Appendix E. Upper Monument Creek Treatment Design Criteria

The Upper Monument Creek (UMC) collaborative recognizes the importance of carefully designing treatments based on clearly defined management goals and an understanding of ecosystem dynamics. In May of 2013, a sub team of the collaborative formed to have more detailed discussions about treatment design specifications. The team's intent was to provide guidance to the Forest Service about what treatments should look like *on the ground,* as well as to describe constraints or sideboards for management by specifying undesirable conditions and actions to avoid.

The team began with discussions about management goals across the ecological systems within the UMC landscape, building on results of the Landscape Conservation Forecasting (LCF) process. The LCF process identified several key points of departure in the current ecological condition of the UMC landscape relative to the expected natural range of variability, including: (1) a nearly 15,000 acre shortfall of open canopy conditions across ecological systems, and (2) a lack of late-seral, old-growth stands and features. These findings shape the overall management approach within the UMC landscape and guide the development of management goals aimed generally at creating more open forest conditions and enhancing structural heterogeneity and old-growth features.

The 15,000 acres identified by the LCF process as in need of treatment span the three primary ecological systems as shown in Table 1. This area represents the "treatment footprint" per ecological system. The majority of the acres (nearly 75%) in need of treatment are in dry forest types such as ponderosa pine – Douglas-fir woodlands and dry mixed-conifer forests. The restoration imperative is clear in these dry forest types, based not only on results of the LCF process but also on numerous studies that have been conducted near the project area that document departures in natural fire regimes and forest conditions that have occurred as a result of human and other influences (see Literature Consulted section below).

Table 1. Results of the LCF process depicting the total number of acres per primary ecological system within the Upper Monument Creek landscape alongside the acres that are currently in a closed canopy condition relative to the acres expected to be in a closed canopy condition based on the landscape's natural range of variability (NRV). The difference between the current condition and the NRV forms the basis for determining acres in need of treatment. From there, acres that are feasible for treatment by mechanical means are determined based primarily on topography and access. Since not all acres in need of treatment are feasible via mechanical means, a portfolio approach that combines mechanical treatments with manual treatments and prescribed fire is recommended.

Ecological System	Total Acres	Acres in closed canopy condition currently (S-classes B and E)	Acres in closed canopy condition based on NRV (S-classes B and E)	Difference between current and NRV	Feasible Acres
Ponderosa Pine – Douglas-fir Woodlands	20,500	11,900	6,200	5,700	2,300
Dry Mixed-Conifer Forests	18,700	10,500	5,600	4,900	1,900
Mesic Mixed-Conifer Forests	15,700	12,400	8,600	3,800	1,800
Totals	54,900	34,800	20,400	14,400	6,000

During summer 2013, the design criteria team held several meetings and took several field trips to visit treatment areas and to discuss treatment design possibilities and practicalities within the UMC landscape. Several points of consideration arose from these meetings and field trips.

First, the team recognized that the feasibility of mechanical treatment may be limited in some situations due to access and steep terrain. Forest Service managers evaluated treatment feasibility based on road access and slope and determined that approximately 6,000 acres could be treated mechanically (Table 1), while the remaining 9,000 acres in need of treatment may be dealt with by manual thinning and prescribed fire. The feasibility analysis highlighted the need for a portfolio approach involving a range of treatment tactics, as well as the need to think strategically about treatment placement. Mechanical treatments should be arranged and implemented in a way that increases the likelihood of being able to use prescribed fire.

Second, where restoration is the primary management goal, the team discussed the value of designing treatments based on ecological dynamics and natural patterns of forest structure and composition that result from interactions among environmental gradients and disturbance regimes. Treatments should attempt to mimic patterns of tree mortality that would be created by natural disturbances but constrained by physiographic settings. Forest structures that more closely resemble the natural range of variation across the landscape are more likely to be sustainable over time and are more likely to foster desirable ecological processes such as low-severity fire that historically characterized drier forest types in the UMC landscape.

Third, the team acknowledged that while landscape restoration is the overall management goal within the UMC landscape, management approaches geared more toward fuels reduction may have a role as well. Fuel reduction treatments are generally less focused on enhancing structural complexity and spatial heterogeneity. Instead, they emphasize surface and ladder fuels reduction, removal of coarse woody debris and other heavy fuels, and spacing of trees in a way that minimizes overlap of crowns and reduces the potential of active crown fire were a fire to occur. Though they are at times in contrast to restoration goals, fuel reduction treatments may be important within the UMC landscape for protecting values at risk and enhancing community safety. They may also set the stage for restoration elsewhere on the landscape by increasing the potential for using prescribed fire as a management tool. The UMC's Integrated Fire Risk Assessment (IFRA) identified overlap between areas of high burn probability and areas containing highly valued resources and assets. Results of this analysis should be consulted to determine where fuels reduction may be most appropriate.

Fourth, the team discussed implications of the Waldo Canyon fire on restoration treatment design, especially pertaining to openings. The Waldo Canyon fire created early-seral (S-Class A) vegetation structures across ecological systems in close proportion to the natural range of variability (as identified by the LCF process). The burn did not, however, create a desirable landscape pattern. The majority of early-seral vegetation is now concentrated in one large patch on the landscape as opposed to being dispersed in smaller patches throughout the landscape. The team determined that results of the LCF analysis should be applied to areas outside of the Waldo Canyon fire scar, and that there is still a need to enhance and create early-seral vegetation structures within the project area, despite the Waldo Canyon fire. The team determined that openings should be created by a variety of methods, including mechanical treatments, hand-thinning, and prescribed fire, in order to increase the proportion of early-seral vegetation structures on the landscape.

Lastly, the team recognized the importance of adaptive management as a framework for dealing with uncertainty that often characterizes the restoration process. Adaptive management encourages the continual evaluation of treatment outcomes, and it emphasizes continual learning and improvement in treatment approaches based on that learning. Monitoring is vital to the adaptive management process as it provides information that can be used to assess the effectiveness of treatments and whether treatments are having desired effects. The team acknowledged the importance of experimentation and innovation in treatment approaches, especially in ecological systems for which management information is limited.

During the team's several field trips, it became apparent that transitions between ecological systems often occur over relatively small spatial scales due to the highly dissected topography that characterizes many areas within the UMC landscape. For example, south-facing slopes may be occupied by ponderosa pine – Douglas-fir woodlands while adjacent north-facing slopes a short distance away may support wet mixed-conifer forests. Treatments may thus incorporate several ecological systems over small areas and implementers should be capable of moving fluidly across the landscape following a broad set of design principles. At the same time, recognizing distinctions associated with individual ecological systems and physiographic settings is important. The design criteria team thus took a two-phased approach to developing design criteria, first identifying overarching treatment considerations that apply *across* ecological systems, and then developing design criteria *within* individual ecological systems.

Provided below are general design considerations that frame the overall treatment approach across the UMC landscape, followed by design criteria specific to individual ecological systems. Support information – including tables, figures, and photos – also follows in order to illustrate key points that the team felt were important to highlight.

<u>Treatment Considerations across Ecological Systems</u>

General considerations that should frame the overall approach to restoration across ecological systems within the UMC landscape include:

- *Treatment priority* – Prioritize ponderosa pine – Douglas-fir woodlands and dry mixed-conifer ecological systems for restoration work. Front Range science and results of the LCF process show these dry forest systems to be most departed from their historical condition, particularly with regard to open forest conditions. Treat mesic mixed-conifer, lodgepole pine, and Gambel oak ecological systems where necessary to improve forest health, enhance landscape diversity, and increase the potential for prescribed fire use in adjacent dry forest types.
- *Treatment size and arrangement* – Ensure that treatment size and arrangement are suitable to the management goals of a given treatment area. Where possible, design treatments that are large and continuous in order to more effectively reduce canopy continuity and provide barriers to wildfire spread. Arrange treatment areas in a way that maximizes implementation efficiency and the number of acres treated within an area.
- *Prescribed fire* – Identify areas where prescribed fire may be reintroduced either immediately, or in the future following initial mechanical fuels reduction. Anchor treatments in and around these areas to increase the potential for safe application of prescribed fire. Fuel reduction treatments and establishment of fire breaks may be required in vicinity areas.
- *Openings* – Look for opportunities to enhance existing openings by reducing tree encroachment along opening peripheries. Also look for opportunities to create new openings. Consider the spatial pattern, size, shape, and rationale for placement of openings. Consider longer-term maintenance requirements as well, based on whether the desired condition for a given opening is to maintain the area as an opening or to create opportunity for tree regeneration.
- *Density* – Vary residual density and basal area among and within treatment areas based on topographic variation and fine-scale variation in substrate characteristics such as soil depth. For example, low-density structures are appropriate along ridges and south-facing slopes and should grade downslope into higher density areas. Avoid uniform densities both within and between treatment areas to prevent an unnatural appearing forest. Changes from one density "matrix" to another (e.g. low-density to high-density matrices as described more below) may occur over relatively small spatial scales based on physiographic setting.
- *Spatial structure* – Enhance the characteristic "groupy" structure of dry forest types such as ponderosa pine and dry mixed-conifer where possible. Group size, number of trees in groups, number of groups per unit area, and distances between groups are all important considerations.
- *Old trees and old-growth stands* – Retain old trees of all species and protect and enhance old-growth stands. Use morphological characteristics such as flattened crown form, thick bark plates, and deep fissures as distinguishing features to identify old trees. Ponderosa pine trees begin taking on these morphological characteristics at approximately 200 years of age, though

younger trees (e.g. 150 years or so) may exhibit some of these characteristics as well and should be retained. Remove small-diameter material and ladder fuels in the vicinity of old trees in order to decrease competition and reduce the potential for crown fire. Map old-growth stands and consider fuels reduction treatments in adjacent stands in order to protect the high ecological value associated with old-growth on the landscape.

- *Age and size distribution* – Remove overrepresented age classes (usually trees 50-120 years old) and size classes (usually smaller-diameter trees) in order to promote more balanced age and size class distributions. Residual age and size class distributions should be multi-modal as opposed to steep reverse-J distributions.
- *Species preferences* – Preferentially retain ponderosa pine over other conifer species. Douglas-fir should be targeted for removal where it competes with ponderosa pine, except in areas where pine is infected with mistletoe. Retain and enhance aspen. Consider "day-lighting" remnant aspen patches by clearing around them in order to increase vigor and abundance.
- *Snags and coarse woody debris* – Retain snags and coarse woody debris where possible to provide structural complexity and important wildlife value. Not every acre has to contain snags and coarse woody debris, but retain these structures where they are locally deficient and where they do not represent hazards or heavy fuel loads.
- *Wildlife structures* – In addition to snags and logs, retain other structures important for wildlife such as turkey roosts and Abert's squirrel nest tree clumps. Leave small pockets of high tree density and shrub thickets where appropriate to provide wildlife cover. Follow habitat management guidelines for rare species where they occur in the project area.
- *Understory vegetation* – Minimize disturbance to the understory vegetation layer by using silvicultural approaches that are as low impact as possible. Follow mechanical treatments with prescribed fire where possible to enhance the understory vegetation response to treatments. Monitoring of understory vegetation response should be conducted to ensure desired responses are occurring. If not, desired native species may need to be seeded or planted. Be aware of noxious weeds and take measures to prevent their spread should they become established.
- *Soils* – Minimize disturbance to the soil surface by adopting low-impact silvicultural practices. Ensure that areas of high soil surface disturbance (e.g. skid trails) are rehabilitated following treatments in order to minimize soil loss due to erosion.
- *Riparian areas* – Ensure protection of riparian areas by implementing Best Management Practices or Forest Plan standards and guidelines. Maintain riparian buffers in order to protect aquatic environments. Prescribed fire should be allowed to back into riparian areas to enhance ecotonal areas between bottomlands and uplands.
- *Silvicultural systems* – Employ a range of silvicultural approaches in order to enhance heterogeneity in residual forest structure. Uneven-aged approaches such as single-tree and group-selection may be appropriate in dry forest types, whereas even-aged approaches may be appropriate in more mesic forest types, simulating natural disturbance effects. Regeneration harvests may be applied to initiate new age-classes. Where aspen is present in the stand, regeneration harvests may be used to encourage aspen proliferation. Small clearcuts may also be employed to create long-term openings, which will need to be maintained over time.
- *Treatment efficacy* - Consider longer-term maintenance requirements of treated areas. For example, anticipate treatment responses such as regeneration based on residual stand conditions and the presence of species like Douglas-fir. It may be wise to discourage regeneration in some situations if the likelihood of follow-up treatment is low.

<u>Design Criteria within Ecological Systems</u>

Ponderosa Pine – Douglas-fir Woodlands

The ponderosa pine – Douglas-fir ecological system occupies approximately 20,500 acres within the Upper Monument Creek landscape, primarily at lower elevations and dry sites at higher elevations. Historically, these systems were shaped by low- to mixed-severity, frequent fire, which maintained an open stand structure with variably spaced individual trees, groups of trees, and openings. Current conditions are much denser than historical conditions for this ecological system, and thus this system is a high priority for restoration. The LCF process identified some 5,700 acres in need of treatment, of which 2,300 acres are suitable for mechanical treatments. The remaining 3,400 acres should be treated with manual thinning and prescribed fire.

Management Goals and Recommendations

Management should be focused on reducing stand densities and restoring spatial structure via enhancement of tree groups, scattered individual trees, and openings. An uneven-aged, open stand condition that supports low-severity fire is the eventual desired condition for this ecological system. Treatment design criteria are summarized in Table 2 and below:

- Residual basal areas (BA) should range from 30 to 50 ft^2 per acre, but should be distributed according to site variability in topography and substrate characteristics such that BA in any given stand may range from 0 ft^2 per acre (openings) up to 80+ ft^2 per acre (high-density patches).
- Openings should occupy 20-25% of the treatment area and should be variable in size, shape, and distribution. Enhancing existing openings should allow for the restoration of larger openings (e.g. up to 50 acres in size), while creating new openings will enhance landscape heterogeneity and break canopy continuity. Suitable locations for openings include low-productivity areas such as shallow soils, areas currently lacking ponderosa pine, areas where disease or insect infestation are present, and plantations established from off-site seed sources. Created openings may range in size from 1 to 20 acres, with a median of about 3 acres.
- Establish a low-density matrix (20 to 40 ft^2 per acre BA) on approximately 30-40% of the treatment area. Suitable locations for low density structures include ridges, south-facing slopes, and other areas of low productivity. Residual trees should be variably spaced. Existing tree groups (i.e. trees having interlocking crowns) should be enhanced by clearing around them. Approximately 50-70 percent of trees may occur in groups, whereas the remaining 30-50 percent may occur as scattered, individual trees at low densities. Tree groups may contain anywhere from 2 to 10+ trees, but will most likely contain around 2-4 trees. Tree groups should be separated from one another by at least 1 to 1.5 tree lengths from drip-line to drip-line, based on the heights of trees in the group.
- A medium-density matrix (40 to 60 ft^2 per acre BA) should be established over 25-35% of the treatment area, most often at mid-slope positions and other areas of intermediate productivity, such as gentle slopes. Approximately 70-90% of trees may occur in groups here and group size may be larger as well, on the order of 5-9 trees per group typically.
- Areas of high density (60 to 80+ ft^2 per acre BA) should be maintained over 5-10% of the treatment area on north-facing slopes and other moist, higher-productivity areas. The characteristic structure of lower-density areas (i.e. tree groups, individual scattered trees, and openings) may be less evident at this higher density level as most trees occur in groups (90+ percent) and fewer as scattered individuals.
- Untreated “reserves” should cover 5-10% of the treatment area, representing unique ecological or cultural areas within the treatment area.

Figures 1 and 2 provide examples of how basal area may be distributed according to site variability and how spatial variability may be enhanced via treatments.

Dry Mixed-Conifer Forests

Dry mixed-conifer forests occupy 18,700 acres within the Upper Monument Creek landscape, often representing subtle transitions from ponderosa pine – Douglas-fir woodlands where moisture availability and the proportion of Douglas-fir both increase. Dry mixed-conifer forests are naturally denser and more productive than ponderosa pine – Douglas-fir woodlands but have similar ecological dynamics. Low-severity fire was the dominant disturbance regime historically, but with some increase in the preponderance of moderate- and high-severity fire and slightly longer fire return intervals compared to ponderosa pine – Douglas-fir woodlands. Dry mixed-conifer forests typically have greater variability in tree group composition, from single-species to mixed-species groups, and from single-aged to multi-aged groups. There is also higher potential for ladder fuel development in this system due to the higher productivity and increased proportion of Douglas-fir.

Similar to ponderosa pine – Douglas-fir woodlands, current dry mixed-conifer forests within the Upper Monument Creek landscape are denser than they were historically and have lost important stand components and spatial variability. The LCF process identified some 4,900 acres in need of treatment to create a more open canopy condition. Approximately 1,900 acres are feasible for mechanical treatments and the remaining 3,000 should be treated manually and with prescribed fire. This ecological system is a high priority for restoration, though less is known about how this system may respond to restoration treatments and thus there is increased need for monitoring and adaptive management.

Management Goals and Recommendations

Management goals for the dry mixed-conifer ecological system are similar overall to those for ponderosa pine – Douglas-fir woodlands. Higher overall tree densities and a higher proportion of Douglas-fir and other conifers such as limber pine should be allowed. Treatment design criteria are summarized in Table 3 and below:

- Residual basal area (BA) should range from 40 to 60 ft^2 per acre and should be distributed according to site variability in productivity, ranging from 0 ft^2 per acre (openings) up to 80+ ft^2 per acre (high-density patches).
- Openings should occupy 10-20% of the treatment area and should be variable in size, shape, and distribution. Sizes may range from 1 to 20 acres. Suitable locations for openings may include low-productivity areas such as shallow soils and areas where disease or insect infestation is present. Higher productivity areas may be suitable as well to mimic 'blow-outs' that occur with mixed-severity fire and to create opportunities for regeneration and early-seral habitat structures.
- A low-density matrix (20 to 40 ft^2 per acre BA) should cover 15-25% of the treatment area primarily in areas where a high ponderosa pine component (as much as 50%) is present. These areas may have been ponderosa pine – Douglas-fir woodlands prior to fire exclusion and conversion back to this woodland structure may be appropriate here. Tree groups, individual scattered trees, and openings should all be present. Approximately 50-70 percent of the trees here may occur in groups containing anywhere from 2 to 10+ trees, but most often containing 2-4 trees. The remaining 30-50 percent of trees may occur as scattered, individuals.
- A medium-density matrix (40 to 60 ft^2 per acre BA) should be established over 20-30% of the treatment area with emphasis still on restoring spatial structure. More trees will occur in

groups (70-90%) at this density and group size is larger, typically 5-9 trees per group. Mixed species groups are appropriate. Ponderosa pine, Douglas-fir, limber pine, and aspen may all occur.

- A high-density matrix (60 to 80+ ft^2 per acre BA) should be maintained over 25-35% of the treatment area in higher productivity areas. Most (90 percent or more) trees may occur in groups here, with groups containing a large proportion of Douglas-fir. Blue spruce may be present here as well.
- Untreated "reserves" should cover 5-10% of treatment area, representing unique ecological or cultural areas within the treatment area.

Mesic Mixed-Conifer Forests

Mesic mixed-conifer forests occupy approximately 15,700 acres within the Upper Monument Creek landscape, primarily in mesic settings such as north-facing slopes and at higher elevations. The presence of Engelmann spruce often signals the transition from dry mixed-conifer to mesic mixed-conifer forests. Historically, mesic mixed-conifer forests were prone to extremes in fire activity, depending on climatic conditions. Under mild conditions they may not have burned at all, whereas during drought they may have burned with high severity. This disturbance dynamic would tend to create more of an even-aged, patch structured system as opposed to the uneven-aged matrix characteristic of drier settings. A range of structural stages would have characterized the system across the landscape, representing varying degrees of recovery following stand-replacing fire.

In general, the restoration imperative begins to fall away in more mesic forests such as mesic mixed-conifer, as these systems are not as ecologically departed from their natural range of variability compared to the drier forest systems. However, the LCF process pointed to a deficiency in late-seral, open stand conditions for mesic mixed-conifer forests within the Upper Monument Creek landscape, representing loss of old-growth features for this forest type. Approximately 3,800 acres were identified as in need of treatment, with 1,800 acres being feasible for mechanical treatment. Treatments that are focused more on fuels reduction than restoration may also be warranted here in order to break canopy continuity and increase the potential for using prescribed fire here and in adjacent dry forests.

Management Goals and Recommendations

Treatments should focus on enhancing structural and age-class diversity between stands (e.g. young stands adjacent to older stands), reducing density of older stands, and reducing fuels. Creating openings and thinning older stands are both appropriate management actions here, but decisions to treat should be based on the local context and presence of values at risk. For example, a high-density patch of mesic mixed-conifer adjacent to an old-growth stand of ponderosa pine may be a candidate for treatment in order to reduce the potential for crown fire and protect the old-growth. Recommended design criteria for this ecological system are fairly broad at this point and are meant to provide a few management options that can be selected from based on local context and site-specific conditions. Additional details regarding treatment design should be worked out during the effects analysis phase of the Forest Service planning process. General recommendations include:

- Create large openings (10 to 20 acres in size) in early- and mid-seral stands to mimic natural disturbances such as wind throw or blow-outs that occurred historically with mixed-severity fire. Diseased or insect-infested areas may provide opportunity for creating openings. Avoid uniform shapes and spacing for openings; place openings only in areas considered to have moderate to low risk of windthrow.

- Reduce density in late-seral, closed stands in order to release large, old trees and accelerate development of structural complexity and old-growth features. Focus on removal of small-diameter trees and ladder fuels.
- Leave a high proportion of the total area in mesic-mixed conifer untreated. Closed forests interspersed with open, drier forests provide a natural and desirable landscape pattern. These “dark timbered” areas are important for wildlife as well.

Lodgepole Pine Forests

The lodgepole pine ecological system occupies approximately 2,400 acres within the Upper Monument Creek landscape primarily along the Rampart Range Road within the north-central part of the project area. Most of the area is above 9,000 feet in elevation and occurs along flat ridges and gentle, rolling topography. Lodgepole pine stands consist of a diverse range of structural types, from late-seral, uneven-aged stands to younger, even-aged stands. The late-seral, uneven-aged stands within the project area appear to be a somewhat rare compositional and structural type for lodgepole pine. They are dominated by lodgepole pine but also include a diverse suite of additional species such as Douglas-fir, limber pine, aspen, and occasionally ponderosa pine. These stands are relatively open with patches of well-developed understory and old trees. Some evidence of surface fire is present throughout these stands as well. Small-scale tree mortality and regeneration processes appear to be operating in these stands, consistent with uneven-aged stand dynamics. In general, late-seral stands occur along flat ridges of the Rampart Range and grade downslope into younger, even-aged stands, particularly on north-facing slopes. These younger stands likely represent recovery from stand-replacing fire and are more typical of lodgepole pine in that they exhibit fairly uniform stand structure and sparse understory vegetation. Stands that are regenerating from clearcuts in the 1960s and 1970s are also present. These stands exhibit the classic “dog-hair” structure of young lodgepole stands.

Because of its small area relative to the total Upper Monument Creek landscape, lodgepole pine was not included in the LCF process and thus ecological and open-canopy departures were not evaluated. Overall however, lodgepole pine in the project area does not appear to be significantly departed from historical conditions for this system type. A suitable range of seral stages are represented at appropriate scales, and the stands currently appear healthy and have not been significantly impacted by the mountain pine beetle.

Management Goals and Recommendations

While ecological restoration is not a high priority for lodgepole pine within the Upper Monument Creek landscape, the system’s proximity to other high priority ecological systems may warrant a fuels-based treatment approach. Fuels reduction within the lodgepole pine system may increase the likelihood of being able to use prescribed fire in downslope ponderosa pine – Douglas fir woodlands and dry mixed-conifer forests, potentially advancing larger landscape restoration goals. Such treatment would also serve to protect the late-seral lodgepole pine stands identified as unique on the landscape. Overall, the goal of these treatments would be to reduce fuel loads and canopy continuity, increase structural diversity and resilience to fire and mountain pine beetle, encourage aspen cover, and move younger, more uniform stands in the direction of late-seral stand structures. Openings should be created to slow the rate of spread and break the direction of an active crown fire, and treatments should be implemented at a level that would negate the need for creation of standard fuel breaks (such as clearcut strips or Finney bricks). Treatments should avoid homogenous patterns such as evenly spaced openings of the same size and even-spacing of trees. General recommendations include:

- Minimize treatments in late-seral, uneven-aged stands; target mid-seral and closed stand structures. Avoid thinning in these stands to minimize windthrow.
- Install patch clearcuts ranging from 10-20 acres in size within the interior of the lodgepole pine area.
- Elsewhere within the treatment footprint, create both small (<1 acre) and large (1-5 acres) openings via an uneven-aged, group selection approach.
- Place openings greater than 1 acre only in areas considered to have moderate-to-low risk of windthrow.
- Where feasible, locate larger openings adjacent to drainages to enhance aspen sprouting.
- Consider precommercial thinning in sapling-size lodgepole pine areas, but leave some denser thickets for wildlife cover.

Gambel Oak – Mixed Montane Shrublands

Gambel oak – mixed montane shrublands occupy around 2,100 acres within the Upper Monument Creek landscape, primarily in lower elevation, dry settings along the eastern flank of the project area near Monument, as well as in the vicinity of Woodland Park. This ecological system occurs both as an oak-dominated shrubland and as more of an understory component within the ponderosa pine – Douglas-fir woodland. As one of the few deciduous tree species present within the project area, Gambel oak adds species diversity and has an important role for wildlife in terms of both cover and forage.

Similar to lodgepole pine, Gambel oak was not included in the LCF process because of its small area relative to the total Upper Monument Creek landscape and because of lack of information regarding historical disturbance dynamics and natural ranges of variability. Given its low-elevation range restriction, Gambel oak likely experienced frequent fire historically, which would have maintained a more open and diverse structural condition than seen on the current landscape. Gambel oak is likely over-represented on today's landscape due to fire exclusion. A range of growth forms from large individual trees to shrubby thickets were likely present historically. A rich understory community of grasses, forbs, and shrubs was likely present as well. The area around Monument is currently composed of dense, uniform Gambel oak following recovery from the 1989 Berry fire. Very little structural diversity occurs here and the area represents high potential for stand-replacing fire. Furthermore, the area is highly visible given its location and may provide opportunity for the Forest Service to set a good treatment example, potentially complementing existing treatments and spurring new treatments on neighboring private lands.

Management Goals and Recommendations

Management goals within the Gambel oak ecological system are to reduce fuels, increase structural diversity, and break canopy continuity where uniform canopy cover exists. Where possible, prescribed fire should be used to reduce fuel loads, increase structural heterogeneity, and enhance understory herbaceous vegetation. General treatment design recommendations include:

- Protect ponderosa pine islands and individual trees by removing Gambel oak and other woody brush that may serve as ladder fuels.
- Remove Gambel oak in the vicinity of ponderosa pine seed trees in order to encourage regeneration and establishment of ponderosa pine.
- Manage for variation in oak growth forms, sizes, age-classes, and densities.
- Maintain large, old oak trees.

- Reduce fuels along roadsides and private land interfaces; focus on areas where treatments may complement defensible space activities implemented by surrounding homeowners.
- Where possible, design treatments to increase the potential for using prescribed fire.
- Maintain treatments; Gambel oak will resprout following mechanical or manual treatments and will require regular maintenance to ensure treatment efficacy.
- Experiment, learn, and adapt – uncertainty characterizes the management approach to Gambel oak perhaps more so than any other ecological system. Experimentation, monitoring, and adaptive management are encouraged for this system in particular.

<u>Literature Consulted</u>

Abella, S. R. 2008. Managing Gambel Oak in Southwestern Ponderosa Pine Forests: The Status of Our Knowledge. USDA Forest Service Gen Tech Rep RMRS-GTR-218.

Abella, S. R. and C. W. Denton. 2009. Spatial variation in reference conditions: historical tree density and pattern on a Pinus ponderosa landscape. Canadian Journal of Forest Research 39:2391-2403.

Alexander, R. R. 1986. Silvicultural systems and cutting methods for old-growth lodgepole pine forests in the Central Rocky Mountains. USDA Forest Service Gen Tech Rep RM-GTR-127.

Alexander, R. R. 1986. Silvicultural systems and cutting methods for ponderosa pine forests in the Front Range of the Central Rocky Mountains. USDA Forest Service Gen Tech Rep RM-GTR-128.

Boyden, S., D. Binkley, and W. Shepperd. 2005. Spatial and temporal patterns in structure, regeneration, and mortality of an old-growth ponderosa pine forest in the Colorado Front Range. Forest Ecology and Management 219:43-55.

Brown, P. M., D. R. D'Amico, A. T. Carpenter, and D. Andrews. 2001. Restoration of montane ponderosa pine forests in the Colorado Front Range: A forest ecosystem management plan for the city of Boulder. Ecological Restoration 19:19-26.

Brown, P. M., M. R. Kaufmann, and W. D. Shepperd. 1999. Long-term, landscape patterns of past fire events in a montane ponderosa pine forest of central Colorado. Landscape Ecology 14:513-532.

Churchill, D. J., M. C. Dalhgreen, A. J. Larson, and J. F. Franklin. 2013. The ICO approach to restoring spatial pattern in dry forests: Implementation guide. Version 1.0. Stewardship Forestry, Vashon, Washington, USA.

Churchill, D. J., A. J. Larson, M. C. Dahlgreen, J. F. Franklin, P. F. Hessburg, and J. A. Lutz. 2013. Restoring forest resilience: From reference spatial patterns to silvicultural prescriptions and monitoring. Forest Ecology and Management 291:442-457.

Dennis, F. C. and B. Sturtevant. 2007. Forest Restoration Guidelines in Ponderosa Pine on the Front Range of Colorado. Colorado Forest Restoration Institute and Colorado State Forest Service, Colorado State University.

Donnegan, J. A., T. T. Veblen, and J. S. Sibold. 2001. Climatic and human influences on fire history in Pike National Forest, central Colorado. Canadian Journal of Forest Research 31:1526-1539.

Franklin, J. F. and K. N. Johnson. 2012. A Restoration Framework for Federal Forests in the Pacific Northwest. Journal of Forestry 110:429-439.

Graham, R.T. 2003. Hayman Fire Case Study. USDA Forest Service Rocky Mountain Research Station, Gen Tech Rep RMRS-GTR-114.

Hadley, K. S. 1994. The Role of Disturbance, Topography, and Forest Structure in the Development of a Montane Forest Landscape. Bulletin of the Torrey Botanical Club 121:47-61.

Jack, J. G. 1900. Pikes Peak, Plum Creek, and South Platte Reserves. United States Government Printing Office, Washington, D.C.

Kaufmann, M. R. 2008. The Status of Our Scientific Understanding of Lodgepole Pine and Mountain Pine Beetles - A Focus on Forest Ecology and Fire Behavior. The Nature Conservancy, Arlington, VA. GFI technical report 2008-2.

Kaufmann, M. R. 2012. Mixed conifer management guidelines in the Southern Front Range, Colorado – A brief case study of the status of our knowledge of ecology and fire science. The Nature Conservancy and Southern Rockies Fire Science Network.

Kaufmann, M. R., D. Binkley, P. Z. Fulé, M. Johnson, S. L. Stephens, and T. W. Swetnam. 2007. Defining old growth for fire-adapted forests of the western United States. Ecology and Society 12:15.

Kaufmann, M. R., C. M. Regan, and P. M. Brown. 2000. Heterogeneity in ponderosa pine/Douglas-fir forests: age and size structure in unlogged and logged landscapes of central Colorado. Canadian Journal of Forest Research 30:698-711.

Kaufmann, M. R., T. T. Veblen, and W. H. Romme. 2006. Historical fire regimes in ponderosa pine forests of the Colorado Front Range, and recommendations for ecological restoration and fuels management. Colorado Forest Restoration Institute, Colorado State University.

Larson, A. J. and D. Churchill. 2012. Tree spatial patterns in fire-frequent forests of western North America, including mechanisms of pattern formation and implications for designing fuel reduction and restoration treatments. Forest Ecology and Management 267:74-92.

Larson, A. J., K. C. Stover, and C. R. Keyes. 2012. Effects of restoration thinning on spatial heterogeneity in mixed-conifer forest. Canadian Journal of Forest Research 42:1505-1517.

Mast, J. N. and T. T. Veblen. 1999. Tree spatial patterns and stand development along the pine-grassland ecotone in the Colorado Front Range. Canadian Journal of Forest Research 29:575-584.

North, M., P. Stine, K. O'Hara, W. Zielinski, and S. Stephens. 2009. An Ecosystem Management Strategy for Sierran Mixed-Conifer Forests. USDA Forest Service Gen Tech. Rep. PSW-GTR-220.

O'Hara, K. and C. L. Kollenberg. 2003. Stocking control procedures for multiaged lodgepole pine stands in the northern Rocky Mountains. Western Journal of Applied Forestry 18:15-21.

Peet, R. K. 1981. Forest vegetation of the Colorado Front Range. Vegetatio 45:3-75.

Schoennagel, T., T. T. Veblen, and W. H. Romme. 2004. The Interaction of Fire, Fuels, and Climate across Rocky Mountain Forests. BioScience 54:661-676.

Veblen, T. T. and J. A. Donnegan. 2005. Historical Range of Variability for Forest Vegetation of the National Forests of the Colorado Front Range. USDA Forest Service, Agreement No. 1102-0001-99-033, University of Colorado, Boulder.

Veblen, T. T., T. Kitzberger, and J. Donnegan. 2000. Climatic and human influences on fire regimes in ponderosa pine forests in the Colorado Front Range. Ecological Applications 10:1178-1195.

Table 2. Design criteria for the Ponderosa pine – Douglas-fir Woodland ecological system.

Ecological System: *Ponderosa Pine – Douglas-fir Woodland* **General Design Criteria:** Treatments within Ponderosa Pine – Douglas-fir woodlands should open existing stands and restore spatial structures characterized by tree groups, scattered individual trees, and openings. Overall basal area (BA) should range from 30 to 50 ft^2 per acre, but should be distributed according to site variability in topography and substrate characteristics such that BA in any given stand may range from 0 ft^2 per acre (openings) to 80+ ft^2 per acre (high-density patches). Attempt to achieve a balance of age-classes throughout the treatment area by targeting overrepresented age- or size-classes for removal (usually trees 50-120 years old), while retaining old trees (> 200 years) and creating some regeneration. Ponderosa pine and aspen should be preferentially retained, while Douglas-fir should be targeted for removal, except in moist areas such as slope bottoms and northerly slopes where it most often occurred historically. Consider "day-lighting" remnant aspen patches by clearing around in order to increase vigor and abundance. Retain snags, logs, and coarse woody debris, except in areas where they represent hazards or heavy fuel buildup.			
Structure	**Residual BA**	**Treatment Area (%)**	**Description**
Openings	0-20	15-25	Enhanced openings – build from existing openings by removing small-diameter tree encroachment. This treatment enables larger openings (e.g. 50 acres or greater) based on existing features. Minimum size to be considered an opening is 1 acre. Maximum size and distribution are variable based on the sizes and locations of existing openings. The goal here is to maintain the area as an opening as opposed to encouraging regeneration. Some individual trees or small groups of trees may be present within openings, but at very low densities.
			Created openings – may be warranted in areas where natural larger-scale openings are lacking. Minimum size is 1 acre and maximum size is around 20 acres, based on operational feasibility and what is likely acceptable within the wildland-urban interface. Median size is around 3 acres. Suitable locations may include low-productivity areas such as shallow soils, areas currently lacking ponderosa pine, areas where disease or insect infestation are present, and areas that were planted during the 1930s reforestation effort (in order to reduce the non-native seed source). In some cases, openings may extend from south-facing slopes to the upper portions of north-facing slopes in order to mimic small 'blow-ups' that occur naturally with mixed-severity fire in these settings. Some individual trees or small groups of trees may be present within openings, but at very low densities. Attention should be given to seed-tree species and location. For example, it may be undesirable to retain Douglas-fir seed trees along a ridge top above a treated area due to the increased regeneration potential in these areas.
Low-density matrix	20-40	30-40	A low-density woodland matrix is appropriate along ridges, south-facing slopes, and other low productivity areas within the treatment area. Ponderosa pine will likely dominate these areas and the desired structure is open woodland characterized by tree groups, scattered individual trees, and openings. Residual trees should be variably spaced. Existing tree groups (i.e. trees having interlocking crowns) should be enhanced by clearing around them. Tree groups may contain anywhere from 2 to 10+ trees, but most likely contain around 2-4 trees. Approximately 50-70 percent of the trees in the treatment area will occur in groups, whereas the remaining 30-50 percent will occur as scattered, individual trees at low densities. Tree groups should be separated from one another by at least 1 to 1.5

			tree lengths. Openings will often be created as a by-product of treatment and may simply represent the grass-forb-shrub interspace between tree groups or individual trees. In some cases, more deliberate creation of openings may be warranted. Openings at this scale should range in size from 0.1 to 2.0 acres, with a median of 1 acre. Similar to larger openings, suitable locations may include shallow soils, areas currently lacking ponderosa pine, and areas where disease or insect infestation is present.
Medium-density matrix	40-60	25-35	A medium-density woodland matrix is appropriate for mid-slopes and other areas of intermediate productivity, such as gentle slopes. Similar to above, enhance spatial structure by focusing on tree groups, individual scattered trees, and openings. Average distance between tree groups may be less in this case (around 1 tree length), and the proportion of trees that occur in groups versus scattered individual trees should increase as well. Approximately 70-90% of trees may occur in groups here and group size may be larger as well, on the order of 5-9 trees per group typically. Openings should be present and still range in size from 0.1 to 2.0 acres, but with a lower median of around 0.75 acres.
High-density matrix	60-80+	5-10	A high-density forest matrix is appropriate on north-facing slopes and other moist, higher-productivity areas. Douglas-fir naturally makes up a higher component of the BA in these settings. Maintain densities above 60 BA to reduce likelihood of Douglas-fir regeneration. The characteristic structure of lower-density settings (i.e. tree groups, individual scattered trees, and openings) may be less evident at this density as most trees occur in groups (90+ percent) and fewer as scattered individuals. Treatments in this setting may involve mild reductions in density by thinning from below or hand-felling of small diameter stems and ladder fuels. Creating openings is most likely not a primary objective here.
Untreated areas	---	5-10	Untreated “reserves” may represent unique ecological or cultural areas within the treatment area such as high-density pockets on north-facing slopes, swales, or in drainages. Areas that are operationally infeasible to treat may be included here as well. These areas are not large enough in scale to be mapped as separate stands; they likely range in size from 0.25 to 5 acres with a median of around 2 acres.

Figure 1a. Example Ponderosa Pine – Douglas-fir stand within the Upper Monument Creek project area. The stand is 28 acres in size and is a high priority candidate for restoration based on its proximity to Woodland Park, access and feasibility, and because it is embedded within a matrix of high-density Dry Mixed-Conifer and Mesic Mixed-Conifer forest and thus represents opportunity for introducing larger-scale heterogeneity and breaking up the continuous canopy condition that is currently present.

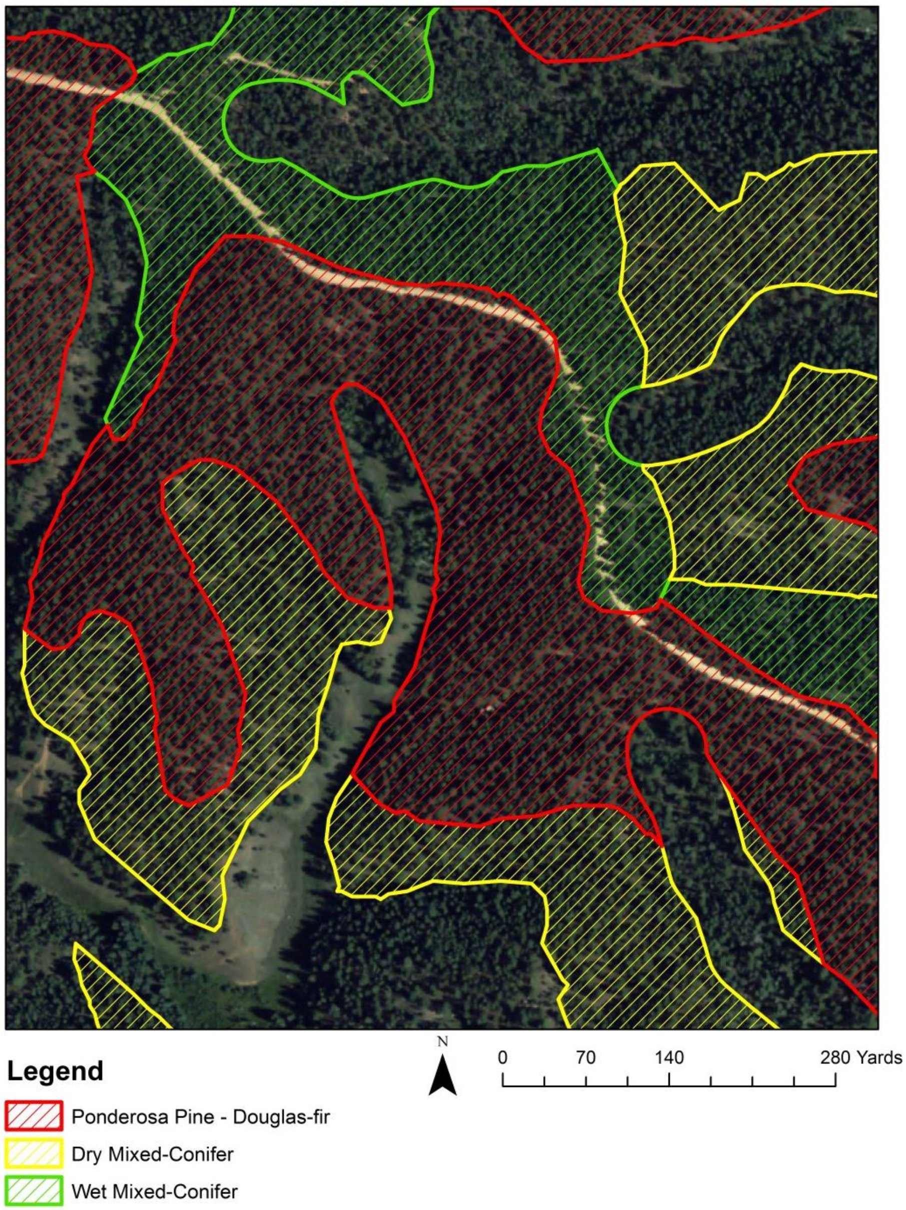

Figure 1b. Example treatment delineations showing enhancement of the existing opening within the stand, followed by identification of suitable areas for the low-density stand matrix along ridge tops and grading down slope along south-facing slopes. High-density areas are delineated along northerly slopes and small, somewhat sheltered drainages. The remainder of the stand represents a medium density matrix.

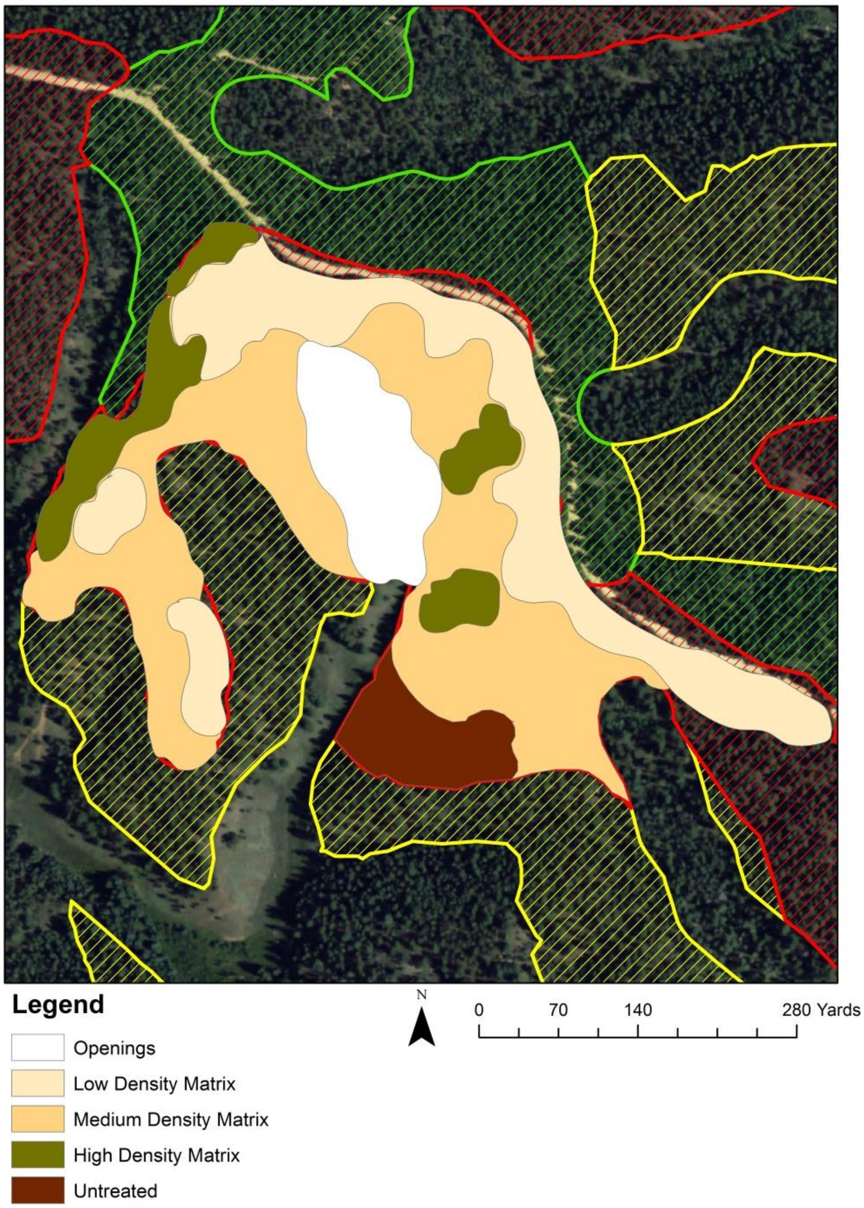

Figure 2a. Hypothetical pre-treatment condition depicting high density, fairly uniform forest conditions characteristic of much of the Upper Monument Creek area today. Historical Ponderosa Pine – Douglas-fir woodlands existed on the south-facing slope and graded into Dry Mixed-Conifer forests toward the slope bottom and Mesic Mixed-Conifer on the north-facing slope.

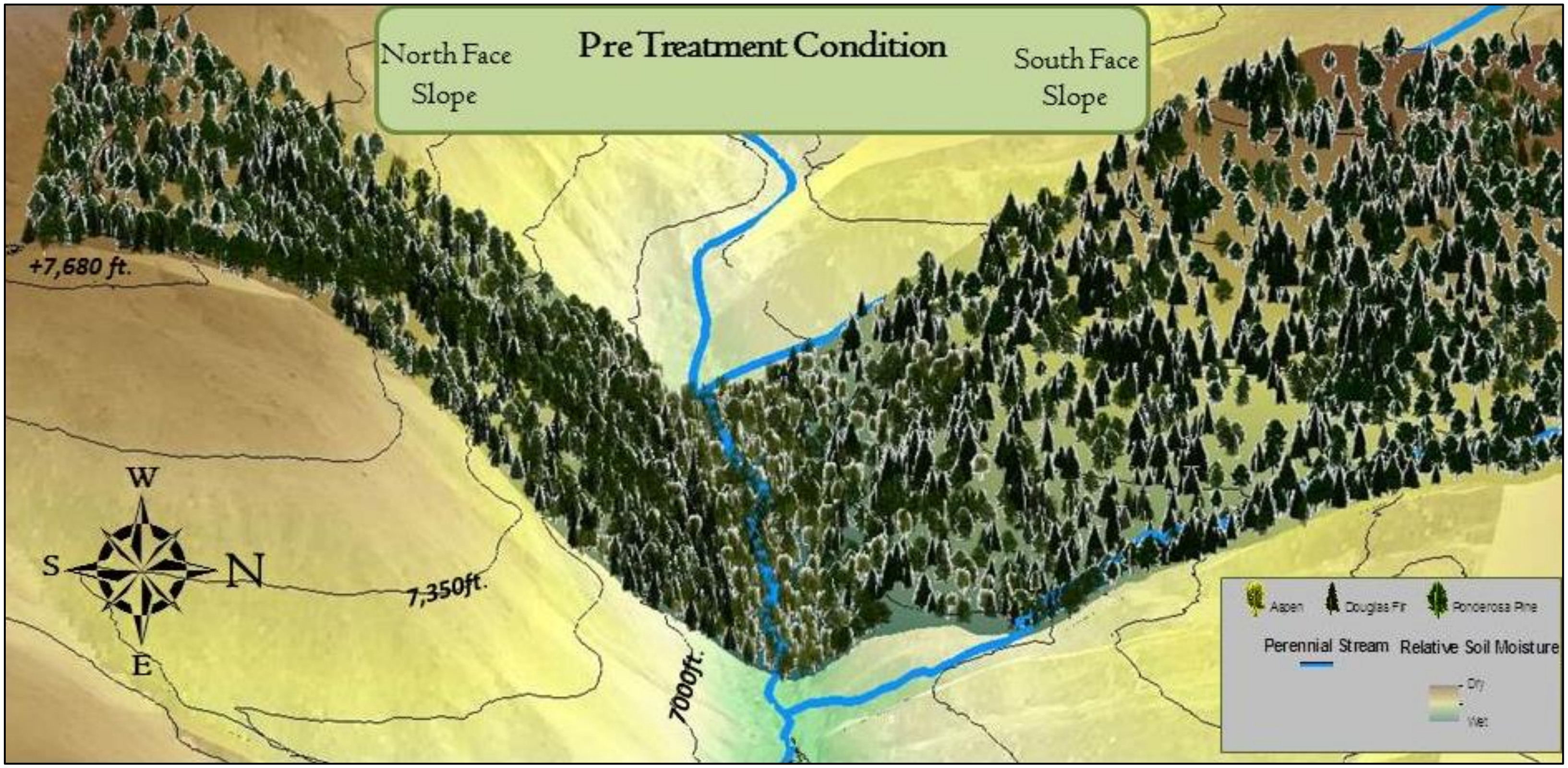

Figure 2b. Hypothetical post-treatment condition. The Ponderosa Pine Douglas-fir woodland on the south-facing slope was prioritized for treatment following design criteria that specified an overall reduction in density, with emphasis on restoration of spatial structure and enhancement of tree groups, scattered individual trees, and openings. A range of BA is present on the upper slope and density gradually increases moving down slope toward the slope bottom. Ponderosa pine and aspen were preferentially retained, whereas Douglas-fir was targeted for removal. The north-facing Mesic Mixed-Conifer forest was not treated in this case, but may have been a candidate for treatment had the south-facing slope contained valuable ecological features such as old-growth.

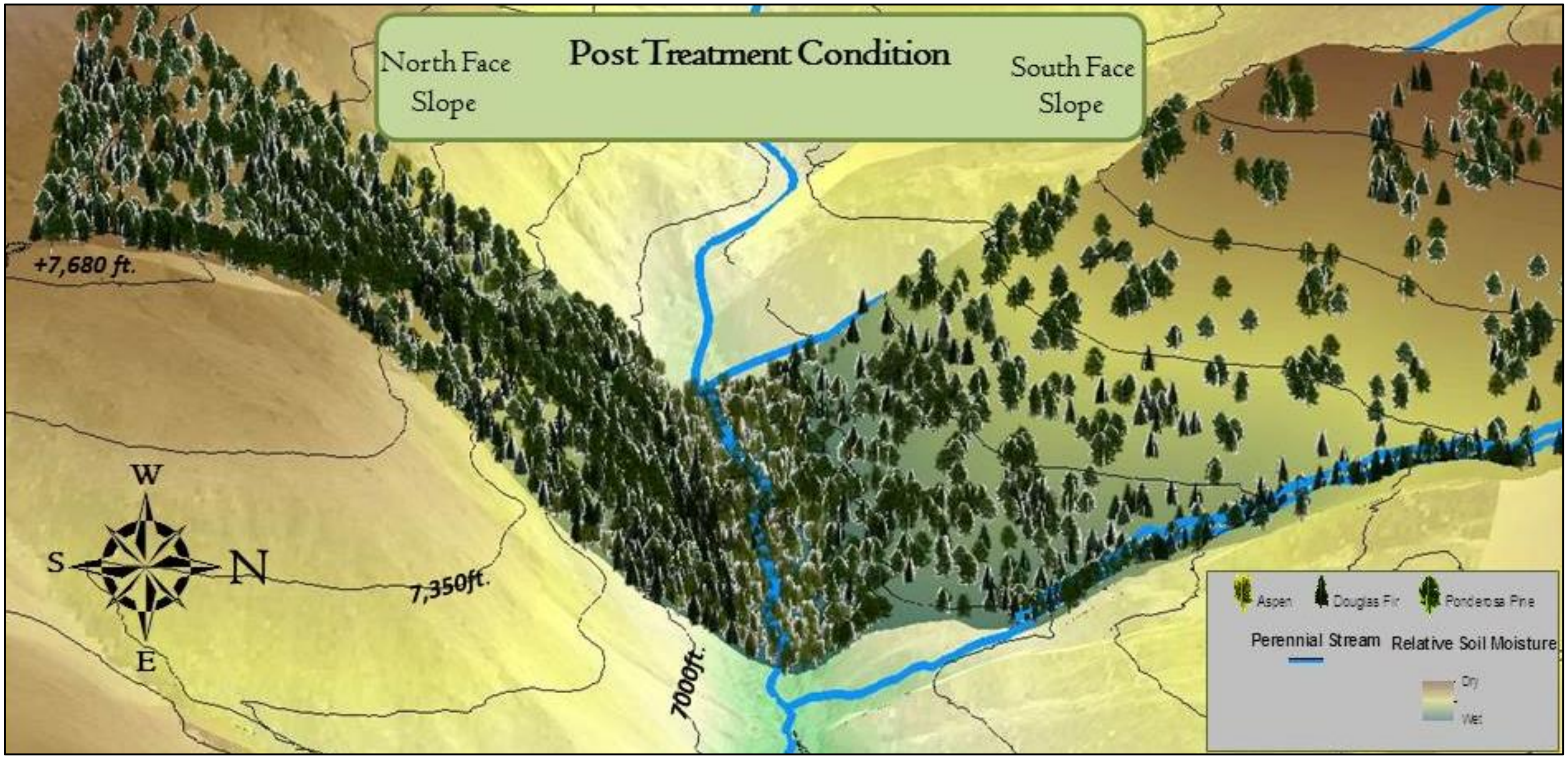

Table 3. Design criteria for the Dry Mixed-Conifer ecological system.

Biophysical Setting: *Dry Mixed-Conifer Forest*

General Design Criteria: Treatment within the dry mixed-conifer ecological system will be similar overall to those for ponderosa pine – Douglas-fir woodlands in that they should be focused on reducing densities and enhancing spatial structure. Higher overall densities and a higher proportion of Douglas-fir and other conifers such as limber pine should be allowed. Overall basal area (BA) should range from 40 to 60 ft^2 per acre and should be distributed according to site variability in productivity. An uneven-aged stand structure is appropriate as are small even-aged pockets. Retain old trees (> 200 years), as well as snags, coarse woody debris, and wildlife structures.

Structural Feature	Residual BA	Treatment Area (%)	Description
Openings	0-20	10-20	Enhance existing openings and create new openings ranging in size from 1 to 20 acres. Similar to ponderosa pine – Douglas-fir woodlands, suitable locations for openings may include low-productivity areas such as shallow soils and areas where disease or insect infestation is present. Higher productivity areas may be suitable as well to mimic 'blow-ups' that occur with mixed-severity fire and to create opportunities for regeneration and early-seral habitat structure. Some individual trees or small groups of trees may be present within openings, but at very low densities.
Low-density matrix	20-40	15-25	A low-density matrix should be established where a high ponderosa pine component (as much as 50%) is present. These areas may have been ponderosa pine – Douglas-fir woodlands prior to fire exclusion and conversion back to this woodland structure may be appropriate here. Tree groups, individual scattered trees, and openings should all be present. Approximately 50-70 percent of the trees here may occur in groups containing anywhere from 2 to 10+ trees, but most often containing 2-4 trees. The remaining 30-50 percent of trees may occur as scattered, individuals. Tree groups should be separated from one another by at least 1 to 1.5 tree lengths. Openings ranging in size from 0.1 to 2.0 acres (with a median about 1 acre) should be present.
Medium-density matrix	40-60	20-30	A medium-density matrix should be established in areas of intermediate productivity, with emphasis still on restoring spatial structure. More trees will occur in groups (70-90%) at this density and group size is larger, typically 5-9 trees per group. Mixed species groups are appropriate. Ponderosa pine, Douglas-fir, limber pine, and aspen may all occur. Avoid groups of pure Douglas-fir as the potential for ladder fuels to develop beneath the group may be high here. Openings should be present and still range in size from 0.1 to 2.0 acres, but with a lower median of around 0.75 acres.
High-density matrix	60-80+	25-35	Establish or retain a high-density matrix in higher-productivity areas such as north-facing slopes. Most (90 percent or more) trees may occur in groups here, with groups containing a large proportion of Douglas-fir. Blue spruce may be present here as well. Openings may be created here to mimic small-scale blow-ups that may occur with mixed-severity fire.
Untreated areas	--	5-10	Untreated "reserves" may represent unique ecological or cultural areas within the treatment footprint that are not large enough in scale to be mapped as separate stands; they likely range in size from 0.25 to 5 acres with a median of around 2 acres.

Photo 1. Photograph taken by John Jack of an area on the present-day Pike National Forest "never visited by lumbermen" (Jack 1900), illustrating the open nature of ponderosa pine stands and a diverse stand structure. Also pictured are snags, coarse woody debris, and an herbaceous understory. Jack described such forests as "generally open and may be traversed by wagon or on horseback, and it is only on comparatively limited areas that any close or dense growth of trees is encountered. In young growths of lodgepole pine only are there what might be called thickets, and occasionally a dense growth of small red fir and its accompanying species is found on some locally favored northern slope."

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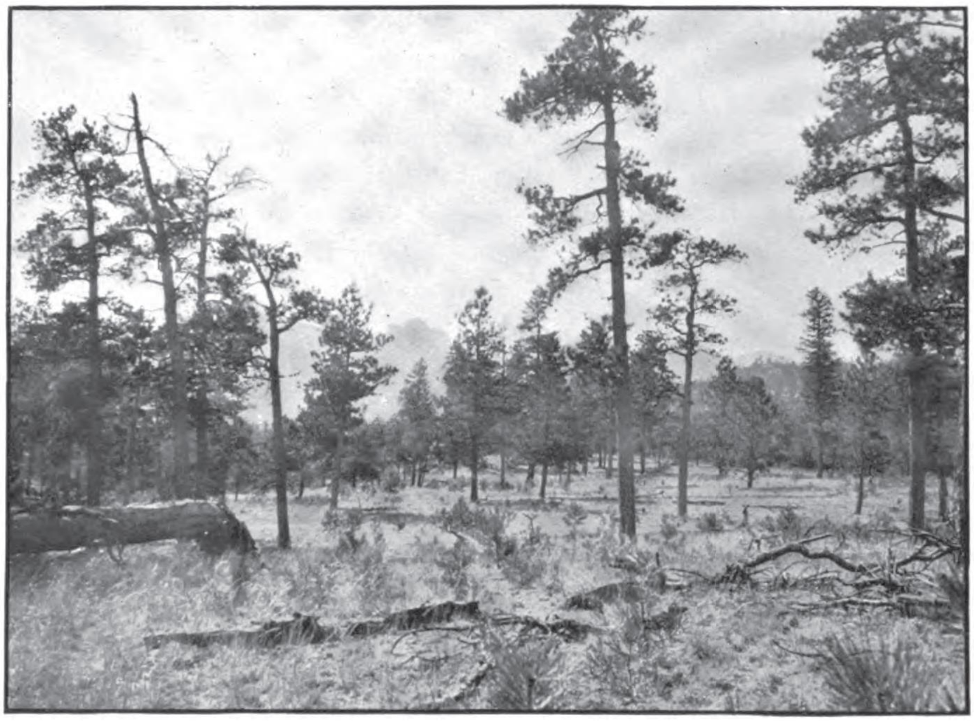

A. VIEW NORTH OF LOST PARK CREEK, 4 OR 5 MILES FROM ITS MOUTH.

Characteristic growth of yellow pine and Douglas spruce on considerable areas never visited by lumbermen, but subjected to surface fires at various times.

Photo 2. Ponderosa pine – Douglas-fir woodland within the Webster Park area north of the Upper Monument Creek landscape depicting an overall open stand condition, with tree groups, scattered individual trees, and small-scale openings.

Photo: Peter Brown

Photo 3. Openings within ponderosa pine – Douglas-fir woodlands reduce the potential for widespread crown fire and provide opportunity for understory vegetation development and wildlife benefit. Openings were a common feature on the historical Upper Monument Creek landscape that have disappeared over time due to tree encroachment and lack of surface fire. Young trees are visible on periphery of the opening below.

Photo: Peter Brown

Photo 4. Fire-scarred ponderosa pine are present throughout ponderosa pine – Douglas-fir woodlands and dry mixed-conifer forests of the Upper Monument Creek landscape, indicative of frequent historical fire.

Photo: Rob Addington

Photo 5. Snags provide structural diversity and wildlife benefit and should be retained where they do not represent hazards.

Photo: Rob Addington

Photo 6. Patches of aspen should be enhanced by clearing young conifers in the vicinity.

Photo: Peter Brown

Photo 7. Dry mixed-conifer stand exhibiting a relatively open condition with a diverse suite of species.

Photo: Peter Brown

Photo 8. Evidence of past harvesting believed to have occurred in the late 1800s and early 1900s is present throughout the Upper Monument Creek landscape. Stumps such as this show that large, old trees were historically present on the landscape.

Photo: Rob Addington

Photo 9. Late-seral (S-class E) lodgepole pine stand within the project area illustrating a diverse stand composition and structure. These stands should be protected by treating adjacent areas that may pose a wildfire hazard.

Photo: Rob Addington

Table 4. Members and organizations represented on the Upper Monument Creek design criteria sub team.

Core Team Member	**Organization**
Rob Addington	Colorado Forest Restoration Institute, Colorado State University
Greg Aplet	The Wilderness Society
Mike Babler	The Nature Conservancy
Mike Battaglia	U.S. Forest Service, Rocky Mountain Research Station
Ed Biery	U.S. Forest Service, Pike-San Isabel
Peter Brown	Rocky Mountain Tree Ring Research
Casey Cooley	Colorado Parks and Wildlife
Yvette Dickinson	Colorado Forest Restoration Institute, Colorado State University
Jonas Feinstein	Natural Resources Conservation Service
Paige Lewis	The Nature Conservancy
Pam Motley	West Range Reclamation
Jeff Underhill	U.S. Forest Service, Pike-San Isabel
Diane Strohm	U.S. Fish and Wildlife Service, Air Force Academy
Advisory Member	**Organization**
Jonathan Bruno	Coalition for the Upper South Platte
Tony Cheng	Colorado Forest Restoration Institute, Colorado State University
Eric Howell	Colorado Springs Utilities
Sara Mayben	U.S. Forest Service, Pike-San Isabel
Jim Thinnes	U.S. Forest Service, Regional Office

Table 5. Dates, locations, and intent of meetings and field trips held by the Upper Monument Creek design criteria sub team as part of the design criteria development process.

Date (2013)	**Location**	**Intent**
May 15-16	Colorado Springs, CO	Team formation and kickoff discussion during the May workshop of the larger Upper Monument Creek Collaborative
May 23	Lakewood, CO	Meeting to discuss design criteria for the ponderosa pine – Douglas-fir ecological system
June 7	Lakewood, CO	Meeting to review design criteria for the ponderosa pine – Douglas-fir ecological system
June 13	Pike National Forest	Field trip to further refine and validate design criteria for ponderosa pine – Douglas-fir ecosystem system and begin discussions for other ecological systems
June 20	Lakewood, CO	Meeting to discuss design criteria for the dry mixed-conifer and mesic mixed-conifer ecological systems
June 26-27	Monument, CO	Presentation and discussion of results to the larger Upper Monument Creek Collaborative
July 8	Pike National Forest	Field trip to evaluate the lodgepole pine ecological system
July 23-24	Monument, CO	Field trip and further discussion of the mesic-mixed conifer, lodgepole pine, and Gambel oak ecological systems during the July workshop of the larger Upper Monument Creek Collaborative
Aug 8	Monument, CO	Meeting to review design criteria for the lodgepole pine ecological system
Sep 6	--	Final webinar to review design criteria across ecological systems prior to incorporation into the final report