Rio Lucero Forest Monitoring Subcontract

Forest Monitoring Report, Fall 2021

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EXHIBIT E: Monitoring Protocols and Data Pertaining to Monitoring Requirements

Contents

Monitoring Protocols

The Taos SWCD student forest monitoring crew followed the monitoring requirements of the contract using these three protocols provided by the New Mexico Forest and Watershed Restoration Institute (NMFWRI):

1. Basic Plot Description with plot photos
2. Common Stand Exam (CSE)
3. Surface Fuels (course and fine woody material, litter, duff, and vegetation)

The field data sheets that we used are available at this link, Basic_plot_forms_2018_km_detailed_descriptions, and the guiding protocol instructions at this link, Protocols_and_datasheets_2018revisions.

Description of Treatment Area

The project treatment area that was designated for forest monitoring ranges in elevation from 8250 to 9400 feet. Our monitoring plots were distributed through the thinning region in a manner to represent 4 distinct thinning areas: Cañoncito; Waterfall; middle bench; and upper bench. Thinning areas were further characterized as riparian or upland based on the presence/absence of riparian tree or shrub species such as cottonwood, willow, mountain alder, and red-osier dogwood. Table 1 below illustrates the diversity of monitoring plots and the range of forest conditions found within El Salto de la Agua Association land.

Table 1. Monitoring Plot Descriptions

Plot	Vegetation Type	Elevation (ft)	Max Slope (%)	Aspect (slope face)	Woody Plant Density (plants/ac)	Canopy Cover (%)
1	Semi-riparian	8397	53	NW	800	60
2	riparian / ephemeral	8342	60	W	540	85
3	riparian / perennial stream	8257	2	W	1200	85
4	riparian / perennial stream	8389	25	NW	820	76
5	upland	8937	35	N	450	42
6	upland	8932	52	S	520	14
7	upland	8964	22	E	410	69
8	upland	9428	13	S	290	64
9	upland	9379	46	S	420	65
10	upland	8431	45	W	680	67
ALL PLOTS	4 streamside or moist environment: 6 dry upland	8257' - 9428'	35% avg	mixed	636 plants / acre	63%

Figure 1. Project area map with the layout of monitor plots withing the four different thinning regions. The southern-most thinning area is situated alongside the perennial Cañoncito Creek where monitoring plots 3 and 4 are located.

Woody Plant Diversity

The diversity of woody plant species in the El Salto section of the project area is shown in the table below. It is considerably more diverse in comparison to the piñon-juniper and ponderosa forest types being managed in other regional thinning projects. This species list is a compilation of any vegetation recorded during any of the three monitoring protocols and at any of the 10 monitoring plots. Exact identification of six shrub species (grey shading) is pending further review.

Table 2. Woody species diversity in project area

Common Name	Scientific name	Plant Type	Plant Growth	Identification Status
white fir	*Abies concolor*	*tree*	coniferous	confirmed
juniper tree	*Juniperus spp.*	*tree*	coniferous	confirmed
piñon pine	*Pinus edulis*	*tree*	coniferous	confirmed
limber Pine	*Pinus flexilis*	*tree*	coniferous	confirmed
ponderosa pine	*Pinus ponderosa*	*tree*	coniferous	confirmed
blue spruce	*Pinus pungens*	*tree*	coniferous	confirmed
narrowleaf cottonwood	*Populus angustifolia*	*tree*	deciduous	confirmed
quaking aspen	*Populus tremuloides*	*tree*	deciduous	confirmed
Douglas fir	*Pseudotsga menziesii*	*tree*	coniferous	confirmed
Rocky Mountain maple	*Acer glabrum*	*tall shrub / multi-stem tree*	deciduous	confirmed
mountain alder	*Alnus incana*	*tall shrub / multi-stem tree*	deciduous	confirmed
chokecherry	*Prunus virginiana*	*tall shrub / multi-stem tree*	deciduous	confirmed
Gambel oak	*Quercus gambelii*	*tall shrub / multi-stem tree*	deciduous	confirmed
manzanita (bearberry)	*Arctostaphylos x coloradoensis*	*small shrub*	broadleaf evergreen	pending
true mountain mahogany	*Cercocarpus montanus*	*small shrub*	deciduous	confirmed
red-osier dogwood	*Cornus Sericea*	*small shrub*	deciduous	pending
cliff jamesia	*Jamesia americana*	*small shrub*	deciduous	pending
creeping mahonia	*Mahonia repens*	*small shrub*	deciduous	confirmed
myrtle pachistima	*Pachistima myrsinites*	*small shrub*	deciduous	pending
woods rose	*Rosa woodsii*	*small shrub*	deciduous	pending
smooth willow	*Salix spp.*	*small shrub*	deciduous	pending
common juniper	*juniperus communis*	small ground shrub	coniferous	confirmed
tulip prickly-pear	*Opuntia phaeacantaha*	*cactus*	succulent evergreen	confirmed

Summary of Monitoring Data to Date (Fall 2021)

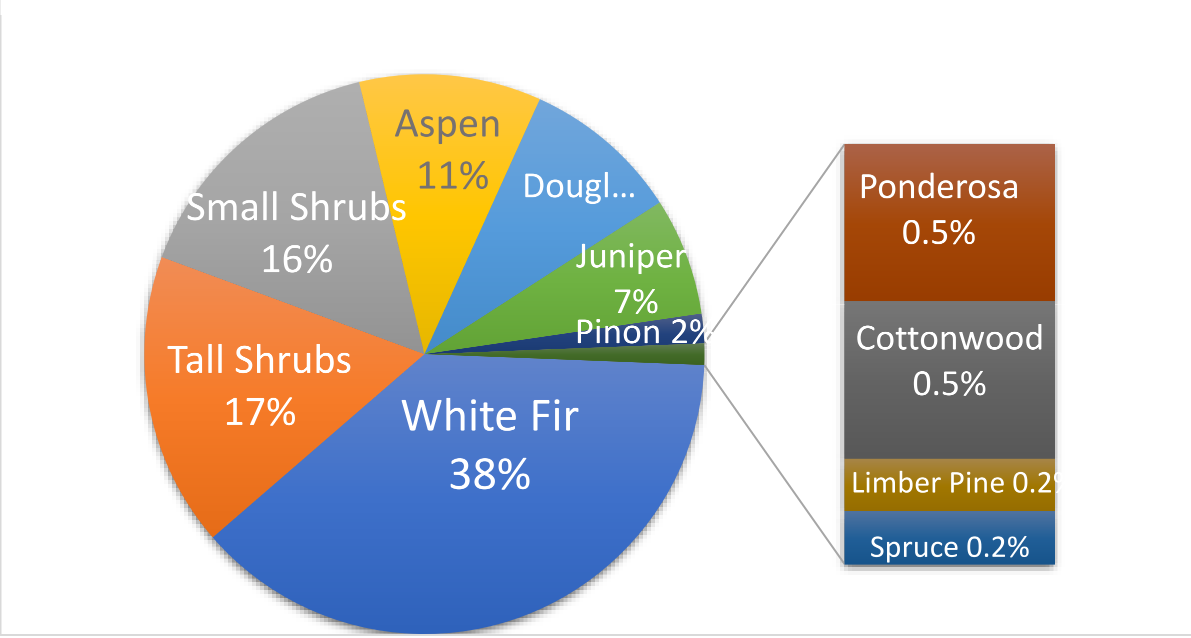
The remainder of this report will focus on the larger woody plant species (>1 inch diameter bole) recorded in the common stand exam. These larger shrubs and trees measured in the common stand exam are most likely to be removed or left as "keep trees" from the project activities. When generally describing the "pre-treatment" forest stand, data shown represent a sum or average of all ten monitoring plots. In analysis of changes after forest thinning treatments, only information from monitoring plots 1, 2, and 3, where thinning has been completed, are used for comparison. Photos providing visual evidence of changes due to thinning are shown at the end of this report in appendix A.

Forest Stand Characteristics

Tree Count and Density. All informations are based on all 10 monitoring plots completed prior to thinning treatment, referred to as the "PRE" condition of the forest. During the summer of 2021 three plots were able to be monitored for "POST" treatment condition after thinning had been completed (plots #1, #2 and #3).

The number of trees per acre (as shown earlier in Table 1.) is a simple view of a forest stand. Pre-treatment tree density ranged from 290 trees per acre at the upland plot #8 on up to 1200 trees per acre in stream riparian area at plot #3. The average trees per acre for all 10 plots was 636 trees per acre. If we consider all woody plants, the number of plants by species is shown in Figure 2 below.

Figure 2. Relative abundance of woody plant species by numbers in all 10 pre-treatment plots.



After thinning treatments on plots 1-3, the tree[1] density decreased significantly to 28% of its original stand density (see Table 3).

Table 3. Changes in tree density after thinning

Plot No.	Pre-Treatment Tree Density (trees/ac)	Post-Treatment Tree Density (trees/ac)
1	800	270
2	480	150
3	1030	230
3-plot average	**770**	**217**

The changes in tree counts indicate a clear reduction in stand density and, as shown in table 4, the successful removal of priority "take" species, notably white fir and juniper. In some cases tree count data may provide misleading information about the removal of target species. Cottonwood, for example, was not a target species for removal as it may appear from the table below. However, it is important to note that the single remaining cottonwood tree post-treatment was a large healthy tree. Of the two cottonwoods removed, one was documented as a "sick" tree and the other was less than 2 inches in diameter and may have been thinned out for a variety of reasons, including as a result of breaking under the fall of a larger "take" tree.

Table 4. Change in tree count by species for treated plots (1,2&3)

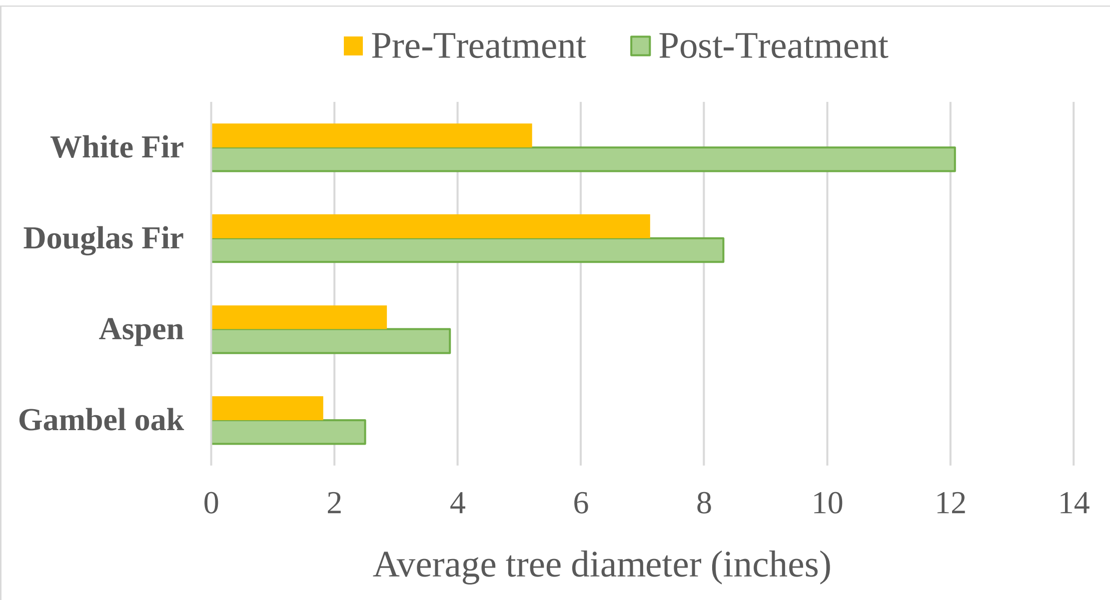
Species	Pre- Treatment	Post- Treatment	Percent Decrease
White Fir	119	14	88%
Juniper	14	0	100%
Cottonwood	3	1	67%
Aspen	20	12	40%
Douglas Fir	8	8	0%
Tall Shrubs	66	29	56%
Small Shrubs	22	9	59%
Totals	**252**	**73**	**71%**

[1] Not including small woody shrubs found abundantly in the riparian areas (eg. dogwood)

Tree Diameter: Another simple metric for assessing a forest stand is tree diameter. This is generally measured as DBH, the diameter at "breast-height" (4.5 feet up from the ground).

While numbers of most species decreased during thinning, the goal of keeping larger, healthier trees was met as the diameter of all species increased. The graph below in Figure 3 illustrates the overall increased tree sizes for select species. The average diameter of white fir, for example, increased 132% as the numbers of fir decreased from 119 to 14 individuals in the 3 treated sites. The less significant 17% diameter increase in Douglas Fir is interesting because none of the 8 Douglas fir in those plots were removed. This increase is likely accounted for by actual tree diameter increases due to growth as well as human error in the DBH measurements. Even considering a potential 10-15% degree of measurement error, the 36%, 38%, and 132% increases in oak, aspen, and white fir, respectively, are all indicative of a new forest stand that is less dense with thicker, and older, trees.

Figure 3. Impact of thinning on average tree diameter (DBH)



Basal Area: Basal area is common “stocking” metric in forestry that requires both tree count and DBH measurements. This calculated metric is based on the cross-sectional area of tree trunks at 4½ feet above the ground and inclusive of the bark. Basal area per acre (BAPA) gives an idea of the stocking of trees in a stand and is usually reported in square feet per acre. The graph in figure 4 (see below) illustrates the dominance of white fir in El Salto forest not only by sheer numbers, but also by basal area.

Basal area calculations are also valuable as they provide a more accurate representation of the actual physical abundance of woody species compared to simple number counts. For example, earlier in Figure 2 we see that small shrubs make up 16% of the pre-treatment forest stand by plant count. However, when we look at the actual basal area of small shrubs as shown in Figure 4, we see that they only make up only 1% of the pre-treatment forest area. On the other hand, while ponderosa trees make up less than 1% of the pre-treatment forest stand by numbers, they represent a more significant part of the El Salto forest basal area at 6%.

Figure 4. Relative basal area (square feet) of woody species in all 10 pre-treatment plots.

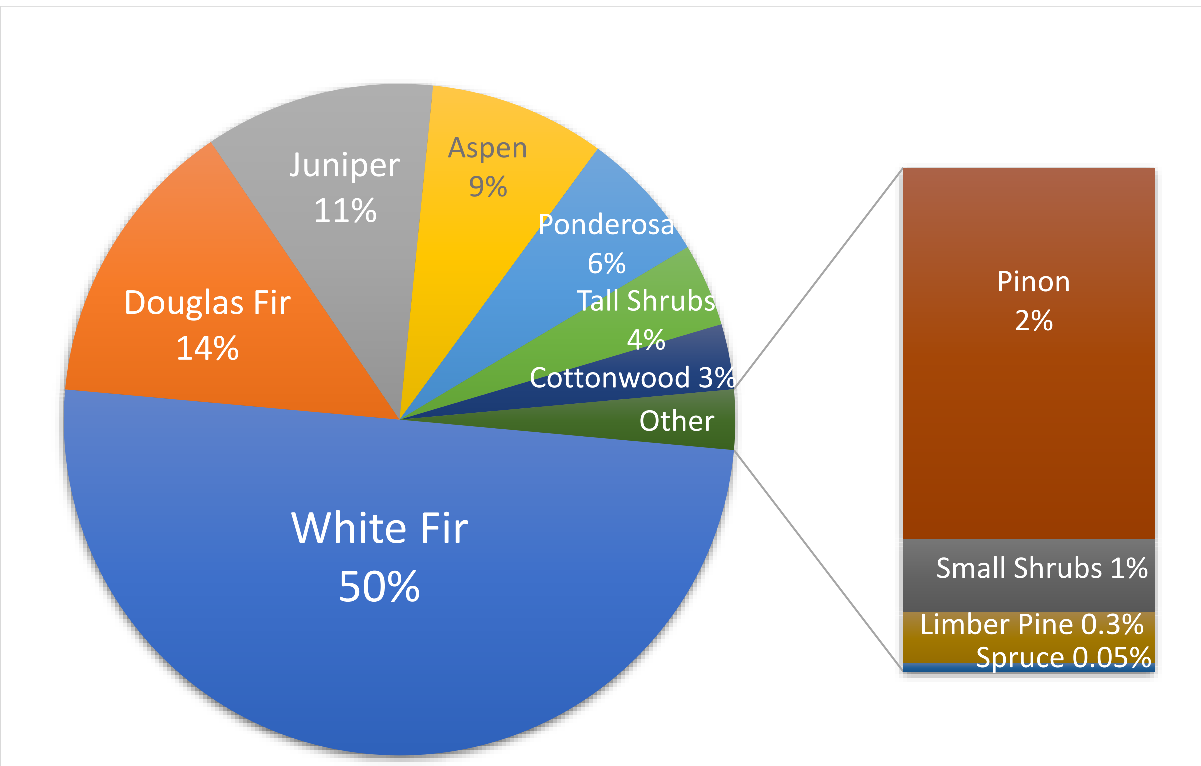


Figure 5. Change in basal area (square feet) by species for treated plots (1,2&3)

Species	Pre- Treatment	Post- Treatment	Percent Decrease
White Fir	30	14	53%
Cottonwood	4.8	4.6	4%
Large Shrubs	2.9	1.5	48%
Douglas Fir	2.6	2.6	0%
Juniper	1.7	0	100%
Aspen	1.3	1.2	8%
Small Shrubs	0.6	0.4	33%
Totals	**43.9**	**24.3**	**45%**

Surface Fuels

Table 5 below summarizes the fuel loads for all monitoring sites before treatment. It also provides a PRE / POST treatment comparison between the three plots (#1-3) where treatments had occurred.

In the PRE / POST comparison, the general trend was an increase in most fuel categories after treatment. This makes logical sense as a large amount of material was cut and not all slash could be removed mechanically or by burning. In cases where fuels appeared to decrease after treatment, such as the 100-hour (1-3 inch) woody material, the difference may relate to successful removal of slash or potentially human error in the monitoring protocol where fuel changes were minimal.

Although much more forest treatment needs to occur for full analysis of fuel loads, the relatively small increase from 29.61 tons per acre to 49.25 tons per acre is evidence of successful thinning loads. A similar forest treatment project in a nearby pinon-juniper woodland[2] had a 169% increase in woody material after treatment, while woody material only increased 76%. Although these data are preliminary with 6 plots left to be treated, this provides evidence of effective slash removal efforts in a high-density forest stand.

Table 5. Surface fuels loads by total weight per acre and litter and duff depths.

	PRE (all 10 plots)		PRE (Plots 1-3)	POST (Plots 1-3)
Fuel Category	**Tons/Acre**		**Tons/Acre**	**Tons/Acre**
1-Hour woody material	0.29		0.42	0.55
10-Hour woody material	1.79		2.88	1.83
100-Hour woody material	1.80		1.80	1.52
1000-Hour woody material	35.8		15.2	31.94
Duff	5.6		5.9	9.2
Litter	3.0		3.4	4.2
TOTAL Fine Wood Fuels	3.89		5.10	3.90
TOTAL Woody Fuels	39.70		20.33	35.84
TOTAL Surface Fuels	48.36		29.61	49.25

Litter and Duff Depths	**Avg. depth (in.)**		**Depth (in.)**	**Depth (in.)**
Duff	3.4		0.59	1.01
Litter	15.2		0.68	0.89
TOTAL DEPTH	18.6		1.27	1.91

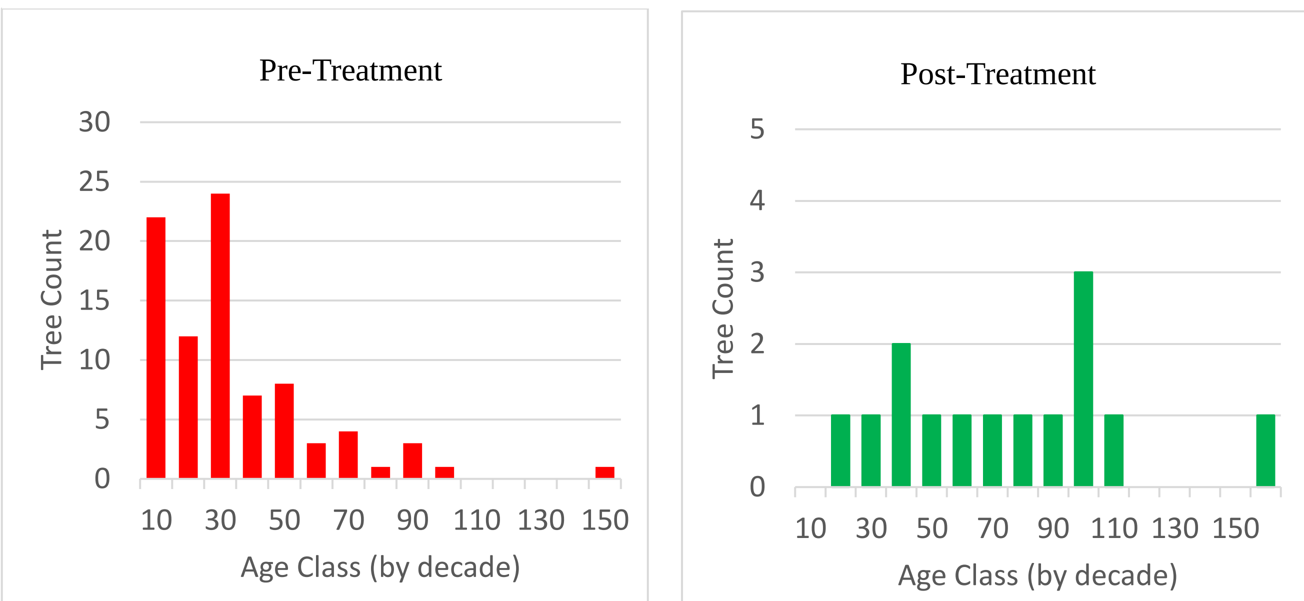
[2] Forest Mayordomo CFRP, A 300-acre forest treatment area between Valdez and San Cristobal.

Relevant Information for Future Forest Management

Age of White Fir: The dominant tree, by both numbers as well as basal area (and likely biomass), in the project area was white fir (*Abies concolor*). Even post-treatment, this tree species remains the dominant tree in the El Salto forest. White fir basal area was reduced by approximate 50% and so, given its relative abundance in the forest mix, this is likely to provide resource opportunities that could allow other species to increase in numbers and area.

This project's prescription targeted the white fir as the primary species for removal. One interesting way to look at the impact of thinning is how tree removal influenced the age-class of a species. The graphs below illustrate the change in this tree's numbers by age-class after thinning efforts. From a sample of 20 different white fir that were cored and aged by P. De'Scoville and K. Namba in 2020, a regression analysis provided a reference relationship to interpolate estimated age from diameter ($r^2=0.96$). The average pre-treatment diameter for white fir was about 5.5 inches, which correlates to an average age of approximately 30 years old.

Figure 6. White fir distribution by age classes (decadal) in treated plots



A reduction in small diameter, often considered "encroaching", young fir trees is evident in the graphs above in Figure 6. Prior to thinning, 60 white fir trees existed in the 0-30 age class. After thinning, only 2 trees remained in this same age class.

Meanwhile, the large fir trees are shown to have been left during the thinning process. This is a positive sign as they are valued for shade, wildlife habitat, potential timber value, and to some extent, they are a lesser concern when it comes to ladder fuels and wildfire danger.

Regeneration Trees: Small trees, those with less than 1 inch in diameter, are designated as "regeneration" and were measured in the plot description protocol. When looking to the future of this forest stand, these measurements are important. The "regen" is further divided into two groups: **seedlings** that are shorter than 4.5 feet; and **saplings** which are taller than 4.5 feet.

Table 6 below illustrates a significant reduction in both seedlings after thinning plots 1-3. This is not surprising to any on the monitoring team because most of us have conducted thinning work ourselves. These trees are very susceptible to damage due to falling trees during the thinning operation. It is also important to note that 14 of the recorded seedlings were Gambel oak. Despite being removed, we are aware that their significant rhizome root network creates suckers as their primary reproductive strategy. The only sapling recorded in the 3 thinned plots still remains, a lone aspen in plot 1.

Table 6. Tree regeneration numbers pre and post thinning

Regeneration Class	Tree size	Pre-Treatment	Post-Treatment
Seedlings	<4.5' feet tall, < 1 inch diam.	26	9
Saplings	>4.5 feet tall, < 1 inch diam.	1	1

Appendix A. Before / After Treatment Photos

Plot 1 looking North from Plot Center

Plot 2 looking South to Plot Center

Plot 3 looking South from Plot Center