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Effects of forest restoration treatments on ponderosa pine ecosystems in Boulder County, Colorado

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1. Introduction and Objectives

Lower montane forests in the Front Range of Colorado have been increasingly affected by severe large-scale disturbances such as wildfire and insect epidemics in recent years. In 2010, the collaborative interagency Front Range Roundtable successfully applied for a Collaborative Forest Landscape Restoration (CFLR) grant from the United States Forest Service (USFS) to help offset the risks to social and ecological communities by facilitating the implementation of restoration treatments across 32,000 acres of ponderosa pine-dominated forests. Collaborative, multi-party monitoring of the impacts of restoration was a required component of the grant; however, the budget for this work was limited, and funds were designated for use on National Forest (NF) lands only. With other members of the Roundtable, we developed supplemental proposals to the Southern Rockies Landscape Conservation Cooperative (SRLCC) in 2011 and Boulder County Parks and Open Space (BCPOS) in 2012 to significantly expand the assessment of the implementation and effectiveness of restoration treatments in the Front Range.

We initiated a study in July 2011 to increase the scope of forest restoration monitoring in the Front Range with 5 key objectives: (1) to monitor the effectiveness of restoration treatments implemented by BCPOS as well as by USFS on National Forest lands; (2) to conduct monitoring in adjacent areas not planned for treatment (controls); (3) to evaluate changes in within-stand structural heterogeneity due to treatments; (4) to measure the use of treated areas by a diverse suite of wildlife species; and (5) to investigate the effects of treatments on understory plant communities.

In this status report, we describe the methods we used to measure pre- and post-treatment forest characteristics across all study areas (National Forest lands as well as BCPOS sites) and present preliminary summaries of results for BCPOS sites which were treated with restoration prescriptions in summer-fall 2011 and surveyed in 2012. In Winter-Spring 2013, we will summarize and describe results to date from all sites in the larger study, to permit comparison of the implementation and effects of diverse treatment prescriptions from different agencies. This full report will be provided to BCPOS, our partners in USFS who have facilitated our work on their sites, and the SRLCC which granted initial funding to the project. After data collection is 100% complete in Summer 2013, we will revise our study reports and prepare a scientific paper for submission to a peer-reviewed journal. We will welcome input and acknowledge contributions from all agency partners during this process.

We note that the current report to BCPOS does not fully reflect all elements in our Small Grant proposal from Winter 2012. As described in a memo to BCPOS staff in August 2012 (Appendix 2; submitted separately from this report), we were not able to conduct point counts of birds or live-trapping of small mammals as planned. In consultation with BCPOS staff, we adjusted the project budget to represent the altered use of time and resources. Also, given the changes in schedule of treatment implementation, we identified and set up different study sites on BCPOS lands in 2012 for post-treatment monitoring, rather than re-surveying 2 sites originally planned for treatment (see Appendix 2 and below). The original CFLRP grant for restoration work in the Front Range has a 10-year time frame, and we hope to continue monitoring the ecological effects of the treatments on all sites in the study in future. The work we report here may be viewed as an initial step in a longer-term, broader scale effort to develop and implement effective monitoring of forested ecosystems in the Front Range where ecological restoration and adaptive management are high priorities.

2. Methods

A. Study sites

Pre-treatment period, 2011.

Data were collected between July and October 2011, on a total of 30 plots and transects divided among 3 “restoration treatment" units (pre-treatment) and 3 untreated “control” areas at the following BCPOS sites:

1. Hall Ranch. One unit, planned to be treated with a 66 acre prescribed fire, was sampled. The fire occurred on October 5, 2011
2. Heil Ranch. Two units of approx. 100 acres each were sampled (PA5 and PA7). The units were scheduled to be thinned Winter-Spring 2012.

Post-treatment period, 2012

1. The Hall Ranch prescribed burn had occurred on the planned date. Post-treatment sampling was done in July 2012.
2. The two Heil units PA5 and PA7 had not been treated, due to constraints on funding and scheduling. Their treatments are now planned for Fall 2012-Winter 2013. We collected a 2nd year of pre-treatment data for some variables on the plots on these sites in August 2012.
3. After discussion with BCPOS staff, we decided to establish a new set of post-treatment plots on
    a. One unit at Hall Ranch which had been treated in summer 2011. We named this site “Hall2”.
    b. One unit at Heil Ranch which had been treated in summer 2011 also. We named this site “Heil3.”

For each of these 2 units, we surveyed 5 treatment plots and 5 control plots for a total of 20 additional plots. We did not have pre-treatment data for these sites.

The locations of our 50 total plots on BCPOS lands and the timing of data collection are summarized in Table 1. In the larger Front Range study, we also collected pre- and post-treatment data on 2 treatment units plus controls on the Pike San Isabel NF (PSI NF) and on 3 units plus controls on the Arapaho-Roosevelt NF (ARNF), representing 49 additional plots at 5 additional sites for a total of 99 plots at 10 sites in the full study.

B. Plot selection

For each of the treatment units, we generated random points in a Geographic Information System (GIS) at a density of about 1 point (plot) per 10 acres. We checked each point in the field and assessed whether it contained at least 5 trees (using a Basal Area Factor (BAF) of 10), and at least 1 sapling/mature ponderosa pine. If so, we used it as a “treatment plot” in this study. If neither of these criteria were met, or if the plot contained unusual conditions such as a high proportion of juniper or beetle-killed ponderosa pine, we moved on to the next random point. We continued this process until we had identified the appropriate number of plots (usually 4 or 5) in each unit.

To determine the location of control plots, we generated random coordinates (in GIS) for plot locations in areas within approx. 1 mile of treatment units that met 2 criteria: 1) the area appeared to have similar species composition to the treatment units, and 2) the area was not scheduled for treatment in the next few years. We visited each random point in the field and evaluated whether the conditions there (i.e. overstory/understory species composition) approximately matched the conditions in one of the treatment plots. If so, we used that location as a control plot. If not, we either continued to the next random point or selected a new site nearby which matched a treatment plot more closely. Overall, we attempted to select a set of control plots in which overstory and understory species composition and structure were similar to those in the treatment plots. We did not attempt to standardize variables such as tree density, slope and aspect between treatment and control plots, although these were sometimes similar.

C. Variables measured

We collected the following data at each plot, using a variable-radius plot (BAF10) for trees and a fixed-radius plot (1/10 acre; 37.2 ft radius) with the same plot center for most other measurements (Figure 1). Most of the variables we measured and the detailed protocols we used followed either the USFS Common Stand Exam (CSE) methods (manual and full documentation available at http://fsweb.nris.fs.fed.us/products/FSVeg/documentation.shtml), or were identified in the Monitoring Plan completed in June 2011 for the Roundtable by the Colorado Forest Restoration Institute (CFRI) (see p. 23-31 in plan available at http://www.frontrangeroundtable.org/uploads/Roundtable_CFLRP_Monitoring_Plan_062511.pdf).

1. Overstory trees.

a. We measured all trees that were at least 4.5 ft tall and had a diameter at breast height (dbh) of at least 1 inch within a variable-radius plot with a Basal Area Factor (BAF) of 10. For each tree, we recorded species, dbh, health status, height, canopy base height, crown ratio, canopy position, and any signs of physical damage, disease, or insect infestation (as defined in the CSE manual.)

b. We inspected all in-plot trees for indications of wildlife use (e.g. nests, cavities, woodpecker foraging sign, tree squirrel feeding sign at base) and recorded these signs if present. We noted if nests appeared to be active or inactive based on whether they had one or more of the following characteristics indicating recent use: presence or visitation or audible calls from birds at the nest (this was rare but did occur); fresh-looking "whitewash" (feces) below the nest; fresh-looking vegetation included in the structure and intact shape of nest structure. If a nest contained only dry-looking, non-green vegetation and the nest structure appeared to have partly or fully disintegrated, we recorded it as inactive. We recorded cavities as "active" if we could identify these types of sign (as appropriate) and/or other fresh signs of use inside the cavity. However, we did not examine the interior of most cavities because they were above eye level, and therefore we recorded most of the cavities' status as "unknown." If in doubt about the type or recency of wildlife use, we took photos for later identification by specialists.

c. We noted an estimated age class for each tree (young/transitional/old) based on morphological characteristics described by Huckaby et al (2003) and/or local foresters.

d. We took a core from one "old"-looking tree of each dominant species present in the plot, and one representative "site" and/or "growth sample" tree per dominant species present. We selected trees to core based on the characteristics of site/growth/old trees described in the CSE manual, Huckaby et al. 2003, and/or by local foresters. If no appropriate trees were present within the plot, we chose trees nearby that fit the criteria, up to a distance of about 100 ft from plot center. We recorded all data on cored trees as described above (dbh, height, etc) ; noted distance and bearing to plot center, and gave each a tag. We saved cores for later processing, dating, and analysis in a lab at the Rocky Mountain Research Station (RMRS).

2. Saplings and seedlings.

We counted all seedlings and saplings (less than 4.5 ft tall) present in a 1/200 acre sub-plot (Fig. 1; 8.3-ft radius around plot center; consistent with CSE protocol.) We identified the species of each and classified them into 5 size classes: less than 1 ft tall, 1-2 ft, 2-3 ft, 3-4 ft, 4-4.5 ft. If any small trees were present (height > 4.5 ft but dbh <5 inches) that had not been counted in the BAF 10 overstory plot, we recorded them here also.

3. *Surface fuels.*

We tallied surface fuels on one 50-ft Brown's transect per plot, established along the north bearing from plot center. We followed standard protocols (Brown 1974 and CSE manual) to define and count all downed woody fuels in the 4 standard size classes that were present:

a. 1-hour fuels (up to 0.25 inches diameter) along an 8-ft section of the transect
b. 10-hr fuels (0.25-1 inches diameter) along an 8-ft section of the transect
c. 100-hr fuels (1-3 inches diameter) along a 12-ft section of the transect
d. 1000-hr fuels (more than 3 inches diameter) along the entire 50-ft length of the transect.

For each of the 1000-hr fuel pieces, we also recorded the decay class, diameter at the transect tape, diameters at the small and large ends, and length (as specified in Brown 1974 and the CSE manual). 1000-hr fuels are classified as coarse fuels or coarse woody debris (CWD). Fuel size classes a-c (1-hr, 10-hr, 100-hr) are classified jointly as fine fuels.

In addition, we measured the depth of the duff and litter layers and fuel bed (to the nearest 0.1 inch) at 2 points on the transect.

4. *Understory plants*.

a. We measured percentage cover of species present in the understory using a point-intercept method. We established 4 transects in the cardinal directions from plot center. Each transect was 30.75 ft long. At 100 evenly spaced points along each of these transects (i.e. every 3 inches between 6' and 30.75'), we recorded any plant present that was up to 4.5' tall. We identified herbaceous, forb, and shrub species present to the species level if possible in the field. If species identification was not possible in the field, we collected a specimen from outside the plot which was pressed for later identification in the lab. We noted substrate type at each point also, i.e. rock, litter, soil, or wood. We noted the size of woody surface fuels (1-hr, 10-hr etc as described above) if present. We noted if portions of trees intersected our sampling points, up to a height of 4.5' off the ground. If more than one substrate and/or species was present at a sampling point, we recorded them all (e.g. litter, kinnickinnick (*Arctostaphylous uva-ursi),* Douglas-fir (*Pseudotsuga menziesii*) sapling.) The number of occurrences of each plant species and substrate type was tallied to calculate percent cover for each species and substrate.

b. We conducted a complete inventory of all understory species present in a 1/10 acre plot (37.2 ft radius). This entailed systematically searching for any plants that did not intercept the 4 transects surveyed for percent cover, and identifying those additional species either in the field, or from a sample that was removed, pressed, and keyed out in the lab.

5. *Wildlife use on forest floor*

a. Within the 1/10 acre plot (37.2 ft radius), we searched for and recorded feeding sign of Abert's squirrels and pine squirrels on the forest floor. We counted all chewed cones, middens, branch clippings, etc, that were present, attributing them to either species of squirrel based on descriptions of each species' typical feeding evidence provided by local wildlife biologists. We categorized the cones and clippings as freshly harvested (since the most recent winter) or older (from the previous season) based on their color.

b. We recorded any scat and tracks present in the 1/10 acre plot. If in doubt as to the species responsible, we took photos or samples for later identification by wildlife specialists. We categorized scat as fresh (from the current spring/summer season) or old (from before the past winter) based on texture, moisture, and other evidence described by local wildlife biologists.

c. If we observed or heard any animals that we could identify to species on or near the plot (within sight from plot center) during the data collection period, we recorded this information. (These data were regarded as "anecdotal only" and not presented or analyzed here, because we recognize that we were not systematically surveying populations and that animals (and species) had variable detectability and variable responses to our presence.)

d. We noted any other signs of animal use, such as game trails, burrows, feathers, bones, etc, and identified the species responsible (and recency of use) in the field or from photos whenever possible. We designated burrows as inactive if there was debris and/or cobwebs covering the entrance, no signs of disturbance of the substrate in or near the entrance, and a disintegrating shape/structure of the entrance hole.

6. Ground-dwelling invertebrates

On most of the plots in the study, we established pitfall traps to capture ground-dwelling insects (Cheng et al 2006). Each trap consisted of two16-ounce plastic cups stacked together and buried in the ground so that the lip was level with the forest floor. One trap per plot was set out and left in place for 2-5 weeks (average for BCPOS plots was 33 days, range 4-52 days). Time of establishment and removal was noted. The insects (and any other organisms) collected in the cups were placed in ziplock bags and frozen to preserve them for later identification by an entomologist at RMRS.

7. Broadcast call surveys for goshawks/raptors

Adjacent to each plot, we performed a brief broadcast call survey for goshawks. These surveys were done before any other activity occurred on the plot. One person stood about 50 ft north of plot center and played a recording of a Northern goshawk alarm call on an iPOD attached to a bullhorn megaphone. The call was played for approximately 30 seconds with the bullhorn pointing in each of the 4 cardinal directions. The observer listened and watched in silence for 30 seconds between each set of calls. Total time needed was 4 minutes. The presence and/or response of any raptors or other birds was noted in as much detail as possible.

8. Within-stand forest structure ("clumpiness").

To measure heterogeneity of stand structure beyond the scale of the plot, we established a sampling transect running 100 m (328ft) north of each plot center. Along this transect, we recorded the distances covered by closed-canopy forest vs. openings. In this context, we defined closed-canopy forest as saplings or overstory trees with a dbh of at least 1 inch. If canopies of trees/saplings were less than 5 feet apart, we counted them as part of the same closed-canopy "segment". We defined openings as areas with no saplings/trees present >1 inch dbh. Shrubs could be present in either openings or closed-canopy segments but were not counted/measured. If regeneration (saplings/seedlings with dbh < 1 inch) was present in an opening, we recorded if regeneration covered less than 50% or greater than 50% of the opening's length along the tape.

Within the closed-canopy areas, we noted whether the structure was single-story vs. multi-story (canopies of > 1 sapling and/or tree intersecting the tape at the same point). If any snags, middens, or trees with an old-growth appearance were present on these transects, we noted their location (i.e. distance from the start of the 100-m tape) and their dbh/species if applicable.

9. Plot descriptive data and marking protocols.

At each plot, we recorded GPS coordinates at plot center (by taking an averaged location from a hand-held GPS unit; stated accuracy usually 5-15 ft), as well as slope (%), slope position, aspect (degrees), elevation (from GPS unit), fuel model (one of the 13 fuel model types described by Anderson 1983), any signs of past disturbance, and the start and end time of the data collection.

We marked plots with a labeled aluminum stake pounded into the ground at plot center. We attached a soft aluminum tag and some colored flagging to the tree closest to the N bearing from plot center, and noted on the tag that tree's bearing and distance from plot center. We also tagged any trees that we had cored and noted their distance and bearing to plot center. We placed additional, labeled aluminum stakes in the ground 37.2 ft N and E from plot center (marking 2 of the 4 radii of the 1/10 acre wildlife use/understory survey plots). Finally, we placed labeled aluminum stakes at 50m and 100m N of plot center to mark the mid-point and end point of the forest structure ("clumpiness") measurement transect. These markers will improve a crew's ability to find the same plot and transect locations to collect data following treatments.

D. Data collection in 2012

<u>Post-treatment additional data collection</u>:
Based on the first year's data collection effort, we modified our sampling protocols as follows:

a. We added 2 additional sub-sampling plots in which we measured tree regeneration (seedlings and saplings.) This was done to better capture the clumped and irregular spacing of seedlings and saplings in the understory. When we had only one 1/200th-acre regeneration measurement plot, the variation among plots was very high. The data from the supplemental plots will not be included in pre- vs. post-treatment comparisons, but will be included in all post-treatment analyses comparing data on treatment vs. control plots over multiple years following treatment .

b. We also added 1 additional 50-ft Brown's surface fuel transect per monitoring plot to better capture the variation in surface fuels on the forest floor. Surface fuels (downed logs, twigs, woody debris) also occur in patches or pockets rather than being evenly distributed on the ground.

c. After recording wildlife scat on the 1/10-acre plots post-treatment, we removed all scat (e.g. deer pellet groups) so that if surveys are done in future years, we will be confident that scat deposited before and shortly after treatment has already been counted and discarded. Any scat present in 2015, for example, can be attributed to animals using the plot area since our post-treatment surveys in July-August 2012.

d. Following treatments, we observed that on most treatment plots, some of the trees had been cut, and downed logs and slash had accumulated. We added protocols to measure:

i. the diameter of all stumps of "in" plot trees cut during the treatment

ii. the dimensions of slash piles (height x length x width) or areas of scorched ground from burned slash piles (length x width). We noted the location of these piles or scars on plots and the approximate area they covered on the forest floor within the plot (e.g. pile occupies 25% surface area of NW quadrant of plot.)

iii. the dimensions of any logs (1000-hr fuels) <u>added</u> to the plots as a result of the treatment. We measured their diameters at the small and large ends, their total length, and their decay class (sound vs. rotten.) We classified "added" logs based on fresh-looking cuts or other evidence indicating they came from a tree felled as part of the recent treatment. "Added" logs were almost always sound, because they had been live trees, but we noted rotten "added" logs also if they appeared to be portions of snags or dead branches of live trees that had been cut during the treatment. We did not record logs that had apparently been present on the plots both before and after the treatment. To improve sampling efficiency and focus on logs which individually might make a considerable contribution to fuel loading and/or habitat structure, we measured only logs >5 ft in length, which had >50% of their total length within the plot boundary. If more than 30 such "new" logs were present, we randomly selected 2 out of the 4 quadrants of the plot in which to measure the logs, to maximize efficiency of sampling. If a large continuous pile of slash (which often included cut logs) was present on the plot, we measured its dimensions as above and also estimated the percentage of the plot area it covered.

F. Data summaries and future analyses

To address the study's main questions about the short-term impacts of restoration treatments on ponderosa pine ecosystems, we will ultimately use the data for our 10 different treatment sites (and 10 controls) on 3 agencies' lands in the Front Range in a Before-After Control-Impact (BACI) analysis. We will evaluate whether the variables listed below differed between treatment and control areas and between the pre- and post-treatment time periods (2011 vs. 2012/3) using 2-way repeated measures analysis of variance (ANOVA). Variation among the 3 different agencies' sites (PSI and AR National Forests, and BCPOS) will be evaluated in the analyses as a covariate. Regression analyses will also be performed to evaluate potential relationships between continuous variables (e.g. overstory basal area and understory percent cover.)

In this report, we present summaries for BCPOS sites of many of the variables listed below, which will be used in the future ANOVAs and regression analyses. Currently, sample sizes of the summarized data are generally too small to permit valid statistical analyses, but when all 10 sites' data are available for the post- as well as pre-treatment periods, the full analyses can be completed.

Variables of interest included in current comparisons and future analyses:

a. Overstory: Basal area (sq ft/acre), tree density (stems (trees) per acre); Table 1.
Future: species composition, canopy cover, canopy base height, canopy bulk density, proportions of trees of different age classes, age of cored trees.

b. Regeneration: Density of seedlings/saplings per acre, species composition.

c. Fuels: Percent cover of fine and coarse fuels based on abundance on plot transects (Table 1).
Future: Total fuel loading, fuel loading of 1, 10, 100, 1000 hr fuels, modeled fire behavior potential (e.g. metrics such as torching index, % of surface fire vs. passive vs. active crown fire if an ignition occurred).

d. Understory: Percent cover (total plant cover); percent cover by plant life form (shrub, forb, grass); percent cover by substrate type (litter, soil, etc.); Table 2.
Future: Total species richness; species richness and cover by functional groups (e.g., native/exotic, grass/forb/shrub, annual/biennial/perennial); cover for species of interest (e.g., noxious species, dominant native understory species)

e. Wildlife: Number of guilds and signs of use per guild recorded at each plot (Tables 7 and 8); percent of plots at each site with use by each guild (Table 9); mean number of signs per guild per site (Table 9); number of orders of insects and arachnids represented in pitfall traps; numbers of individual insects and arachnids present (Table 5).
Future: amount of use by individual species/guilds (e.g., squirrels – quantified as numbers of feeding sign recorded; ungulates – quantified using pellet counts; ground-dwelling insects- quantified by counts of individuals present in pitfall traps.) Types of use of area (e.g., foraging, nesting, cover) will also be compared (quantified by signs of use per category across guilds, e.g. ungulate browsing sign on shrubs in plot and sapsucker foraging sign on tree trunks would both be tallied under "foraging.") For the invertebrates, final analyses of the pitfall trap data will be standardized by time the traps were left out, i.e. number of orders/individuals collected per day.

f. Within-stand forest structure: Number of openings/clumps; size of openings/clumps; total transect distance covered by openings vs. clumps (Figure 1).
Future: number of single-storied vs. multi-storied clumps.

3. Preliminary summary of selected data

a. Overstory

Basal area (BA) of trees across all untreated BCPOS sites (Hall1 T pre-treatment, Hall1 C, Hall2C, and Heil3C) ranged from 72.5 square feet/ac to 116 square feet/acre. The prescribed burn treatment did not change the basal area or trees per acre at Hall1T, because no trees scorched in the fall fire on our 4 monitoring plots appeared to have died by the following summer. However, the thinning treatments at Hall2 and Heil3 did reduce BA and TPA considerably, relative to the control sites (assuming that the control sites were adequate representations of the pre-treatment stand conditions.) At Hall2, basal area on the control site was 102 sq ft/ac with 348 trees per acre (TPA). On the Hall2 treated site, basal area was 67% less – 36 sq ft/ac – with only 33 TPA present (Table 2). The differences between the BA and TPA values also suggest that a greater proportion of larger trees were present post-treatment at Hall2T vs. Hall2C. On the treated site at Heil3, lower values of both BA and TPA were also measured compared to on the control site (although the differences were less than at Hall2): 62 sq ft/ac and 115 TPA at Heil3 T vs. 116 sq ft/ac and 313 TPA at Heil3C.

b. Understory, substrate, and fuels

Mean percent cover of understory plants on all 4 untreated sites as well as on the 2 post-thinning treatment sites, Hall2 and Heil3, was 13-26%. No major differences in understory total cover were apparent between the thinned treatment and control sites (Hall2 and Heil3; Table 2; as shown by the overlapping standard error values (SEs) around the means.) However, mean understory cover was considerably lower at Hall1T (10.06 ± 1.35%) following the prescribed burn treatment than at Hall1C (25.25 ± 4.61%). Cover of litter on the forest floor was uniformly high – approximately 87 ± 8.56% across 5 of 6 BCPOS T and C sites – all except Hall1T. After the burn, mean litter cover at Hall1T was only 63.8% , and mean cover of soil substrate was 8.7% (vs. 3.2% on the control site). However, the burn did not appear to "add" any fine or coarse fuels to the Hall1T site relative to the control. In contrast, on the 2 thinned sites Hall2T and Heil3T, mean cover of fine fuels was almost twice as great relative to the controls (approx. 7% vs approx. 3.5%). Treatments did not "add" cover of coarse fuels recorded on the transects within treated plots, but did add slash piles, individual cut logs, and/or burn scars as shown in Table 3; these covered an average of around 5% of plot area on 3 plots at Hall2T, and 23% plot area on 2 plots at Heil3T.

Prior to treatment, cover of exotic plants was generally very low throughout the Front Range sites (<1%; data not shown in this report), but at Heil Ranch PA5, higher proportions of cheatgrass (*Bromus tectorum*) and Canada bluegrass *(Poa compressa*) were present on most plots (1-5% of total plant cover). Overall, 15 exotic species were encountered in the broader Front Range study (data not shown in this report). Five are listed as noxious weeds in Colorado: cheatgrass (*Bromus tectorum*), musk thistle (*Carduus nutans*), Canada thistle (*Cirsium arvense*), Dalmation toadflax (*Linaria dalmatica*) and mullein (*Verbascum thapsus*.) Three of these five (all but the thistles) were recorded on our BCPOS plots in low numbers. Metrics of native species diversity, plant community composition, substrate composition, and several other variables describing the understory will be presented in the final Front Range study report.

c. Wildlife use

Numerous species were identified as having used plots, through sign and/or visual or aural detection (Table 6). These fell into 6 major guilds. Examples of the species encountered on our BCPOS plots are:

i. Tree squirrels: Abert's squirrel
ii. Small mammals: Deer mouse, chipmunks, ground squirrels, rabbit/hare
iii. Large mammals: Coyote, fox, black bear, mountain lion

iv. Ungulates: Deer, elk
v. Birds: Northern flicker, Steller's jay, American robin, Merriam's turkey, Western tanager, owls, hummingbirds, sapsuckers, woodpeckers
vi. Insects: ground-dwelling insects and arachnids, e.g. beetles, ants, bees, mites, flies, spiders, daddy-long-legs (identified to order and/or family; Tables 4 and 5).

In 2011, prior to treatment, we found that almost all plots contained fresh and/or older sign of 2, 3, or 4 of these 6 guilds (Table 7). One plot had evidence of 5 guilds' use. Most plots had multiple signs of use per guild per plot, e.g. scat and burrows of small mammals; game trails and browsing by ungulates. However, we emphasize that our methods were intended to identify general trends in use over time, and we did not attempt to quantify numbers of individuals from these data. If we found one active burrow with a 3-inch diameter opening, we could not estimate how many rodents might be using it, or which species. We simply recorded this as one instance of habitat use by small mammals.

As we expected, the pre-treatment data showed no obvious differences in levels of wildlife use between the treatment and control units (Table 7) over a period of approximately 2 years prior to treatment (recent and older signs were pooled in Table 7, because we intend to use this as a basis for comparison for future post-treatment surveys.) Every pre-treatment plot in the study showed use in this pre-treatment period by ungulates, and most were also used by Abert's squirrels and/or ground-dwelling small mammals (Table 7). No pine squirrel use was recorded and no pine squirrels were observed on BCPOS lands. Signs of birds and large mammals were relatively less common at all sites. No raptors responded to the goshawk alarm calls. Ground-dwelling insects and spiders were not sampled in all plots before treatment, but 16 of 17 plots with pitfall traps did record at least 1 capture.

In 2012, on the 3 treated sites (Hall1, Hall2, Heil3), general patterns of presence/absence of wildlife use sign did not appear to be very different from the control sites or, in the case of Hall1, from the pre-treatment period also (Table 8; compare to Table 7, noting that Heil 5 and Heil 7 were not treated, and Hall2 and Heil3 were not sampled pre-treatment). Most plots on both the treated and the control sites had evidence of use by 3, 4, or 5 guilds.

Comparing the post-treatment and control sites in more detail (Table 9), and focusing on fresh sign only (estimated a) to have been left since the recent winter or b) to be active or present since the treatment), revealed some interesting differences. Only 25% (1 of 4))plots on both the T and C sites at Hall1 had recent sign of Abert's squirrel feeding before the treatment, but all 4 plots on the burn site had fresh Abert's sign after the treatment, as well as 3 of 4 plots on the control. In contrast, no plots on the burn had signs of ungulate use after the burn, although 3 pre-burn and 3 control plots post-burn did have ungulate sign. Small mammal use appeared fairly high both before and after the burn on both T and C plots, but no large mammal sign was detected post-burn. Two of 4 plots had recent bird use sign after the burn, as well as 2 of 4 control plots.

On the 2 thinned sites, tree squirrel use was similar at both sets of treatment and control sites (100% plots used at Hall2, 40% plots used at Heil3). For small mammals, 20-40% plots at Hall2 T and C and Heil C had sign, but none was recorded on HeilT. 20% of plots had recent signs of use by birds at Hall2 C and Heil3 T and C, but none were used by birds on Heil3T. Interestingly, one small raptor did respond to the goshawk call survey at a plot on Hall2C, by approaching silently to a distance of about 50ft from the field crew, but no identification was possible. Use by ungulates appeared similar at Hall2 T and C (40% and 60% of plots respectively, with 1-3 types of sign), but at Heil3 only 1 treated plot and no control plots had ungulate sign. For large mammals, only 2 plots at Hall2 C had sign; no sign was recorded at any of the other sites.

d. Insects and arachnids

Due to various scheduling issues, we sampled different sites in 2011 with pitfall traps than were actually treated. Therefore, we have pre-treatment data for sites Heil5 and Heil 7 (not summarized in this report) and post-treatment data for Hall1 T and C, Hall 2T and C, and Heil 3 T and C. On the post-treatment sites, invertebrates were identified from a total of at least 14 families representing 9 known orders of insects and arachnids (Table 4). Spiders, ants, and beetles were found at the greatest number of plots. The mean numbers of orders present did not appear to differ greatly between treated and untreated control sites (Table 5), generally ranging from 1-3 orders per site. However, the mean numbers of individuals trapped varied greatly among plots within sites (from 1-72; Table 5). Due to this variation, no significant differences are likely to be generally detected between individual counts of invertebrates at treated and untreated sites (as shown by the overlapping values for standard errors in Table 5), except at Hall2, where 15.2 +/- 7.47 (mean =/- standard error; SE) individuals were captured on plots at the treated site and only 5.2 +/- 2.44 individuals were trapped in plots at the control site.

e. Stand structure

We found considerable variation among sites in measurements of stand structure prior to treatment. All 10 sites in the Front Range study study are included in Figure 1, which shows that some sites had stands with relatively few, relatively large openings (e.g. Hall1 C, Hall2 T and C); some had many small openings (e.g. sites on the PSI NF); and some had few small openings (e.g. Heil 5 and Heil 7).

On BCPOS lands, the mean proportion of transects covered by openings (vs. covered by closed-canopy forest) ranged from approx. 60-75% in the more meadow-y forested areas of Hall1, Hall2, and Heil3, and from 20-40% at Heil 5 and Heil 7 which represented denser, closed-canopy conditions overall. Due to treatment schedule variations, pre-treatment data were not collected before treatment (at Hall 2 and Hall 3) and post-treatment data cannot yet be collected at Heil 5, Heil 7, and ARNF EV 13. The mean numbers of openings present ranged from an average of around 4 openings per stand transect at Hall1, Hall2, and Heil5, to an average of around 7 openings at Heil3 and Heil7. The mean sizes of openings were fairly similar at most sites in the study, including Hall1T, and all sites at Heil – between 5 and 12 m in length. However, Hall1 C and Hall2 T and C had larger openings on average – 20-23m in length.

Comparing the post-treatment metrics between T and C sites shows that all 3 values (% transect length covered by openings, mean number of openings, and mean size of openings) did not differ greatly at either Hall1, Hall2, or Heil 3, as shown by the similar mean values and overlapping standard error bars for all of these sites in each of the 3 panels in Fig. 1. Hall1 T and C had different sizes of openings before the treatment, and the treatment of prescribed fire would not have been expected to change the stand structure greatly unless numerous trees were killed and fell soon after the burn. The lack of difference between T and C sites at Heil3 and Hall2 is more surprising, but a greater number of sampling transects should be installed to increase confidence that this pilot method is adequate to represent the actual structure of the stand. By chance, we may have measured non-representative cross-sections of the stands with our relatively few transects per stand.

4. Preliminary summary and discussion

The prescribed burn treatment at Hall1 did not change the numbers of trees per acre or basal area relative to pre-treatment conditions. Although some of the trees in our monitoring plots were scorched by the fire, none had died by the time of the post-treatment survey 10 months later. The numbers of trees per acre and basal area both pre- and post-treatment were fairly similar between the Hall1 treatment site and the Hall1 control site (Table 2), although the Hall2 control site was somewhat more open with fewer trees and lower BA. In contrast, although we had not measured pre-treatment conditions, the thinning treatments at the Hall2 and Heil3 sites reduced both BA and TPA considerably relative to the controls. At Hall2, BA was lower by a factor of 3 and TPA was lower by a factor of 10. At Heil3, the difference was less in magnitude but in the same direction: BA was half as great and TPA was 3 times lower on the treatment compared to the control. It is interesting that the stand structure metrics did not reflect these different average BA and TPA values for the sites, but as noted, our "clumpiness transects" are a pilot method that should be repeated at greater frequency per site before we can be confident to what degree these measurements represent the stand structure.

At the time of the post-treatment surveys, the mean understory cover at Hall1T was only half the average value measured on the control site, Hall1C. However, the understory total cover values at Hall2 and Heil3 were similar to those on their control sites. This suggests that the thinning treatment affected understory cover less strongly than did the burn, and (or) that understory re-grew more rapidly within one year post-thinning than one year post-burn. The lower value for total cover at Hall1T appeared to be mostly due to a reduction in grass cover on the burn relative to the control. In contrast, at Hall2 and Heil3, values for grass and shrub cover were generally similar between treatments and controls, but the forb cover values on the treated sites were higher. More detailed analysis of the species present at each site will help clarify the possible mechanisms of understory responses to the different treatments over time. We will also evaluate correlations between overstory and understory variables, but these preliminary results do not suggest a tightly linked relationship – for example, basal area of trees remaining after treatment at Heil3 was twice as high as at Hall2, but total understory cover was similar (Table 3).

Several expected changes were detected in substrate and fuels cover on treated sites relative to controls: the prescribed fire at Hall1 appeared to decrease litter on the forest floor and expose soil, but did not alter woody surface fuels. The thinning treatments did not apparently change litter or soil but did increase fine fuel cover and added components such as logs, slash piles and burn scars at scattered locations across the treated sites.

The general patterns of wildlife use that we recorded from sign did not reveal major changes between treatment and control areas or across sites. Pre-treatment, older and recent signs of many of the major guilds were found on almost all of our monitoring plots. Post treatment, signs of recent use by tree squirrels and ground-dwelling small mammals were most common, and use by large mammals (bear, mountain lion, coyote and fox) was least common. We found variable patterns of ungulate use, including a lack of use on the prescribed-burn plots after treatment, some use of thinned treated sites, but no use on one control site. Use by birds was low but occurred across almost all sites post-treatment in 2012. Ground-dwelling invertebrates were captured at almost all plots where we established traps, both before and after treatment, but numbers varied widely among plots and we did not detect clear differences between pre- and post-treatment sites for this guild.

In summary, we emphasize that our monitoring of the effects of restoration treatment on diverse components of the ponderosa pine ecosystems on BCPOS lands should be considered a preliminary step in the collaborative, longer-term study of 10 total sites in the Front Range that was initiated by the national CFLRP program and the SRLCC. We used well-established methods for measuring overstory trees, fuels, and understory plants, but developed new pilot methods for documenting wildlife use and stand structure. We acknowledge that the level of information generated by these pilot methods is relatively coarse (e.g., we cannot draw inferences about population sizes for wildlife species) but anticipate that our data may still help to identify general changes and patterns of use over longer time frames in a relatively affordable manner. To date, our comparison of 3 post-treatment sites with untreated control sites on BCPOS lands suggests that the prescribed burn treatment affected overstory, stand structure, understory cover, substrate and fine fuels cover, and use by various wildlife guilds somewhat differently than did the 2 thinning treatments in the first year following treatment. Not all of these responses were consistent between the 2 thinned sites and their controls, but trends were detected and baselines measured at all 3 sites that can be re-evaluated in future years. After presenting a full summary of results and analyses for all variables for all sites in 2013 to all our agency partners in this project, we will also be able to discuss modifying our sampling methods to increase their utility in generating data that can be effectively used in the adaptive management cycle for facilitating high-priority restoration efforts in forests of the Front Range.

H. References

Brown, J. K. 1974. Handbook for inventorying downed woody material. USDA Forest Service Gen. Tech. Rep. INT-16, 24p. Ogden, UT.

Cheng, Z, K. Grady, S. Stephens, J. Villa-Castillo, and M. R. Wagner. 2006. Fuel reduction treatment and wildfire influence on carabid and tenebrionid community assemblages in the ponderosa pine forest of northern Arizona, USA. Forest Ecology and Management 255: 168-177

Colorado Forest Restoration Institute (CFRI). 2011. Front Range Roundtable Collaborative Forest Landscape Restoration Project: Ecological, Social and Economic Monitoring Plan. Available at: http://www.frontrangeroundtable.org/uploads/Roundtable_CFLRP_Monitoring_Plan_062511.pdf).

Huckaby, L. S., M. K. Kaufman, P.J. Fornwalt, J. M. Stoker, and C.Dennis. 2003. Field Guide to Old Ponderosa Pines in the Colorado Front Range. USDA Forest Service Gen. Tech. Rep. RMRS-GTR-109. 44p.

USDA Forest Service Natural Resource Management Field Sampled Vegetation (NRIS FS Veg) Common Stand Exam (CSE) User's Guide Manual. 2011. Available at: http://www.fs.fed.us/nrm/fsveg/index.shtml.

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					Data collected												
Site/Unit	**Trt date**	**Survey dates**	**# trt plots**	**# control plots**	**overstory trees**	**seedlings/saplings***	**surface fuels**	**CWD from treatment**	**tree ages (cores)***	**wildlife use on trees**	**squirrel feeding sign**	**Scat**	**other wildlife sign on ground**	**insect pitfall traps**	**understory plants and substrate % cover**	**understory species - full inventory***	**forest clumpiness transect**
Hall Rx burn		pre-trt, Aug '11	4	4	X	X	X		X	X	X	X	X	X	X	X	X
	Fall'11	post-trt, July '12	same	Same	X	X	X	n/a	X	X	X	X	X	X	X	X	X
Heil3 2011 unit	Summer '11	post-trt, Aug '12	5	5	X	X	X	X	X	X	X	X	X	X	X	X	X
Hall2 2011 unit	Summer'11	post-trt, July '12	5	5	X	X	X	X	X	X	X	X	X	X	X	X	X
Heil PA5	not yet	pre-trt, Aug '11	7	6	X	X	X	n/a	X	X	X	X	X	X	X	X	X
		pre-trt, Aug '12	same	Same				n/a		X	X	X	X	X	X	X	
Heil PA7	not yet	pre-trt, Aug '11	5	4	X	X	X	n/a	X	X	X	X	X	X	X	X	X
		pre-trt, Aug '12	same	Same				n/a		X	X	X	X	X	X	X	
		total plots:	26	24													

Table 1. Names, treatment dates, numbers of plots, survey dates, and checklist of variables measured on monitoring plots at each of 5 study sites on BCPOS lands, 2011-2. Asterisks by 3 variables indicate that information on these data are not included in this status report, but will be included in the full Front Range study report in 2013.

Table 2. Overstory characteristics for the 3 BCPOS sites treated in 2011 and surveyed in 2012: trees per plot (mean number live and/or cut); total trees on plots at site; basal area (square feet per acre) for site; and total trees per acre for site.

Agency	Unit	Trt vs. ctl? (T or C)	Date 2011 survey	Date 2012 Survey	#plots	Mean # Trees live/plot	SE # live/plot	Mean # Trees cut/plot	SE #cut/plot	Total # trees per site	Basal Area total/site	Trees per acre total/site
BCPOS	Hall1	T (burn)	8/3/2011	7/19/2012	4	8.75	1.80	n/a	n/a	35	87.5	299.12
BCPOS	Hall1	C	8/2/2011	7/23/2012	4	7.25	1.60	n/a	n/a	29	72.5	255.72
BCPOS	Hall2	T (thin)	n/a	7/30/2012	5	3.6	0.68	6.8	0.49	18	36	32.45
BCPOS	Hall2	C	n/a	7/26/2012	5	10.2	1.53	n/a	n/a	51	102	347.63
BCPOS	Heil3	T (thin)	n/a	8/2/2012	5	6.2	1.56	4.5	0.95	31	62	114.91
BCPOS	Heil3	C	n/a	8/14/2012	5	11.6	1.63	n/a	n/a	58	116	312.52

Table 3. Characteristics of understory, substrate, and surface fuels at the 3 BCPOS sites treated in 2011: percent cover of understory (total cover and cover by life form), substrate type (litter vs. soil), surface fuels, and slash piles/burn scars if present.

Site and year	Basal area (sq. ft./ac)	Trees per acre	Understory total cover (mean %, SE)	Understory Grass cover (mean %, SE)	Understory Forb cover (mean %, SE)	Understory shrub cover (mean %, SE)	Understory Substrate-litter cover (mean %, SE)	Understory Substrate-Soil cover (mean %, SE)	Understory substrate-fine fuels cover (mean %, SE)	Understory substrate – coarse fuels cover (mean %, SE)	Post-treatment-new logs, slash piles (SP), burn scars (BS)	% total plot area (approx) covered by logs, SP, BS
Hall1 T, 2012	87.5	299	10.06 (1.35)	6.6 (1.2)	2.6 (0.6)	0.9 (0.4)	63.8 (4.5)	8.7 (2.1)	2.4 (0.6)	0.1 (0.1)	None	n/a
Hall1 C, 2012	72.5	256	25.25 (4.61)	16.9 (3.7)	5.0 (1.6)	3.3 (1.0)	83.1 (6.8)	3.2 (1.4)	2.9 (0.9)	0.3 (0.3)	None	n/a
Hall2, T,2012	36	32	17.80 (3.92)	8.8 (2.1)	6.2 (2.1)	2.9 (1.3)	81.4 (5.0)	5.7 (2.4)	6.8 (0.9)	0.8 (0.4)	1 SP, 5 BS	4-5.5% (3 plots)
Hall2, C, 2012	102	348	13.80 (4.39)	8.8 (3.9)	3.6 (0.9)	1.5 (0.6)	85.5 (2.9)	5.4 (1.5)	2.9 (0.8)	0.1 (0.1)	None	n/a
Heil3, T, 2012	62	115	21.85 (5.40)	14.6 (3.8)	7.2 (2.1)	0.2 (0.1)	86.0 (3.7)	3.7 (1.5)	7.1 (1.8)	1.7 (0.7)	6 logs, 11 SP	20-26% (2 plots)
Heil3, C, 2012	116	312	15.90 (2.66)	10.8 (2.3)	3.7 (1.6)	1.5 (1.3)	89.3 (2.0)	0.3 (0.3)	4.8 (0.7)	1.3 (0.6)	None	n/a

Table 4. Orders and/or families of insects and arachnids found in 2012 on the 3 BCPOS sites treated in 2011 and their respective untreated controls (26 plots total had traps established in 2012). More information is presented in Table 5.

Order (Insects and Arachnids)	**Family (common name)**	**Number of plots where found**
Coleoptera	Tenebrionid beetles	0
	Carabid beetles	0
	Other beetles	15
Hymenoptera	Bees	4
	Ants	11
	Spechidae (thread-waisted wasps)	2
Diptera	Flies	2
Orthoptera	Grasshoppers	0
	Crickets	2
Lepidoptera	Butterflies	0
	Moths	0
Acari	Mites	5
Microcoryphia (bristletails)		3
Hemiptera (true bugs)		2
Arachnids	Araneae (Spiders)	10
	Opilones (Daddy long legs)	7

Table 5. Summary of 2012 pitfall trap collection results for traps established at 3-5 plots per site at 3 sites treated in 2011 (Hall1, prescribed fire; Hall2 and Heil 3, thinning treatments) plus nearby untreated control sites. Traps were left in place for an average of 33 days (range 4-52 days). Names of the insect and arachnid orders are in Table 4.

Plots - site, treatment (T) vs. control (C) and year	Number of ID-ed orders trapped per plot	Mean # (SE) orders per site	Numbers of intact, ID-ed individuals	Numbers of intact, unknown individuals or individuals accounted for by parts	Total individuals per plot	Mean # (SE) individuals per site	Miscellaneous additional parts present
Hall1 T1, 2012	2		4	1	5		4
Hall1 T2, 2012	2		4	27	31		0
Hall1 T3, 2012	4		20	2	22		7
Hall1 T4, 2012	3	2.75 (0.48)	11	1	12	17.5 (5.69)	9
Hall1 C1, 2012	7		66	6	72		0
Hall1 C2, 2012	1		1	4	5		14
Hall1 C3, 2012	3		11	1	12		37
Hall1 C4, 2012	4	3.75 (1.25)	8	2	10	24.75 (15.82)	7
Hall2, T1,2012	3		17	21	38		45
Hall2, T2,2012	3		14	14	28		49
Hall2, T3,2012	1		1	1	2		7
Hall2, T4,2012	2		2	0	2		0
Hall2, T5,2012	3	2.4 (0.4)	3	3	6	15.2 (7.47)	14
Hall2, C1, 2012	2		4	6	10		5
Hall2, C2, 2012	0		0	0	0		0
Hall2, C3, 2012	5		8	4	12		9
Hall2, C4, 2012	0		0	1	1		14
Hall2, C5, 2012	0	1.4 (0.98)	0	3	3	5.2 (2.44)	18
Heil3, T1, 2012	0		0	4	4		23
Heil3, T2, 2012	0		0	0	0		0
Heil3, T3, 2012	4		4	1	5		12
Heil3, T4, 2012	0		0	0	0		1
Heil3, T5, 2012	1	1 (0.77)	2	0	2	2.2 (1.02)	5
Heil3, C1, 2012	2		3	1	4		8
Heil3, C2, 2012	1		1	0	1		5
Heil3, C3, 2012	0	1 (0.58)	0	12	12	5.67 (3.28)	37

Table 6. Summary of wildlife use signs included in data set (Tables 7, 8, 9) as evidence that a plot/site was used by each of the 6 major guilds in this study.

Type of use	**Tree squirrels**	**Birds**	**Ungulates**	**Small mammals**	**Large mammals**	**Ground-dwelling insects**
Presence	n/a (visual/aural detections not included)	Turkey pellets; owl pellets; feathers; (visual/aural detections not included)	Deer pellets; elk pellets; game trails	Scat (rabbit/hare; rodent); (visual/aural detections not included)	Scat (fox, coyote, bobcat, mountain lion, bear)	Identified in pitfall trap collections
Foraging	Chewed cone cobs; needles clippings; peeled twigs; distinct feed trees; middens	Woodpecker foraging holes; Sapsucker foraging holes	Evidence of browsing on shrubs/saplings; browse sign on tree trunks	Partially consumed material (e.g. seed shells, berries) on rock/stump “feeding stations”	Sign of bear foraging on insects in logs/stumps; Sign of mtn lion predation of ungulate	
Cover	Nests	Nests; Cavities	Day beds	Burrows		

Table 7. Presence vs. absence of the 6 major guilds monitored, as recorded by diverse signs of use described in text and in Table 6, on plots PRE treatment in Summer 2011. Note that Heil PA5 and PA7 were not sampled after treatment (not yet treated.) Both older (greater than ~ 6 months old) and recent (less than ~ 6 mo old) signs are included in this summary.

Area	Unit	T vs. C	Plot	Pre vs Post	Year	Presence (y) vs. absence (n) of sign of guild						
						Tree squirrels	Birds	Ungulates	Lg. Mammals	Sm. Mammals	Ground invertebrates	Total
Hall	1	T	1	Pre	2011	N	N	Y	N	Y	.	2
Hall	1	T	2	Pre	2011	N	Y	Y	Y	Y	.	4
Hall	1	T	3	Pre	2011	N	N	Y	N	Y	.	2
Hall	1	T	4	Pre	2011	Y	N	Y	N	Y	.	3
Heil	PA5	T	1	Pre	2011	Y	N	Y	N	N	.	2
Heil	PA5	T	2	Pre	2011	Y	N	Y	N	N	Y	3
Heil	PA5	T	3	Pre	2011	Y	N	Y	N	N	Y	3
Heil	PA5	T	4	Pre	2011	Y	N	Y	N	N	Y	3
Heil	PA5	T	5	Pre	2011	Y	N	Y	N	N	Y	3
Heil	PA5	T	6	Pre	2011	Y	N	Y	N	N	Y	3
Heil	PA5	T	7	Pre	2011	Y	N	Y	Y	N	N	3
Heil	PA7	T	1	Pre	2011	Y	Y	Y	N	N	Y	4
Heil	PA7	T	2	Pre	2011	Y	Y	Y	N	N	Y	4
Heil	PA7	T	3	Pre	2011	Y	N	Y	N	N	Y	2
Heil	PA7	T	4	Pre	2011	Y	N	Y	Y	N	Y	4
Heil	PA7	T	5	Pre	2011	Y	Y	Y	N	N	Y	4
Hall	1	c	1	Pre	2011	N	Y	Y	N	Y	.	3
Hall	1	c	2	Pre	2011	Y	N	Y	N	N	.	2
Hall	1	c	3	Pre	2011	N	N	Y	Y	Y	.	3
Hall	1	c	4	Pre	2011	N	N	Y	N	Y	.	2
Heil	PA5	c	1	Pre	2011	Y	N	Y	N	N	Y	3
Heil	PA5	c	2	Pre	2011	Y	Y	Y	N	N	Y	4
Heil	PA5	c	3	Pre	2011	Y	N	Y	N	N	Y	3
Heil	PA5	c	4	Pre	2011	Y	N	Y	N	N	Y	3
Heil	PA5	c	5	Pre	2011	Y	N	Y	N	N	Y	3
Heil	PA5	c	6	Pre	2011	Y	Y	Y	Y	N	Y	5
Heil	PA7	c	1	Pre	2011	Y	Y	Y	N	N	.	3
Heil	PA7	c	2	Pre	2011	N	N	Y	Y	N	.	2
Heil	PA7	c	3	Pre	2011	Y	N	Y	N	N	.	2
Heil	PA7	c	5	Pre	2011	Y	Y	Y	Y	N	.	4

Table 8. Presence vs. absence of signs of use (recent and older; see text) of the 6 major guilds monitored, on plots POST treatment* surveyed in Summer2012.

Site		T/C	Plot	Time	Year	Tree squirrels	Birds	Ungulates	Large Mammals	Sm. mammals	Gr. inverts	**Total**
Hall	burn	T	1	Post	2012	Y	y	y	N	y	Y	5
Hall	burn	T	2	Post	2012	Y	n	y	N	y	Y	4
Hall	burn	T	3	Post	2012	N	y	y	Y	y	Y	5
Hall	burn	T	4	Post	2012	Y	y	y	N	y	Y	5
Hall	burn	C	1	Post	2012	Y	n	y	N	y	Y	4
Hall	burn	C	2	Post	2012	Y	y	y	N	y	Y	5
Hall	burn	C	3	Post	2012	Y	n	y	N	y	Y	4
Hall	burn	C	4	Post	2012	N	n	y	N	y	Y	3
Hall	Hall2-thin	T	1	Post	2012	Y	n	y	N	n	Y	3
Hall	Hall2-thin	T	2	Post	2012	Y	n	y	N	n	Y	3
Hall	Hall2-thin	T	3	Post	2012	Y	n	y	N	y	Y	4
Hall	Hall2-thin	T	4	Post	2012	Y	n	y	N	y	Y	4
Hall	Hall2-thin	T	5	Post	2012	Y	n	y	N	y	Y	4
Hall	Hall2	C	1	Post	2012	Y	n	y	N	y	Y	4
Hall	Hall2	C	2	Post	2012	Y	n	y	N	y	N	3
Hall	Hall2	C	3	Post	2012	.	.	.	.	.	.	.
Hall	Hall2	C	4	Post	2012	Y	n	y	N	y	Y	4
Hall	Hall2	C	5	Post	2012	Y	n	y	Y	n	Y	4
Heil	Heil3-thin	T	1	Post	2012	Y	n	y	Y	n	Y	4
Heil	Heil3-thin	T	2	Post	2012	Y	y	y	N	y	N	4
Heil	Heil3-thin	T	3	Post	2012	Y	n	y	N	y	Y	4
Heil	Heil3-thin	T	4	Post	2012	N	y	y	N	n	Y	3
Heil	Heil3-thin	T	5	Post	2012	Y	n	y	N	n	Y	3
Heil	Heil3	C	1	Post	2012	N	y	y	N	y	Y	4
Heil	Heil3	C	2	Post	2012	Y	n	y	Y	y	Y	5
Heil	Heil3	C	3	Post	2012	Y	n	y	N	y	Y	4
Heil	Heil3	C	4	Post	2012	N	n	y	N	n	Y	2
Heil	Heil3	C	5	Post	2012	Y	y	y	N	n	Y	4

*Sites Hall2 and Heil3 were not sampled prior to treatment.

Table 9. Percentage of monitoring plots with signs of use by 5 major wildlife guilds monitored on treated and control plots at the 3 BCPOS sites treated in 2012.The mean (SE) number of different signs recorded per guild (e.g. scat plus grazing sign = 2 signs) is shown for the plots at each site on which sign was present. Sign included in this table represents FRESH use/active status sign only, recorded in summer 2012.

	Tree Squirrels		Birds		Ungulates		Small Mammals		Large Mammals	
Site	**% plots at site w sign**	mean (SE) #s of signs if sign present	**% plots at site w sign**	mean (SE) #s of signs if sign present	**% plots at site w sign**	mean (SE) #s of signs if sign present	**% plots at site w sign**	mean (SE) #s of signs if sign present	**% plots at site w sign**	mean (SE) #s of signs if sign present
Hall1T-2011	**25**	1 (0)	**25**	1 (0)	**75**	1 (0)	**50**	1.0 (0)	**25**	1.0 (0)
Hall1C-2011	**25**	1 (0)	**0**	n/a	**75**	1.33 (0.58)	**50**	1.0 (0)	**25**	1.0 (0)
Hall1T-2012	**100**	1.5 (0.58)	**50**	1 (0)	**0**	n/a	**25**	1.0 (0)	**0**	n/a
Hall1C-2012	**75**	1.33 (0.58)	**50**	1 (0)	**75**	2 (0)	**75**	1.0 (0)	**0**	n/a
Hall2T-2012	**100**	2 (0.71)	**0**	n/a	**40**	1 (0)	**20**	1.0 (0)	**0**	n/a
Hall2C-2012	**100**	2.6 (0.89)	**20**	1 (0)	**60**	1.67 (0.58)	**40**	1.0 (0)	**40**	2 (1.41)
Heil3T-2012	**40**	2 (1.41)	**20**	1 (0)	**20**	1 (0)	**0**	n/a	**0**	n/a
Heil3C-2012	**40**	1 (0)	**20**	2 (0)	**0**	n/a	**20**	1.0 (0)	**0**	n/a

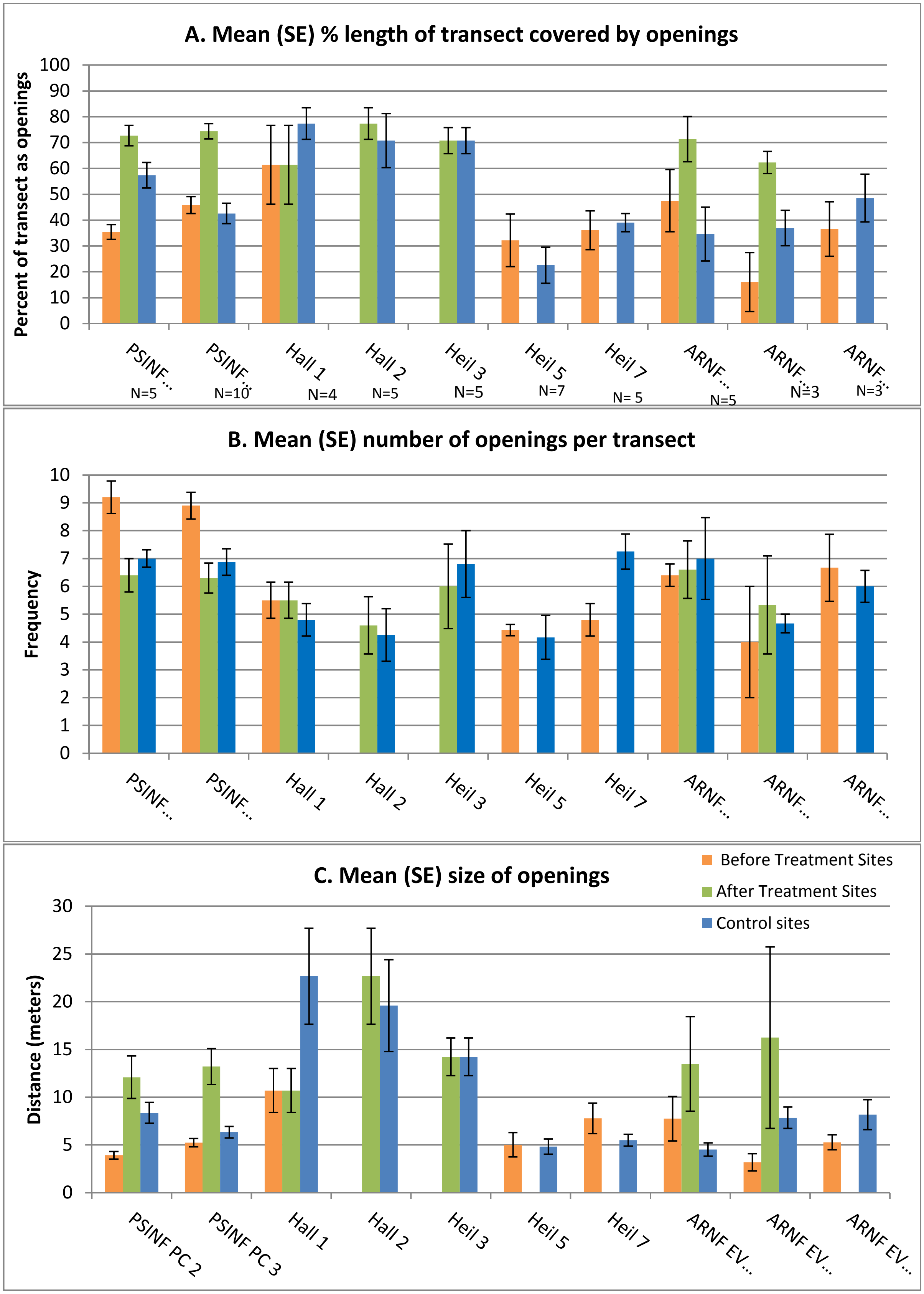

Figure 1. Metrics of stand structure at 10 Front Range sites (including 5 BCPOS sites at Heil and Hall): A) mean percentage of stand transects (100m) covered by openings (vs. trees); b) mean number of openings and c) mean size of openings. At most sites, data were collected before treatment (orange); after treatment (green); and on control sites (blue) which were not treated. Samples sizes (N transects per site) as stated in Panel A. Error bars show standard error (SE.)

Appendix 1. Literature review summary

Studies of the effects of diverse forest treatments on small mammals, reviewed as part of this project. A copy of each paper, brief summary of the findings of each study, and synthesis of the general conclusions across all studies has been produced for BCPOS staff by Jenny Briggs.

A. General, national-scale, or synthesis papers

1. Converse SJ et al. 2006a. Small mammals and forest fuel reduction: national-scale responses to fire and fire surrogates. Ecological Applications 16: 1717-1729
2. Fontaine JB and Kennedy PL. 2012. Meta-analysis of avian and small-mammal response to fire severity and fire surrogate treatments in U.S. fire-prone forests. Ecological Applications 22: 1547-1561
3. Hansen, AJ et al. 1991. Conserving biodiversity in managed forests. Bioscience 41: 382-391.
4. Lehmkuhl, JF et al. 2007. Seeing the forest for the fuel: integrating ecological values and fuels management. Forest Ecology and Management 246: 73-80
5. Pilliod, DS et al. 2008. Wildlife and invertebrate response to fuel reduction treatments in dry coniferous forests of the western United States: a synthesis. USDA General Technical Report, RMRS-GTR-173. 34 p.
6. Zwolak, R. 2009. A meta-analysis of the effects of wildfire, clearcutting, and partial harvest on the abundance of North American small mammals. Forest Ecology and Management 258: 539-545

B. Regional, treatment type- or site-specific studies

1. Bock CE and Bock JH, 1983. Responses of birds and deer mice to prescribed burning in ponderosa pine. Journal of Wildlife Management 47: 836-840
2. Bowman, JC et al. 2000. The association of small mammals with coarse woody debris at log and stand scales. Forest Ecology and Management 129: 119-124
3. Carey AB. 2000. Effects of new forest management practices on squirrel populations. Ecological Applications 10: 248- 257
4. Chambers CL. 2002. Forest management and the dead wood resource in ponderosa pine forests: effects on small mammals. In: Laudenslayer et al, 2002. Proceedings of the symposium on the ecology and management of dead wood in western forests. PSW-GTR-181: 679-693
5. Converse SJ et al. 2006b. Small mammal response to thinning and wildfire in ponderosa pine-dominated forests of the southwestern United States. Journal of Wildlife Management 70: 1711-1722
6. Craig VJ et al 2006. Relationships between deer mice and downed wood in managed forests of southern British Columbia. Canadian Journal of Forest Research 33: 2283-2296
7. Ganey JL and Vojta SC. Rapid increase in log populations in drought-stressed mixed conifer and ponderosa pine forests in Northern Arizona. Open Journal of Forestry 2: 59-64
8. Goodwin JG and Hungerford CR. 1979. Rodent population densities and food habits in Arizona ponderosa pine forests. RM-GTR-14, 12 p.
9. Kalies EL et al. 2012. Community occupancy responses of small mammals to restoration treatments in ponderosa pine forests, northern Arizona, USA. Ecological Applications 22: 204-217
10. Loberger CD et al. 2011. Use of restoration-treated ponderosa pine forest by tassel-eared squirrels. Journal of Mammalogy 92: 1021-1027.
11. Loeb SC. 1999. Responses of small mammals to coarse woody debris in a southeastern pine forest. Journal of Mammalogy 80: 460-471
12. Manning JA and Edge WD. 2004. Small mammal survival and downed wood at multiple scales in managed forests. Journal of Mammalogy 85: 87-96
13. Manning JA and Edge WD. 2007. Small mammal responses to fine woody debris and forest fuel reduction in southwest Oregon. Journal of Wildlife Management 72: 625-632
14. Steventon et al. 1998. Response of small mammals and birds to partial cutting and clearcutting in northwest British Columbia. The Forestry Chronicle 74: 703-713.
15. Sullivan TP et al 2001. Stand structure and small mammals in young lodgepole pine forest: 10-year results after thinning. Ecological Applications 11: 1151-1173
16. Wampler CR et al 2008. Mammals in mechanically thinned and non-thinned mixed-coniferous forest in the Sacramento Mountains, New Mexico. The Southwestern Naturalist 53: 431-443