Whiskeytown National Recreation Area (Whiskeytown, California):

Phase II Forest Restoration Activities[1]

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Forest Restoration Prescriptions for Whiskeytown National Recreation Area

This document summarizes forest restoration prescriptions developed for two sites at Whiskeytown National Recreation Area, Whiskeytown, California (Units A and E in Figure 1). Sites were visited and preliminary prescriptions were developed in July, 2009. Data were collected in October 2009 and analyzed in 2010 to simulate prescription outcomes, prepare estimates of removal volume, and inform about potential changes in forest stand dynamics. During fall 2010 site visits, the preliminary prescriptions were refined and timber was marked. Additional stand data were gathered following timber marking to most accurately quantify the effects of the restoration. The prescriptions are restorative and intend to place stands on trajectories of development toward conditions assumed to occur throughout the pre-settlement landscape. The map below displays the general location of the two proposed restoration sites (A and E).

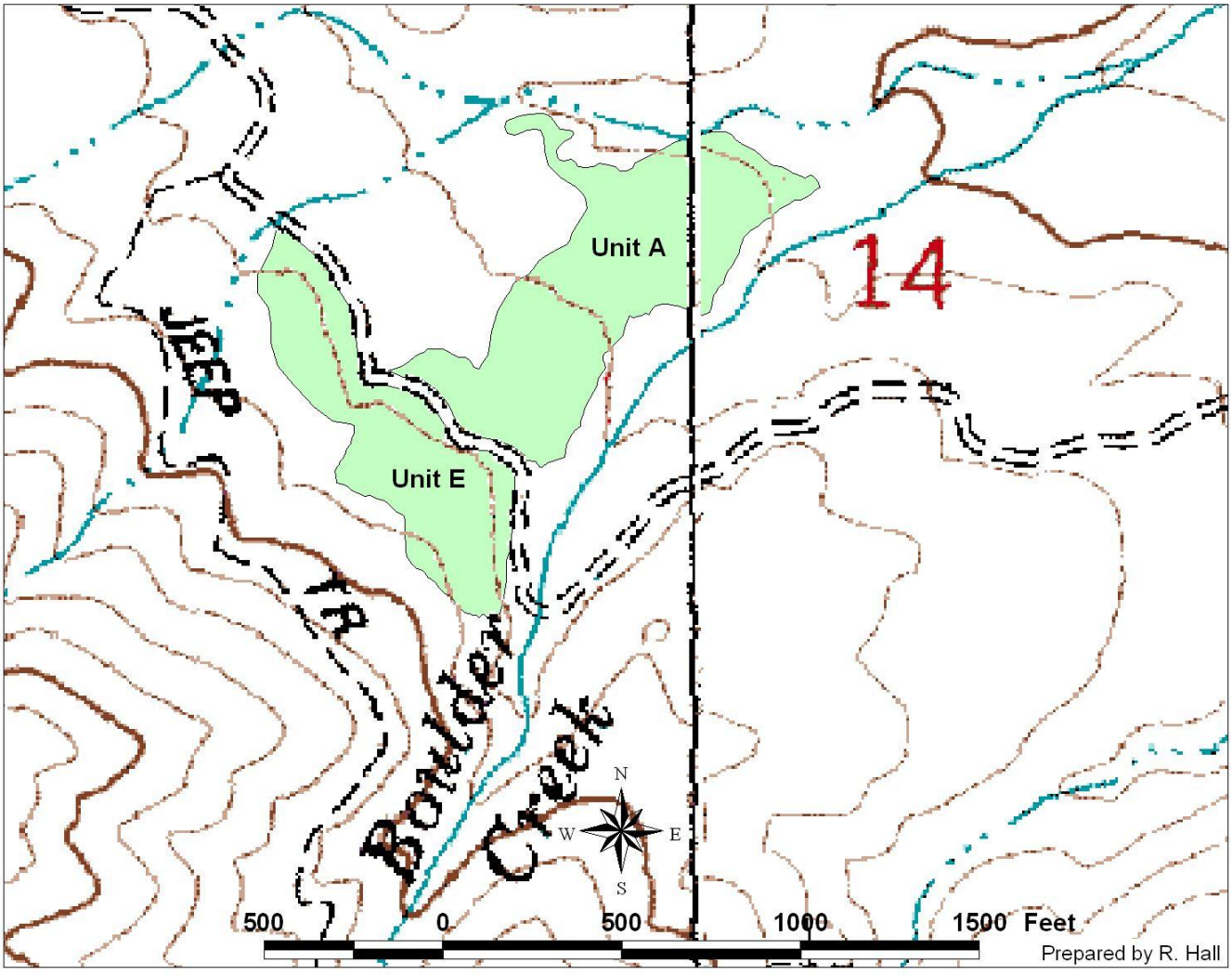

Figure 1. Location map of forest restoration projects in the Boulder Creek drainage at Whiskeytown NRA (Units A and E).

Stand Dynamics

Both stands, Units A and E, are exemplified by mixed species multi-cohort stands developing along similar developmental pathways. European settlement in the area resulted in extractive logging, mining and changes to the natural disturbance regime, most notably fire. These historical changes have resulted in the densification of stands and shifts in species composition. Soil disturbance, increase in available light and the exclusion of wildfire have facilitated a dense hardwood understory and an increase of Douglas-fir in the stands.

Age data were collected on a sample of Douglas-fir and ponderosa pine trees in Unit A during October 2010. This data indicates that the larger pines in the stand originated earlier than the Douglas-firs. The age data also indicates the Douglas-fir originated as a single cohort, establishing in a pulse following changes in disturbance regimes approximately 60 years ago. The mean breast-height age of Douglas-fir in the stand is 53 years, compared to a mean breast height age of 82 years for the pine. Unit E was sampled in the field and confirmed that this trend is common to both stands.

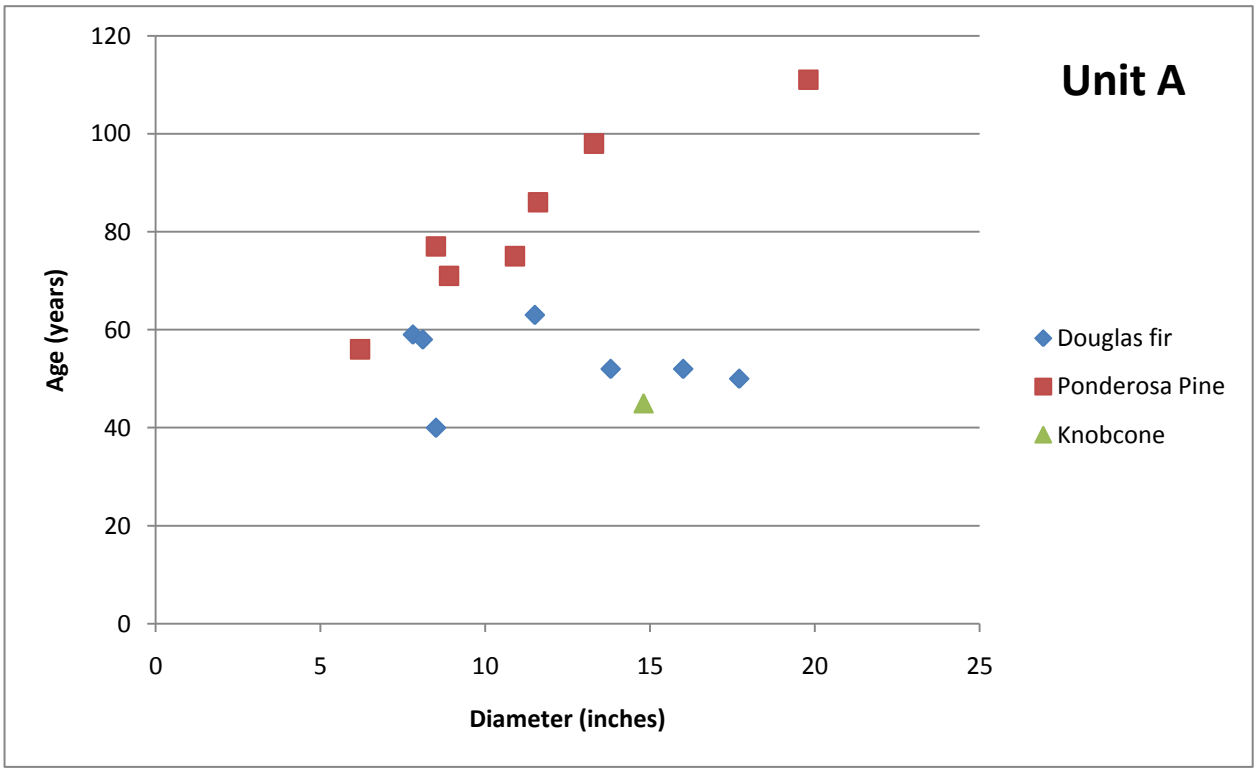

Figure 2. Conifer age structure in Unit A.

Unit A

Multi-cohort mixed species stand, 9.1 acres. This stand has numerous very large trees with multiple species represented in large diameter classes (greater than 20 inches). Following extractive logging around World War II, and lacking regular natural understory disturbance, a dense understory of Douglas-fir and hardwood trees became established and has encroached upon the older trees. The intent of this prescription is to accentuate the species and structural diversity within the stand, while promoting the vigor and long-term persistence of the large-diameter trees present.

The prescription proposed for Unit A is a reduction in stand density (thinning) across all diameter classes between 6 and 18 inches dbh for conifers and across all diameter classes less than 18 inches for hardwoods. Douglas-fir is the primary conifer species targeted for reduction, while canyon live oak and tanoak are the targeted hardwood species. All large legacy trees, and all trees greater than 18 inches dbh, are retained in the stand. Conifers below 6 inches are retained. Under-represented and unique species are retained – specifically, sugar pine, incense-cedar, and black oak. All healthy ponderosa pines are retained. Douglas-fir is selected for removal anywhere other tree species are present, allowing residual trees to fill canopy space following thinning. Small diameter tanoak and live oak are selected for removal to reduce hardwood density; however, the percentage of basal area occupied by each of these species in the post-harvest stand remains very close to the pre-harvest perentage (seeTables 1 and 2).

This prescription redistributes growing space to dominants and greatly reduces midstory ladder fuels while maintaining mast-producing species and trees across all diameter classes. The result is an open, two-layered stand with distinct hardwood and softwood components. The post-harvest stand density is high enough to facilitate canopy closure, precluding the development of an undesirable dense understory. This allows some smaller conifers and hardwoods to occupy canopy space, effectively limiting light to the forest floor and thus maintaining open understory conditions.

Specific instructions to logging contractor to fulfill the prescription: Cut no tree greater than 18.0 inches dbh. Cut no tree marked with blue paint. Cut no black oak, incense-cedar, or sugar pine. Remove all unmarked Douglas-fir and knobcone pine whose diameter is between 6.0 and 18.0 inches. Remove all unmarked hardwoods with a diameter of less than 18.0 inches.

Figure 3. High density of small-diameter hardwood stems in Unit A.

Figure4. Encroachment of small diameter hardwoods on a relictual ponderosa pine in Unit A.

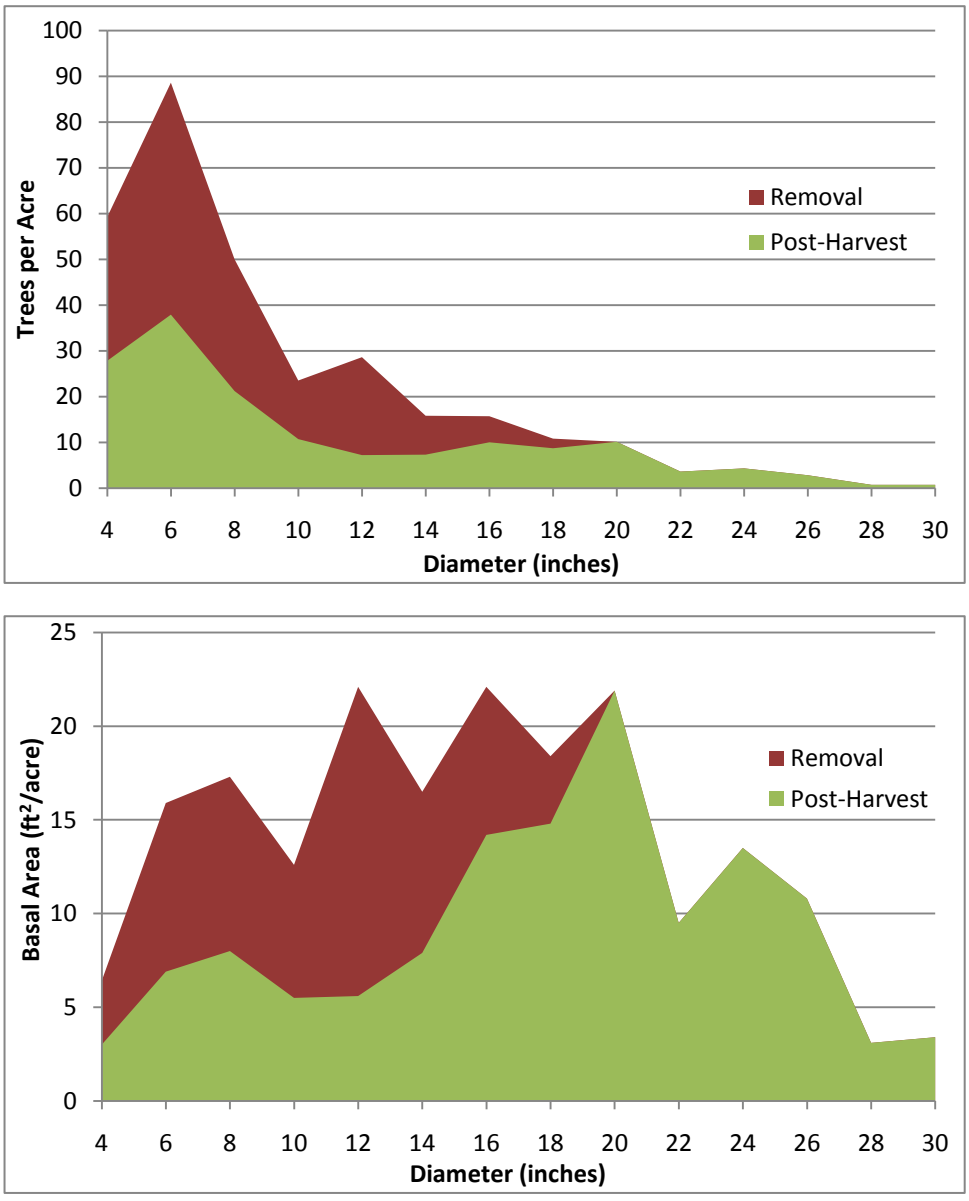

Figure 5. Diameter distributions displaying the changes in stand density from the restoration prescription in terms of both trees per acre (top) and basal area (bottom) for Unit A. The prescription reduces stand density across the smaller diameter classes. However, it maintains trees in every diameter class following harvest. This allows larger trees and pines to persist in the stand while creating a stand with a multi-layered canopy and residual density sufficiently high to allow canopy closure before the development of a dense understory.

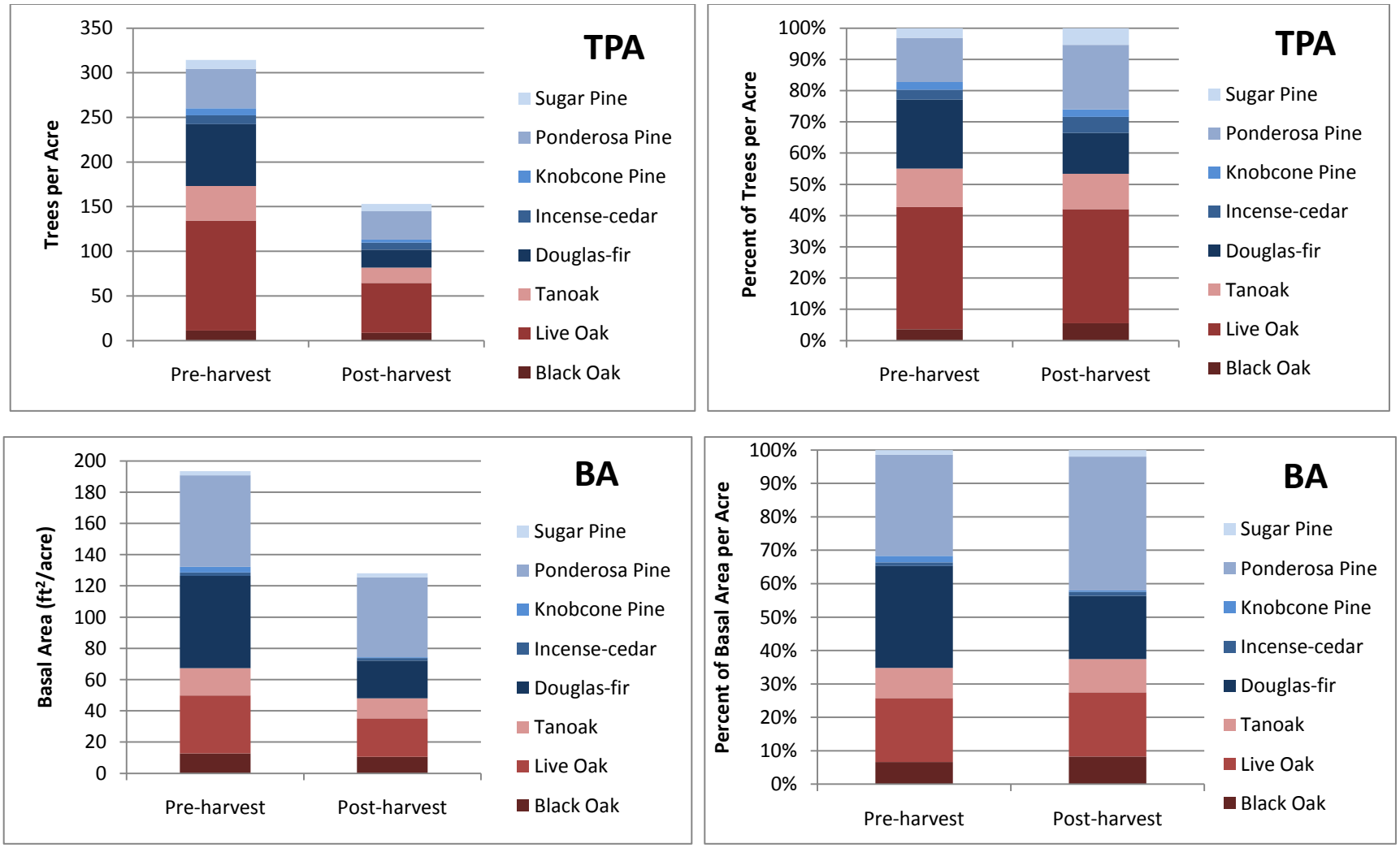

Figure 6. Changes in stand density by species, expressed in absolute and relative terms (percentage of the total stand), Unit A. Density is displayed in both trees per acre (TPA, top charts) and basal area (ft^2/ac; BA, bottom charts). Broadleaved species in shades of red; conifers in shades of blue.

Stand density changes for Unit A are quantified by an approximately 50% reduction in the number of trees per acre (314 tpa pre-harvest to 153 tpa post-harvest) and reduction in basal area (ft^2/ac) by approximately 33% (193.5 ft^2/ac to 128.1 ft^2/ac). The proportion of hardwoods and conifers in the stand remains fairly constant, with the primary change being an increase in the ratio of ponderosa pine to Douglas-fir. The stem density pre-harvest is 55% hardwoods; post-harvest it is projected to be 53.4% hardwoods. The composition changes in terms of basal area are also negligible: 34.8% hardwoods pre-harvest and 37.5% hardwoods post-harvest projection. Basal area of ponderosa pine increases from 30.2% to 40.0% of the stand total, whereas Douglas-fir basal area is reduced from 30.5% to 18.9% of the stand total. These trends are displayed in Figure 5 (previous page) and in Tables 1 and 2 (below).

Table 1. Stand density changes by species for Unit A: trees per acre.

Species	Trees per Acre		Trees per Acre (% of total)	
	Pre-harvest	Post-harvest	Pre-harvest	Post-harvest
Black oak	11.3	8.5	3.6	5.6
Live oak	123	55.9	39.1	36.5
Tanoak	38.7	17.3	12.3	11.3
Douglas-fir	69.3	20	22.0	13.1
Incense-cedar	10	7.9	3.2	5.2
Knobcone pine	7.8	3.6	2.5	2.4
Ponderosa pine	44.4	31.6	14.1	20.7
Sugar pine	9.9	8.2	3.1	5.4
All	314.4	153	100	100

Table 2. Stand density changes by species for Unit A: basal area.

Species	Basal Area (ft^2/acre)		Basal Area (% of total)	
	Pre-harvest	Post-harvest	Pre-harvest	Post-harvest
Black oak	12.8	10.6	6.6	8.3
Live oak	37.1	24.6	19.2	19.2
Tanoak	17.4	12.8	9.0	10.0
Douglas-fir	59.1	24.2	30.5	18.9
Incense-cedar	2.1	1.6	1.1	1.2
Knobcone pine	3.7	0.5	1.9	0.4
Ponderosa pine	58.5	51.3	30.2	40.0
Sugar pine	2.8	2.5	1.4	2.0
All	193.5	128.1	100	100

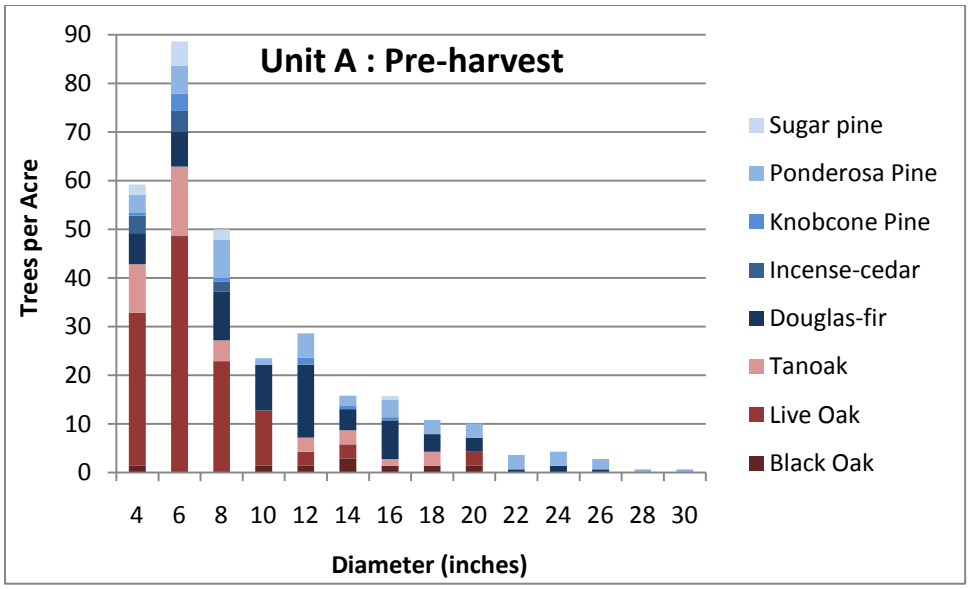

Figure 7. Diameter distribution of current stand stem density (trees per acre).

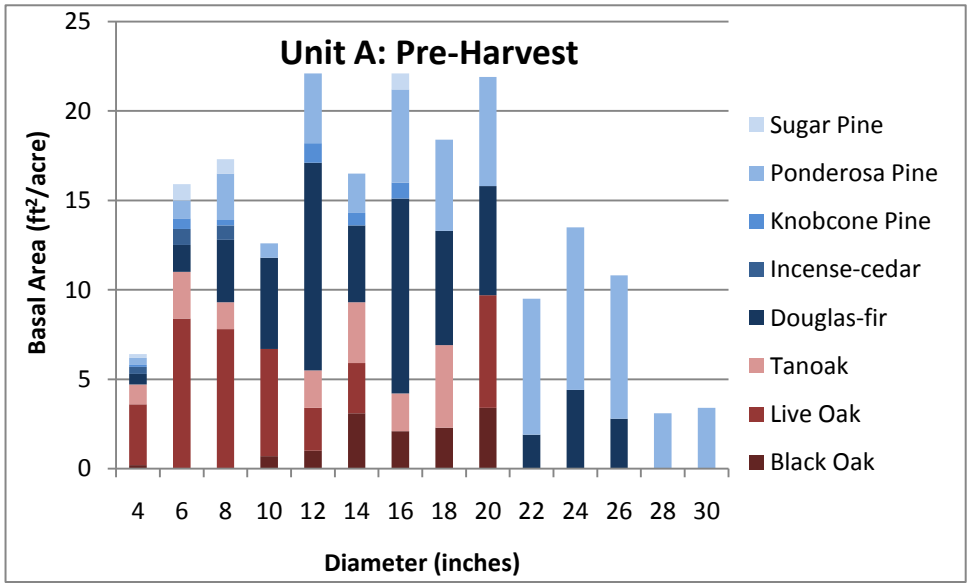

Figure 8. Diameter distribution of current stand basal area (ft^2/ac).

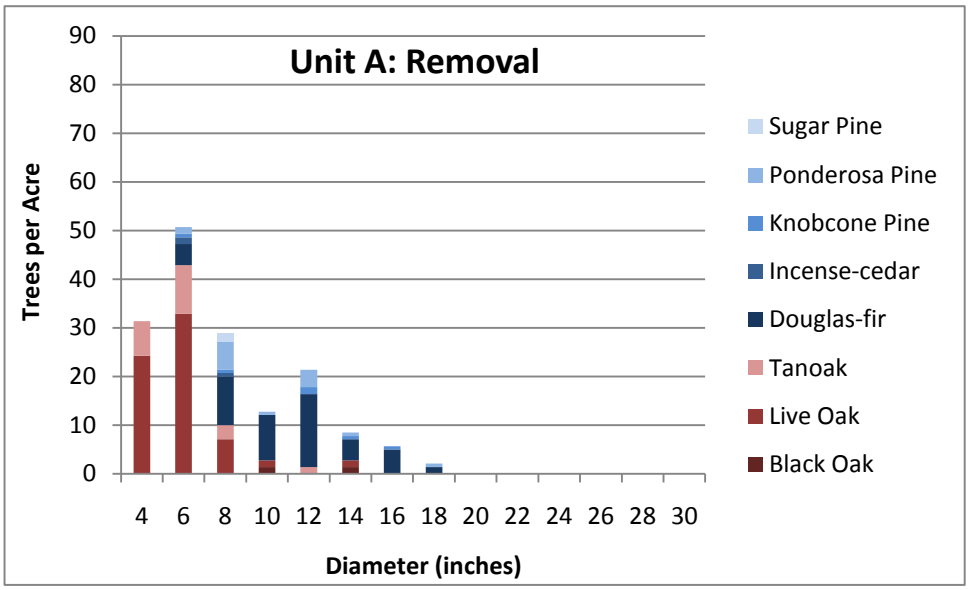

Figure 9. Diameter distribution of stems removed (trees per acre).

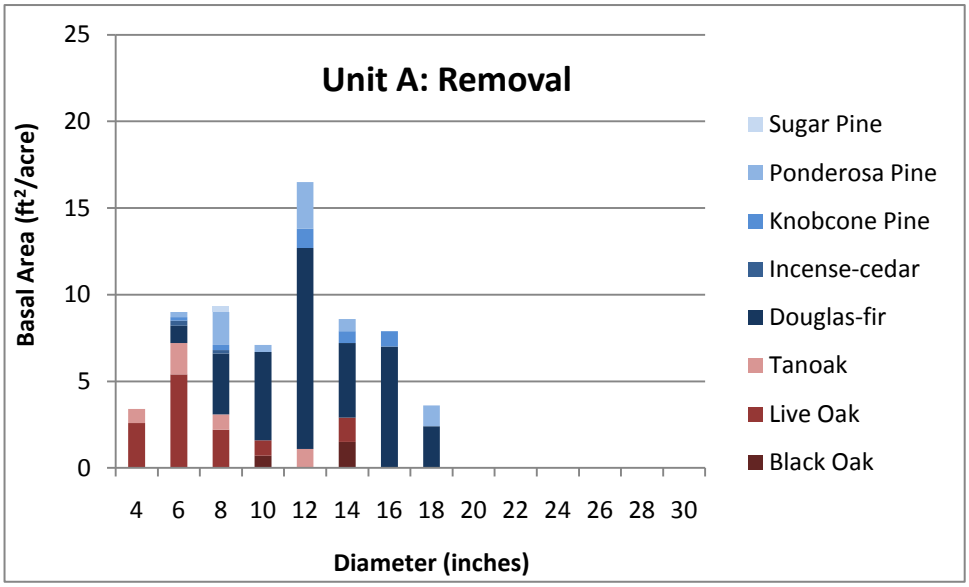

Figure 10. Diameter distribution of basal area removed (ft^2/ac).

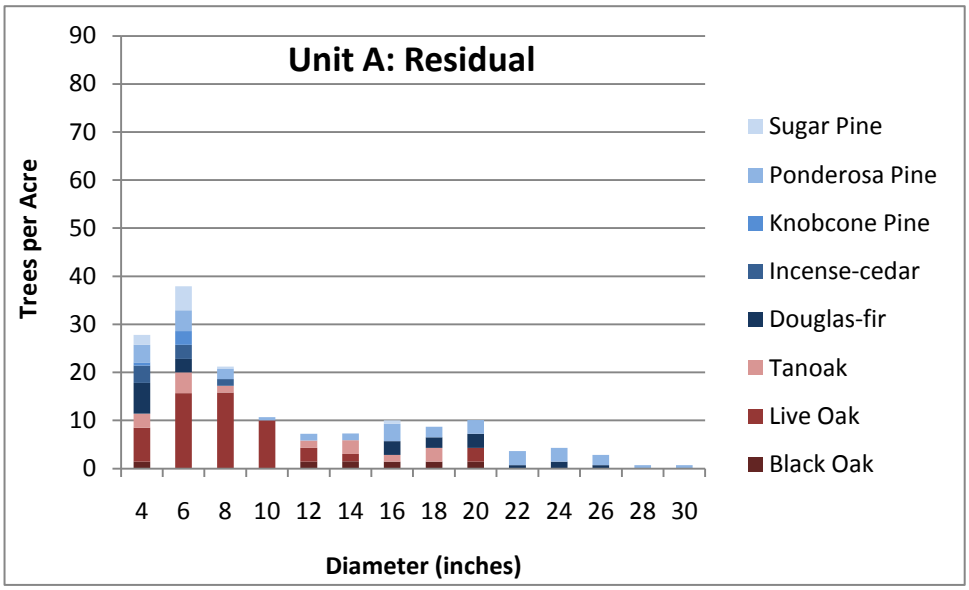

Figure 11. Diameter distribution of projected post-harvest stem density (trees per acre).

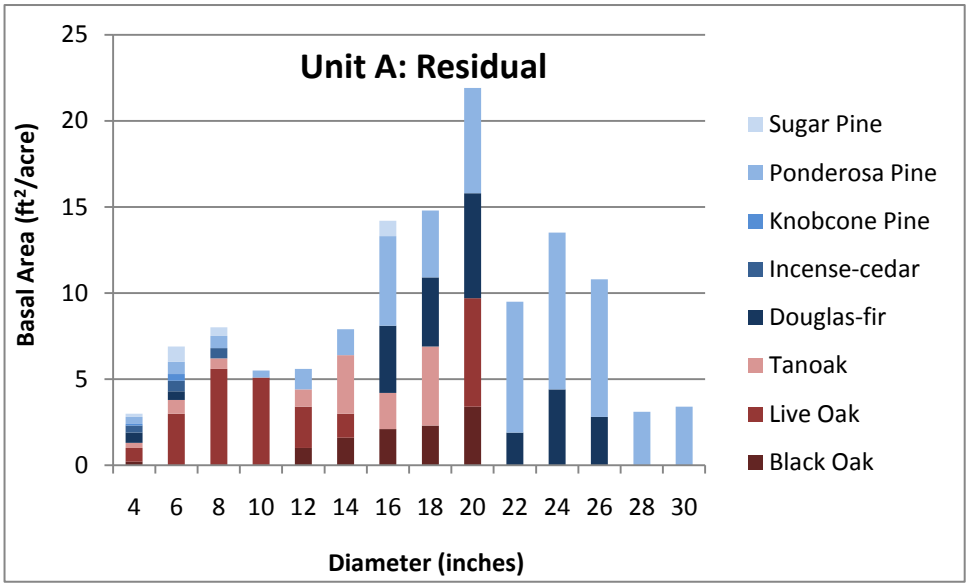

Figure 12. Diameter distribution of projected post-harvest basal area (ft^2/ac).

The prescription for Unit A reduces stem density across trees with a diameter less than 18 inches. 68.7% of the removal is concentrated in the 4, 6, and 8 inch diameter classes. A total of 85.3% of the removals are from the Douglas-fir (30.5%), live oak (41.6 %,) and tanoak (13.2%) components.

More than 2/3^{rds} of the stems removed are from the 8-inch diameter class and lower; this accounts for 1/3rd of the basal area removed from the stand. In terms of basal area, the 12-inch class has the most substantial removal of any diameter class. One quarter of the total basal area removed is within this class; 70% of the removals in this class are Douglas-fir, accounting for a major portion of the young Douglas-fir encroachment cohort.

Table 3. Volumes per acre by diameter class and species. Cubic volume (CuFt) is provided for small diameter Douglas-fir and ponderosa pine and all diameters for all hardwoods and other softwoods. Currently the local sawlog market is for ponderosa pine and Douglas-fir; board foot (BdFt) volume is provided for these two species.

Unit A: Volume per Acre										
DBH	CuFt	CuFt	CuFt	CuFt	CuFt	CuFt	CuFt	BdFt	CuFt	BdFt
	Black oak	Live oak	Tanoak	Incense-cedar	Knobcone pine	Sugar pine	Douglas-fir		Ponderosa pine	
4	0.0	40.6	12.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6	0.0	100.7	32.0	2.6	2.5	0.0	15.4	0.0	3.4	0.0
8	0.0	50.9	21.9	2.1	5.4	4.1	66.0	0.0	23.4	0.0
10	18.1	24.2	0.0	0.0	0.0	0.0	0.0	471.2	0.0	21.4
12	0.0	0.0	34.4	0.0	26.1	0.0	0.0	1220.9	0.0	176.7
14	44.7	45.7	0.0	0.0	19	0.0	0.0	542.6	0.0	64.3
16	0.0	0.0	0.0	0.0	27.3	0.0	0.0	1028.2	0.0	0.0
18	0.0	0.0	0.0	0.0	0.0	0.0	0.0	385.6	0.0	149.9
All	62.8	262.1	100.4	4.7	80.3	4.1	81.4	3648.5	26.8	412.3

Table 4. Total cubic foot (CuFt) and board foot (BdFt) per-acre volumes by species, left. Unit-wide harvest volumes (cubic foot and board foot), right.

Unit A: Volume per Acre			
DBH	CuFt	BdFt	BdFt
	All	DF	PP
4	52.7	0.0	0.0
6	156.6	0.0	0.0
8	173.8	0.0	0.0
10	42.3	471.2	21.4
12	60.5	1220.9	176.7
14	109.4	542.6	64.3
16	27.3	1028.2	0.0
18	0.0	385.6	149.9
All	622.6	3648.5	412.3

Unit A: Total Harvest Volume			
DBH	CuFt	BdFt	BdFt
	All	DF	PP
4	481.151	0.0	0.0
6	1429.758	0.0	0.0
8	1586.794	0.0	0.0
10	386.199	4302.056	195.382
12	552.365	11146.82	1613.271
14	998.822	4953.938	587.059
16	249.249	9387.466	0.0
18	0.0	3520.528	1368.587
All	5684.338	33310.81	3764.299

Unit E

Multi-cohort mixed species stand, 7.3 acres. This stand is adjacent to Unit A, located just to the north of the Boulder Creek Trail and Unit A. It has similar charcteristics as Unit A, including numerous large trees with multiple species represented in large diameter classes (greater than 20 inches). Both Units have similar stand history (extractive logging around World War II and an absence of regular natural understory disturbance); however, Unit E burned in a wildfire during the summer of 2008. Fire behavior was a low intensity surface fire. The fire backed down the slopes of Shasta Bally and resulted in limited mortality of understory hardwoods and small diameter conifers. The Boulder Creek Trail served as a fire break and prevented the fire from entering Unit A. These events have created a heterogenous stand with areas of dense hardwoods and conifers, with scattered emergent conifers protruding through the stand canopy.

The prescription in Unit E is a reduction in stand density (thinning) across all merchantable diameter classes less than 18 inches dbh. The prescription goal is to promote the vigor and persistence of the large-diameter trees present, while also accentuating the stand's species diversity and elements of structural diversity. All large legacy trees, and all trees greater than 18 inches dbh, are retained in the stand. Conifers below six inches are retained. Under-represented or unique species are retained, specifically sugar pine and black oak. All healthy ponderosa pines are retained. Small diameter tanoak and live oak are favored for removal to reduce the density of these more shade-tolerant hardwoods.

The prescription redistributes growing space to dominants and greatly reduces midstory ladder fuels while maintaining mast-producing species and trees across all diameter classes. Douglas-fir is the primary conifer species targeted for reduction, while canyon live oak and tanoak are the targeted hardwoods. The result will be an open stand with distinct hardwood and softwood components. The canopy will be two layered, with a post-harvest stand density that is high enough to facilitate canopy closure, and which will preclude the development of an undesireable dense understory.

Specific instructions to logging contractor to fulfill the prescription: Cut no tree greater than 18.0 inches. Cut no tree marked with blue paint. Cut no black oak, incense-cedar, or sugar pine. Remove all unmarked Douglas-fir and knobcone pine whose diameter is between 6.0 and 18.0 inches. Retain all hardwoods greaterthan 6.0 inches unless they are preventing or interfering with the removal of conifers designated as cut trees.

Figure 13. Example of typical stand conditions in Unit E.

Figure 14. Example of typical stand conditions in Unit E.

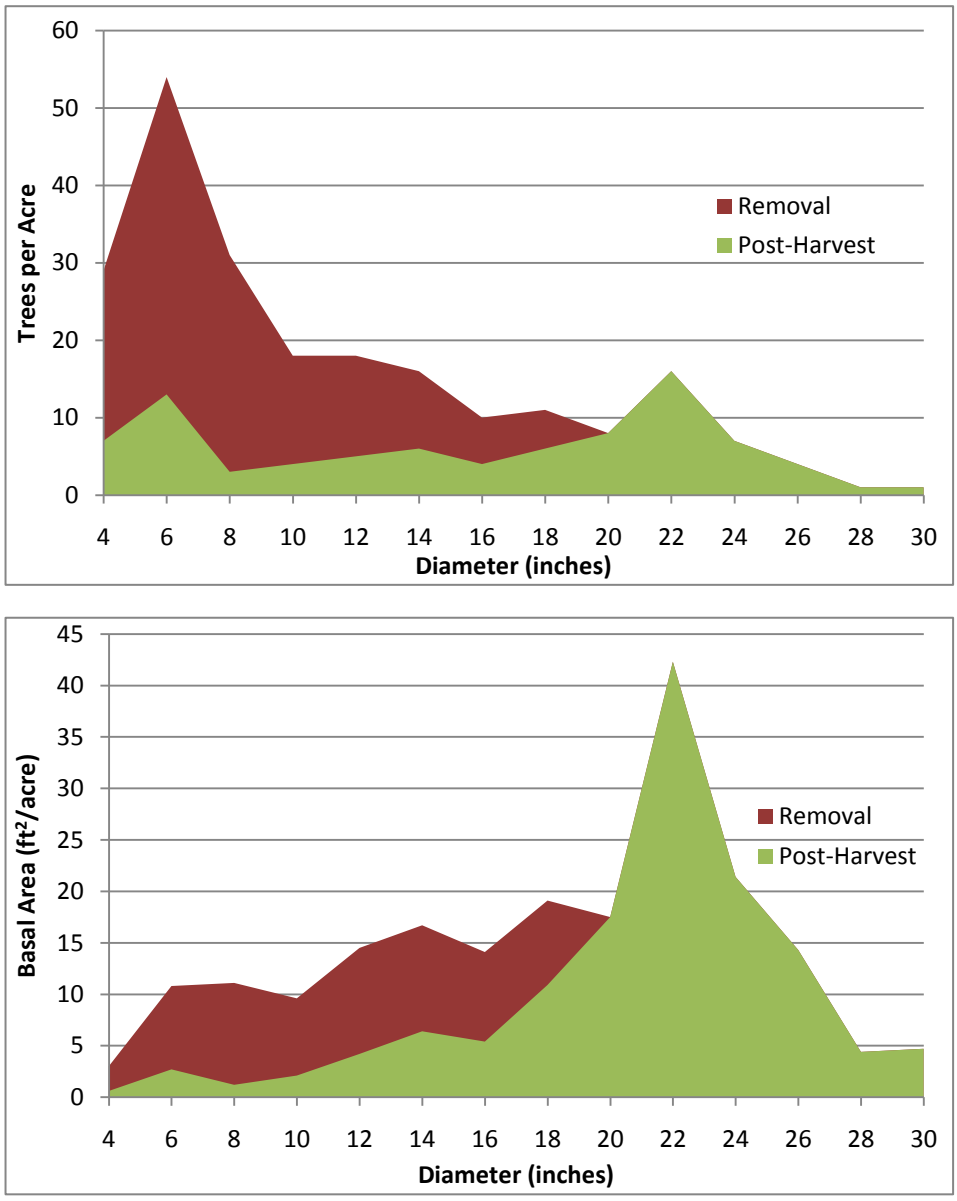

Figure 15. Diameter distributions displaying the changes in stand density from the restoration prescription in terms of both trees per acre (top) and basal area (bottom) for Unit E. The prescription for Unit E reduces stand density across the smaller diameter classes. However, it maintains trees in every diameter class following harvest. This allows larger trees and pines to persist in the stand while creating a stand with a multi-layered canopy and residual density high enough to allow canopy closure before the development of a dense understory.

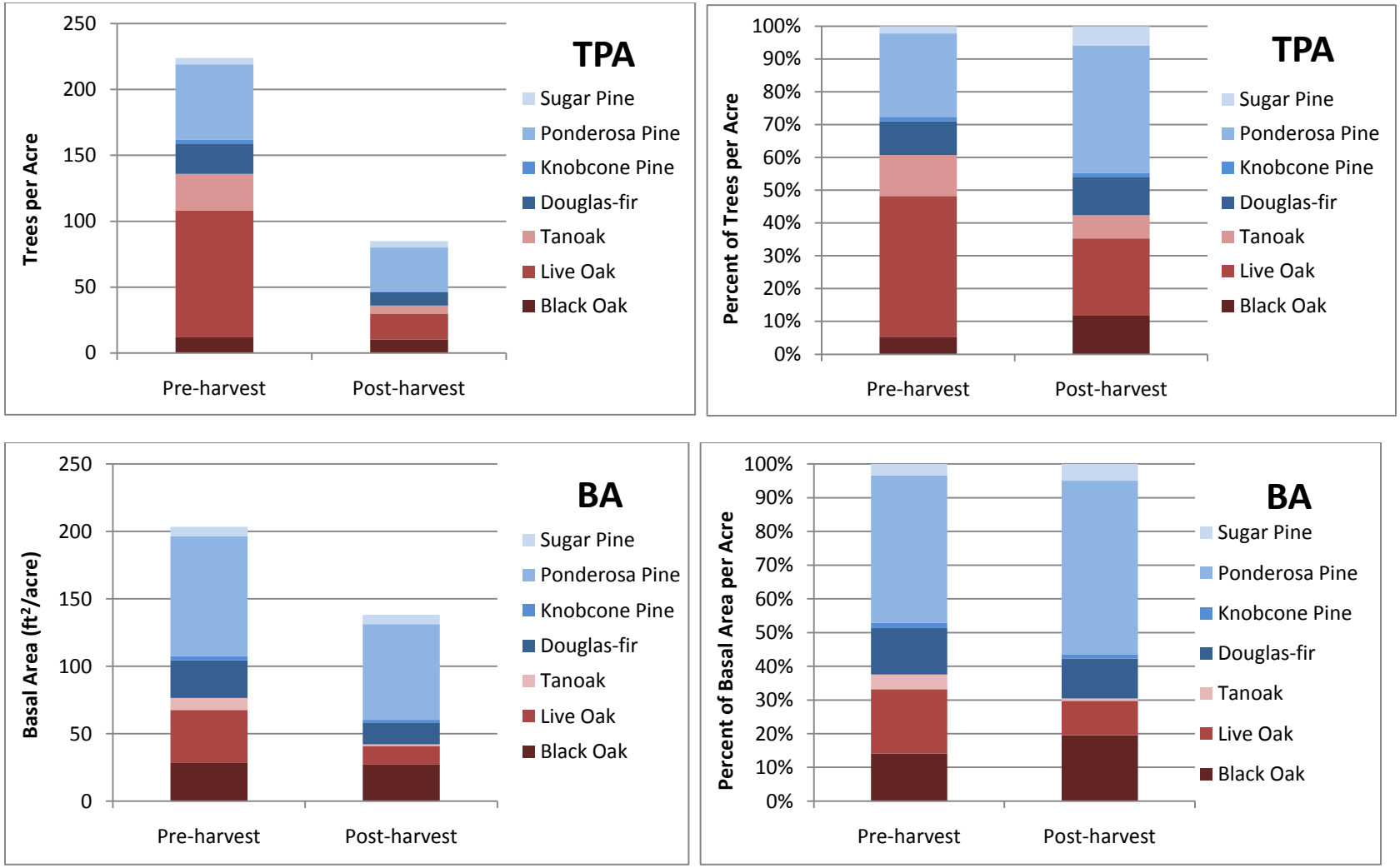

Figure 16. Changes in stand density by species expressed in absolute and relative terms (percentage of the total stand) at Unit E. Density is displayed in both trees per acre (TPA, top charts) and basal area (ft^2/ac; BA, bottom charts). Broadleaved species in shades of red; conifers in shades of blue.

Stand density changes for Unit E are quantified by an approximately 62% reduction in stems (224 trees per acre pre-harvest to 85 trees per acre post-harvest) and approximately 32% in basal area (203.3 ft^2/ac to 138.1 ft^2/ac). The proportion of hardwoods in the stand changes from 60.7% pre-harvest to 42.4% post-harvest. This shift is less pronounced in terms of basal area, where pre-harvest hardwood density accounts for 37.6% of the pre-harvest stand total and decreases to 30.4 % post-harvest. Changes to the stand density of individual species are most pronounced for live oak (decrease) and ponderosa pine (increase). Ponderosa pine basal area increases from 43.8% of the pre-harvest to 51.4% of the post-harvest, whereas live oak decreases from 19.1% pre-harvest to 10.1% post-harvest. These trends are displayed in Figure 15 (previous page) and Tables 5 and 6 (below).

Table 5. Stand density changes by species for Unit E: trees per acre.

Table 5	Trees per Acre		Trees per Acre (% of Total)	
	Pre-harvest	Post-harvest	Pre-harvest	Post-harvest
Black Oak	12	10	5.4	11.8
Live Oak	96	20	42.9	23.5
Tanoak	28	6	12.5	7.1
Douglas-fir	23	10	10.3	11.8
Knobcone pine	3	1	1.3	1.2
Ponderosa pine	57	33	25.4	38.8
Sugar pine	5	5	2.2	5.9
All	224	85	100	100

Table 6. Stand density changes by species for Unit E: basal area.

Table 6	Basal Area (ft^2/acre)		Basal Area (% of Total)	
	Pre-harvest	Post-harvest	Pre-harvest	Post-harvest
Black Oak	28.6	27	14.1	19.6
Live Oak	38.9	14	19.1	10.1
Tanoak	8.9	1.1	4.4	0.7
Douglas-fir	27.9	16.4	13.7	11.9
Knobcone pine	3.2	1.8	1.6	1.3
Ponderosa pine	89	71	43.8	51.4
Sugar pine	6.8	6.9	3.3	5.0
All	203.3	138.1	100	100

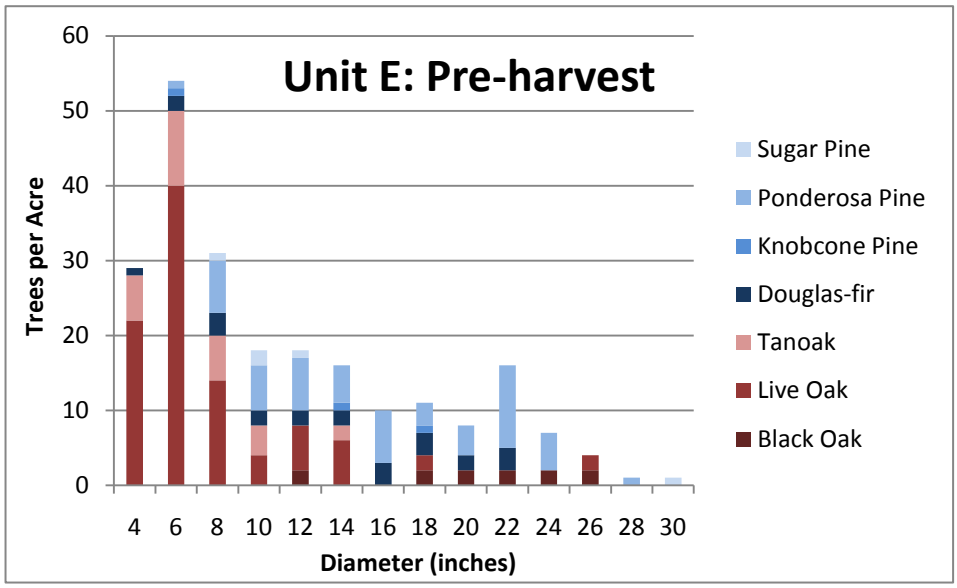

Figure 17. Diameter distribution of current stem density: trees per acre (tpa).

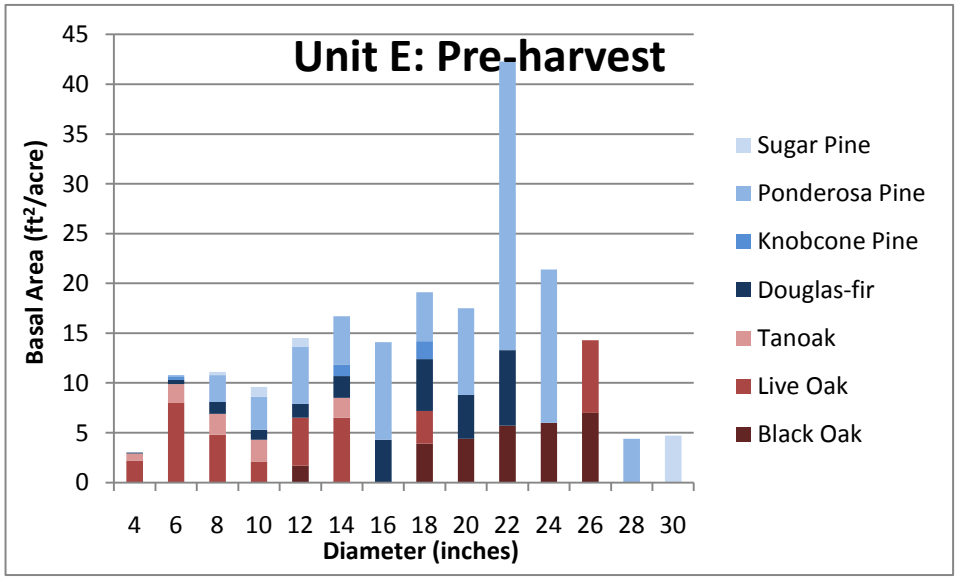

Figure 18. Diameter distribution of current stand density: basal area (BA; ft^2/ac).

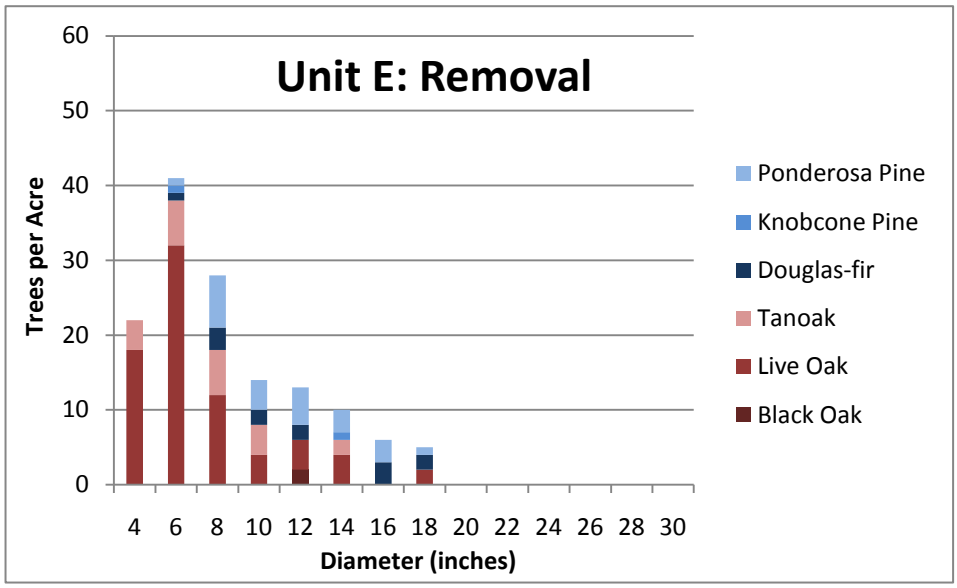

Figure 19. Diameter distribution of removals : trees per acre (tpa).

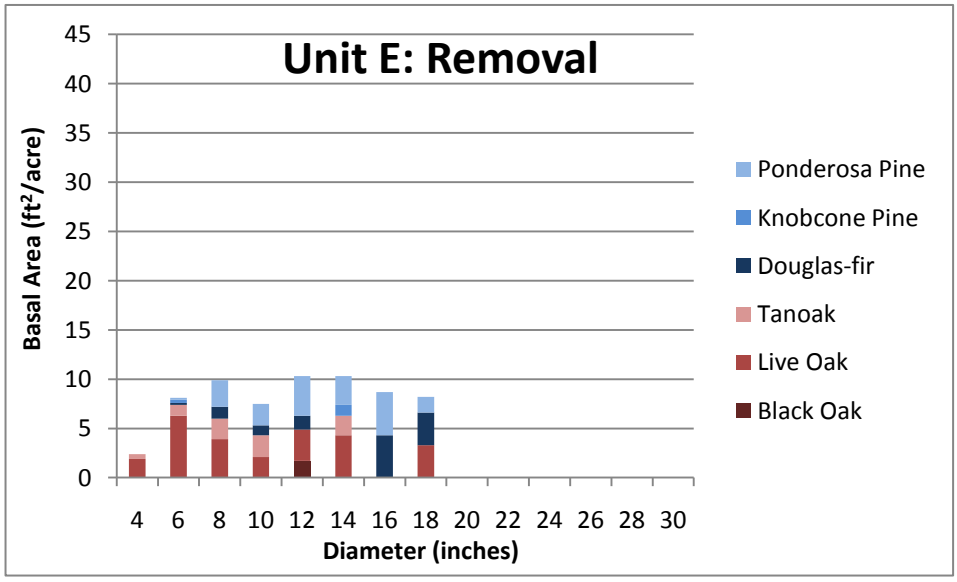

Figure 20. Diameter distribution of removals: basal area (BA; ft^2/ac).

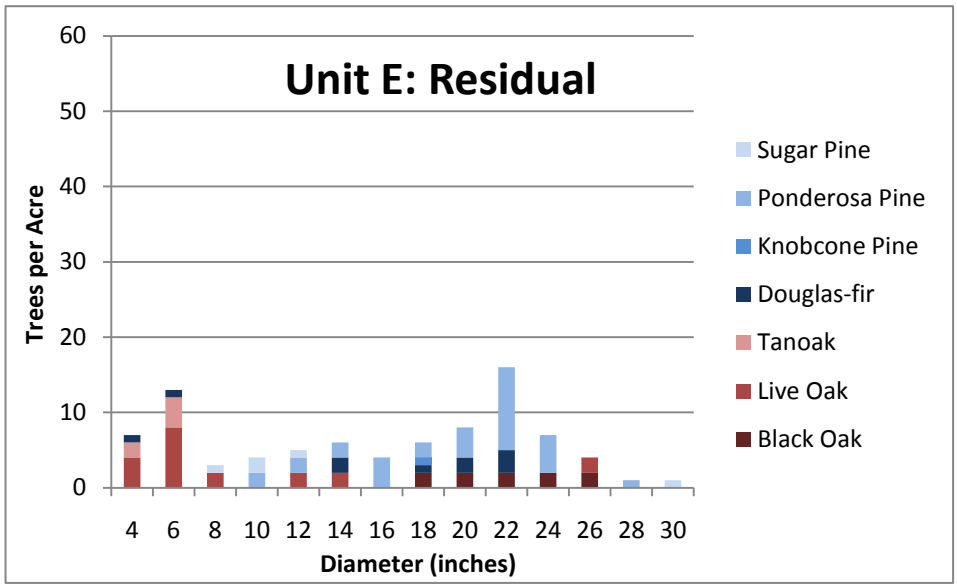

Figure 21. Diameter distribution of post-harvest stem density: trees per acre (tpa).

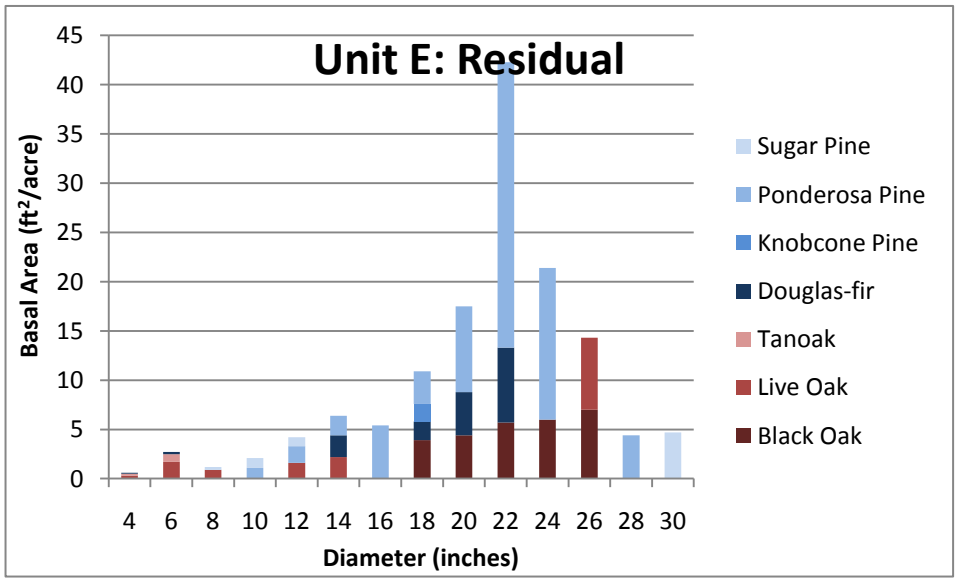

Figure 22. Diameter distribution of post harvest stand density: basal area (BA; ft^2/ac).

The prescription for Unit E reduces stem density across trees with a diameter less than eighteen inches. 65.5% of the stems removed are in the eight-inch class and smaller. Live oak makes up the majority of the removal in terms of both stems and basal area, with the majority of stems taken from the six inch diameter class. This accounts for 9.6% of the basal area removed. Douglas-fir density is lower in Unit E compared to Unit A, and the proportion of this species is maintained close to the pre-harvest level following the harvest.

Table 7. Volumes per acre by diameter class and species. Cubic volume (CuFt) is provided for small diameter Douglas-fir and ponderosa pine and all diameters for all hardwoods and other softwoods. Currently the local sawlog market is for ponderosa pine and Douglas-fir; board foot (BdFt) volume is provided for these two species.

Unit E: Volume per Acre									
DBH	CuFt	CuFt	CuFt	CuFt	CuFt	CuFt	BdFt	CuFt	BdFt
	Black oak	Live oak	Tanoak	Knobcone pine	Sugar pine	Douglas-fir		Ponderosa pine	
4	0.0	29.2	8.0	0.0	0.0	0.0	0.0	0.0	0.0
6	0.0	122.8	20.4	4.2	0.0	3.3	0.0	2.4	0.0
8	0.0	90.4	49.8	0.0	0.0	24.5	0.0	38.1	0.0
10	0.0	55.0	58.8	0.0	0.0	0.0	85.0	0.0	90.0
12	50.0	96.8	0.0	0.0	0.0	0.0	120.0	0.0	276.5
14	0.0	142.6	62.6	20.9	0.0	0.0	0.0	0.0	270.0
16	0.0	0.0	0.0	0.0	0.0	0.0	620.0	0.0	520.0
18	0.0	119.6	0.0	0.0	0.0	0.0	510.0	0.0	200.0
All	50.0	656.4	199.6	25.1	0.0	27.8	1335.0	40.5	1356.5

Table 8. Total cubic foot (CuFt) and board foot (BdFt) per-acre volumes by species, left. Unit-wide harvest volumes (cubic foot and board foot), right.

Unit E: Volume per Acre			
DBH	CuFt	BdFt	BdFt
	All	DF	PP
4	37.2	0.0	0.0
6	153.1	0.0	0.0
8	202.8	0.0	0.0
10	113.8	85.0	90.0
12	146.8	120.0	276.5
14	226.1	0.0	270.0
16	0.0	620.0	520.0
18	119.6	510.0	200.0
All	999.4	1335.0	1356.5

Unit E: Total Volume			
DBH	CuFt	BdFt	BdFt
	All	DF	PP
4	284.6	0.0	0.0
6	1397.8	0.0	0.0
8	1851.6	0.0	0.0
10	1039.0	776.1	821.7
12	1340.3	1095.6	2524.4
14	2064.3	0.0	2465.1
16	0.0	5660.6	4747.6
18	1091.9	4656.3	1826.0
All	9124.5	12188.6	12384.8