Current Forest Conditions for the Uncompahgre Mesas Forest Restoration Project

Prepared by the Colorado Forest Restoration Institute,
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SUMMARY

The Uncompahgre Mesas Forest Restoration Project is the result of years of community-based, collaborative learning, dialogue, planning, and trust-building. Taking place on the Ouray District of the Grand Mesa, Uncompahgre, and Gunnison National Forest (GMUG) managed by the USDA Forest Service, the "Unc Mesas" project encompasses 17,200 acres and will utilize a mix of mechanical methods, prescribed fire and wildland fire use strategies to restore forest stand structure and composition more consistent with the landscape's historic range of variability.

A participatory assessment of historical forest structure conducted in August 2008 provided the basis for the restoration prescriptions (see further, "Historical forest structure on the Uncompahgre Plateau: informing restoration prescriptions for mountainside stewardship", accessible online at: http://warnercnr.colostate.edu/images/docs/cfri/UPP25MesaFinal.pdf). This report presents a summary of current forest conditions within the Unc Mesas project area based on 18 monitoring plots dispersed across six stands representing the diversity of forest types in the project area: Ponderosa pine, Ponderosa pine mixed with spruce, warm-dry mixed conifer, cool-moist mixed-conifer, and spruce-fir.

The Ponderosa pine-dominated stand shows a slightly overstocked stand compared to historical conditions, with aspen representing the majority (90%) of the tree regeneration and Ponderosa pine comprising the remainder of the regeneration. A diversity of shrubs, forbs, and grasses are present. The Ponderosa pine-spruce stand had nearly four times as many trees per acre and almost three times the basal area than the historical stand assessment. Dense tree regeneration was found (1,275 trees/acre), with aspen seedlings dominating. Seven different species of shrubs had an average canopy cover of 50% and three graminoid species at 30% average cover. In the three stands characterized as mixed-conifer, including a mixed Ponderosa pine-spruce stand, tree densities and basal area are up to four and three times, respectively, the estimated historical conditions.

In the cool-moist mixed-conifer, Ponderosa pine and Douglas-fir basal area have declined from around 40% and 50%, respectively, of the stand to 10% each. Engelmann spruce, blue spruce, and subalpine fir are the succeeding tree species, with no pine regeneration detected. A spruce-fir stand was measured to gauge the effect of logging on regeneration of young stands. The stand is being cut to provide economic returns to support restoration treatments in lower elevations, but also to spur young spruce-fir stands which are under-represented across the landscape (but not outside of historical range of variability).

Background

Forests are dynamic systems that vary over space. For example, a few hundred feet in elevation brings enough extra precipitation, and cooler conditions, to allow a different combination of tree and plant species to develop. Similarly, forests vary over time, either gradually or suddenly. On the Uncompahgre Plateau (UP) in Western Colorado, the absence of a normal fire regime – the pattern, frequency, and intensity of fires that occurred prior to active fire suppression – has changed forest conditions across the UP. Compared to the forests that evolved with historical fire regimes, today's UP forests generally have higher tree densities, more ladder fuels, and a lack of small meadows. A lot of the forest's variation over space and time has been lost.

Working collaboratively for nearly 20 years through the Public Lands Partnership and, subsequently, the Uncompaghre Plateau Project, local communities, organized interests, and land managers have developed a collective commitment to restoring the UP's forests to function in a more ecologically sustainable manner, be more capable of recovering from disturbances, adapt to a changing environment, and continue to provide a broad range of socially desired values, goods and services. Linked to these goals is the desire for local communities to strengthen their connections to the UP landscape through the involvement of local contractors, youth, grazing permittees, recreationists, and the general citizenry in collaborative stewardship.

While ecological restoration is a positive goal, there is a need and opportunity to do it well. In particular, we need to know if we: 1) accomplished intended outcomes; 2) created any surprises (e.g., increased invasive weed species), and 3) gained insights that would improve the way future restoration treatments are designed and implemented. As a starting point in summer 2007, a working group composed of individuals reflecting a diverse set of backgrounds, interests, and organizations committed to learning how to operationalize broad restoration goals and principles on a specific forest landscape. Thus was born the Uncompahgre Mesas Forest Restoration Project. Taking place on the Ouray District of the Grand Mesa, Uncompahgre, and Gunnison National Forest (GMUG) managed by the USDA Forest Service, the "Unc Mesas" project encompasses 17,200 acres and will utilize a mix of mechanical methods and prescribed fire and wildland fire use strategies to restore forest stand structure and composition more consistent with the historic range of variability of conditions and disturbances on the Uncompahgre Plateau.

The restoration guidelines and prescriptions were based in large part on a participatory assessment of historical forest structure in August 2008 (see further, "Historical forest structure on the Uncompahgre Plateau: informing restoration prescriptions for mountainside stewardship", accessible online at: http://warnercnr.colostate.edu/images/docs/cfri/UPP25MesaFinal.pdf). The assessment produced the following insights:

• Lower elevation forest stands dominated by ponderosa pine had much lower basal area that almost any stands currently on the Plateau; small meadows interspersed with clumps of pine were common but are now rare.

• The mixed-conifer forests also probably had lower basal area that the majority of similarly composed stands on the Plateau at present, but no evidence was found for major forest type-conversions from ponderosa pine to mixed-conifer.

• Lack of major mixed-severity fires and stand-replacing fires for more than a century has resulted in a near-absence of young, post-fire forests; at least some of the current mixed-conifer forests probably have higher densities of shade-tolerant, small and medium size conifers than would have been typical in past centuries.

This report summarizes the pre-treatment condition of six stands in the Unc Mesas project area, providing quantitative baseline to determine the impacts of restoration treatments. In May 2009, the Unc Mesas collaborative work group defined the following monitoring questions which guide the measurements:

<u>For Ponderosa Pine Forest Type:</u>

• Is the likelihood of stand-replacing wildfires being lessened?

• Are forest structure, age-class distribution, and species composition more consistent with historical patterns?

• Are native understory plants increasing in diversity and productivity, and non-native invasive plants minimal or absent?

• Are there more small meadows interspersed with tree clumps per historical patterns?

<u>For Mixed-Conifer Forest Type:</u>

• Is the likelihood of stand-replacing wildfires being lessened?

• Are tree species composition and size-class distribution more closely aligned with patterns which most likely existed in pre-settlement conditions and historical fire regimes?

• Is aspen responding favorably to restoration treatments?

• Is ponderosa pine and Douglas-fir being favored in response to restoration treatments due to changing climate?

Approach

Sampling protocols were designed to capture pre-treatment and post-treatment conditions within the 17,200 acre project boundary (see Appendix for full details). The pre-treatment data will provide a baseline to determine the impacts of the restoration treatments and the post-treatment data will allow us to assess the effects of the restoration activities over time. Eighteen monitoring sites were setup within six different stands and three different overstory cover types across the project area (see map and Table 1). The cover types are ponderosa pine, mixed conifer, and spruce. Each stand was sampled using three 150-feet by 150-feet square, half-acre plots. There were five categories of data collected; overstory, tree regeneration, understory, fuel characteristics, and photo points.

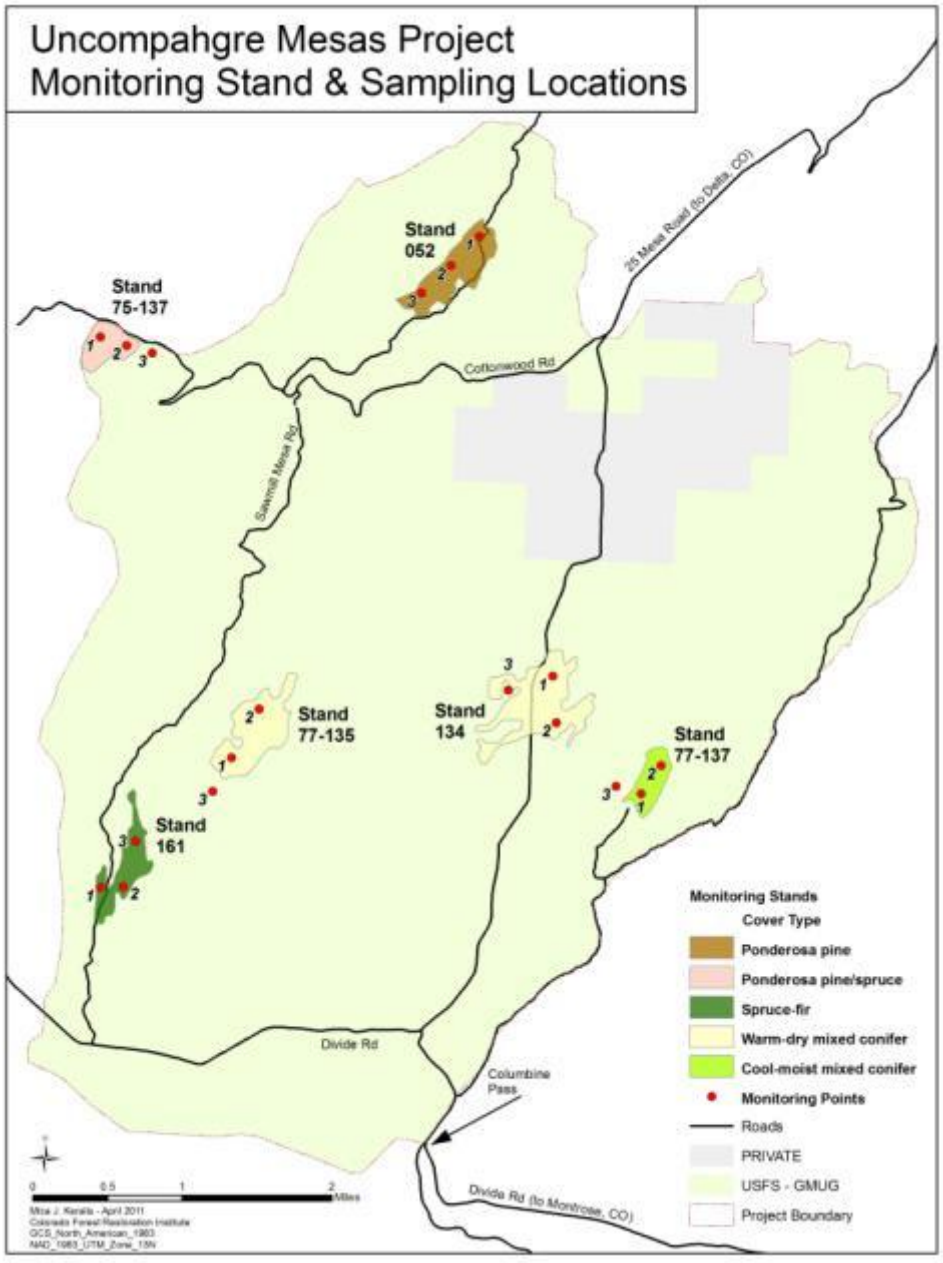


Table 1: Cover type by monitoring stand

Stand	Cover Type
77-052	Ponderosa pine
75-137	Ponderosa pine/spruce
77-161	Spruce-fir
77-135	Warm-dry mixed conifer
77-134	Warm-dry mixed conifer
77-137	Cool-moist mixed conifer

The half-acre plot was designed using a quadrant layout (see Appendix). The sides of the plot are 150-feet by 150-feet. Central axes ran south to north (y-axis) and east to west (x-axis) through the center of the plot. The axes were used to delineate the locations of 10 Daubenmire 20- by 50-cm quadrat frames, four tree regeneration plots, four fuels planar transects, four shrub linear intercepts, and 18 photo point locations.

The overstory was classified of trees greater than 4.5-inches at diameter breast height (DBH). The species, DBH, tree status, crown base height (CBH), crown class, presence of insect or disease, and location were collected for each tree in the plot. Trees were located on a central y-axis, running south to north, to the nearest foot and placed in 10-feet distance classes along the x-axis, running east to west. The x-axis coordinates were assigned the mid-point value of each class and were then randomized within each class to remove the regularity created by the distance classes. Percent canopy cover was recorded at the same ten locations as the understory Daubenmire quadrat frame locations, described below.

Trees less than 4.5" DBH were tallied on four 1/300th acre, 6.8-feet radius, circular plots. The plots were located along the center axes at 45-feet from plot center in the north, east, south, and west directions. Seedlings were classified as trees less than 4.5-feet tall and saplings were greater than 4.5-feet tall and less than 4.5-inches DBH. Seedlings and saplings were tallied separately and by species.

The Daubenmire method (Interagency Technical Reference, 1999) was used to collect vegetative attributes of forbs, graminoids, and shrubs. Ten sub-plots were located within the

half-acre plot. Five plots were placed along the y-axis and 5 plots were placed along the x-axis. The percent aerial cover was recorded for each species and vegetation functional group present within the 20- x 50-cm quadrat. Percent ground cover of bare mineral soil, rocky material, litter, and live basal vegetation was estimated. The presence or absence of moss on soil, lichen on soil, elk pellets, deer pellets, and cow pie was recorded. The average-estimated height was recorded for forbs, graminoids, and shrubs. A digital photo point documenting the quadrat was established at all 10 quadrat locations.

Daubenmire method (P. Motley)

Line intercept method (P. Motley)

A line intercept method (Interagency Technical Reference 1999) was used to estimate cover of shrubs. Four 35-feet shrub linear intercepts were placed at 45-feet from plot center on the north, east, south, and west axes. The four transects were located 90-degrees to each axes and run in a counter-clockwise direction. For example the transect located at 45-feet on the north axis was on an azimuth of 270-degrees, or 90-degrees counter-clockwise from 0-degrees north. The length of each transect was 35-feet. The horizontal linear length of each species of shrub was measured.

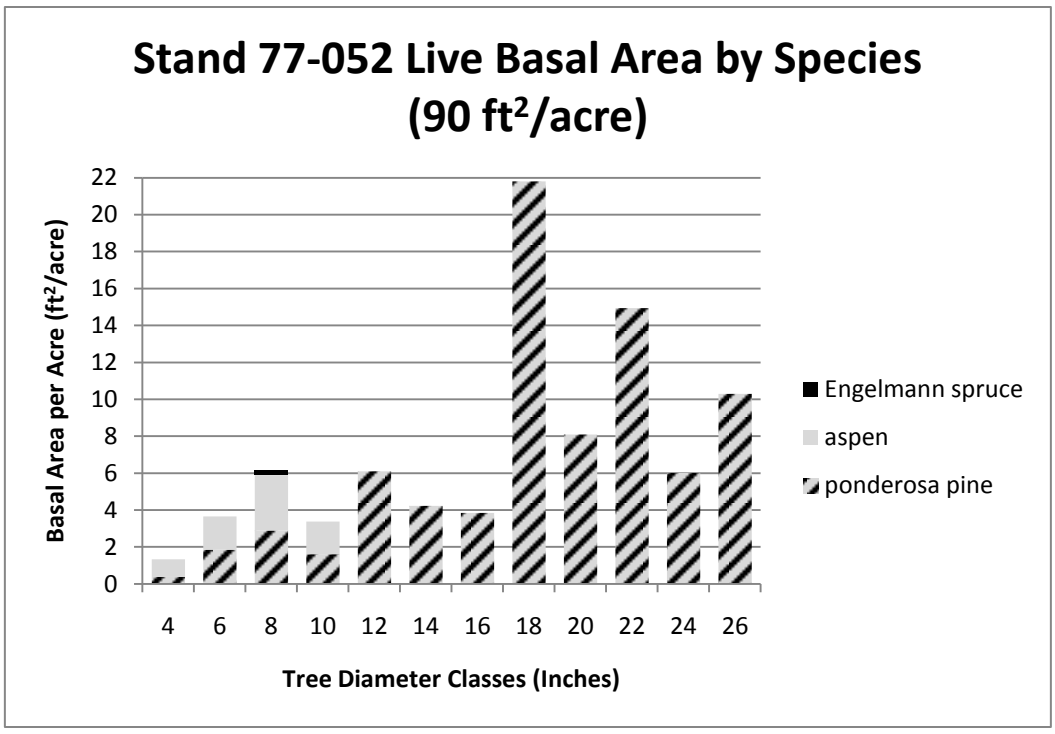
Fuel loading was estimated using four planar fuels transects (Brown et al. 1982) that were 35-feet long and 6-feet tall were established in the same location as the shrub linear intercepts. Dead and down woody debris (DWD) was collected in two specific components; fine woody debris (FWD) and coarse woody debris (CWD). FWD is classified as pieces that are smaller than 3” in diameter and is separated into three diameter size classes; 1-hour, 0” to 0.25”, 10-hour, >0.25” to 1”, and 100-hour, > 1” to 3”. CWD is classified as pieces that are greater than 3” in diameter and is separated into two classes; 1000-hour sound and 1000-hour rotten. Each fuel class was sampled along different transect lengths; 1-hour and 10-hour fuels were sampled from 0-feet to 6-feet, 100-hour fuels were sampled from 0-feet to 10-feet, and 1000-hour fuels were sampled along the entire 35-feet transect. FWD intersects were counted along the designated transect length. The diameter and sound or rotten condition of the CWD was recorded.

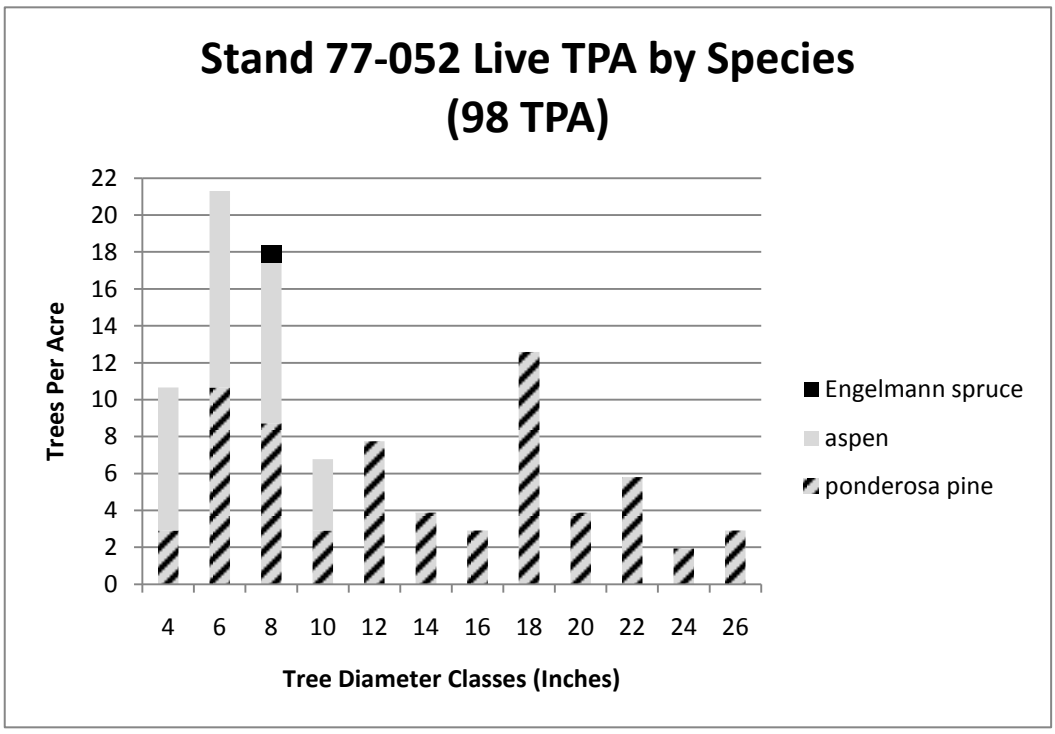
Results for Ponderosa Pine Type

Stand 77-052 is 103 acres dominated by ponderosa pine. This stand was selected because it has easy access for public demonstration and is a good representative pine stand for the project area. Currently, the stand is slightly overstocked compared to 1875 data, with very little pine regeneration in the understory. The overstory is comprised of mostly ponderosa pine with some aspen, very little Engelmann spruce and has stand totals of 98 trees per acre and a basal area of 90 ft^2 per acre. Historically ponderosa pine stands on the Uncompahgre Plateau had a range of 30 to 90 trees per acre and a basal area of 20 to 90 ft^2 per acre (CFRI 2008). The composition of the trees in the understory is drastically different. Regeneration was 1050 trees per acre with aspen representing more than 90% of the tree regeneration with 750 seedlings per acre and 225 saplings per acre. Ponderosa pine had 75 saplings per acre and no recorded seedlings. Shrubs had an average canopy cover of 30% and were comprised of seven different species with roundleaf snowberry (*Symphoricarpos rotundifolius*) representing approximately 11% canopy cover. A total of nine graminoid species had 11% cover and 28 forb species had 27% cover. Fuel loading in this ponderosa pine stand was 16.2 tons per acre. The understory vegetation height was over two feet tall and when those heights are coupled with the tons per acre and the mid-level regeneration height, which vertically connected the surface fuels to the crown bases, an active crowning fire scenario is a likely possibility.

Stand 77-052 Plot 003

Stand 77-052 Plot 001


Stand 77-052 Live Basal Area by Species
(90 ft²/acre)
Basal Area per Acre (ft²/acre)
22
20
18
16
14
12
10
8
6
4
2
0
4 6 8 10 12 14 16 18 20 22 24 26
Tree Diameter Classes (Inches)
Engelmann spruce
aspen
ponderosa pine

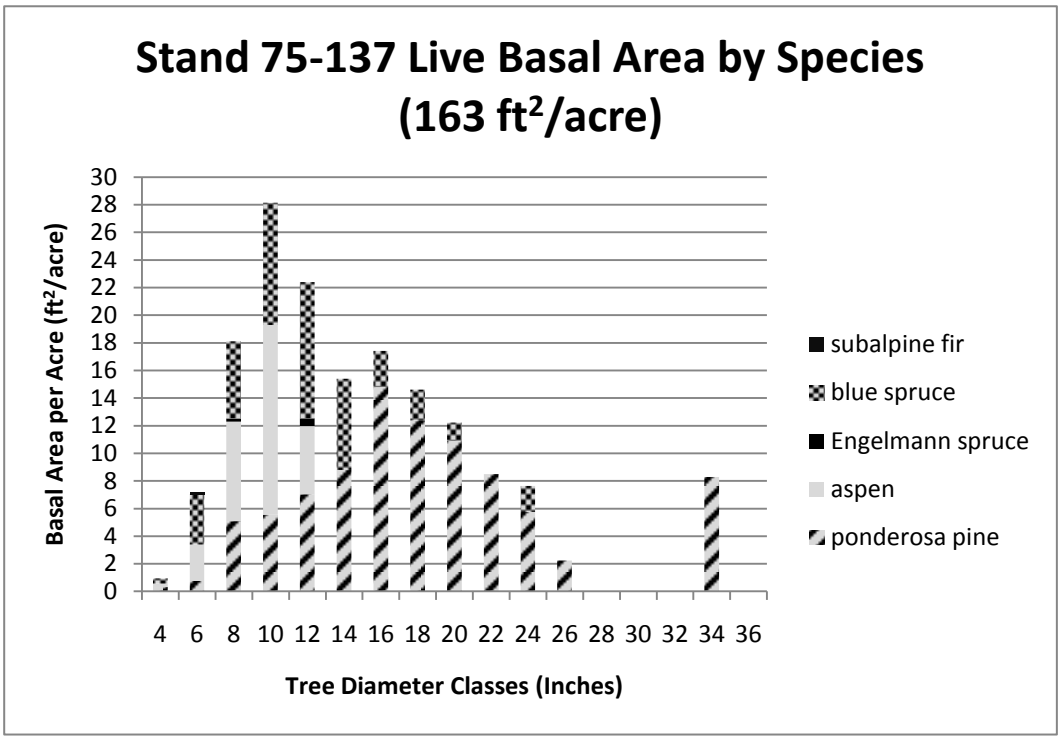

Stand 77-052 Live TPA by Species
(98 TPA)
Trees Per Acre
22
20
18
16
14
12
10
8
6
4
2
0
4 6 8 10 12 14 16 18 20 22 24 26
Tree Diameter Classes (Inches)
Engelmann spruce
aspen
ponderosa pine

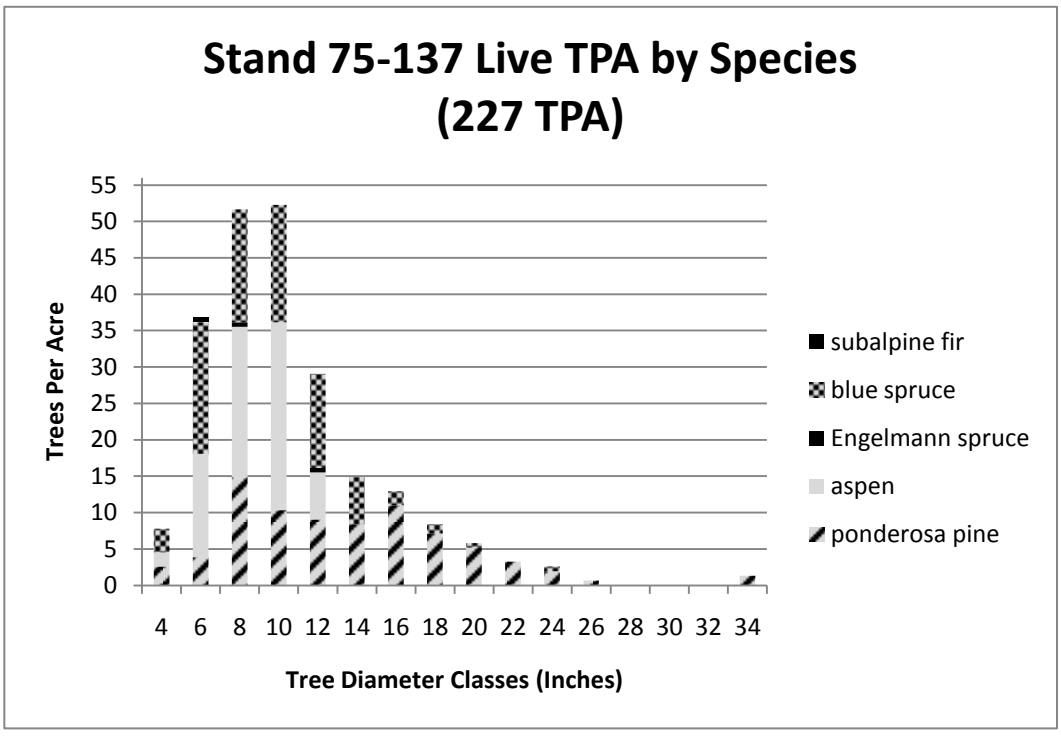
Results for Mixed Ponderosa Pine-Spruce Stand

Stand 75-137 was selected for its species composition and because it's geographical location, on the edge of the project boundary, which helps to meet the goal of having a distribution of monitoring sites over the entire 17,200 acre project area. This stand is 51 acres with an overstory comprised of ponderosa pine, aspen, Engelmann spruce, blue spruce, and subalpine fir. There are currently 227 trees per acre and a basal area of 163 ft^2 per acre. This represents four times as many trees per acre and almost three times the basal area as was probably present in 1875 (CFRI 2008). The absence of fire over the past century has fostered large numbers of shade-tolerant conifers, such as blue spruce. The absence of fire has also allowed relatively high rates of aspen regeneration. There are 1275 trees per acre of regeneration, 70% of which is aspen seedling and the rest is comprised of ponderosa pine and blue spruce. Shrubs had an average canopy cover just over 50% and were comprised of seven different species with Saskatoon serviceberry (*Amelanchier alnifolia*) representing over 20% canopy cover. There were only three graminoid species with 30% cover and dryspike sedge (*Carex siccata*) having a frequency of 50%. The understory also included 19 forb species with 23% cover. The fuel loading was 28.6 tons per acre, 10 tons greater than stand 77-052. The continuous vertical fuel structure, with a 3-feet tall understory and mid-level tree regeneration, indicates an active crown fire scenario is also very likely in this stand.

Stand 75-137 Plot 003.

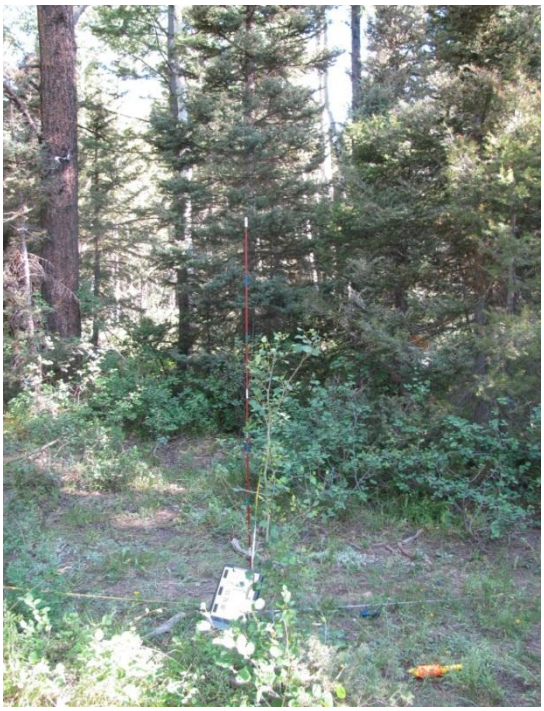
Stand 75-137 Plot 003.


Stand 75-137 Live Basal Area by Species
(163 ft²/acre)
Basal Area per Acre (ft²/acre)
0
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30
4 6 8 10 12 14 16 18 20 22 24 26 28 30 32 34 36
Tree Diameter Classes (Inches)
subalpine fir
blue spruce
Engelmann spruce
aspen
ponderosa pine


Stand 75-137 Live TPA by Species
(227 TPA)
Trees Per Acre
0
5
10
15
20
25
30
35
40
45
50
55
4 6 8 10 12 14 16 18 20 22 24 26 28 30 32 34
Tree Diameter Classes (Inches)
subalpine fir
blue spruce
Engelmann spruce
aspen
ponderosa pine

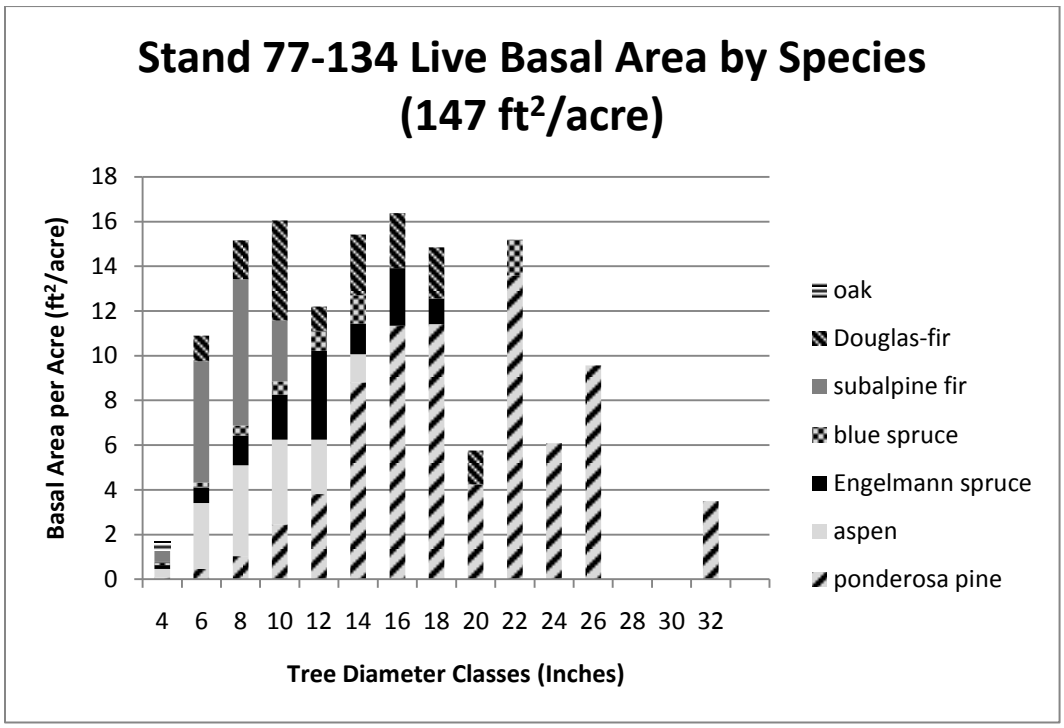
Results for Warm-Dry Mixed-Conifer Types

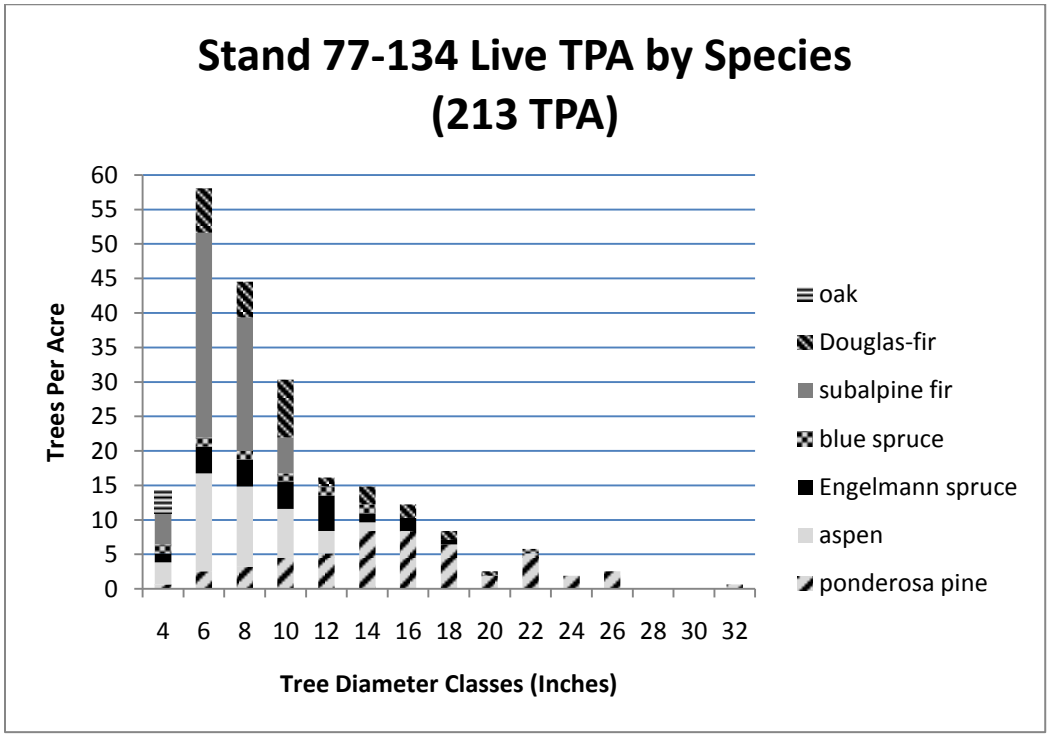
Stand 77-134 is 164 acres and was chosen for its ease of access for public demonstration. This is a stand that stakeholders clearly identified in need of restoration treatments in order to promote ponderosa pine. There is concern with a stand of this type since there is a clear succession from what was a ponderosa pine stand to a now heavily mixed conifer stand. ponderosa pine has a basal area of 76 ft^2 per acre but represents very little of the basal area in the smaller diameter classes. The remaining species have a basal area of approximately 15 ft^2 per acre each and include aspen, Engelmann spruce, blue spruce, subalpine fir, and Douglas-fir. The stand has 213 trees per acre and a basal area of 147 ft^2 per acre, which is over 3.5 and 2.5 times the historical conditions, respectively. Aspen, spruce, and fir make up the regeneration, with 1400 trees per acre. There was no recorded instance of ponderosa pine seedlings or saplings. Historical conditions appear to have favored high dominance by ponderosa pine, but the trajectory over the past century has included major in growth of other conifer species. Shrubs cover percentage ranged from 18% to 49% across the three plots, with an average cover of 31%. Six separate shrub species were recorded with Saskatoon serviceberry at 15% cover and roundleaf snowberry at 9% cover. Graminoids had four species present, and Geyer's sedge (*Carex geyeri*) had the highest cover with 14%. Twenty-one forb species were present with 20% cover. There is 20.65 tons per acre of downed and dead woody debris accounting for the fuel loading and an active transition from surface to crown fire in this stand under severe weather conditions.



Stand 77-134 Plot 001

Stand 77-134 Plot 002

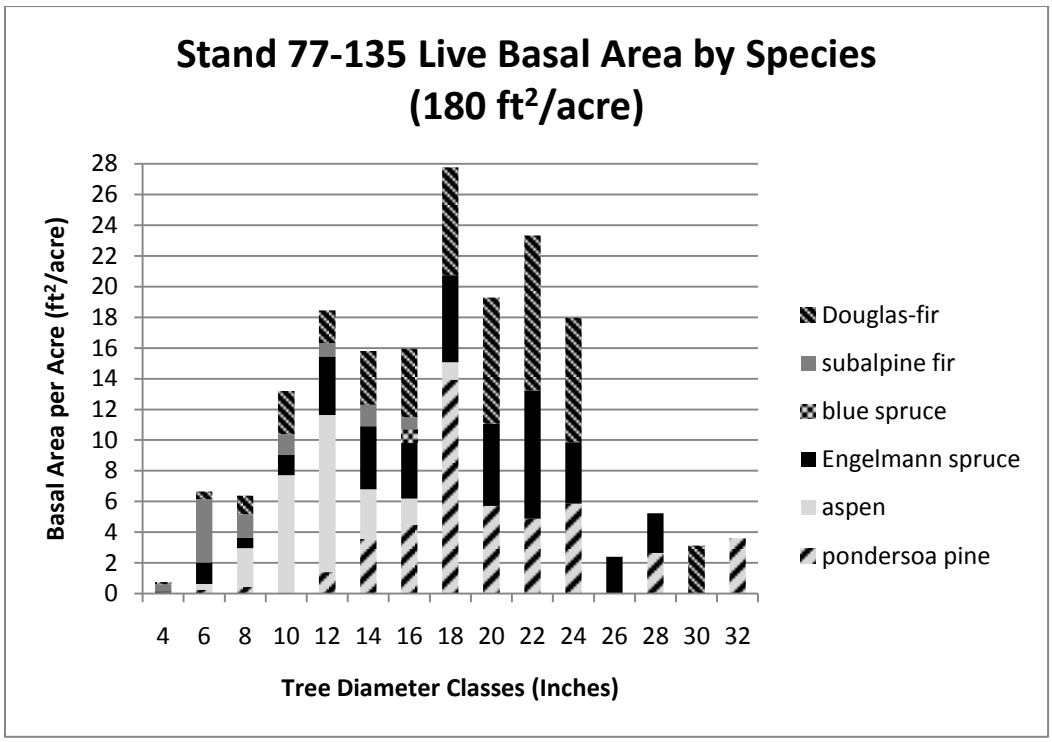

Stand 77-134 Live Basal Area by Species
(147 ft²/acre)
Basal Area per Acre (ft²/acre)
0
2
4
6
8
10
12
14
16
18
4 6 8 10 12 14 16 18 20 22 24 26 28 30 32
Tree Diameter Classes (Inches)
oak
Douglas-fir
subalpine fir
blue spruce
Engelmann spruce
aspen
ponderosa pine

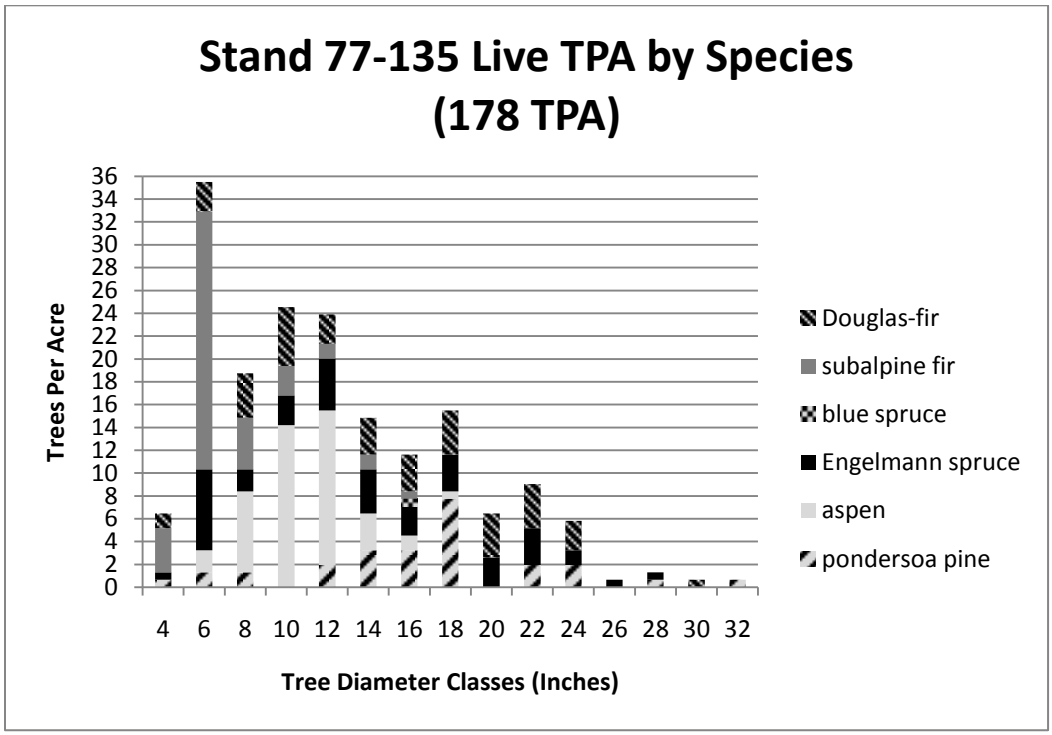

Stand 77-134 Live TPA by Species
(213 TPA)
Trees Per Acre
0
5
10
15
20
25
30
35
40
45
50
55
60
4 6 8 10 12 14 16 18 20 22 24 26 28 30 32
Tree Diameter Classes (Inches)
oak
Douglas-fir
subalpine fir
blue spruce
Engelmann spruce
aspen
ponderosa pine

Stand 77-135 is a 119 acre warm-dry mixed conifer stand. The stand was selected since it is within a non-roaded portion of the UP. This stand has a great deal of diversity across all diameter classes. Historical evidence indicates that warm-dry mixed conifer stands on the plateau had a majority mix of ponderosa pine and Douglas-fir with some spruce and fir (CFRI 2008). Ponderosa pine represented about 40% of the basal area and Douglas-fir was almost 50% of the basal area (CFRI 2008). Currently only 25% of the basal area is ponderosa pine and Douglas-fir only represents 28% of the basal area. Engelmann spruce contributes 44 ft^2 per acre of basal area, or 25%, and has been a long standing member of the stand along with Douglas-fir and ponderosa pine. The remaining 25% of basal area is comprised of aspen, subalpine fir, and very little blue spruce. The stand was heavily stocked with 178 trees per acre, about three times higher than the historical average (CFRI 2008). Subalpine fir is the dominant species in the smaller diameter classes and also accounted for 1275 trees per acre of the 1800 trees per acre of seedlings and saplings. Aspen seedlings made up the remaining 525 trees per acre of regeneration. There were no recorded instances of ponderosa pine, Douglas-fir, or Engelmann spruce in any of the regeneration plots. This could mean there is a potential for type conversion in this stand. There was only 11% shrub cover represented by five different species and all individually averaging less than 10% cover across all three plots. Graminoids had a total of 42% cover by three species and forbs represented 49% cover by 19 species. The fuel load was the greatest in this stand at 45 tons per acre and would contribute to a very severe surface and crown fire.

Stand 77-135 Plot 003.

Stand 77-135 Plot 002.


Stand 77-135 Live Basal Area by Species
(180 ft²/acre)
Basal Area per Acre (ft²/acre)
0
2
4
6
8
10
12
14
16
18
20
22
24
26
28
4 6 8 10 12 14 16 18 20 22 24 26 28 30 32
Tree Diameter Classes (Inches)
Douglas-fir
subalpine fir
blue spruce
Engelmann spruce
aspen
pondersoa pine

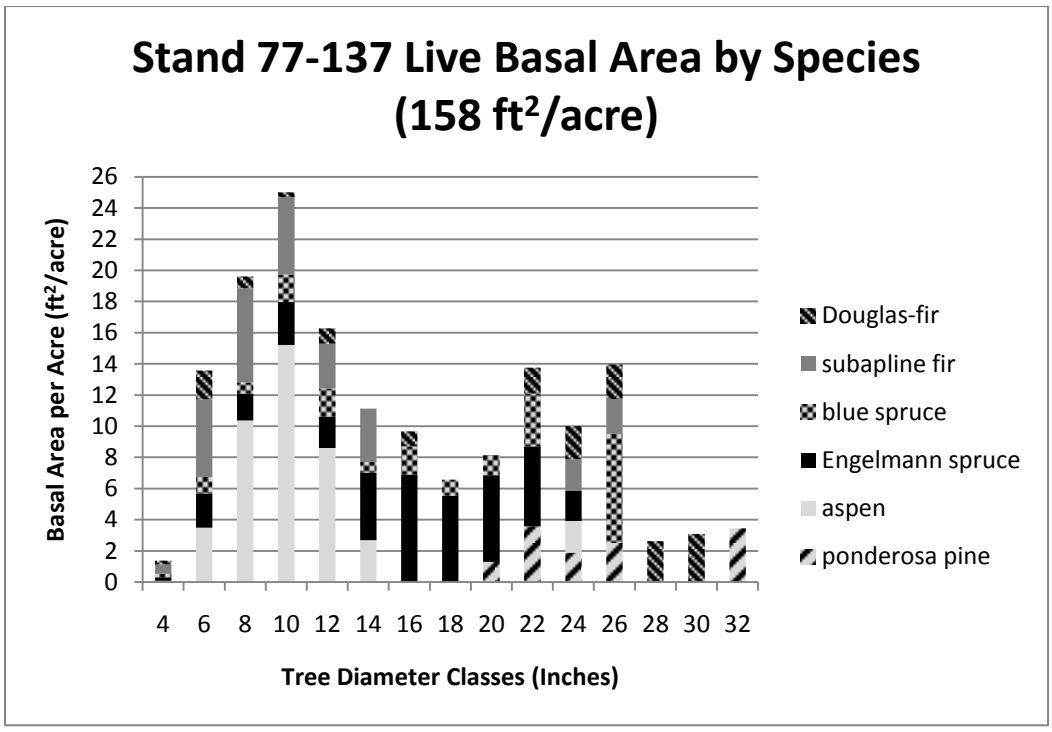

Stand 77-135 Live TPA by Species
(178 TPA)
Trees Per Acre
0
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30
32
34
36
4 6 8 10 12 14 16 18 20 22 24 26 28 30 32
Tree Diameter Classes (Inches)
Douglas-fir
subalpine fir
blue spruce
Engelmann spruce
aspen
pondersoa pine

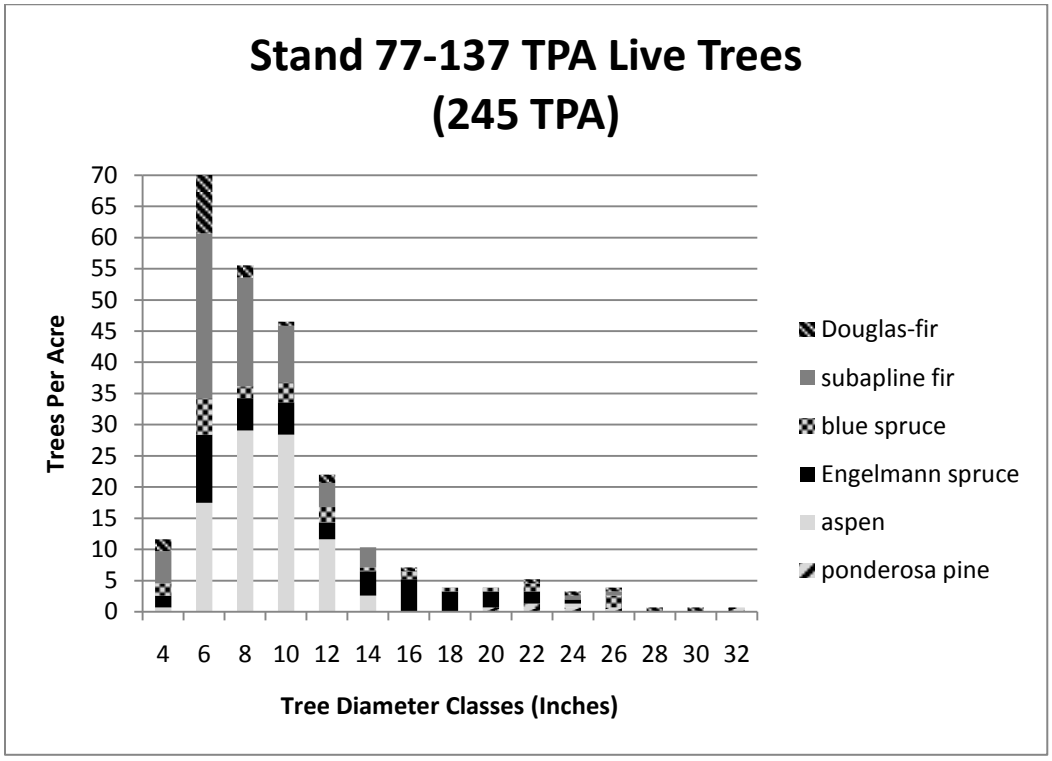
Results for Cool-Moist Mixed-Conifer Type

Stand 77-137 is a 47 acre cool-moist mixed conifer stand. This stand was selected since it is within a non-roaded portion of the UP, will not be treated, and will be a valuable comparison stand to stands 77-135 and 77-134, which will be treated. There is no ponderosa pine in the 18-inch and smaller diameter classes and was less than 10% of the total basal area. Douglas-fir also only accounted for 10% of the total basal area. Like the other mixed conifer stands, ponderosa pine and Douglas-fir historically account for 40% and 50%, respectively, of the basal area per acre. Aspen had the greatest basal area with 42.5 ft^2 per acre and 90 trees per acre mostly in the 14-inch and smaller diameter classes. Engelmann spruce accounted for 25% of the basal and blue spruce and subalpine fir were less than 20% each. This is markedly different from historical stands and is almost opposite than what was more than likely present in 1875 (CFRI 2008). Once again there is no ponderosa pine present as seedlings or saplings and most of the regeneration that is occurring is from aspen and subalpine fir. There were only four species of shrubs with 10% cover in the stand and one plot having less than 1% shrub cover. There were 29 forb species recorded with a total live coverage of 101.3% and tuber starwort (*Pseudocymopterus montanus*) had the highest cover of the forb species with 17.4%. There was also the presence of thistle (*Cirsium spp.*), a noxious weed, with 1.3% cover and a frequency of 3.3%. Six graminoid species were present with 46.5% cover and Geyer's sedge filled in 37.4% of the total live coverage. The fuel load was 24.8 tons per acre and in severe weather conditions would torch and crown.

Stand 77-137 Plot 001

Stand 77-137 Plot 003


Stand 77-137 Live Basal Area by Species
(158 ft²/acre)
Basal Area per Acre (ft²/acre)
0
2
4
6
8
10
12
14
16
18
20
22
24
26
4 6 8 10 12 14 16 18 20 22 24 26 28 30 32
Tree Diameter Classes (Inches)
Douglas-fir
subapline fir
blue spruce
Engelmann spruce
aspen
ponderosa pine

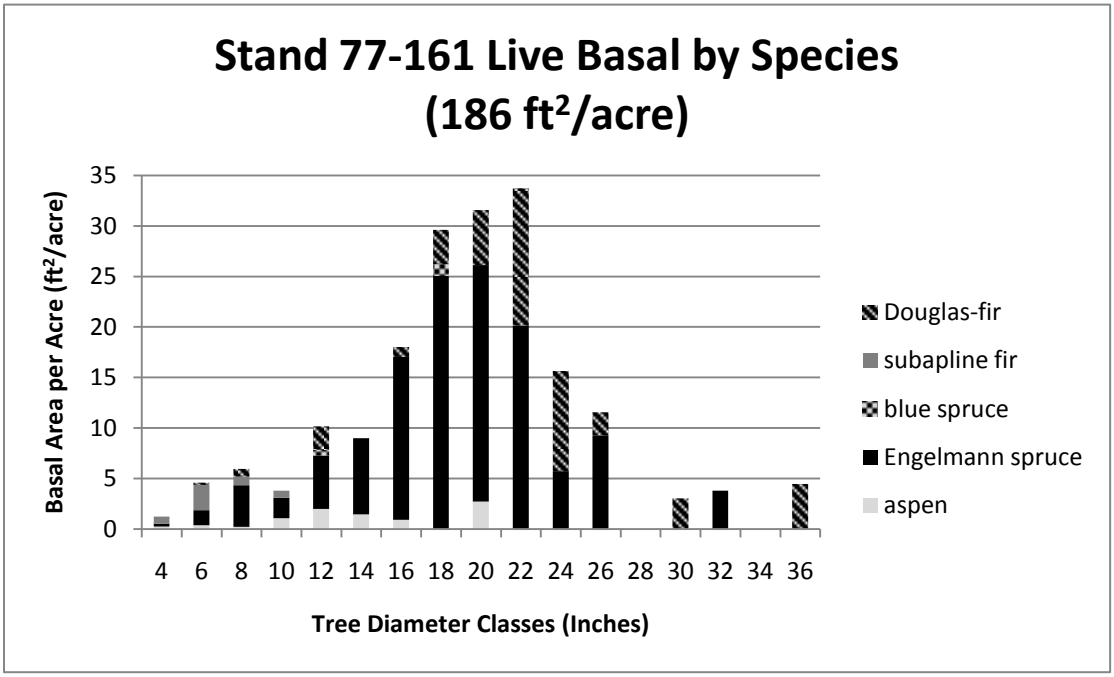

Stand 77-137 TPA Live Trees
(245 TPA)
Trees Per Acre
0
5
10
15
20
25
30
35
40
45
50
55
60
65
70
4 6 8 10 12 14 16 18 20 22 24 26 28 30 32
Tree Diameter Classes (Inches)
Douglas-fir
subapline fir
blue spruce
Engelmann spruce
aspen
ponderosa pine

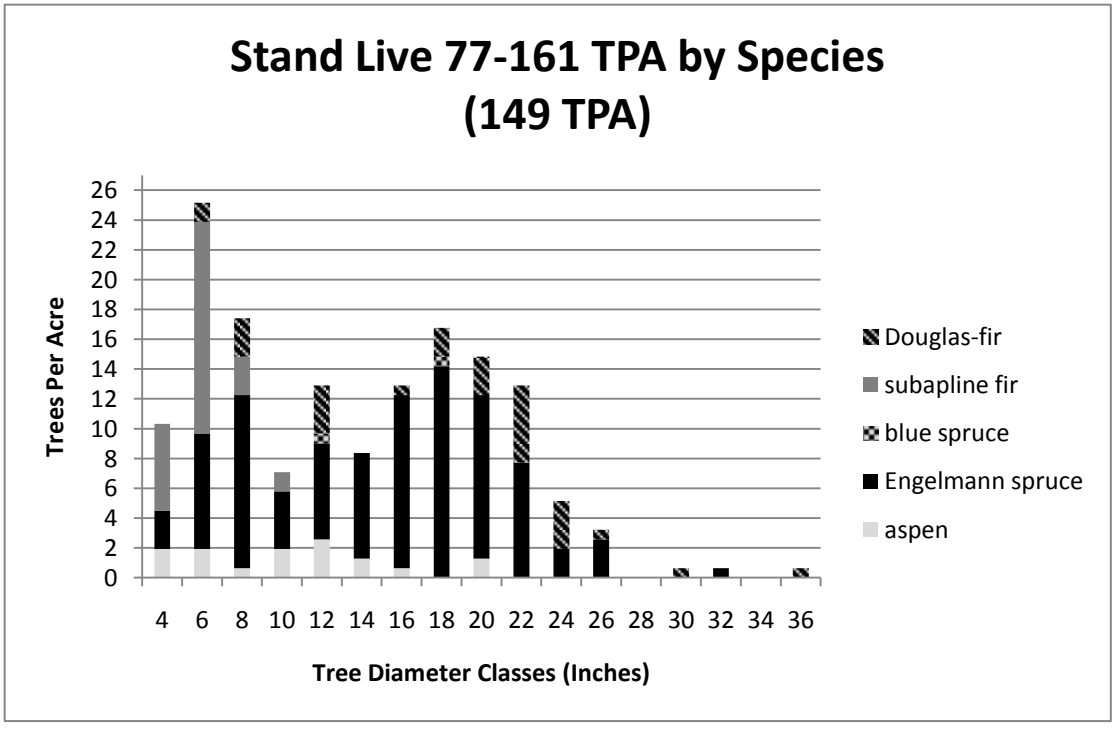
Results for Spruce-Fir Type

Stand 77-161 is a 73 acre spruce-fir stand. This stand was selected for monitoring because it will be logged to help pay for the cost of restoration in the other stands and is not designated as a restoration stand. This stand may not be outside historical conditions, but the landscape as a whole has very few areas with young spruce-fir forests. Harvesting this stand will improve the landscape-scale variety of spruce/fir age classes, as well as provide funds to help support restoration in lower elevation forests. There was a total of 186 ft^2 per acre basal area and 149 trees per acre. Engelmann spruce accounted for the most basal area with 124 ft^2 per acre with Douglas-fir a distant second with 46 ft^2 per acre. Aspen, subalpine fir and blue spruce all accounted for about 15 ft^2 per acre. This stand had the greatest number of regenerating trees per acre with 2375. Subalpine fir had the greatest number of seedlings and saplings with 1850 trees per acre with aspen and a very little Engelmann spruce (~2%) filling in the rest. Shrub cover was around 20% with 7 different species, including greenleaf manzanita (*Arctostaphylos patula*) being present in one of the plots with 23% cover. Graminoids only had coverage of 8.4% with three different species and Geyer's sedge occupying 8.2% of the total. Seventeen forb species represented 26.5% cover. This stand had the second highest fuel load with 40.4 tons per acre of dead and downed woody debris and litter which would be an active crown fire in severe weather conditions.

Stand 77-161 Plot 003

Stand 77-161 Plot 001


Stand 77-161 Live Basal by Species
(186 ft²/acre)
Basal Area per Acre (ft²/acre)
35
30
25
20
15
10
5
0
4 6 8 10 12 14 16 18 20 22 24 26 28 30 32 34 36
Tree Diameter Classes (Inches)
Douglas-fir
subapline fir
blue spruce
Engelmann spruce
aspen


Stand Live 77-161 TPA by Species
(149 TPA)
Trees Per Acre
26
24
22
20
18
16
14
12
10
8
6
4
2
0
4 6 8 10 12 14 16 18 20 22 24 26 28 30 32 34 36
Tree Diameter Classes (Inches)
Douglas-fir
subapline fir
blue spruce
Engelmann spruce
aspen

Lessons Learned

The monitoring approach developed for the Unc Mesas project was purposely designed to accommodate a multi-party monitoring program involving youth, community volunteers, interested stakeholders, and seasonal field crews. As such, there was an effort to balance scientific rigor with operational and financial feasibility. It required an average of 4 hours for an experienced field crew of 4 individuals to complete measurements for plots in the pure Ponderosa pine stands; it took 8 hours for a field crew of 4 individuals to complete measurements in the mixed-conifer stands. Some improvements to consider:

- In retrospect, a less-intensive approach could have provided enough insight to address our initial monitoring questions. The identification of understory species and cover took a large portion of the crew's time, and in the future the focus could be on overall understory cover, with special information on species of special concern (such as invasives). The combination of basic information and the set of photopoints should provide a strong foundation for detecting changes that would be large enough for concern by the collaborators.
- The collaborators may consider whether simpler approaches could be used to characterize the tree size and species. A key monitoring question for the mixed-conifer type was: "Are tree species composition and size-class distribution more closely aligned with patterns which most likely existed in pre-settlement conditions and historical fire regimes." For example, it may be more efficient to conduct precise tree stem counts only along the North-South axis and use linear transects 10 meters wide along the East-West axis of the 0.5 acre plot.
- A larger number of photo points within the plots can compensate for the lack of measurement specificity to gauge change over time after treatments. Visual assessments of repeated photos are suitable to detect changes and compare with desired results.
- Repeated 360^{o} photos and photos of vertical structure in each plot would be easy to do and useful for detecting change over time.
- Our monitoring effort tackled two separate issues, aiming to characterize historical stand structure and current stand structure. If more insights on historical conditions would be important for the monitoring questions (such as the size of historical mini-meadows), then more explicit information would be useful (such as mapping locations of not only presettlement trees, but also logs and stumps that contributed to presettlement structure). Characterization of current conditions needs to include young trees that were not present in the 1800s, but it may not be important to know the spatial location of these "in growth" trees. The spatial locations of post-restoration trees may be an important factor in answering the monitoring questions, even if current spatial patterns are not so important.
- Many organizations have contributed, and continue to contribute, to the Unc Mesas monitoring work. Sustaining the high level of collaborative involvement will require

commitment of money, time, and people. This can be a particular challenge after the initial champions have moved on to other endeavors.

The ultimate success of the multi-party monitoring of the Uncompahgre Mesas Forest Restoration Project rests on consistent and enduring commitment on the part of all parties. Funding, personnel, and, perhaps most importantly, Forest Service leadership are needed to ensure future success.

APPENDIX:

Monitoring plan and protocol for Uncompahgre Mesas Forest Restoration Project

Introduction

Based on the scientific foundation provided by Drs. Dan Binkley and Bill Romme of Colorado State University, Colorado Forest Restoration Institute, areas have been identified for treatment on the Uncompahgre Plateau. The goals of these treatments are to reduce fuels and restore historic stand conditions and fire regime. Six monitoring stands, with 18 representative monitoring plots, have been identified by the Uncompahgre Mesas Forest Restoration Project. The six monitoring stands are displaced across a 17,200 acres project area representing the diversity of forest types in the project area: ponderosa pine, ponderosa pine mixed with spruce, warm-dry mixed conifer, cool-moist mixed conifer, and spruce-fir. The purpose of these ecological monitoring protocols is to provide an overview of how to collect the data which will allow the US Forest Service and its constituents to track the response of these stands to mechanical and prescribed fire treatments.

Ecological Indicators to Monitor

In order to achieve all goals and objectives in a manner that is logistically feasible, low cost, simple and scientifically valid, the Forest Restoration Institutes formed under the South West Ecological Restoration Institutes Act have worked with the USDA Forest Service to identify a suite of indicators that can be used to measure pre and post-treatment conditions. The two suites of indicators that have been chosen for this project are fire and fuels, and forest health.

Objective: Fire and Fuels
Tree characteristics: density, size, species
Fuel loading
Crown base height
Canopy cover
Understory cover and species composition
Photo points

Objective: Forest Health
Tree Characteristics: density, size, species
Crown Base Height
Fuel loading
Landscape patch

Where and When

The timing of monitoring will be before and after treatments take place for a comparison of pre- and post-stand conditions. Pre-treatment data will be collected during the summers of 2009 and 2010. Treatments will commence in Fall 2010.

In order to ensure that measurements are replicated as closely as possible, permanent plots will be set up, marked with aluminum numbered tags, recorded by GPS point and photographed as part of permanent photo-points for future monitoring.

Data collection is separated into three categories per monitoring plot. The categories are overstory, understory, and fuel loading. An inventory of all three categories will be conducted at the same permanent plot locations, within the treatment and control areas. Each category can be inventoried independently of the other categories depending upon variables such as the time of year, number of volunteers, level of experience, and logistics to name a few.

- Collect overstory inventory data, fuel loading data, and understory cover and species composition on a portion of the treatment and control areas that will represent the stand characteristics of that area.
- To ensure the ability to conduct long term monitoring, we recommend using permanent plots.
- Record a GPS point at the plot's center and mark it by placing an aluminum tags on a "tag trees" facing plot center. Place the tag at the base of a "tag tree" less than 4-inches above the ground and facing plot center. This will increase the likelihood of the tag remaining in position after mechanical treatments. Tags placed higher may be destroyed by harvesting methods or will be transported with the tree.
- Record the distance and compass bearing to the plot's center from the tagged tree for every plot. It is best to have at least three tag trees, if not more, to make locating plot center easier in the years to follow.
- This process will allow mechanical treatments to be conducted without the risks that a metal T-post or bar presents to the operator. It also removes any bias that could be encountered if an operator knew where an inventoried site was located.

Data Collection Planning & Setup

1) Number of Plots

After consultation with the Uncompahgre Mesas Project Workgroup, the US Forest Service and Dr. Dan Binkley, it was decided to use large half-acre plots to collect data. The half-acre plots will be designed to collect overstory, fuel, and understory data at the same plot locations. There will be three plots per monitoring stand, and will include two treatment plots and one control plot.

2) Location of Permanent Plots on Public Land

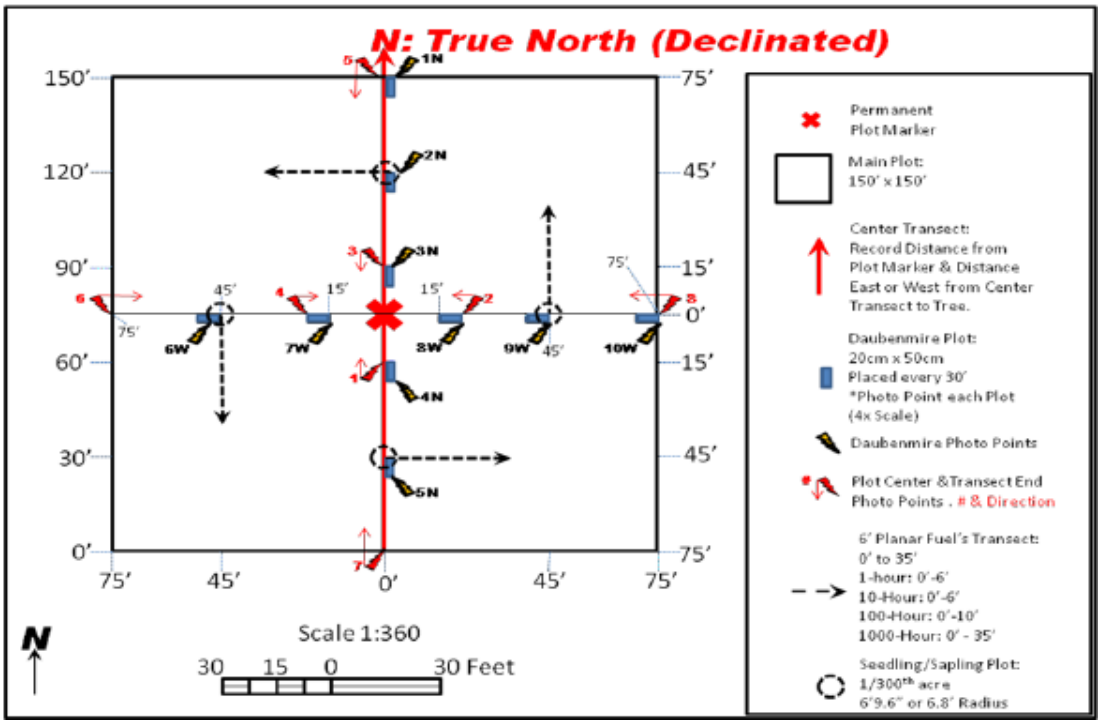
After the USFS staff, specifically Tim Garvey, silviculturalist, determined the areas to be treated in consultation with the UP Project, the workgroup went into the field on July 14 and 15 with Dr. Dan Binkley to determine the sites that would be used for monitoring.

The following stands were selected as monitoring sites:

1. 7703010052 (pine)
2. 7702020134 (dry, warm mixed conifer with little aspen)
3. 7703010135 (mixed conifer-non roaded)
4. 7702020137 (mixed conifer – non-roaded)
5. 7703010161 (spruce fir)
6. 7503010137 (pine/blue spruce)

Field Procedures

Figure 1: Diagram of Measurement Plot



Once the plots have been identified, place plot markers for each plot as shown above. The location should then be staked and identified for the taking of photo points. After photo points have been taken, plot identifying tag tree needs to be selected. The tag trees should be the near to plot center. The tree will then be tagged with an aluminum numbered tag. The tag number, distance to plot center, and bearing ***from the tag tree to plot center*** will be recorded. This information is recorded on the overstory and understory field data.

From the place marker, measure 150 feet at right angles and from there identify and stake the north-south center axis (red line in diagram above). Trees are measured up to 75 feet at right angles of the center transect line.

The field data sheets are now ready to be filled out. Information recorded are: 1) Names of data collectors, 2) Date, 3) Site name, 4) Slope, 5) Aspect 6) Plot number, 7) GPS coordinates, 8) Treatment site or Control site, 9) Pre- or Post- treatment, 10) Number of years since treatment, 11) Comments. The comments section is used to record additional notes, such as stand structure, plot location, landmarks, etc. The following steps will detail the processes involved in both overstory and understory inventories.

Overstory Measurement Protocols

Measurement protocols in relation to overstory pertain to trees that are on either side of the 150 ft transect line. If the protocols relate to the site tree only, this will be notes.

Measure the distance from the center transect to the center of each tree (right or left); record tree species, dbh and other measurements as desired (see options below). This makes it possible to have stem maps for each plot, which will be very helpful for followup sampling in the future. It might be also helpful to help follow up sampling in the future by putting an aluminum tag on each tree (with aluminum nails) – but that could also be done during the second measurement, after treatment.

Tree Species (spp): Mature trees that have a DBH of 4.5" or greater will be measured. Tree species is the recording of a 4 letter code that consists of the first two letters of the genus and species. For example a ponderosa pine, *Pinus ponderosae,* code is PIPO. Other species are *Abies lasiocarpa* (subalpine fir), *Picea engelmanii* (Engelmann spruce) *Picea pungens* (Blue Spruce), *Populus tremuloides* (Aspen), and *Pseudotsuga menziesii* (Douglas fir).

Diameter Breast Height (DBH): Mature trees that have a DBH of 4.5" or greater will be measured. DBH is measured using a logger's tape that has a diameter measure on one side of the tape. The measurement is taken at breast height, or 4.5' above the ground. The 4.5' is measured on the uphill side of the tree. DBH is measured to the nearest $1/10^{th}$ of an inch.

Crown Base Height Class (CBH): Mature trees that have a DBH of 4.5" or greater will have their Crown Base Height Class recorded. Crown base height is the distance from ground line to the lowest branch whorl having live branches in at least two quadrants of the tree bole. CBH will be recorded according to 5 CBH Classes. Class 1: 0' -6'; Class 2: 6' -10'; Class 3: 10' – 15'; Class 4: 15' – 20'; Class 5: > 20'.

Tree Status: Trees with a DBH of 4.5" or greater will be measured. Tree status is the description of the condition of the tree. There are 4 codes to record for tree status; L – Live, D – Dead, X – Downed & Dead, Y – Downed & live.

Crown Class (CC): All Trees with a DBH of 4.5" or greater will be measured. Crown class is a description of the rank of the tree crown when compared to other competing trees within the plot radius. There are 5 codes to record crown class; OP – Open-grown or isolated, DO – Dominant, CO – Codominant, IN – Intermediate, OV – Overtopped.

Insect(s) & Disease(s): Identify all tallied, mature trees that are greater than 4.5' tall and also have a DBH of 5.0" or greater that exhibit signs or symptoms of insect(s) or disease(s). Identify any regeneration or sapling tree species that are displaying signs or symptoms of insect(s) or disease(s). The number of regeneration or sapling trees that are showing signs or symptoms should be recorded along with total number of each tree species as detailed below.

Seedlings & Saplings: Seedlings and saplings counts will be collected within a 1/300th acre regeneration plot. Seedlings are classified as any tree less than 4.5' in height. Saplings are trees that have a DBH less than 4.5" and are taller than 4.5' in height. The number present of each species of tree, within the 1/300th acre regeneration plots, will be tallied as part of the inventory. A seedling or sapling is considered inside the plot if the base of the tree facing plot center is within the 1/300th acre plot. A 1/300th acre plot has a radius of 6' 9.6" or 6.8'.

Understory Measurement Protocols

The understory sampling method will consist of 10 Daubenmire plots distributed along the 150 ft. transect at equal intervals beginning at permanent plot center and measured over a horizontal distance, corrected for slope. The fuels loading planar transect will be used to collect data on dead and downed woody debris, duff, litter, and understory vegetation composition and percent cover.

Understory Vegetation - Daubenmire plots

Understory percent cover estimates will be obtained with the use of a Daubenmire Frame Plot. The Daubenmire Frame is 20cm x 50cm and has markings along the side of the frame that indicate different percent covers.

- The percent aerial cover of forbs, grasses, and shrubs will be recorded for each Daubenmire Frame Plot. The total percentage for each plot can be greater than 100%.
- The percent ground cover of Litter/Duff, Rocky Material, Bare Mineral Soil, and Live Basal Vegetation will also be recorded at each Daubenmire Frame Plot. The percent ground cover will add up to 100%.
- The average height of forbs, grasses, and shrubs will be recorded at each Daubenmire Frame Plot.
- The presence of Moss on Soil, Lichen on Soil, Elk Pellets, Deer Pellets, and Cow Pie will be recorded for each Daubenmire Frame Plot.

Fuel Loading – 75 ft long, 6' tall Planar Transect

Downed woody debris (DWD) are defined as woody material, such as stems, branches, or twigs, that are dead and have no live foliage and persists from year to year. The data collected will include fine woody debris counts, diameter and decay class of coarse woody debris, litter and duff and litter depths.

Fuel Loading – 75 ft long, 6' tall Planar Transect

Downed woody debris (DWD) are defined as woody material, such as stems, branches, or twigs, that are dead and have no live foliage and persists from year to year. The data collected will

include fine woody debris counts, diameter and decay class of coarse woody debris, litter and duff and litter depths.

Fuel loading will be measured from the center point of the 1/300th acre regeneration plot. A 75' transect will be laid out in one of the four cardinal directions. The first 15' of the transect will be skipped due to trampling. 1-hour fuels, which are between 0" – 0.25" in diameter, will be tallied from 15' – 21' (Table 2). 10-hour fuels, which are between 0.25" – 1.0" in diameter, will be tallied from 15' – 21' (Table 2). 100-hour fuels, which are between 1.0" – 3.0" in diameter, will be tallied from 15' – 30' (Table 2). 1000-hour fuels, which are greater than 3.0" in diameter, will have their diameter recorded and if the fuel is sound or rotten from 15' – 75' (Table 2). Any fuel that intersects the transect along the ground and up to a height of 6' will be tallied. Litter and Duff depths will be recorded at any point within 1' of the transect. Litter is the loose layer of fine woody debris and needles/leaves on the surface that are still identifiable as individual pieces, and have little alteration due to decomposition. Duff is the layer of decomposed material beneath the litter layer and above the mineral soil layer. Duff is no longer identifiable as individual pieces of material and is generally darker that the litter layer.

Table 1: Dead woody fuels are grouped according to their diameter.

Dead Woody Material Class	Fuel Diameter
1-hour fuels	0" to 0.25"
10-hour fuels	0.25" to 1.0"
100-hour fuels	1.0" to 3.0"
1000-hour and greater fuels	> 3.0"

1-hour & 10-hour fuels: DWD that are classified as 1-hour and 10-hour fuels are also called fine woody debris (FWD) are counted individually from 0' to 6' as they cross the transect plane. A 1-hour fuel has a diameter less than 0.25", while a 100-hour fuel has a diameter between 0.25" and 1.0".

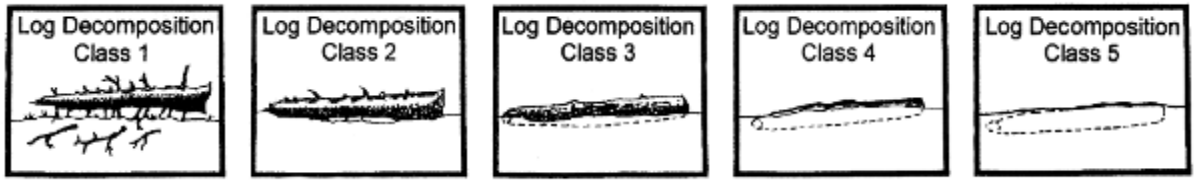
100-hour fuels: DWD that are classified as 100-hour fuels are also considered FWD and are counted from 0' to 10' as they cross the transect plane. A 100-hour fuel has a diameter between 1.0" and 3.0".

1000-hour or greater fuels: DWD that are classified as 1000-hour or greater fuels are also called coarse woody debris (CWD) and are counted and have their diameter and decay class recorded from 0' to 35' as they cross the transect plane. A 1000-hour fuel has a diameter of 3.0" or greater. CWD, that meet the DWD standards, are counted if the central axis crosses anywhere through the 6' high transect plane. The diameter of the CWD is measured where the CWD meets the transect. If a piece of CWD crosses the transect more than once, it is measured at each intersection. Diameter can be measured with a diameter tape or a ruler. CWD are not sampled if the central axis of the CWD is below the duff/litter layer where it intersects the transect or if the transect does not cross the central axis of the CWD. If a piece of CWD runs in

line with the transect the large end diameter is measured. The decay class (Table 2) of each piece of CWD that crosses the transect is also recorded.

Table 2: Log Decay Class for CWD.

Code	Bark	Twigs	Texture	Shape	Wood Color	Portion of log on ground
1	Intact	Present	Intact	Round	Original	None, elevated on supporting points
2	Intact	Absent	Intact to soft	Round	Original	Parts touch, still elevated, sagging slightly
3	Trace	Absent	Hard large pieces	Round	Original to faded	Bole on ground
4	Absent	Absent	Soft blocky pieces	Round to oval	Light brown to faded brown	Partially below ground
5	Absent	Absent	Soft, powdery	Oval	Faded light yellow or gray	Mostly below ground



Ecological Monitoring Support and Protocols Submitted July 29, 2009 by:

1. Director, Colorado Forest Restoration Institute: Dr. Tony Cheng
2. UP Mesas Scientific Research and Consultation: Dr. Daniel Binkley and Dr. William Romme, Colorado State University and Colorado Forest Restoration Institute
3. Project Management: Dr. Jessica Clement, Colorado Forest Restoration Institute
4. Technical Support and Training: Mica Keralis, Colorado State University and Colorado Forest Restoration Institute

Date: Stand No: Plot No:

UPP INVENTORY FIELD DATA SHEET				Cruiser Names	
START DATE:		START TIME:		Last Name	First
STAND # / Plot #:	/	Plot Slope:			
Plot Aspect:		Plot Elevation:			
END DATE:		END TIME:			
GPS Datum/Projection Used:					
UTM Zone:					
GPS Latitude:	Deg°	Min′	. Sec″		
GPS Longitude:	Deg°	Min′	. Sec″		
GPS UTM (Easting):					
GPS UTM (Northing):					

Pre-Treatment: ☐	Treatment Site: ☐	Yrs After Treatment:			
Post-Treatment: ☐	Control Site: ☐				
Plot Center Photo Points	1) S - N: ☐	2) E - W : ☐	End Transect Photo Points	5) N - S: ☐	6) W - E : ☐
	3) N – S: ☐	4) W – E: ☐		7) S - N: ☐	8) E - W: ☐
Daubenmire Photo Points	1N: ☐	2N: ☐	3N: ☐	4N:☐	5N:☐
	6W: ☐	7W: ☐	8W: ☐	9W:☐	10W: ☐

PLOT NOTES: (Record Non-Native/Noxious Weeds and other Details about the entire plot to aid future crews).

Daubenmire Plots: % Aerial & Ground Cover: Forbes, Grasses, Shrubs; Average Height; Presence of Scat, Moss/Lichen

	% Aerial Cover of Each (Can be > 100%)				% Ground Cover of Each (Totals to 100%)				Average Height of Each (Ft.′ In.″)			Presence of Each (X= Yes or Blank = No)				
	Forbes	Grasses	Shrubs	% Overstory Canopy Cover: Daubenmire Frame. Facing Plot Center	Bare Mineral Soil	Rocky Material	Litter/Duff	Live Basal Vegetation	Forbes	Grasses	Shrubs	Moss on Soil	Lichen on Soil	Elk Pellets	Deer Pellets	Cow Pie
Plot 1																
# Species																
Plot 2																
# Species																
Plot 3																
# Species																
Plot 4																
# Species																
Plot 5																
# Species																
Plot 6																
# Species																
Plot 7																
# Species																
Plot 8																
# Species																
Plot 9																
# Species																
Plot 10																
# Species																

Date: **Stand No:** **Plot No:**

Daubenmire Plots % Aerial Cover by Species				Daubenmire Plots % Aerial Cover by Species				Daubenmire Plots % Aerial Cover by Species			
Plot #	Life Form F/ G/ S	Species	Cover Class	Plot #	Life Form F/ G/ S	Species	Cover Class	Plot #	Life Form F/ G/ S	Species	Cover Class

Date: Stand No: Plot No:

Fuel Loading: 4 x 35' long, 6' Tall Planar Fuel's Transects. > 3": Record Diameter and Sound (S) or Rotten (R). (ex: 4"R or 4"S)

Transect 1 - Fuels Intersect Counts		% Slope:		Transect 2 - Fuels Intersect Counts		% Slope:		Litter & Duff (Inches)	
0"-0.25' (0' - 6')	0.25"-1" (0' - 6')	1"-3" (0' – 10')	>3" (0' – 35')	0"-0.25' (0' - 6')	0.25"-1" (0' - 6')	1"-3" (0' – 10')	>3" (0' – 35')		
Count	Count	Count	Diameter	Count	Count	Count	Diameter	Transect 1	Transect 2
								Litter Depth (in.)	
								Duff Depth (in.)	

Transect 3 - Fuels Intersect Counts		% Slope:		Transect 4 - Fuels Intersect Counts		% Slope:		Litter & Duff (Inches)	
0"-0.25' (0' - 6')	0.25"-1" (0' - 6')	1"-3" (0' – 10')	>3" (0' – 35')	0"-0.25' (0' - 6')	0.25"-1" (0' - 6')	1"-3" (0' – 10')	>3" (0' – 35')		
Count	Count	Count	Diameter	Count	Count	Count	Diameter	Transect 3	Transect 4
								Litter Depth (in.)	
								Duff Depth (in.)	

Shrubs: Linear Interception. Along Fuel's Transects from 0' to 35'.

Transect 1			Transect 2			Transect 3			Transect 4		
Spp.	From	To	Spp.	From	To	Spp.	From	To	Spp.	From	To

Date: Stand No: Plot No:

Seedlings/Saplings: 1/300th acre Plots. 6' 9.6" Radius (6.8' Radius). Located at 45' on each 75' transect.							
Regen Plot 1 (North)				Regen Plot 2 (West)			
Seedlings		Saplings		Seedlings		Saplings	
Species	Count	Species	Count	Species	Count	Species	Count
Regen Plot 3 (South)				Regen Plot 4 (East)			
Seedlings		Saplings		Seedlings		Saplings	
Species	Count	Species	Count	Species	Count	Species	Count

SITE/Growth TREE: Pick 1 Dominant, Live, Healthy Tree on Plot.					
Quadrant Number	Tree No.	Species	Total Height	Age @ DBH	Last 10-year Growth (1/20th inch)
OAK DATA: Choose an Average sized Oak on plot					
Quadrant Number	DRC	HEIGHT	AGE	Appox. No. Oak in Plot	

Date: Stand No: Plot No:

OVERSTORY INVENTORY (150' x 150' Plot): Inventory Live & Dead Standing Trees.																		
Tree No.	Species	DBH	CBH Class	Tree Status	Crown Class	Insect/ Disease	Dist. N or S	Dist. E or W CLASS	Tree No.	Species	DBH	CBH Class	Tree Status	Crown Class	Insect/ Disease	Dist. N or S	Dist. E or W CLASS
1									51								
2									52								
3									53								
4									54								
5									55								
6									56								
7									57								
8									58								
9									59								
10									60								
11									61								
12									62								
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44									94								
45									95								
46									96								
47									97								
48									98								
49									99								
50									100								

Date: Stand No: Plot No:

OVERSTORY INVENTORY (150' x 150' Plot): Inventory Live & Dead Standing Trees.																		
Tree No.	Species	DBH	CBH Class	Tree Status	Crown Class	Insect/ Disease	Dist. N or S	Dist. E or W Class	Tree No.	Species	DBH	CBH Class	Tree Status	Crown Class	Insect/ Disease	Dist. N or S	Dist. E or W Class
101									151								
102									152								
103									153								
104									154								
105									155								
106									156								
107									157								
108									158								
109									159								
110									160								
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140									190								
141									191								
142									192								
143									193								
144									194								
145									195								
146									196								
147									197								
148									198								
149									199								
150									200								

Date: Stand No: Plot No:

OVERSTORY INVENTORY (150' x 150' Plot): Inventory Live & Dead Standing Trees.																	
Tree No.	Species	DBH	CBH Class	Tree Status	Crown Class	Insect/ Disease	Dist. N or S	Dist. E or W CLASS	Tree No.	Species	DBH	CBH Class	Tree Status	Crown Class	Insect/ Disease	Dist. N or S	Dist. E or W CLASS
201									251								
202									252								
203									253								
204									254								
205									255								
206									256								
207									257								
208									258								
209									259								
210									260								
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213									263								
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223									273								
224									274								
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229									279								
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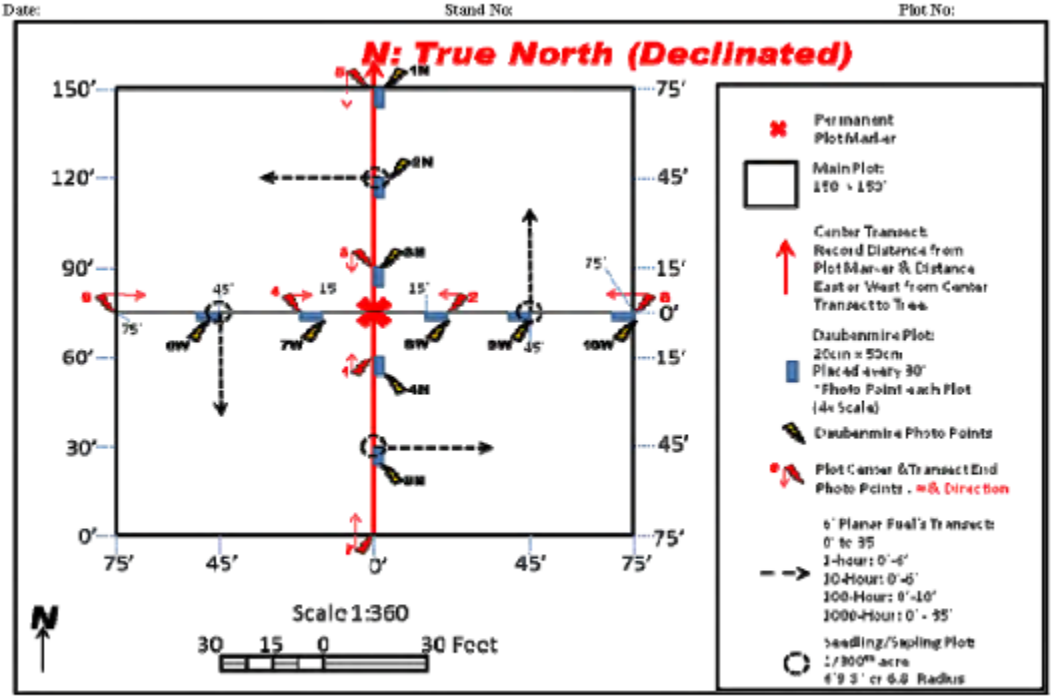
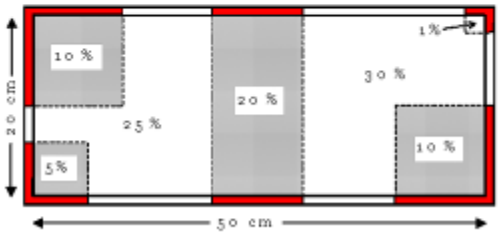
245									295								
246									296								
247									297								
248									298								
249									299								
250									300								

Date: Stand No: Plot No:



Tree Status	L: LIVE	D: DEAD	S: STUMP				
CROWN CLASS	OG: Open Grown	DOM: Dominant	COD: Co-Dominant	INT: Intermediate	OT: Over Topped		
Crown Base Height	0' - 6'	6' - 10'	10' - 15'	15' - 20'	> 20'		
CBH Class	1	2	3	4	5		
East/West Distance	0' – 10'	10' – 20'	20' - 30'	30' – 40'	40' – 50'	50' – 60'	60' – 75'
East/West Distance Class	1	2	3	4	5	6	7

Insect/Disease/Damage	Code	Insect/Disease/Damage	Code
Dwarf Mistle Toe	DMT	Aspen Conk	AC
Mountain Pine Beetle	MPB	Aspen Rot	AR
Ips Beetle	IPS	Animal Damage	AND
Spruce Beetle	SB		
Doug-Fir Beetle	DFB		
Spruce Bud Worm	SBW		



% Cover Classes: Forbes, Grasses, Shrubs					
Cd	RANGE	MID	Cd	RANGE	MID
T	0-1%	0.5%	5	45-55%	50%
0	1-5%	3%	6	55-65%	60%
1	5-15%	10%	7	65-75%	70%
2	15-25%	20%	8	75-85%	80%
3	25-35%	30%	9	85-95%	90%
4	35-45%	40%	A	95-99%	97%
			X	99-100%	99.5%

Sampling Vegetation Attributes Interagency Technical Reference, 1999. Sampling Vegetation Attributes. BLM Technical Reference
1734-4. National Business Center, Denver, CO. 158 p.
http://www.blm.gov/nstc/library/pdf/samplveg.pdf

Interagency Technical Reference. 1999. Sampling
Vegetation Attributes. BLM Technical Reference
1734-4. National Business Center, Denver, CO.
158 p

USDI-Bureau of Land Management. 1996. Sampling vegetation attributes - Interagency technical reference. BLM/RS/ST-96/002+1730. Bureau of Land Management, National Applied Resource Sciences Center, Denver, Colorado.

Sampling Vegetation Attributes: Interagency Technical
Reference. 1996. BLM/RS/ST-96/002+1730. *Available at:* http://www.blm.gov/nstc/library/techref.htm
Accessed 14 February, 2006.

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