Colorado Front Range Collaborative Forest Landscape Restoration Project: 2011-2012 Pre- and Post-treatment Stand Structure Analyses for the Pike and San Isabel and Arapaho and Roosevelt National Forests

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Introduction

The Colorado Front Range Collaborative Forest Landscape Restoration Project (FR-CFLRP) is taking action to restore high priority lower montane forests of the Colorado Front Range. Through targeted forest treatments within National Forest systems, the FR-CFLRP is restoring ecological conditions that have departed from natural or historical conditions due to human influence such as fire suppression. By restoring the forests in these areas, the FR-CLFRP aims to protect ecosystems, communities, and municipal watersheds from risks of uncharacteristically large and severe wildfires.

The FR-CFLR project requires ecological, economic and social monitoring. Monitoring is an important part of the adaptive management process. Monitoring provides a means of assessing whether or not management goals and desired conditions are being achieved. Ecological monitoring described in the FR-CFLRP's monitoring plan[1] is designed to measure progress toward establishing a "complex mosaic of forest density, size and age classes at stand and landscape scales" along the Front Range. Restoration treatments are aimed generally at creating more open stand conditions, enhancing spatial heterogeneity, and promoting old-growth features. Desired trends in forest structure described in the monitoring plan include:

- Tree density – decrease basal areas and numbers of trees per acre
- Tree sizes – increase quadratic mean tree diameter
- Tree species – increase the ratio of ponderosa pine to other conifers
- Tree age – increase ratio of old trees (>200 years) to transitional and young trees
- Spatial heterogeneity – increase tree clumps and the number of openings

This report provides an analysis of pre- and post-treatment forest conditions inventoried in 2011 and 2012 on the Pike and San Isabel National Forests (PSI) and the Arapaho and Roosevelt National Forests (AR). It focuses primarily on Tier 1 variables from the monitoring plan, including tree densities, basal areas, species composition, and quadratic mean diameter. Tier 1 variables pertaining to fire regimes (e.g., surface fuels and fire behavior) are not discussed here, nor are Tier 2 variables such as understory vegetation cover and wildlife use.

[1] Clement, J. and P. Brown. 2011. Front Range Roundtable Collaborative Forest Landscape Restoration Project 2011 Ecological, Social and Economic Monitoring Plan. Colorado Forest Restoration Institute. 51p.

Methods

Pre-treatment data were collected in 2011 and post-treatment data were collected in 2012 using the Forest Service Common Stand Exam (CSE) protocol. The CSE protocol is a plot-based field measurement approach designed to provide information about key stand structural variables such as tree density and tree size class distributions. Field measurements associated with the CSE protocol can be found on the Forest Service's Field Sampled Vegetation (FSVeg) webpage: (http://www.fs.fed.us/nrm/fsveg/index.shtml).

CSE data were extracted from FSVeg and summarized using Microsoft Excel and the freely available statistical software, R, version 3.0.2. Stand structural variables were summarized by stands, units, or projects, depending on the forest. Only live trees were included in the analyses. Seedlings and saplings (defined as trees with a diameter at breast height (DBH) less than five inches) were dealt with separately so that tree density estimates would not be skewed by regeneration responses, especially for aspen. In some cases, aspen was also segregated from conifer species so that treatment effects specific to conifers could be assessed. The general goal of treatments is to reduce conifers in the short term and expand aspen in the long term. Species encountered in the data set are shown in Table 1.

Table 1. Common names, scientific names, and codes of tree species encountered in the CSE data set.

Common name	Scientific name	Code
Rocky Mountain Juniper	*Juniperus scopulorum*	JUSC
Lodgepole Pine	*Pinus contorta*	PICO
Engelmann Spruce	*Picea engelmannii*	PIEN
Limber Pine	*Pinus flexilis*	PIFL
Ponderosa Pine	*Pinus ponderosa*	PIPO
Colorado Blue Spruce	*Picea pungens*	PIPU
Aspen	*Populus tremuloides*	POTR
Douglas-fir	*Pseudotsuga menziesii*	PSME

Results

Pike and San Isabel National Forests – Phantom Creek

Treatments during 2011-2012 on the PSI National Forests were concentrated in an area known as Phantom Creek. Within this area, CSE data were collected before and after treatment on 104 plots covering 20 stands. These stands partially cover Phantom Creek project 1 and completely cover Phantom Creek projects 2 and 3 (Figure 1). An additional 65 plots across 14 stands were sampled after treatment in 2012 in Phantom Creek projects 1 and 2, in order to increase the sample size and to continue experimenting with the sampling design. The relationship between stands, units, and projects is shown in Appendix A.

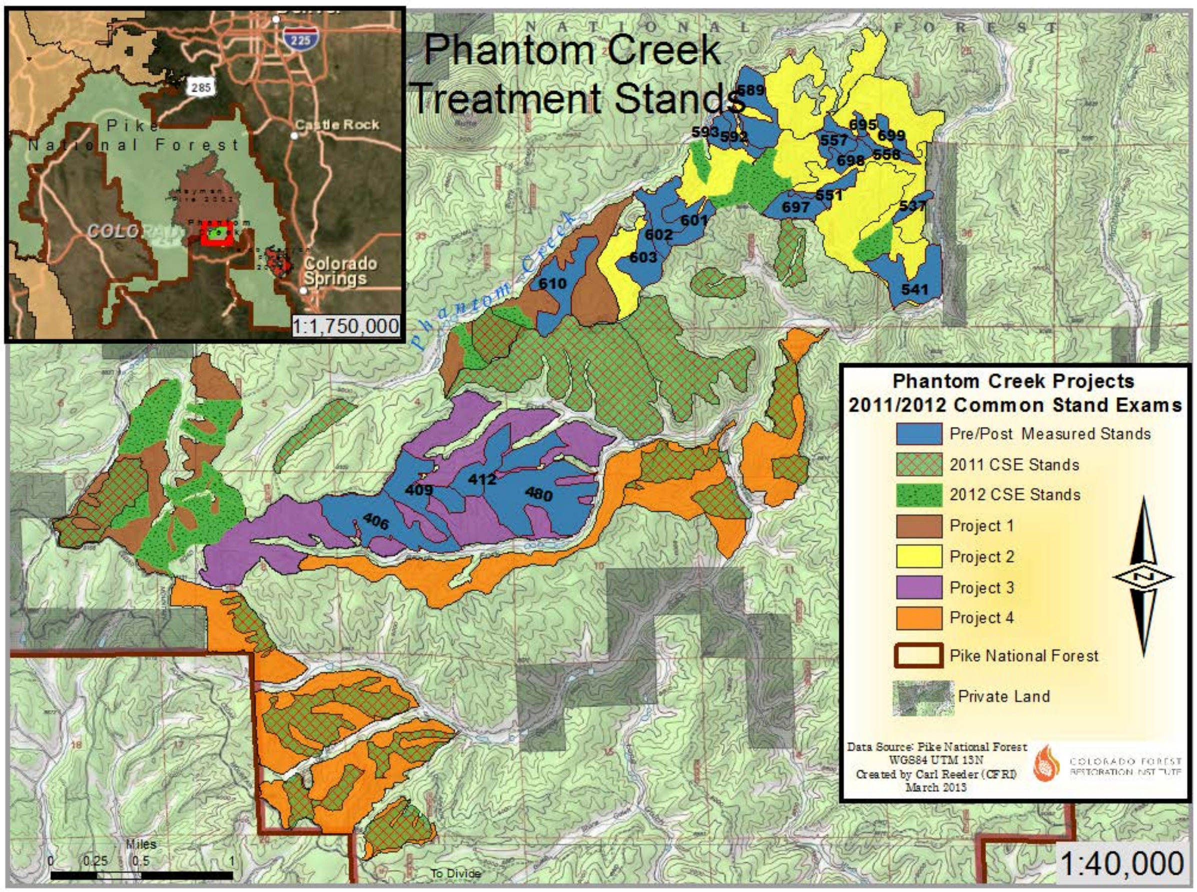

Figure 1. PSI National Forest Phantom Creek projects with pre- and post-treatment data highlighted by stand.

Results across stands in the Phantom Creek projects

Basal area and trees per acre

Across the 20 stands measured before and after treatment in Phantom Creek, basal area decreased by an average 32% and trees per acre decreased by 46% as a result of treatments (Figure 2; Table 2). Conifers represented the majority of the basal area across stands, and conifer basal area decreased an average 31%. Aspen basal area declined 25%. On average, stands had 28 ft^2 per acre of basal area removed and 79 trees per acre removed (Table 2). Stands 541, 589, and 697 had the highest initial basal areas, averaging 122 ft^2 per acre, and saw the greatest reductions to an average basal area of 64 ft^2 per acre. Stands 537, 551, and 558 exhibited very little change as treatments in these stands primarily involved manual as opposed to mechanical thinning and targeted smaller-diameter trees.

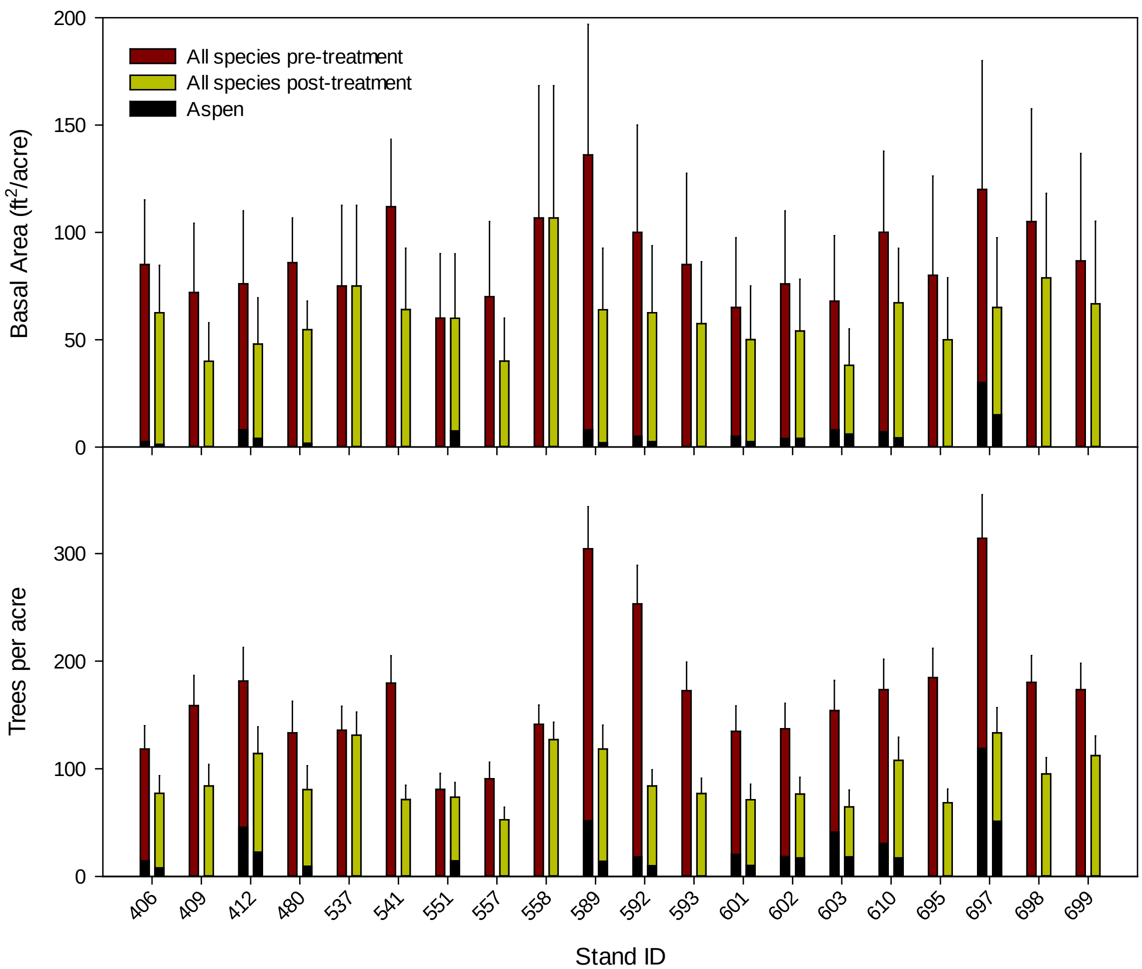

Figure 2. Pre- and post-treatment stand basal area (top panel) and trees per acre (bottom panel) for trees > 5 inches in diameter in the Phantom Creek project area on the PSI National Forest. Pre-treatment values are represented by the red bars while post-treatment values are in yellow. The proportion of aspen in each stand is shown in black.

Table 2. Summary of pre- and post-treatment forest inventory data including the number of plots, stand acres, sample intensity, and live conifer and aspen basal areas for trees greater than 5 inches DBH.

Stands	Plots	Sample acres	Sample intensity (% of project area)	Sample Timing	Total basal area (ft^2/acre)	Conifer basal area (ft^2/acre)	Aspen basal area (ft^2/acre)	Total stems per acre	Conifer stems per acre	Aspen stems per acre
Inventory data with pre- and post-treatment samples										
20	104	666	31	pre-	88	84	4	170	152	18
				post	60	58	3	91	81	10
All post-treatment inventory data										
34	169	945	45	post	55	53	2	82	73	9

Across the Phantom Creek landscape, stand basal areas were reduced by restoration treatments (Figure 3).

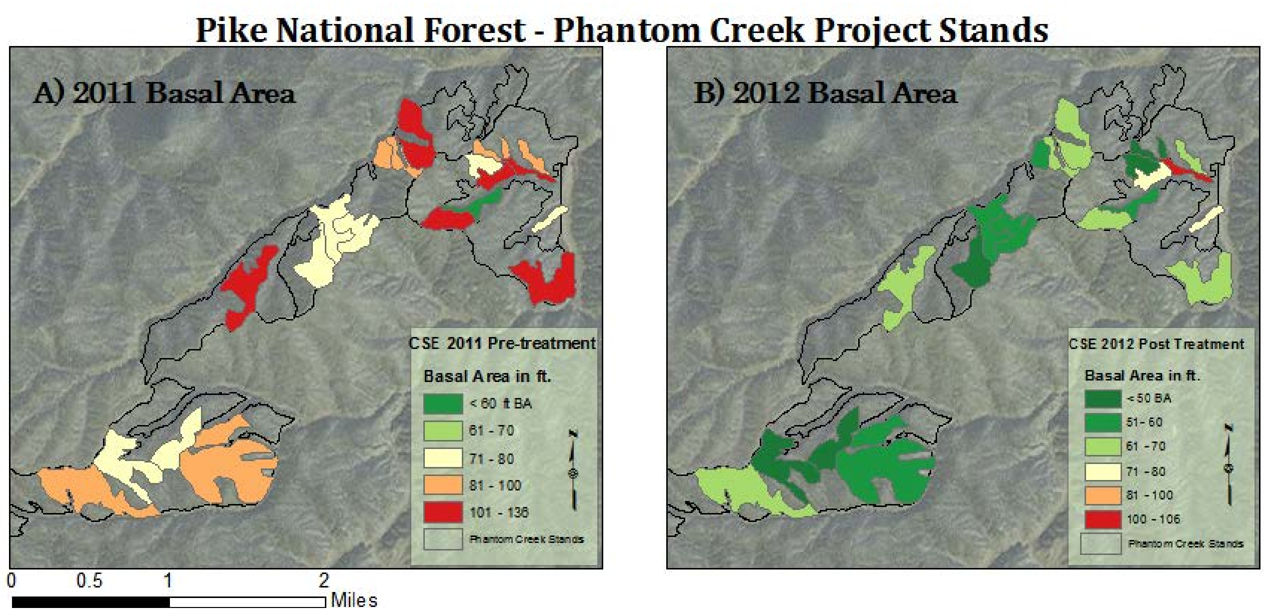

Figure 3. Stand-level change in basal area from (A) pre- to (B) post-treatment within the PSI National Forest Phantom Creek Project.

Species Composition

Across stands, treatments increased the percent composition of ponderosa pine relative to Douglas-fir (Figure 4). Ponderosa pine increased from 52.8% to 59.1% while Douglas-fir decreased from 35.4% to 30.0%.

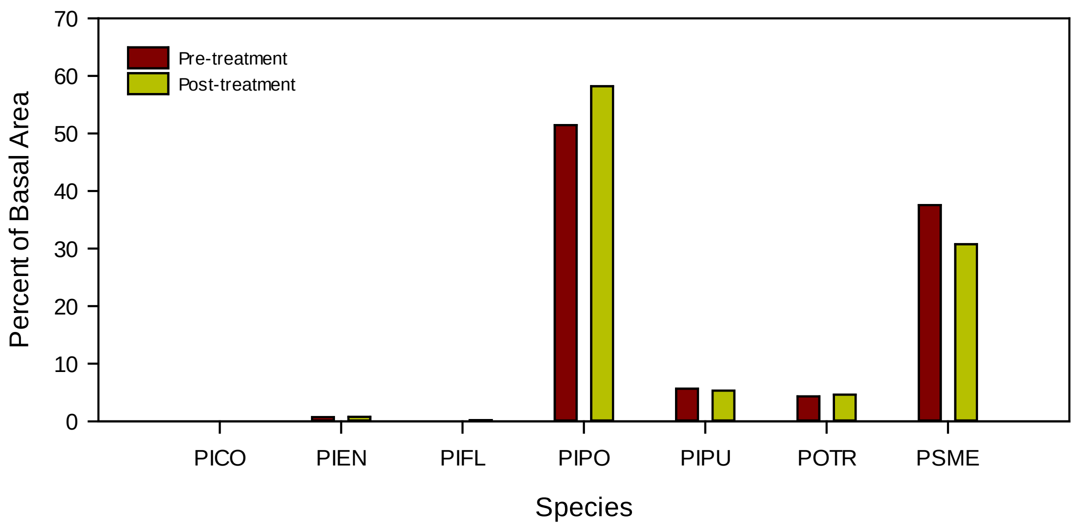

Figure 4. Proportion of each species in basal area for trees > 5 inches in diameter recorded pre and post treatment for all stands on the PSI National Forest. Pre-treatment values are in red and post-treatment in yellow.

Tree sizes

Treatments focused primarily on removal of smaller diameter trees (typically less than 12 inches in DBH), but removal across size classes occurred as well (Figure 5). Across stands, treatments changed the distribution of both basal area and trees per acre by size class. Post-treatment stands are still characterized by a reverse-J distribution, representing more small trees than large trees, but the curve is much less steep post treatment compared to pre-treatment. Aspen made up the majority of the small tree size class (< 2.9 inches in diameter) both before and after treatment. Tree QMD increased across stands from an average 9.9 inches before treatment to 11.0 inches post treatment, reflecting the higher proportion of large trees now making up the basal area and number of trees per acre.

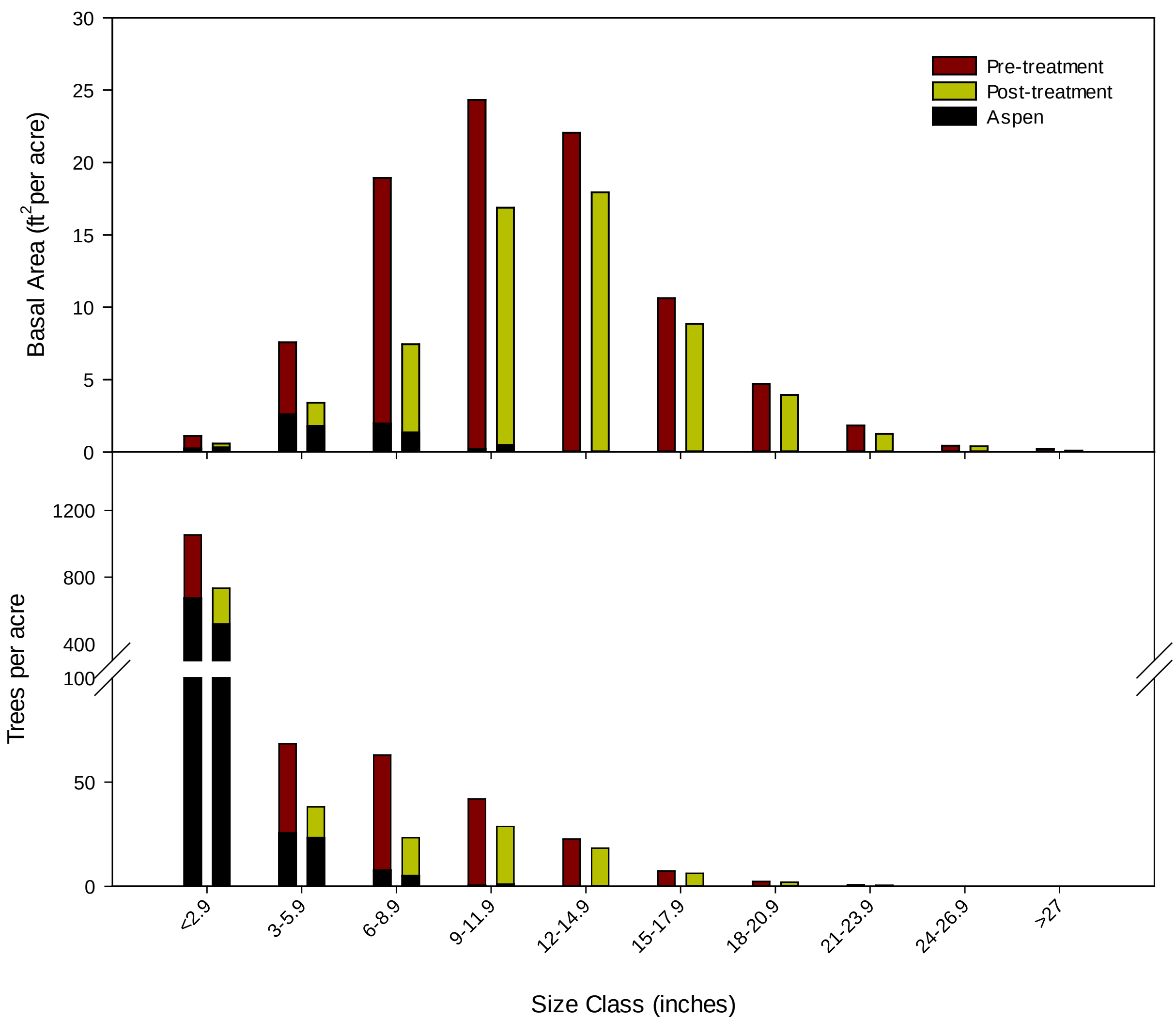

Figure 5. Basal area (top panel) and trees per acre (bottom panel) by tree size class for all stands pre- and post-treatment within the Phantom Creek project area on the PSI National Forest. The proportion of aspen in each size class is shown in black.

Spatial heterogeneity

Plot-to-plot variation in basal area and trees per acre was evaluated as a measure of variability at the stand scale, under the assumption that standard errors from plot to plot should be greater for heterogeneous stands compared to homogenous stands. The standard error for basal area pre and post treatment at the stand level was 41 and 28, respectively (Figure 6). For trees per acre, the pre- and post-treatment standard error was 26 and 18, respectively. Both basal area and tree density were more variable *before* treatment.

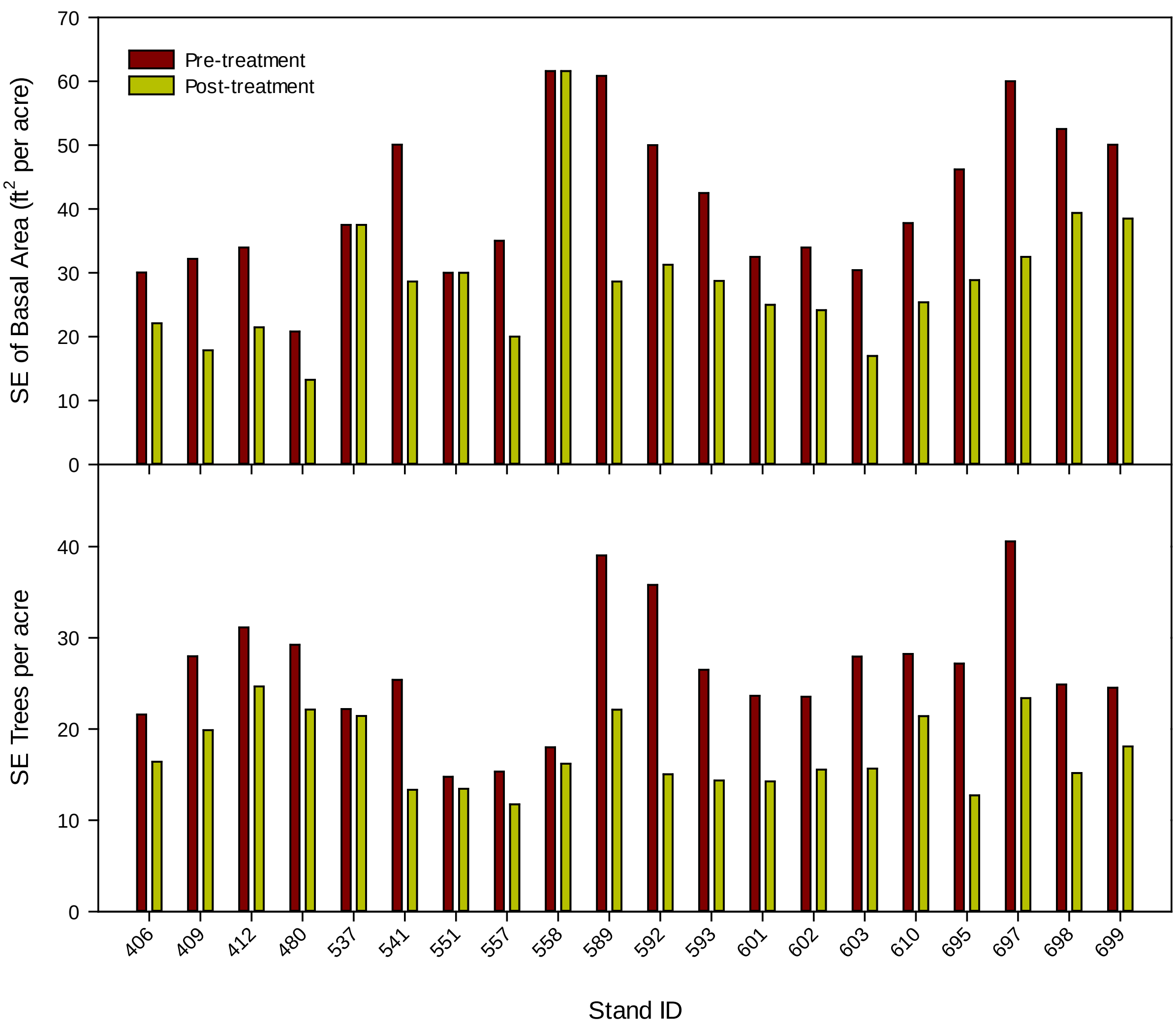

Figure 6. Pre- and post-treatment standard error (SE) of basal area (top panel) and trees per acre (bottom panel) for plot-to-plot variation within stands on the PSI National Forest. Pre-treatment values are shown in red and post-treatment are shown in yellow.

Results at the Unit Scale

Pre- and post-treatment CSE data were also analyzed at the unit level within projects in order to evaluate trends associated with different restoration treatments such as ground-based logging versus manual hand-thinning applied at the unit scale. There were a total of five treatment units across three projects that had stands with pre- and post-treatment CSE plots.

Units 2, 3, 5, and 7 were all treated using ground-based logging and exhibited substantial reductions in both basal area and trees per acre (Table 3). Unit 5A was a manual treatment and showed a more modest reduction in basal area and trees per acre. Similar to stand-level results, QMD increased across units as tree removals focused primarily on smaller diameter trees (Table 3, Figure 7). With the exception of Unit 2 and Unit 5, seedling and sapling densities were substantially reduced from pre to post treatment (Table 3).

Table 3. Mean (± SE) basal area, trees per acre, quadratic mean diameter, and seedlings and saplings per acre for treatment units on the PSI National Forest. The first row for units 2, 3, and 5 represents the pre- to post-treatment comparison among stands for which data was collected both prior to and after treatment, while the second row incorporates the additional stands for which pre-treatment data was not collected.

	Basal area (ft^2 $acre^{-1}$)		Trees $acre^{-1}$		Quadratic Mean Diameter (inches)		Seedlings and Saplings $acre^{-1}$	
Unit	Pre-	Post-	Pre-	Post-	Pre-	Post-	Pre-	Post-
1	--	45(±5)	--	69(±13)	--	11.4	--	2056(±360)
2	100(±11)	67(±10)	174(±27)	108(±18)	10.3	10.7	1357(±123)	1250(±386)
		58(±4)		75(±17)		12.3		1566(±183)
3	89(±8)	54(±4)	193(±28)	82(±7)	9.2	11.0	1028(±185)	546(±125)
		54(±4)		80(±7)		11.2		698(±142)
5	96(±8)	57(±5)	189(±29)	86(±12)	9.7	11.0	500(±166)	500(±259)
		55(±4)		82(±12)		11.3		867(±383)
5A	85(±9)	78(±9)	134(±18)	105(±13)	10.8	11.7	1000(±349)	450(±204)
7	80(±6)	52(±4)	137(±17)	83(±12)	10.3	10.7	1451(±274)	1097(±251)

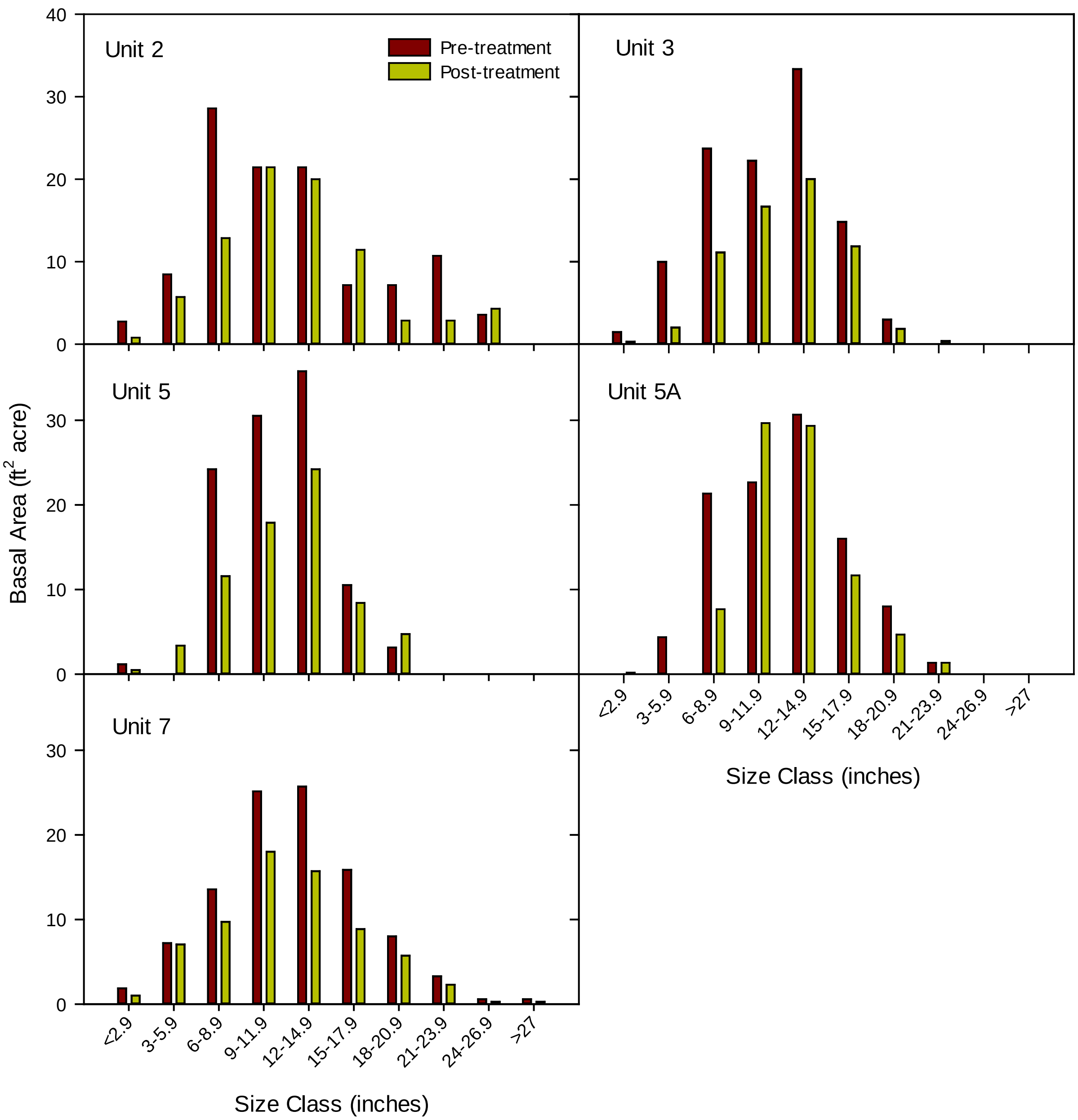

Figure 7. Basal area by tree size class for treatment units on the PSI National Forest. Units include: Unit 2(top left), Unit 3(top right), Unit 5(middle left), Unit 5A (middle right), and Unit 7(bottom left).

Species compositional data at the unit level generally mirrored the stand-level trends as well. The proportion of ponderosa pine increased in all units whereas the proportion of Douglas-fir decreased (Table 4). A high proportion of aspen made up the seedling and sapling size class, especially for Units 2 and 7.

Table 4. Pre- and post-treatment tree species percent composition for basal area, trees per acre, and seedling & sapling trees per acre for treatments units on the PSI National Forest. The values in parentheses for units 2, 3, and 5 include the additional stands that were sampled in 2012 that did not contain pre-treatment data.

Species	Pre-Treatment			Post-Treatment		
	% Basal area	% Trees acre^{-1}	% Seedling & saplings acre^{-1}	% Basal area	% Trees acre^{-1}	% Seedling & saplings acre^{-1}
Unit 1						
PICO	--	--	--	0	0	0
PIEN	--	--	--	3	2	3
PIFL	--	--	--	2	2	0
PIPO	--	--	--	60	57	2
PIPU	--	--	--	2	1	2
POTR	--	--	--	7	19	83
PSME	--	--	--	26	19	10
Unit 2						
PICO	0	0	0	0	0	0
PIEN	0	0	0	0	0	0
PIFL	0	0	0	0	0	0
PIPO	29	30	8	43 (46)	38 (44)	0
PIPU	11	23	3	13 (4)	20 (7)	0 (7)
POTR	7	18	76	6 (5)	16 (10)	83 (74)
PSME	54	30	13	38 (44)	25 (39)	17 (19)
Unit 3						
PICO	0	0	0	0	0	0
PIEN	3	1	1	3 (14)	2 (5)	0
PIFL	0	0	0	0	0	0
PIPO	48	49	8	54 (45)	52 (46)	7 (5)
PIPU	3	1	4	3 (3)	3 (2)	0
POTR	6	14	49	5 (6)	15 (11)	58 (57)
PSME	41	35	39	35 (34)	28 (33)	36 (38)
Unit 5						
PICO	0	0	0	0	0	0
PIEN	0	0	0	0	0	0
PIFL	0	0	0	0	0	0
PIPO	67	64	11	71 (74)	66 (72)	3 (11)
PIPU	0	0	0	0	0	0 (1)
POTR	7	13	32	6 (3)	12 (5)	53 (43)
PSME	26	23	58	24 (23)	22 (23)	45 (45)
Unit 5A						
PICO	0	0	0	0	0	0
PIEN	0	0	0	0	0	0
PIFL	0	0	0	0	0	0
PIPO	66	58	3	70	69	0
PIPU	0	0	0	0	0	0
POTR	0	0	52	3	4	33
PSME	34	42	45	27	27	67
Unit 7						
PICO	1	1	0	1	1	0
PIEN	1	1	0	1	1	0
PIFL	1	0	0	1	2	0
PIPO	48	50	8	53	54	5
PIPU	15	18	5	11	9	3
POTR	2	7	77	3	11	83
PSME	33	24	10	29	22	9

Pike and San Isabel National Forests – Ryan Quinlan

The Ryan Quinlan project area on the PSI National Forest was also treated during 2011-2012, however only post-treatment CSE data were available for this area. The project area contained 35 plots distributed across nine stands. Post-treatment basal area and trees per acre are within a desirable range, averaging 46 ft^2 per acre and 65 trees per acre across stands (Figure 8).

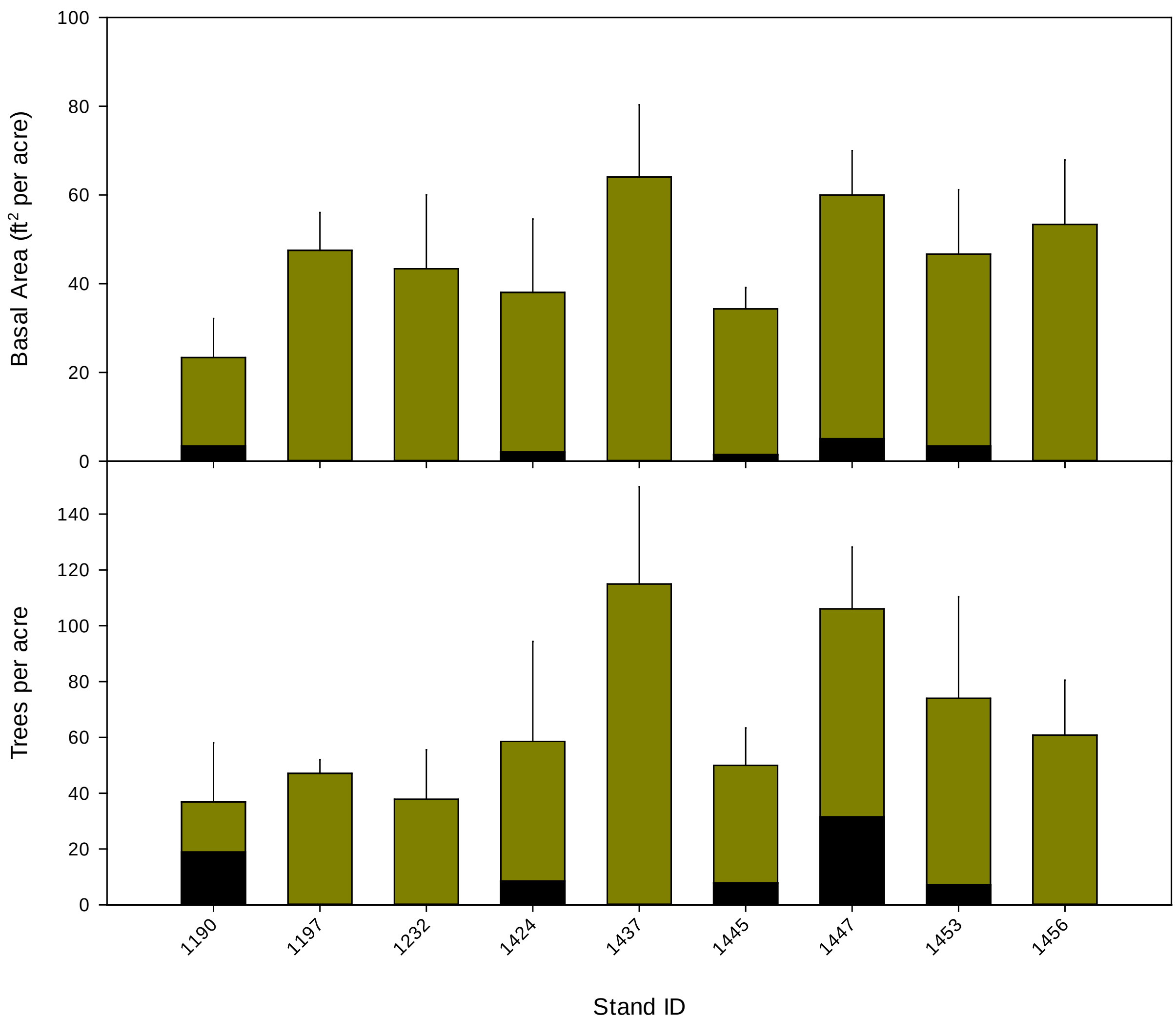

Figure 8. Post-treatment stand basal area (top panel) and trees per acre (bottom panel) for trees > 5 inches in diameter within the Ryan Quinlan project area on the PSI National Forest. The proportion of each stand in aspen is represented by the nested black bars.

Large trees (> 12 inches in diameter) make up a large proportion of the basal area across stands (Figure 9). Aspen makes up a large proportion of the small tree size class (< 2.9 inches in diameter) across stands after treatment.

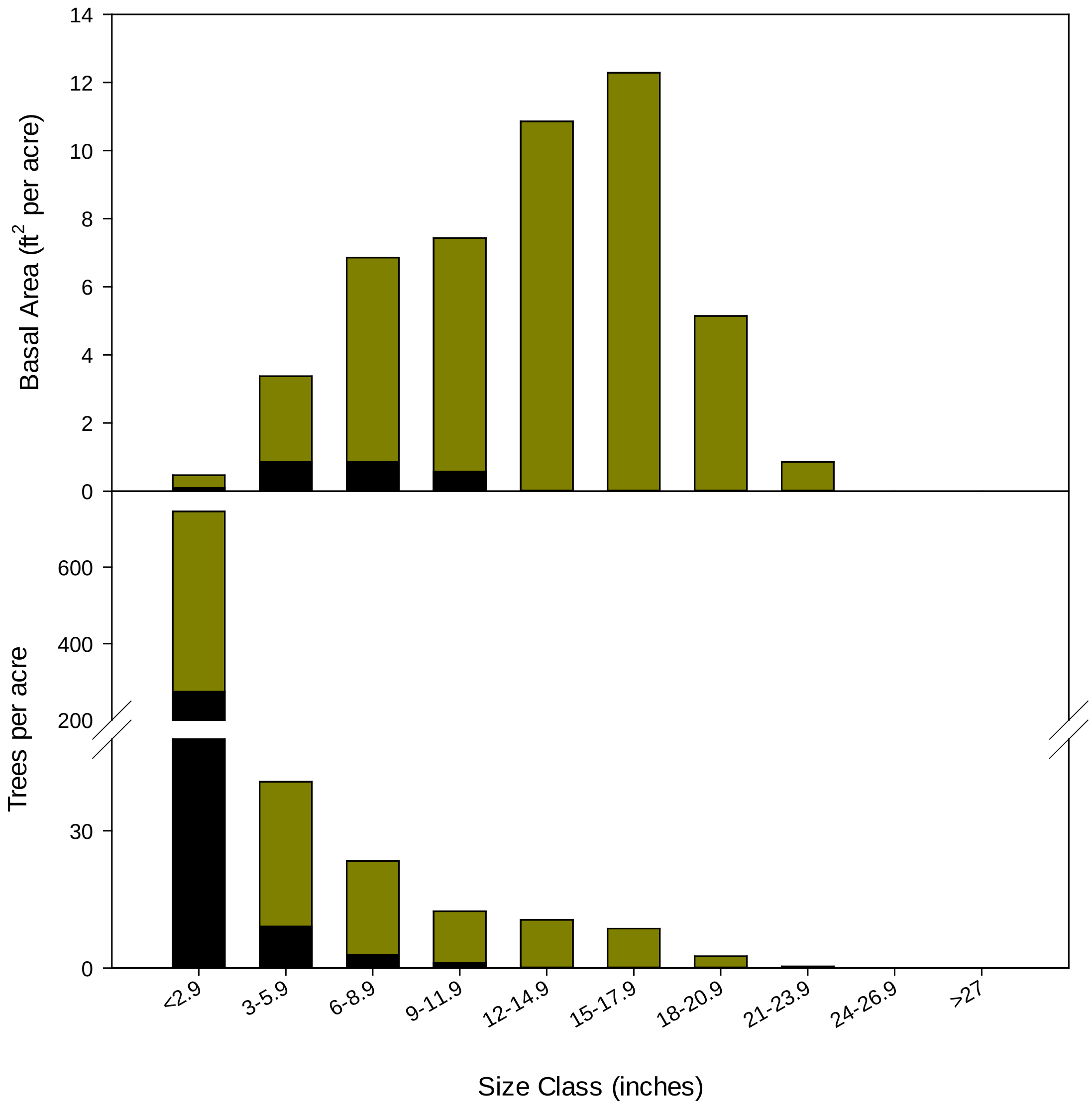

Figure 9. Post-treatment basal area (top panel) and trees per acre (bottom panel) by tree size class for stands within the Ryan Quinlan project area on the PSI National Forest. The proportion of aspen within each size class is represented by the nested black bars.

Arapaho and Roosevelt National Forests

Six project areas have undergone treatment on the AR National Forest: Red Feather, Estes Valley, Thompson River, Walker Red, Walker Black and Taylor Mountain (Figure 10). Red Feather was not included in the analysis because the treatments were recently applied and post-treatment data were not yet available at the time this report was compiled. Pre- and post-treatment data for the AR were organized by project rather than by unit or stand, and thus the analysis differed slightly from the PSI with less emphasis on stand-level results. There were a total of 315 plots for which CSE data was collected pre-treatment and 304 plots collected post-treatment.

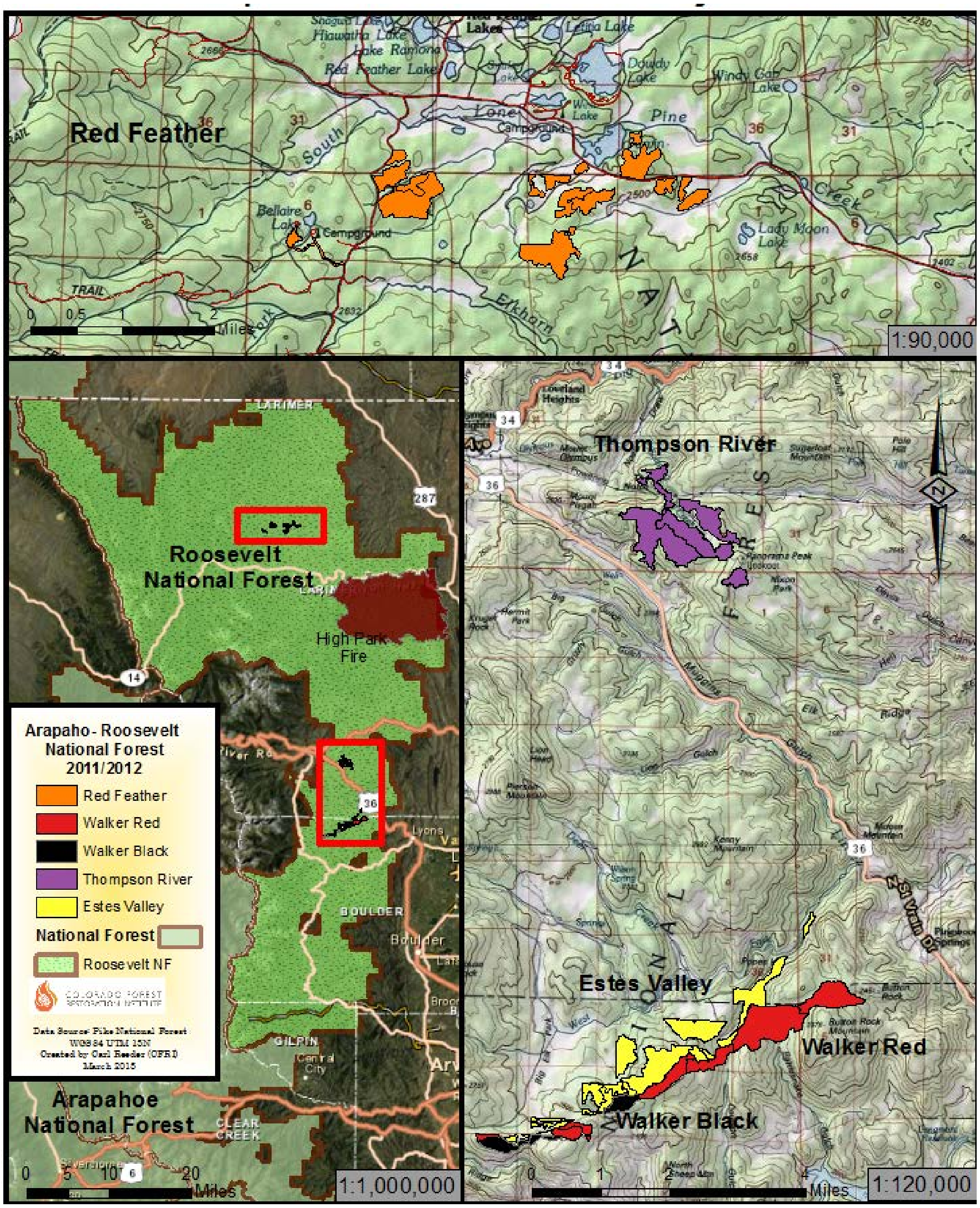

Figure 10. AR National Forest projects. Note: spatial data for Taylor Mountain was not available.

Basal area and trees per acre

Across all projects, basal area decreased by an average 25% from 69 ft^2 per acre prior to treatment to 52 ft^2 per acre following treatment (Figure 11). Taylor Mountain and Estes Valley saw the overall largest decreases in basal area, with approximately 22 ft^2 per acre removed for each of these projects. Tree density decreased as well across projects by 39% from an average 148 trees per acre pre-treatment to 90 trees per acre following treatment. On average, 58 trees per acre were removed across projects. Very few aspen greater than 5 inches in diameter were recorded across projects.

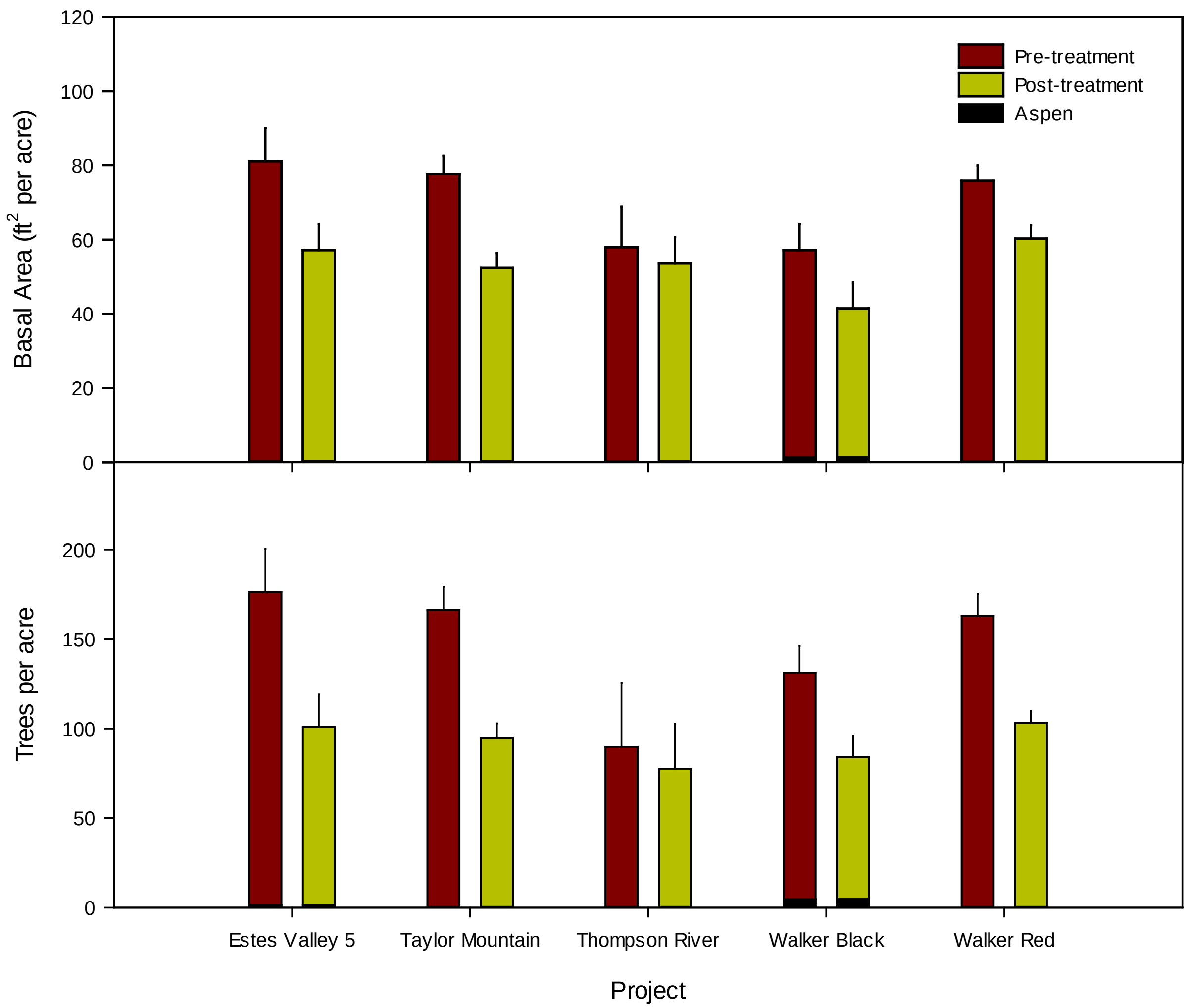

Figure 11. Pre- and post-treatment basal area and trees per acre for trees > 5 inches in diameter by project on the AR National Forest. Pre-treatment values are in red and post-treatment in yellow. The proportion of aspen in each project area is represented by the nested black bars.

Stand basal areas were generally reduced by restoration treatments across the AR landscape (Figure 12), though little change was observed for Thompson River.

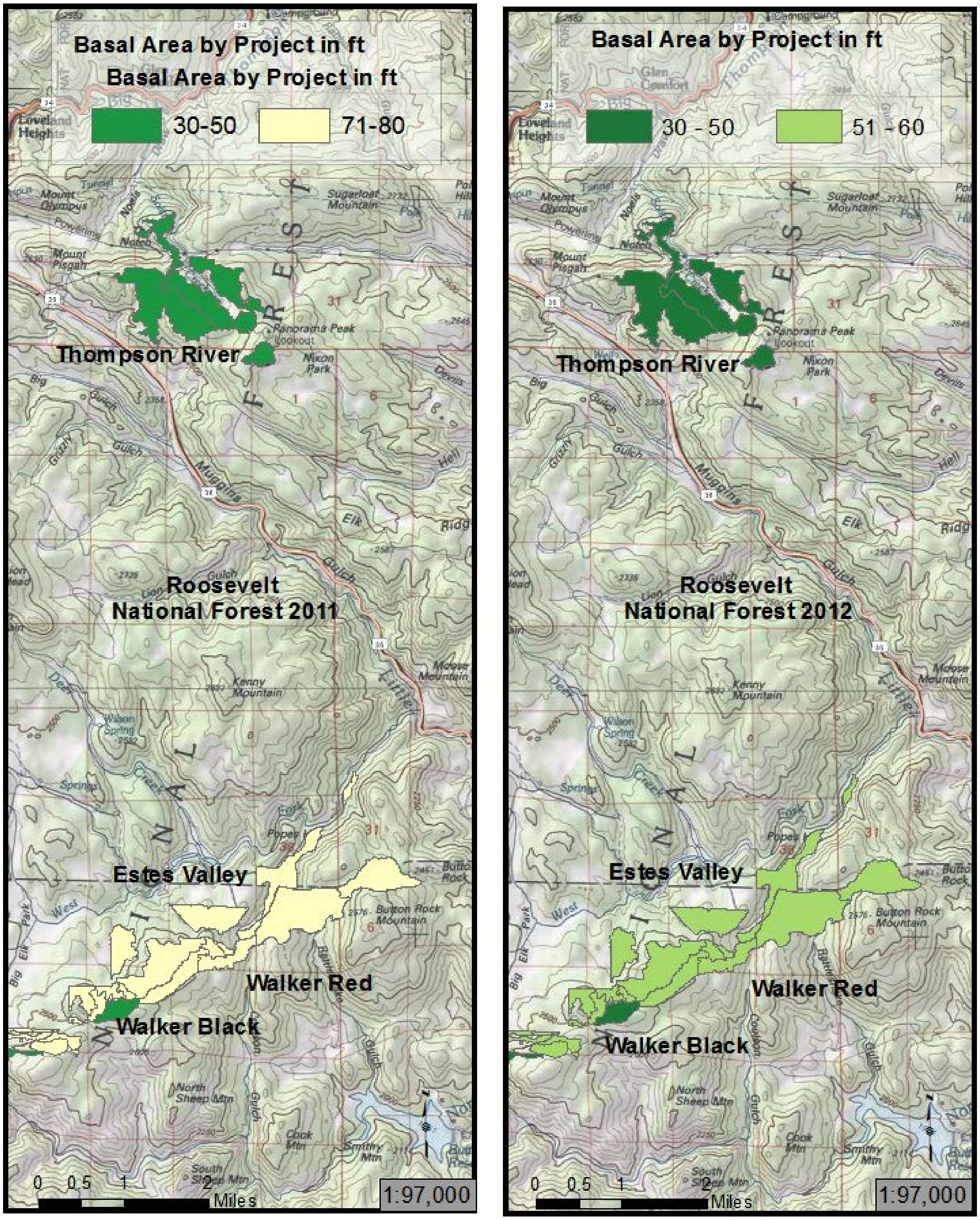

Figure 12. Change in basal area at the project level from pre- to post-treatment for projects on the AR National Forest.

Species Composition

In terms of basal area, percent composition of ponderosa pine increased across projects from 47% before treatment to 52% after treatment (Figure 13). Douglas-fir increased as well from 25% to 28%. These increases were balanced by a decrease in lodgepole pine from 23% to 16%. The seedling and sapling size class contained mostly Douglas-fir, aspen, and ponderosa pine. Young aspen benefited the most from restoration treatments. Within-project trends are shown in Table 5.

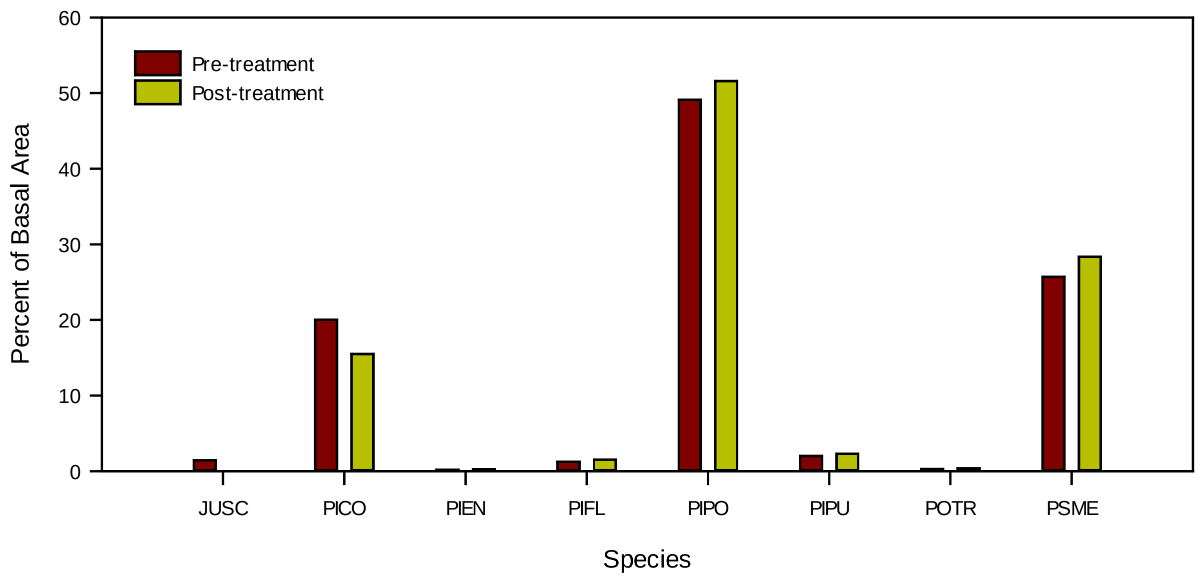

Figure 13. Species percent composition of basal area for trees > 5 inches in diameter recorded pre- and post-treatment across projects on the AR National Forest. Pre-treatment values are in red and post-treatment in yellow.

Table 5. AR National Forest projects pre- and post-treatment species composition by basal area, trees per acre, and seedlings and saplings.

Species	Pre-Treatment			Post-Treatment		
	% Basal area	% Trees acre^{-1}	% Seedlings & saplings acre^{-1}	% Basal area	% Trees acre^{-1}	% Seedling & saplings acre^{-1}
Walker Black						
JUSC	0	0	5	0	0	0
PICO	12	14	3	7	14	0
PIEN	2	1	0	3	1	0
PIFL	2	1	0	3	2	0
PIPO	51	41	20	52	40	12
PIPU	0	0	0	0	0	0
POTR	2	4	16	3	6	34
PSME	29	40	56	31	38	54

Table 5 continued.						
Walker Red						
JUSC	2	4	3	0	0	1
PICO	20	24	5	20	24	1
PIEN	0	0	0	0	1	0
PIFL	1	1	1	1	2	1
PIPO	46	37	18	48	39	16
PIPU	2	1	0	2	1	0
POTR	0	0	31	0	0	46
PSME	29	33	41	29	34	34
Taylor Mountain						
JUSC	2	1	0	0	0	0
PICO	14	23	3	15	29	2
PIEN	0	0	1	0	0	2
PIFL	2	2	6	2	4	6
PIPO	70	62	10	63	47	8
PIPU	0	0	0	0	0	0
POTR	0	0	67	0	0	73
PSME	14	11	14	20	19	11
Thompson River						
JUSC	0	0	1	0	0	1
PICO	15	21	32	12	19	15
PIEN	0	0	0	0	0	0
PIFL	15	18	9	14	18	11
PIPO	51	46	23	53	47	21
PIPU	0	0	0	0	0	0
POTR	0	0	7	0	0	20
PSME	20	14	29	22	16	32
Estes Valley 5						
JUSC	1	2	2	0	1	3
PICO	23	26	9	12	16	3
PIEN	0	0	0	0	0	0
PIFL	0	0	0	0	0	0
PIPO	48	42	23	53	45	21
PIPU	3	3	1	4	4	1
POTR	0	1	14	1	1	24
PSME	24	26	52	30	34	47

Tree Sizes

Tree removal was concentrated in smaller-diameter size classes across and within projects (Figures 14a, 14b). Trees greater than 12 inches in diameter were generally retained. Aspen made up a high proportion of the small tree size class (< 2.9 inches in diameter) both before and after treatment.

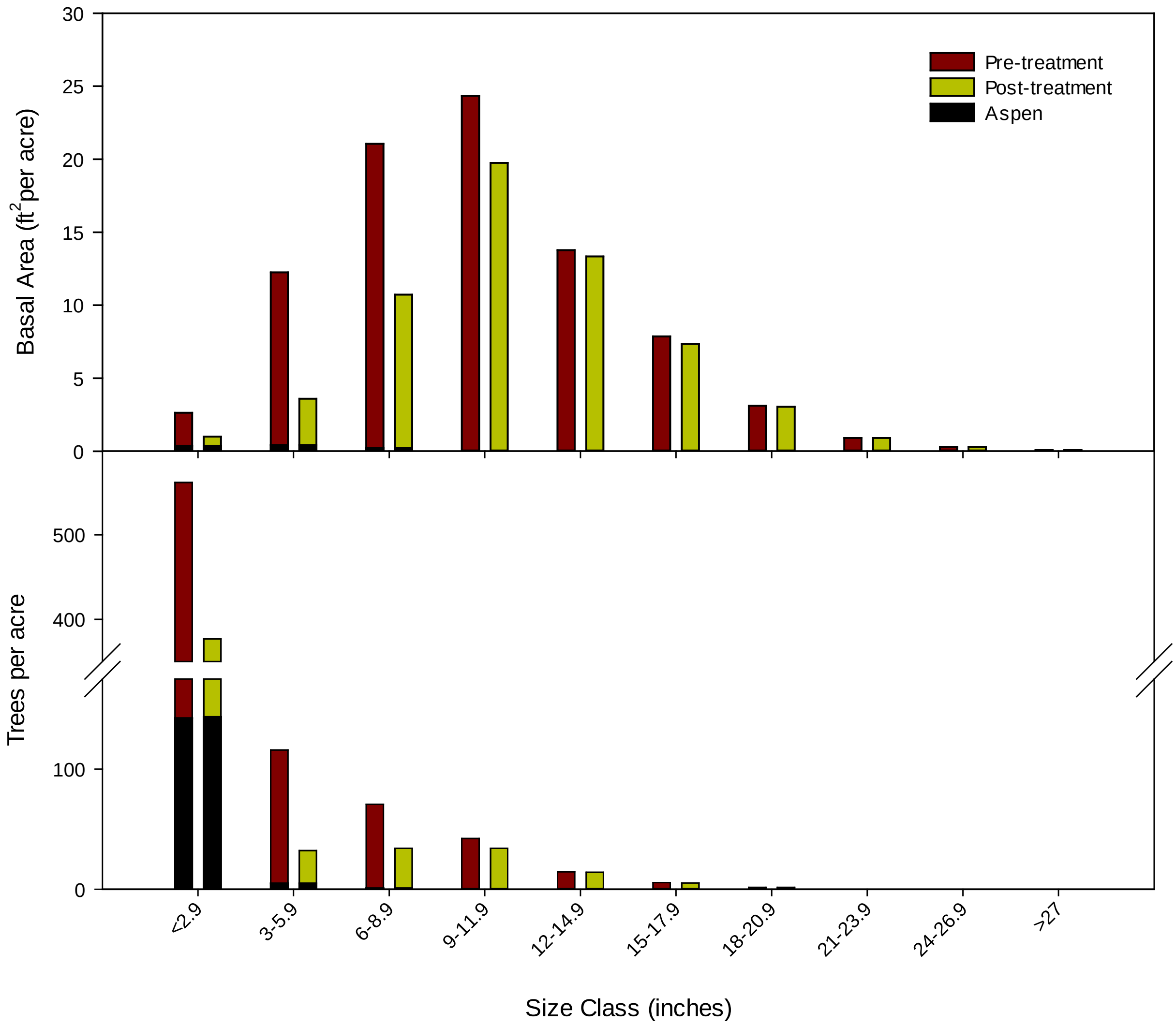

Figure 14a. Basal area (top panel) and trees per acre (bottom panel) by tree size class across projects pre- and post-treatment on the AR National Forest. The proportion of aspen in each project area is represented by the nested black bars.

Quadratic mean diameter increased from 9.0 inches prior to treatment to 10.3 inches after treatment across projects (Table 6) as a result of small tree removal.

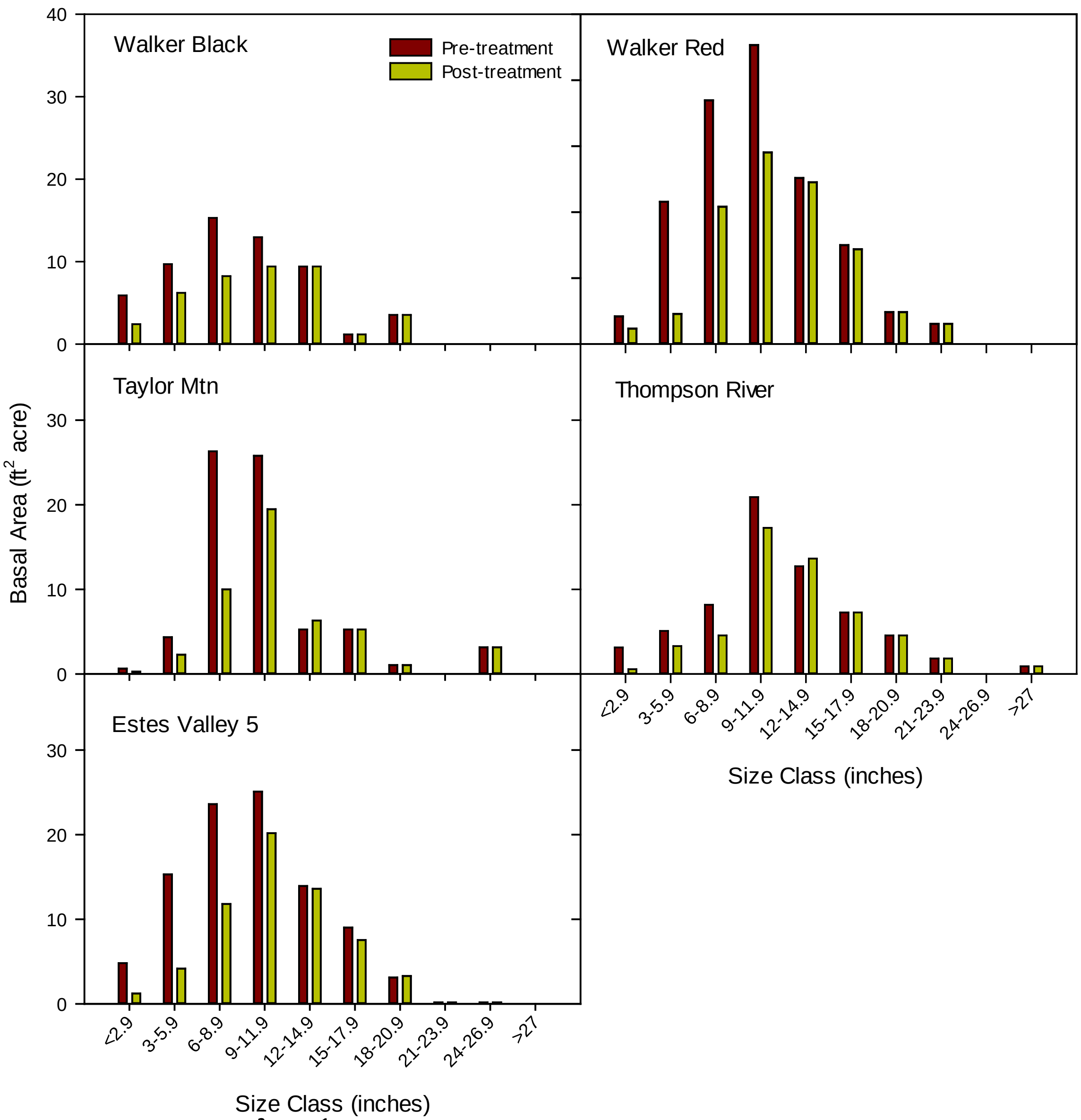

Figure 14b. Basal area (ft^2 acre^{-1}) by tree size class for each project on the AR National Forest, including Walker Black (top left), Walker Red (top right), Taylor Mountain (middle left), Thompson River (middle right), and Estes Valley 5(bottom left).

Table 6. Quadratic mean diameter (inches) pre- and post-treatment by project on the AR National Forest.

	Quadratic Mean Diameter (inches)	
Project	Pre-	Post-
Walker Black	9.0	9.5
Walker Red	9.2	10.3
Taylor Mountain	9.2	10.1
Thompson River	10.8	11.2
Estes Valley 5	9.2	10.2
Total	**9.2**	**10.3**

Summary and Next Steps

For both the PSI and AR National Forests, there were decreases in basal areas and trees per acre associated with restoration treatments across projects, consistent with desired trends expressed in the FR-CFLRP's monitoring plan. Tree removals were concentrated in smaller-diameter size classes on both forests, resulting in higher quadratic mean diameters and a more balanced size class distribution following treatment. Species composition generally showed a shift toward ponderosa pine over other conifers, although Douglas-fir increased in percent composition on the AR. This trend should be evaluated further for the AR to determine if more Douglas-fir is being retained than is desirable, especially given the regeneration capabilities of this species and its potential for capturing sites following treatments.

The CSE data could not be used to determine trends in tree age class distributions before and after treatments as tree ages are not included in the data set. Large tree retention is generally practiced on both forests, however, and likely captures most of the old trees present prior to treatment. Whether or not more information for tree age class distributions pre and post treatment is desired should be discussed by the FR-CFLRP. The CSE protocol is also not designed to adequately assess stand- or landscape-scale spatial heterogeneity. Other methods are being explored by the FR-CFLRP for this assessment.

Next steps should include incorporating additional methodologies for assessing spatial heterogeneity and integration with other monitoring efforts addressing Tier 2 variables, such as that being conducted under the Southern Rockies Landscape Conservation Cooperative. Additional work is also needed to better describe the FR-CFLRP's process for using monitoring data in the context of adaptive management. While monitoring data are presented here in the context of desired conditions, there is a need to better define how the collaborative collectively determines whether progress toward desired conditions is being achieved.

Establishing a template or standard reporting method should also be considered by the FR-CFLRP. Determining how best to present the data so that it is interpretable by a wide audience is important. Appendix C includes some instruction on how the data were summarized for this report in an effort to standardize the analysis and reporting methods and make the process easier in subsequent years. Consistency between forests in the scale of data presentation (i.e. stand-level vs. project-level) may be desirable as well and should be discussed by the CFLRP.

Appendices

Appendix A. Relationship of stands to units to projects for the Pike and San Isabel National Forests. Also included are stand acres and stand physiographic information.

Stands with both pre- (2011) and post- (2012) treatment data

Project	Unit	Stand ID	Acres	Elevation (ft)	Aspect	Slope (%)
Phantom Creek 1	2	610	49.5	8911	NW	11
Phantom Creek 2	3	589	42.6	8744	WE	14
Phantom Creek 2	3	592	12.5	8729	NW	11
Phantom Creek 2	3	593	11.1	8699	NW	13
Phantom Creek 2	3	601	29.5	8803	NE	12
Phantom Creek 2	3	602	33.2	8829	NO	14
Phantom Creek 2	3	603	32.0	8908	WE	9
Phantom Creek 2	5	541	50.6	8480	EA	17
Phantom Creek 2	5	557	14.7	8599	SE	13
Phantom Creek 2	5	695	10.3	8601	EA	11
Phantom Creek 2	5	697	24.1	8723	NO	17
Phantom Creek 2	5	699	9.7	8526	NE	9
Phantom Creek 2	5A	537	8.5	8403	EA	18
Phantom Creek 2	5A	551	13.9	8593	NO	20
Phantom Creek 2	5A	558	9.0	8477	SE	11
Phantom Creek 2	5A	698	14.5	8516	SE	16
Phantom Creek 3	7	406	78.8	9080	SO	9
Phantom Creek 3	7	409	54.5	9055	EA	9
Phantom Creek 3	7	412	34.1	9001	SE	10
Phantom Creek 3	7	480	132.9	8924	EA	10

Stands with post- (2012) treatment data only

Project	Unit	Stand ID	Acres	Elevation (ft)	Aspect	Slope (%)
Phantom Creek 1	2	614	9.6	8935	NO	11
Phantom Creek 1	2	616	15.6	8946	NW	10
Phantom Creek 1	1	668	14.6	9045	WE	12
Phantom Creek 1	1	669	14.0	9053	NW	11
Phantom Creek 1	1	676	23.8	9078	SO	11
Phantom Creek 1	1	678	68.0	9122	NW	10
Phantom Creek 1	1	681	16.4	8905	EA	10
Phantom Creek 1	1	682	21.3	8954	EA	10
Phantom Creek 1	1	683	7.8	8984	NW	10
Phantom Creek 1	1	688	12.4	9079	EA	12
Phantom Creek 2	5	536	18.2	8607	NO	17
Phantom Creek 2	5	552	30.6	8756	EA	15
Phantom Creek 2	3	596	16.7	8810	NW	7

Appendix A cont'd.

Phantom Creek 2	3	598	9.7	8673	NE	10
Ryan Quinlan	4/5	1190	22.3	8491	SE	8
Ryan Quinlan	10	1197	18.9	8082	NE	5
Ryan Quinlan	7/8/11	1232	27.3	8223	EA	10
Ryan Quinlan	7/8	1424	24.2	8325	NE	10
Ryan Quinlan	5	1437	25.5	8444	NE	6
Ryan Quinlan	3	1445	39.5	8529	SE	9
Ryan Quinlan	2/3	1447	11.7	8510	NE	7
Ryan Quinlan	1	1453	17.6	8623	SE	11
Ryan Quinlan	1	1456	12.0	8580	SO	9

Appendix B. Selected permanent photopoints from the Pike and San Isabel National Forest depicting pre-treatment (2011, on left) and post-treatment (2012, on right) conditions. Compiled by Yvette Dickinson (CFRI, CSU) and Ed Biery (PSI-NF).

406_1: Small aspen on left in foreground of pre-treatment photo aligns with small aspen in middle of post-treatment photo. Opening up of stand understory in both foreground and background, but maintaining small aspen. Some soil disturbance; however, this is immediately post-treatment and understory plants are expected to recolonize in the next few years.

412_2: Note the opening up of the stand by removing trees on the left hand side of the photos, while retaining a clump in the foreground on the right.

412_5: Note seedling on right aligns in each photo. Stand opened up by removing large trees. No soil disturbance in foreground.

480_1: Some areas within treatment areas were left undisturbed, with no change between pre- and post-treatment. Note that this is the same stand as below.

480_5: Opening up of the stand by removing trees in middle of photo. Note the use of coarse woody debris post treatment to close the skid trail and prevent the use of this trail by all-terrain vehicles (ATVs).

558_2: Opening up of stand in background on right, with removal of encroaching conifers around aspens and opening. Note the protection of the recreation trail on left of photo.

589_04: Note that the CWD on the right hand side of each photo align. Stand has been opened up by thinning small trees and regeneration. The crest of the hill is now visible in background.

601_2: Dramatic change, opening up the stand by removing smaller trees. Note the level of soil disturbance; however, this is immediately post-treatment and understory vegetation is expected to recolonize the site in the next few years. Note the increased visibility of rocky outcrop in background.

610_02: Opening up of stand on right hand side of photos, but retaining clump of trees (left of pre-treatment photo, middle of post-treatment photo). Some light thinning of clump. Disturbance of soil in foreground is minimal, with some additional coarse woody debris.

697_3: Note that the conifer branch on far left, and aspen on right align. This is an example of opening up of the stand while retaining medium sized aspen.

697_3: Same stand as above. Coarse woody debris next to pink flag in foreground, and small aspen on left align in both photos. Note the removal of clump of trees at top in pre-treatment photo. Also note the opening up of the stand in background post-treatment. Soil disturbance is moderate to low.

Appendix C. Steps to reproduce the CSE data summary and analyses performed in this report.

1. Export Treeinit table from Access database as an excel file
2. Export Plotinit table from Access database as an excel file
3. Identify the plot level unit and the stand level unit using the plotinit table
4. Count the number of plots per stand/project in plotinit table
    a. In Pivot table STAND_ID as row label, Count of PLOT_ID for Values
5. Create a new column in the treeinit table and classify plots to specific stands/projects table
6. Create a new column in the treeinit table to calculate BA per tree (=0.005454*(diameter)^2)
7. Create a new column in the treeinit table to calculate BA per acre per tree (=BA per tree*Tree count)
8. Insert Pivot table in another sheet in the TreeInit file
9. Get the BA and TPA by plot
    a. Make sure to check the option to include plots with no data
    b. Filter by diameter (>5.0) and history (live trees = 1)
10. Get the Seedling and Sapling TPA by changing the diameter filter
11. Get the BA and TPA by species
    a. Remove plots from the Row labels and add SPECIES
    b. Make sure to check the option to include records with no data
12. Get the Seedling and Sapling TPA for SPECIES by changing the diameter filter
13. Calculate the average, standard deviation and standard error. Also calculate proportion for Tree Species.

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The Colorado Forest Restoration Institute (CFRI) was established in 2005 as an application-oriented program of the Department of Forest & Rangeland Stewardship in the Warner College of Natural Resources at Colorado State University. CFRI's purpose is to develop, synthesize, and apply locally-relevant science-based knowledge to achieve forest restoration and wildfire hazard reduction goals in Colorado and the Interior West. We do this through collaborative partnerships involving researchers, forest land managers, interested and affected stakeholders, and communities. Authorized by Congress through the Southwest Forest Health and Wildfire Prevention Act of 2004, CFRI is one of three Institutes comprising the Southwest Ecological Restoration Institutes, along with centers at Northern Arizona University and New Mexico Highlands University.

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