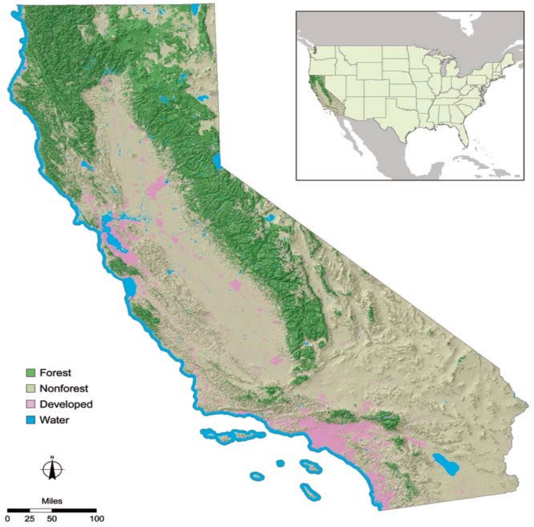
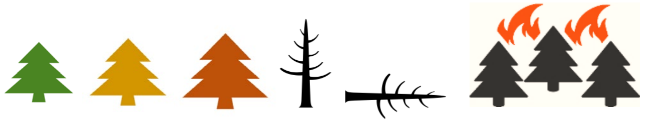
Characterizing ground and surface fuels in Sierra Nevada forests shortly after the 2012–2016 drought





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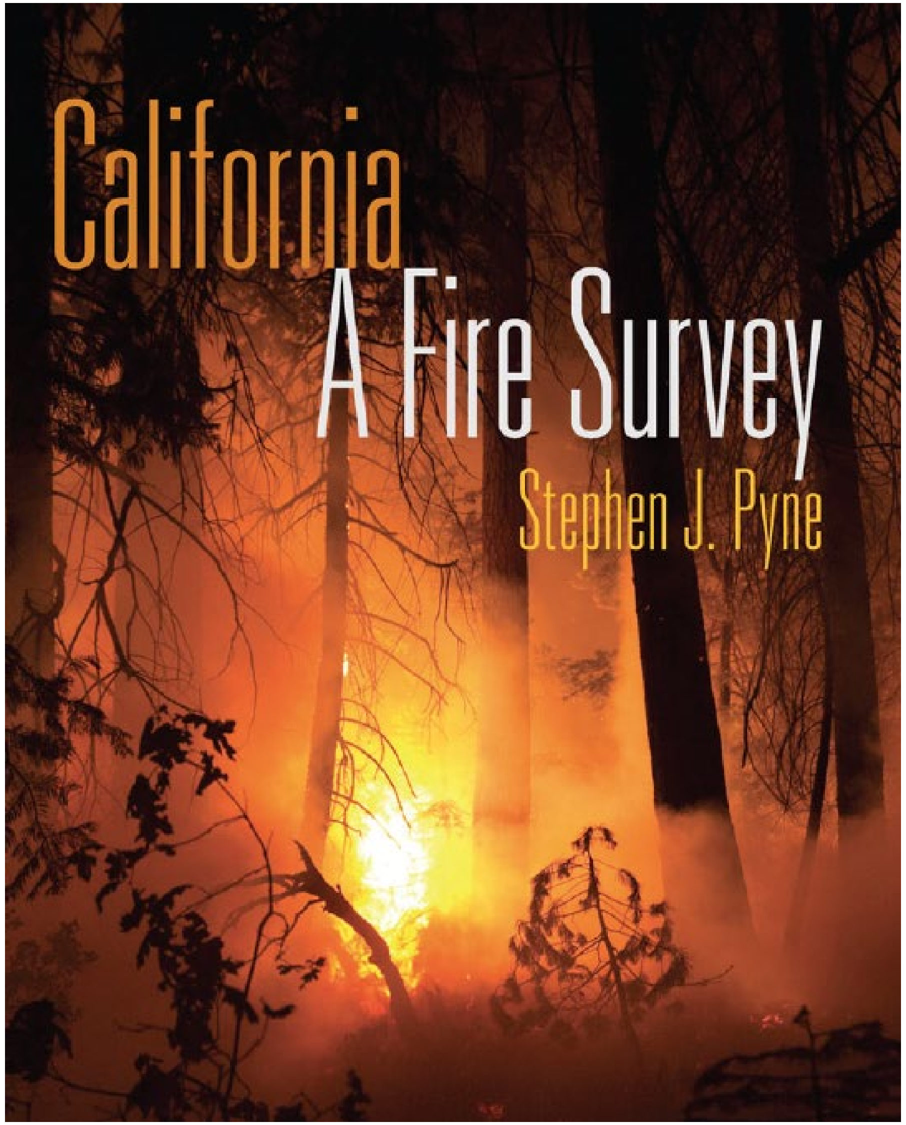
UNIVERSITY OF CALIFORNIA

Leif Mortenson, Lauren Cox, Beverly Bulaon, Jamie Lydersen
Chris Fettig, John Battles, Jodi Axelson

March 10th, 2021

California as a fire-prone landscape

Forest ecosystems adapted to fire



Pyne (2016) The University of Arizona Press

"…California burns, and frequently conflagrates. The coastal sage and shrublands burn. The mountain-encrusting chaparral burns. The montane woodlands burn. The conifer-clad Sierra Nevada burns… "

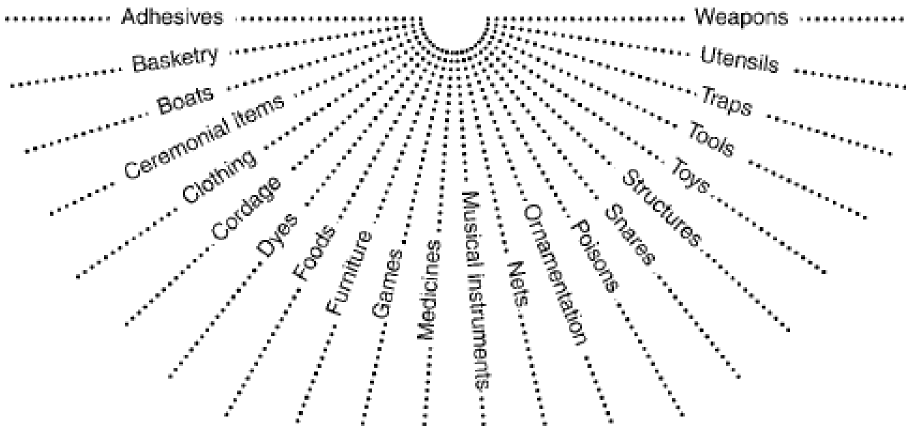
"…An estimated 54 percent of California ecosystems are fire dependent, and most of the rest are fire adapted… "

"…Fire season, so the saying goes, lasts 13 months… "

California as a fire-prone landscape

Native communities used fire for their livelihood

Map 1. The territories associated with California Indian language groups. Names in bold represent a language family of two or more languages and multiple dialects.



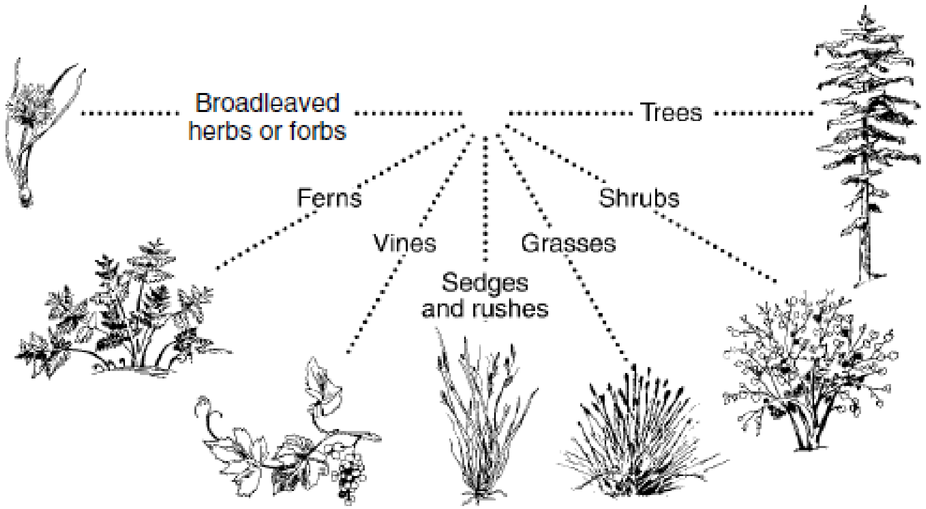
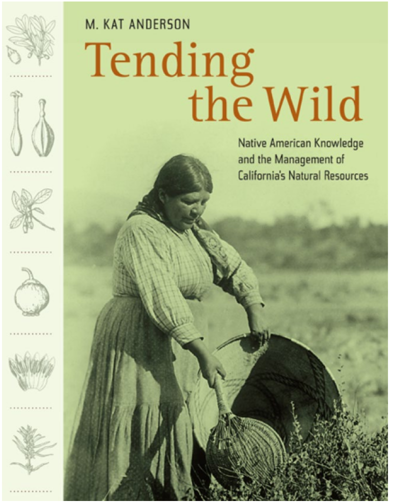


Figure 5. The rich variety of cultural uses for California's native plants that constituted the "material culture" of Indian tribes.

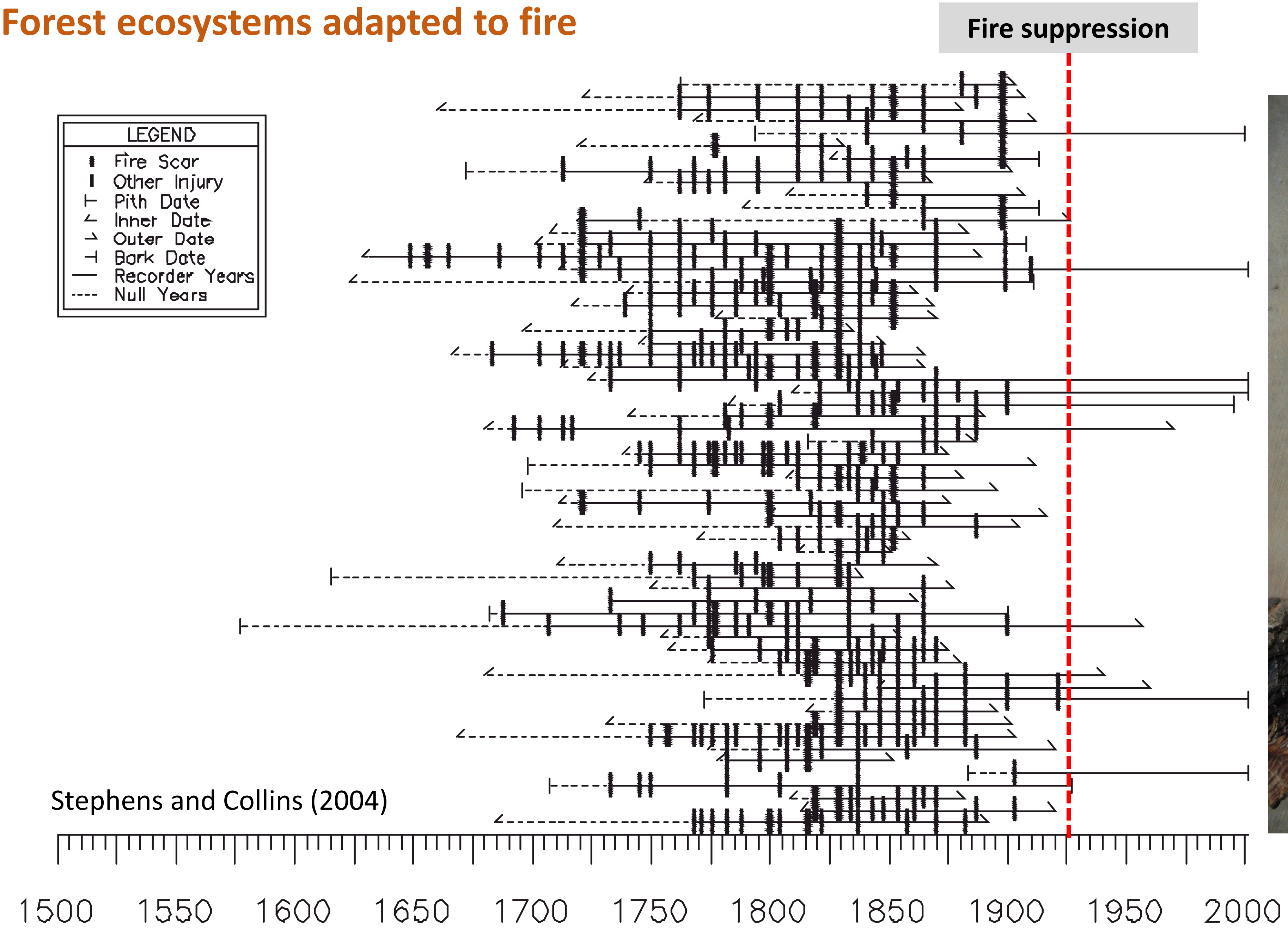
Anderson (2005)

© NatGeo

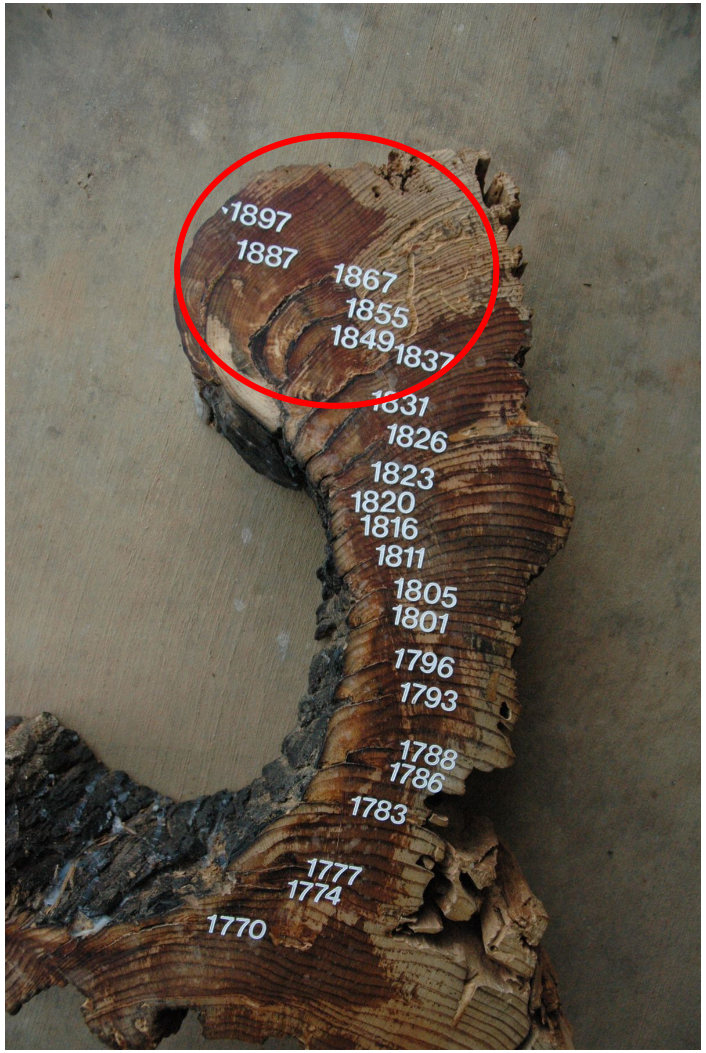


California as a fire-prone landscape

Forest ecosystems adapted to fire



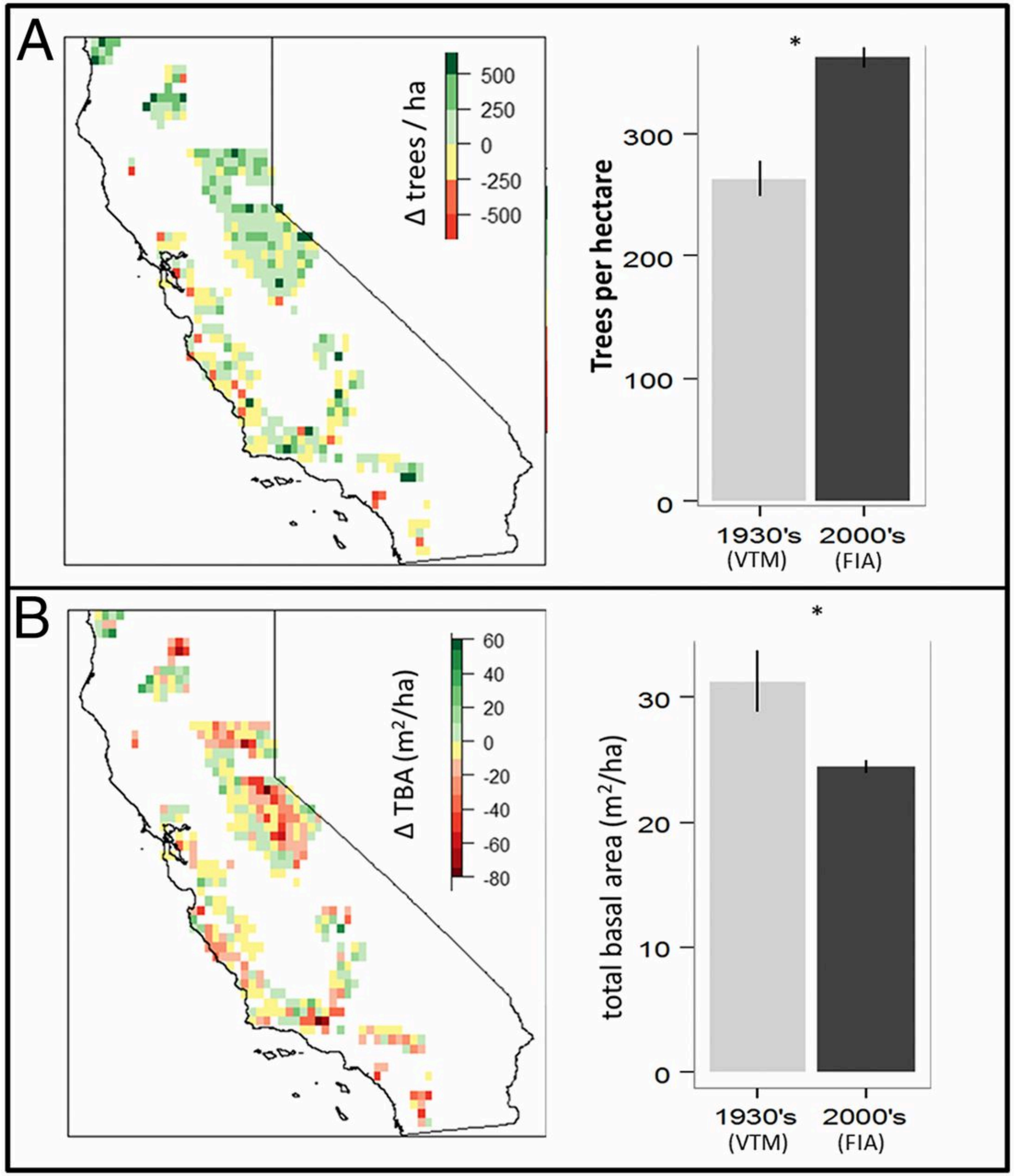
Stephens and Collins (2004)



Current situation of California forests

Higher density - overstocking

Ngu & Chinoy, 2018. To help prevent the next big wildfire, let the forest burn. The New York Times. Photo: Yosemite Valley



McIntyre et al. (2015) PNAS

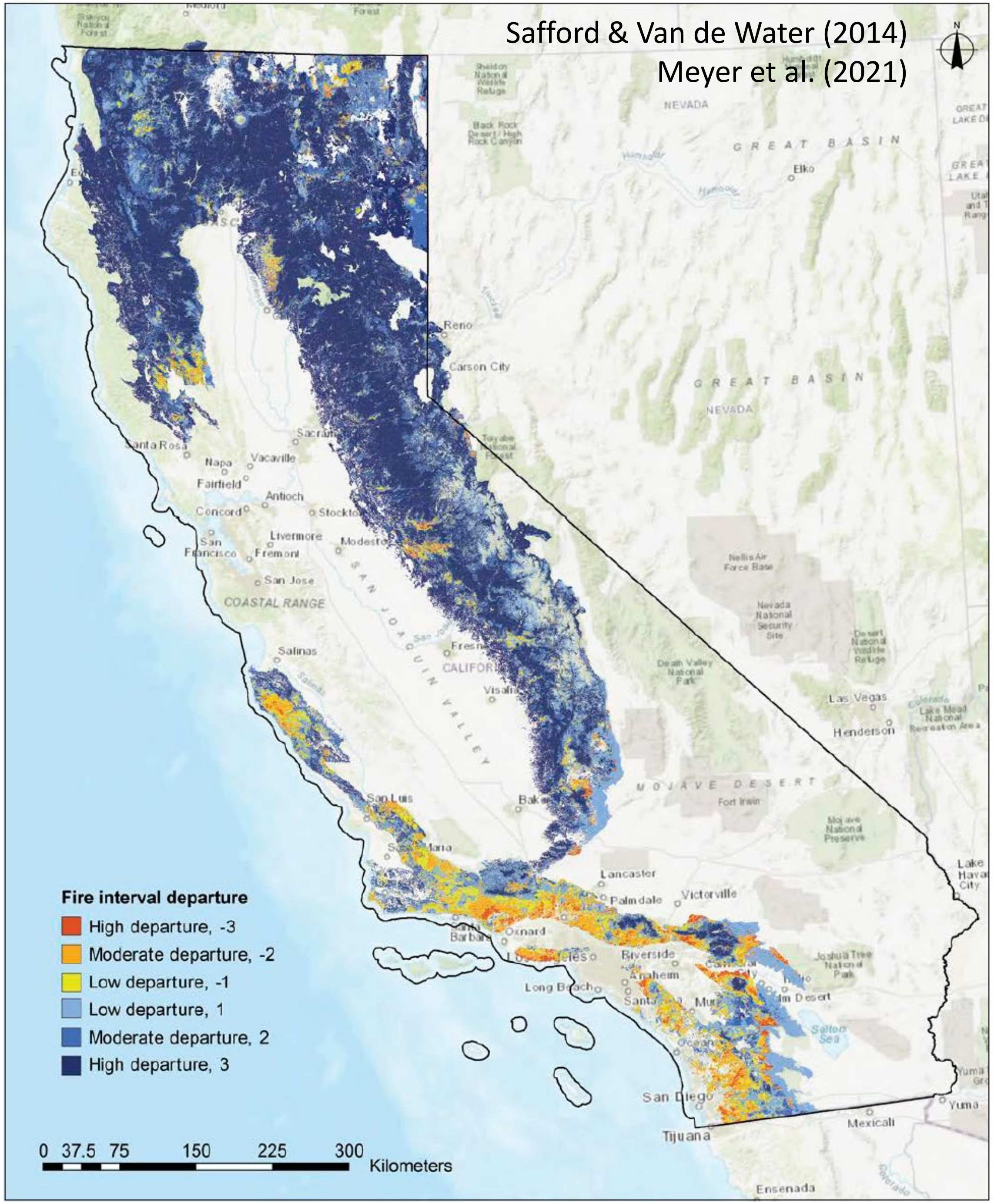
Current situation of California forests

Fire deficit throughout most of the region

Positive departures (blue)indicate areas that are burning less often than before Euro-American colonization

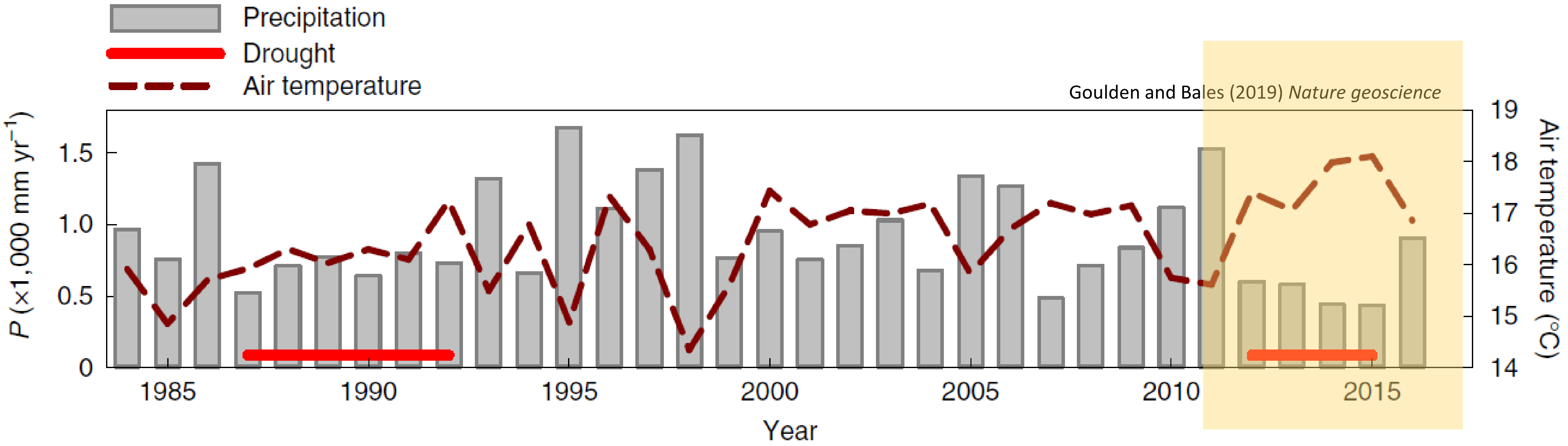
Drawing by van Pelt et al. (2008)

Negative departures (yellow-red) indicate areas that are currently burning more frequently than before Euro-American colonization.



Current situation of California forests

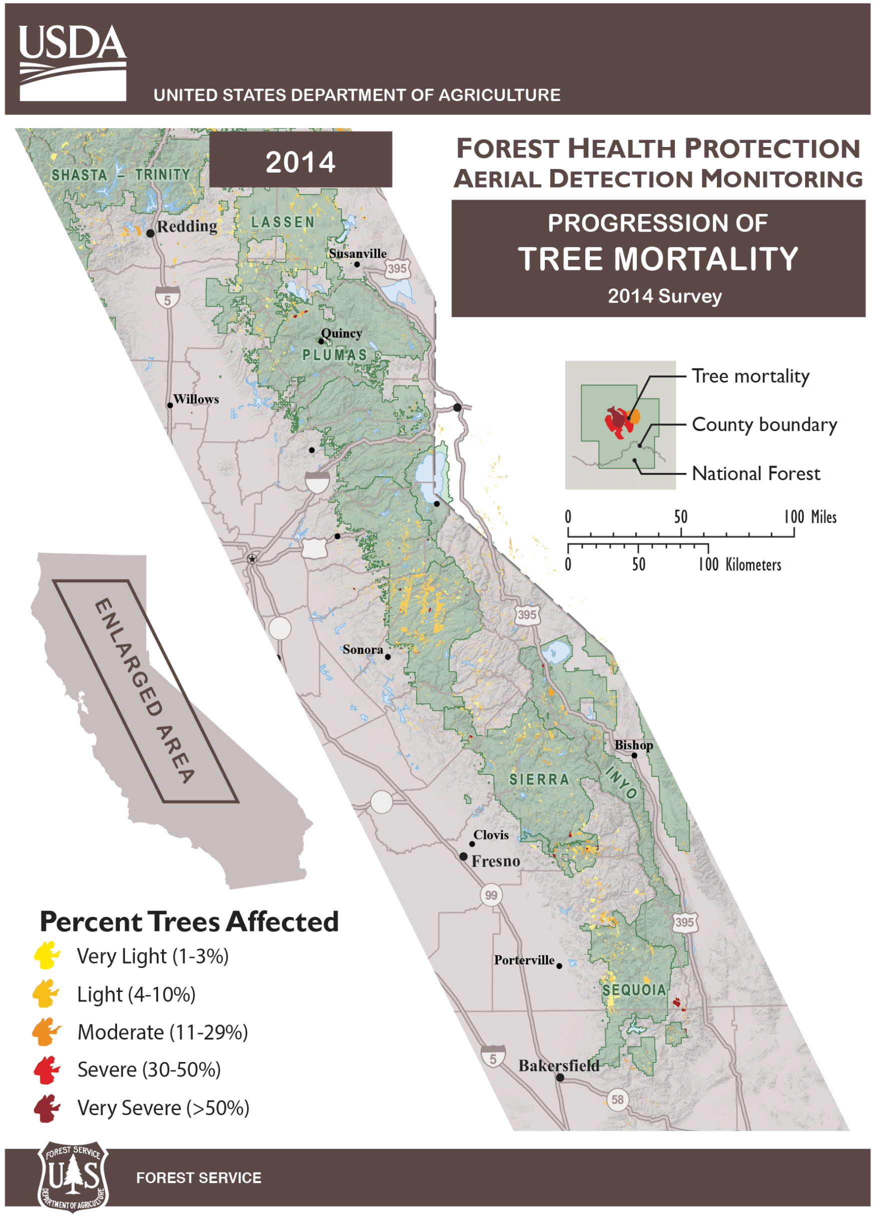
Higher density + altered fire regime + severe droughts

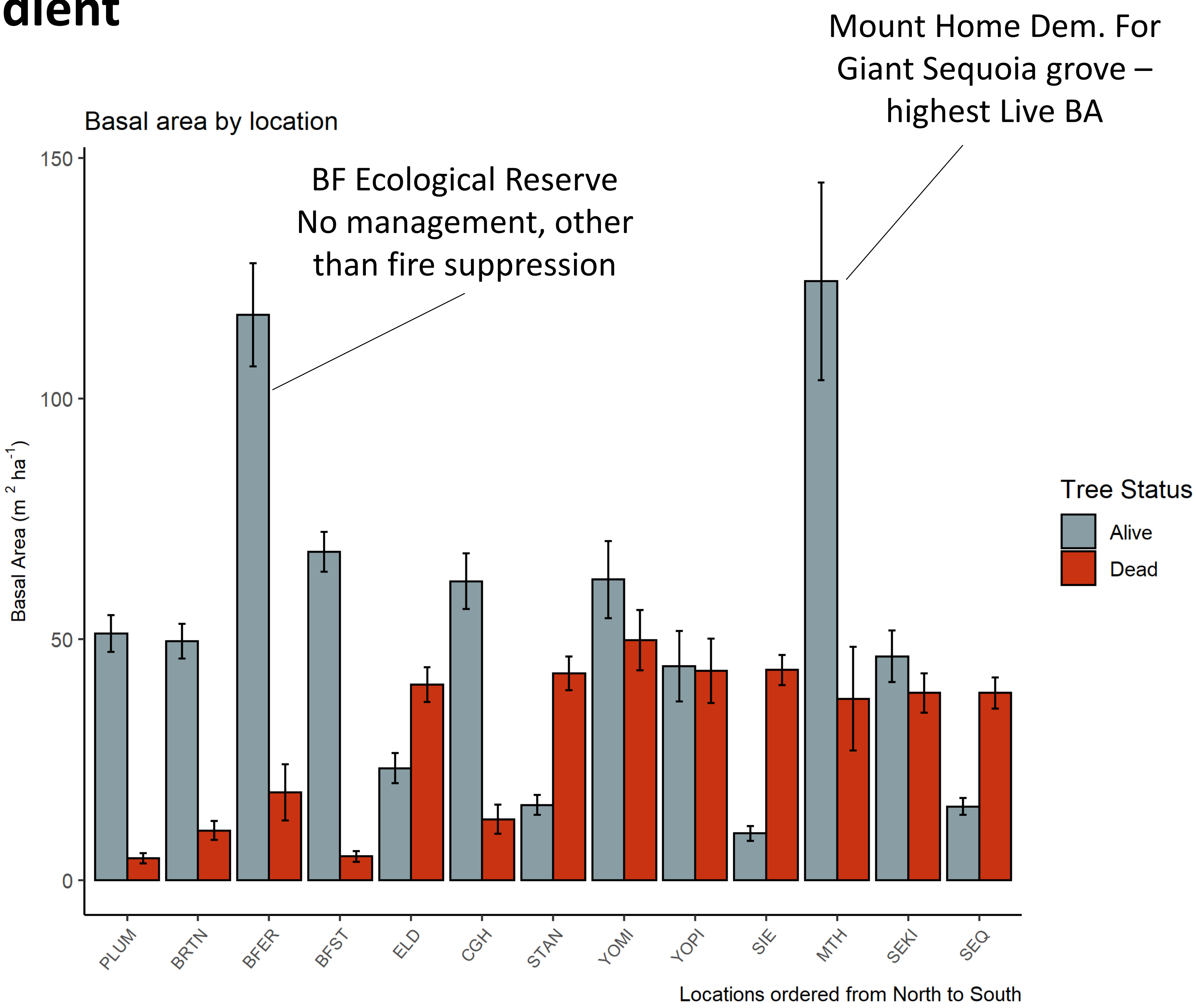


Sierra National Forest © Emilio Vilanova

➡ Annual water year (October to September) cumulative precipitation (P) and mean maximum temperature in southern Sierra Nevada from PRISM. Horizontal red bars indicate extended droughts.

North to South mortality gradient





Current situation of Sierra Nevada forests

Summary

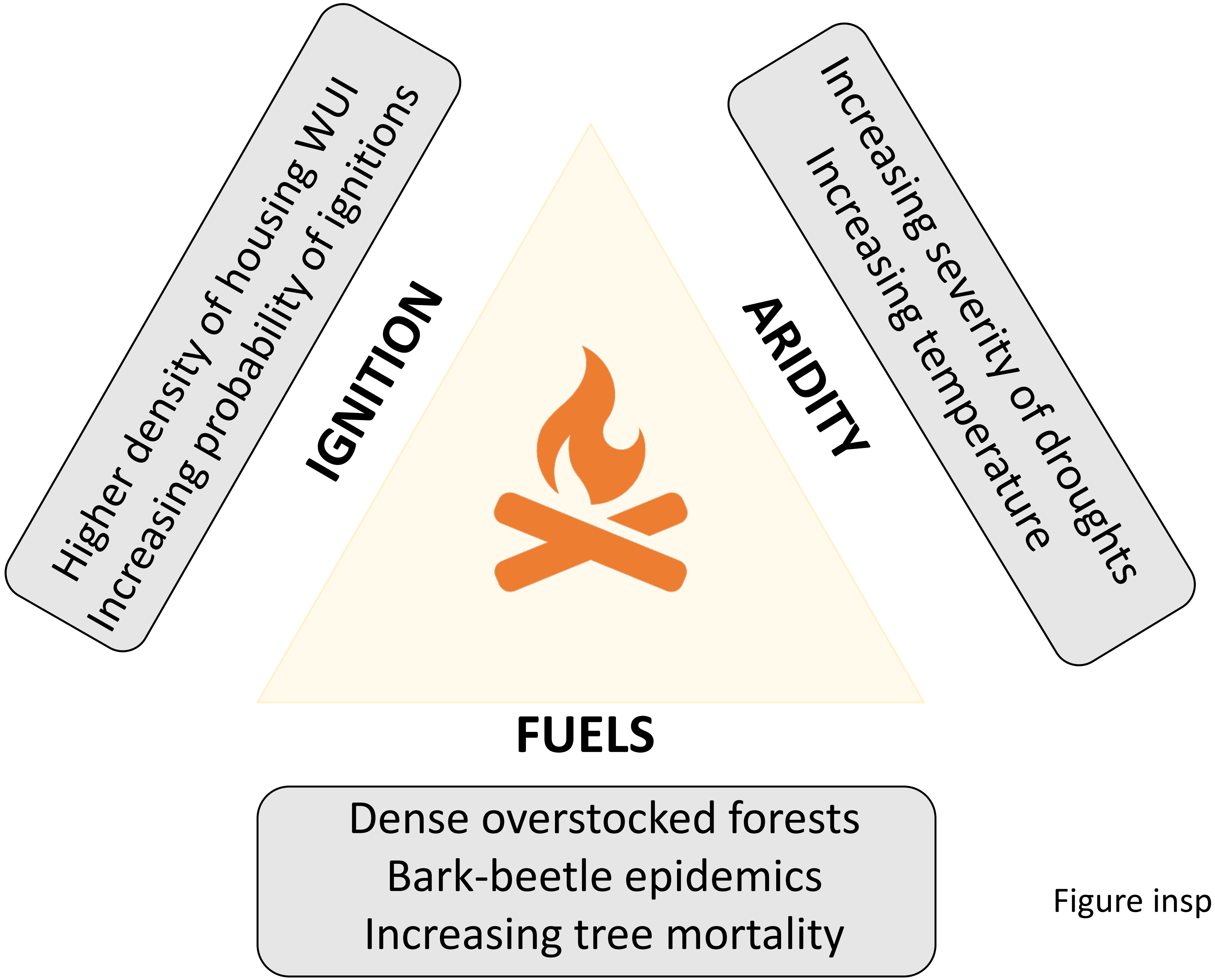


Figure inspired by Park Williams
@peedublya

Ground and surface fuels

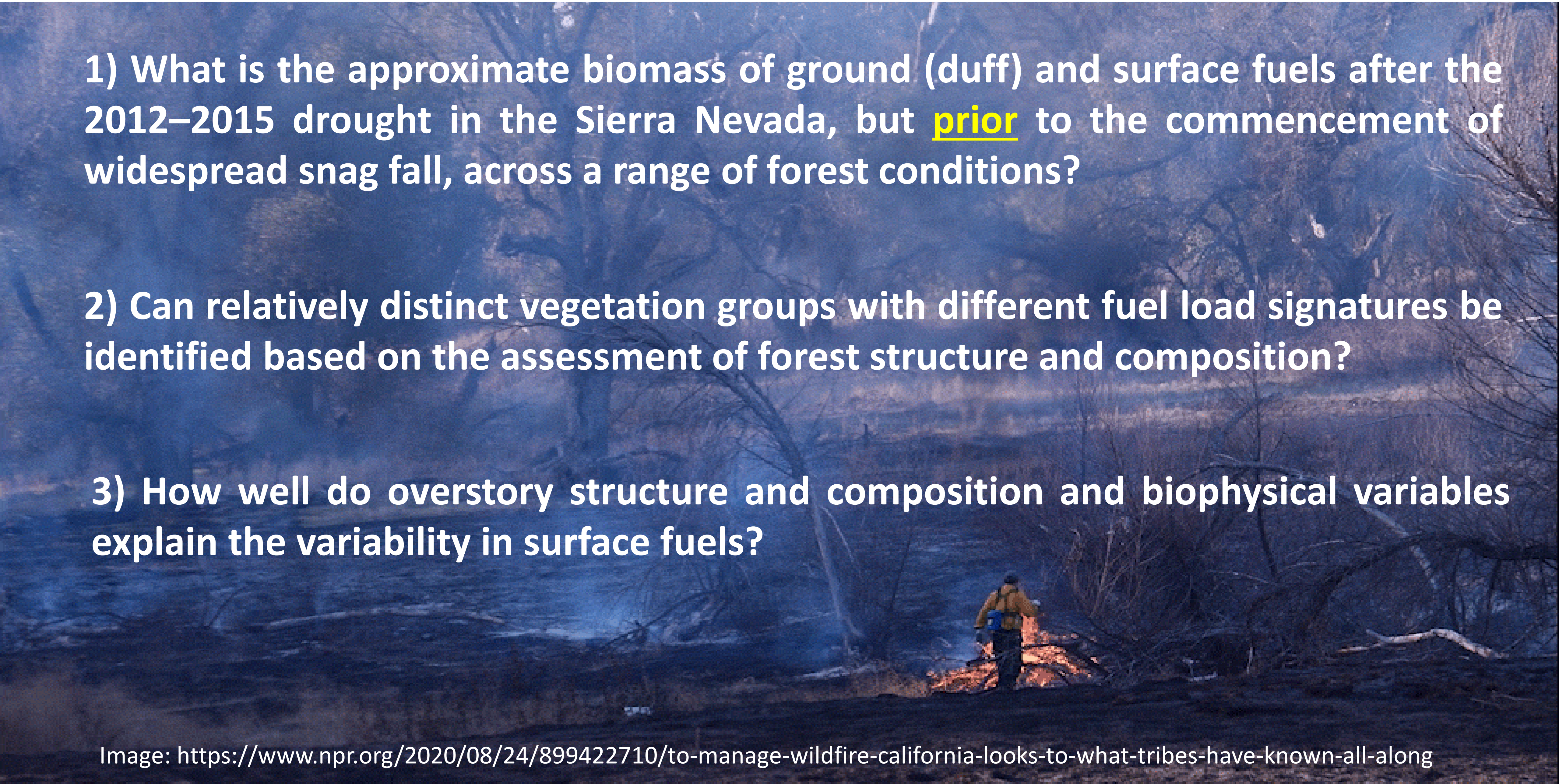
Generalities

- In combination with weather, topography and vegetation structure, ground (duff) and surface fuels, are of interest because these fuels are fundamental factors **driving fire behavior, severity and intensity** (Lydersen et al. 2015);

- Greater surface **fuel loads increase potential surface fire flame** lengths and can lead to canopy torching (Agee & Skinner, 2005);

- **Accurate estimates** of fuel loads can help in efforts to reduce wildfire risk (e.g., prescribed burning, thinning), restoration planning and carbon projections.

Research questions



1) What is the approximate biomass of ground (duff) and surface fuels after the 2012–2015 drought in the Sierra Nevada, but <u>prior</u> to the commencement of widespread snag fall, across a range of forest conditions?

2) Can relatively distinct vegetation groups with different fuel load signatures be identified based on the assessment of forest structure and composition?

3) How well do overstory structure and composition and biophysical variables explain the variability in surface fuels?

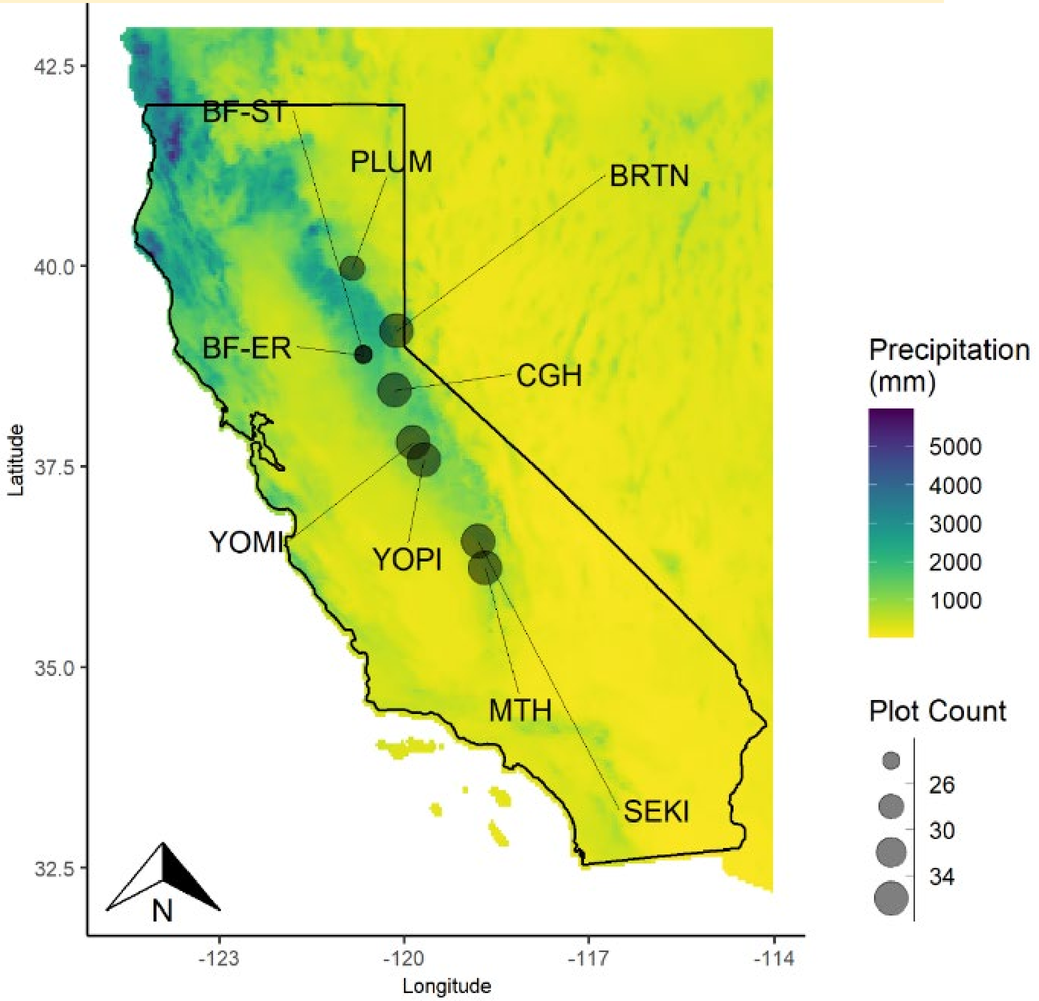
Image: https://www.npr.org/2020/08/24/899422710/to-manage-wildfire-california-looks-to-what-tribes-have-known-all-along

Methods

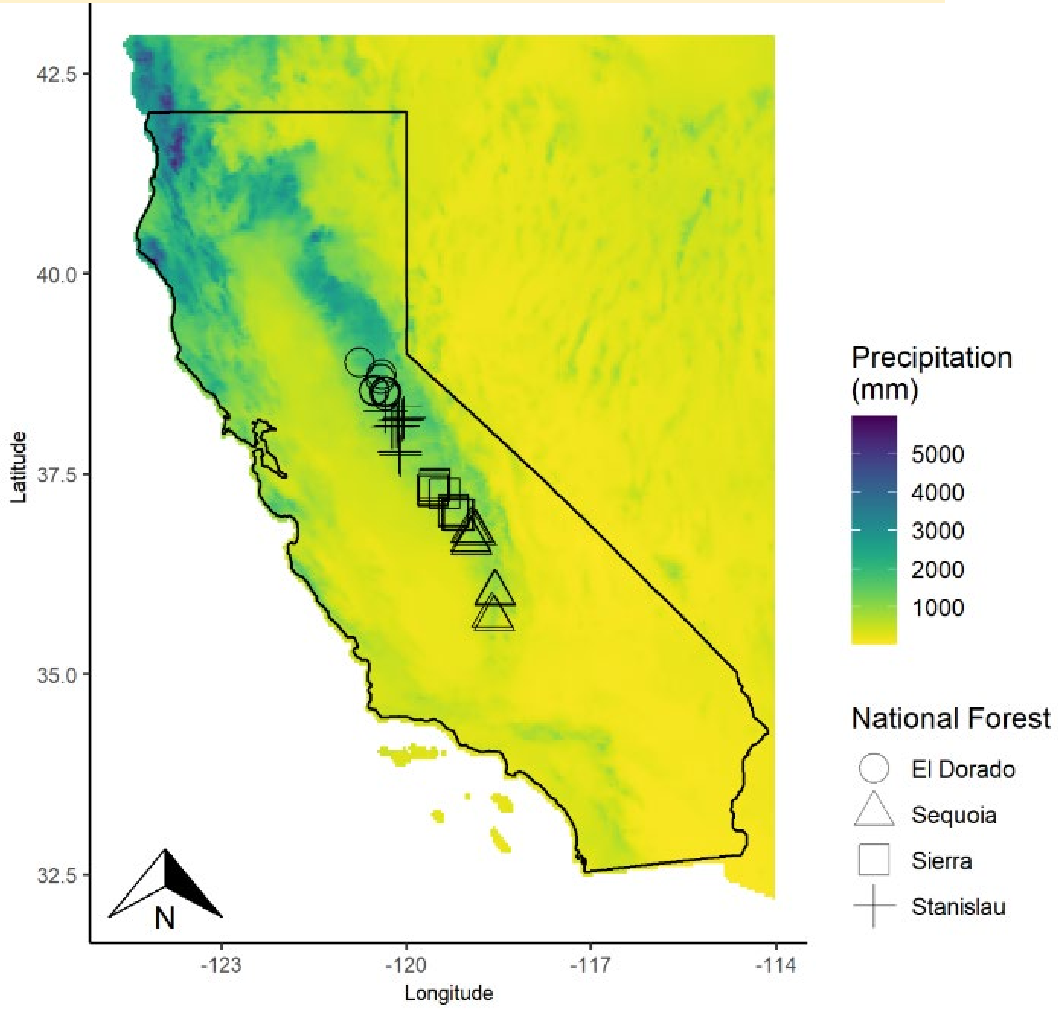
Combination of two plot networks

462 plots – 13 locations – 1,386 fuels transects
Overstory: 10,773 stems (66.2% alive)

DX: 2017-2018 data collection:
- 9 sites (10-15 plots per 1.0 km²)
- 282 plots → 846 transects total

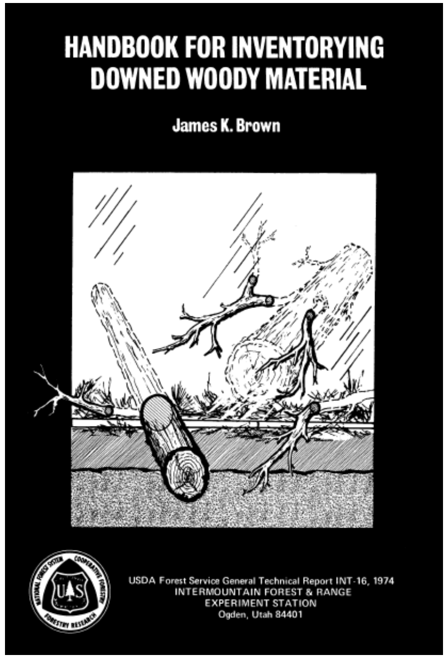


USFS: 2016-2017 data collection:
- 4 National Forests
- 180 plots – 45 per NF → 540 transects



Methods

Field data collection



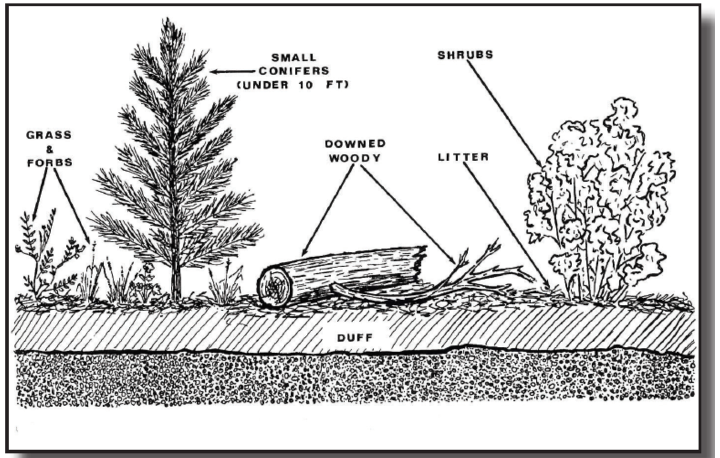


Figure 5. The sampling components that are collected in a fixed-plot sample.

Table 2. Fuel classifications and characteristics.

Fuel classifications	Diameter (inches)	Description
1-hour	<0.25 ≤ 0.64 cm	needles and twigs
10-hour	0.25–1 > 0.64 ≤ 2.54 cm	twigs, stems, small branches
100-hour	1–3 > 2.54 ≤ 7.62 cm	branches and stems
1000-hour	3–8 > 7.62 cm	small logs and limbs
litter	N/A*	identifiable plant parts, such as needles and twigs, on the forest floor; typically behaves like 1-hour fuels
duff	N/A	more decomposed plant parts beneath the litter; typically behaves like 1000-hour fuels

McMahon et al. (2020)

Methods

Estimation of surface fuels

462 plots – 13 locations – 1,386 fuels transects

- Rfuels package was developed by Danny Foster (UC Berkeley) includes all the equations, constants, and coefficients needed from Brown (1974), van Wagtendonk et al. (1996) and Harmon et al (2008)

plot_id	inv_date	azimuth	slope_percent	x1h_length_m	x10h_length_m	x100h_length_m	x1000h_length_m	count_x1h	count_x10h	count_x100h	duff_depth_cm	litter_depth_cm	sum_d2_1000r_cm2	sum_d2_1000s_cm2
1	9/20/2017	90	6	2	2	3	12.62	10	2	0	1.75	1.75	0	0
1	9/20/2017	210	5	2	2	3	12.62	1	0	0	2	0	0	0
1	9/20/2017	330	11	2	2	3	12.62	6	1	0	2.25	1	0	0

+

plot_id	inv_date	species	dbh
1	9/20/2017	ABCO	14.9
1	9/20/2017	ABCO	51.1
1	9/20/2017	PIJE	50.3
1	9/20/2017	PIJE	46.8

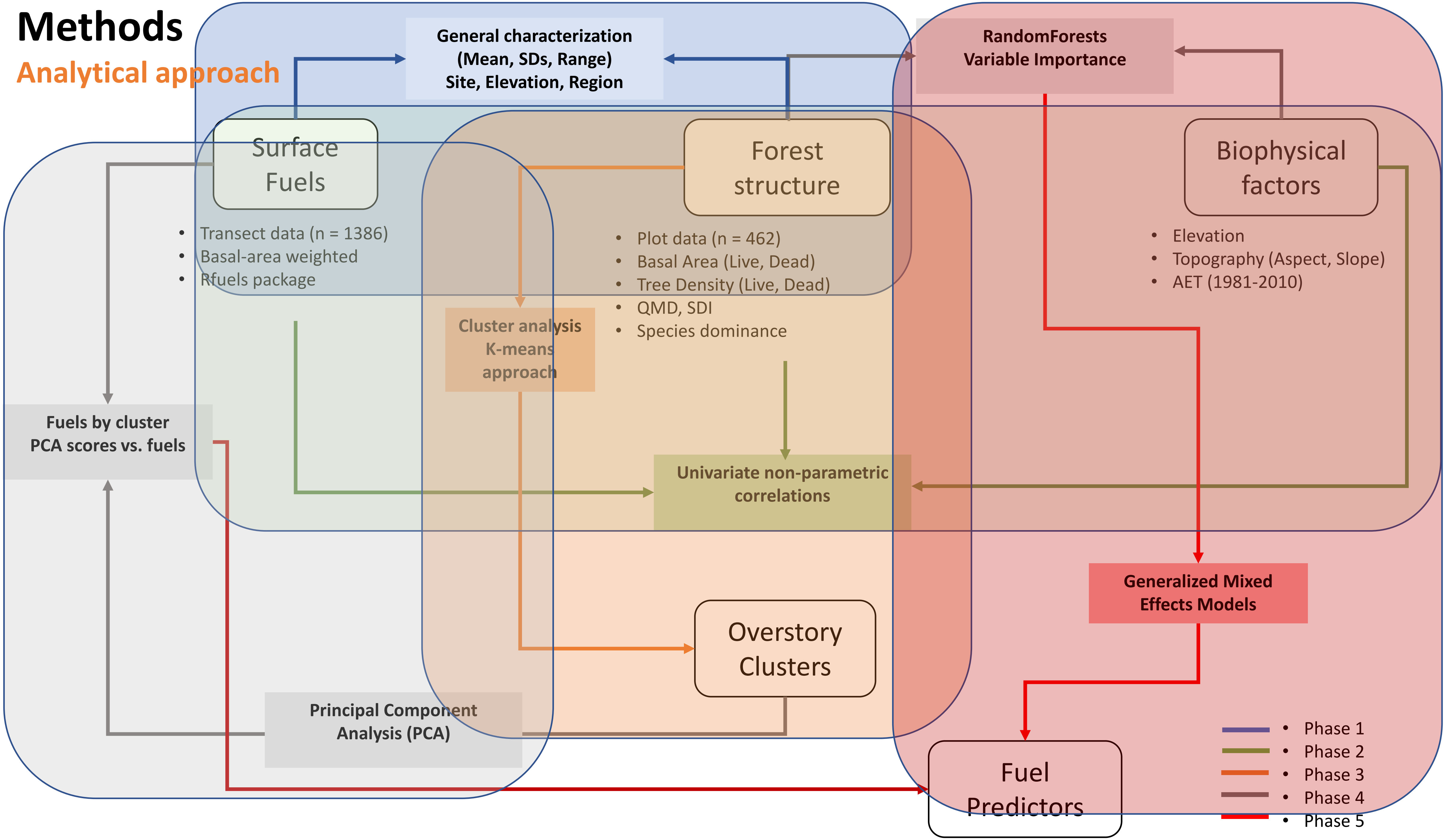
↓

plot_id	inv_date	pBA_ABCO	pBA_ABMA	pBA_CADE	pBA_OTHER	pBA_PICO	pBA_PIJE	pBA_PILA	pBA_PIPO	pBA_(all)	azimuth	slope_percent	fuelload_litter_Mgha	fuelload_duff_Mgha	fuelload_1h_Mgha	fuelload_10h_Mgha	fuelload_100h_Mgha	fuelload_1000s_Mgha	fuelload_1000r_Mgha	fuelload_fwd_Mgha	fuelload_1000h_Mgha	fuelload_surface_Mgha	fuelload_total_Mgha
1	9/20/2017	0.413364	0.013131	0	0	0	0.573505	0	0	1	90	6	11.31036	28.50989	0.40669	0.886099	0	0	0	1.292789	0	12.60315	41.11305
1	9/20/2017	0.413364	0.013131	0	0	0	0.573505	0	0	1	210	5	0	32.58274	0.040647	0	0	0	0	0.040647	0	0.040647	32.62338
1	9/20/2017	0.413364	0.013131	0	0	0	0.573505	0	0	1	330	11	6.463065	36.65558	0.245045	0.444922	0	0	0	0.689967	0	7.153032	43.80861

R fuels package: https://github.com/danfosterfire/Rfuels

Methods

Analytical approach

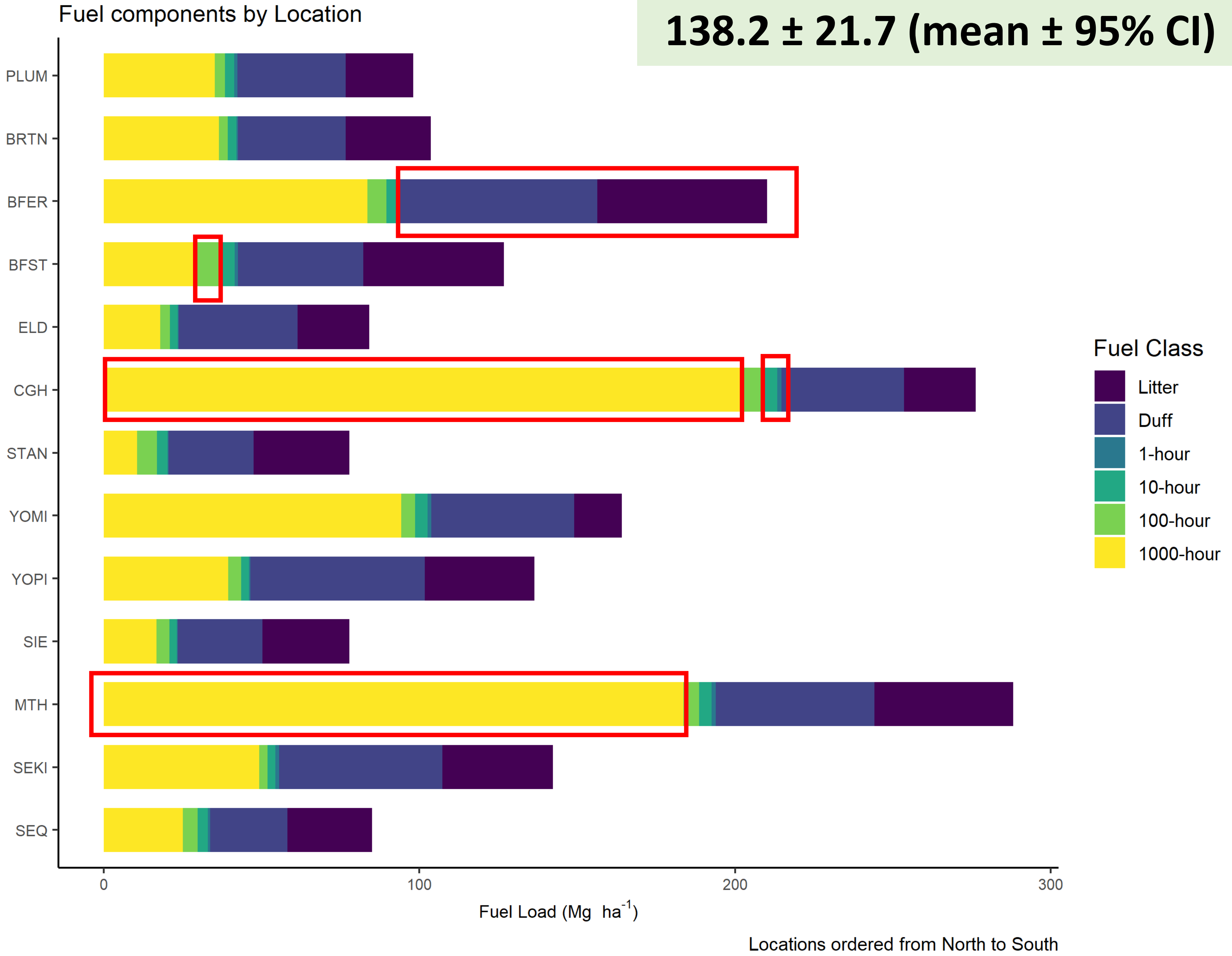


Results

Fuels by location

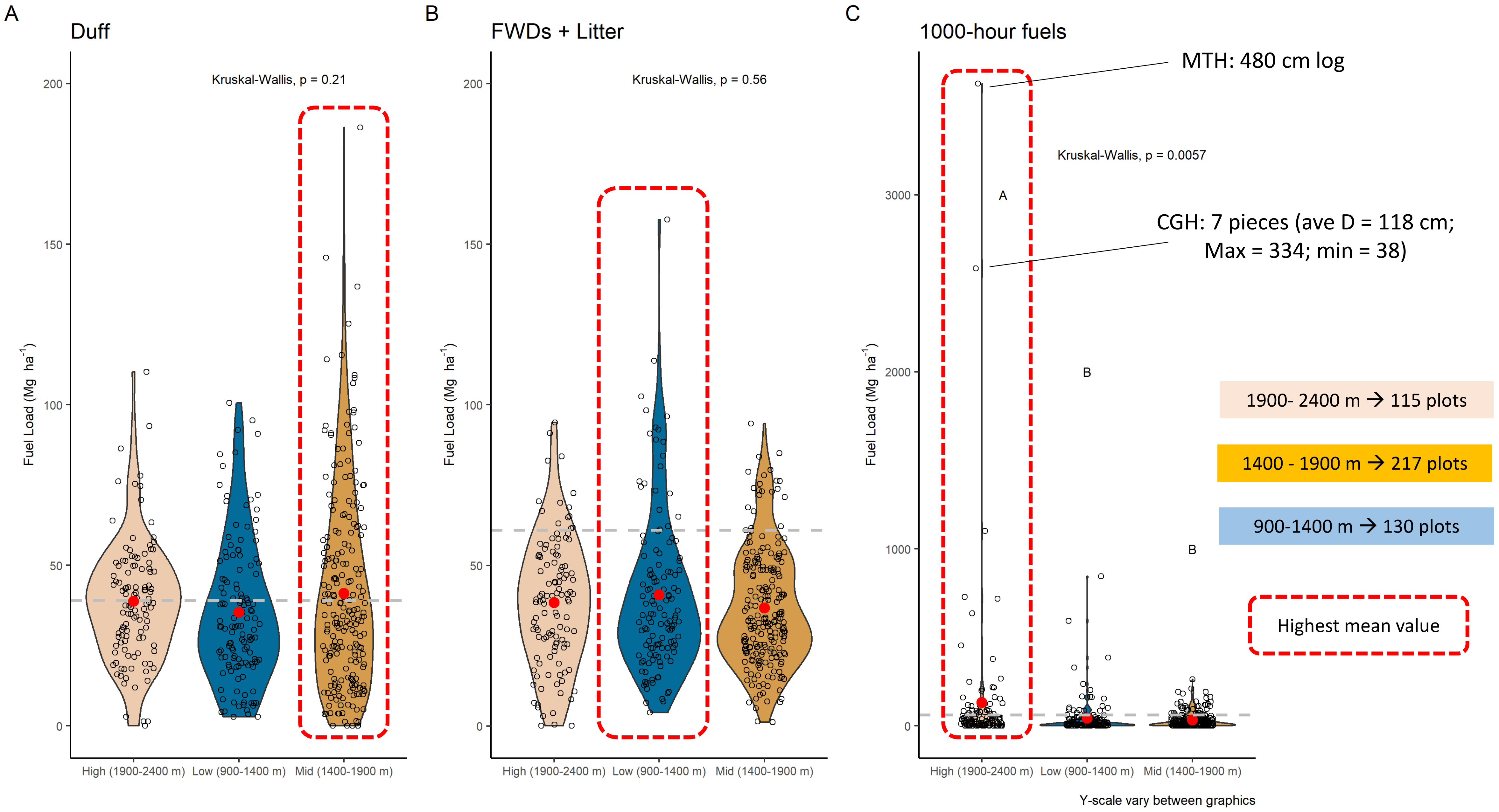
Total fuels average:
138.2 ± 21.7 (mean ± 95% CI)

Frasier Mill site (Mount Home Demonstration Forest), post-Castle fire, October 16, 2020 © Carina Bilodeau



Results

Surface fuels by elevation



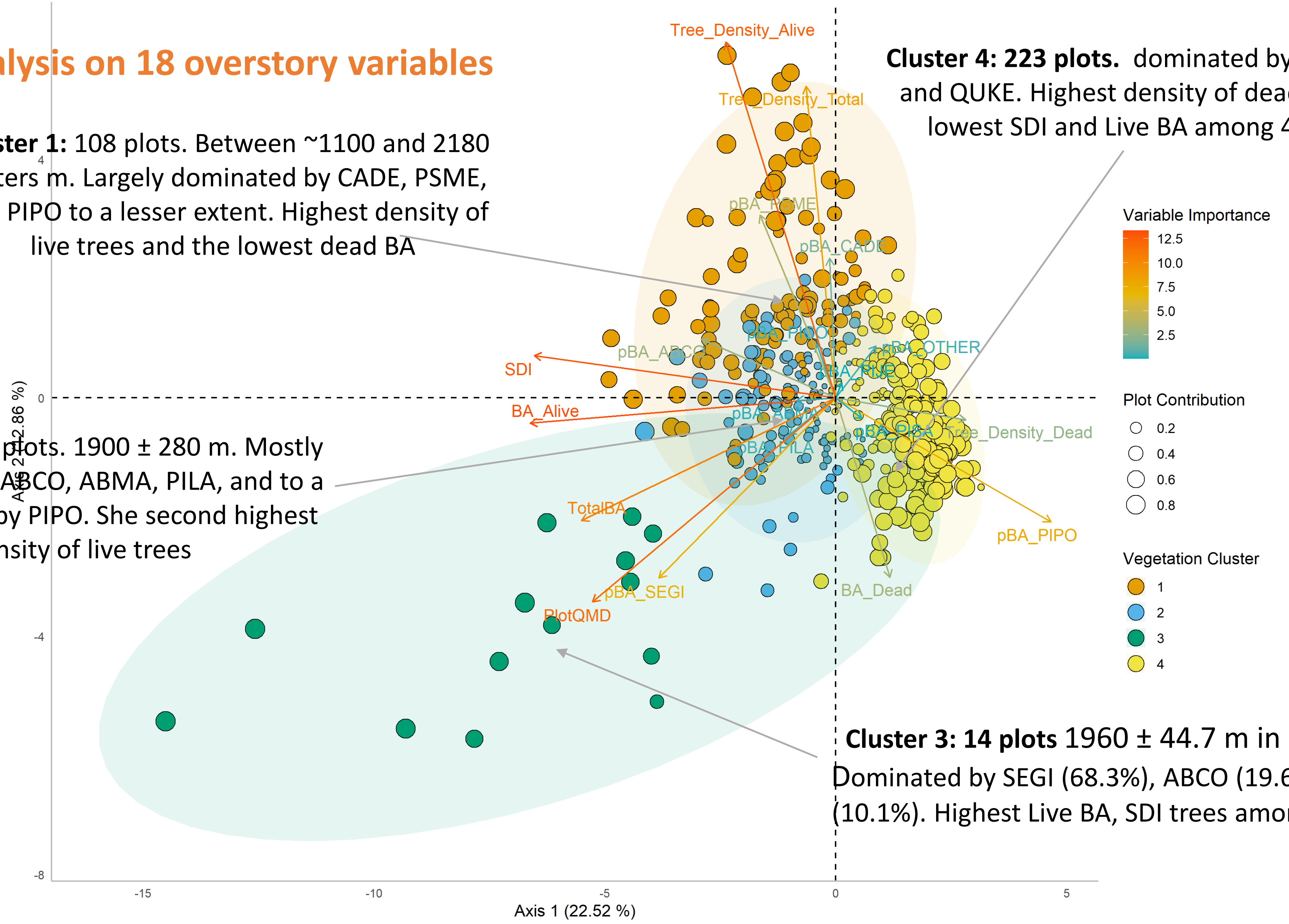
Results

K-means analysis on 18 overstory variables

Cluster 1: 108 plots. Between ~1100 and 2180 meters m. Largely dominated by CADE, PSME, and PIPO to a lesser extent. Highest density of live trees and the lowest dead BA

Cluster 4: 223 plots. dominated by PIPO, CADE and QUKE. Highest density of dead trees and lowest SDI and Live BA among 4 clusters

Cluster 2: 117 plots. 1900 ± 280 m. Mostly dominated by ABCO, ABMA, PILA, and to a lesser extent by PIPO. She second highest density of live trees



Cluster 3: 14 plots 1960 ± 44.7 m in elevation. Dominated by SEGI (68.3%), ABCO (19.6%) and PILA (10.1%). Highest Live BA, SDI trees among 4 clusters

Cluster Analysis

Fuels

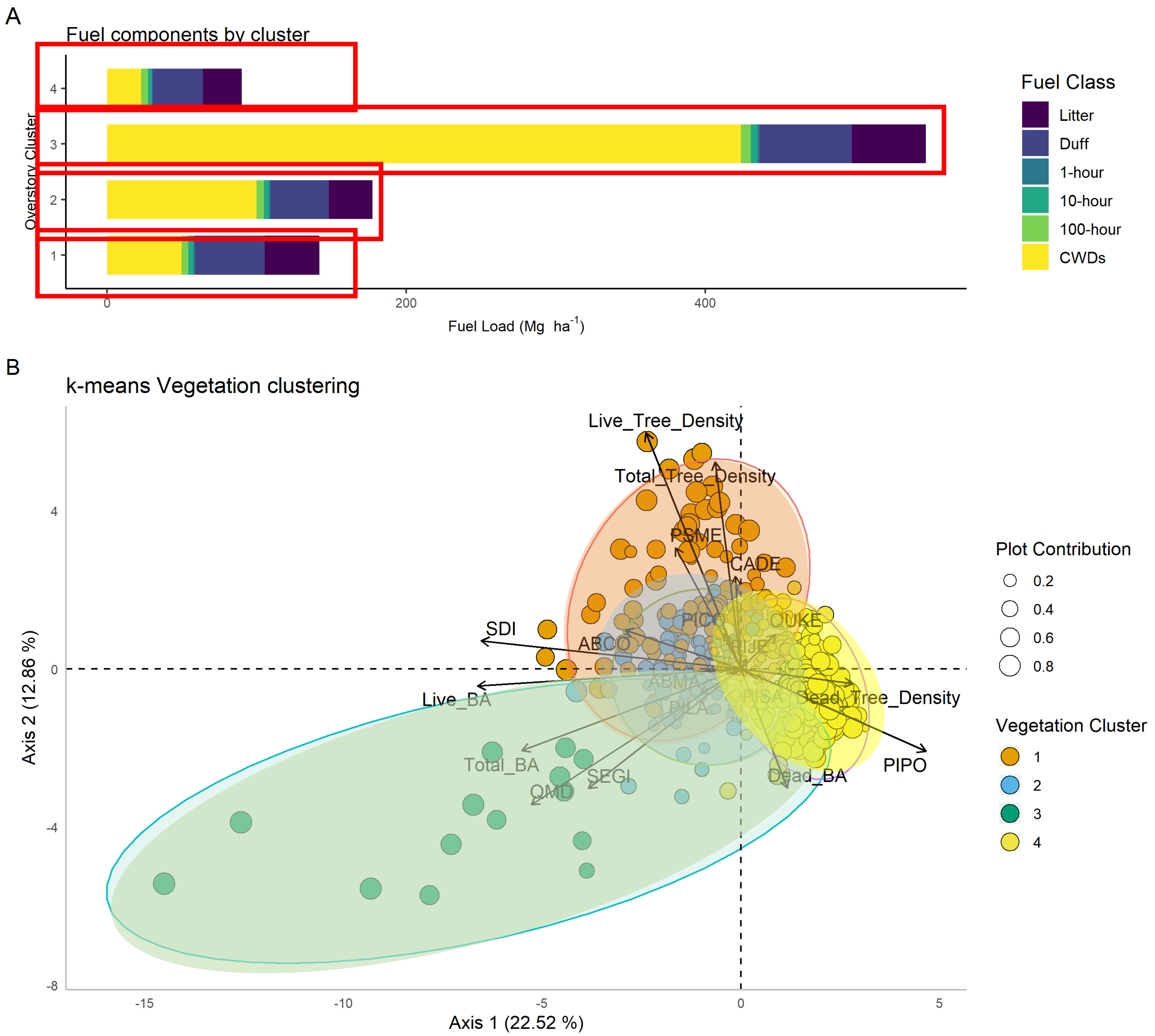
Cluster	Litter %	Duff %	1-hour %	10-hour %	100-hour %	CWDs %
1	25.61	32.96	0.61	2.43	3.22	35.18
2	16.39	21.92	0.59	2.01	2.85	56.23
3	9.02	11.31	0.22	0.82	1.21	77.41
4	28.61	37.54	0.51	3.07	4.74	25.53

Cluster 1 (CADE, PSME, PIPO): 108 plots → ~ 60% of fuels Litter+Duff

Cluster 2 (ABCO, ABMA): 117 plots → ~ 60% of fuels CWDs

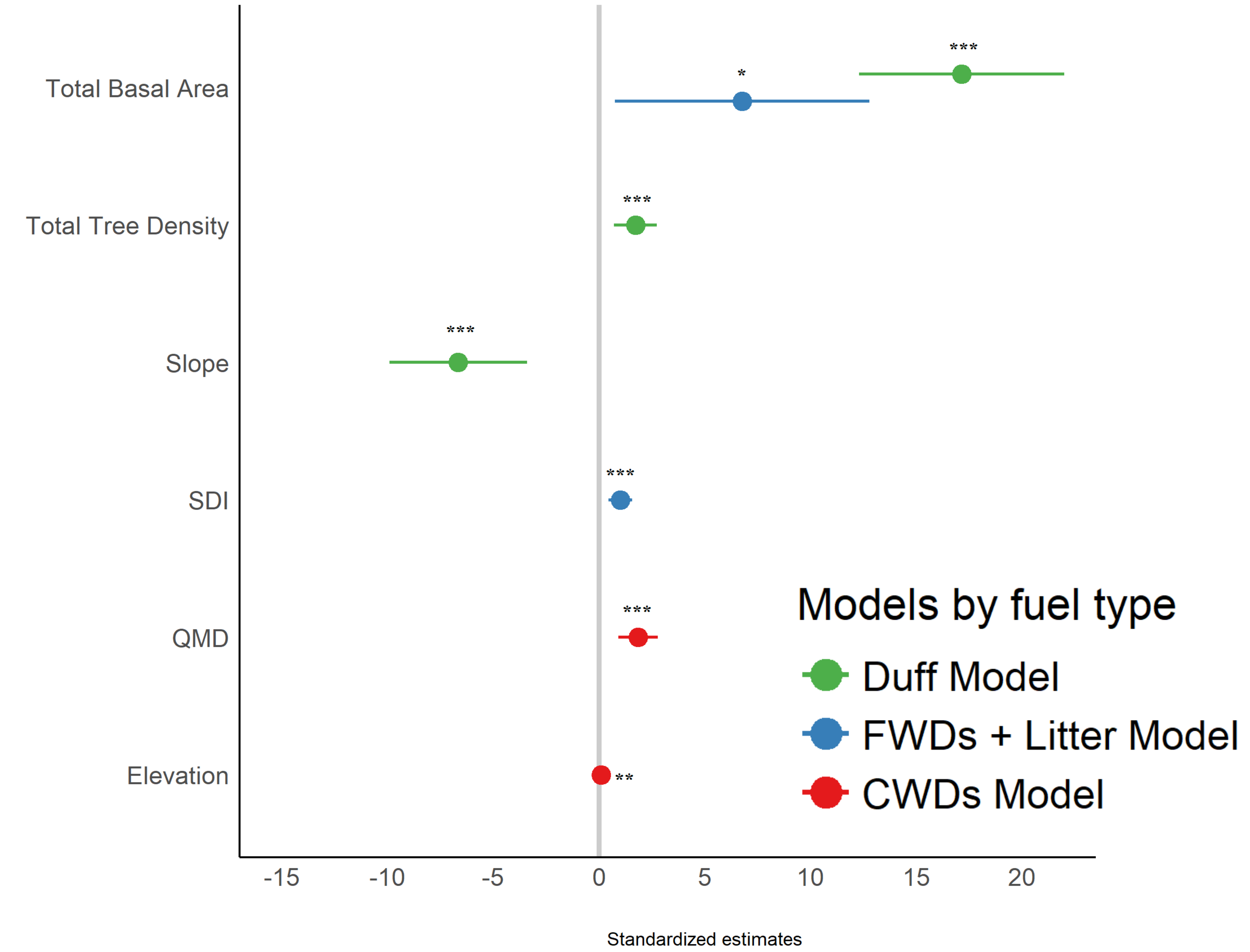
Cluster 3 (SEGI,ABCO): 14 plots → ~ 80% of fuels CWDs

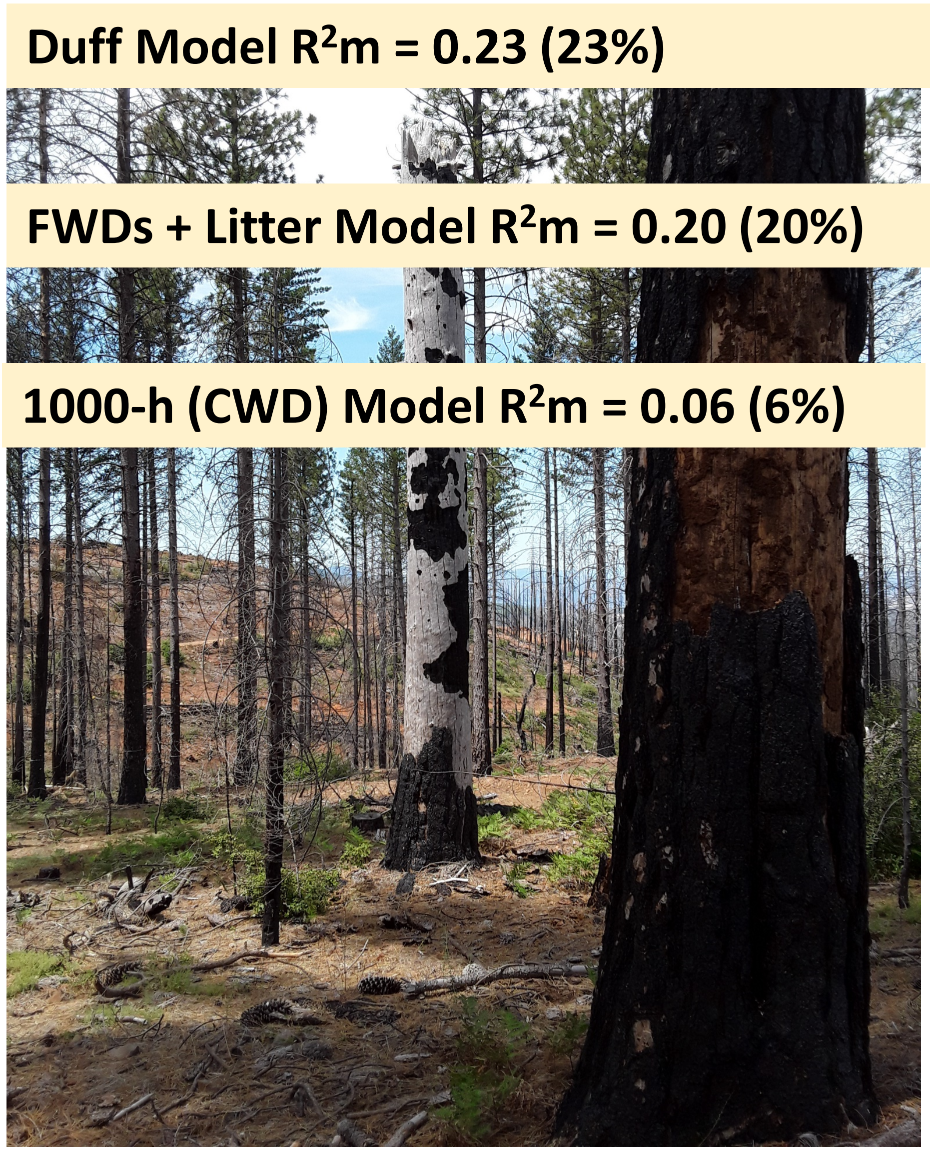
Cluster 4 (PIPO, CADE, QUKE): 223 plots. → ~ 66% of fuels Litter+Duff; Highest 100-h biomass



Generalized Mixed Models on all data

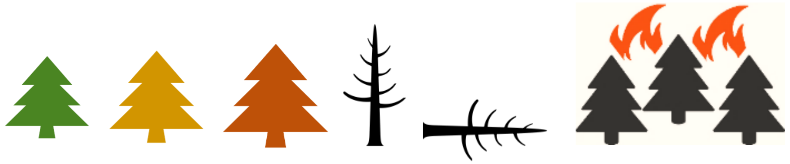
Summary of "best" models





Boggs Demonstration Forest

Take home messages



- Overall **high levels of fuels**, with our values closer to the pre-treatment fuel levels from other studies, reflecting that most of the plots measured in this study were in areas lacking recent fire or treatment;

- **Two potential 'extremes'** in the range of surface fuels load:
  ~ On the high end, SEGI-dominated stands where large 1000-h fuels occupied the largest proportion of the surface fuel profile;
  ~ Low end: PIPO-dominated stands where duff and litter occupied the largest proportion of the fuel profile; High mortality;
  ~ Snags still standing may further exacerbate 1000-h loads in the near future;

- More heavily overstocked forests tend to have higher surface fuel loads. A maximum of **23% of the variation** in fuels could be explained by both overstory and biophysical data. a) fuels spatially clumped at multiple scales; b) skewed distributions.

Thanks!

Got any questions?

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