RESULT SUMMARIES: Tree Drought Mortality Collaboration

March 2017

Agenda - Tree Mortality in the Sierra Nevada: 2017 Results

McClellan Conference Centre
Room N115 Guide
March 12th, 2018
8:30 to noon

Desired Outcomes

1) Increase understanding of drought induced tree mortality and regeneration in the Sierra Nevada by sharing results of the drought mortality data collaborative 2017 field season on live and dead trees, causation, regeneration, fuels, and carbon
2) Solicit input from partners and managers on useful data summary products
3) Discuss on-going collaboration on field data collection, interpretation and use

8:00 – 8:30 Light breakfast & refreshments

8:30 – 8:45 Introductions, Project Overview & Goals (Susie Kocher/Jodi Axelson)
8:45 – 9:05 Tree mortality and bark beetles (Elliot Kuskulis)
9:05 – 9:20 Tree mortality in treated/untreated stands (Christina Restaino)
9:25 – 9:40 Pesticide injection trial and update on western pine beetle biology work (Sheri Smith)
9:40 – 10:00 Questions and Discussion

10:00 – 10:15 Coffee Break

10:20 – 10:30 Carbon and Fuels (John Battles)
10:30 – 10:40 Regeneration (Lauren Cox)
10:40 – 10:45 Inventory-based mortality estimates for California forests, 2001-2015 (Stella Cousins)
10:45 – 10:55 ADS and Biomass (Carmen Tubbesing)
10:55 – 11:10 e-DART update (Michèle Slaton)

11:10 – 11:50 Discussion/input on data products (Susie Kocher)

a. Is the information presented useful – does it fulfill expectations that people have of what this kind of studies/monitoring can tell us
b. If not what else can we do with existing data
c. Next field season plans
d. Additional desired variables, on-going communication/ website, reporting schedule/ field trip, funding

11:50 – 12:00 Wrap up and 2018 field season (John Battles)

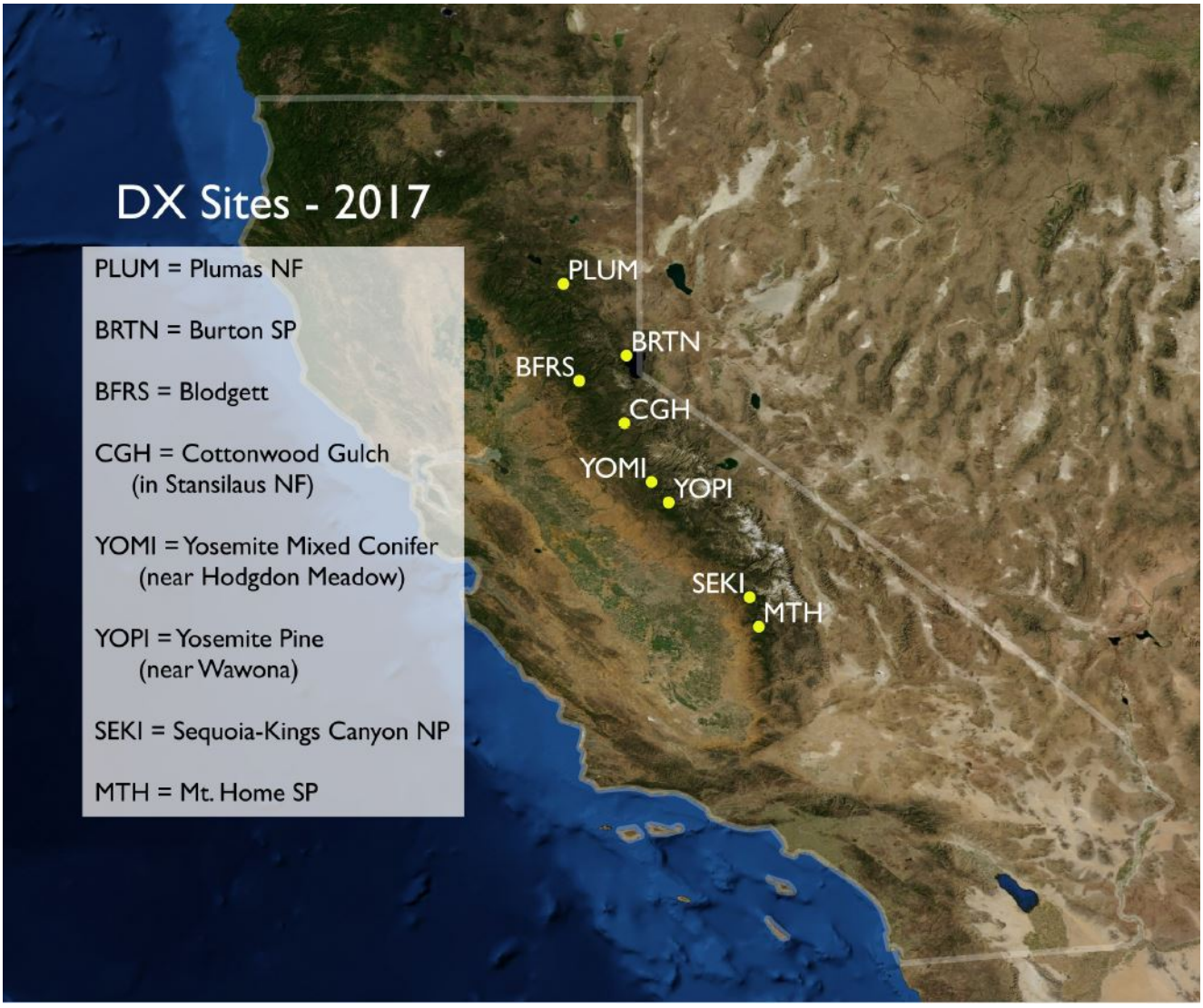


Figure 1. Map of California with site locations.

2017 UCB Drought Mortality Survey: Plumas National Forest Initial Summary

Site Description

The Plumas National Forest (PLUM) site is located 11 mi northeast of Quincy in Plumas County, CA. The 470-ac study site is managed by the US Forest Service. Mean elevation is 4870 ft. Average annual temperature is 48°F (January: 34°F, July: 67°F) and average annual precipitation is 43 in. The site is dominated by Douglas-fir, ponderosa pine, and white fir. Some stands within the study area have been commercially thinned (late 1980s) or harvested using a group selection system (2012).

Key Results

Across the site, live trees had far more density and basal area than dead trees (Table 1). White firs in the large DBH class and sugar pines in the intermediate DBH class exhibited the greatest rates of recent mortality at close to 20%, but overall mortality for all major species was low (Figure 2). Almost two thirds of recent tree mortality was caused by bark beetles, with fir engraver beetles responsible for the majority of attacks and mountain pine beetle responsible for a moderate percentage of attacks (Table 2). 12.5% of all lethal attacks were classified as new in 2017—almost 19% of fir engraver attacks were new, as was the only western pine beetle attack recorded (Table 3). Total fuel loading was moderately high, with 1000-hour fuels and duff contributing the most to this total (Table 4). The seedling and sapling layers were dominated by a mix of white fir, incense-cedar, and Douglas-fir (Figures 3 and 4). Sapling densities were high at the PLUM site compared to others (Figure 4). This trend may be caused by differences in land use and management history. Stands within this site were relatively young compared to those at other sites, and recent harvest activities may be responsible for higher sapling densities.

Table 1. Site characteristics for the site in Plumas National Forest (PLUM). Density, basal area, and dominance values were calculated from live and recently dead overstory trees (trees ≥ 4 in DBH) only. Recently dead trees were defined as having a decay class of 1, corresponding to the least advanced level of decay. Live trees represented far more basal area and density than dead trees on average. The two most dominant tree species are shown (see Figure 2 for species codes), along with their corresponding percent dominance.

Number of Plots (n)	Elevation (ft)	Slope (%)	Mean Density ± SE (trees ac^{-1})		Mean Basal Area ± SE (ft^2 ac^{-1})		Dominance (%)
			Live	Dead	Live	Dead	
29	4488-5118	3-53	343.7 ± 27.7	8.9 ± 3.0	207.8 ± 14.8	5.2 ± 1.7	PSME (36%); CADE (24%)

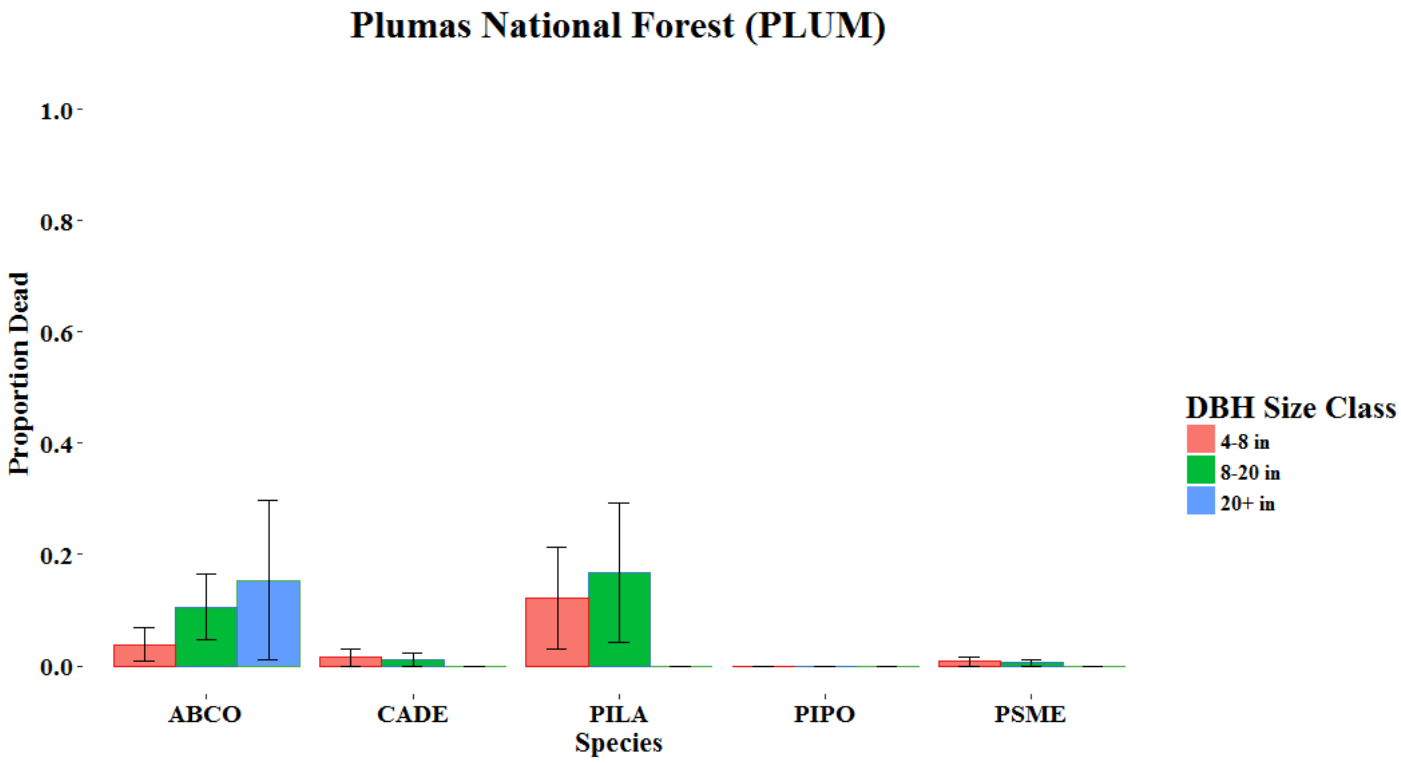


Figure 2. Proportion of recently dead trees by species and DBH size class for major species at PLUM. ABCO = white fir (*Abies concolor*); CADE = incense-cedar (*Calocedrus decurrens*); PILA = sugar pine (*Pinus lambertiana*); PIPO = ponderosa pine (*P. ponderosa*); PSME = Douglas-fir (*Pseudotsuga menziesii*). Bars represent 95% confidence intervals.

Table 2. Percentage of recently dead trees lethally attacked by each beetle type, and percentage of recently dead trees lethally attacked by any beetle type. FEB = fir engraver beetles (*Scolytus* spp.); MPB = mountain pine beetle (*Dendroctonus ponderosae*); WPB = western pine beetle (*D. brevicomis*). Both old and current mass attacks were defined as lethal, but partial attacks were excluded from this category.

All	FEB	MPB	WPB
Proportion ± SE	Proportion ± SE	Proportion ± SE	Proportion ± SE
62.5% ± 8.6%	43.8% ± 8.8%	18.8% ± 6.9%	0% ± 0%

Table 3. Percentage of lethally attacked trees (live and recently dead) that exhibited evidence of "new" beetle activity in 2017. New activity was represented by current mass attacks only; current partial attacks were excluded. Note: Trees were considered live if they had any green foliage. The only WPB attack observed was a current mass attack on a live tree.

All	FEB	MPB	WPB
Proportion ± SE	Proportion ± SE	Proportion ± SE	Proportion ± SE
12.5% ± 6.8%	11.8% ± 7.8%	0% ± 0%	100% ± 0%

Table 4. Fuel loads by fuel component for PLUM. Duff and 1000-hour fuels accounted for the greatest portions of the total fuel load on average. Litter also represented a moderate portion of the total fuel load.

Fuel Component	Mean ± SE (tons ac^{-1})	Range (tons ac^{-1})
Litter	8.5 ± 0.9	3.5-22.5
Duff	16.9 ± 1.7	5.2-48.3
1-hour	0.5 ± 0.1	0.1-1.4
10-hour	1.4 ± 0.2	0-4.1
100-hour	1.5 ± 0.2	0-4.1
1-100-hour	3.4 ± 0.3	0.8-7.1
1000-hour	16.6 ± 3.9	0-93.9
Total	45.3 ± 4.1	17.8-118.4

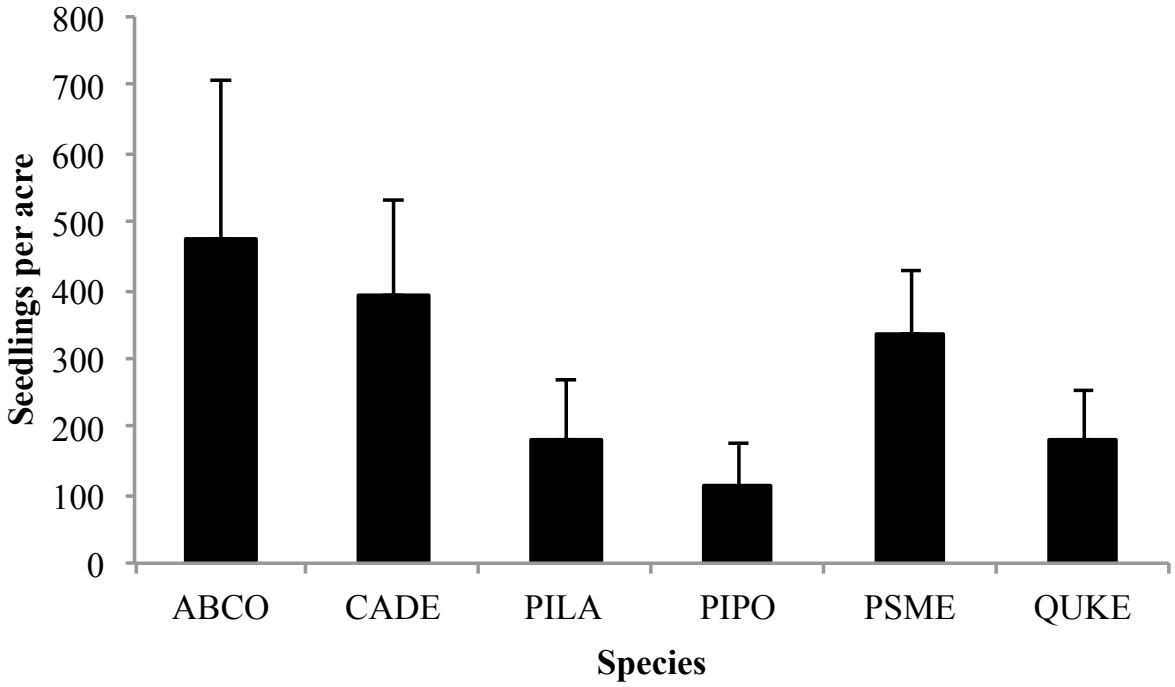


Figure 3. Density of seedlings (stems <4.5 ft height) across all species at PLUM. First year germinants were excluded from the data. Bars represent standard errors.

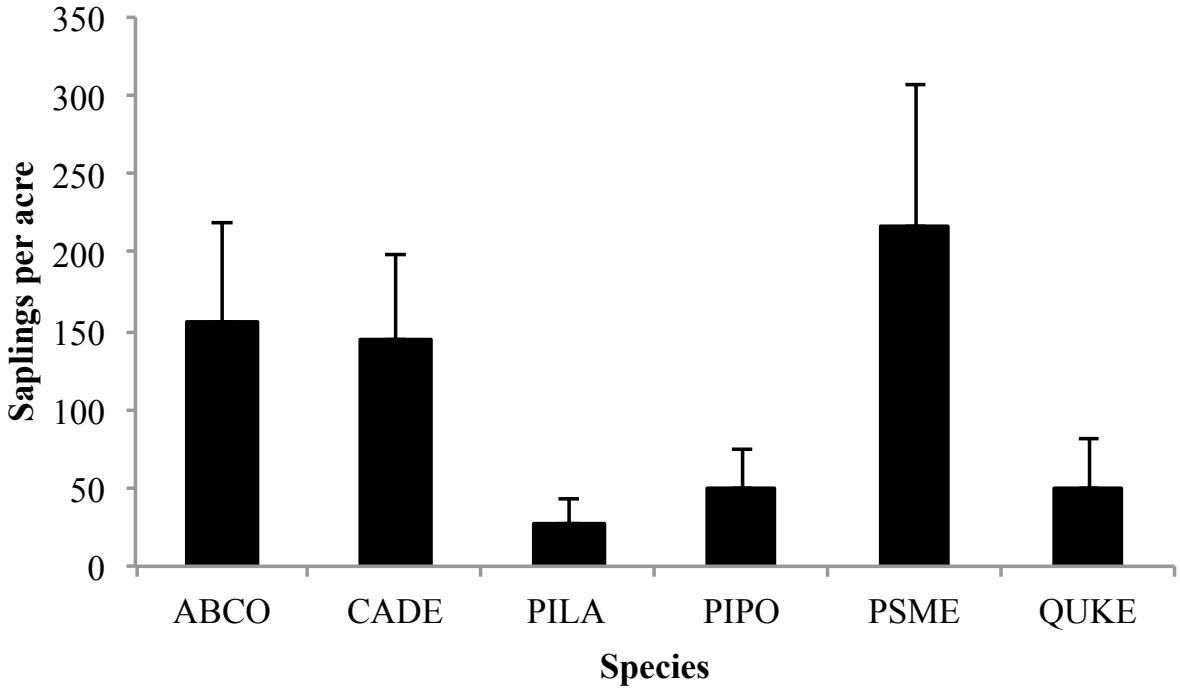


Figure 4. Density of saplings (stems ≥ 4.5 ft height; < 4 in DBH) at PLUM. Bars represent standard errors.

2017 UCB Drought Mortality Survey: Blodgett Forest Research Station – Ecological Reserve Initial Summary

Site Description

The Blodgett Forest Research Station – Ecological Reserve (BF-ER) site is located 13 mi east of Georgetown in El Dorado County, CA. The 586-ac study area is managed by the UC Center for Forestry. Mean elevation is 4327 ft. Average annual temperature is 58 °F (January: 43 °F; July 75 °F) and average annual precipitation is 53 in. Ponderosa pine, incense-cedar, and white fir dominate the site. Ecological reserves experience no management activity other than fire suppression.

Key Results

Across the site, live trees accounted for about 10 times the density and 18 times the basal area of dead trees (Table 1). This points to a greater die-off of small trees. Although overall mortality was low, sugar pines in the intermediate DBH class experienced almost 60% recent mortality, while intermediate-DBH white firs and small-DBH incense-cedars exhibited recent mortality rates slightly greater than 20% (Figure 2). Around one quarter of recent tree deaths were due to bark beetle attacks, with fir engraver and mountain pine beetles responsible for the greatest percentage of attacks (Table 2). 30% of lethal beetle attacks were new in 2017, although the percentage of 2017 attacks was considerably higher for western pine beetle at 57% (Table 3). Total fuel loading was very high (Table 4); the largest contributions came from duff and 1000-hour fuels. The regeneration layer was dominated by white fir and incense-cedar stems (Figures 3 and 4).

Table 1. Site characteristics for the ecological reserve areas at Blodgett (BF-ER). Density, basal area, and dominance values were calculated from live and recently dead overstory trees (trees ≥ 4 in DBH) only. Recently dead trees were defined as having a decay class of 1, corresponding to the least advanced level of decay. Live trees represented far more density and basal than dead trees on average. The two most dominant tree species are shown (see Figure 2 for species codes), along with their corresponding percent dominance.

Number of Plots (n)	Elevation (ft)	Slope (%)	Mean Density ± SE (trees ac^{-1})		Mean Basal Area ± SE (ft^2 ac^{-1})		Dominance (%)
			Live	Dead	Live	Dead	
22	4209-4406	4-38	181.1 ± 22.8	18.6 ± 6.1	431.7 ± 56.6	23.5 ± 7.8	PIPO (27%); CADE (22%)

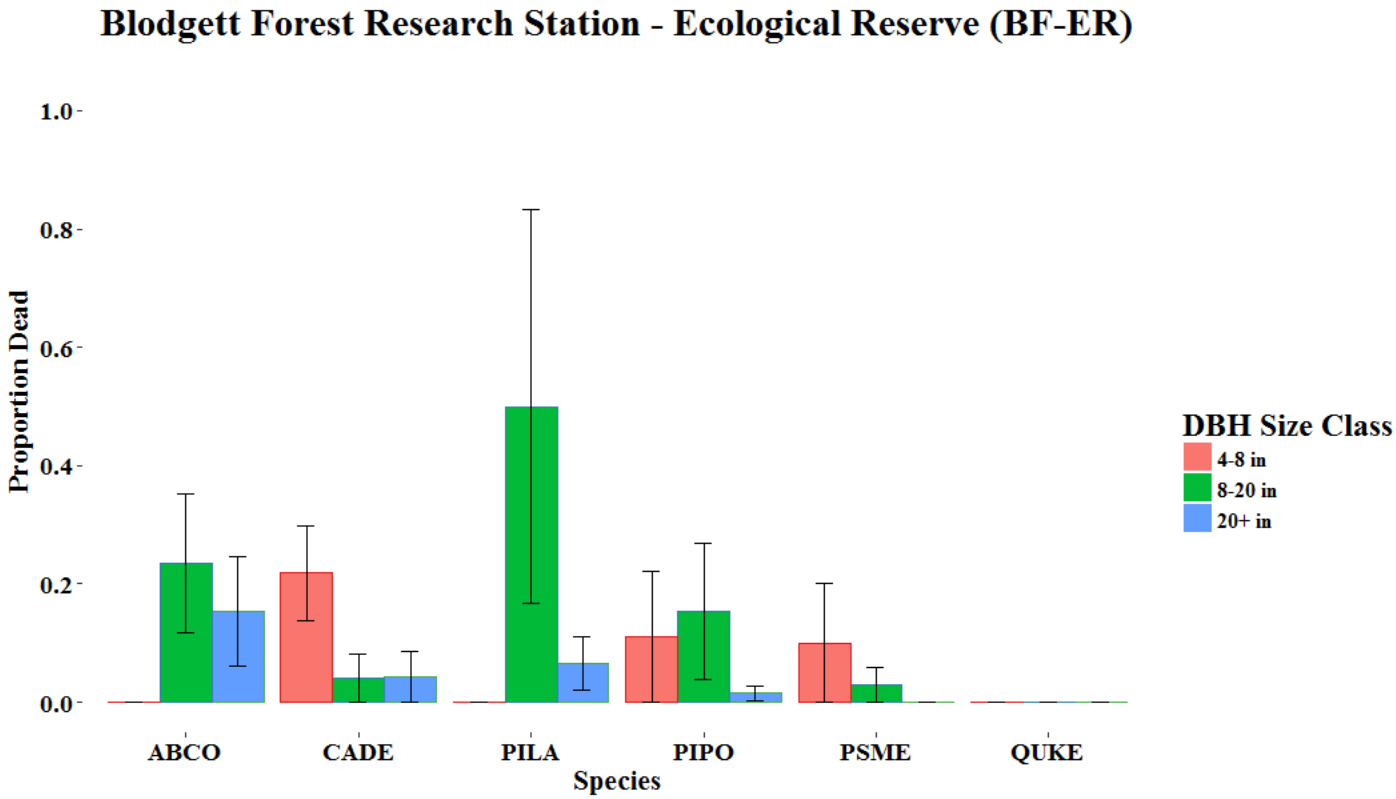


Figure 2. Proportion of recently dead trees by species and DBH size class for major species at BF-ER. ABCO = white fir (*Abies concolor*); CADE = incense-cedar (*Calocedrus decurrens*); PILA = sugar pine (*P. lambertiana*); PIPO = ponderosa pine (*P. ponderosa*); PSME = Douglas-fir (*Pseudotsuga menziesii*); QUKE = black oak (*Quercus kelloggii*). Bars represent 95% confidence intervals.

Table 2. Percentage of recently dead trees lethally attacked by each beetle type, and percentage of recently dead trees lethally attacked by any beetle type. FEB = fir engraver beetles (*Scolytus* spp.); MPB = mountain pine beetle (*Dendroctonus ponderosae*); WPB = western pine beetle (*D. brevicomis*). Both old and current mass attacks were defined as lethal, but partial attacks were excluded from this category.

All	FEB	MPB	WPB
Percentage ± SE	Percentage ± SE	Percentage ± SE	Percentage ± SE
26.4% ± 6.1%	11.3% ± 4.4%	9.4% ± 4.0%	5.7% ± 3.2%

Table 3. Percentage of lethally attacked trees (live and recently dead) that exhibited evidence of "new" beetle activity in 2017. New activity was represented by current mass attacks only; current partial attacks were excluded. Note: Trees were considered live if they had any green foliage.

All	FEB	MPB	WPB
Percentage ± SE	Percentage ± SE	Percentage ± SE	Percentage ± SE
30.0% ± 10.2%	25.0% ± 15.3%	0% ± 0%	57.1% ± 18.7%

Table 4. Fuel loads by fuel component for BF-ER. Duff accounted for the greatest portion of the total fuel load on average, followed closely by 1000-hour fuels.

Fuel Component	Mean ± SE (tons ac^{-1})	Range (tons ac^{-1})
Litter	13.7 ± 1.4	2.3-27.9
Duff	45.5 ± 5.1	2.1-96.1
1-hour	0.3 ± 0	0-0.6
10-hour	1.5 ± 0.1	0.3-2.9
100-hour	2.8 ± 0.4	0-7.8
1-100-hour	4.5 ± 0.5	0.4-10.5
1000-hour	38.4 ± 17.5	2.5-378.0
Total	102.1 ± 21.7	16.3-516.2

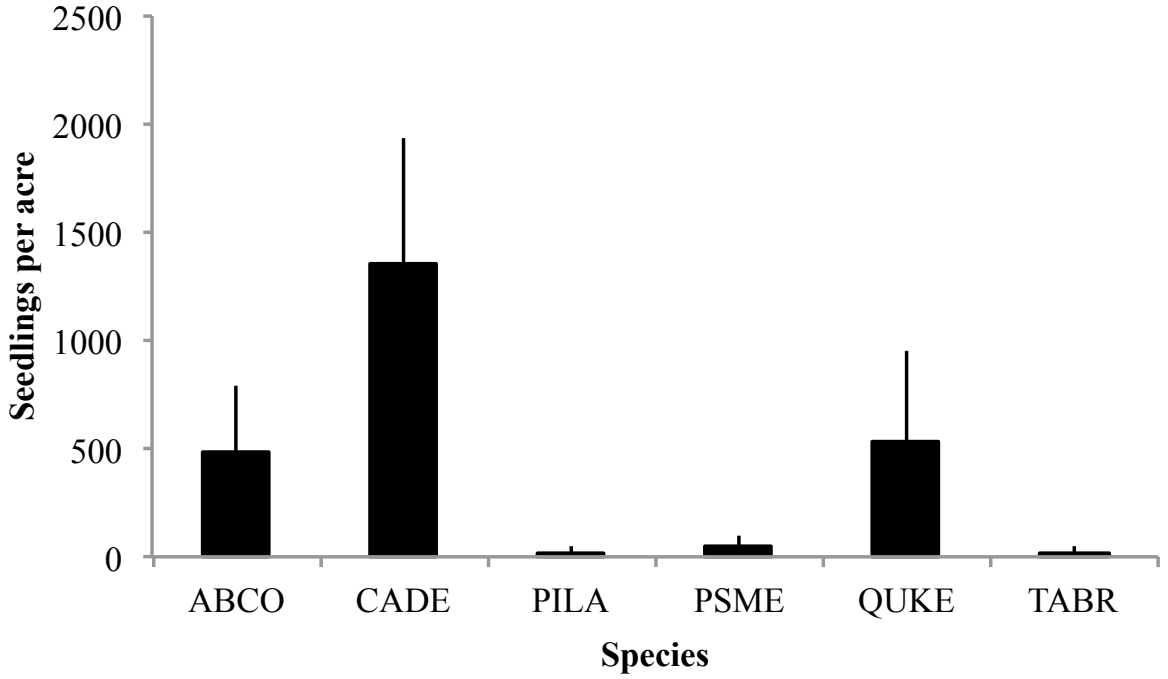


Figure 3. Density of seedlings (stems < 4.5 ft height) across all species at BF-ER. First year germinants were excluded from the data. Bars represent standard error.

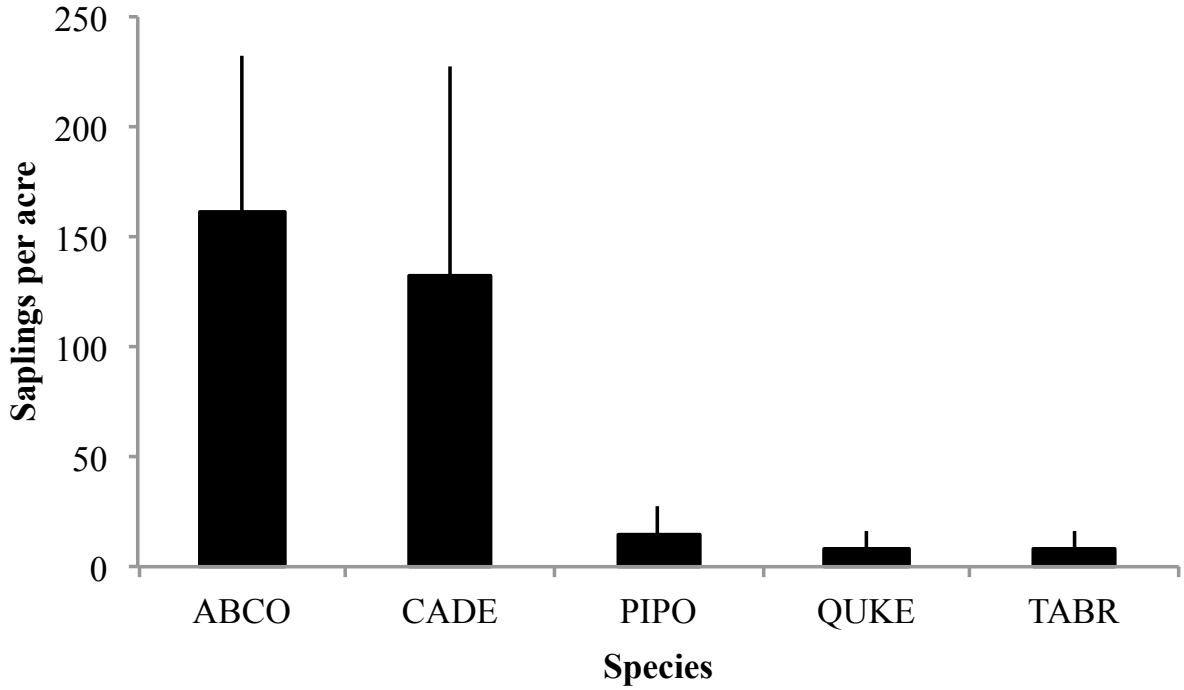


Figure 4. Density of saplings (stems ≥ 4.5 ft height; < 4 in DBH) at BF-ER. Bars represent standard error.

2017 UCB Drought Mortality Survey: Burton Creek State Park Initial Summary

Site Description

The Burton Creek State Park (BRTN) site is located 2.5 mi from Tahoe City along the northwest shore of Lake Tahoe in Placer County, CA. The 690-ac study site has been managed by California State Parks since 1978. Mean elevation is 6630 ft. Average annual temperature is 43 °F (January 31 °F, July: 60 °F) and average annual precipitation is 46 in. The site is dominated by white fir, Jeffrey pine, and red fir. Prescribed burning and understory thinning have been the primary management tools used on the site since 1978.

Key Results

Across the site, live trees greatly outweighed dead trees in terms of density and basal area, and live-to-dead density and basal area ratios were similar in magnitude (Table 1). Recent mortality was greatest for red firs at around 20-30%, with roughly 10% mortality for white firs in all DBH classes and Jeffrey pines in the intermediate class (Figure 2); no recently dead incense-cedars, sugar pines, or ponderosa pines were observed. 60% of recent deaths occurred due to beetle attacks, with the majority of these attacks carried out by fir engraver beetles (Table 2). Slightly more than half of all lethal beetle attacks were new in 2017, and fir engraver beetles had the highest percentage of new attacks among the beetle types recorded (Table 3). Total fuel loading was moderately high, and the two largest contributions to the total came from duff and 1000-hour fuels, respectively (Table 4). Seedlings were dominated by red fir and white fir (Figure 3), while saplings were dominated by white fir (Figure 4).

Table 1. Site characteristics for the site at Burton Creek SP (BRTN). Density, basal area, and dominance values were calculated from live and recently dead overstory trees (trees ≥ 4 in DBH) only. Recently dead trees were defined as having a decay class of 1, corresponding to the least advanced level of decay. Live trees represented far more basal area and density than dead trees on average. The two most dominant tree species are shown (see Figure 2 for species codes), along with their corresponding percent dominance.

Number of Plots (n)	Elevation (ft)	Slope (%)	Mean Density ± SE (trees ac^{-1})		Mean Basal Area ± SE (ft^2 ac^{-1})		Dominance (%)
			Live	Dead	Live	Dead	
36	6375-6742	0-59	136.3 ± 25.1	10.4 ± 5.9	193.4 ± 21.3	13.1 ± 7.0	ABCO (54%); PIJE (35%)

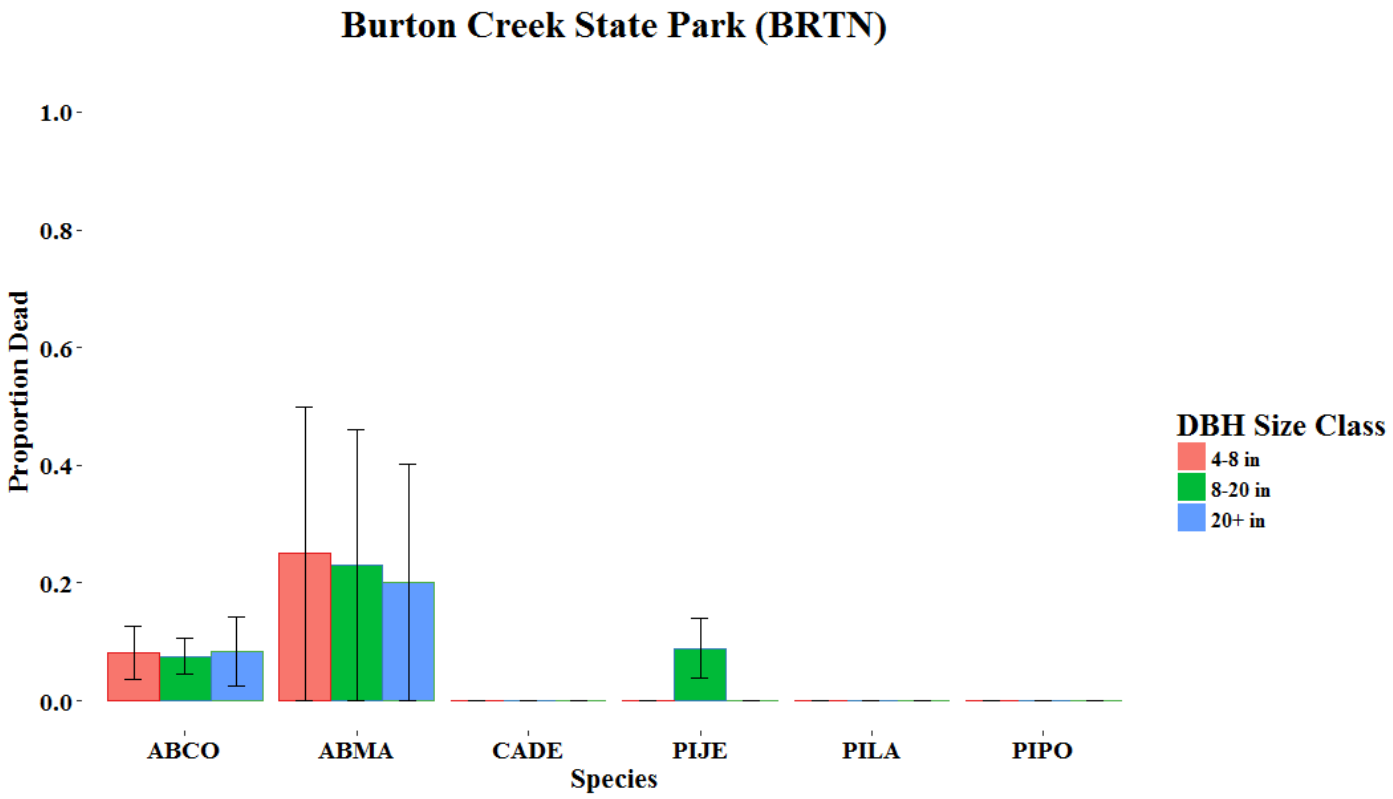


Figure 2. Proportion of recently dead trees by species and DBH size class for major species at BRTN. ABCO = white fir (*Abies concolor*); ABMA = red fir (*A. magnifica*); CADE = incense-cedar (*Calocedrus decurrens*); PIJE = Jeffrey pine (*Pinus jeffreyi*); PILA = sugar pine (*P. lambertiana*); PIPO = ponderosa pine (*P. ponderosa*). Bars represent 95% confidence intervals.

Table 2. Percentage of recently dead trees lethally attacked by each beetle type, and percentage of rec dead trees lethally attacked by any beetle type. FEB = fir engraver beetles (*Scolytus* spp.); MPB = mount beetle (*Dendroctonus ponderosae*); WPB = western pine beetle (*D. brevicomis*); JPB = Jeffrey pine beetle (*jeffreyi*). Both old and current mass attacks were defined as lethal, but partial attacks were excluded from this category.

All	FEB	MPB	WPB	JPB
Percentage ± SE	Percentage ± SE	Percentage ± SE	Percentage ± SE	Percentage ± SE
60.4% ± 7.1%	45.8% ± 7.2%	0 ± 0	0 ± 0	14.6% ± 5.1%

Table 3. Percentage of lethally attacked trees (live and recently dead) that exhibited evidence of "new" beetle activity in 2017. New activity was represented by current mass attacks only; current partial attacks were excluded. Note: Trees were considered live if they had any green foliage. No MPB or WPB attacks (new or old) were observed.

All	FEB	MPB	WPB	JPB
Percentage ± SE	Percentage ± SE	Percentage ± SE	Percentage ± SE	Percentage ± SE
52.5% ± 6.5%	57.1% ± 7.1%	NA	NA	30.0% ± 14.5%

Table 4. Fuel loads by fuel component for BRTN. Duff accounted for the greatest portion of the total fuel load on average. 1000-hour fuels also represented a large portion of the total fuel load.

Fuel Component	Mean ± SE (tons ac^{-1})	Range (tons ac^{-1})
Litter	6.5 ± 0.4	1.0-13.4
Duff	24.2 ± 2.6	0-72.4
1-hour	0.2 ± 0	0-1.3
10-hour	1.3 ± 0.2	0-4.4
100-hour	1.3 ± 0.3	0-5.7
1-100-hour	2.8 ± 0.3	0-8.4
1000-hour	14.7 ± 2.7	0-97.7
Total	48.2 ± 4.7	1.0-142.4

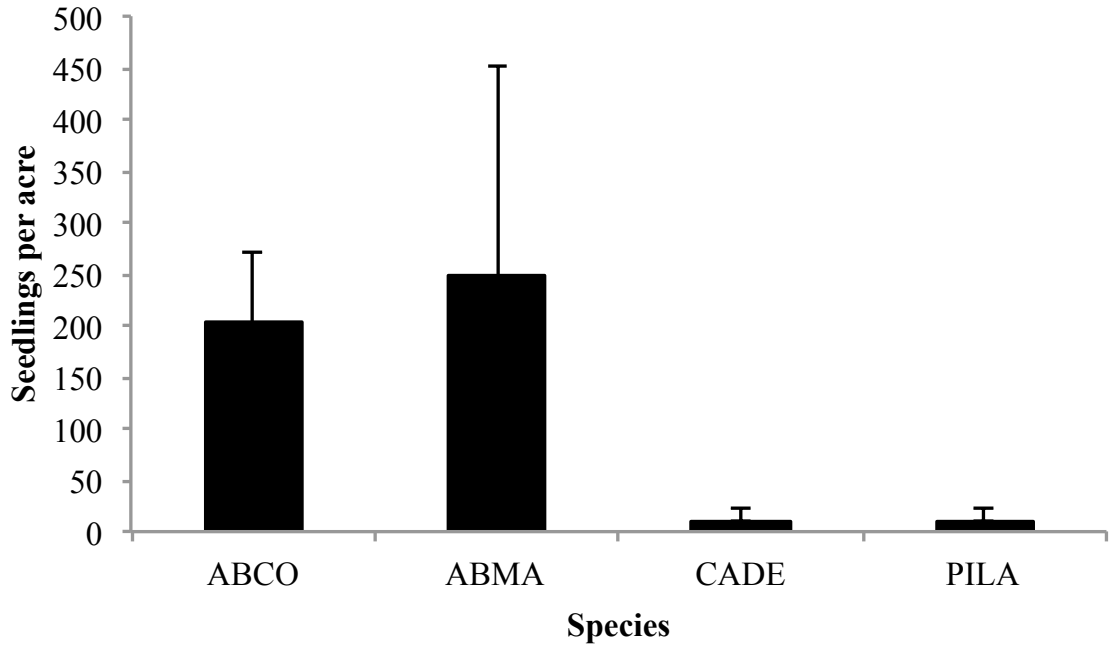


Figure 3. Density of seedlings (stems <4.5 ft height) across all species at BRTN. First year germinants were excluded from the data. Bars represent standard error.

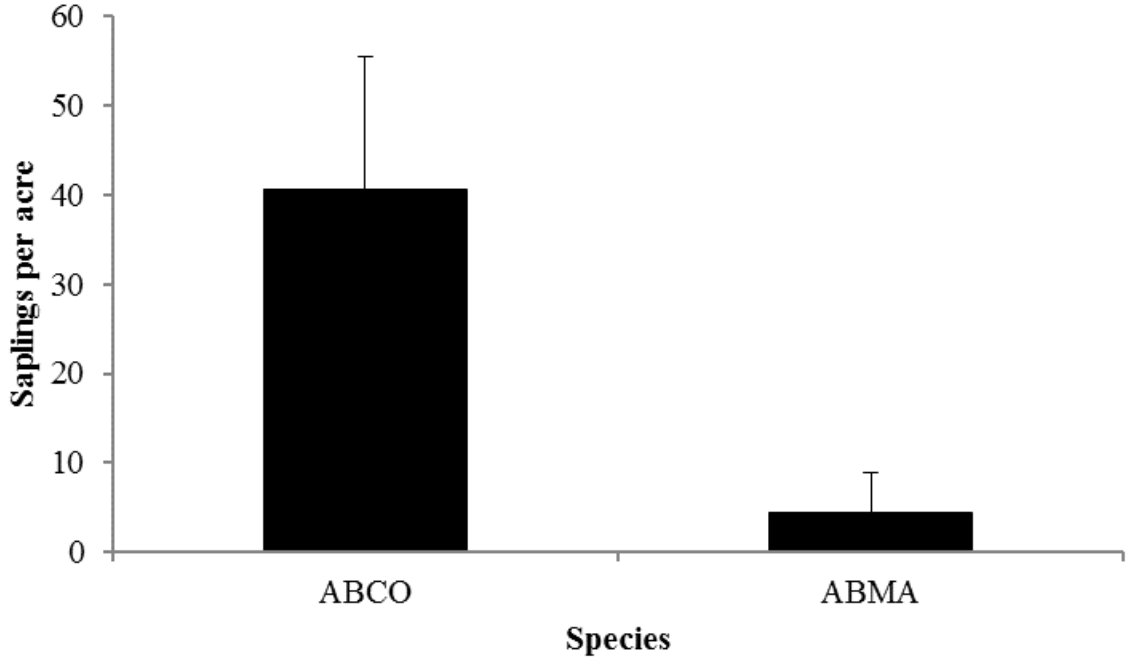


Figure 4. Density of saplings (stems ≥ 4.5 ft height; < 4 in DBH) at BRTN. Bars represent standard error.

2017 UCB Drought Mortality Survey: Cottonwood Gulch (Stanislaus National Forest) Initial Summary

Site Description

The Cottonwood Gulch (CGH) site is located within the Stanislaus National Forest approximately 6 mi east of Bear Valley in Calaveras County, CA. The 667-ac study area is managed by the Stanislaus National Forest and has not experienced any recent timber harvests. Mean elevation is 7110 ft. Average annual temperature is 51 °F (January: 38 °F; July: 68 °F) and average annual precipitation is 51 in. White fir, red fir, and Jeffrey pine dominate the site.

Key Results

Across Cottonwood Gulch, live trees represented roughly 15 times as much density and 17 times as much basal area as dead trees (Table 1). Sugar pines in the intermediate DBH class suffered the highest rate of recent mortality, but only three trees were observed in this category. Of the groups with many observations, red firs in the small and large DBH classes exhibited the highest proportion of recently dead trees at around 15%, but overall mortality was low (Figure 2). Roughly three quarters of recent tree deaths were due to beetle attacks, most of which were attributable to fir engraver beetles (Table 2). Just over one quarter of all recorded beetle attacks were new in 2017, and the percentage of new fir engraver attacks was slightly higher than the percentage of new attacks for all species combined (Table 3). Total fuel loading was very high and was dominated by contributions from 1000-hour fuels (Table 4). White fir was the most common species in the regeneration layer, and relatively few pine seedlings and saplings were present (Figures 3 and 4).

Table 1. Site characteristics for the Cottonwood Gulch site in Stanislaus National Forest (CGH). Density, basal area, and dominance values were calculated from live and recently dead overstory trees (trees ≥ 4 in DBH) only. Recently dead trees were defined as having a decay class of 1, corresponding to the least advanced level of decay. Live trees represented far more basal area and density than dead trees on average. The two most dominant tree species are shown (see Figure 2 for species codes), along with their corresponding percent dominance.

Number of Plots (n)	Elevation (ft)	Slope (%)	Mean Density ± SE (trees ac^{-1})		Mean Basal Area ± SE (ft^2 ac^{-1})		Dominance (%)
			Live	Dead	Live	Dead	
36	6634-7552	4-36	162.1 ± 20.6	11.1 ± 3.6	312.8 ± 43.6	17.9 ± 9.6	ABCO (47%); ABMA (42%)

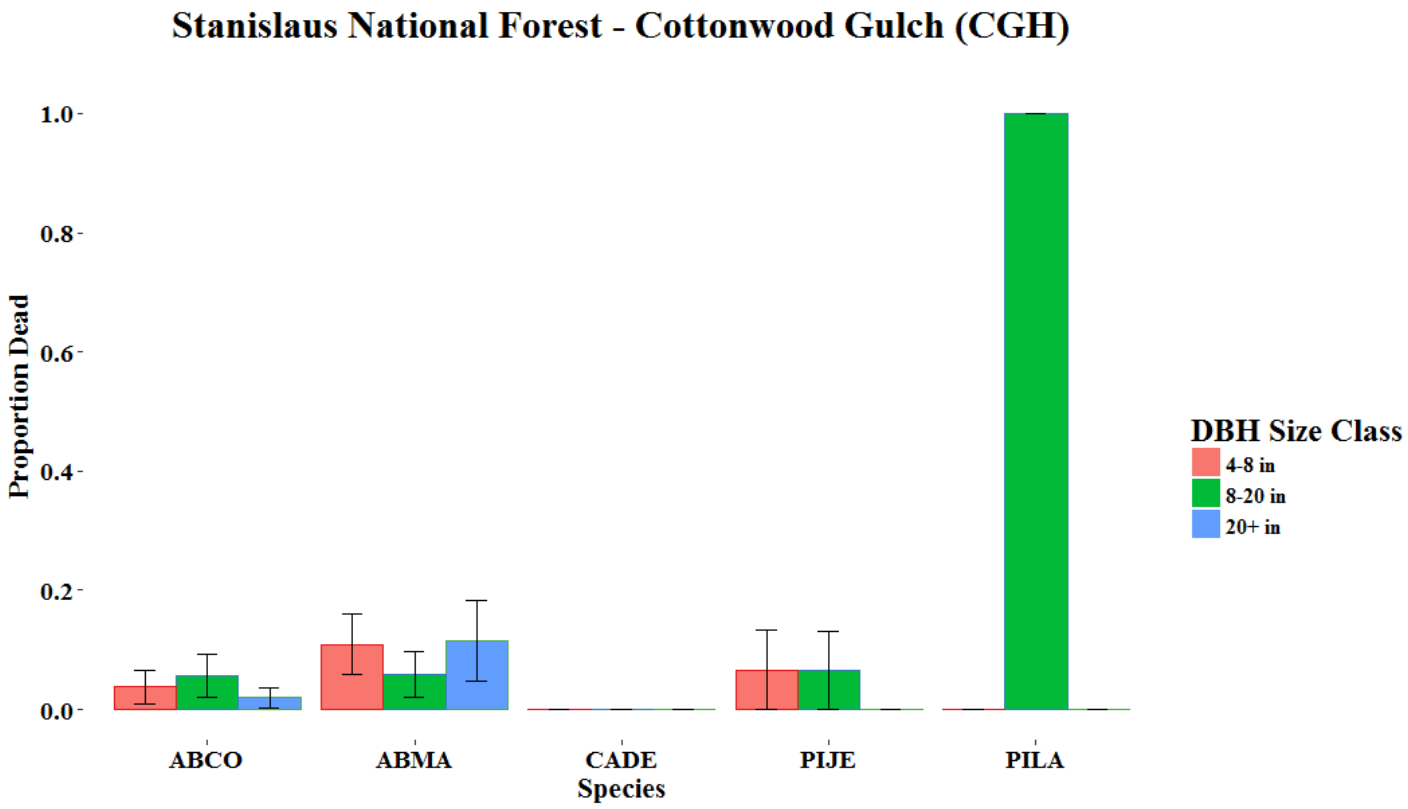


Figure 2. Proportion of recently dead trees by species and DBH size class for major species at CGH. ABCO = white fir (*Abies concolor*); ABMA = red fir (*A. magnifica*); CADE = incense-cedar (*Calocedrus decurrens*); PIJE = Jeffrey pine (*Pinus jeffreyi*); PILA = sugar pine (*P. lambertiana*). Bars represent 95% confidence intervals. Note: The only three PILA stems in the intermediate DBH class were dead, but no other PILA mortality was observed.

Table 2. Percentage of recently dead trees lethally attacked by each beetle type, and percentage of recently dead trees lethally attacked by any beetle type. FEB = fir engraver beetles (*Scolytus* spp.); MPB = mountain pine beetle (*Dendroctonus ponderosae*); WPB = western pine beetle (*D. brevicomis*); JPB = Jeffrey pine beetle (*D. jeffreyi*). Both old and current mass attacks were defined as lethal, but partial attacks were excluded from this category.

All	FEB	MPB	WPB	JPB
Percentage ± SE	Percentage ± SE	Percentage ± SE	Percentage ± SE	Percentage ± SE
74.5% ± 6.1%	62.7% ± 6.8%	5.9% ± 3.3%	0% ± 0%	5.9% ± 3.3%

Table 3. Percentage of lethally attacked trees (live and recently dead) that exhibited evidence of "new" beetle activity in 2017. New activity was represented by current mass attacks only; current partial attacks were excluded. Note: Trees were considered live if they had any green foliage. No WPB attacks (new or old) were observed.

All	FEB	MPB	WPB	JPB
Percentage ± SE	Percentage ± SE	Percentage ± SE	Percentage ± SE	Percentage ± SE
26.3% ± 5.8%	29.4% ± 6.4%	0% ± 0%	NA	0% ± 0%

Table 4. Fuel loads by fuel component for CGH. 1000-hour fuels accounted for the bulk of the total fuel load on average. Duff also represented a moderate portion of the total fuel load.

Fuel Component	Mean ± SE (tons ac^{-1})	Range (tons ac^{-1})
Litter	6.9 ± 0.6	0-16.3
Duff	22.9 ± 2.1	0-57.5
1-hour	0.7 ± 0.1	0-1.8
10-hour	2.0 ± 0.2	0-4.9
100-hour	3.0 ± 0.5	0-10.7
1-100-hour	5.7 ± 0.6	0-17.7
1000-hour	107.3 ± 43.6	0-1554.6
Total	142.8 ± 43.8	0-1582.7

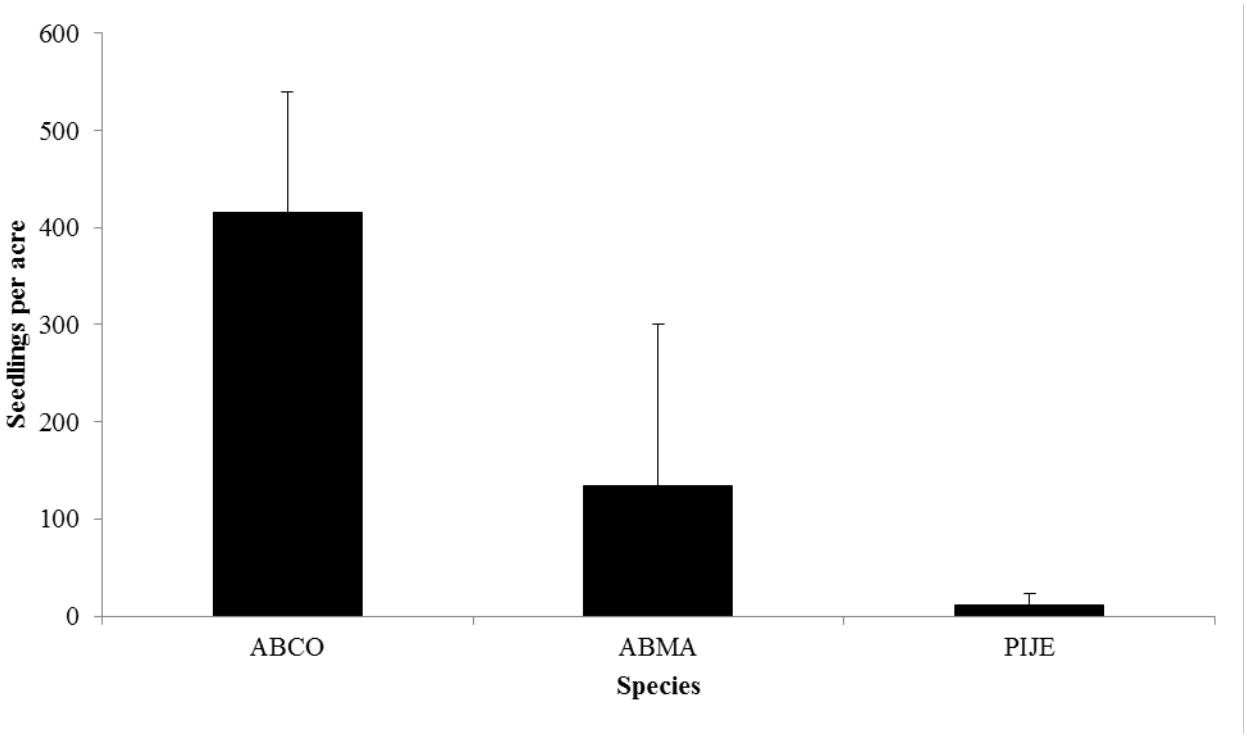


Figure 3. Density of seedlings (stems < 4.5 ft height) across all species at CGH. First year germinants were excluded from the data. Bars represent standard error.

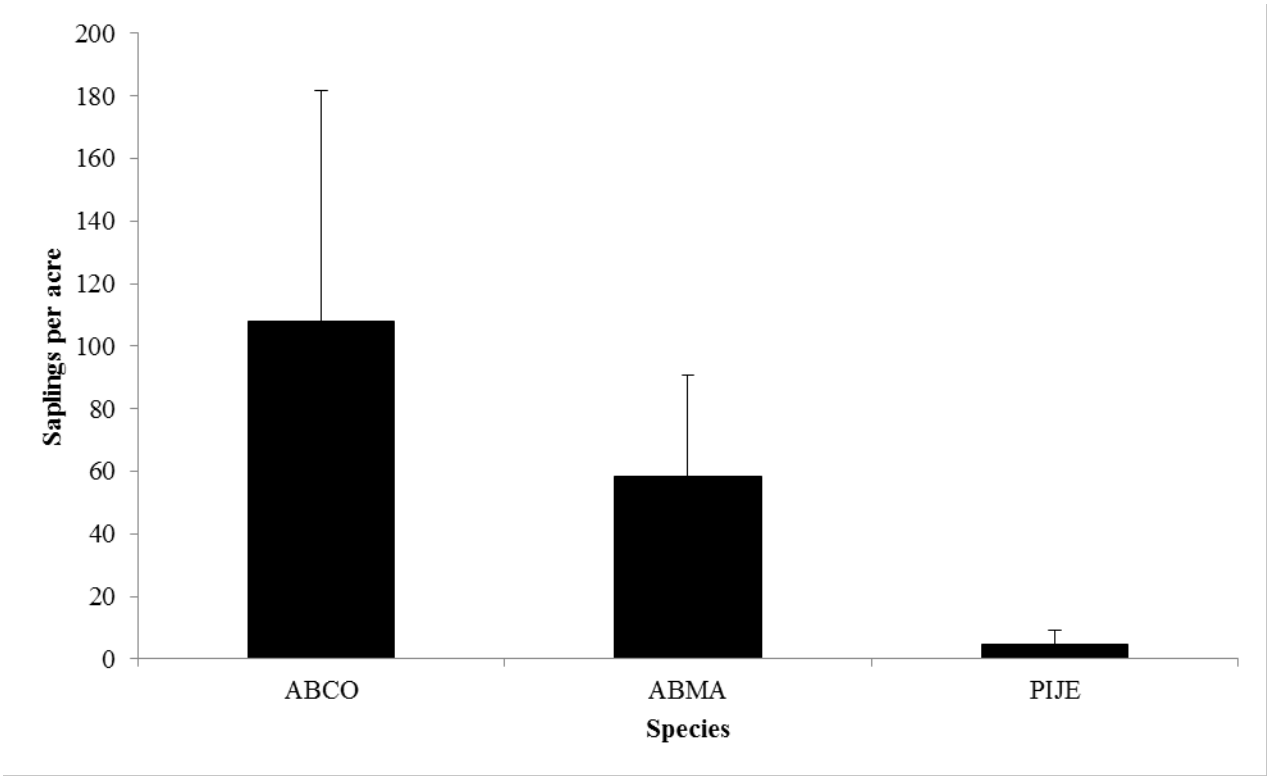


Figure 4. Density of saplings (stems ≥ 4.5 ft height; < 4 in DBH) at CGH. Bars represent standard error.

2017 UCB Drought Mortality Survey: Yosemite Mixed-Conifer Initial Summary

Site Description

The Yosemite Mixed-Conifer (YOMI) site is situated near the Hodgdon Meadow campground at the Big Oak Flat Entrance station in Tuolumne County, CA. The 642-ac study site is managed by the National Park Service. Mean elevation is 4665 ft. Average annual temperature for the site is 52° F (January: 39 °F; July: 68 °F) and average annual precipitation is 39 in. The site is dominated by white fir, incense-cedar, and sugar pine. No recent timber harvests have been conducted at the site. However, prescribed fire was utilized across the study area in 2011 and 2012, which may influence mortality patterns and current understory conditions. The fire footprint is likely responsible for low number of saplings and very high seedling density.

Key Results

Across the site, live trees represented roughly twice as much basal area as dead trees; however, the difference in mean density between live and dead trees was less pronounced (Table 1), which suggests that dead trees tended to be smaller than live trees on average. White firs in the small DBH class exhibited the greatest rates of recent mortality at around 70%, followed closely by intermediate white firs, small incense-cedars, and large ponderosa pines (Figure 2). Bark beetle attacks accounted for roughly one third of recent tree deaths, with fir engraver beetles responsible for the majority of recent beetle-caused mortality (Table 2). About 5.5% of all beetle attacks were new in 2017 (Table 3). Total fuel loading was high, primarily due to large contributions from 1000-hour fuels (Table 4). The regeneration layer was dominated by white fir and, to a lesser extent, incense-cedar (Figures 3 and 4). Overall seedling density was very high, and sapling density was low.

Table 1. Site characteristics for the mixed-conifer site near Hodgdon Meadow, Yosemite NP (YOMI). Density, basal area, and dominance values were calculated from live and recently dead overstory trees (trees $\geq$ 4 in DBH) only. Recently dead trees were defined as having a decay class of 1, corresponding to the least advanced level of decay. Live trees represented roughly twice as much basal area as dead trees on average, although the density of live trees was only 36.5% greater than that of dead trees. The two most dominant tree species are shown (see Figure 2 for species codes), along with their corresponding percent dominance.

Number of Plots (n)	Elevation (ft)	Slope (%)	Mean Density ± SE (trees ac^{-1})		Mean Basal Area ± SE (ft^2 ac^{-1})		Dominance (%)
			Live	Dead	Live	Dead	
37	4383-4948	6-66	81.5 ± 7.0	59.7 ± 7.2	223.0 ± 25.7	114.1 ± 21.8	CADE (25%); ABCO (20%)

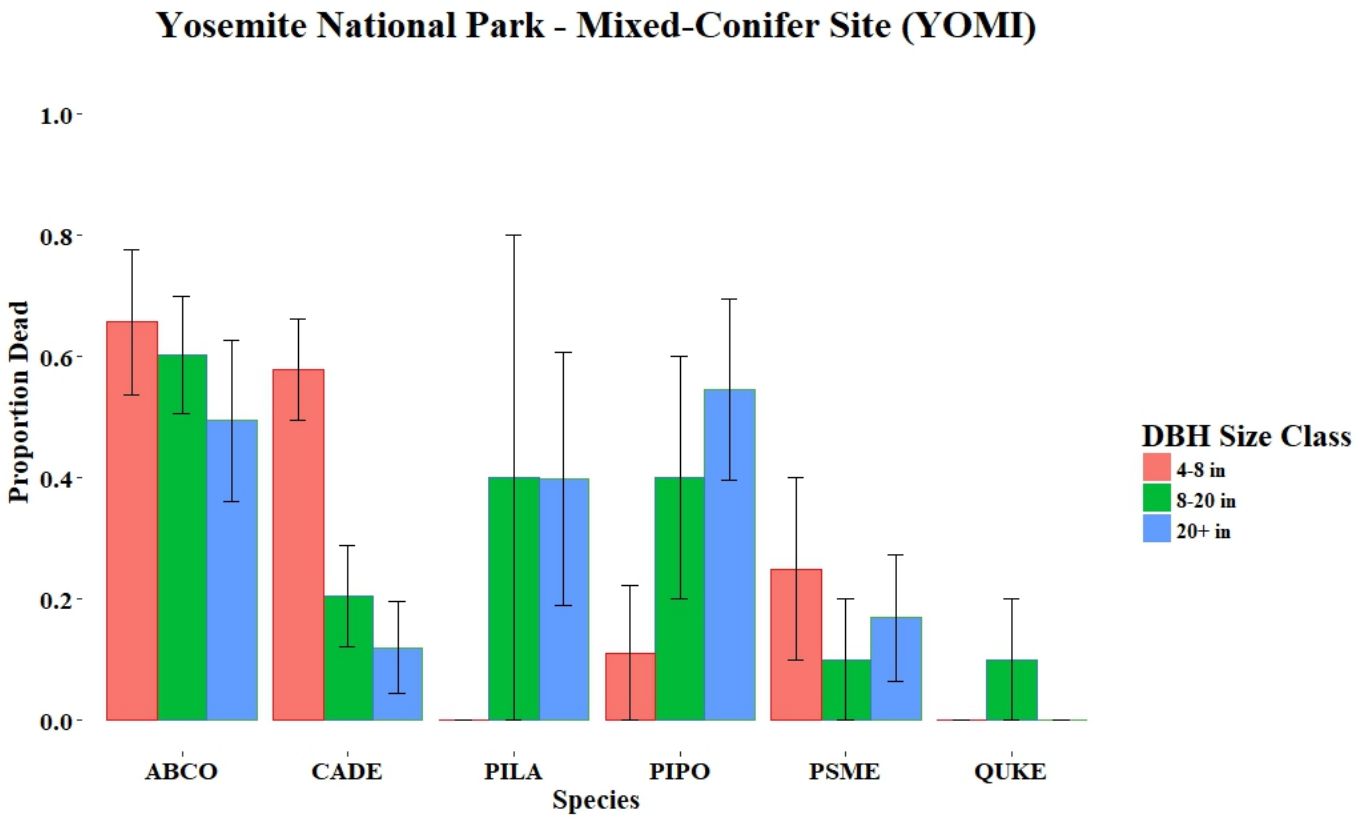


Figure 2. Proportion of recently dead trees by species and DBH size class for major species at YOMI. ABCO = white fir (*Abies concolor*); CADE = incense-cedar (*Calocedrus decurrens*); PILA = sugar pine (*Pinus lambertiana*); PIPO = ponderosa pine (*P. ponderosa*); PSME = Douglas-fir (*Pseudotsuga menziesii*); QUKE = black oak (*Quercus kelloggii*). Bars represent 95% confidence intervals.

Table 2. Percentage of recently dead trees (decay class = 1) lethally attacked by each beetle type, and percentage of recently dead trees lethally attacked by any beetle type. FEB = fir engraver beetles (*Scolytus* spp.); MPB = mountain pine beetle (*Dendroctonus ponderosae*); WPB = western pine beetle (*D. brevicomis*). Both old and current mass attacks were defined as lethal, but partial attacks were excluded from this category.

All	FEB	MPB	WPB
Percentage ± SE	Percentage ± SE	Percentage ± SE	Percentage ± SE
37.2% ± 2.9%	23.9% ± 2.5%	3.5% ± 1.1%	9.8% ± 1.8%

Table 3. Percentage of lethally attacked trees (live and recently dead) that exhibited evidence of "new" beetle activity in 2017. New activity was represented by current mass attacks only; current partial attacks were excluded. Note: Trees were considered live if they had any green foliage.

All	FEB	MPB	WPB
Percentage ± SE	Percentage ± SE	Percentage ± SE	Percentage ± SE
5.5% ± 2.2%	4.2% ± 2.4%	9.1% ± 8.7%	7.1% ± 4.9%

Table 4. Fuel loads by fuel component for YOMI. 1000-hour fuels represented most of the total fuel load across the site. Litter and duff also accounted for substantial portions of the total fuel load.

Fuel Component	Mean ± SE (tons ac^{-1})	Range (tons ac^{-1})
Litter	10.1 ± 0.8	2.7-21.8
Duff	12.3 ± 1.2	0-28.1
1-hour	0.6 ± 0.1	0-1.4
10-hour	1.8 ± 0.2	0.1-4.8
100-hour	2 ± 0.3	0-5.7
1-100-hour	4.4 ± 0.4	0.3-11.5
1000-hour	44.3 ± 10	0-282.5
Total	71.2 ± 10.7	10.7-325.6

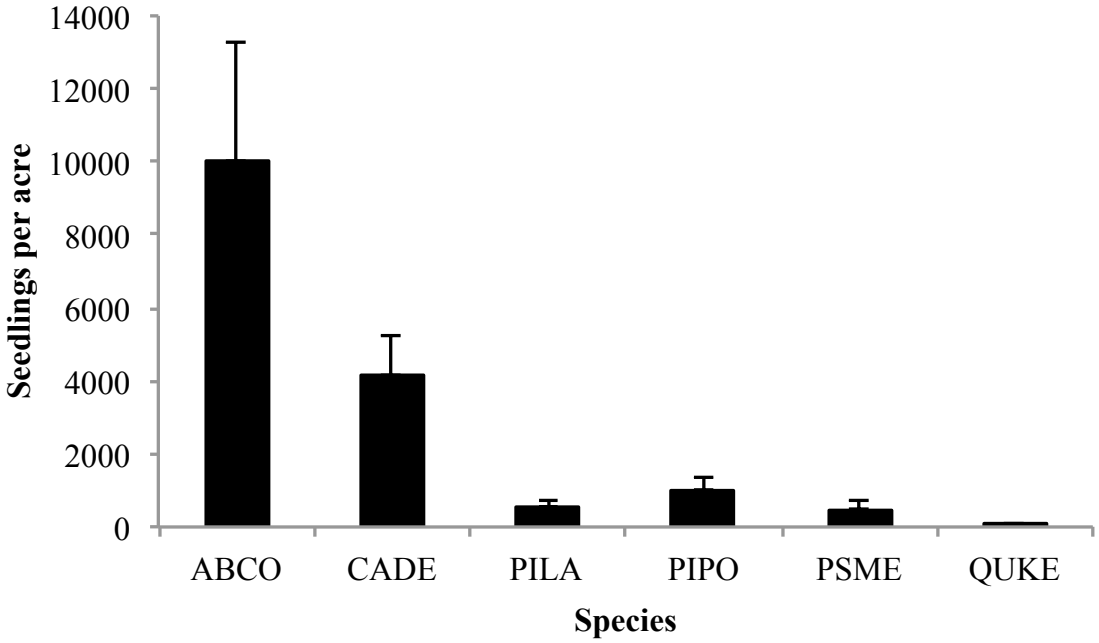


Figure 3. Density of seedlings (stems <4.5 ft height) across all species at YOMI. First year germinants were excluded from the data. Bars represent standard error.

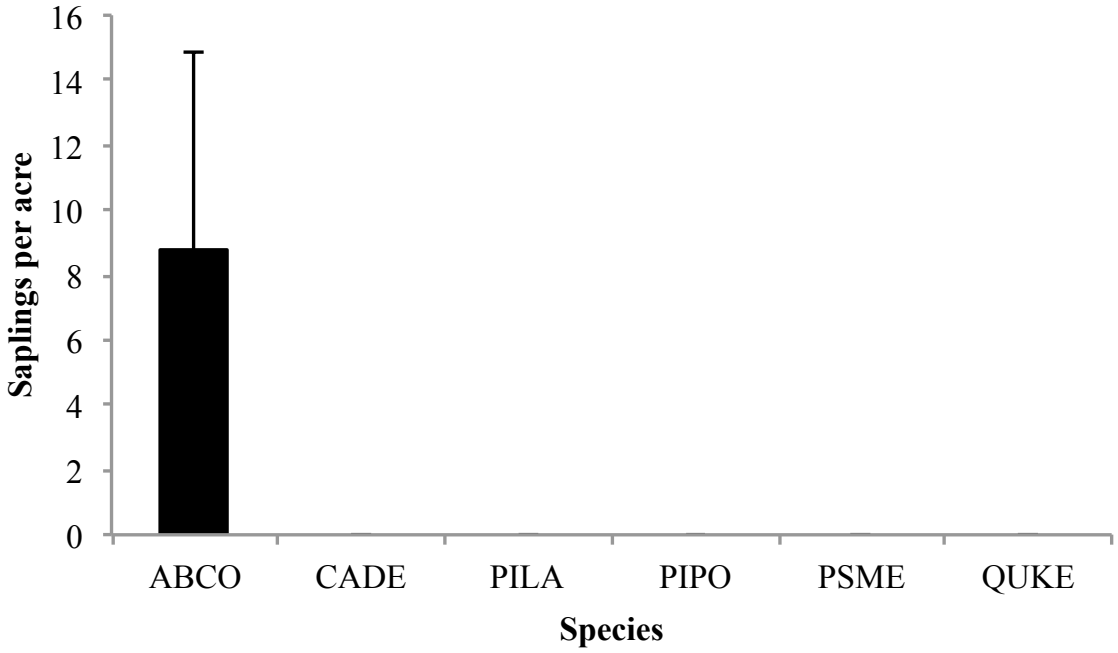


Figure 4. Density of saplings (stems ≥ 4.5 ft height; < 4 in DBH) at YOMI. Note: Only 2 saplings were measured across the entire site in only two plots. Bars represent standard error.

2017 UCB Drought Mortality Survey: Yosemite Pine Initial Summary

Site Description

The Yosemite Pine (YOPI) site is located along Wawona Rd. 7 mi from the southern entrance to Yosemite National Park in Mariposa County, CA. The site spans 981 ac and is managed by the National Park Service. Mean elevation within the site is 5650 ft. Average annual temperature is 50 °F (January: 37 °F; July: 66 °F) and average annual precipitation is 41 in. Ponderosa pine and incense-cedar dominate the site. No recent timber harvests or fires have affected the study site.

Key Results

Across the site, live and recently dead trees represented similar amounts of basal area, but density of live trees exceeded that of recently dead trees by 71% (Table 1). This suggests a disproportionately high die-off of larger-diameter trees. Ponderosa pines in the intermediate DBH class and white firs in the large DBH class experienced the greatest rates of recent mortality at around 75%, while sugar pines experienced similar rates of recent mortality across all DBH classes (Figure 2). Bark beetle attacks accounted for roughly two thirds of recent mortality, with western pine beetle responsible for almost half of all recent tree deaths (Table 2). Around 8% of all beetle attacks were new in 2017, and western pine beetle exhibited a greater percentage of 2017 attacks than other beetles (Table 3). Total fuel loading was high, with the duff layer making the largest contribution; 1000-hour fuels and litter also accounted for substantial portions of this total (Table 4). The regeneration layer was dominated by white fir and incense-cedar. Relatively few pine seedlings and saplings were present (Figures 3 and 4).

Table 1. Site characteristics for the pine site near Wawona, Yosemite NP (YOPI). Density, basal area, and dominance values were calculated from live and recently dead overstory trees (trees $\geq$ 4 in DBH) only. Recently dead trees were defined as having a decay class of 1, corresponding to the least advanced level of decay. Live trees represented only slightly more basal area than dead trees on average, although the density of live trees was 71% greater than that of dead trees. The two most dominant tree species are shown (see Figure 2 for species codes), along with their corresponding percent dominance.

Number of Plots (n)	Elevation (ft)	Slope (%)	Mean Density ± SE (trees ac^{-1})		Mean Basal Area ± SE (ft^2 ac^{-1})		Dominance (%)
			Live	Dead	Live	Dead	
35	5118-6243	6-72	142.3 ± 13.3	83.2 ± 12.9	172.5 ± 27.9	140.3 ± 23.5	PIPO (55%); CADE (28%)

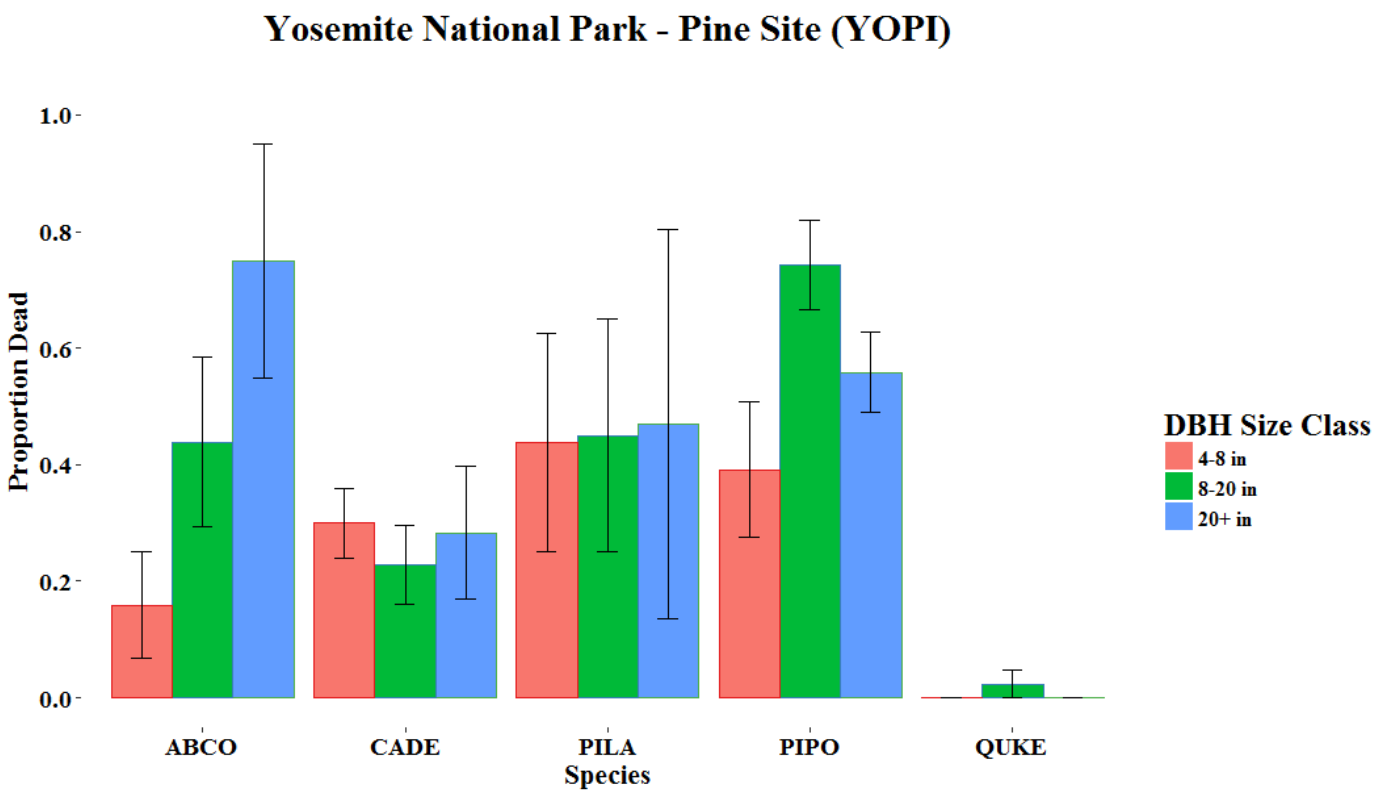


Figure 2. Proportion of recently dead trees by species and DBH size class for major species at YOPI. ABCO = white fir (*Abies concolor*); CADE = incense-cedar (*Calocedrus decurrens*); PILA = sugar pine (*Pinus lambertiana*); PIPO = ponderosa pine (*P. ponderosa*); QUKE = black oak (*Quercus kelloggii*). Bars represent 95% confidence intervals.

Table 2. Percentage of recently dead trees lethally attacked by each beetle type, and percentage of recently dead trees lethally attacked by any beetle type. FEB = fir engraver beetles (*Scolytus* spp.); MPB = mountain pine beetle (*Dendroctonus ponderosae*); WPB = western pine beetle (*D. brevicomis*). Both old and current mass attacks were defined as lethal, but partial attacks were excluded from this category.

All	FEB	MPB	WPB
Percentage ± SE	Percentage ± SE	Percentage ± SE	Percentage ± SE
61.8% ± 2.5%	7.1% ± 1.3%	7.9% ± 1.4%	46.9% ± 2.6%

Table 3. Percentage of lethally attacked trees (live and recently dead) that exhibited evidence of "new" beetle activity in 2017. New activity was represented by current mass attacks only; current partial attacks were excluded. Note: Trees were considered live if they had any green foliage.

All	FEB	MPB	WPB
Percentage ± SE	Percentage ± SE	Percentage ± SE	Percentage ± SE
8.2% ± 1.8%	6.7% ± 4.6%	3.2% ± 3.2%	9.3% ± 2.1%

Table 4. Fuel loads by fuel component for YOPI. Duff accounted for the greatest portion of the total fuel load on average. 1000-hour fuels and litter also represented large portions of the total fuel load.

Fuel Component	Mean ± SE (tons ac^{-1})	Range (tons ac^{-1})
Litter	15.6 ± 1.3	1.9-32.0
Duff	24.6 ± 3.3	0-83.1
1-hour	0.2 ± 0	0-0.5
10-hour	1.2 ± 0.1	0-3.8
100-hour	1.9 ± 0.3	0-7.9
1-100-hour	3.3 ± 0.4	0.1-10.8
1000-hour	18.8 ± 3.5	0-79.3
Total	62.3 ± 6.0	6.9-153.2

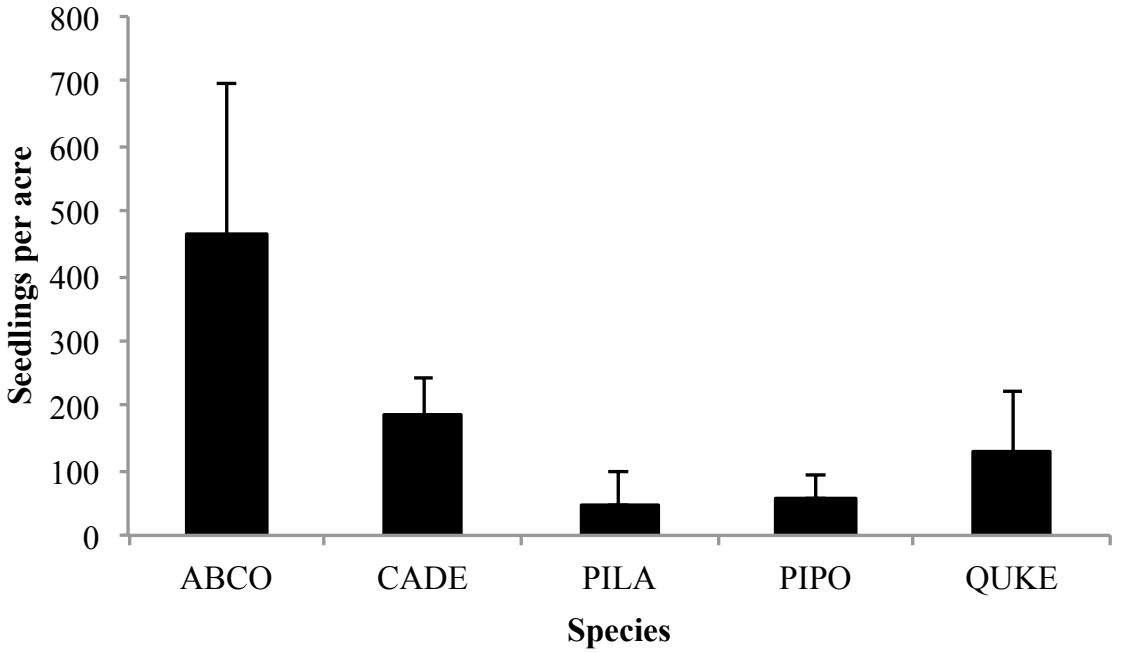


Figure 3. Density of seedlings (stems < 4.5 ft height) across all species at YOPI. First year germinants were excluded from the data. Bars represent standard error.

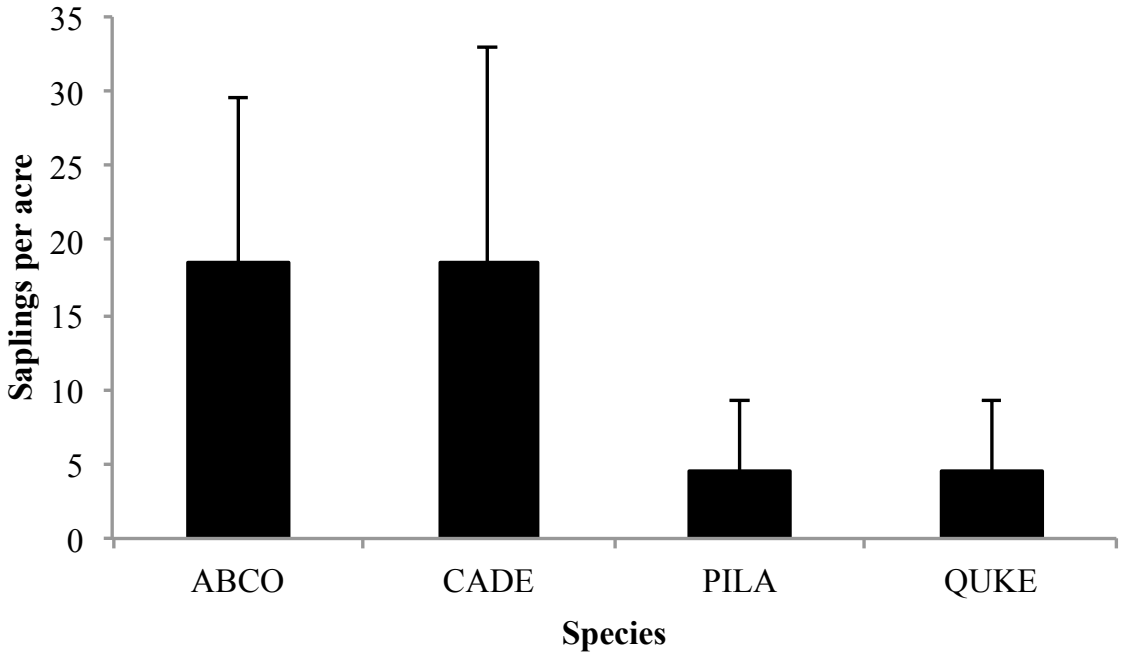


Figure 4. Density of saplings (stems ≥ 4.5 ft height; < 4 in DBH) at YOPI. Bars represent standard error.

2017 UCB Drought Mortality Survey: Sequoia-Kings Canyon National Parks Crystal Cave Initial Summary

Site Description

The Sequoia-Kings Canyon National Parks (SEKI) site is located in the Crystal Cave area of Sequoia National Park in Tulare County, CA. The 420-ac study area is managed by the National Park Service and has not experienced recent timber harvests. Mean elevation is 5535 ft. Average annual temperature is 45 °F (January: 32 °F; July: 63 °F) and average annual precipitation is 45 in. White fir and incense-cedar dominate the site. Although situated near old giant sequoia groves, no giant sequoia were documented within the study area.

Key Results

Across the site, live trees represented about twice as much basal area as dead trees, although the density of live trees was more than double that of dead trees (Table 1). This implies a greater die-off of larger-diameter trees. Pines in the intermediate and large DBH classes experienced the greatest rates of recent mortality, and white firs in the small DBH class had a greater rate of recent mortality than those in the larger DBH classes (Figure 2). Bark beetle attacks accounted for almost half of recent tree mortality, with around 25% of recent tree deaths attributable to attack by fir engraver beetles (Table 2). 18% of all beetle attacks were new in 2017, though the percentage of new fir engraver beetle attacks was even higher at almost 28% (Table 3). Total fuel loading was high, with duff and 1000-hour fuels making the largest contributions to the total load (Table 4). The regeneration layer was dominated by incense-cedar seedlings and saplings, but black oak seedlings were also abundant (Figures 3 and 4).

Table 1. Site characteristics for the site in the Crystal Cave area of Sequoia-Kings Canyon NP (SEKI). Density, basal area, and dominance values were calculated from live and recently dead overstory trees (trees ≥ 4 in DBH) only. Recently dead trees were defined as having a decay class of 1, corresponding to the least advanced level of decay. Live trees represented roughly twice as much basal area as dead trees on average, although the mean density of live trees was more than double that of dead trees. The two most dominant tree species are shown (see Figure 2 for species codes), along with their corresponding percent dominance.

Number of Plots (n)	Elevation (ft)	Slope (%)	Mean Density ± SE (trees ac^{-1})		Mean Basal Area ± SE (ft^2 ac^{-1})		Dominance (%)
			Live	Dead	Live	Dead	
29	5184-5961	19-102	126.5 ± 13.5	49.3 ± 9.0	182.5 ± 20.9	93.2 ± 14.4	ABCO (32%); CADE (26%)

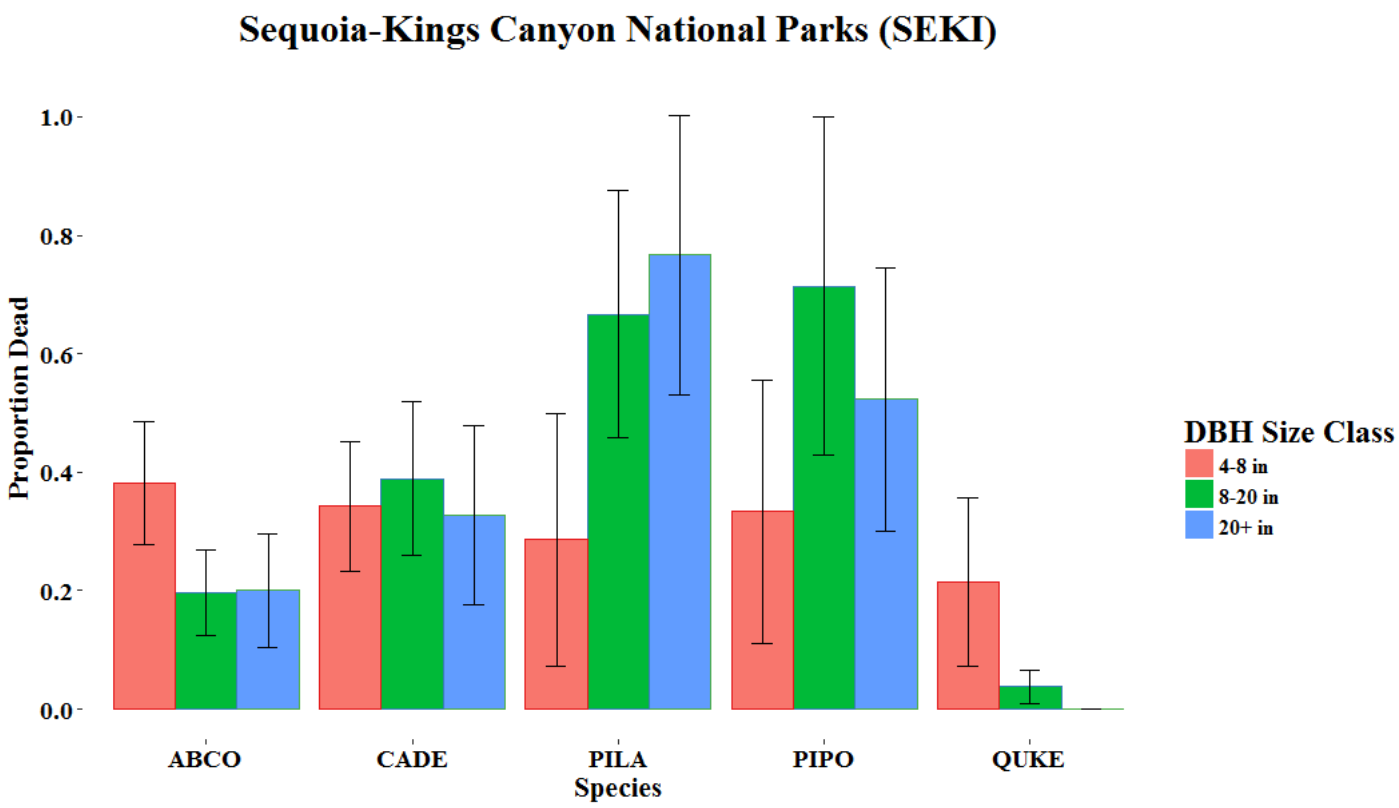


Figure 2. Proportion of recently dead trees by species and DBH size class for major species at SEKI. ABCO = white fir (*Abies concolor*); CADE = incense-cedar (*Calocedrus decurrens*); PILA = sugar pine (*Pinus lambertiana*); PIPO = ponderosa pine (*P. ponderosa*); QUKE = black oak (*Quercus kelloggii*). Bars represent 95% confidence intervals.

Table 2. Percentage of recently dead trees lethally attacked by each beetle type, and percentage of recently dead trees lethally attacked by any beetle type. FEB = fir engraver beetles (*Scolytus* spp.); MPB = mountain pine beetle (*Dendroctonus ponderosae*); WPB = western pine beetle (*D. brevicomis*). Both old and current mass attacks were defined as lethal, but partial attacks were excluded from this category.

All	FEB	MPB	WPB
Percentage ± SE	Percentage ± SE	Percentage ± SE	Percentage ± SE
46.5% ± 3.7%	25.4% ± 3.2%	15.1% ± 2.6%	5.9% ± 1.7%

Table 3. Percentage of lethally attacked trees (live and recently dead) that exhibited evidence of "new" beetle activity in 2017. New activity was represented by current mass attacks only; current partial attacks were excluded. Note: Trees were considered live if they had any green foliage.

All	FEB	MPB	WPB
Percentage ± SE	Percentage ± SE	Percentage ± SE	Percentage ± SE
18.1% ± 3.8%	27.7% ± 5.6%	3.4% ± 3.4%	0% ± 0%

Table 4. Fuel loads by fuel component for SEKI. Duff accounted for the greatest portion of the total fuel load on average. 1000-hour fuels and litter also represented large portions of the total fuel load.

Fuel Component	Mean ± SE (tons ac^{-1})	Range (tons ac^{-1})
Litter	10.7 ± 1.0	1.9-28.5
Duff	32.2 ± 2.7	0-63.4
1-hour	0.6 ± 0.1	0.1-2.1
10-hour	1.2 ± 0.2	0.2-4.6
100-hour	1.3 ± 0.2	0-4.5
1-100-hour	3.0 ± 0.4	0.4-11.2
1000-hour	23.6 ± 3.7	0-76.3
Total	69.5 ± 5.0	8.0-160.0

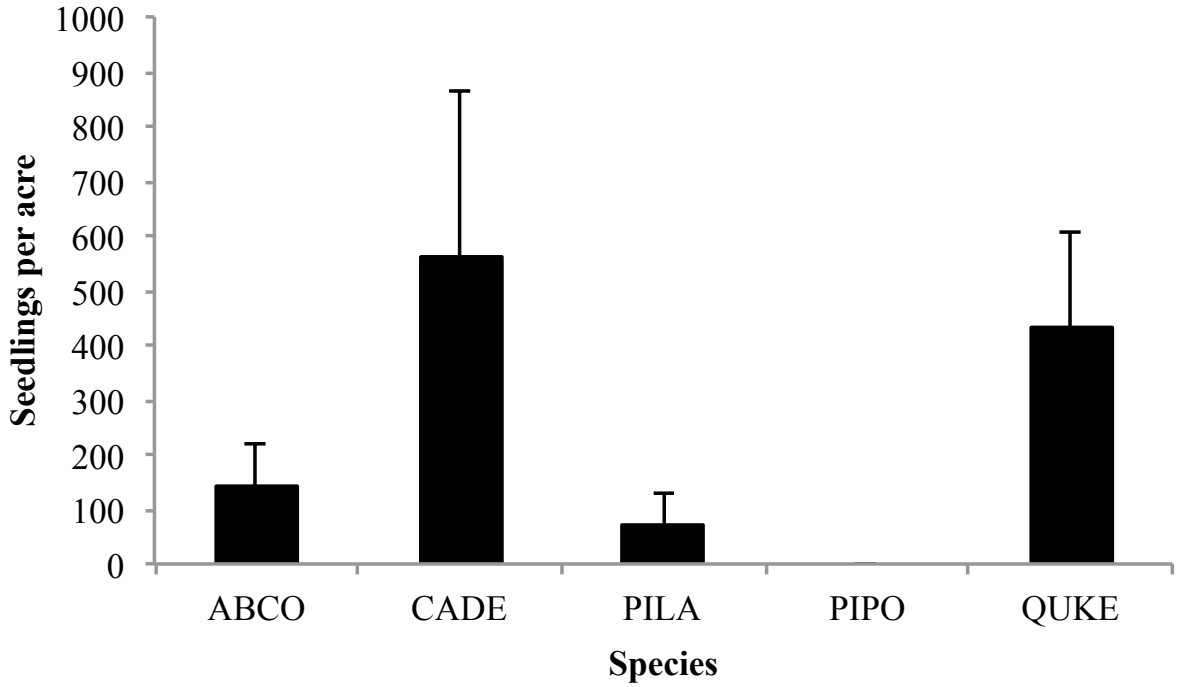


Figure 3. Density of seedlings (stems <4.5 ft height) across all species at SEKI. First year germinants were excluded from the data. Bars represent standard error.

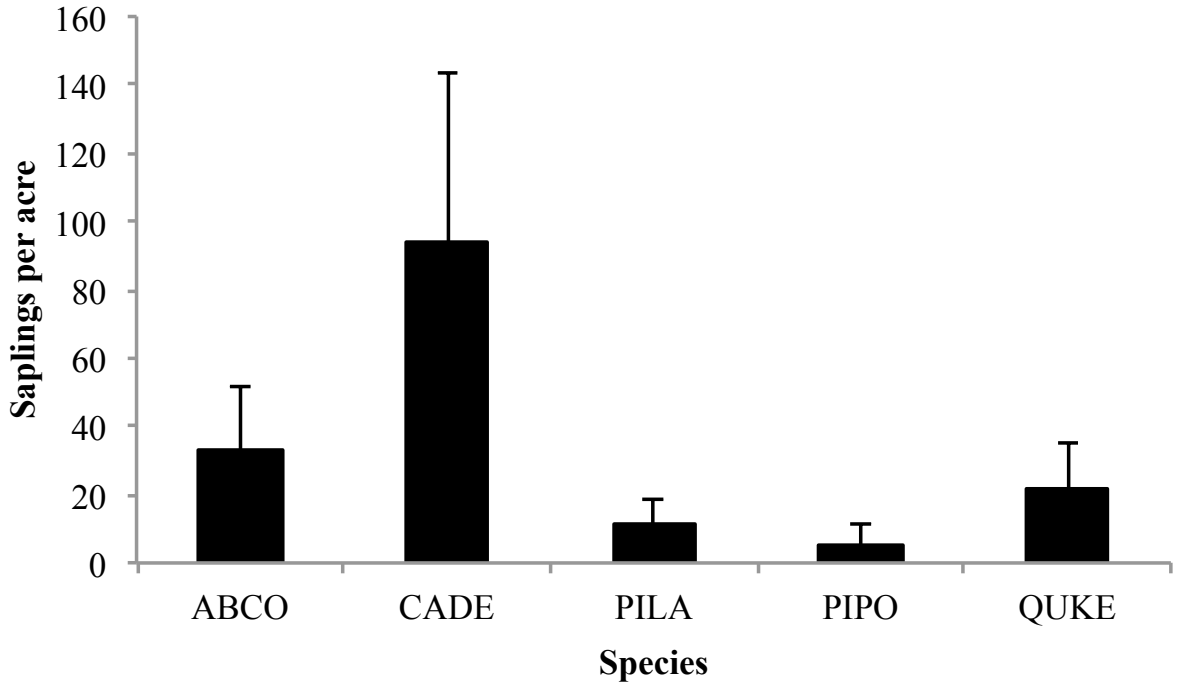


Figure 4. Density of saplings (stems ≥ 4.5 ft height; < 4 in DBH) at SEKI. Bars represent standard error.

2017 UCB Drought Mortality Survey: Mountain Home Demonstration State Forest Initial Summary

Site Description

The Mountain Home Demonstration State Forest (MTH) site is located 20 mi northeast of Springville in Tulare County, CA. The 716-ac study area is managed by the California Department of Forestry and Fire Protection. Mean elevation is 6407 ft. Average annual temperature is 48 °F (January: 35 °F; July: 64 °F) and average annual precipitation is 43 in. Giant sequoia, white firs, and incense-cedar dominate the site. The primary management objective of MTH is to promote development of giant sequoia stands. Management guidelines indicate protection for old-growth giant sequoia and management of young-growth giant sequoia to replace old-growth giant sequoia. Salvage logging, group selection harvests, and prescribed fire are options described in the management plan to meet these objectives within the study area.

Key Results

Across the site, live trees represented roughly nine times as much basal area but only five times as much density as dead trees (Table 1). This is likely due to the abundance of live, old-growth giant sequoia trees. Pines in the large and intermediate DBH classes experienced the greatest rates of recent mortality (Figure 2). More than half of the recent tree mortality was caused by bark beetles; fir engraver beetle attacks accounted for the largest portion of recent deaths, closely followed by mountain pine beetle attacks (Table 2). Slightly over one third of all beetle attacks and over half of fir engraver attacks were new in 2017 (Table 3). Total fuel loading was very high, with 1000-hour fuels contributing the most to this total (Table 4). Overall densities of seedlings and saplings were low within the study area (Figures 3 and 4).

Table 1. Site characteristics for the site at Mountain Home Demonstration State Forest (MTH). Density, basal area, and dominance values were calculated from live and recently dead overstory trees (trees ≥ 4 in DBH) only. Recently dead trees were defined as having a decay class of 1, corresponding to the least advanced level of decay. The two most dominant tree species are shown (see Figure 2 for species codes), along with their corresponding percent dominance.

Number of Plots (n)	Elevation (ft)	Slope (%)	Mean Density ± SE (trees ac^{-1})		Mean Basal Area ± SE (ft^2 ac^{-1})		Dominance (%)
			Live	Dead	Live	Dead	
36	6014-6716	5-70	95.7 ± 11.0	20.9 ± 5.7	434.3 ± 100.2	51.4 ± 17.9	SEGI (54%); ABCO (29%)

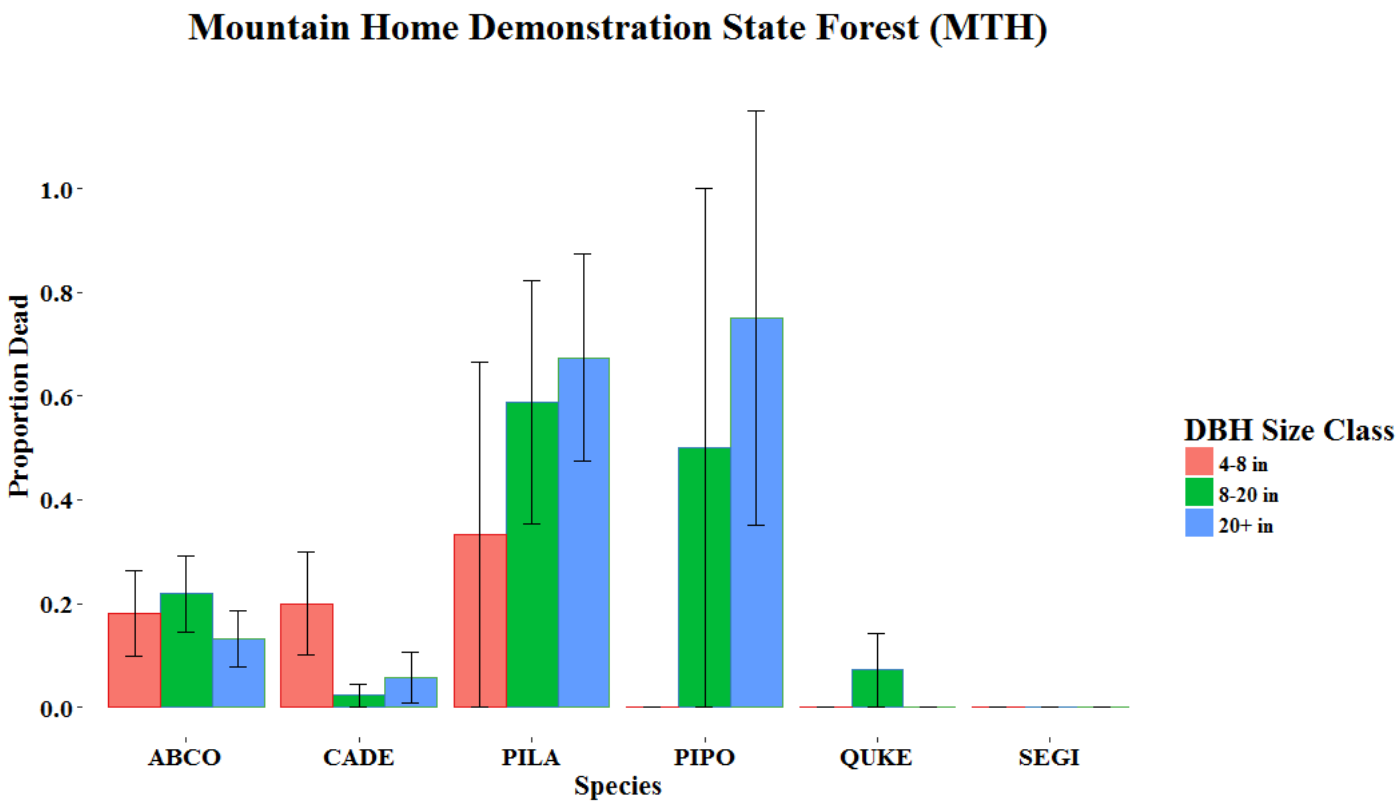


Figure 2. Proportion of recently dead trees by species and DBH size class for major species at MTH. ABCO = white fir (*Abies concolor*); CADE = incense-cedar (*Calocedrus decurrens*); PILA = sugar pine (*Pinus lambertiana*); PIPO = ponderosa pine (*P. ponderosa*); QUKE = black oak (*Quercus kelloggii*); SEGI = giant sequoia (*Sequoiadendron giganteum*). Bars represent 95% confidence intervals.

Table 2. Percentage of recently dead trees lethally attacked by each beetle type, and percentage of recently dead trees lethally attacked by any beetle type. FEB = fir engraver beetles (*Scolytus* spp.); MPB = mountain pine beetle (*Dendroctonus ponderosae*); WPB = western pine beetle (*D. brevicomis*). Both old and current mass attacks were defined as lethal, but partial attacks were excluded from this category.

All	FEB	MPB	WPB
Percentage ± SE	Percentage ± SE	Percentage ± SE	Percentage ± SE
59.6% ± 4.9%	29.3% ± 4.6%	25.3% ± 4.4%	5.1% ± 2.2%

Table 3. Percentage of lethally attacked trees (live and recently dead) that exhibited evidence of "new" beetle activity in 2017. New activity was represented by current mass attacks only; current partial attacks were excluded. Note: Trees were considered live if they had any green foliage.

All	FEB	MPB	WPB
Percentage ± SE	Percentage ± SE	Percentage ± SE	Percentage ± SE
37.2% ± 5.0%	54.0% ± 6.3%	3.8% ± 3.8%	0% ± 0%

Table 4. Fuel loads by fuel component for MTH. 1000-hour fuels accounted for the greatest portion of the total fuel load on average. Duff and litter also represented considerable portions of the total fuel load.

Fuel Component	Mean ± SE (tons ac^{-1})	Range (tons ac^{-1})
Litter	13.1 ± 0.8	4.5-25.0
Duff	33.0 ± 1.9	5.6-55.1
1-hour	0.6 ± 0.1	0-1.4
10-hour	1.9 ± 0.2	0.2-5.5
100-hour	2.4 ± 0.5	0-11.0
1-100-hour	4.9 ± 0.6	0.7-14.2
1000-hour	85.4 ± 47.5	0-1634.1
Total	136.4 ± 48.9	12.7-1719.0

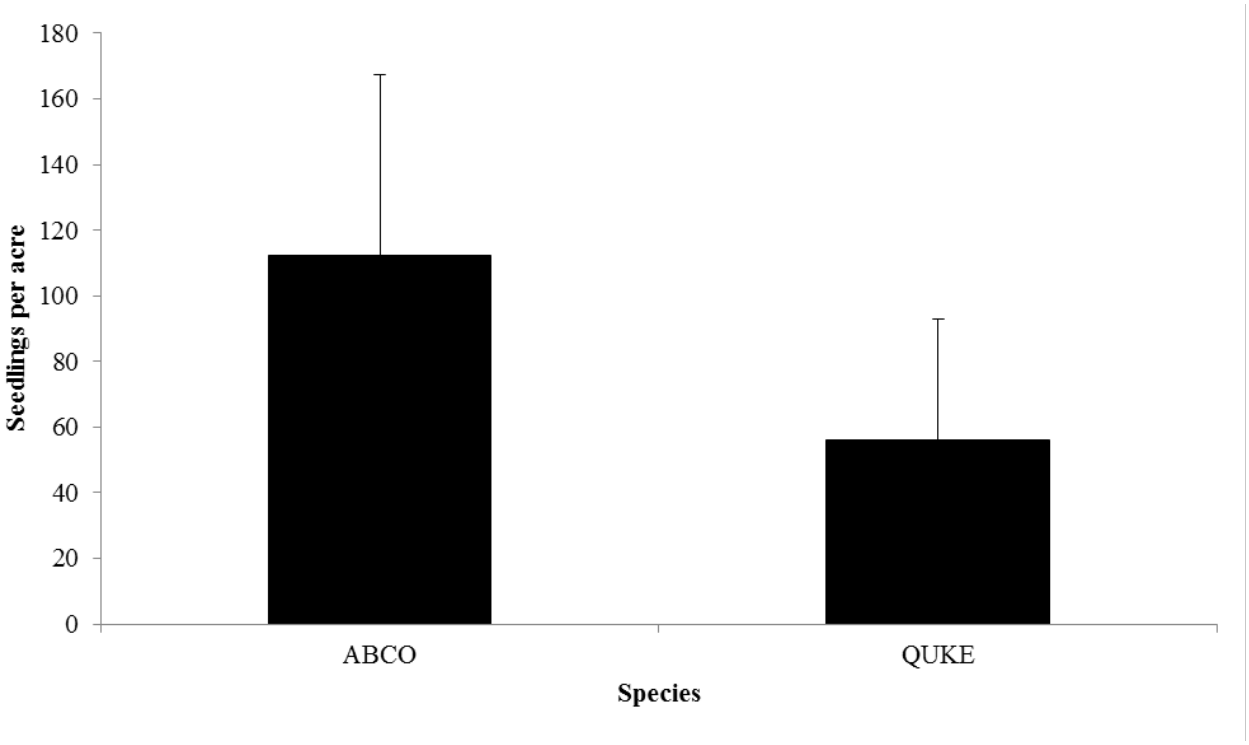


Figure 3. Density of seedlings (stems < 4.5 ft height) across all species at MTH. First year germinants were excluded from the data. Bars represent standard error.

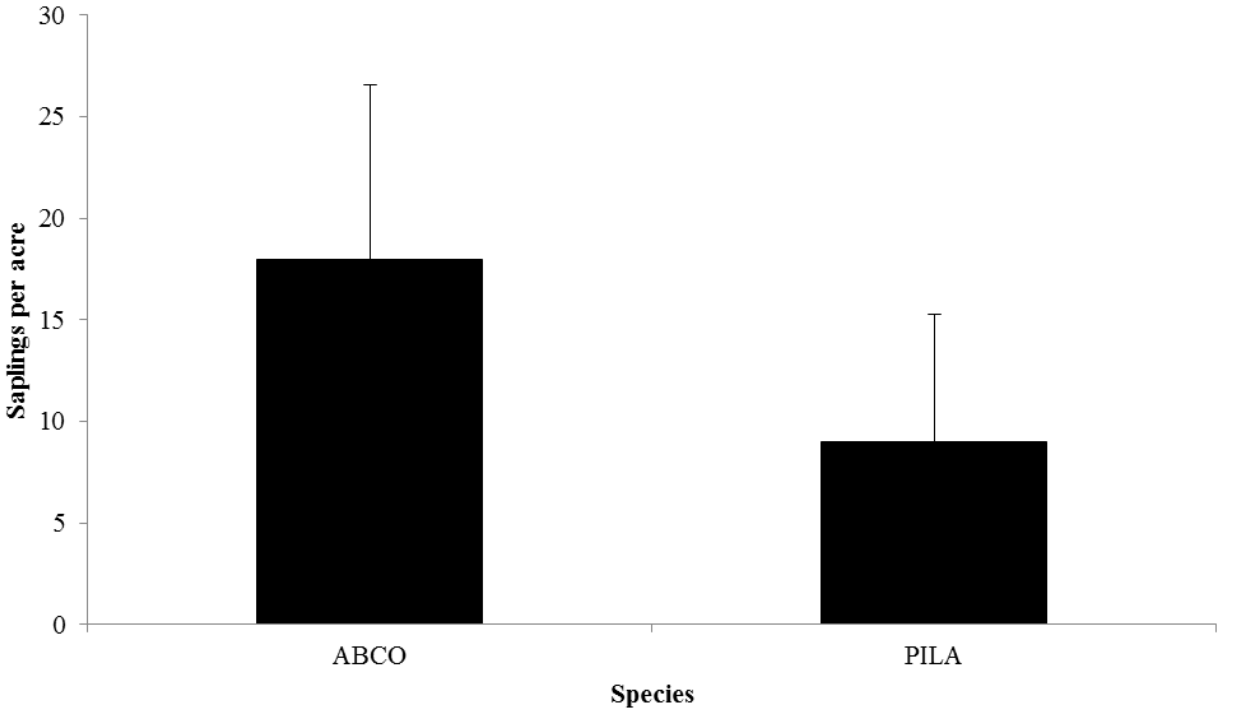


Figure 4. Density of saplings (stems ≥ 4.5 ft height; < 4 in DBH) at MTH. Bars represent standard error.

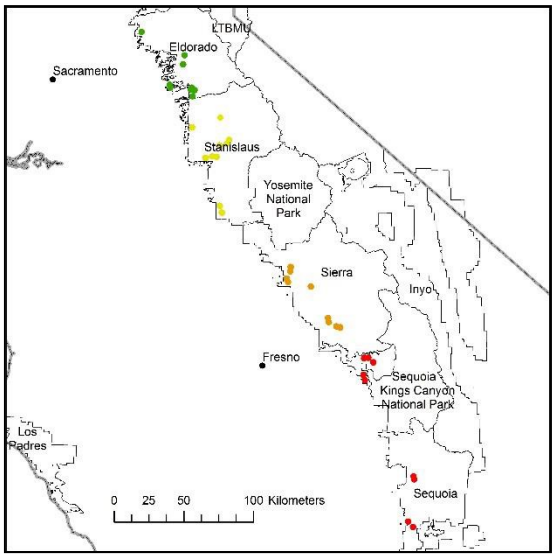
Tree Mortality in the Central and Southern Sierra Nevada:
Causes, Extent, Severity and Impact

Christopher J. Fettig
Research Entomologist and Team Leader
Pacific Southwest Research Station (PSW)
USDA Forest Service
1731 Research Park Drive
Davis, CA 95618
530-759-1708
cfettig@fs.fed.us

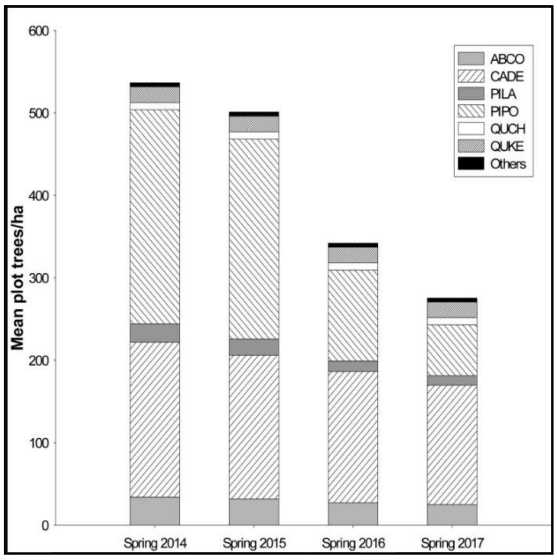
Leif A. Mortenson
Biological Science Technician
PSW
USDA Forest Service
2480 Carson Road
Placerville, CA 95667
530-295-3032
leifmortenson@fs.fed.us

Partners: Beverly Bulaon, Forest Health Protection (FHP); Patra Foulk, Eldorado National Forest; Ross Gerrard, PSW; Marc Meyer, Region 5; Danny Cluck, FHP; Justin Runyon, Rocky Mountain Research Station; Amarina Wuenschel, Region 5.

Methods: In brief, 180 11.3-m fixed-radius plots (15 plots/elevation band/forest) were installed on four national forests (below). Elevation bands ranged from 762-1218, 1219-1676, and 1677- 2134 m. Within each plot, all trees ≥6.35 cm diameter at breast height (dbh, 1.37 m) were tagged with the species, dbh, total height, height to the base of the live crown, status (live or dead), causal agent of mortality (if applicable), and year of tree death (if applicable) recorded.
Surface fuels were recorded along three modified Brown's transects. Tree regeneration, shrub species, and other flora were recorded on a 1/100th-acre subplot surrounding plot center and at the end of each Brown's transect. Invasive plants were surveyed on each plot.



Network of 180 plots installed within areas heavily impacted by drought and outbreaks of native bark beetles on four national forests in the central and southern Sierra.



Mean number of trees ha^{-1} based on 180 0.041-ha circular plots within areas heavily impacted by drought and outbreaks of native bark beetles.

Select, preliminary results and observations (2014-2017):

- At initiation of this study, stand conditions were more uniform across the network of plots than might be expected, ranging from 520 ± 39 trees ha^{-1} on the Sequoia National Forest to 557 ± 47 trees ha^{-1} on the Sierra National Forest; from 53 ± 4 m^2 ha^{-1} of basal area on the Sequoia National Forest to 64 ± 5 m^2 ha^{-1} of basal area on the Eldorado, and from 49 ± 4% ponderosa pine on the Sequoia National Forest to 60 ± 4% ponderosa pine on the Eldorado.

- Similar fewer differences were observed among elevation bands than might be expected. For example, ranging from 497 ± 43 trees ha^{-1} in the lowest band to 600 ± 40 trees ha^{-1} in the highest band, and 47 ± 3 m^2 ha^{-1} of basal area in the lowest band to 63 ± 4 m^2 ha^{-1} of basal area in the middle band.

- By 2017, 54 ± 2% of trees died. Most of this mortality was concentrated in the pine component (*see* figure above) within the larger-diameter classes, although other tree genera and plant associations were affected.

- Ponderosa pine and sugar pine collectively lost 85% of their live basal area.

- Ninety-five percent of ponderosa pines ≥19 cm dbh were colonized by western pine beetle (*Dendroctonus brevicomis*), while 80% of sugar pines ≥19 cm were colonized by mountain pine beetle (*D. ponderosae*). Drought is known to increase the performance and impact of western pine beetle and mountain pine beetle (Kolb et al. 2016. *For. Ecol. Manage.* 380:321−334).

- Sixty-three percent of trees (all species) ≥19 cm dbh died, while 80% of trees (all species) ≥57.2 cm dbh died.

- Tree regeneration is dominated by incense cedar (569 ± 102 ha^{-1}) and black oak (316 ± 68 ha^{-1}) seedlings, and incense cedar (755 ± 177 ha^{-1}) and ponderosa pine (245 ± 58 ha^{-1}) saplings.

- Cheatgrass (*Bromus tectorum*) was the most common invasive plant recorded.

- Several snags have already fallen and become part of the surface fuel profile. We expect the half-life of snags to be lower than reported elsewhere (e.g., in studies that have focused on lodgepole pine or ponderosa pine in the Pacific Northwest).

- Data analyses are ongoing. A manuscript focusing on initial impacts to overstory trees will be submitted to *Forest Ecology and Management* this spring.

- Plots will be monitored on an annual basis for causes and levels of tree mortality and snag retention. Surface fuel profiles and impacts to forest pollinators will be measured every third year.

Conifer mortality and fuel loading changes due to bark beetles and drought in Central and Southern California – Preliminary Summary of 2016 and 2017 data for Forest Health Protection Evaluation and Monitoring Project

Sharon M. Hood, Fire, Fuels, and Smoke Science Program, Rocky Mountain Research Station, USDA Forest Service, Missoula, MT; **Sheri Smith**, Forest Health Protection, USDA Forest Service, Susanville, CA; **Beverly Bulaon**, Forest Health Protection, USDA Forest Service, Sonora, CA; **Danny Cluck**, Forest Health Protection, USDA Forest Service, Susanville, CA; **Adrian Poloni**, University of California, Davis, CA; **Andrea Hefty**, Forest Health Protection, USDA Forest Service, San Bernardino, CA; **Stacy Hishinuma**, Forest Health Protection, USDA Forest Service, San Bernardino, CA; **Lindsay Grayson**, Fire, Fuels, and Smoke Science Program, Rocky Mountain Research Station, USDA Forest Service, Missoula, MT; **Stacy Drury**, Pacific Southwest Research Station, USDA Forest Service, Davis, CA.

In 2016 we began a study to investigate factors that increase susceptibility of forest stands to conifer mortality in central and southern California and to assess the changes in fuel loading and fire hazard due to drought and bark beetle-killed trees. The objectives of this study are to: (1) determine temporal changes in fuel loading and hazard due to bark beetle and drought-associated mortality and (2) identify the edaphic site, stand, and tree growth factors relating to conifer tree mortality and monitor changes in vegetation after mortality. Plots will be re-measured annually for 5 years for changes in tree status and fuel loading.

We installed fuels and vegetation monitoring plots on the Sierra (50 plots) and Los Padres (27 plots) National Forests. On the Sierra NF, plots were selected from an existing network of LIDAR plots and stratified by mortality severity using Aerial Detection Survey (ADS) and had vegetation sampling in 2015. Plots on the Los Padres NF were chosen based on singleleaf pinyon pine dominance and stratified based on the 2015 ADS data. At both locations, plots were further divided into high or low mortality levels. Sites with anticipated management activities were avoided.

Individual tree measurements, plot vegetation data, and plot fuel loading were measured on a 0.04 hectare fixed-radius circular macroplot. All trees over 12.7 cm diameter at breast height (DBH) on the Sierra and 12.7 cm groundline diameter on the Los Padres were tagged. Standard inventory data were taken for each, as well as snag status and beetle attack status. Seedling and sapling data were collected on a 0.04 hectare fixed-radius circular microplot. We estimated fine fuel (1-100 hr), shrub, and herbaceous loading using the Photoload method on eight, 1 m^2 quadrats within the 0.04 hectare macroplot. We measured litter and duff depth at each quadrat. Coarse fuel loading (1000 hr) was estimated by measuring the length, decay class, and end diameters of each log ≥ 7.6 cm on the macroplot.

Los Padres

Site Description

The Los Padres (LP) plot network is located on the Mt. Pinos Ranger District of the Los Padres National Forest. Plots are generally along Frazier Mountain Park Rd. between the communities of Pine Mountain Club and Lake of the Woods. Plot elevations range from 1672 to 1892 m. Average temperature is 11.2° C (January: 3.9 ° C; July: 20.7 ° C) and average precipitation is 355 mm (http://prism.oregonstate.edu/explorer/). The plots are dominated (98%) by singleleaf pinyon pine. No recent activity has occurred on the plots.

Key Results

Across all plots, 27% of the pinyon were dead in 2016 and an additional 3% died in 2017 for a total of 30% mortality, as measured by stem density. Due to the study design of placing plots in high and low mortality areas, the extent of mortality varied greatly from 26% of basal area dead in the low mortality level plots to 74% dead in the high mortality level plots (Table 1). Larger trees were generally more likely to die than smaller trees (Figure 1). Trees lost needles rapidly after dying (Table 2). Pinyon pine regeneration is low and patchy; 26% of plots had live saplings and 19% had live seedlings. Regeneration density for all plots was 110 saplings/ha and 128 seedlings/ha. Average fuel loading was low and mostly from 1000 hr logs (Table 3).

Table 1. Basal area and DBH by tree status and plot mortality type for the Los Padres site. Only trees ≥ 12.7 cm groundline diameter included.

Mortality Level	Plots	Total Basal Area (m^2/ha)	Dead Basal Area (m^2/ha)	Dead Basal Area (%)	Live DBH (cm)	Dead DBH (cm)
Low	17	30.3	7.8	26	28.2	26.7
High	10	28.2	20.9	74	23.4	33.8

Table 2. Needle retention patterns of recently dead pinyon pine.

No. Recently Dead Trees	Needle Retention 2016 (%)	Needle Retention 2017 (%)	Rate of Annual Needle Loss
85	35	9	78%

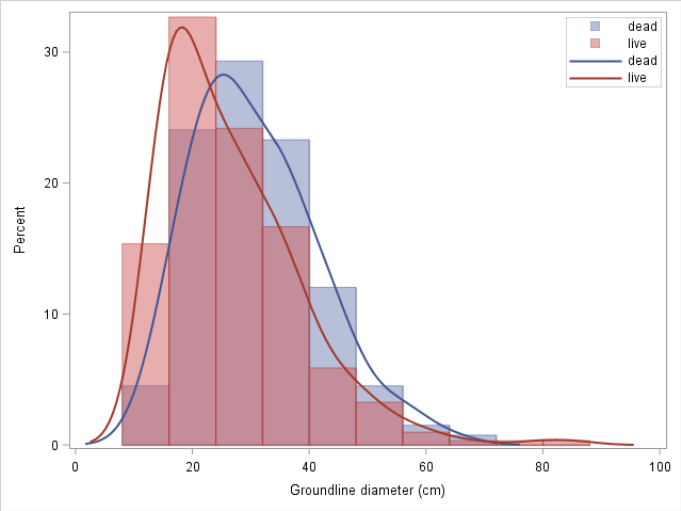


Figure 1. Diameter distribution by live and dead pinyon pine as of 2017. Smoothed lines are density estimates to help distinguish the differences in shape of the two overlapping histograms.

Table 3. Average fuel loading by component for Los Padres plots.

Component	kg/m^2
litter	0.97
duff	0.17
1 hour	0.14
10 hour	0.21
100 hour	0.06
1 - 100 hour	0.41
1000 hour	0.69
Total	2.66

Sierra

Site Description

The Sierra (LP) plot network is located in the Dinkey Landscape Restoration Project area on the Sierra National Forest. Plot elevations range from 1218 to 2221 m. Average temperature is 11.6° C (January: 5.2 ° C; July: 21.3 ° C) and average precipitation is 1002 mm (http://prism.oregonstate.edu/explorer/). The plots are mixed conifer and range from areas dominated by ponderosa pine up to the red fir zone. No recent activity has occurred on the plots.

Key Results

On the Sierra plot network mortality was high, especially in pines, with 93% sugar pine mortality and 89% ponderosa pine mortality (Table 4). Due to the study design of placing plots in high and low mortality areas, the extent of mortality varied greatly from 21% of basal area dead in the low mortality

level plots to 59% dead in the high mortality level plots (Table 5). There was not a clear pattern between tree size and mortality for any species (Figure 2). Trees lost needles quickly after dying, though ponderosa pine tended to retain needles longer (Table 6).

Regeneration was mostly white fir (Table 7). Fuel loading was very high, likely due to past fire exclusion. Total fuels averaged 17.4 m^2/kg, mostly due to 1000 hr logs (Table 8).

Table 4. Mortality by species and year for the Sierra plots.

	Total dead in 2016	Total dead in 2017
Species	%	%
White fir	37	44
Red fir	11	17
Incense cedar	25	35
Sugar pine	90	93
Ponderosa pine	77	89
CA black oak	47	48

Table 5. Basal area and DBH by tree status and plot mortality type for the Sierra site. Only trees ≥ 12.7 cm included. Species dominance of all plots is white fir (27%), ponderosa pine (21%), incense cedar (19%), and red fir (13%).

Mortality Level	Plots	Total Basal Area (m^2/ha)	Dead Basal Area (m^2/ha)	Dead Basal Area (%)	Live DBH (cm)	Dead DBH (cm)
Low	25	66.1	20.9	32	40.9	32.0
High	25	78.3	58.5	75	38.6	39.9

Table 6. Needle retention patterns of recently dead trees by species.

No. Recently Dead Trees	Needle Retention 2016 (%)	Needle Retention 2017 (%)	Rate of Annual Needle Loss
White fir	59	63	21
Sugar pine	36	74	26

Ponderosa pine	140	80	36

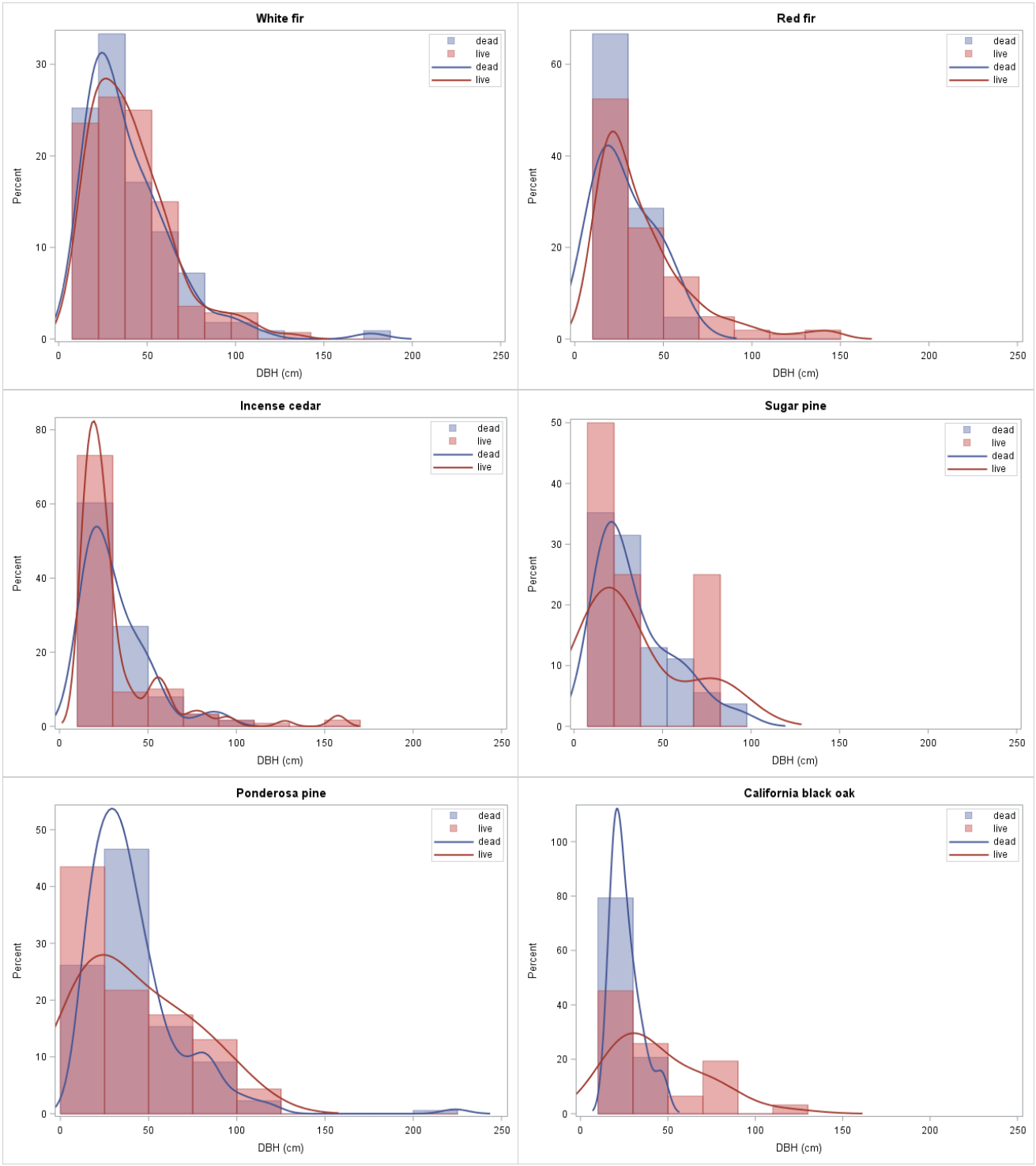


Figure 2. Diameter distribution by live and dead trees and species as of 2017. Smoothed lines are density estimates to help distinguish the differences in shape of the two overlapping histograms.

Table 7. Seedling and sapling density by species.

Species	Seedlings	Saplings
	hectare	
White fir	1700	203
Incense cedar	657	89
Sugar pine	25	0
Ponderosa pine	30	84
CA black oak	519	10

Table 8. Average fuel loading by component for the Sierra plots.

Component	kg/m^2
litter	2.3
duff	2.3
1 hour	0.1
10 hour	0.3
100 hour	0.5
1 - 100 hour	0.9
1000 hour	11.0
Total	17.4