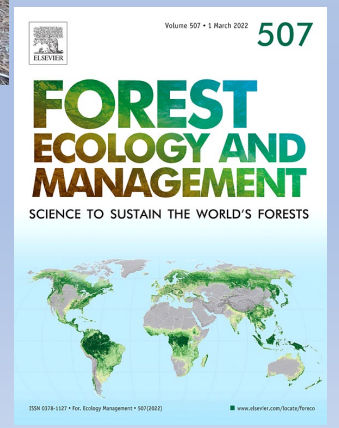
Managing density to resist multiple stressors in mixed conifer forests

Operational resilience in western US frequent-fire forests*



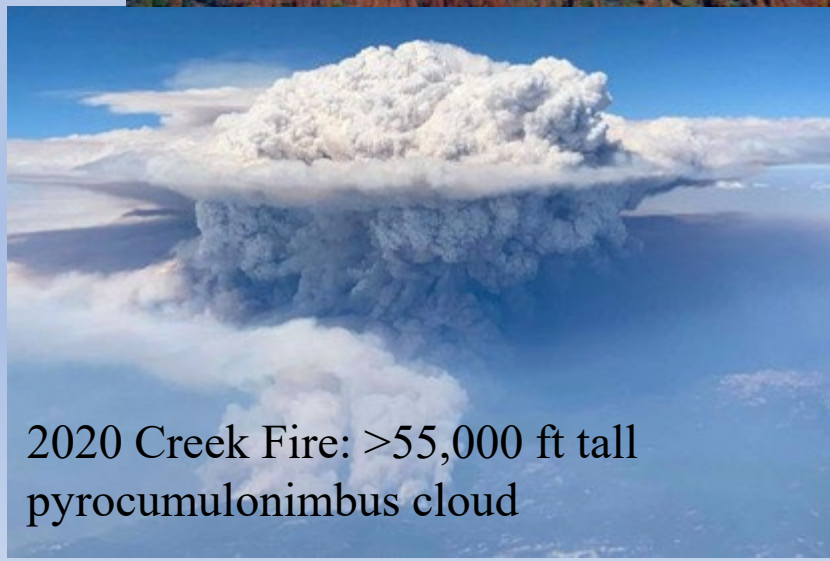
*North, M.P., R.E. Tompkins, A.A. Bernal, B.M. Collins, S.L. Stephens, and R.A. York. 2022. Forest Ecology and Management 507: 120004.

Current Conditions

- 15% of California's 40 million ac of forests burned in the last 2 years
- Most of these forests evolved with frequent (every10-20 years) low to moderate severity fire, but current wildfires are often high-severity, crown fire
- 2012-2016 CA drought resulted in >150 M dead trees in the Sierra Nevada

Consequences

- In 2018, $150 billion in economic losses in CA alone
- In the last decade 43,000 homes burned and 173 fatalities



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

Desperate times call for desperate measures?

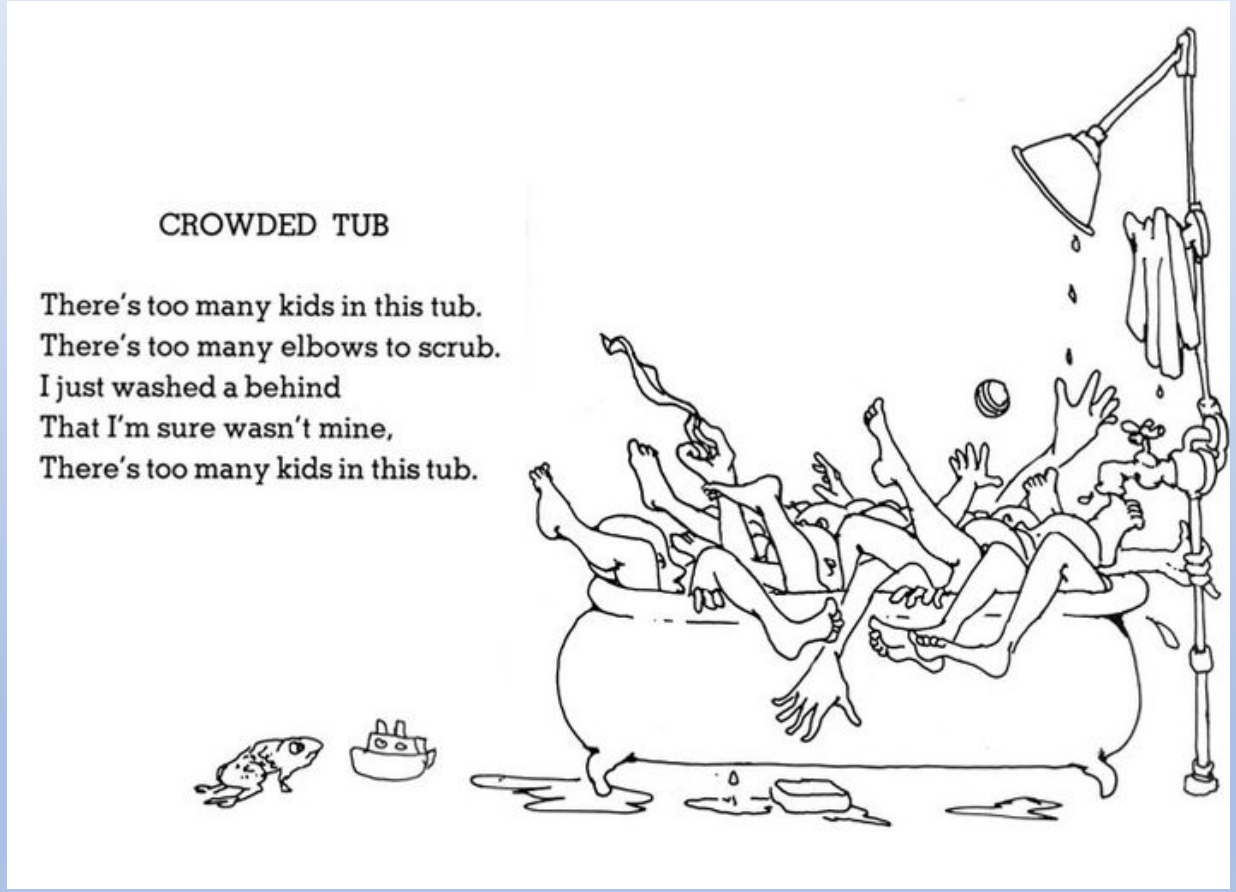
First, look to the past

Then see if past conditions are an adequate target given today's challenges (wildfire and drought)

Over the past decade, numerous archived data sets have been found

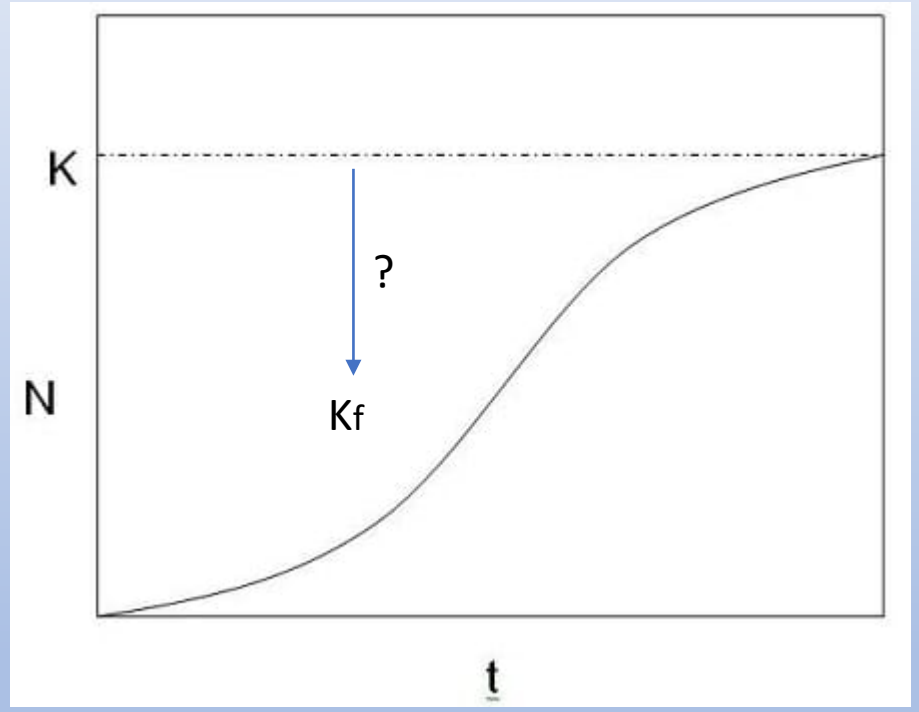
	Study Site	Forest Type	Time period	Trees per Acre[1]	Basal Area (ft^2/acre)[1]	Diameter (inches)[1]
Taylor 2004, 2006, & 2007	N. Sierra: Lake Tahoe	JP - Mixed conifer	Pre-fire suppression (ca. 1870-1900)	28 (12 - 46)	**111 (55- 166)**	26.6 (21.5 - 33.6)
Taylor (unpublished data) in Taylor 2008	Central Sierra: Yosemite Valley	Ponderosa Pine - Black Oak	Pre-fire suppression (unknown)	36 (31 - 38)	**95 (39 - 117)**	21.9[A]
Taylor and Scholl 2006 in Taylor 2008	Central Sierra: Yosemite NP	JP - Mixed conifer	Pre-fire suppression (ca. 1899)	54 (4 - 210)	**186 (21 - 452)**	25.2 [A]
Scholl and Taylor 2010	Central Sierra: Yosemite NP	JP - Mixed conifer	Pre-fire suppression (ca. 1899)	65 (16 – 263)	**130 (1 – 387)**	20.7 (3.2 – 43.6)
Stephens & Gill 2005	N. Mexico: Sierra San Pedro Martir	JP - Mixed conifer	Contemporary Forest with unaltered disturbance regime	59 (12 - 130)	**87 (25 - 221)**	12.8 (1.0 - 44.1)
Taylor 2001, Taylor 2010	S. Cascades: Ishi Wilderness	Ponderosa Pine -Black Oak	Contemporary Forest with relatively unaltered disturbance regime	47 (29 - 64)	**108 (65 - 142)**	20.6 (17.6 -23.6)
Hagmann et al.	South Central Oregon	Mixed conifer dry	Pre fire suppression effects1914-1922	26 (17 – 35)	**74 (39 – 109)**	22.8
Hagmann et al.	South Central Oregon	Mixed conifer moist	Pre fire suppression effects1914-1922	32 (17 – 47)	**83 (48 – 118)**	21.8
Hagmann et al. 2013	South central Oregon	Ponderosa pine	Pre fire suppression effects1914-1922	25 (15 – 35)	**57 (52 – 96)**	20.4
Collins et at 2015	Stanislaus	PP-Mixed Conifer	Pre-fire suppression (1911)	22 (15-32)	**78 (43-131)**	25.8 (20-30)
Need to add Collins 2017						

Put results of forest structure in terms of competition



Shel Silverstein

Crowded Forest



K = carrying capacity without fire

K_f = carrying capacity with fire

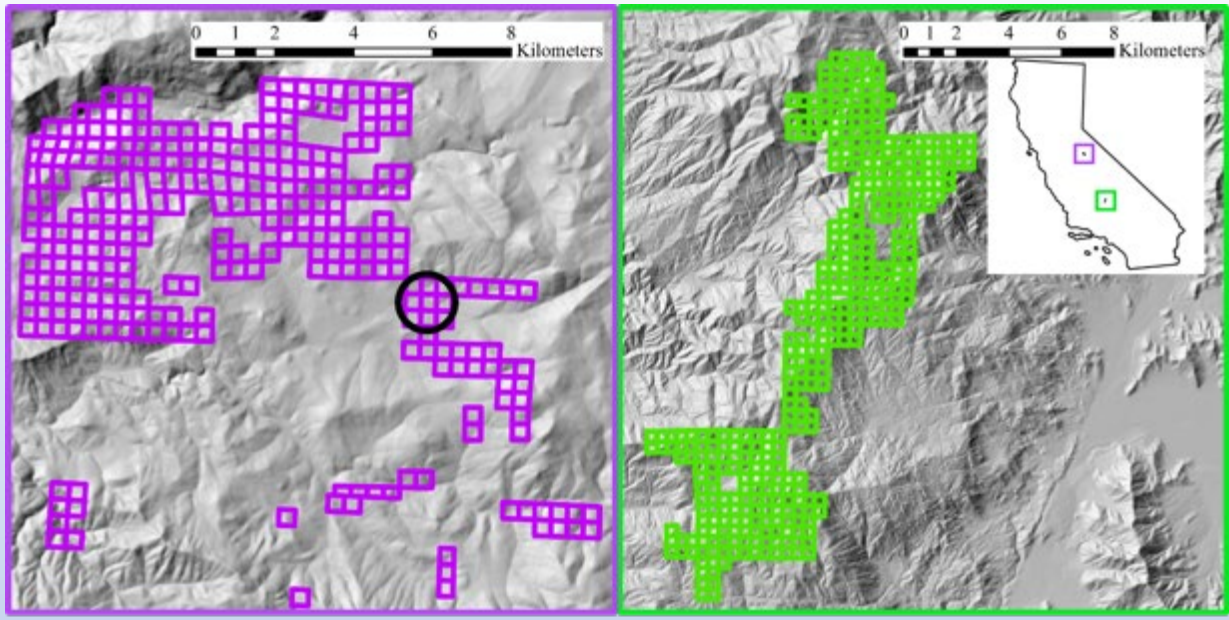
Study Methods

1911 tree inventories in the Stanislaus (upper left) and Sequoia (upper right) National Forests

Each square is a 40 acre quarter-quarter (QQ) sections

Sample included 644 QQ sections, covering over 24,000 acres

Analyze within different types:
Pine mixed conifer
Xeric mixed conifer
Mesic mixed conifer



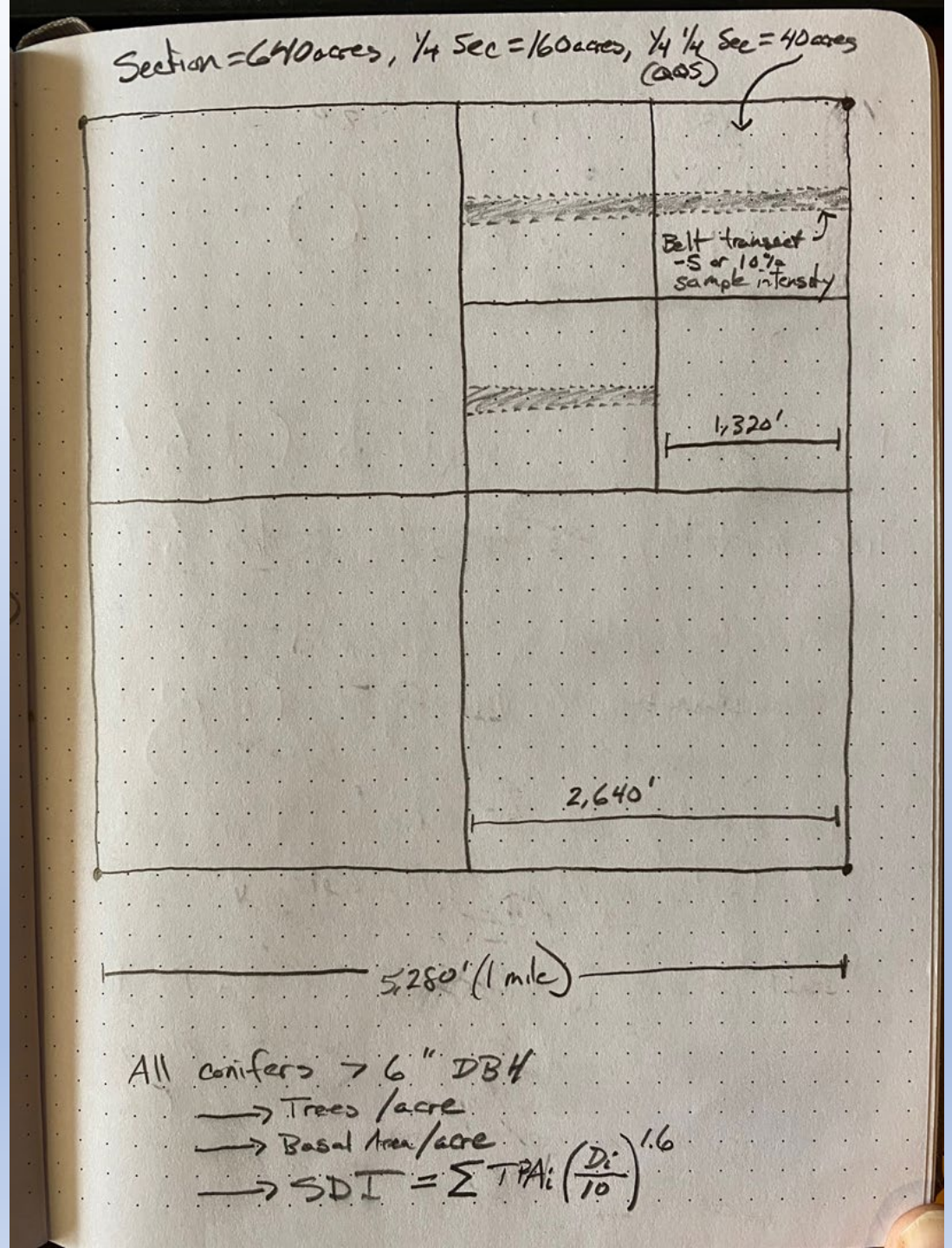
Belt transects, 66 or 132’ wide and 1,320’ long

5 – 10 % sample intensity

Great even by today’s standards

1911 v. 2011 comparison

2011 forest conditions in same area assessed with F3 (combination of LiDAR, FIA, field plots)



Relative Stand Density Index: A tool to express density relative to the maximum

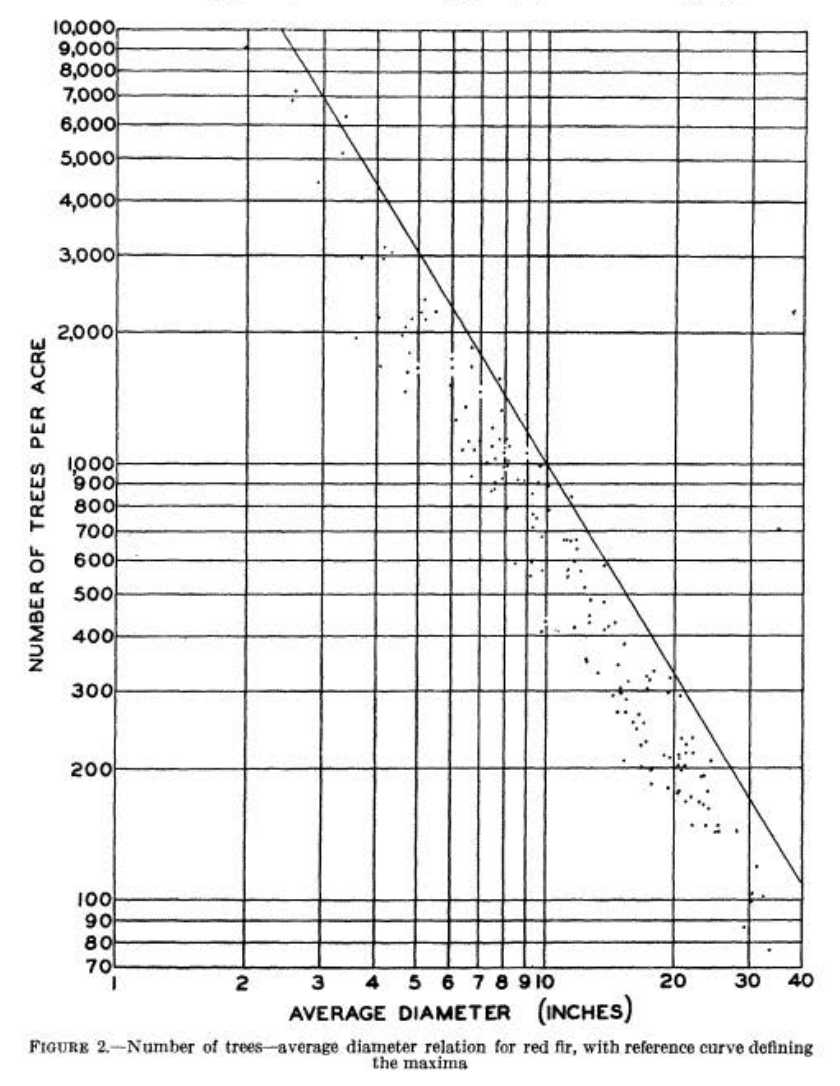
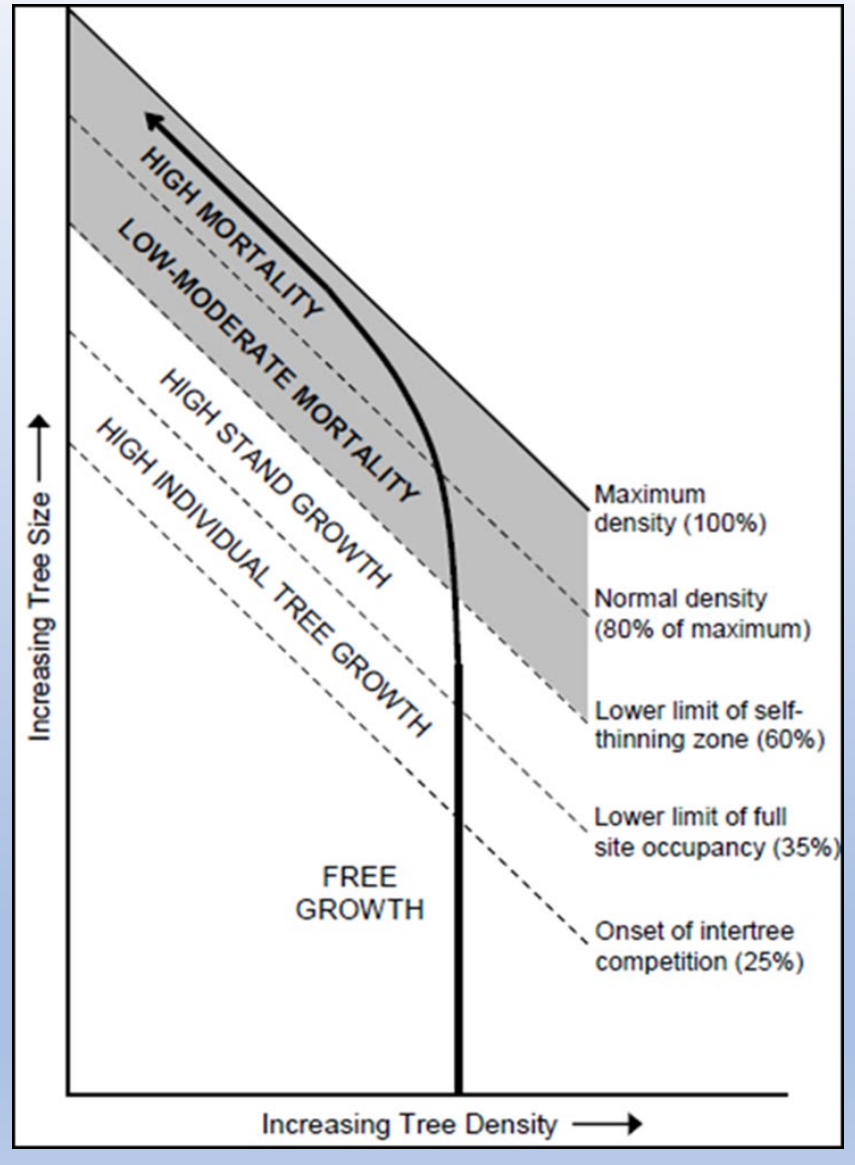


FIGURE 2.—Number of trees—average diameter relation for red fir, with reference curve defining the maxima

Reineke 1933



Stand density management diagram

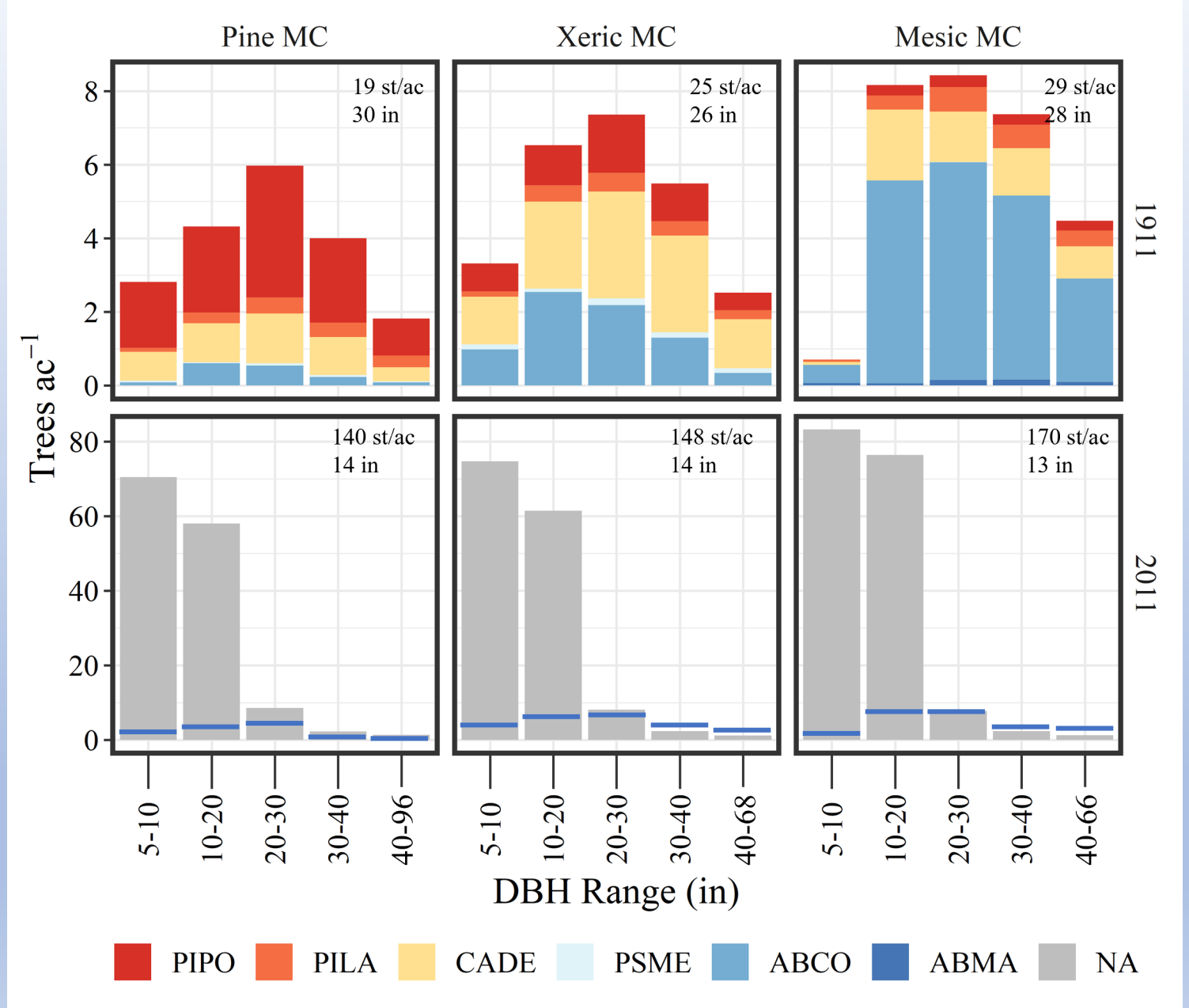
Results

Density was WAAAAAY lower

Especially trees <20” dbh

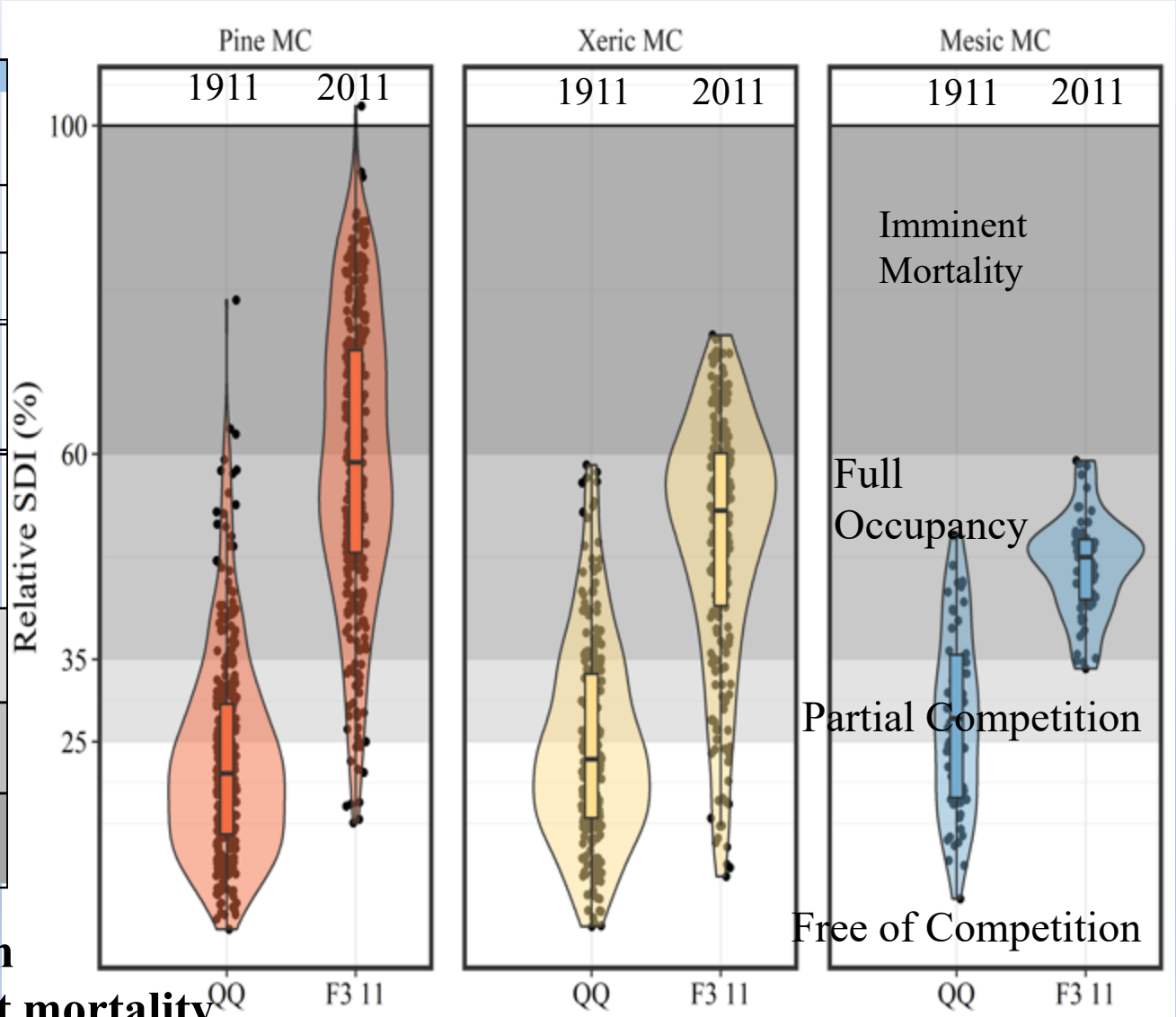
True for both dry and wet sites

Nothing new here…



Change in Forest Competitive Environment from 1911 to 2011

	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

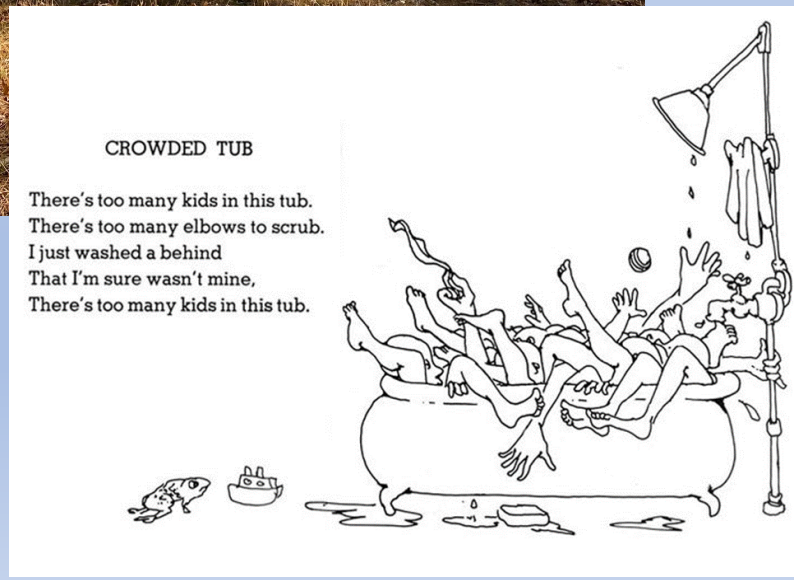


1911: 73-85% of forest in free of to partial competition

2011: 82-95% of forest in full competition to imminent mortality

Ecological reasoning for why low competition forests = resilient forests

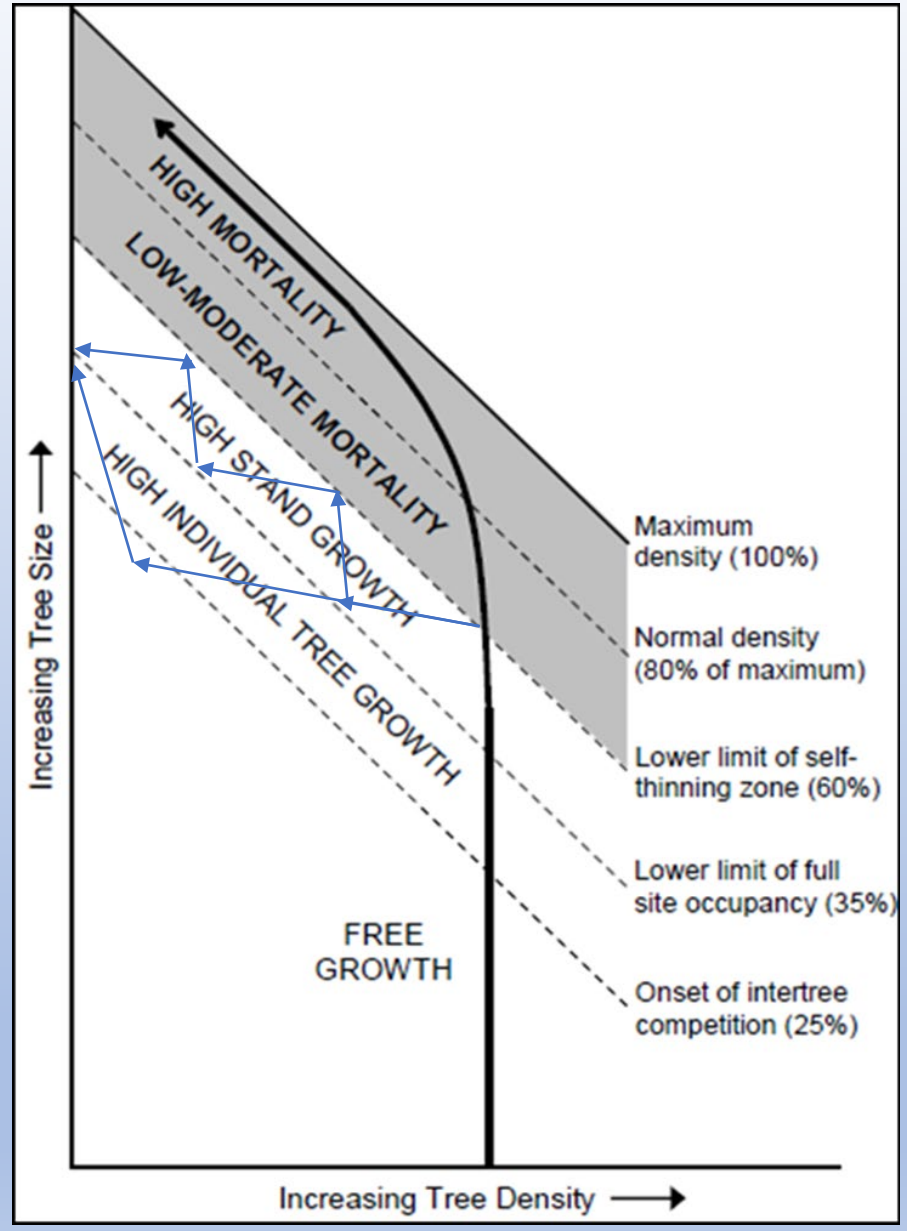
- Low competition = rapid growth of individual trees
- Rapid growth = high vigor
- High vigor = resistance to drought
- High vigor = large trees
- Large trees = resistance to wildfire mortality
- When forests RESIST multiple stressors, they are RESILIENT



Implications

- Competition is twice as high as it used to be
  - 2012-2016 drought would have killed trees… but not 150 M!

- Fire and humans were not managing for timber
  - Timber: aim for 35 to 60% SDI
  - Fire and Native Americans: 15 to 35% SDI



Management challenges

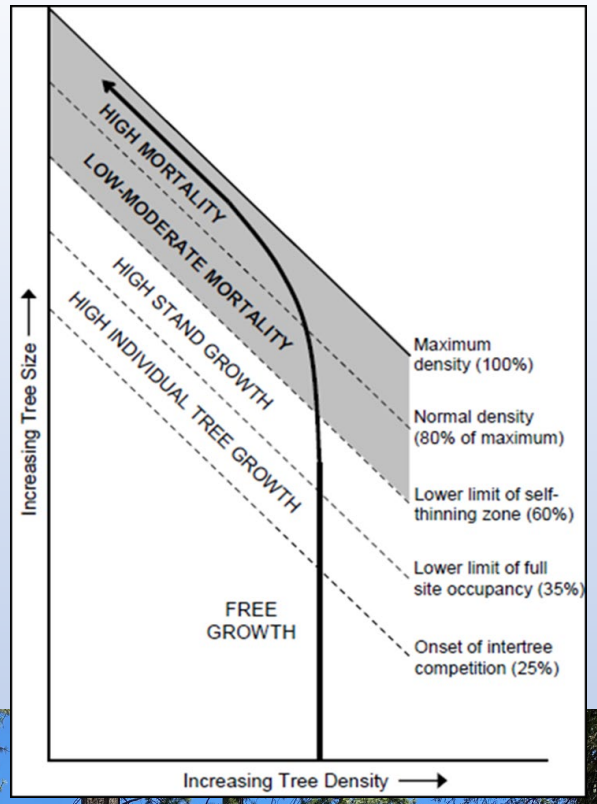
1. Managing for low-competition environments would currently or eventually require either cutting or burning large trees (>30” dbh)

2. Long-term timber yields would be lower than max

3. Even more material removed = more utilization/disposal hurdles

4. Shrub and regeneration growth would be rapid
   - How to manage (herbicide, fire, mechanical)

5. Retention standards on private and federal lands



What does a low-competition stand LOOK like?

Park like stand at Blodgett… still too dense

Park like stand, with gap-based silviculture… pretty close