MF Finishing Talk

Connie Ryan

Overview

- Quantitative Information on Historical Forests in California
    - Variety of Sources
- Quantifying Resilience
    - Stand Density Index
- 2 Projects
    - QQ Dataset Synthesis
    - Applied Historical SDI

Brown & Brown, Inc.

QQ Dataset Synthesis

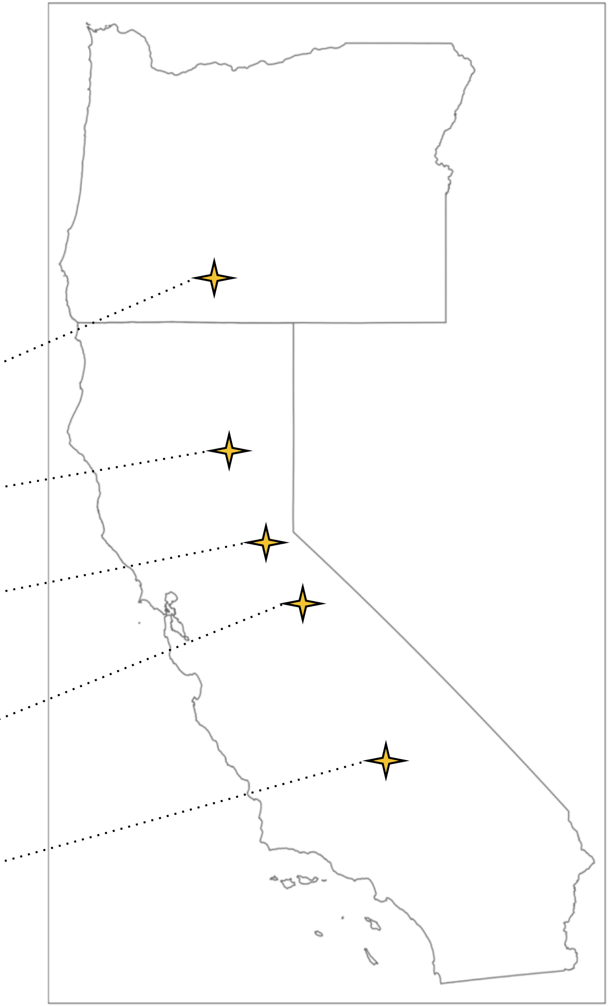
1. What were landscape-scale patterns of forest structure & composition across the most robust historical datasets?
    - Structure & Composition Summaries

1. What effects do common analysis choices have on resulting forest structure & composition metrics?
    - Low BA, Minimum Diameter, SDI Calculation Method

1. Is forest structure and composition distinct between California & Southern Oregon datasets?
    - Clustering Analysis

Study Sites

Location	Name	Year	Sample Size	Citations
Former Klamath Indian Reservation	KIR	1914-1922	18,018	Hagmann et al. 2013, 2017, 2019
Collins Pine Company	COLLINS	1924	1,552	Collins et al. 2021
El Dorado National Forest	ELDO	1923-1936*	631	Stephens et al. 2018
Stanislaus National Forest + Yosemite National Park	STAN	1911	269	Collins et al. 2011, 2015, 2017
Sequoia National Forest	KERN	1911	379	Stephens et al. 2015



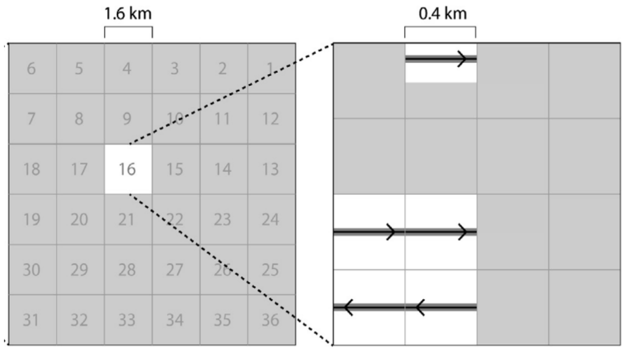
Study Sites

- Mixed-Conifer, Ponderosa Pine
- Mediterranean Climate
- Frequent Fire

Dataset	Forest Type	Elevation (m)	Annual Precipitation (cm)	Fire Return Interval (yr)
KIR	Ponderosa + Mixed-Conifer	1400	60 - 70	14.9
COLLINS	Mixed-Conifer	1554	124	12 - 14
ELDO	Fir Mixed-Conifer	1846	140	4.7 - 20+
STAN	Pine Mixed-Conifer	1432	100	12
KERN	Ponderosa + Mixed-Conifer	1833	32*	5 - 20

Data Collection

- Transects on PLSS
- Tree Size & Species
- Varying Resolution & Scale → “Sample”



Hagmann et al. 2013

Dataset	Scale	Resolution	Sampling Intensity	Minimum Diameter (cm)	Species Included
KIR	Q, Half QQ	Individual Tree	Majority 10% (20%) per Q (Half-QQ)	15.2	Conifers
COLLINS	QQ	Averages	40% per QQ	30.5	Conifers
ELDO	QQ	Averages	Majority 10% per QQ	15.2	All Species
STAN	QQ	Individual Tree	10% per QQ	15.2	Conifers
KERN	QQ	Individual Tree	5% per QQ	30.5	Conifers

Data Preparation & Cleaning

- Live Trees & Conifers
- Removed Samples
  - Incomplete Data
  - Unforested
  - Logged
  - Lodgepole-dominated
- 30.5cm Minimum Diameter

Analyses - Structure & Composition

- Sample Scale
- Structure & Composition Variables
  - Quadratic mean diameter (QMD, cm), tree density (TPH, trees ha^{-1}), basal area (BA, $m^2 ha^{-1}$), stand density index (SDI, metric), relative SDI (%)
  - Species Composition (BA)
  - Pine & Fir Fraction
- SDI
  - Additive, Traditional, Corrected
  - SDI_{max} by Species Composition
- Summarize Within & Across Datasets
  - Mean, SD, Range

Analyses - Analysis Choices

- Low-BA Sample Removal
  - $<9 m^2 ha^{-1}$
- Minimum Diameter Increase
  - 15.2cm vs. 30.5cm
- SDI Ratio
  - SDI_A:SDI_T

$SDI_A = \sum_i^N TPH_i * (\frac{DBH_i}{25.4})^{1.6}$, where N = number of trees sampled, TPH_i = trees ha^{-1} represented by the i^{th} tree, and DBH_i = DBH of the i^{th} tree (cm)

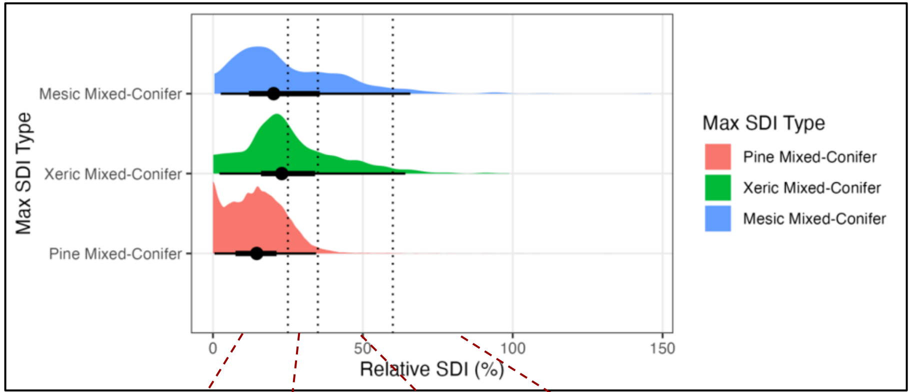
$SDI_T = TPH * (\frac{QMD}{25.4})^{1.6}$, where TPH = trees ha^{-1} and QMD = quadratic mean diameter (cm) of the sampled stand

Analyses - Clustering

- PCA → K-Means
  - Key Structure & Composition Variables
  - 3 Principal Components
  - 4 Clusters
- Structure & Composition of Clusters
  - Descriptively Characterized
  - Mean, SD, Range

Results - Summary Across Datasets

- Low Density (TPH), Stocking (BA), Competition (relative SDI); Moderate to Large Trees
- Pine-Dominated
- Highly Variable



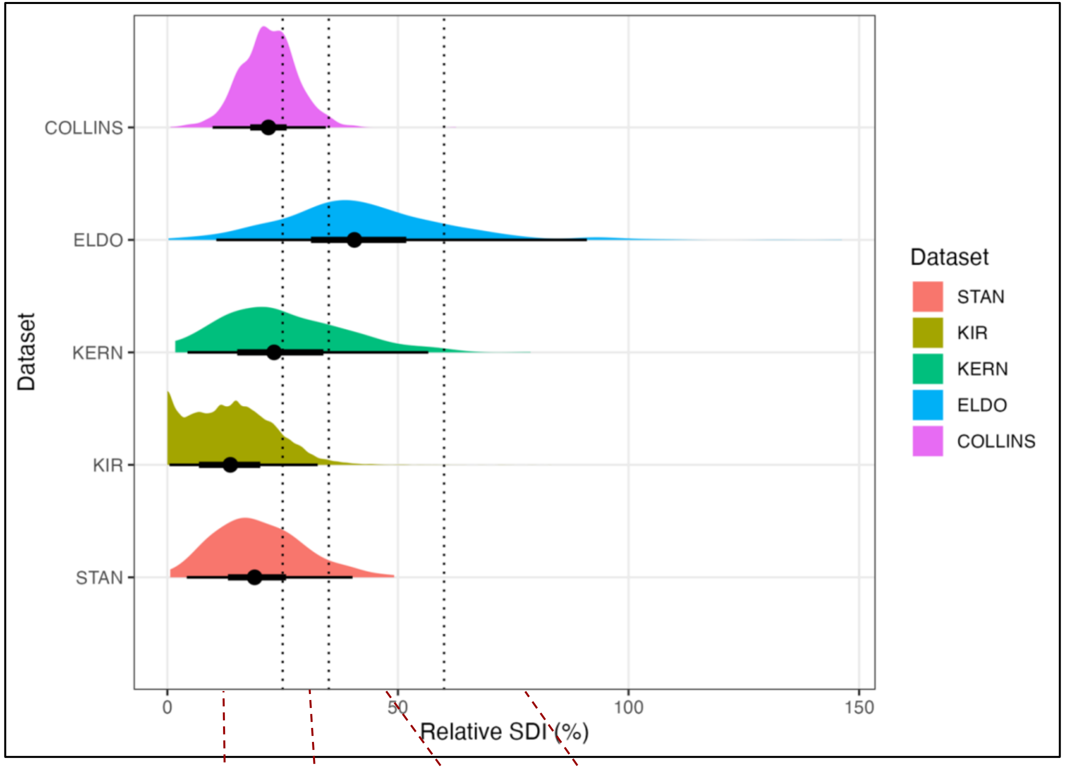
Competition: NONE LITTLE MODERAT
E HIGH

	Total
QMD (cm)	68.3 ± 10.5 (21.9* - 133.6)
BA ($m^2 ha^{-1}$)	11.5 ± 9.1 (0 - 158.8)
Tree density (trees ha^{-1})	31.9 ± 23.2 (0 - 354.6)
SDI (metric)	149 ± 112.7 (0.1 - 1987.5)
Relative SDI (%)	15.8 ± 10.8 (0 - 146.2)
% Pine (*Pinus*)	89.4 ± 21.1 (0 - 100)
% Fir (*Abies*)	6.9 ± 16.1 (0 - 100)

Results - Summary by Dataset

	COLLINS	ELDO	KERN	KIR	STAN
QMD (cm)	68.9 ± 5.6 (52.2 - 87.8)	80.4 ± 11.4 (21.9* - 129.6)	73.7 ± 10.9 (42.3 - 109.9)	67.6 ± 10.4 (30.5 - 133.6)	74.4 ± 9.6 (47.9 - 106.6)
BA (m^2ha^{-1})	16.1 ± 4.6 (0.5 - 42.9)	40.6 ± 18.4 (0.1 - 158.8)	22 ± 12.2 (1.1 - 59.7)	9.8 ± 6.4 (0 - 59.2)	15.6 ± 7.6 (0.5 - 38.5)
Tree density (trees ha^{-1})	43.6 ± 12.4 (2 - 123.3)	81.5 ± 38.9 (1.2 - 354.6)	54.5 ± 33 (2.5 - 170.6)	28.6 ± 20.3 (0 - 294.1)	35.4 ± 15.6 (1.8 - 91.4)
SDI (metric)	209.2 ± 58.2 (7.5 - 564.6)	494.4 ± 222.3 (2.2 - 1987.5)	273.7 ± 151.9 (15.4 - 710.4)	128.5 ± 82.5 (0.1 - 849.1)	192 ± 90 (6.9 - 449.5)
Relative SDI (%)	22 ± 6.1 (0.7 - 62.6)	42.5 ± 18.5 (0.2 - 146.2)	25.4 ± 13.3 (1.7 - 78.8)	14.1 ± 9 (0 - 83.3)	20 ± 9.5 (0.6 - 49.2)
% Pine (*Pinus*)	63.3 ± 16.4 (2.7 - 100)	34.5 ± 20.8 (0 - 100)	45.9 ± 31.1 (0 - 100)	94.9 ± 14.2 (0 - 100)	58.7 ± 19.8 (0 - 100)
% Fir (*Abies*)	24.1 ± 12.7 (0 - 97.3)	46 ± 26.8 (0 - 100)	24.7 ± 22.9 (0 - 100)	3.7 ± 12.2 (0 - 100)	4 ± 14.1 (0 - 100)

Results - Summary by Dataset



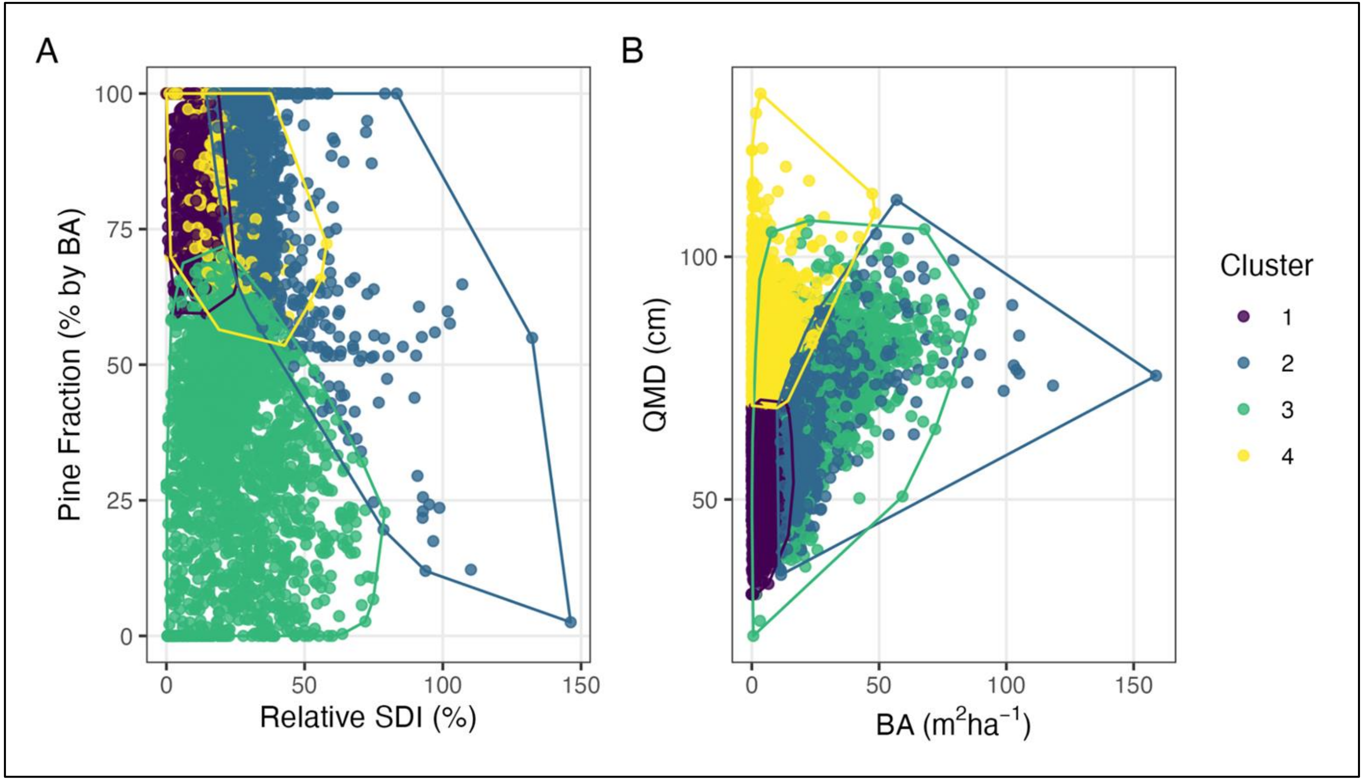
Competition: NONE LITTLE MODERAT
E HIGH

Results - Analysis Choices

- Low-BA Sample Removal
  - Variable Amount by Dataset
  - Increased Means except QMD
- Minimum Diameter Increase
  - Variable Amount by Dataset
  - Increased QMD, Decreased TPH, Negligible on BA & Relative SDI
- SDI Ratio
  - Small Effect

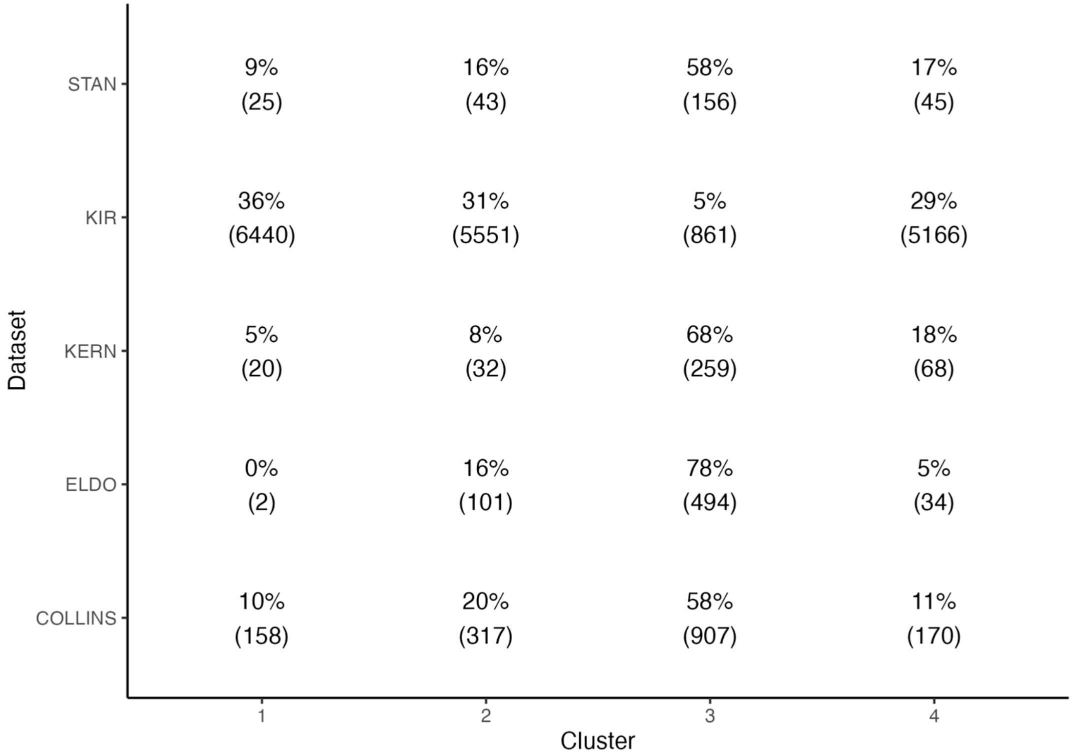
Results - Clustering

- Cluster Differentiation
  - Pine Fraction, Competition & Stocking, QMD
- Clusters
  - **1:** low stocking, high pine, lower QMD
  - **4:** low stocking, high pine, higher QMD
  - **2:** moderate stocking, high pine
  - **3:** moderate stocking, low pine



Results - Clustering

- California Datasets vs. KIR
    - Cluster 3
    - Shared Membership



Conclusions - QQ Data Synthesis

1. Structure & Composition
    - Restates findings of large trees & low densities in historical forests, with variability across landscape

1. Analysis Choices
    - Removal of Low-BA areas affects values of density, stocking, competition, but not tree size
    - Higher minimum diameter limits affect tree size and density, but not stocking or competition
    - Traditional SDI calculation likely overestimates competition 2-4%

1. Clustering
    - Pine fraction differentiates KIR from California datasets
    - However, common structure and composition types found across Sierras into Southern Cascades in Oregon

Applied Historical SDI

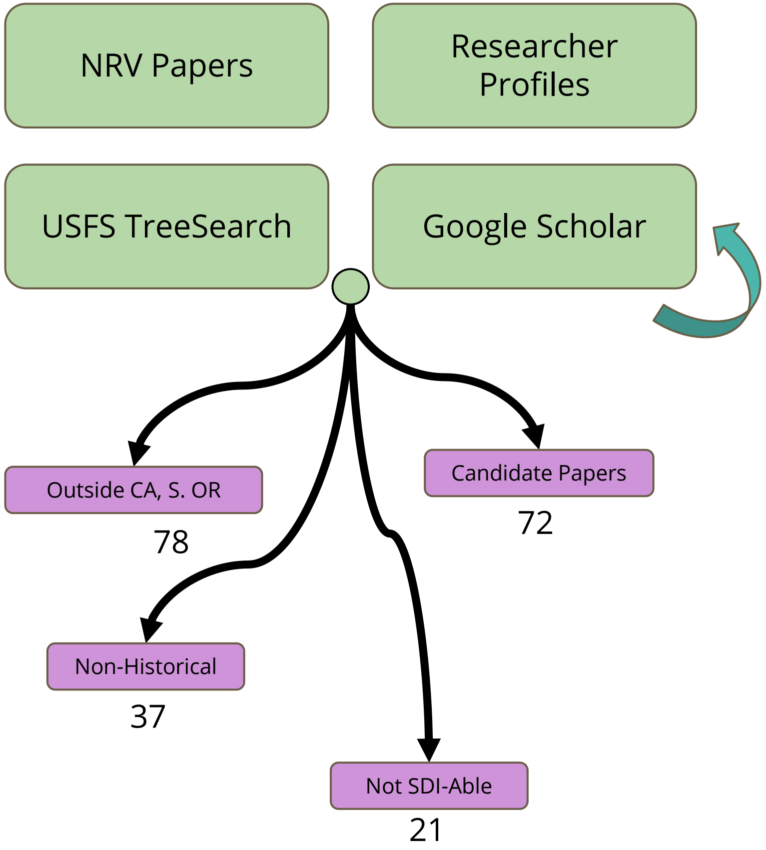
1. What were historical levels of competition and stocking in California & how do they compare to CA Forest Practice Rules stocking standards?
   - Literature Search → Summary Table

1. What stocking levels are private forestland owners managing to?
   - CalTREES Plan Review

1. What would a silvicultural system informed by historical stocking levels look like?
   - Forest Vegetation Simulator Modeling (FVS)

Literature Search

- California & Southern Oregon
  - Montane forests
- Peer-reviewed + gray literature (agency publications, theses)
- “SDI-Able”
- Historical (~pre-1940s)



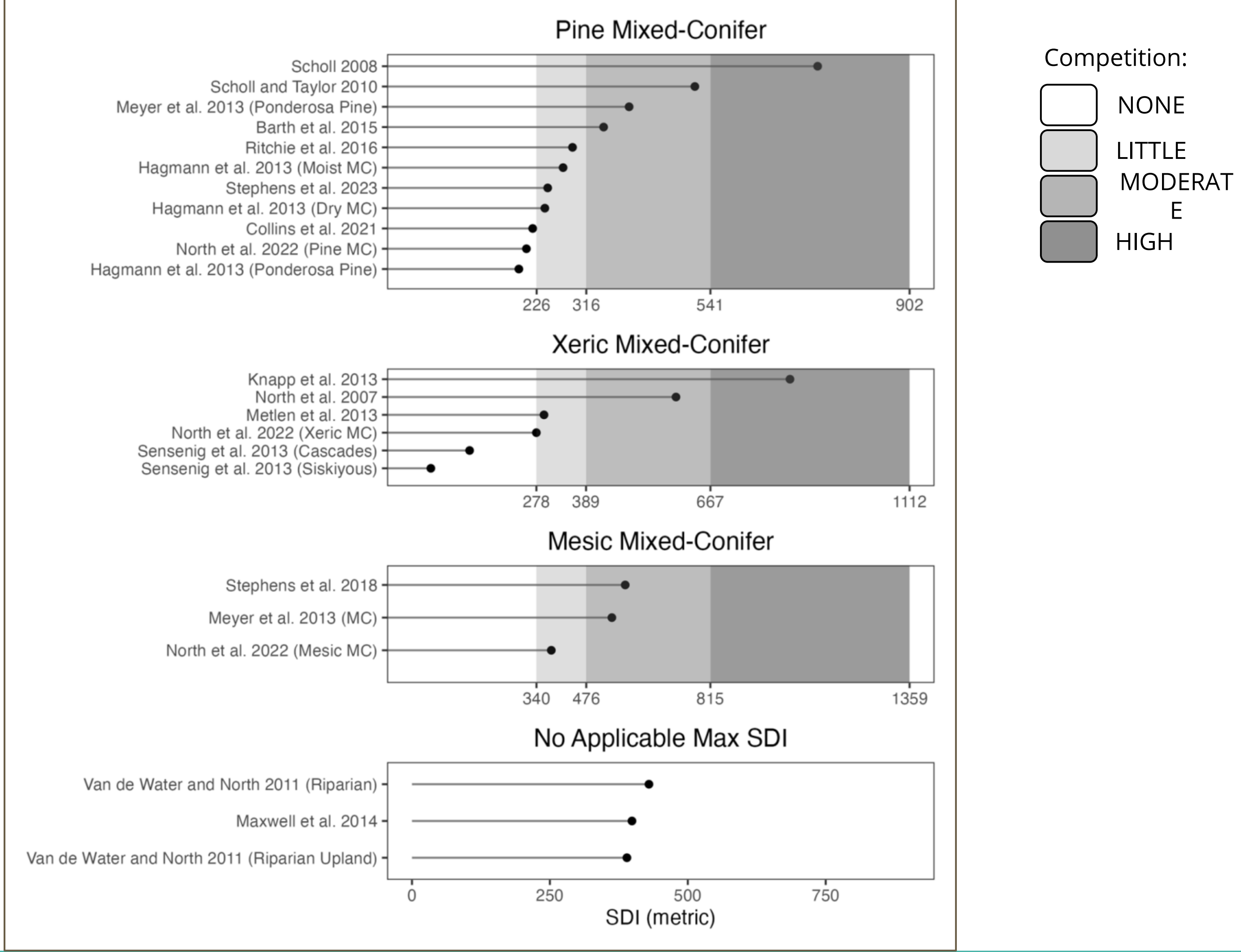
Final Papers:

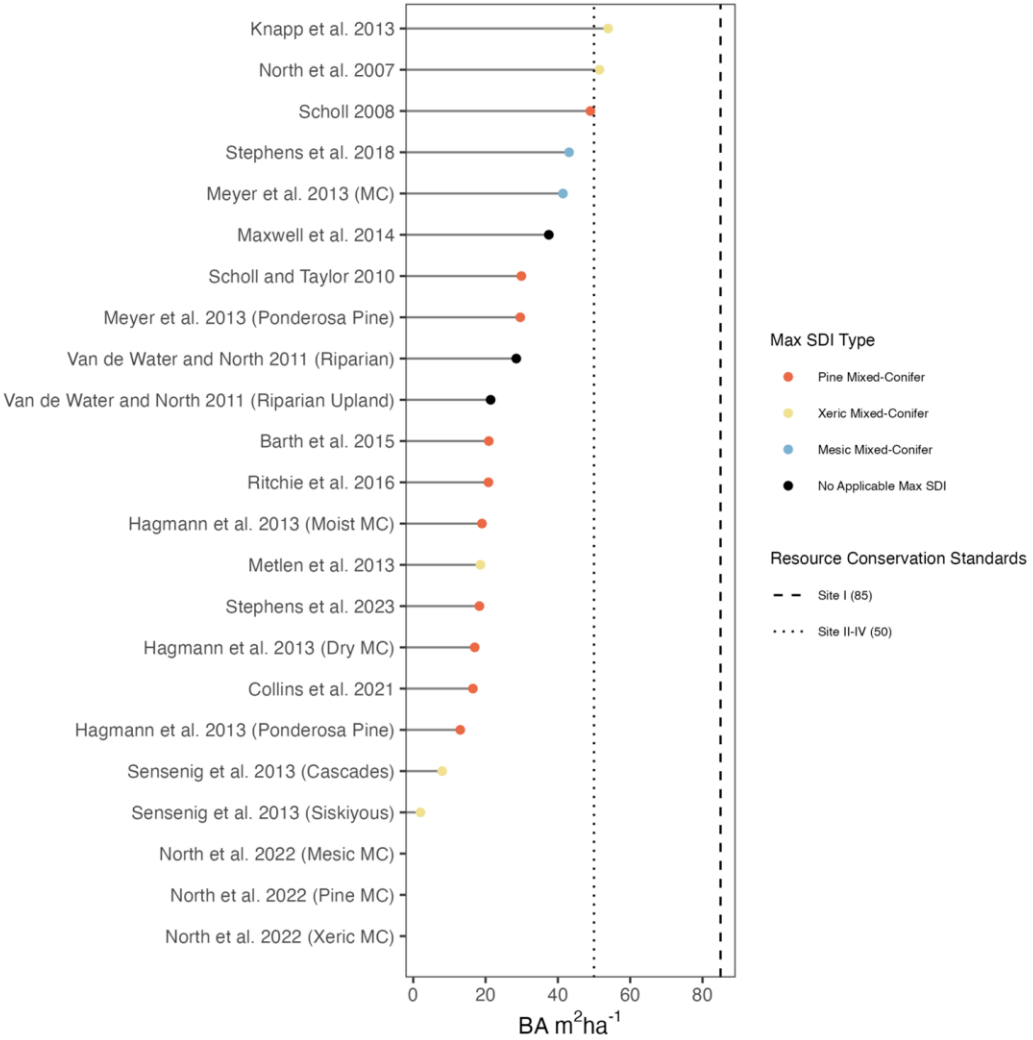
- 16 Studies
  - 23 Study-Subtype

Notable Exclusions:

- Not Visualized
  - Collins et al. 2015
  - Stephens et al. 2015
  - Taylor 2004
  - Taylor et. al 2014

- Wieslander VTM
- GLO Witness Tree
  - Baker 2014
  - Knight et al. 2020
- Sudworth Plots
- Lieberg 1902


Pine Mixed-Conifer
Scholl 2008
Scholl and Taylor 2010
Meyer et al. 2013 (Ponderosa Pine)
Barth et al. 2015
Ritchie et al. 2016
Hagmann et al. 2013 (Moist MC)
Stephens et al. 2023
Hagmann et al. 2013 (Dry MC)
Collins et al. 2021
North et al. 2022 (Pine MC)
Hagmann et al. 2013 (Ponderosa Pine)
226 316 541 902
Xeric Mixed-Conifer
Knapp et al. 2013
North et al. 2007
Metlen et al. 2013
North et al. 2022 (Xeric MC)
Sensenig et al. 2013 (Cascades)
Sensenig et al. 2013 (Siskiyous)
278 389 667 1112
Mesic Mixed-Conifer
Stephens et al. 2018
Meyer et al. 2013 (MC)
North et al. 2022 (Mesic MC)
340 476 815 1359
No Applicable Max SDI
Van de Water and North 2011 (Riparian)
Maxwell et al. 2014
Van de Water and North 2011 (Riparian Upland)
0 250 500 750
SDI (metric)
Competition:
NONE
LITTLE
MODERATE
HIGH



Knapp et al. 2013
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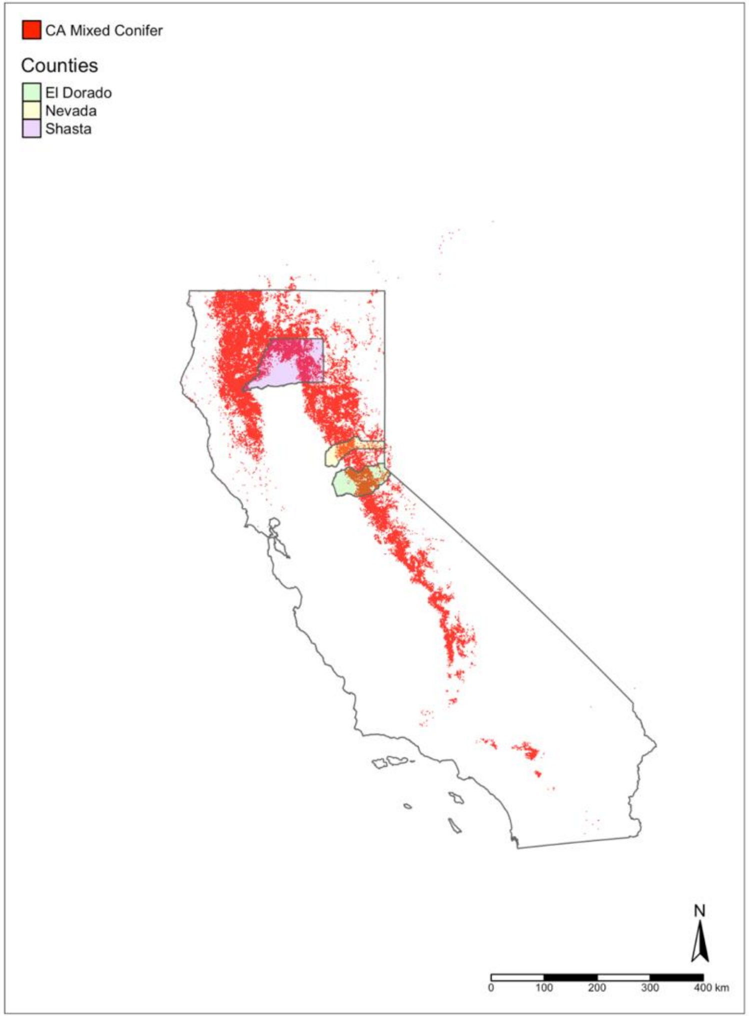
Sensenig et al. 2013 (Cascades)
Sensenig et al. 2013 (Siskiyous)
North et al. 2022 (Mesic MC)
North et al. 2022 (Pine MC)
North et al. 2022 (Xeric MC)
0
20
40
60
80
BA m^2ha^{-1}
Max SDI Type
Pine Mixed-Conifer
Xeric Mixed-Conifer
Mesic Mixed-Conifer
No Applicable Max SDI
Resource Conservation Standards
Site I (85)
Site II-IV (50)

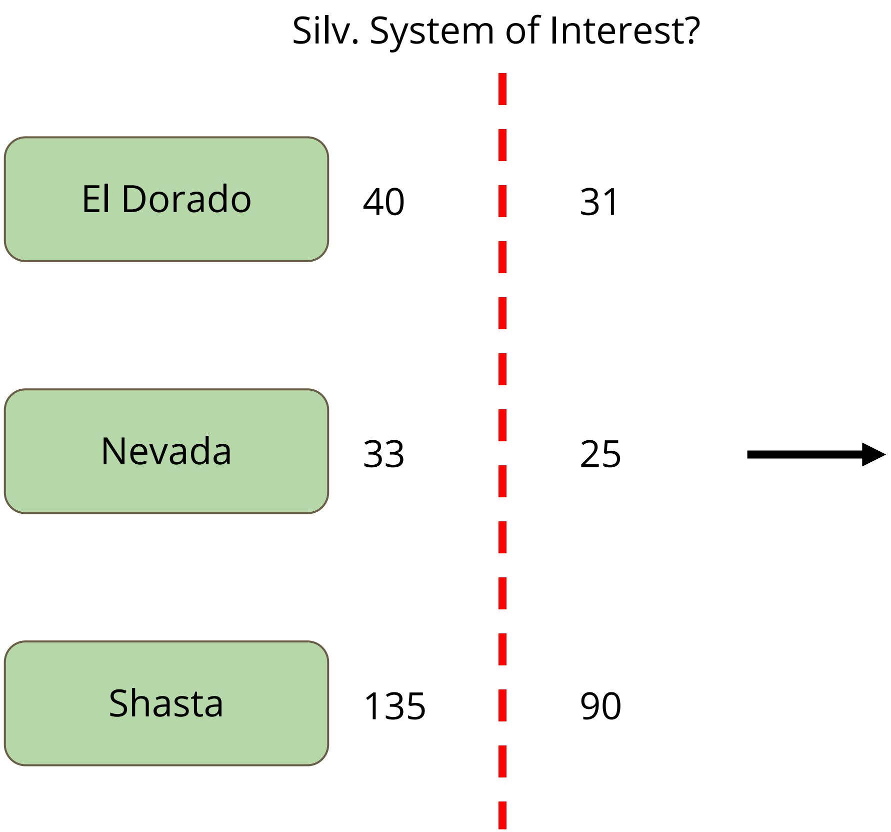
CalTREES Plan Review

- El Dorado, Nevada, and Shasta Counties
- 2018-2023



CalTREES Plan Review

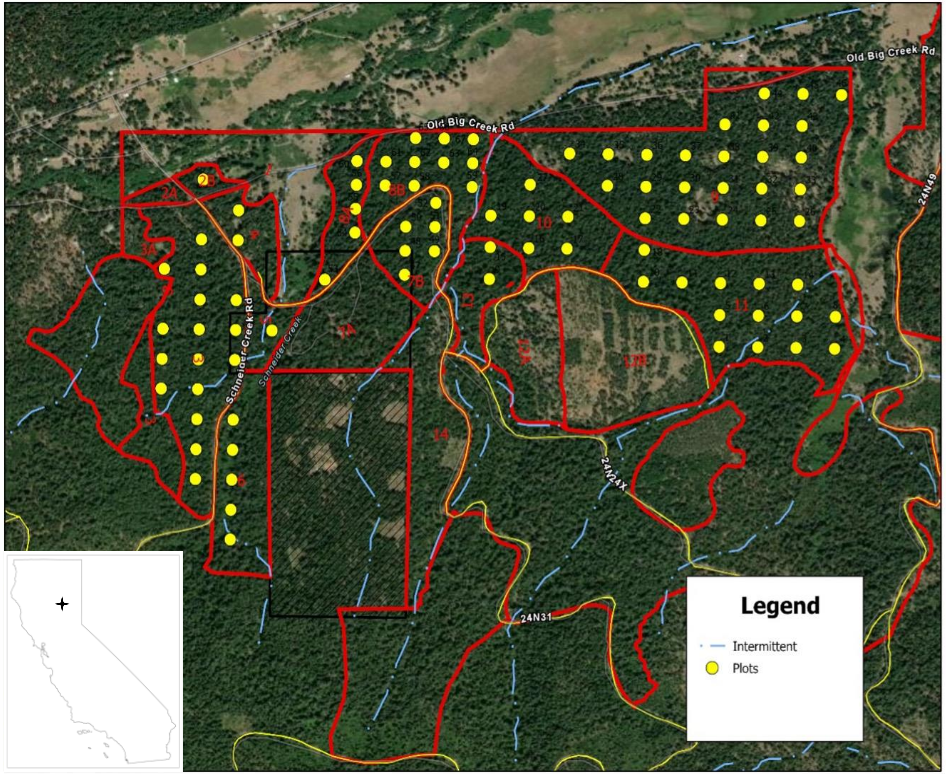
- Plan Type
  - (+) Timber Harvest Plan, Program Timber Harvest Plans, Nonindustrial Timber Management Plans, Working Forest Management Plans
  - (-) Emergencies (Fuel Hazard Reduction, S.O.D., Salvage), Exemptions (Drought, Disease, Fire Prevention, Utility right-of-way, Structure Protection, etc.)
- Silvicultural Methods
  - (+) Selection, Group Selection, Variable Retention, Seed Tree Seed Step, Shelterwood Seed Step, Commercial Thin, Sanitation Salvage
  - (-) Clearcut, Seed Tree Removal Step, Shelterwood Removal Step, Plantation, Conversion to Non-Forest, Road right-of-way, Non-Harvest



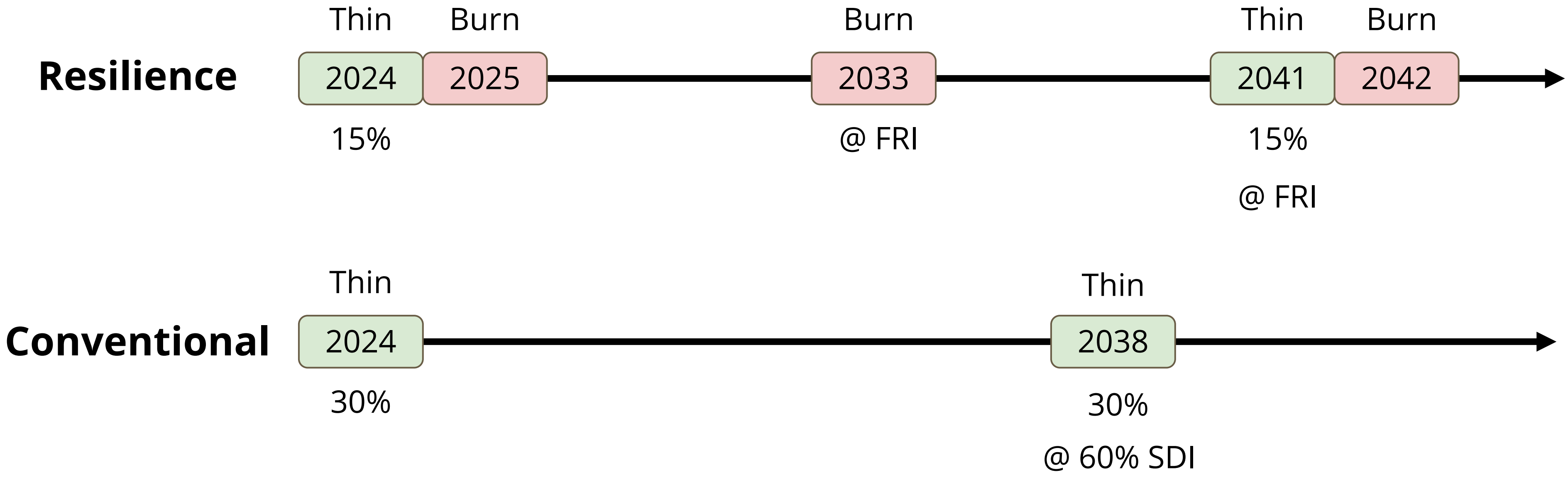
System	Mean Acreage	Count "Above"	Count "Below"
Alternative	242.75	0	1
Commercial Thinning	287.73	0	7
Group Selection	1023.65	6	0
Seed Tree Seed Step	29.54	0	0
Selection	181.81	15	0
Shelterwood Seed Step	20.00	0	0
Transition	43.00	0	0
Variable Retention	21.00	0	0

FVS Modeling

- Conventional vs. Resilience
- 30-inch Upper Diameter Limit
- Preliminary Model



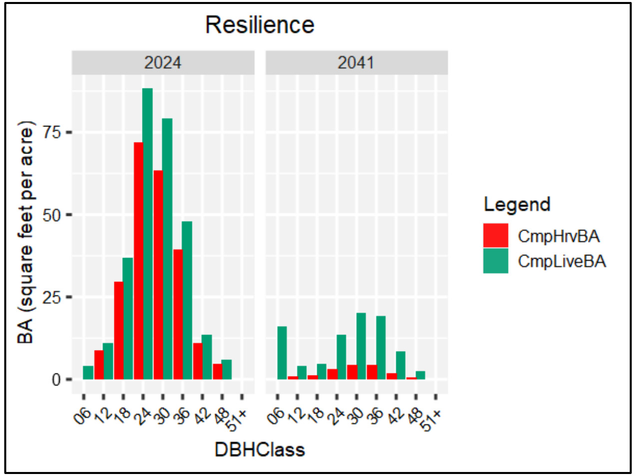
Weather Variable	Value	Fuel Size Class	Fuel Moisture
Weather Stations (2000-2010)	Quincy (#040910) , Pierce (#040915), and Cashman (#040916)	1-hour fuel moisture	1.0%
		10-hour fuel moisture	2.0%
Season	June 1 to September 15	100-hour fuel moisture	5.5%
Temperature (F)	93°	1,000-hour fuel moisture	6.0%
Fuel Model Choice	TU5	Herbaceous fuel moisture	29%
Source: Ryan Tompkins		Woody fuel moisture	69%



× With & Without 30-inch UDL =

- Resilience
- Resilience-Limit
- Conventional
- Conventional-Limit

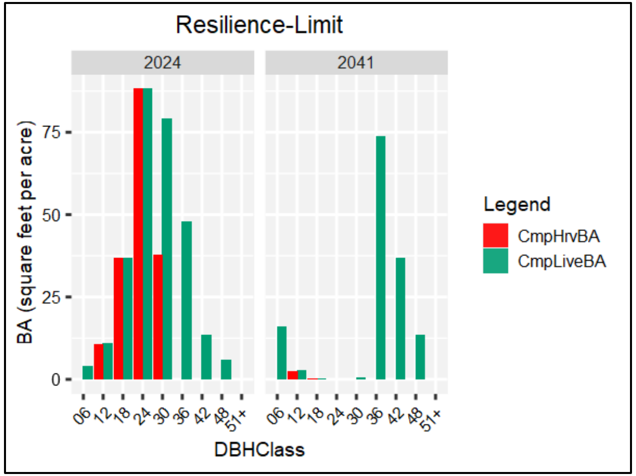
SDI_{max} = 450 *(English units)*
- 15% = 67.5
- 30% = 135
- 60% = 270



1st Entry:
- 53,894 BdFt acre^{-1}
- 17% rSDI

2nd Entry:
- 4,104 BdFt acre^{-1}
- 27% rSDI

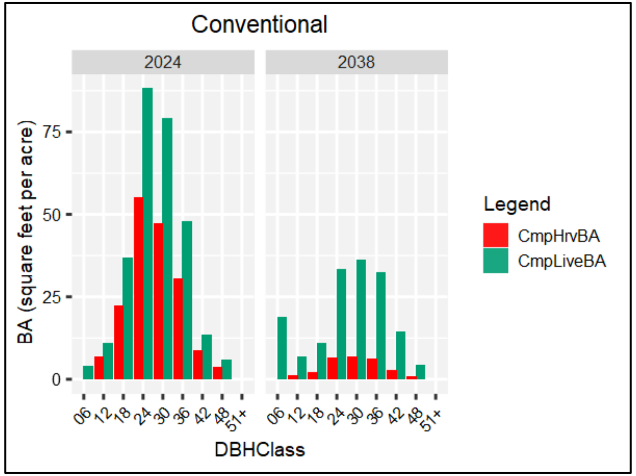
Growth:
- 593 BdFt acre^{-1} yr^{-1}



1st Entry:
- 35,153 BdFt acre^{-1}
- 29% rSDI

2nd Entry:
- 307 BdFt acre^{-1}
- 42% rSDI

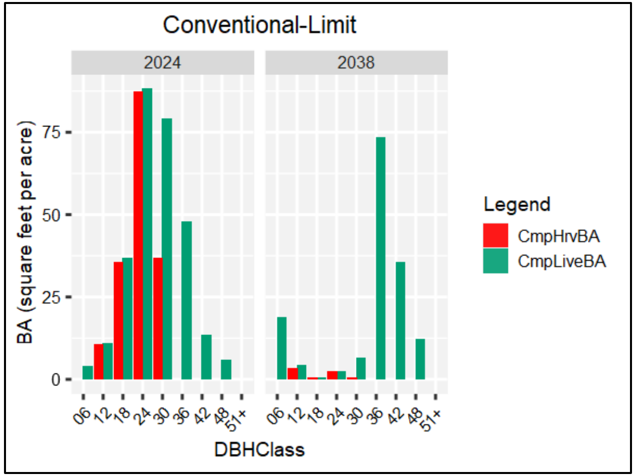
Growth:
- 335 BdFt acre^{-1} yr^{-1}



1st Entry:
- 41,153 BdFt acre^{-1}
- 32% rSDI

2nd Entry:
- 7,145 BdFt acre^{-1}
- 47% rSDI

Growth:
- 568 BdFt acre^{-1} yr^{-1}



1st Entry:
- 34,475 BdFt acre $^{-1}$
- 30% rSDI

2nd Entry:
- 1,157 BdFt acre^{-1}
- 47% rSDI

Growth:
- 400 BdFt acre^{-1} yr^{-1}

Conclusions - Applied Historical SDI

1. Historical Levels of Stocking
   - Low levels of competition and stocking across historical data sources
   - Historical stocking below minimum standards in California Forest Practice Rules

1. Stocking Levels Used by Private Forestland Owners
   - Timber operations almost never manage at densities lower than stocking standards

1. Silvicultural System from Historical SDI Levels
   - Timber growth & yield potentially feasible for historically-informed Resilience system, but constrained by upper diameter limit
   - Regeneration management will be necessary & likely intensive

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Thanks! Questions?

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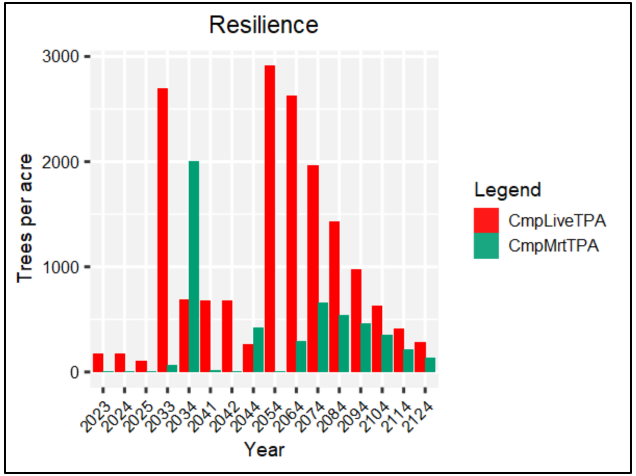
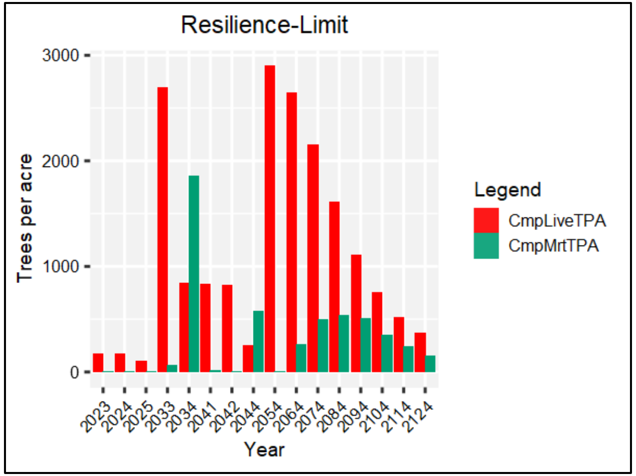
- **Family & Friends <3**

Extra Slides →

System	Minimum Basal Area by Site Class			
	I	*II*	*III*	*IV/V*
Commercial thin	125 or 100*	100 or 75*	75	50
Selection	100	75	75	50
Group Selection	100	75	75	50
Transition	85	50	50	50
Fuel Break / Defensible Space	Resource Conservation Minimums			
Sanitation Salvage	Resource Conservation Minimums			
Resource Conservation Minimums	85	50	50	50


Resilience
Trees per acre
Year
Legend
CmpLiveTPA
CmpMrtTPA


Resilience-Limit
Trees per acre
Year
Legend
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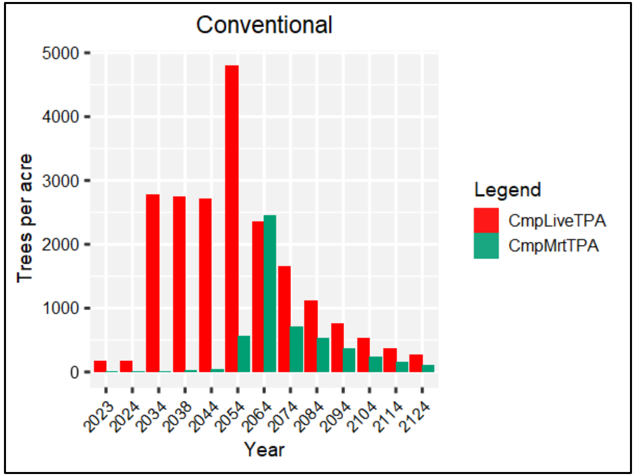
Conventional
Trees per acre
Year
Legend
CmpLiveTPA
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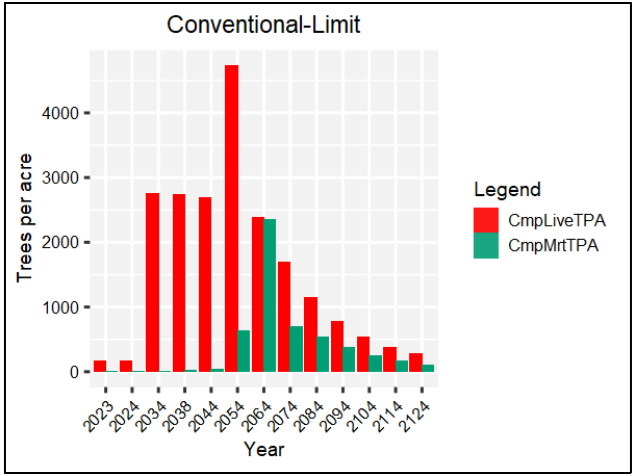
Conventional-Limit
Trees per acre
Year
Legend
CmpLiveTPA
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