Mexican Spotted Owl Habitat Monitoring
Flagstaff Watershed Protection Project
Dry Lake Hills Area

Progress Report

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Introduction

The Flagstaff Watershed Protection Project (FWPP) represents a unique partnership between the City of Flagstaff, the State of Arizona, and Coconino National Forest to help reduce hazardous forest fuels and potential for uncontrollable wildfire and flooding on approximately 10,544 acres of Coconino National Forest land. Two general areas of the Forest were identified for fuels reduction treatment -- Dry Lake Hills and Mormon Mountain. Much of this land is important habitat for the Mexican spotted owl (MSO), a federally threatened wildlife species. Habitat characteristics that are preferred by MSO for nesting and roosting include complex, multi-layered, mixed conifer and pine-oak forests on steep slopes. High quality habitat tends to have higher large tree densities and canopy cover, an abundance of large live trees and standing dead snags, and an abundance of large logs (Ganey and Balda 1994, Ganey et al. 1999, May et al. 2004). Although Mexican spotted owls are often found in forests with higher tree density and canopy cover, two primary threats to MSO populations are timber harvest (i.e., logging of larger trees) and stand-replacing wildfire.

The recently revised MSO Recovery Plan (USFWS 2012) describes how hazardous fuels treatments may be conducted within Protected Activity Centers (PACs), i.e., designated protected sites where owls have been observed (US Fish and Wildlife Service 2012). However, presently there is very little information regarding how owls may respond to fuels treatments. Essentially no research has been conducted to test MSO responses to alternative treatment prescriptions and intensities within PACs.

In collaboration with the US Fish and Wildlife Service (FWS), US Forest Service (FS), City of Flagstaff, and Greater Flagstaff Forests Partnership (GFFP), the Ecological Restoration Institute (ERI) at Northern Arizona University is helping to investigate MSO responses to changes in habitat characteristics associated with FWPP hazardous fuels treatments. Due to the importance of MSO conservation, findings from this work likely will serve as one benchmark for evaluating success of FWPP. In summer of 2014, the ERI initiated installation of forest structure, vegetation, and fuels monitoring plots, and collected pre-treatment data in the Dry Lake Hills (DLH) area of FWPP. Specific objectives of 2014 work were to do the following: 1) quantify forest structure, vegetation, and fuels characteristics in PACs before hazardous fuels reduction treatments are implemented; 2) quantify forest structure, vegetation, and fuels characteristics in reference PACs that will not be treated under FWPP; and 3) make data summaries available to USFWS researchers and US Forest Service staff for their analysis.

Funding for plot installation, data collection and analysis, and production of this pretreatment summary report was provided by FWPP bond funds (City of Flagstaff), Arizona Technology Research Initiative Funds (TRIF), and a USDA Forest Service grant (USDA-FS #14-DG-11031600-055) awarded to the Southwest Ecological Restoration Institutes (SWERI) under authorization of the Southwest Forest Health and Wildfire Prevention Act.

Methods

Study Sites

In summer of 2014 the ERI installed long-term monitoring plots and sampled attributes of forest structure, vegetation, and fuels within three PACs to be treated in Dry Lake Hills area of FWPP as well as three PACs that are to remain untreated (reference) and are located outside of FWPP (Figure 1). The three sampled PACs within FWPP were "Mt Elden", "Orion Spring", and "Schultz Creek". The three Control PACs outside FWPP were "Little Springs", "East Bear Jaw", and "Snow Bowl". PACs were 600-659 acres in size and ranged from 7,361 to 8,998 ft in elevation, with East Bear Jaw being the lowest in elevation and Orion Spring the highest (Table 1). Annual precipitation varies from approximately 20 to 31 inches across the six PACs. Soils are derived from primarily mixed igneous parent material, and are classified in the Alfisol and Mollisol soil orders (Table 1). Common forest overstory species include ponderosa pine (*Pinus ponderosa* Lawson & C. Lawson.), Douglas-fir (*Pseudotsuga menziesii* (Mirb.) Franco), limber pine (*Pinus flexilis* James), white fir (*Abies concolor* (Gord. & Glend.) Lindl. ex Hildebr.), and quaking aspen (*Populus tremuloides* Michx.). Although limber pine and southwestern white pine co-occur in habitats across the study sites, they are difficult to distinguish from one another and may naturally hybridize (K. Waring personal communication). In this work, we did not attempt to separate the two species and categorized all as limber pine.

Field Sampling

To characterize forest structure, vegetation, and fuels, we established 21-36 long-term monitoring plots in each of the six PACs. We used a stratified random sampling design with an intensity of approximately one plot per 22 acres. Plot stratification was based on treatment type within PACs. Plots were randomly located within treatments using a geographic information system (GIS; ArcView 9.3).

In the field, we navigated to plot locations using handheld geographic positioning system (GPS) units. We used Garmin 12 GPS units that have a nominal accuracy of 15 m (root mean square error; rms). At each location, we drove a small piece (3/4" x 8") of steel rebar into the soil to monument the plot for future relocation. On each piece of rebar, we affixed an aluminum tag, on which the site and plot number was embossed. We also nailed an aluminum reference tag to the base on a large, live tree nearby and embossed the distance and direction to the rebar on this tag. Tree reference information was recorded in an electronic database. Using the rebar as the center point, we sampled forest structure, and vegetation using nested, circular plots (Fig. 2). Within a 0.2-ac plot, we located "large" snags (standing dead trees ≥ 16 diameter at breast height (dbh; 4.5 ft above the ground surface). Each large snag was identified to species and measured for dbh and height. Within a nested 0.10-ac plot, we located all live trees ≥ 1 in dbh. Trees species was recorded and all live trees were measured for dbh, total height, and crown base height. Also with the 0.1-ac plot, we located large dead and down logs (≥16 inches diameter at stump height (dsh) measured at 40 cm above root collar) and measured dsh. Logs were measured if they had been once live trees rooted within the plot. Coarse woody debris (e.g., tree branches, chunks of wood, etc.) that could not be identified as an individual tree originating in the plot was not sampled. Numbered aluminum tags were nailed to all snags and trees in the plots.

In smaller nested plots (0.025-ac) centered on the rebar, we tallied small trees (< 1 inch dbh) and tree seedlings (< 4.5 ft height) (hereafter "regeneration"). For each of these tallied, we recorded species and condition (live or dead). We also tallied shrubs by species in these plots. We did not assign numbered tags to small trees, seedling.

On each plot, we sampled dead, woody, surface fuels on two 50-foot planar transects according to methods described in Brown (1974). The two transects were systematically oriented along south and west cardinal directions, respectively, radiating outward from the center point rebar. Woody fuels were tallied by the following moisture lag classes: 1) 1-hour (0.0.25 inches in diameter); 2) 10-hour (0.25-1.0 inches diameter); 3) 100-hour (1.0-3.0 inches diameter); and 4) 1000-hour (> 3 inches diameter). The largest class (1000-hour) was additionally subdivided into sound and rotten categories. Planar transects used for surface fuels measurements were also used to estimate canopy cover. On each transect, canopy cover "hits" (yes/no) were determined at 10 equally spaced points using a sighting tube-type densitometer. Thus, 20 canopy cover points were sampled on each plot.

Lastly, we collected digital photographs at each plot. Photos were taken from two cardinal points (north and east) on the boundary of the nested overstory plot. Photos were taken from points toward the center rebar. Digital photos and all data described above were archived and stored electronically on a data server at Northern Arizona University.

Analysis

For pretreatment summaries, we calculated means and standard deviations of forest structure, vegetation and fuels variables for individual PACs. Forest structure variables included trees ac^{-1}, basal area (BA; ft^2 ac^{-1}), large (> 16 in) snags ac^{-1}, large (>16 in) logs ac-1, density (no. ac^{-1}) of live shrubs and tree regeneration. We calculated mean relative importance (RI) index values for species within PACs following methods adapted from Curtis and McIntosh (1951). This index was calculated for each species as the relative density ((species trees ac^{-1}/total trees ac^{-1})*100) plus relative dominance ((species BA/total BA)*100). Thus, importance index values for each species within PACs ranged from 0 (not occurring) to 200 (completely monotypic). To classify composition of PACs based on importance values, we included overstory species with importance values > 20. We calculated canopy cover as: (no. canopy "hits"/20)*100. To provide baseline summaries for monitoring potential fire hazard, we calculated both crown and surface fuel loading. We used species-specific component biomass equations given in Ter-Mikaelian and Korzukhin. (1997) to calculate individual tree foliage mass, then summed these amounts to calculate crown fuel loading (kg m^{-2}) on plots. Note that crown fuel load is commonly expressed in Standard International units; however, conversion to English units is the following: 1 kg m^{-2} =

0.2048 lb ft^{-2}. We used equations in Brown (1974) to calculate woody surface fuel loading (t ac^{-1}) by moisture-lag class.

Data were summarized for each PAC in terms of habitat elements described in the MSO Recovery Plan (US Fish and Wildlife 2012). In addition, we also provide summaries for the nest core area of the Schultz Creek PAC (Appendix 1).

Results

Stand structure and vegetation

Tree species composition varies across the six PACs sampled (Table 1). Based on relative importance (RI) values, all with the possible exception of the Little Springs PAC, should be considered warm/dry mixed conifer forests (see Reynolds et al. 2013). For example, ponderosa pine is common (RI > 20) in all PACs except Little Springs. This species was more important than other species in Orion Spring, Schultz Creek, and East Bear Jaw PACs. Douglas-fir also was common and showed RI values > 20 in all PACs. This species had the highest relative importance in the Snowbowl PAC. White fir and limber pine were less important than ponderosa pine and Douglas-fir; however, white fir was more important than other species in the Mount Elden PAC. Limber pine was the most important species in the Little Springs PAC. Aspen occurred in all PACs except East Bear Jaw but was least important overall. Aspen showed RI values >20 in both the Little Springs and Snowbowl PACs (Table 1).

Tree density across the six PACs ranged from 253 trees ac^{-1} (Snowbowl) to 495 trees ac^{-1} (Little Springs) (Table 2). The Little Springs PAC was at least 49% greater in tree density than all other PACs sampled. Smaller trees (< 8 inches dbh) were more abundant than large size classes in all PACs (Fig. 3). Schultz Creek and East Bear Jaw PACs had the fewest numbers of large trees (> 16 inches and > 24 inches dbh) (Table 2). Basal area (BA) showed a similar pattern to tree density, and ranged from 97 ft^2 ac^{-1} (Schultz Creek) to 207 ft^2 ac^{-1} (Little Springs). BA among the other four PACs ranged 123-164 ft^2 ac^{-1} (Table 2). East Bear Jaw had noticeably lower percentages total BA comprised of large trees (> 16 inches dbh and > 18 inches dbh) than the other PACs (Table 2.). Canopy cover for all PACs except Little Springs (81%) was below 60% (Table 2). The Mount Elden PAC had the lowest canopy cover (46%).

Tree heights were variable across the six PACs (Fig. 4). Orion Spring, Little Springs, and Snowbowl PACs tended to have proportionally greater numbers of taller trees as well greater ranges (interquartile) of tree heights than the other three PACs. The Mount Elden and Schultz Creek PACs had the lowest tree height medians (20.3 ft and 22.3 ft, respectively), whereas the East Bear Jaw PAC had the smallest interquartile range (23.3 ft) of tree heights (Fig. 4).

Density of large (> 18 inches dbh) standing dead snags was similar and ranged 6.8-7.9 snags ac^{-1} across all PACs except East Bear Jaw, which showed only 4.2 snags ac^{-1} (Table 3). Density of large dead and down logs (> 18 inches dsh) was similar among PACs and ranged 11.5-15.5 ac^{-1} (Table 3).

Tree regeneration was by far highest (2476 ac^{-1}) in the Orion Spring PAC, and lowest (128 ac^{-1}) in the East Bear Jaw PAC (Table 3). Regeneration in the Orion Spring PAC was composed primarily of small (1-2-year-old) ponderosa pine seedlings. Ponderosa pine (5-1717 ac^{-1}) as well as Douglas-fir (18-565 ac^{-1}) regeneration was found in all PACs. White fir regeneration was found in meaningful numbers only in Mount Elden and Schultz Creek PACs (220 $ac^{-}1$ and 119 ac^{-1}, respectively), but was also observed in Orion Spring and East Bear Jaw PACs (32 $ac^{-}1$ and 1 ac^{-1}, respectively). Both limber pine (8-164 ac-1) and aspen (16-361 ac^{-1}) regeneration was found in all PACs except East Bear Jaw.

Shrub density ranged from 1194 individuals ac^{-1} (East Bear Jaw) to 4961 ac^{-1} (Snowbowl) (Table 3). Oregon grape (*Berberis repens*) was the most abundant shrub observed (371-4691 ac^{-1}) and was found in all six PACs. Other common shrubs included mountain snowberry (*Symphoricarpus oreophilus*), wild raspberry (*Rubus idaeus*), and Fendler's ceanothus (*Ceanothus fendleri*).

Fuel loading

Crown fuel loads across the six PACs ranged from 0.80 kg m^{-2} (Snowbowl) to 1.20 kg m^{-2} (Mount Elden) (Table 4) (for conversion to English units, see Methods *Analysis*). Crown fuel load of individual species within PACs generally followed orders of relative importance. One exception was the Little Springs PAC, within which Douglas-fir (0.65 kg m^{-2}) had a greater crown fuel load than limber pine (0.29 kg m^{-2}) (Table 4).

Dead woody surface fuels ranged from 15.9 t ac^{-1} (East Bear Jaw) to 237.8 t ac^{-1} (Little Springs) across the six PACs (Table 5). All PACs except Little Springs showed total woody surface fuel loads less than 65 t ac^{-1}. Thus, the total surface fuel load at Little Spring was more than 275% greater than any other PAC (Table 5). The high total value at Little Springs was due to larger amounts of coarse woody debris (CWD; i.e., wood pieces > 3 in (diameter), not necessarily logs of trees originating on the plot. See Methods *Field Sampling*). The Snowbowl PAC also showed larger amounts of CWD, relative to the other PACs (Table 5). Forest floor depths ranged from 1.1 in (Mount Elden and East Bear Jaw) to 2.1 in (Little Springs) across the six PACs (Table 5).

Discussion

Protected Activity Centers sampled in this work varied in terms of forest species composition, structure, and fuel loading. For example, among PACs to be treated as a component of FWPP, the Orion Spring PAC is primarily composed of relatively large ponderosa pine and Douglas-fir trees, with a dense understory of ponderosa pine regeneration. In contrast, the Schultz Creek PAC has proportionally more white fir in the overstory, smaller trees, and lower density of tree regeneration in the understory. Reference PACs showed similar variability, with the Little Springs and East Bear Jaw PACs apparently occupying opposite ends of an elevation/productivity gradient. At this time, it is unclear how this variability may affect baseline owl responses such as occupancy and fledging success.

Tree densities in PACs were similar to those in other warm/dry mixed conifer forests in northern Arizona. For example, Cocke et al. (2005) found 293-332 trees ac^{-1} in ponderosa pine and mixed conifer forests, respectively, on the south slopes of the San Francisco Peaks near the Dry Lake Hills area. Cocke et al. (2005) reported basal area to range 150-197 ft^{2} ac^{-1}. Contemporary conditions reflect substantial structural changes compared with conditions occurring in the late 1800s (Cocke et al. 2005). These changes were likely brought on by interruption of surface fire disturbance regimes, and existing conditions warrant restoration and fuels reduction treatments. For example, Chancellor et al. (2013) found that the NEXUS fire behavior model predicted active crown fire for warm/dry mixed conifer forests with similar crown fuel loading in the White Mountains of Arizona. Differences among PACs in composition, structure, and fuel loading require site-specific prescriptions to effectively reduce fuel hazards while also attempting to maintain MSO habitat quality. Fuel hazard reduction prescriptions developed to address site-specific characteristics of the individual PACs will likely vary in several important ways, including treatment intensity, tree size class and species targets, and type (e.g., manual thinning and/or prescribed fire). To account for this variability, long-term monitoring forest dynamics and MSO responses in both FWPP PACs as well as untreated reference PACs is of critical importance.

Pretreatment data summaries presented in this report provide an initial baseline for monitoring, and can help in adapting treatment plans and future studies. Monitoring of both structural changes and effects of treatments on fuel loading can be assessed using these data.

Monitoring Recommendations

Work on this project led to two main recommendations for adjusting monitoring methods and measurements. The following adjustments will be made in future work:

1. Decrease minimum standing dead snag size to 11.8 inches (30 cm) dbh
2. Incorporate coarse woody debris (CWD) sampling. CWD should be tallied on 0.10-ac nested overstory plot in the following classes:
    a. Small logs: 3.3-9.7 ft (1.0-2.95 m) length, and 7.9-18 in (20.0-45.7 cm) diameter large end
    b. Medium logs: ≥9.8 ft (3.0 m) length, and 7.9-18 in (20.0-45.7 cm) diameter large end; Or, 3.3-9.7 ft (1.0-2.95 m) length and ≥18 in (45.7 cm) diameter large end
    c. Large logs: ≥9.8 ft (3.0 m) length, and ≥18 in (45.7 cm) diameter large end

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Table 1. Characteristics of Protected Activity Centers (PACs). Mount Elden, Orion Spring, and Schultz Creek are PACs that will received Flagstaff Watershed Protection Project (FWPP) treatments. Little Springs, East Bear Jaw, and Snowbowl PACs are outside of FWPP and will remain as untreated reference sites. Precipitation estimates, soil parent material, and soil order information is given in Miller et al. (1995). Overstory classification reflects importance values calculated in this report (see Methods *Analysis*).

PAC	Size (ac)	Elevation (ft)	Precipitation (in)	Parent material	Soil order	Overstory*
Mount Elden	630	7,546-8,816	20-28	Mixed igneous	Alfisol/Mollisol	ABCO/PIPO/PSME
Orion Spring	604	7,831-8,998	20-28	Mixed igneous	Alfisol/Mollisol	PIPO/PSME
Schultz Creek	659	7,430-8,537	20-28	Mixed igneous	Alfisol/Mollisol	PIPO/ABCO/PSME
Little Springs	608	8,221-8,821	20-31	Mixed igneous	Mollisol/Alfisol	PIFL/PSME/POTR
East Bear Jaw	600	7,361-8,396	20-28	Mixed igneous	Alfisol	PIPO/PSME
Snowbowl	604	8,093-8,895	24-28	Andesite/Basalt	Alfisol/Mollisol	PSME/PIPO/PIFL/POTR

* Tree species codes: ABCO (*Abies concolor*); PIFL (*Pinus flexilis*); PIPO (*Pinus ponderosa*); POTR (*Populus tremuloides*); PSME (*Pseudotsuga menziesii*)

Table 2. Attributes (means) of forest structure within Protected Activity Centers (PACs). Mount Elden, Orion Spring, and Schultz Creek are PACs that will received Flagstaff Watershed Protection Project (FWPP) treatments. Little Springs, East Bear Jaw, and Snowbowl PACs are outside of FWPP and will remain as untreated reference sites.

	PAC					
Structural Variable	Mount Elden	Orion Spring	Schultz Creek	Little Springs	East Bear Jaw	Snowbowl
Density						
Total (trees ac^{-1})	326	274	273	495	339	253
Trees ac^{-1} > 16 in	27.0	37.3	14.8	31.9	13.1	26.9
Trees ac^{-1} > 24 in	5.0	5.0	2.6	6.9	1.9	4.6
Basal Area						
Total (ft^2 ac^{-1})	135	164	97	207	123	141
Trees 12-18 in (%)*	39.9	34.0	31.6	34.2	34.4	35.9
Trees > 16 in (%)*	45.0	50.9	34.3	38.4	19.3	45.8
Trees > 18 in (%) *	36.9	39.2	26.7	27.6	11.8	34.5
Canopy cover						
Total (%)	46	54	49	81	51	59

* Percentage of total basal area comprised of trees within the size (diameter at breast height) ranges given.

Table 3. Density (mean no. ac^{-1}) of large snags, large logs, tree regeneration, and shrubs within Protected Activity Centers (PACs). Mount Elden, Orion Spring, and Schultz Creek are PACs that will received Flagstaff Watershed Protection Project (FWPP) treatments. Little Springs, East Bear Jaw, and Snowbowl PACs are outside of FWPP and will remain as untreated reference sites.

PAC	Large snags (> 18 inches dbh)	Large logs (> 18 inches dsh)	Tree regeneration	Shrubs
Mount Elden	7.8	13.0	503	3,976
Orion Spring	7.2	15.0	2,476	1,716
Schultz Creek	6.8	15.5	476	2,123
Little Springs	7.9	14.6	701	3,278
East Bear Jaw	4.2	11.5	128	1,194
Snowbowl	7.9	14.6	979	4,961

Table 4. Crown fuel loading (means (kg m^{-2}))* within Protected Activity Centers. Shown is total crown fuel loading along with amounts for major overstory species**. Total includes all species occurring on plots (major species, plus others occurring in low abundance).

		Species				
PAC	Total	ABCO	PIFL	PIPO	POTR	PSME
Mount Elden	1.20	0.61	0.03	0.32	0.00	0.24
Orion Spring	1.10	0.01	0.02	0.63	0.01	0.43
Schultz Creek	0.81	0.28	0.02	0.35	0.00	0.14
Little Springs	1.08	0.00	0.29	0.09	0.05	0.65
East Bear Jaw	0.93	0.00	0.00	0.75	0.00	0.17
Snowbowl	0.80	0.00	0.08	0.29	0.03	0.39

*Crown fuel loading is commonly given in metric units. Conversion to English units is: 1 kg m^{-2} = 0.2048 lb ft^{-2}.

** Tree species codes: ABCO (*Abies concolor*); PIFL (*Pinus flexilis*); PIPO (*Pinus ponderosa*); POTR (*Populus tremuloides*); PSME (*Pseudotsuga menziesii*)

Table 5. Surface fuels (means) within Protected Activity Centers (PACs). Mount Elden, Orion Spring, and Schultz Creek are PACs that will received Flagstaff Watershed Protection Project (FWPP) treatments. Little Springs, East Bear Jaw, and Snowbowl PACs are outside of FWPP and will remain as untreated controls.

PAC	Litter depth (in)	Duff depth (in)	1-hour ($t\ ac^{-1}$)	10-hour ($t\ ac^{-1}$)	100-hour ($t\ ac^{-1}$)	1000-hour sound ($t\ ac^{-1}$)	1000-hour rotten ($t\ ac^{-1}$)
Mount Elden	0.4	0.7	0.39	1.12	2.69	14.43	12.27
Orion Spring	0.3	1.0	0.21	0.64	1.82	15.06	9.54
Schultz Creek	0.2	1.1	0.13	0.88	3.49	8.40	12.09
Little Springs	0.6	1.5	0.34	0.99	2.49	98.72	135.28
East Bear Jaw	0.3	0.8	0.21	0.94	1.35	2.76	10.63
Snowbowl	0.3	1.5	0.11	0.66	2.62	23.39	36.51

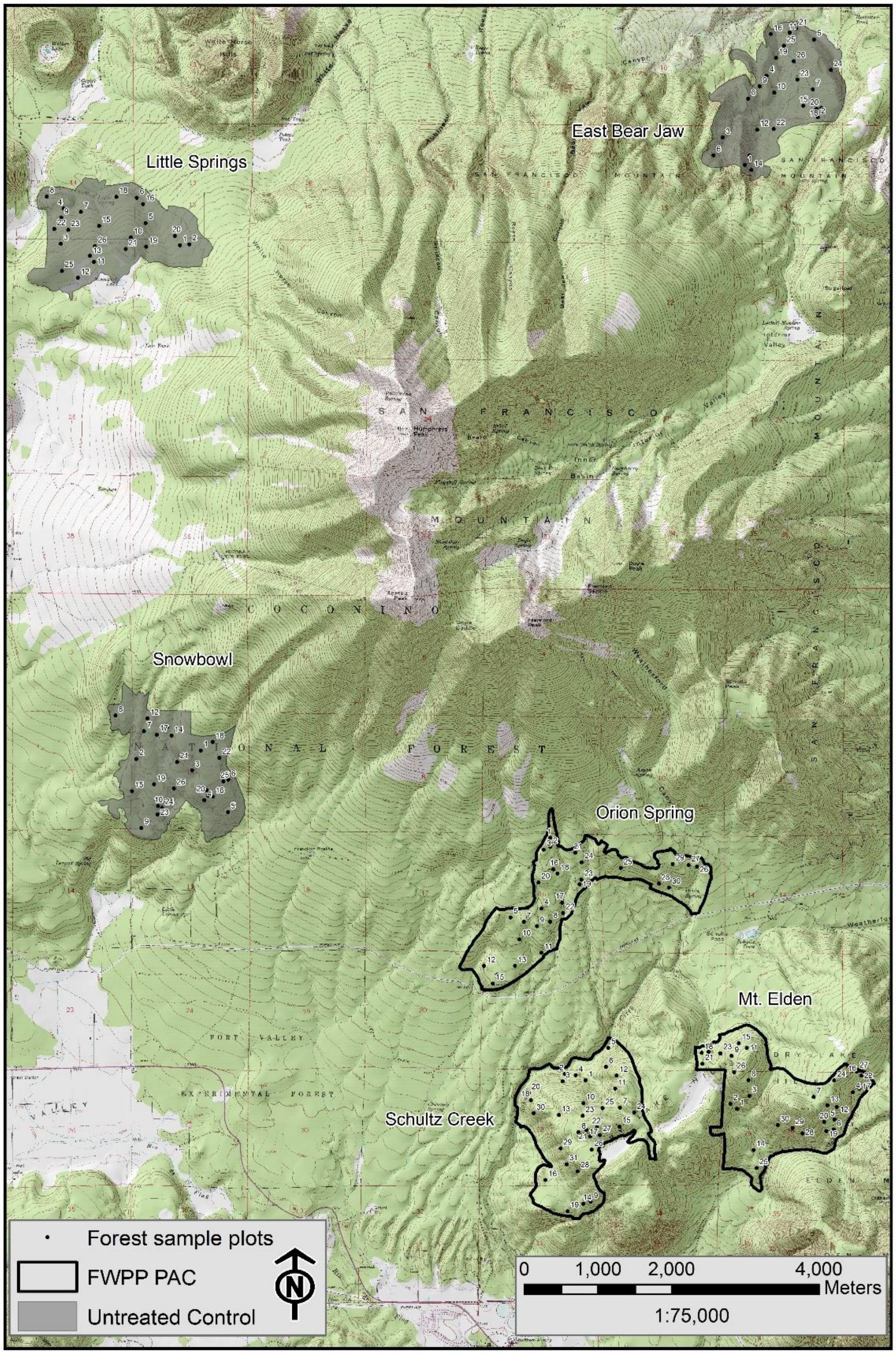

Figure 1. Map showing location of Protected Activity Centers (PACs) and long-term monitoring plots sampled by the Ecological Restoration Institute in 2014. PACs to be treated in the Dry Lake Hills area as a component of the Flagstaff Watershed Protection Project are shown (FWPP PAC) as well as PACs outside FWPP that will remain as untreated reference sites.

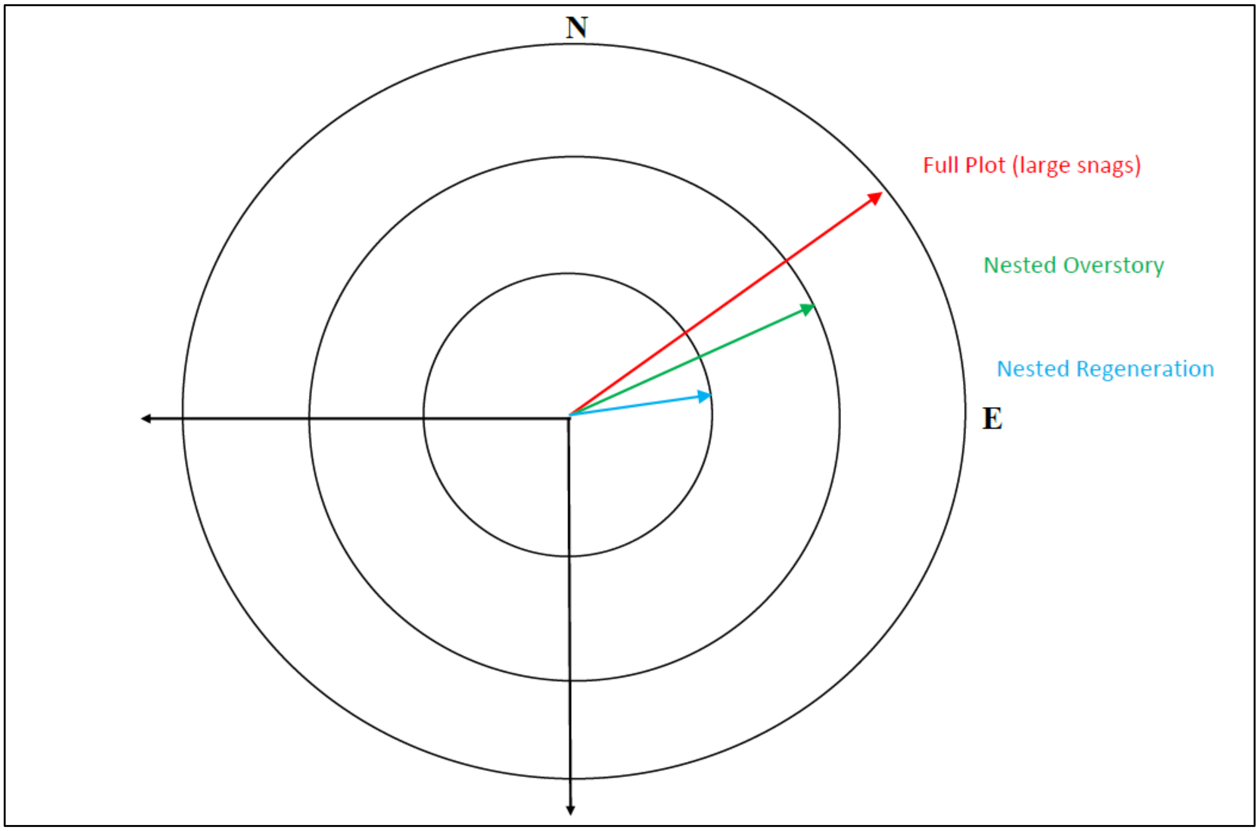

Figure 2. Diagram showing layout of plots used to sample large snags (Full Plot), overstory trees (Nested Overstory), and small trees, tree seedlings, and shrubs (Nested Regeneration). Also shown are two transects used to sample woody, surface fuels, and oriented along the south and west cardinal directions (solid black lines with arrows).

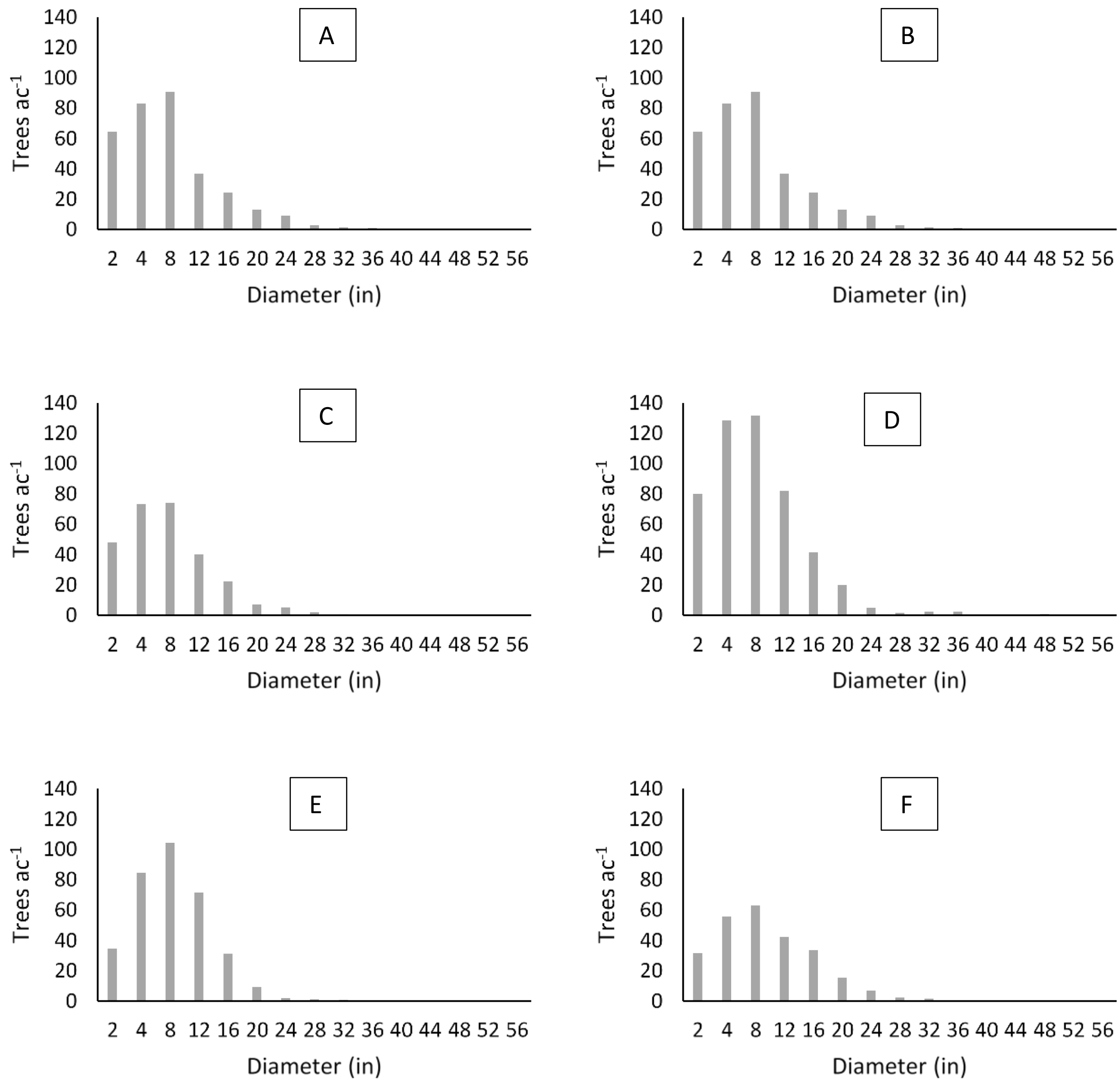

Figure 3. Tree diameter (diameter at breast height (dbh)) distribution within Protected Activity Centers. Mount Elden (A), Orion Spring (B), and Schultz Creek (C) are PACs that will received Flagstaff Watershed Protection Project (FWPP) treatments. Little Springs (D), East Bear Jaw (E), and Snowbowl (F) PACs are outside of FWPP and will remain as untreated reference sites.

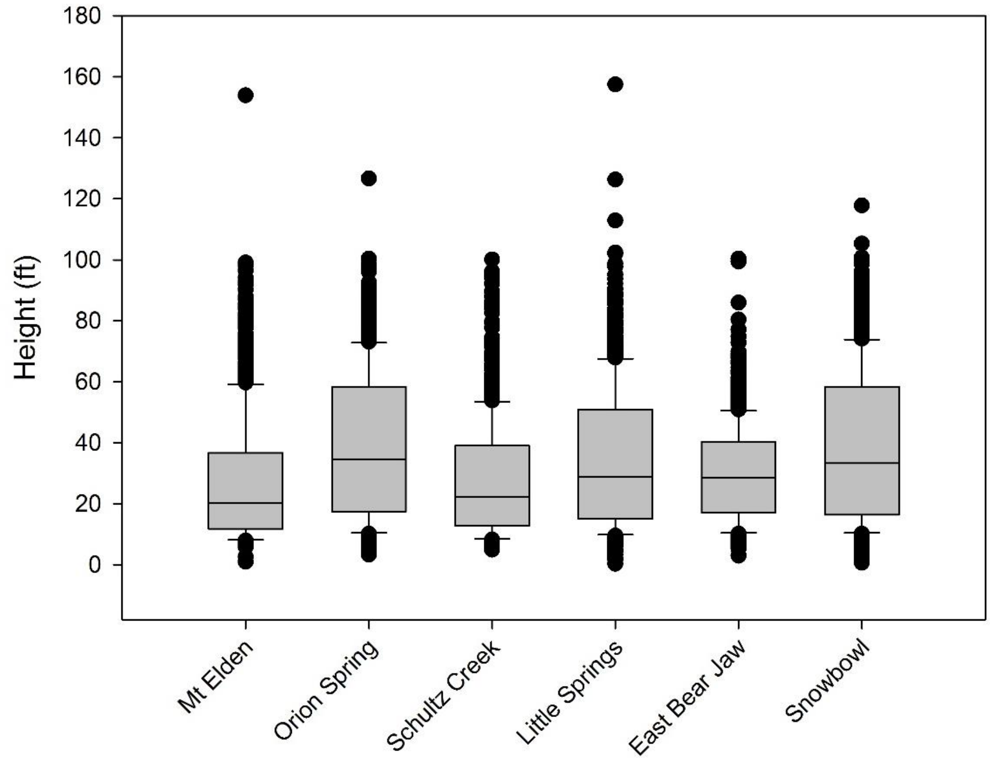

Figure 4. Distribution of tree heights (ft) within PACs. Box plots show median (horizontal line), data quartiles (box outline and bars), and outliers (filled circles). Mount Elden, Orion Spring, and Schultz Creek are PACs that will received Flagstaff Watershed Protection Project (FWPP) treatments. Little Springs, East Bear Jaw, and Snowbowl PACs are outside of FWPP and will remain as untreated reference sites.

Appendix 1. Means and standard deviations (SD) for forest structure and fuels variables within Schultz Creek PAC nest core area (n=6).

Variable	Mean	SD
Relative Importance: PIPO	33.3	33.6
Relative Importance: PSME	64.4	24.6
Relative Importance: PIFL	13.4	23.1
Relative Importance: ABCO	81	45.9
Tree density (no. ac^{-1})	445	168.6
Trees > 24 in (no ac^{-1})	1.7	4.1
Total BA (ft^2 ac^{-1})	110	34.4
Percent BA 12-18 in (%)	27.3	15.1
Percent BA > 16 in (%)	18.5	28.8
Percent BA > 18 in (%)	15	23.5
Snags > 16 (no. ac^{-1})	5	4.5
Logs > 16 (no. ac^{-1})	36.7	22.5
Crown fuel load (kg m^{-2})	1.1	0.31
Litter depth (in)	0.2	0.1
Duff depth (in)	1.1	0.4
Surface fuels 1-hr (t ac^{-1})	0.4	0.5
Surface fuels 10-hr (t ac^{-1})	1.5	1.7
Surface fuels 100-hr (t ac^{-1})	4.5	3.9
Surface fuels 1000-hr sound (t ac^{-1})	6.5	9.7
Surface fuels 1000-hr rotten (t ac^{-1})	16.9	27.4