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

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Introduction

This report, written in Spring 2012, focuses on a rapid assessment of the ecology and fire science for mixed conifer forests in the southern Front Range -- more specifically the science applicable to the Upper Fountain Creek watershed in the Pikes Peak area west of Colorado Springs, CO. A portion of this watershed is the subject of imminent work on mixed conifer management (both restoration and fuel hazard mitigation) on private and other non-federal lands in the vicinity of the Pike National Forest. The work is funded through a national partnership between the U.S. Forest Service and The Nature Conservancy known as *Scaling Up to Promote Ecosystem Resilience (SPER).* The intent of the funding is to demonstrate the value of implementing forest restoration on non-federal lands that complement planned treatments on federal land. The Upper Fountain Creek watershed project is designed to complement future projects that will be implemented in the Catamount planning area by the Pike National Forest as part of the Front Range Collaborative Forest Landscape Restoration Project (CFLRP). The southern Front Range is also within the jurisdiction of the Southern Rockies Fire Science Network (SRFSN), which is sponsoring this writing effort.

This rapid assessment report is written to assist resource planners and implementers with sufficient preliminary scientific guidelines to assure that initial treatments are within reasonable ecological guidelines as identified by the scientific community. We do not list source publications, but our findings are based upon extensive knowledge and experience of the participants in the ecology and fire science of forests in the Front Range area, including mixed conifer. This report is the first step of two that address mixed conifer forests in the newly expanded SRFSN, which includes Colorado, eastern Utah, southern Wyoming, and the Black Hills. The second step of our mixed conifer assessment will be a more comprehensive examination of mixed conifer ecology and fire science for the SRFSN. We expect that findings included in this first report will be integrated into the more thorough assessment.

Background

Mixed conifer forests occur throughout the West. These forests occur at middle elevations and are the transition zone between lower-elevation montane forests dominated in the southern Rockies and Southwest by ponderosa pine, and upper-elevation subalpine forests dominated by spruce and fir, lodgepole pine, or five-needled pines in this same region. The term “mixed” derives from the often lengthy list of tree species typically found in a complex mosaic of distribution in this vegetation zone, which precludes most areas being classified using conventional forest types. Disturbance regimes tend to be mixed in their intensity and extent of their effects, enhancing landscape complexity. In the Pikes Peak area, mixed conifer forests include ponderosa pine, Douglas-fir, Engelmann spruce, Colorado blue spruce, white fir, subalpine fir, limber pine, and aspen. The area not only has elevational gradients in vegetation, but also represents a latitudinal blending of more northerly mixed conifer commonly having lodgepole and limber pine with more southerly forests having white fir and bristlecone pine. A more detailed description of mixed conifer forests and differences across the SRFSN will be included in the lengthier ecology and fire science assessment.

In a February 2012 meeting, scientists and managers (listed above) met to discuss the status of existing scientific knowledge to guide imminent management activities in the Upper Fountain Creek watershed. Management issues here are similar to those elsewhere in mixed conifer and in other vegetation zones, especially at lower elevations. First, are restoration treatments needed in these forests to assure healthy ecosystem conditions in the years ahead? And second, how should hazardous fuels be managed to protect human and ecological values at risk?

The primary goal of this meeting was to assess how presently available scientific knowledge could guide initial treatment planning and implementation where restoration or hazardous fuel management concerns exist. Historical natural disturbance and landscape structure patterns inform us of the range of conditions and processes that comprise sustainable mixed conifer landscapes. Historical information is particularly valuable for assessing the degree of departure of current mixed conifer conditions from the historical conditions. Historical conditions may or may not provide a template for today's forest management, however. While fuel hazard management and restoration treatments may use historical conditions as a guide, potential effects of climate change, or uncertainty about what those changes may entail, may also impact the degree to which historical conditions may apply or the elevations for which recommendations are appropriate. However, historical conditions, even those that evolved during the Little Ice Age, were the product of processes that engendered ecosystem persistence for long periods of time including climatic fluctuations, i.e. sustainability. Furthermore, local considerations stemming from socio-economic constraints may steer actions in a somewhat different direction and preclude bona fide restoration in some cases. The group outlined and reviewed several topics focused on understanding mixed conifer ecology:

- Presettlement natural disturbances (historical natural disturbance effects on mixed conifer forest structure, composition, and processes)
- Post-settlement vegetation response to past management actions (and potential current management concerns)
- Vegetation legacy effects (carryover successional effects of long-term vegetation shifts)
- Landscape dynamics
- Climate change and potential impacts on ecology and stand successional trajectories

Patterns of species distribution in Front Range forests depend largely on elevation and aspect, which affect species site suitability through temperature and moisture regimes. Environmental conditions in the Upper Fountain Creek watershed are suitable for the occurrence and persistence of the mixed conifer species listed above. While environmental conditions typically vary as a continuum over space and time, it is useful to consider two general types of forest conditions and related behavior in the mixed conifer zone. *Dry mixed conifer* forests are those found typically on more exposed south-facing slopes where radiation load and temperatures tend to deplete moisture readily. Ponderosa pine, limber pine, and Douglas-fir, prominent species at slightly lower elevations, are commonly found in dry mixed conifer forests. *Wet mixed conifer* forests are found typically on north-facing slopes and in deep drainages protected from high solar radiation loads, and where cooler temperatures and more moist soil and canopy conditions prevail. Spruce and fir species, more prominent at higher elevations, are more common in wet mixed conifer forests. The temperature and moisture differences affect stand structure and composition of dry and wet mixed conifer forests, and they greatly affect natural disturbance occurrences and outcomes.

Mixed conifer forests are especially patchy, however, more so than expected from temperature and moisture regimes alone. Local variations in soils may contribute to local patch variability, but most local patchiness stems from varying patterns of natural disturbances over space and time. Fire, insects, and diseases as well as drought and wind affect tree mortality, forest regeneration, and growth rates; and the size, intensity, and duration of these disturbances as well as species responses have strong effects on overall patch characteristics of the forest landscape. In the sections below, we compare and contrast natural disturbance processes and effects in dry and wet mixed conifer forests.

Key Pre-settlement Natural Disturbances of the Southern Front Range of Colorado

Some of the features of historical natural disturbances in the southern Front Range are summarized below. These descriptions are based upon research data gathered locally where available and upon interpretation by scientists based upon research efforts in the broader Front Range area as appropriate. Historical data are most readily available for fire, as past fires left many fire-scarred trees, remnant wood, and stand age structures for study. Insect, disease, and physical disturbances generally leave little legacy material for study of landscapes prior to the 20th century, and historical patterns are projected primarily based on knowledge of these disturbances from records after Euro-American settlement in the mid to late 19th century. Nonetheless, our insights into fire and other disturbances can be used with rather high confidence, given the large body of scientific literature on natural disturbances that has been developed locally and throughout the interior West in recent decades.

Prior to settlement, fire and insect/disease outbreaks are believed to have been the primary natural disturbance drivers affecting mixed conifer landscapes and changes in patch structure over time. Wind and other disturbances may have been important locally or occasionally, but generally had smaller, less frequent, or less severe impacts on patch characteristics. The effects of periodic drought were likely to have affected tree growth rates, vulnerability to insect attack, and regeneration success, thereby having both spatially broad and more localized impacts. All types of natural disturbance, however, likely impacted patch structure and resulted in a landscape mosaic of constantly shifting patch dimensions and composition. Even small-scale changes could have contributed to the natural variability among patches constituting the landscape. Furthermore, the range of outcomes stemming from multiple possible disturbances, including variation in their size, intensity, and frequency, would have resulted in such a wide range of outcomes that nearly any resultant patch structure or change is possible in the natural landscape. Local topography is highly variable, and local proximity of dry and wet mixed conifer stands undoubtedly amplified interactions in disturbance patterns in the landscape. In fact, the least likely outcome is uniformity among patches at a landscape scale.

<u>Dry mixed conifer</u>

Fire. Historically, most fires in dry mixed conifer forests were surface fires that burned grasses and shrubs but usually did not result in mortality of dominant trees. Torching (passive crown fire) of individual trees or crown fires in small patches likely occurred. Fire frequency was typically 15-25 years between fires at a watershed scale, but only portions of the larger landscape burned in each fire. Patches of crown fire may have occurred where fuel ladders had developed, but crown fire patches ranged from very small to moderate in size (less than one acre to 100 acres or more). During regional droughts, fires were more intense and widespread.

Insects and disease. The historical frequency, size, and intensity of insects and disease outbreaks are fairly hard to document. Unlike fire, insect and disease disturbances leave little residual evidence a century or more after events occur. Nonetheless, we believe that mountain pine beetle activity was likely a factor in stands containing ponderosa pine either as a dominant species or lesser component. While mountain pine beetle activity likely occurred in lodgepole pine as well, lodgepole is uncommon in the Upper Fountain Creek area of the southern Front Range. Mountain pine beetle endemic populations result in distributed small patches of mortality. They typically occur during the 15-20 year interval commonly observed between more severe outbreaks that result in more extensive tree mortality. Such patterns likely occurred prior to Euro-American settlement. Dwarf mistletoe and Douglas-fir beetle most likely also occurred, though to a lesser extent than mountain pine beetle. For these biotic disturbances, patches were probably no larger than 10 acres, though larger patches of insect outbreaks could eventually coalesce and may reach epidemic levels across the landscape. Periodic fire may have limited the size of patches and intensity of infection with dwarf mistletoe compared with recent mistletoe patch size, but most certainly mistletoe was present historically.

Drought. Because these forests by nature were fairly dry (esp. south aspects), tree mortality from drought was relatively rare. However, periodic regional drought tended to be severe and did affect historical fire frequency, size, and intensity over large areas. Drought may have also intensified the effects of biotic disturbances, synchronizing them in time, and spatially broadening disturbance effects across large areas. In addition to drought, in some years wetter than normal growing conditions may have contributed to higher understory productivity and enhanced subsequent fire spread during dry seasons.

Blowdown / Windthrow / Snow Breakage. Significant wind events associated with weather fronts or microbursts can blow down a large number of trees, though such events are uncommon and unpredictable. When they occur where Douglas-fir is present, they may result in elevated populations of Douglas-fir beetle that extend beyond the blowdown area. Windthrow of individual trees occurs when overstory trees are uprooted. Overstory trees on drier mixed conifer sites tend to be more open grown than trees on wetter sites. Thus they are regularly exposed to greater physical stresses of wind on individual tree crowns than occur in more closed forest canopies. Furthermore, they tend to have hardier root systems and shorter stems, making them less prone to windthrow. Snow breakage may occur when heavy snow accumulations, perhaps aided by wind, result in excessive stress on tree boles. Again, snow breakage is usually not extensive especially in drier forests having stronger trees, and it is fairly unpredictable. On balance, these physical disturbances historically were probably limited to relatively small numbers of trees, though they may have accounted for occasional insect outbreaks.

<u>Wet mixed conifer</u>

Fire. Wet mixed conifer forests accumulate more surface fuels and fuel ladders over time than dry forests, and they tend to have greater overstory canopy cover and crown bulk densities. Historically, high fuel moisture in these forests would have limited fire occurrence to a frequency of typically 30-60 years, usually during dry periods. Surface fires did occur in mesic sites, but because conditions suitable for fire spread occurred during drought, fires tended to be more intense and widespread than those in dry mixed conifer. Mixed severity fires with stand-replacing components were common in wet mixed conifer forests. Because fires occurred during periods of drought, which were conducive to fire spread, they may also have been larger (100 acres or more) than the more frequent surface fires and especially the stand-replacing component in dry mixed conifer.

Insects and disease. Douglas-fir beetle and western spruce budworm were probably the more important insect disturbances in wet mixed conifer forests because of the greater prevalence of Douglas-fir and white fir. Mountain pine beetle had less widespread effect than in dry forests. Western spruce budworm outbreaks would have tended to focus on small white fir and Douglas-fir trees, with attacks occurring every 15-60 years, and tree-ring based reconstructions suggest that some outbreaks may have covered fairly extensive areas (watersheds to whole mountain ranges). Douglas-fir beetle outbreaks probably occurred with a frequency of 15-20 years, often affecting bigger trees, and tending to follow western spruce budworm. Outbreaks most likely occurred in patches less than 10 acres in size, though small patches may have coalesced into larger ones.

Drought. Drought conditions in wet mixed conifer forests may lower fuel moisture enough that the probability of fire ignition and spread is increased significantly, particularly in severe drought years. Furthermore, drought may weaken tree resistance to insect attack (especially mountain pine beetle), enhancing the likelihood of outbreaks and synchronizing their effects over large areas. Thus drought may be correlated with larger scale disturbance and larger resulting patches.

Blowdown / Windthrow / Snow Breakage. Wetter forests generally have denser canopies and shallower root systems than found in drier forests. Spruce and subalpine fir tend to be shallow rooted and more susceptible to blow down and wind throw than ponderosa pine, while Douglas-fir and white fir are in between. Blowdown was probably more common where dense canopies lost individual trees to insect damage, thereby allowing wind currents to penetrate the canopy and increase stress on residual trees. Windthrow of individual trees more commonly occurs on wetter sites where trees are not as deeply rooted, and after Euro-American settlement may have become more extensive following forest thinning practices that open up the canopy to wind penetration. Stem breakage under heavy snow load may have created small patches where canopies of Douglas-fir collapsed, but the effect was probably local and not very significant in landscapes except in unusual cases. However, historical data for these physical disturbances are nearly non-existent.

Key Post-settlement Disturbances and Management Concerns in the Southern Front Range of Colorado

In the Front Range and throughout the interior West, Euro-American settlement brought about changes in forests and landscapes, particularly through logging, grazing, and increased fire ignitions followed by decades of fire suppression. These effects were extensive in lower elevation ponderosa pine/Douglas-fir forests that were more accessible throughout the year, and where fires historically were a prominent feature governing the forest landscape. But mining and other activities also may have affected mixed conifer forests in the Pikes Peak area. Some forests were logged, grazed, or otherwise impacted later than others depending on their topography and distance to markets. A few have even escaped logging, but all have been affected by fire suppression policies and reduced fine fuel due to grazing for much of the last century.

Several observations can be made about mixed conifer forests subjected to human influence in the southern Front Range.

- Any natural disturbance event or human impact affecting overstory structure elicits a change in patch characteristics, but the actual successional or stand development pathway depends upon multiple factors. These include the species mix at the time of disturbance, the intensity and frequency of disturbances, the presence of residual trees of any size existing after the disturbance, seed sources for regeneration into forest gaps or openings, and seedbed and post-germination conditions that affect seedling establishment and survival. Significant differences between moist and dry sites are common.
- While ponderosa pine seed production tends to be episodic with many years between good seed crops, other conifer species produce seeds far more regularly. Thus tree reproduction

depends specifically on the seeds and establishment conditions available after an area becomes suitable for regeneration.

- Even a small amount of aspen may exhibit a strong sprouting response after a disturbance. Thus natural and human disturbances may result in an increase in aspen patches and stands. However, grazing by elk, deer, and cattle may impact sprout growth enough to severely limit the successful establishment of new aspen groves. Aspen reestablishment after various treatments may be viewed as a positive step toward restoration, as aspen was a prominent species in historical mixed conifer forests. Furthermore, aspen serves as an effective barrier for fire spread where important natural or human resource values are at risk.

Several outcomes after human-caused or natural disturbance would be viewed as unacceptable or undesired.

- Conditions that result in a single species or uniform patch and stand characteristics over large areas (spatial homogeneity) could support a massive insect outbreak. Examples might include extensive stands of maturing ponderosa pine or lodgepole pine (the latter not common in the southern Front Range) susceptible to mountain pine beetles. At present, a mountain pine beetle outbreak in the northern Front Range is mainly concentrated in the lodgepole pine found in mixed-conifer forests, but the potential for spread to the south exists, and this may become an important management consideration in coming years.
- Similarly, extensive uniform stands having closed canopies and limited age and size class variability (temporal homogeneity) may be more vulnerable to uncharacteristically large crown fires. Openings and variable density stands return potential landscape fire behavior away from active crown fires, and toward the historical range of variability of surface fires with patches (up to 100-200 acres or so in size) of passive or active crown fires.
- A lack of diversity in patch size, species composition, density, and age structure (e.g. landscape homogeneity stemming from spatial and temporal homogeneity) would be inconsistent with historical ecological features, and such forests would be suitable for restoration that re-creates patch diversity.
- Extensive areas lacking regeneration or vulnerable to soil erosion or invasion by exotic overstory or understory plant species are undesirable and would also be viable candidate areas for restoration. Such areas are uncommon in mixed conifer forests, however.
- Any conditions that threaten loss of viability of keystone species or species of concern generally should be avoided. While studies of ecosystem function have illustrated that some negative effects of certain restoration activities on individual species may occur in the short run, there also may be benefits to keystone species or species of concern, and restoration of habitat may enhance populations of such species in the long term. Consistent and thorough monitoring and careful evaluation of potential treatments should be done by biologists and the research community to assure that management activities reflect the best knowledge available at the time.
- Invasive species often threaten biodiversity and divert vegetation responses from intended, and ecologically desirable, trajectories.
- Some management outcomes could result in impacts to aesthetic and resource values (including viewsheds, timber and other outputs, and recreational opportunities) that threaten public acceptance and safety.
- Lack of an understanding and implementation of adaptive management practices that include the full suite of planning, action, monitoring, and improvement through evaluation could lead to repetition of undesired management techniques and poor ecological or management outcomes.

Planning for Desirable Future Outcomes in Mixed Conifer Forests of the Southern Front Range of Colorado and the Role of Monitoring

Climate and climate change

Most evidence from research and modeling indicates that climate change is already having significant effects on forests throughout the West, and these are likely to intensify with time. We expect that climate change will produce profound effects on mixed conifer forests in the Front Range in the foreseeable future, including changes in disturbance regimes such as large fires and insect outbreaks. Recent modeling studies of forest distribution for individual species suggests dramatic changes in site environmental conditions, with temperature and moisture conditions favoring species movement to higher elevations and more northerly latitudes. There is usually a lag between changes in conditions and species migration; mature vegetation can persist in a less than optimum climate, but following a stand-replacing disturbance, regeneration will favor species better suited to current conditions if seed sources are available. The heterogeneous nature of mixed conifer landscapes enables such adaptation.

We note that these modeling efforts are not definitive; they are projections, not observations, and only suggest trends in species and ecosystem responses. Nonetheless, there is a far greater likelihood that species shifts will be toward higher elevations, not lower. This could have significant implications for management focused on fuel hazard mitigation and forest restoration, including treatment placement in relation to elevation. Inventories and monitoring of forest conditions now and into the future are valuable tools for managers to decide when and where climate changes may be driving ecosystem responses, and how management actions such as ecological restoration or fuel management might reflect those changes.

Contingency plans for reaching desired outcomes

Restoration of spatial, temporal and landscape heterogeneity of mixed conifer forests in the southern Front Range and mitigation of hazardous fuels can be accomplished (often simultaneously) with careful design, implementation, and sequencing of treatments, even where our scientific understanding is less than complete. Several initial guidelines seem reasonable, derived from the scientific knowledge available for the local treatment areas and the broader Front Range. More concrete and detailed plans can be completed as more knowledge and treatment experience are accumulated. It must be recognized that no one treatment or combination of treatments is likely to suffice. Patch uniformity across the landscape is to be avoided; rather, historical forests teach us that diversity of patches across the landscape is more the ecological norm and assures more resilience in the face of change. Furthermore, sustaining landscape diversity is a long-term process and may involve multiple management steps in the decades ahead.

Planning of forest management activities should be done in the context of the current condition of mixed conifer forests at a landscape scale (e.g. large watershed), and based upon a recognition of ecological shortcomings such as landscape homogeneity that presently exist. The following conditions or processes deserve attention:

- Some components of mixed conifer forests in the southern Front Range are under-represented in the landscape (such as aspen and open ponderosa pine-dominated stands), and some are over-represented (dense young stands, white fir). Fires have been suppressed, and fire should be reintroduced as a keystone process that helps shape patches and patch dynamics in the mixed conifer landscape. Both surface and mixed severity fire are desirable, but dense forest conditions often preclude the use of mixed severity fire, thus surrogate thinning to modify forest structure along with the use of surface fire should be considered.

- Efficient treatments are those that take advantage of current patch diversity where it exists and of any past treatments that work in the direction of restored ecological condition of the landscape.
- Potential climate change effects on patch dynamics, particularly involving species distribution, should be assessed and incorporated into treatment planning as appropriate (i.e., favor species better adapted to warmer and drier conditions, such as ponderosa pine). Thought should be given to the relative benefits and desired outcomes of restoration activities at the lower ecotone of a species compared with the upper ecotone, given that climate modeling suggests movement of ecotones toward higher elevations.

The following general guidelines may be followed as early treatment goals, recognizing that long-term planning may refine these guidelines as better scientific understanding falls into place.

- Basic monitoring protocols should be selected and implemented at the outset, to assure that adaptive management practices incorporating new knowledge can be followed. It is essential that monitoring begin before treatments are implemented, to assure that treatment effects can be evaluated properly.
- Restoration treatments can often be crafted to meet ecological restoration goals while also mitigating fuel hazards and mitigating potential mortality levels from bark beetle outbreaks.
- Fuel mitigation treatments do not all have to meet restoration goals provided that ecological restoration is accomplished in nearby parts of the landscape.
- Large area prescriptions employing a single overstory template of species composition, age structure, and density are *not* okay and should be avoided.
- More aspen in the landscape is desired.
- More ponderosa pine in the landscape is desired.
- Variable age structure among and in some cases within patches is desirable.
- Variable tree densities, including stands with few or no trees, are desired.
- More and larger openings and meadows are okay.
- Older trees should be preserved to restore their role as components of the landscape.
- Attention should be given to rare species or habitats.
- Attention also should be given to potential exotic species that threaten natural species diversity and ecological function of the landscape.
- Fire and its natural effects should be restored wherever possible.
- Mechanical treatments (including thinning) may be needed as a surrogate for fuel removal by fire if fire can't be used, or if needed as a precursor to safe fire use. Mechanical treatments alone may not be sufficient for ecological restoration of mixed conifer forests.
- Residual coarse woody debris left on the forest floor after treatments may be acceptable, but excessive amounts may be inconsistent with a good ecological outcome and may lead to unintended consequences such as severe fire or insect outbreaks.

<u>Enhanced planning for ecological restoration and fuel hazard mitigation</u>

The material presented above will serve as an adequate interim basis for the early stages of management of mixed conifer forests in the southern Front Range. Better documentation and more research will be needed to serve as an adequate knowledge base for restoration activities as treatment areas expand and extend to larger portions of the mixed conifer landscape. As noted at the beginning, preparation of this document is the first of two steps. We intend to complete the second step in the near future when a more detailed document will be prepared. This document will focus on a more complete understanding of our knowledge of mixed conifer ecology and fire science in the broader southern Rocky Mountain area while providing guidance for restoration activities to land managers.