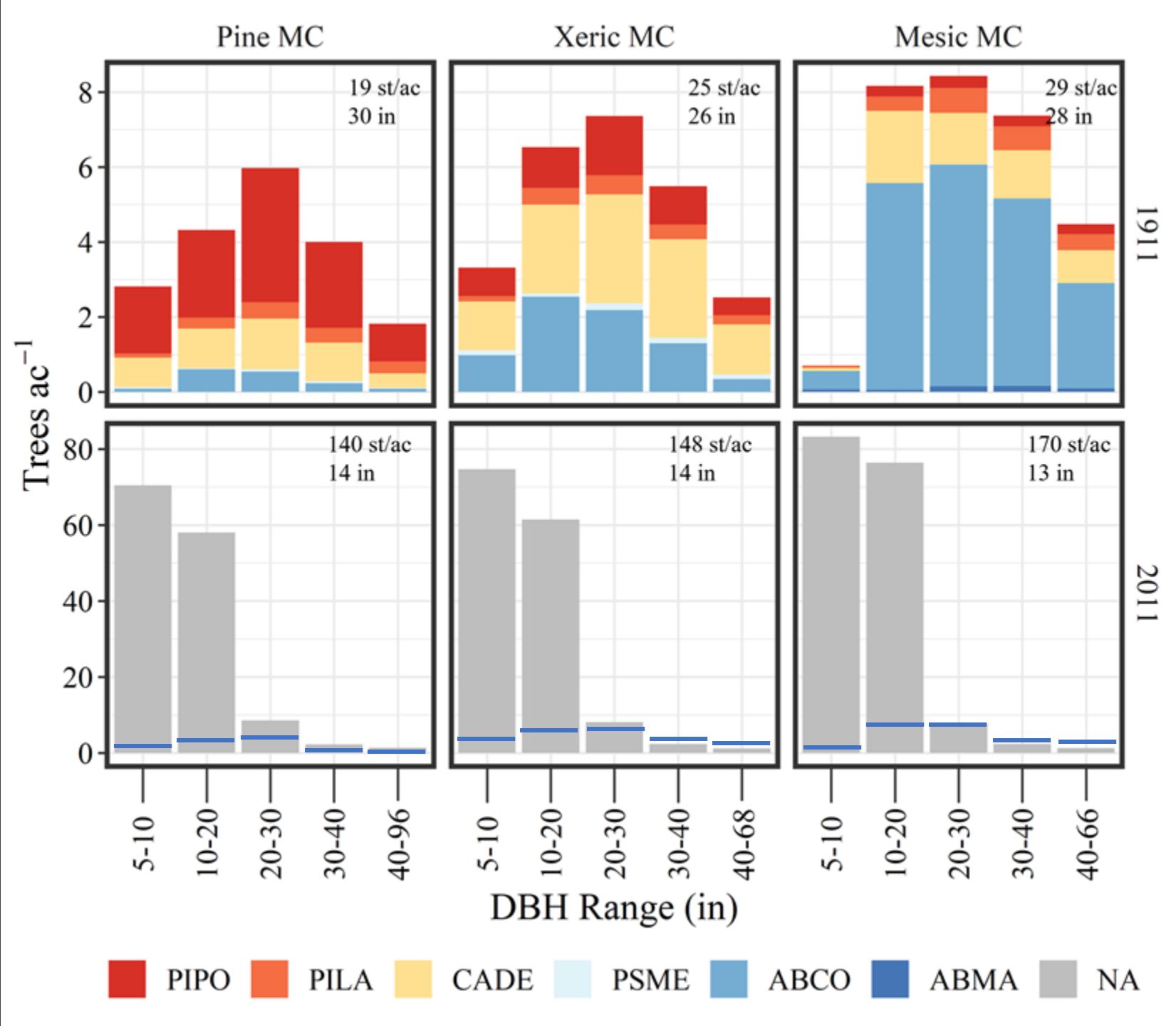
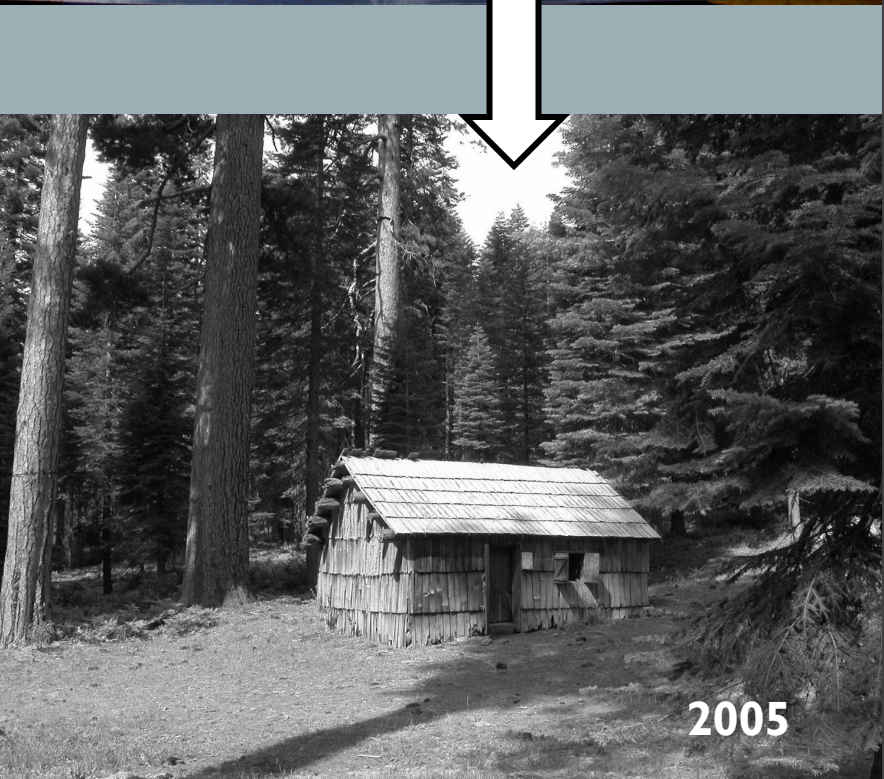
2011 forest conditions assessed with USFS F3 data: FIA, FVS, & FastEmap. (Huang et al 2018)

Form 321 a. UNITED STATES DEPARTMENT OF AGRICULTURE, FOREST SERVICE. "Forty" Estimate Sheet.

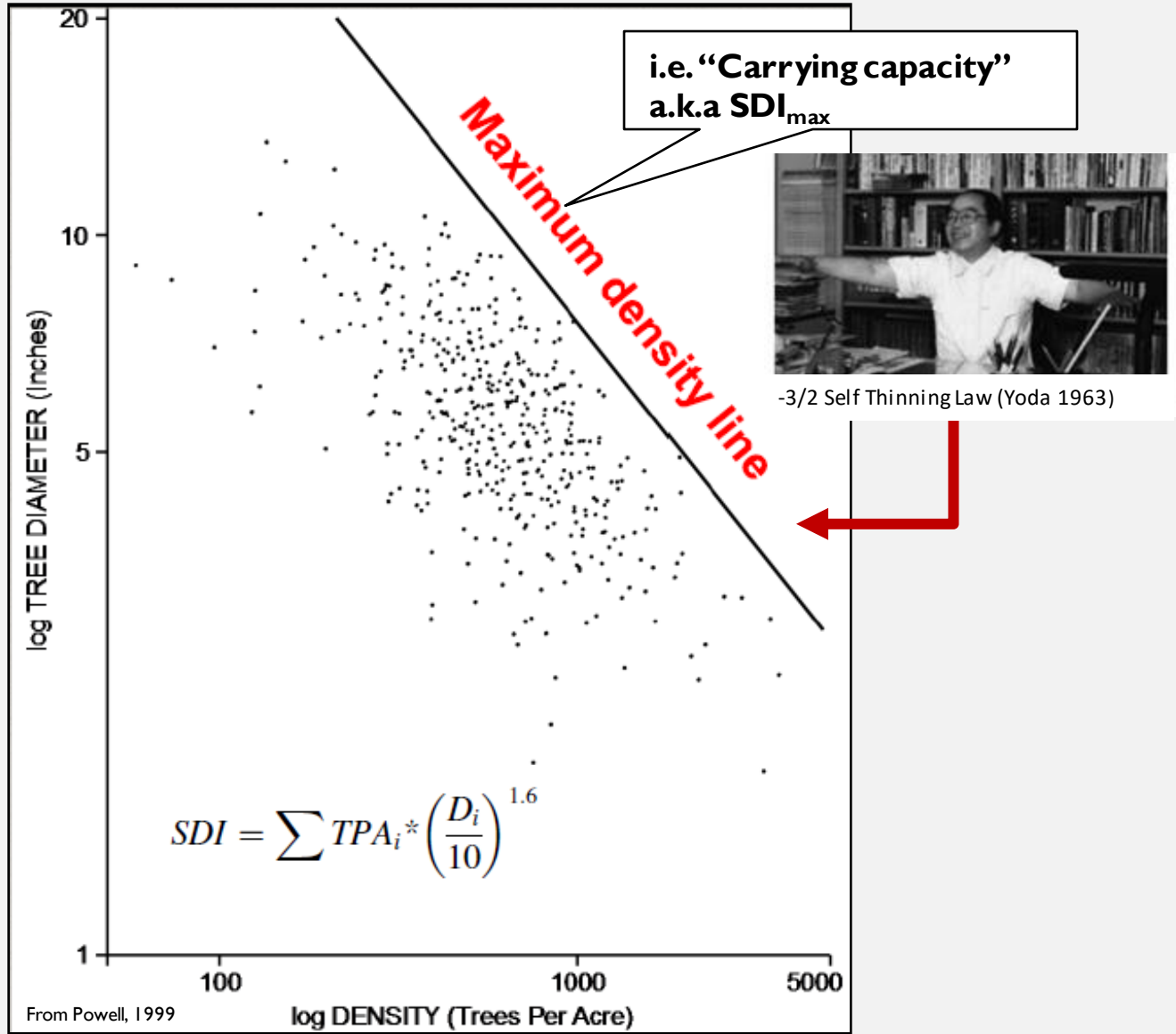
Tp. 15, R. 20 E, M.D. M. Sec. 19, Forty Course DUEBY Slope SW
 Sheet Number 293 Series Date 7-8, 1911 Examiners Estimator E.H. COLLISON
 Compassman J.R. BERRY

D. B. H.	Y P	Species	SP	WF	IC	Miscellaneous Green; Dead (All Species)	
INCH	1	Number of Logs	1	1	1	SP WF IC	
12	✓					15	hullings 20
14						10	saplings 8
16						4	Dead 3
20	✓		4	4	3		
22	✓						
24	✓						
26	✓						
28	✓						
30	✓						6 logs
32	✓						
34	✓						
36	✓						
38	✓						
40	✓						
42	✓						
44	✓						
46	✓						
48	✓						
50	✓						
52	✓						

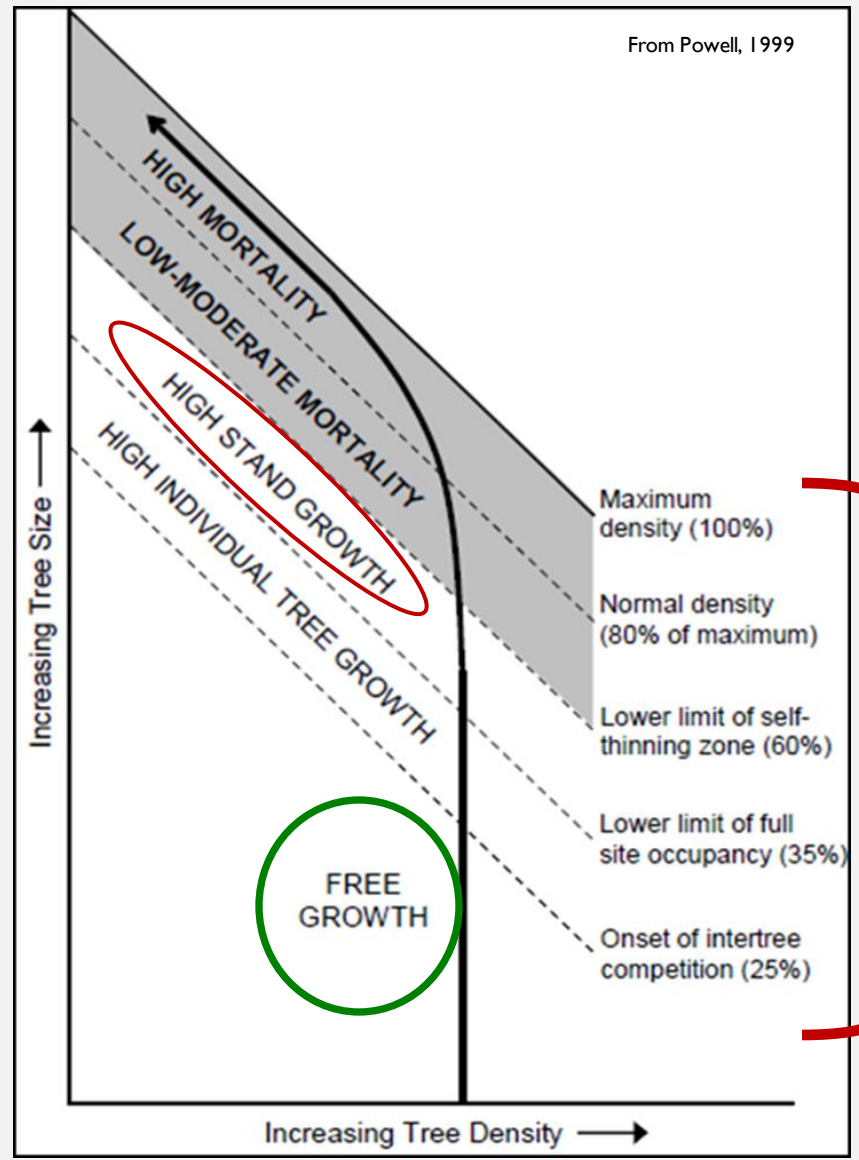
Examined 3 Forest Types based on historical data	
Pine Mixed Conifer	> 50% pine
Xeric Mixed Conifer	≤ 50% pine & ≤ 50% fir
Mesic Mixed Conifer	> 50% fir



ECOLOGICAL IMPORTANCE OF RELATIVE STAND DENSITY: CHARACTERIZING COMPETITION & GROWTH

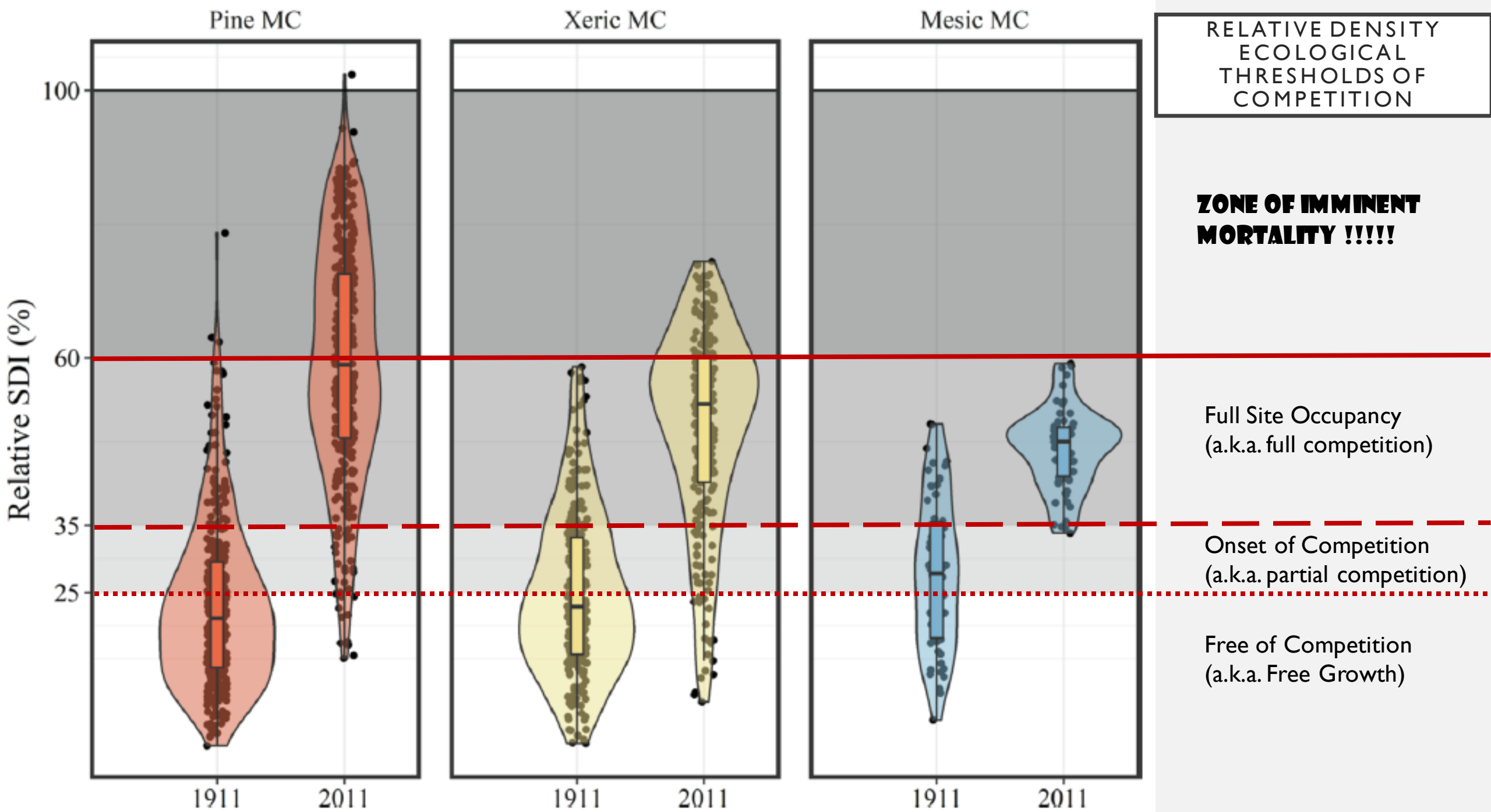


Stand Density Index (Reinecke 1933)



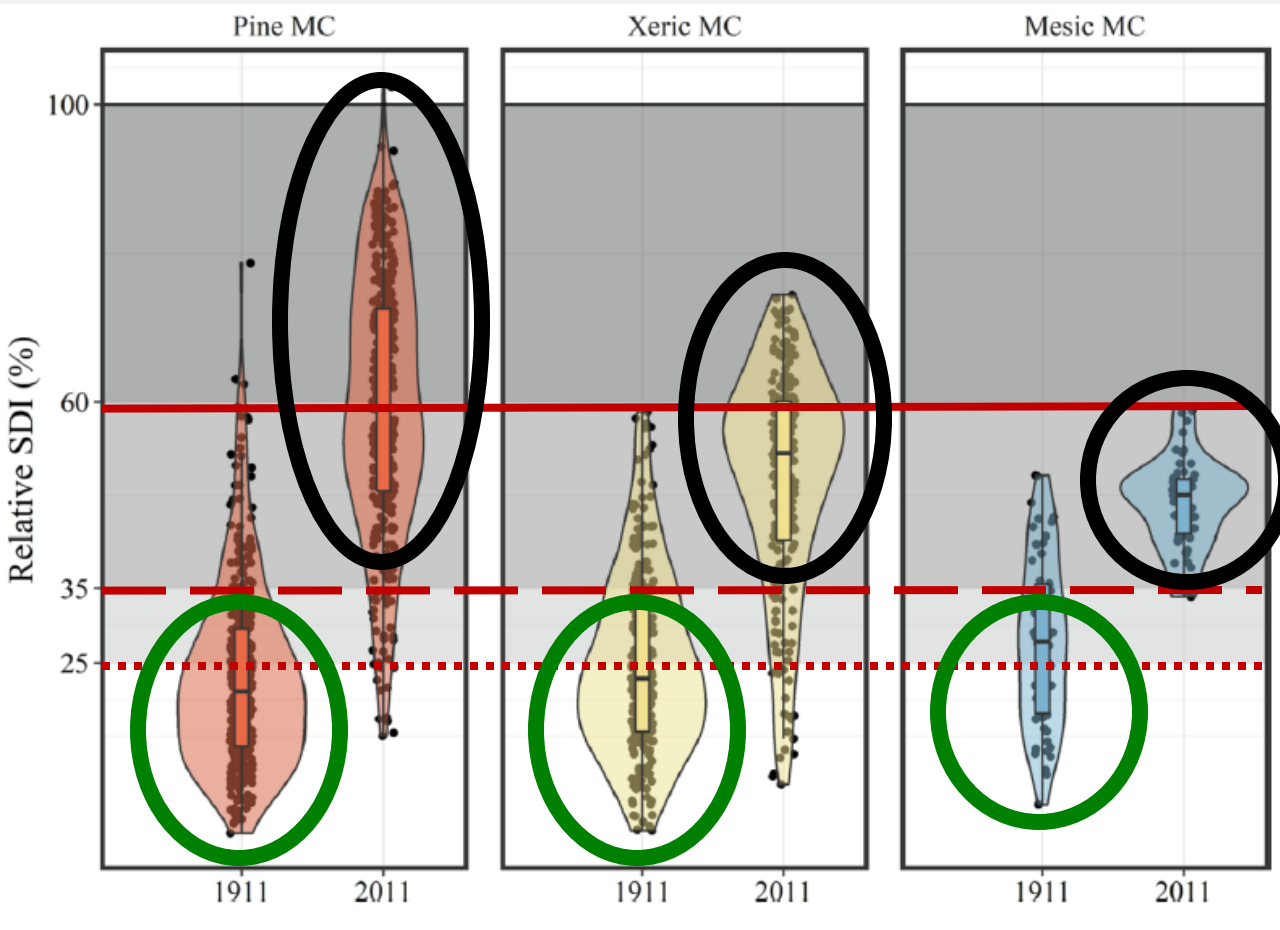
Drew & Flewelling 1979 & Long 1985

Competition Thresholds



SHIFTS IN THE COMPETITIVE ENVIRONMENT

RELATIVE DENSITY AS A RESILIENCE METRIC



	Pine MC		Xeric MC		Mesic MC	
A) Absolute SDI						
SDI_{metric}	1911 206 (123-267)	2011 535 (433-655)	1911 275 (175-370)	2011 551 (462-668)	1911 378 (247-483)	2011 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 were in full competition or in the zone of imminent mortality

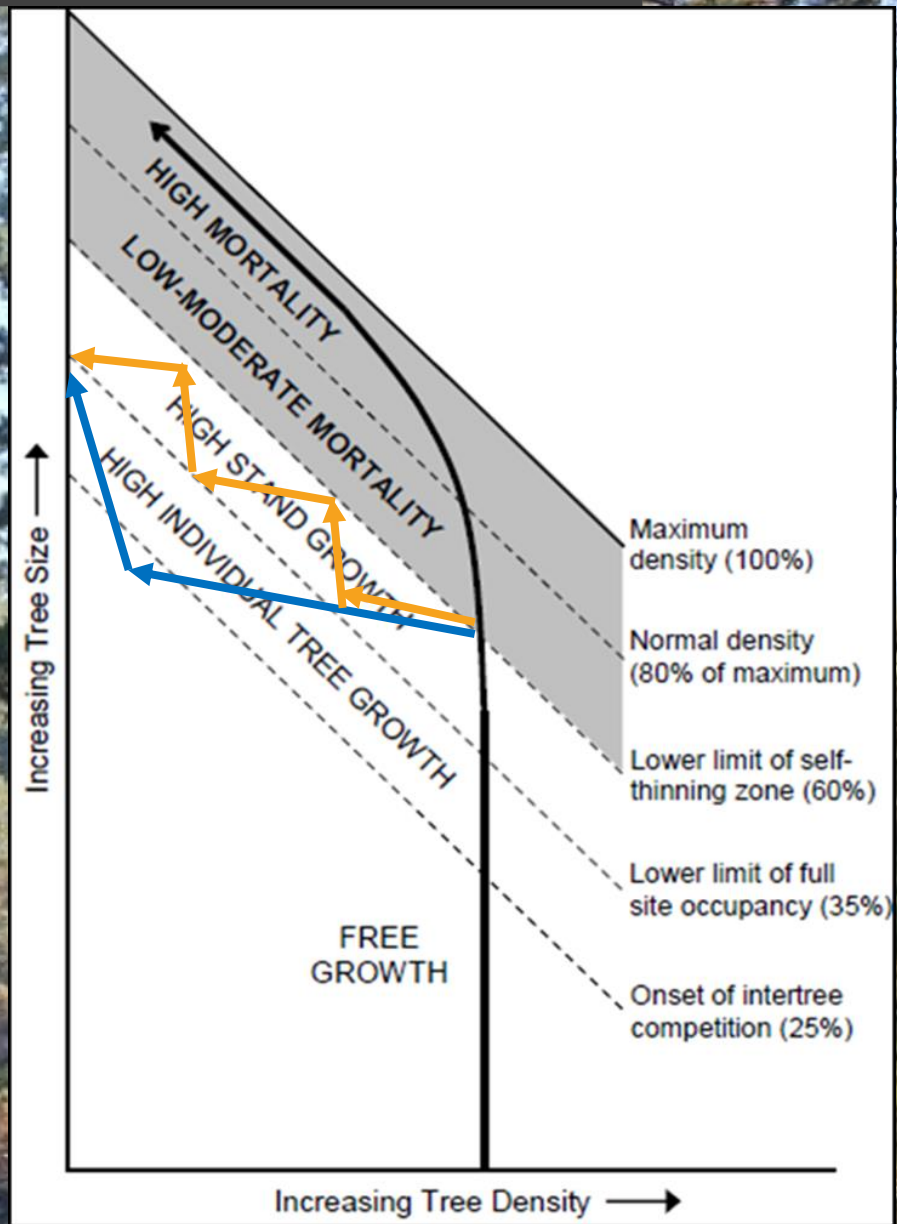
HOW LOW RELATIVE STAND DENSITY PROMOTES RESILIENCE: QUANTIFIED METRIC FOR DEFINING LARGE TREE HABITAT REQUIREMENTS

- **Fire as a predator analog: limiting competition from onset of regeneration**
- **Low stand density minimizes competition for resources (e.g. WATER!)**
- **Low competition maximizes individual tree growth & vigor**
 - **Resistance to drought, insects, & disease**
 - **Adaptations with greater resistance to wildfire**
- **Low densities of large drought/fire resistant trees are the “backbone” of resilient dry mixed conifer forests**

Relative Stand Density Provides:

- **Competition Metric**
- **Ecological thresholds for treatment efficacy & longevity**
- **Characterizes habitat requirements for large tree development**

SO WHAT? MANAGEMENT & POLICY IMPLICATIONS: TARGETS BASED ON COMPETITIVE ENVIRONMENT



MANAGEMENT & POLICY IMPLICATIONS:

LOW RELATIVE DENSITIES PROMOTE HETEROGENEITY (i.e. ICO pattern, multi-age, shade intolerants)



Sierra San Pedro Martir:
32 TPA Relative Density ~23%
Murphy et al. 2021. *Forest Ecology and Management*.

MANAGEMENT & POLICY IMPLICATIONS:

RESTORATION OF BOTH STRUCTURE + PROCESS IS CRITICAL TO RESTORATION OF ECOLOGICAL FUNCTION

Structure only: Mechanical thinning...

...low intensity burn in Dixie Fire



Relative Density ~30%

MANAGEMENT & POLICY IMPLICATIONS:

RESTORATION OF BOTH STRUCTURE + PROCESS IS CRITICAL TO RESTORATION OF ECOLOGICAL FUNCTION

Structure only: Mechanical thinning



Relative Density~48%

...Intense burning conditions in Dixie Fire



MANAGEMENT & POLICY IMPLICATIONS:

RESTORATION OF BOTH STRUCTURE + PROCESS IS CRITICAL TO RESTORATION OF ECOLOGICAL FUNCTION

Process only: RxFire 3 times in 20 years



Relative Density~76%

Structure + Process: Thinning & Gap Harvest + 1 RxFire



Relative Density~34%

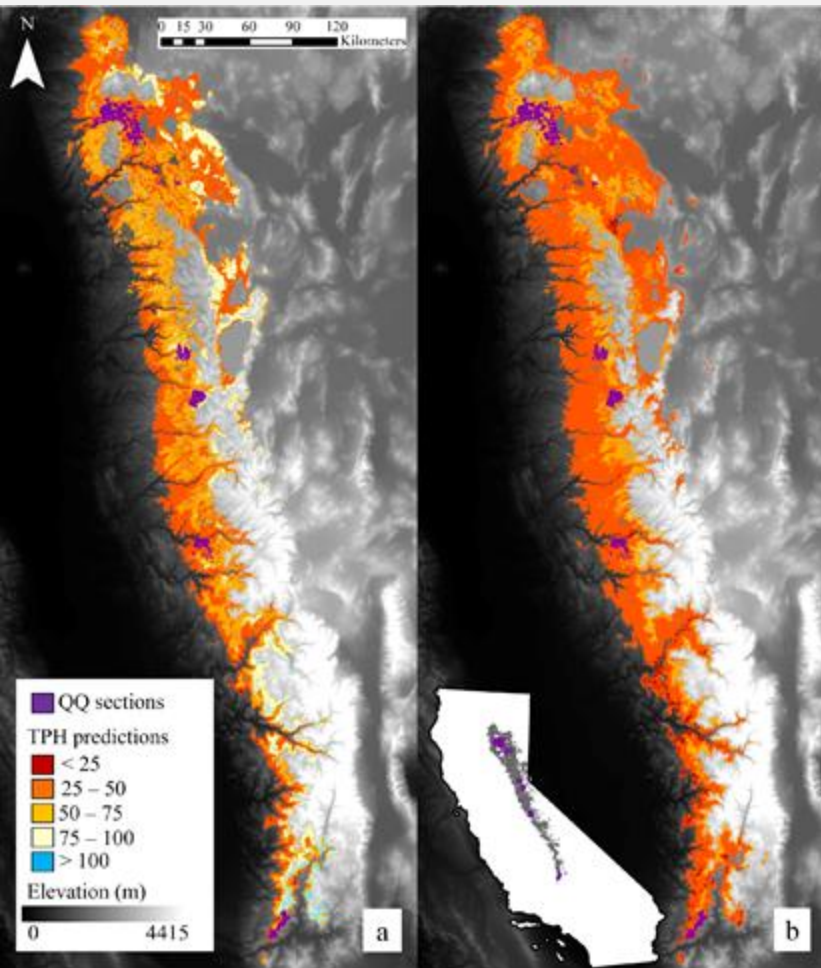
WHAT DOES RESILIENCE LOOK LIKE IN THE FUTURE?

Bernal et al. 2022; Environmental Research Letters

Low tree densities (low end of NRV)

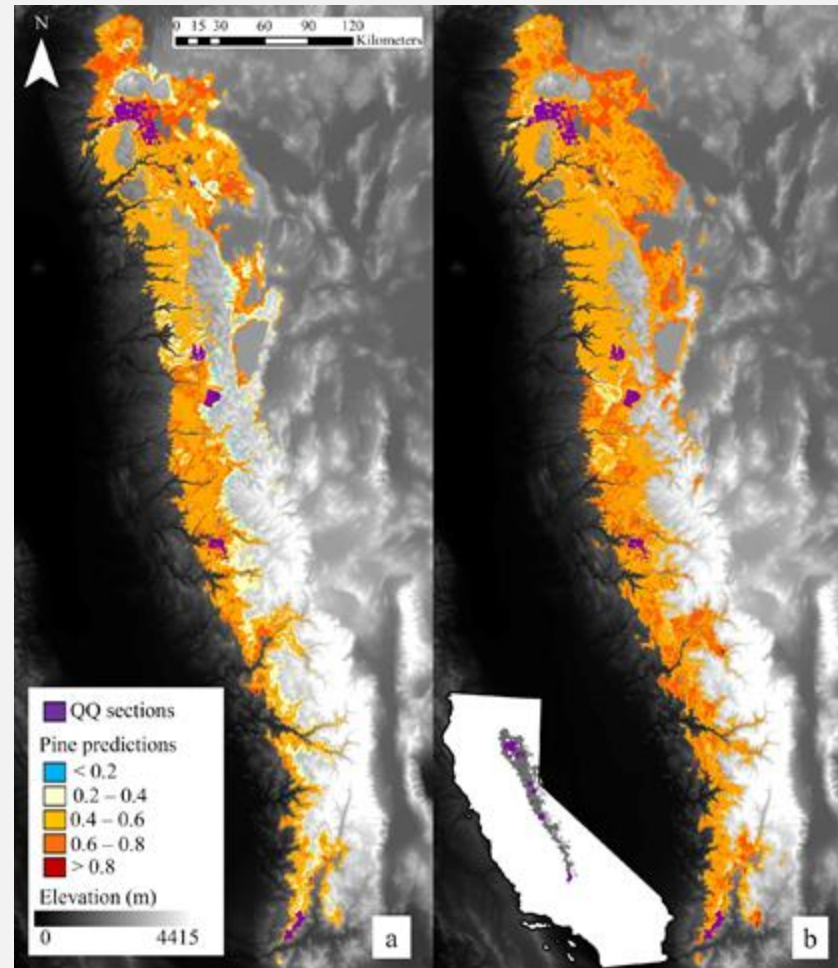
Higher Pine Dominance

Supports <25% of current AGLB



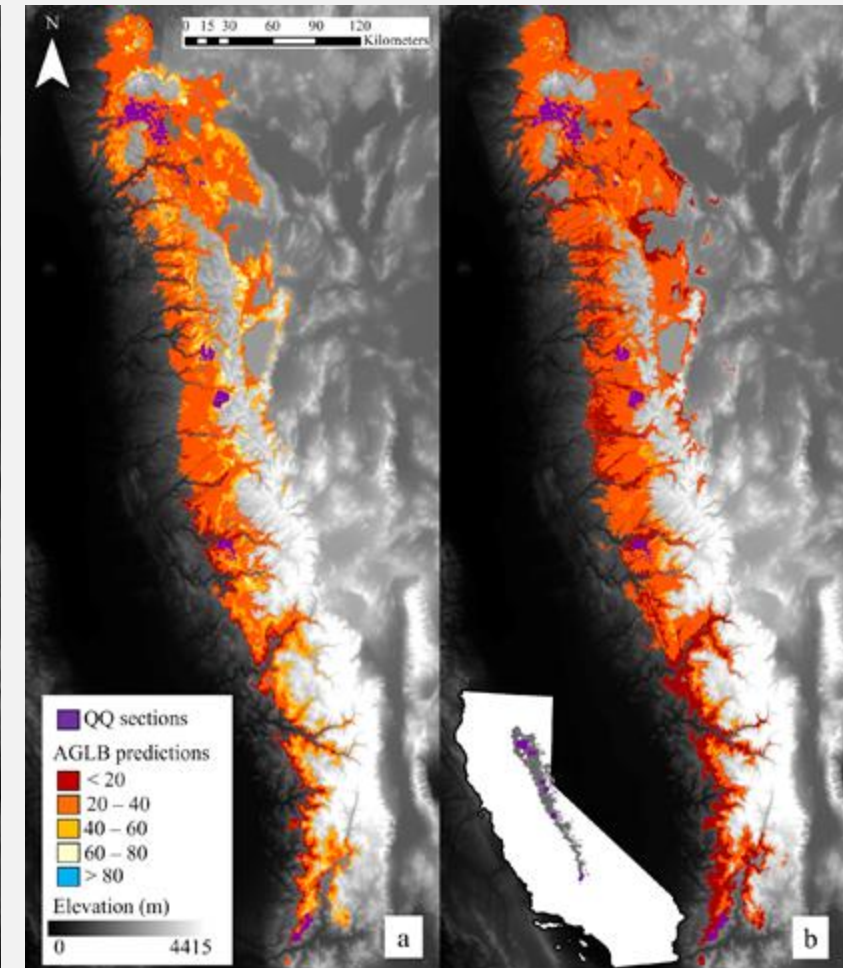
Historical (1911-1936)

Future (2040-2069)



Historical (1911-1936)

Future (2040-2069)



Historical (1911-1936)

Future (2040-2069)

An aerial photograph of a forested hillside. The terrain is covered with a mix of green pine trees and brown, rocky ground. A semi-transparent white text box is overlaid on the upper portion of the image, containing the main title and several bullet points. The text is in a bold, black, sans-serif font.

MANAGEMENT & POLICY IMPLICATIONS: PRACTICE & POLICY IS NOT WELL ALIGNED WITH RESTORATION

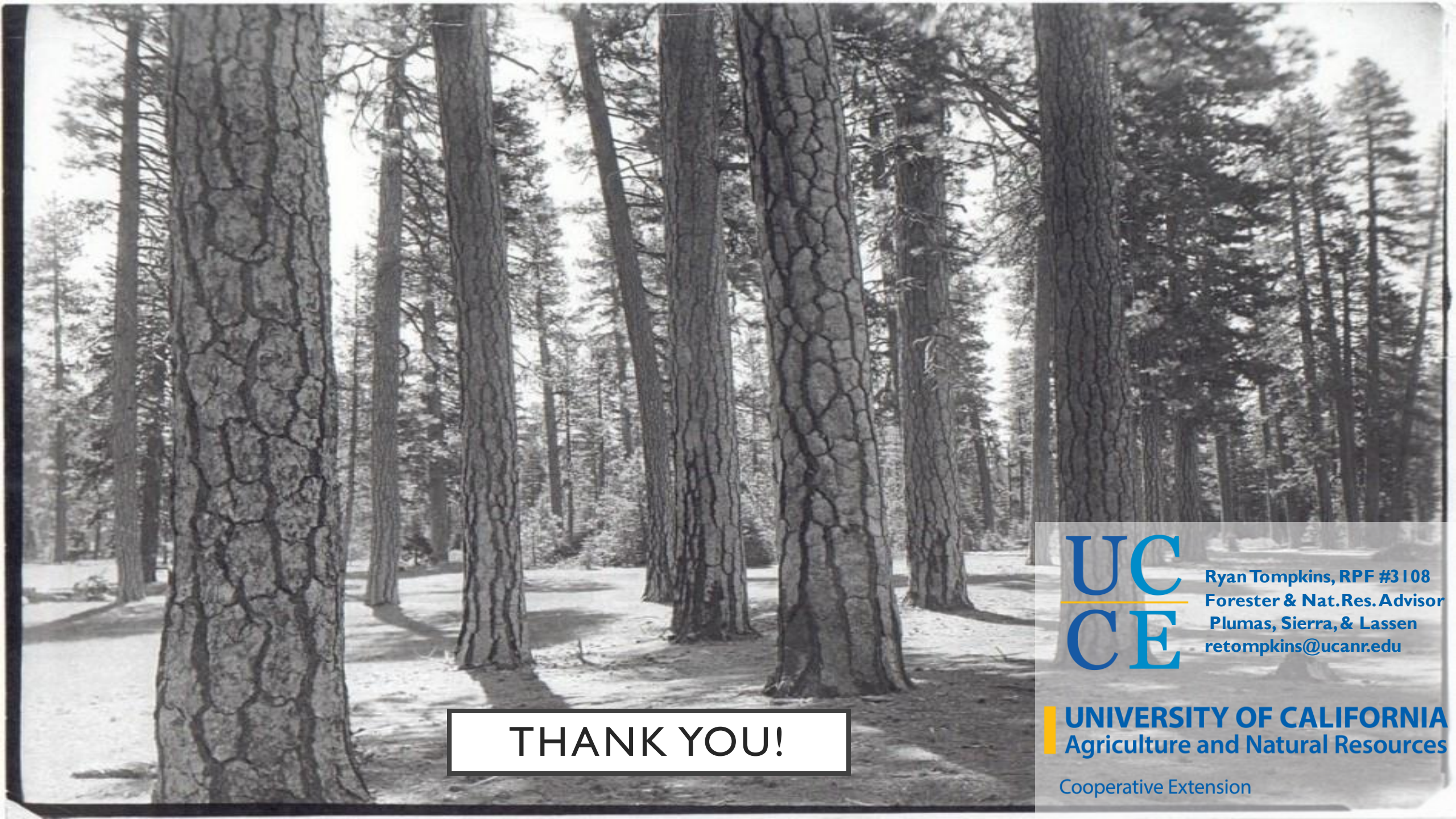
20th century conservation biology constructs may not be well aligned with 21st century disturbances

- Half a century of forest Policy (NFMA & CFPR) focused on stocking retention
- Perhaps “understocking” is the desired condition for restoration because it promotes large trees!

Federal Policy: 2004 SNFPA management direction may not attain stated goals

- Widespread wildlife habitat average minimum canopy covers >40-50% do not promote large tree resilience
- Standard management guidelines preclude restoration of low-density conditions

State Policy: How does one achieve these goals under the Forest Practices Act?



THANK YOU!

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CE

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