Front Range Roundtable
Collaborative Forest Landscape Restoration Project
2011 Ecological, Social and Economic Monitoring Plan

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Chapter 1. Introduction

In 2010 the Arapaho and Roosevelt National Forests (AR) and the Pike and San Isabel National Forests (PSI) worked together with the Colorado forest collaborative effort Front Range Roundtable to prepare a proposal for consideration under the Collaborative Forest Landscape Restoration Act (see http://www.frontrangeroundtable.org/ for original proposal and maps). This Collaborative Forest Landscape Restoration Project (CFLRP) proposed to treat approximately 34,000 acres of lower montane lower montane(*Pinus ponderosa*) forest on National Forest System lands. These acres had been identified as high priority by the collaborative because of their location within Colorado's Front Range Wildland Urban Interface (WUI), and within a zone of 800,000 acres that had been identified as being in need of restoration. The need for restoration was described as a function of the extent to which a stand was outside the natural range of variability that existed in the past, also known as historic range of variability or HRV (Landres, Morgan and Swanson, 1999). Around 70% of the acres in the CFLRP proposal was determined by the FRR to be outside HRV. Funding was granted to the AR and PSI to restore a portion of these acres using both mechanical methods and prescribed fire. One of the requirements under this funding is to conduct ecological, economic and social monitoring to record the benefits and lessons learned from these restoration efforts. Another criterium under CFLRA is that restoration efforts and monitoring are conducted using collaborative, multi-stakeholder methods. A subgroup of FRR, the Monitoring Working Group (MWG) was tasked with the creation of a CFLRP monitoring plan by Summer 2011. This document represents the first iteration of the Monitoring Plan, a living document, that resulted from these collaborative deliberations, to be revised by the FRR as monitoring data is evaluated and new information presents itself over the 10-15 year course of the CFLRP.

> **Natural Range of Variability:** *"The ecological conditions - and the spatial and temporal variations in these conditions - that were relatively unaffected by people, within a period of time and geographical area appropriate to an expressed goal". (Landres et al. 1999)*

This Monitoring Plan outlines the collaborative process used, the learning the group engaged in to agree on ecological, economic and social protocols and the protocols themselves. The protocols are where the rubber meets the road, for monitoring purposes, and have been created after intensive and lengthy collaborative research and deliberation. This plan therefore does not include an Executive Summary but instead the protocols have been formatted to be stand-alone sections that can be copied and used by monitoring teams in the field or other groups (pages 21-26). This Plan is the result of many individual and organizations' efforts who worked tirelessly as part of the MWG (see Appendix C). The collaborative process and integration of science into that process, as well as the compilation of this plan, was conducted by Jessica Clement and Peter Brown of the Colorado Forest Restoration Institute. Scientific support was also provided by a number of scientists who were part of the MWG and a panel of scientific experts who were consulted during the scientific discovery phase of this process. Gali Beh of Beh Consulting provided flawless logistical and organization support.

The Desired Conditions the group established, based on the original CFLRP proposal, and which determined the group's choice of variables to measure and protocols to use, are:

1. Establish a complex mosaic of forest density, size and age (at stand scales)
2. Establish a more favorable species composition favoring lower montaneover other conifers.
3. Establish a more characteristic fire regime
4. Increase coverage of native understory plant communities
5. Increase the occurrence of wildlife species that would be expected in a restored lower montane forest.
6. Establish a complex mosaic of forest density, size and age (at landscape scale)

These Desired Conditions are reflected in the Monitoring Protocols Table, Table 2.

1.1 Explicit Points of Uncertainty

The CFLRP is an endeavor that will take place over 10 years and the monitoring protocols take both this length of time and the large landscape scale into consideration. In this endeavour the group discovered and made explicit a number of points of uncertainty, which in turn helped inform the monitoring plan.

One of the uncertainties that the MWG had to embrace is the indeterminate amount of funding that will be available for treatments and monitoring from year to year. The group hopes that in due course additional monitoring funds will be found to compliment the USFS CFLRP funding. One way the group has addressed this uncertainty is to identify core or Tier 1 (see page 23) and Tier 2 (see page 27) variables to be measured. The core variables are measurements the group suggests should be conducted consistently at each CFLRP monitoring plot across both Forests and have been designed to fit within existing USFS Common Stand Exam data collection methods. Another uncertainty is the location and number of monitoring sites which is tied to a lack of precise information on where treatments will take place over the next ten years. These uncertainties could not be adequately resolved due to lack of time in which to gain the appropriate information for this first iteration of the Monitoring Plan.

At the time of writing this first draft, the social and economic monitoring protocols are in the final phases of deliberation. The MWG has identified collaboratively the variables they prefer to see measured in the 10-15 year lifetime of this CFLRP. Although ideas were presented for these methods, the final protocols are not yet determined. A meeting took place on June 13, 2011 in Colorado Springs where members of the MWG and other Front Range Roundtable stakeholders who represented communities and the business sector further discussed these variables. The outcome of this meeting was twofold: 1) a more industry and community oriented set of variables were agreed to based on the MWG’s preferences and 2) it was decided that Tony Cheng (CFRI) and Julie Schaefers (USFS Region 2) will convene another meeting late summer or early fall 2011 to determine the protocols to measure them.

Colorado's forests, similar to other forests nationally, are experiencing an immense bark beetle outbreak that first established itself in higher elevation forests but is now increasingly affecting lower montane forests. The interaction of climate and beetles and how this should influence restoration treatments in lower elevation stands, and how to increase resilience under these conditions, raised another set of questions for the group (Romme, Clement, Hicke, Kulakowski, MacDonald, Schoennagel and Veblen 2007).

A last important uncertainty was the group's inability to quantitatively define ecological restoration prescriptives, e.g. the amount of residual BA (basal area) or trees per acre. Despite a thorough review by the group of the literature and numerous interviews of experts regarding restoration in lower montane, ponderosa pine dominated forests, it became clear that site variability currently may play too great a role to provide quantitative certainty.

Uncertainties are inherent in most natural resource management systems and associated projects and the use of collaborative learning is an important tool to reduce uncertainty. This group's collaborative agreement on how to reduce uncertainty, as well as the use of adaptive management, have become important and explicit features of these multi-party monitoring efforts.

1.2 Adaptive Management and Collaborative Learning

This Plan and the MWG's efforts are rooted in a consensus regarding the need to use adaptive management as a tool to reduce uncertainty over time through a structured, iterative process of ecological, social and economic monitoring. In this way, information is collected using collaboratively deliberated methods to improve future management (Holling 1978). As has been described in other sources, there is usually a tension in adaptive management approaches between gaining knowledge to improve management in the future and achieving the best short-term outcomes based on current knowledge (Stankey and Allen 2009). The uncertainties described above underline the fact that this tension exists also in the case of this CFLRP. This monitoring plan describes the protocols that were derived through collaborative learning (CL), and through continued collaborative learning and an adaptive management, the ensuing data will allow the FRR and the USFS reduce uncertainty using the best available and trusted information.

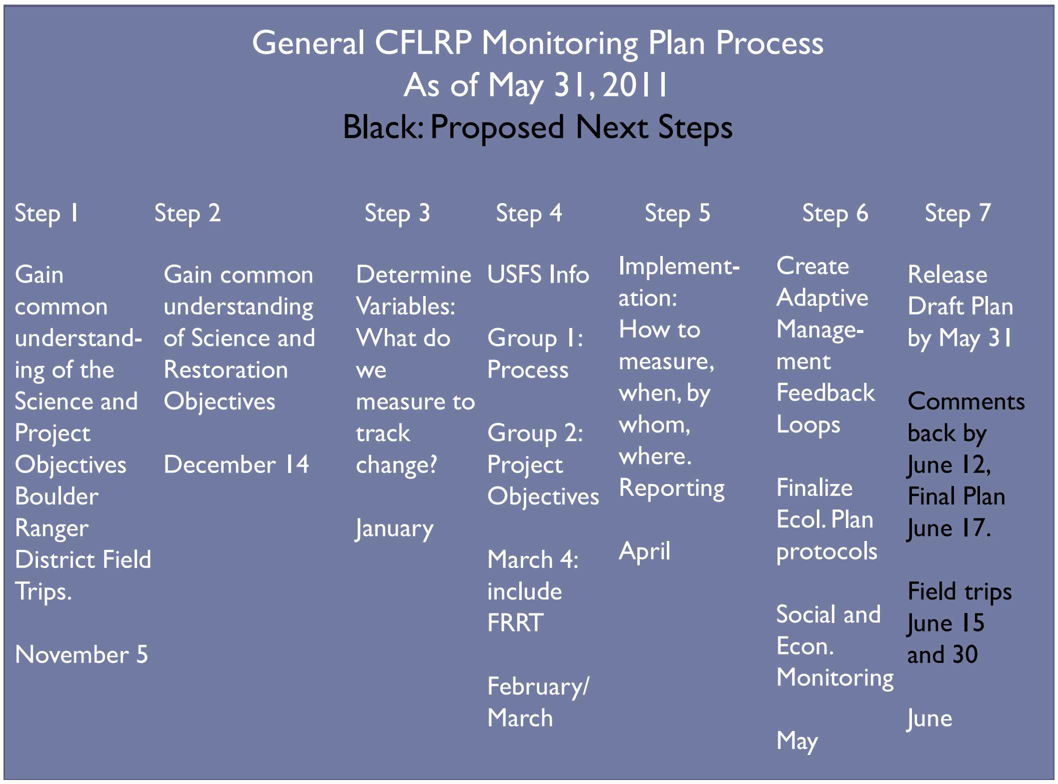
Chapter 2. Process Methods

A process has to be used in order to create a multi-party monitoring plan that includes ecological, social and economic parameters. Both the Collaborative Forest Landscape Restoration Act and the Front Range CFLR proposal (Appendix C) call for using a collaborative process. If collaboration is the act of working with multiple stakeholders to achieve progress, collaborative learning is the method which encourages people to learn actively, to think systemically, and to learn from one another about a particular situation (Daniels and Walker 2001). The first phase of a collaborative learning process, including this CFLRP monitoring effort, includes the creation of a common understanding, in this case regarding what "restoration" means in these forests, therefore what USFS restoration approaches might be and for the MWG, what should be monitored to track whether this objective is achieved. In the middle stages, CL participants focused on concerns and interests regarding the specific situation, in this case the ground-truthing of that common understanding through a review of the relevant science. Out of this review, in the last phase, the CL participants identified possible monitoring protocols that would allow the USFS and FRR to establish whether restoration and fuels reduction objectives are being achieved. CL activities included participants sharing their knowledge and opinions, field trips, large group discussions, break-out groups and review of applicable science/research.

This CFLRP Monitoring Plan is therefore the result of intense multiple stakeholder learning and deliberations by the Front Range Roundtable Monitoring Working Group. The multiple stakeholder group consisted of members of both the Pike - San Isabel and Arapaho and Roosevelt National Forests, USFS Region 2, Colorado State Forest Service, US Fish and Wildlife Service, Colorado Department of Wildlife, Natural Resource Conservation Service, The Nature Conservancy, The Wilderness Society, Colorado Wild, Rocky Mountain Research Station, University of Colorado and Tree Ring Laboratory, Boulder County and the City of Boulder, and many other stakeholders. The Colorado Forest Restoration Institute convened the meetings, designed, facilitated and guided the process, culminating in this Plan. Beh Consulting, who convenes and facilitates the Front Range Roundtable collaborative, worked with CFRI to organize meetings and to conduct the multiple stakeholder review of the literature and expert opinions (see below).

At the beginning of Plan development in October 2010, CFRI proposed a process that was collaboratively adapted as needed by the group in order to reach objectives in time, to allow the USFS to start collecting pre-treatment data. The process itself remained basically unchanged but some elements were added or changed. At the time of drafting this plan, the process looked as follows:

Figure 1: Collaborative Learning Process used by the Monitoring Working Group



CFRI sought to ensure that some basic collaborative requirements were met including the drafting of a process that was collaboratively agreed to and collaboratively adapted as needed, the adoption of a decision-making method, and transparency and efficiency in communication. The outcomes of all meetings and all presentations were posted on the Front Range Roundtable website by Beh Management Consultants.

In order to show the collaborative progression that the Monitoring Working Group went through to create the Monitoring Plan, sometimes with the support of the larger FRR collaborative, below is a chronology of events.

2.1 Collaborative Process Chronology

Date	Event
10-15-'10	Kick-off Meeting – Clement proposed a process which was accepted by the group, restoration terminology was discussed, initial meeting dates set, the purpose of the CFLRP on the Front Range, and the roles of CFRI and the Front Range Monitoring Working Group.
11-5-'10	Discussion regarding CFLRP objectives. Ecological science presentations by Tom Veblen and Tanya Schoennagel (CU). Field trip to Boulder Open Space and Taylor Mountain Unit.
12-14-'10	Clement presented language to allow group to consider what collaboration means for its purposes. Peter Brown presented considerations regarding project objectives and possible variables to measure. Established decision-making method of thumbs: up, down or side-ways. Break-out groups explored project objectives. General outcome: Use language in original proposal but there were still questions regarding wildlife that needed to be answered.
1-24-'11	Discussions and presentations regarding wildlife monitoring consideratons, the Uncompahgre Plateau CFLRP and Peter Brown presented a discussion regarding possible core variables. Break-out groups to establish the group's initial thoughts regarding Tier 1 (core) and Tier 2 (other important) variables. Jessica proposed changes to the team process to allow the group to 1. Learn from the USFS and 2. address adaptive management process and metrics/variables issues in efficient manner. Group agrees and two issue-specific sub-groups are formed to work on Ecological Restoration Metrics and Adaptive Management Process during the month of March. In February, USFS to present information.

Date	Event
2-16-'11	1. Received in-depth infromation from the USFS regarding Common Stand Exam protocols, budget and staff considerations, prescription and implementation procedures, etc . 2. Split up into process and metrics groups to plan March activities.
3-1-'11	FRR Executive Team meeting to update the Team on CFLRP Monitoring Working Group progress.
3-4-'11	FRR Quarterly Meeting – updated Roundtable on Monitoring Working Group progress. Generally supported activities. Roundtable members invited to join the process and metrics teams during March.
3-8-'11	Process Group met in Golden. Outcomes (see website): 1. The Monitoring Working Group will propose to FRR and the Executive Committee a methodology for inserting its information into the larger collaborative process, engaging the FRR and Exec. Committee in learning, and get the feedback/approval it needs if necessary from either or both the FRR and Exec Committee. 2. The FRR Executive Committee will create a process that addresses a. The fact that the monitoring working group (MWG) is only one of several FRR subgroups that need to have a way of inserting their information into the larger collaborative process and b. There are outside groups and individuals that need to be able to have input and a response from the FRR, which is what Gali's proposal addresses.
3-11-'11	Metrics Team meeting in Boulder. Created of metrics spreadsheet based on literature (see website), interview guide and team methodology. For the rest of March members of the group either contributed their own expertise as scientists, or group members interviewed experts and contributed their notes to the database.
3-31-'11	Metrics Team meeting in Lakewood: Review of expert interview results. The group has herewith completed the scientific review necessary for Evidence-based Restoration as described by the Ecological Restoration Institute, which in turn can be used for adaptive management to explore monitoring data.

Date	Event
4-5-'11	Full Monitoring Working Group: review metrics and process group outcomes. Identified Core ecological variables and Tier 2 variables. Introduction to Social and Economic Variables.
4-27-'11	Full Monitoring Working Group – combined Hal Gibb's chart with restoration parameters, metrics, measurment techniques and measurement timing with Peter Brown's chart with desired conditions, variables to measure and measurement techniques into one monitoring protocol table (see Table 2). Discussed Sampling on plot scale and landscape scale – Jonas proposed method that combines Common Stand Exam data collection methods with transects between plots to record size and nature of openings between clumps.
5-10-'11	Review of Collaborative Chronology. Ecological monitoring variables and protocols have been described in monitoring protocol table, together with desired conditions, measurement techniques and timing and other considerations. The group reviewed the entire table and after deliberation went through a line-by-line thumbs decision making process to agree to the final table. A subgroup was formed to finalize social and economic monitoring protocols on June 13, 2011 in Colorado Springs.
6-13-'11	Front Range Roundtable social and economic monitoring subteam met in Colorado Springs. The group reviewed MWG efforts on this subject so far, and discussed possible variables to measure in light of what would benefit USFS and FRR constituents e.g. communities and the private sector. A final list of variables was compiled. Tony Cheng and Julie Schaefers will convene a follow-up meeting to decide measurement methods.

2.2 Key subjects deliberated in the course of these meetings were:

1. A CFLRP implementation site known as Taylor Mountain presented a learning opportunity for the group when local residents and environmental groups raised concerns. This raised questions regarding old and large trees in lower and higher elevation mixed conifer stands, how to define old growth, and how much to retain in the face of the mountain pine beetle outbreak. This project also raised the question of communication and how the Front Range Roundtable wishes to respond to such

concerns from local residents, or whether this is a matter only for the USFS if it is their project.

2. There was considerable amount of discussion regarding the implementation of adaptive management in the context of this CFLRP collaborative. The summary above notes the outcomes of the Process group, which consisted of a subteam of the Front Range Roundtable who took the time to deliberate these issues. The outcomes of this group are discussed under Recommendations at the end of this Plan.

3. The group spent time discussing what "restoration" meant in lower montane forests: what are the desired conditions that entail "restoration", what treatments will achieve restoration and are there metrics that help define how restoration can be achieved? After going through a collaborative exercise to explore the literature, and to interview experts (see Appendices for results) the group discovered that the experts generally agreed that restoration will need to be achieved in different ways depending on site variability. The fact that there was no clear language or metrics identified to provide a clear indication of the meaning of restoration in this case was disappointing to many stakeholders. As mentioned before, continued collaborative learning and adaptive management will assist in decreasing existing uncertainty.

4. A final topic that took some time was the roles of the Front Range Roundtable collaborative, the Monitoring Working Group (which will eventually be devolved back into the already existing Science and Monitoring group) and the Front Range Roundtable Executive Committee in light of the CFLRP. For example, although many in the group assumed that FRR document "Living With Fire: Protecting Communities and Resotring Forests, Finding and Recommendations of the Front Range Fuels Treatment Partnership Roundtable" (2006) would provide a significant foundation for ecological description of restoration in these systems, the group discovered there were large gaps in information. This in turn raised the question whether the monitoring working group was in a position to fill the gaps for the entire collaborative. The monitoring working group decided to turn to the larger FRR collaborative to create the process and metrics groups to unravel issues that had a larger bearing than just the CFLRP. The metrics group addressed the larger FRR question of whether and how to quantitatively define metrics for ecological restoration, the process group addressed the larger FRR question of how to create adaptive management feedback loops.

Chapter 3: Ecological Monitoring

3.1. Background: Historical Ranges of Variability and the Need for Ecological Restoration in Front Range Lower Montane Forests

Forests dominated by lower montanein the Front Range of Colorado are not the same as they were before European settlement that began in the latter half of the 1800s. Current conditions in many stands are generally believed to be outside their historical ranges of variability in stand structures (basal areas and tree per acre), tree and understory species composition, landscape patterns of openings, woodlands, and forested stands, and fire behavior. This section is a brief review of several key elements of the history and ecology of lower montaneand ponderosa pine/Douglas-fir dominated Front Range forests. The purposes of this review are: 1) to briefly outline the historical ecological situation to provide a contrast with present-day forest conditions; and 2) to add to the ecological basis for the landscape monitoring program.

3.1.1. Historical Range of Variability

Morgan et al. (1994) and others have proposed that managers use measures of historical ranges of variability (HRV) in fire regimes and ecosystem conditions as models for management goals that promote sustainable ecosystem behavior over longer time scales (Figure 2). A historical range of variability in an ecosystem component is a way to define the bounds of behavior and conditions that were present before significant human impacts occurred. Although Native Americans are known to have affected ecosystems in some areas, HRV refers to periods prior to Euro-American settlement when major impacts such as logging, livestock

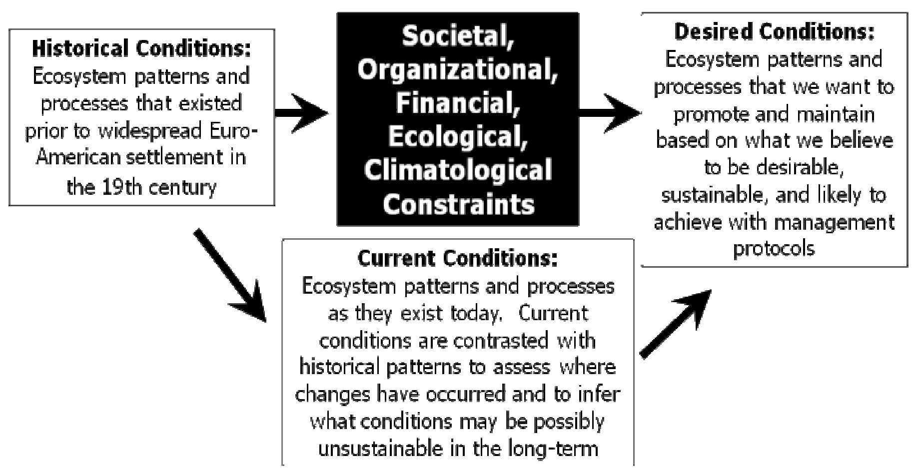


Figure 2. Historical conditions are contrasted with current conditions to develop desired conditions. In general, it is difficult to impossible to recreate historical conditions because of numerous constraints in current and future ecosystems. Instead, HRV should be considered as *models* for what desired conditions should be, and how to achieve them.

grazing, fire suppression, and the introduction of invasive plant and animal species occurred. The central premise of HRV is that ecosystems function best under conditions to which they have adapted over long (multi-decadal to multi-millennial) time scales (Landres et al. 1999). Note that HRV does not refer to a "snapshot" of conditions in the past, and in general it is not appropriate to use some central tendency or a single point in time as a management goal. Instead, HRV explicitly refers to the dispersion of conditions through time and space, including variations through time due to factors such as changes in climate changes or disturbances such as fire or bark beetles. Definition of HRV in ecosystem components also permits greater operational flexibility and adaptability in management goals since the ranges of possible outcomes to specific management actions may be expanded. In addition, in most cases HRV conditions cannot be simply duplicated in current ecosystems because of various social, economic, or even ecological constraints. For example, in most Front Range forests in particular, it will be difficult to reintroduce wildland fire anywhere near its historical frequency or extent because of chances for escape in populated areas and issues with smoke.

3.1.2. Historical Conditions in Front Range Lower Montane Forests

There is abundant evidence found in fire scars recorded in tree ring series to document that fires were common disturbances in lower montane forests of the Front Range before the late 1800s or early 1900s (Figure 3; Brown and Shepperd 2001, Veblen and Donnegan 2006, Sherriff and Veblen 2006, Kaufmann et al. 2006). For much of the lower montane zone, these fires were relatively low-intensity surface fires burning through grasses, forbs, and needle litter at the bases of mature trees. Mature lower montanetrees are well-adapted to low-intensity fires, with thick bark that protects growing tissues from girdling and high crowns that lessen the possibility of crown scorch. However, smaller seedlings and saplings are susceptible to being killed by even the most benign surface fires. The overall ecological result was that most of the seedlings and smaller saplings were killed during wildland fires, while the larger and older trees were spared (Figure 4). Occasionally, individual saplings or groups of saplings survived

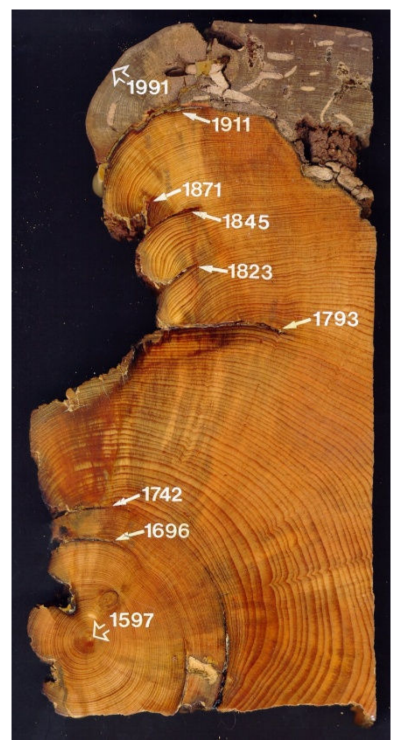


Figure 3. A section from a fire-scarred ponderosa pine. The tree was killed by bark beetles, as evidenced by the blue stain in the sapwood at the top.

and became new members of the overstory. Also, patches (acres to tens of acres in size) of crown fire would occasionally occur, killing stands of overstory trees. These passive crown fires (in which fire spread across a landscape was predominately through surface fuels) added to landscape diversity by creating small meadows and openings. This pattern of recurrent surface fires, passive crown fires, widespread seedling and sapling mortality, and occasional sapling survival resulted in a diverse landscape mosaic of generally multi-aged, multi-sized, and variable density forests, woodlands, and meadows across the Front Range lower montanezone.

The above observations, however, did not fit all areas of the Front Range uniformly. The main reason is that Front Range lower montane forests occur across a broad range of environmental conditions as a result of variation in elevations, soil conditions, and topographic complexity. Fires regimes (the balance of fire frequency, severity, and burn patterns) varied largely as a result of variation in these local environmental factors and differences in the tree and associated vegetation communities found in different sites. The overall result was that Front Range forests experienced a greater range of fire behavior and resulting stand structures and composition than, for example, lower montane forests of Arizona and New Mexico that experienced predominately surface fires. However, the general pattern was that fires occurred relatively frequently and were mainly low to moderate severity, in that not all trees were killed across large landscapes such as what occurred in higher elevation subalpine forests (Schoennagel et al. 2004, Kaufmann et al. 2006). Furthermore, as a general pattern, Front Range forests experienced a gradient from predominately surface fires in the lowest elevation stands on the border with the Plains grasslands to mixed surface and passive crown fires as elevation and moisture conditions increased through the lower to upper montane zones. Fire frequencies varied from more frequent fires (every 10 to 15 years) at the lowest elevations to less frequent fires (every 30 to 60 years) at higher elevations. This variability in fire frequency and severity, in combination with variability in the physical environment, further contributed to the formation of highly diverse landscape structures that ranged from large open meadows, woodlands of widely spaced and diversely structured lower montanetrees and associated species, to denser stands of even-aged forests on especially north-facing slopes and higher elevations.

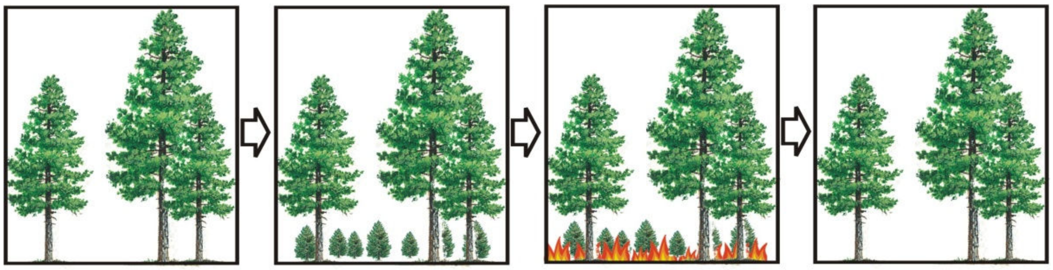


Figure 4. The *historical* pattern in which surface fires played a "keystone" role in structuring Front Range lower montaneforest ecosystems by killing many of the younger trees before they became part of the forest overstory.

3.1.3. Current Conditions in Front Range Lower Montane Forests

Beginning with Euro-American settlement and continuing through much of the 20th century, major changes in Front Range lower montane forests were caused by timber harvesting (e.g., Veblen and Donnegan 2007). Ponderosa is an excellent timber species, tall and straight-growing, and was easily obtained from the foothills and mountains just above rapidly growing cities just to the east. The earliest harvesting was unregulated, and consisted mainly of so-called "logger's choice" methods in which the biggest, tallest, and straightest trees were cut for the mills. After the start of the 20th century, the Forest Service initiated sustainable harvest practices, but this still consisted of largely selective cutting methods concentrated mainly on larger trees (Veblen and Donnegan 2007). The result has been that over the years the largest and oldest trees have been removed from the vast majority of Front Range lower montane landscapes, and current stands generally consist of much younger and smaller trees than those that occurred historically (e.g., Kaufmann et al. 2000).

But perhaps even more important than direct impacts from timber harvest were indirect changes caused by fire cessation that began with settlement in the late 1800s. Initially fires stopped because cattle, sheep, and other livestock grazing that accompanied settlement removed grass and herbaceous fuels through which surface and passive crown fires spread. Later, beginning in the early 20th century, fires were actively suppressed by Forest Service and other land managers, due to societal demands to protect timber and other natural and human resources. The ecological result was that instead of only occasional new trees becoming part of the overstory, all seedlings now had the potential to survive (Figure 5). This resulted in both greatly increased tree densities in individual stands and homogenization of stand conditions across landscapes, especially when coupled with the loss of larger trees from timber harvest and other mortality factors such as mountain pine beetles. These changes together have substantially increased the potential for more extensive and severe crown fires, both because of the presence of smaller trees that act as "ladder fuels" that allow surface fires to jump up into forest canopies and the much more widespread areas of continuous canopy fuels across landscapes. Active crown fire (in which wildfires spread across landscapes through continuous canopy fuels) has largely replaced passive crown fires and surface fires because of greatly increased connectivity of landscape forest structure (Figure 6). Increased tree densities, the change to even-aged and even-sized forests, and a loss of landscape diversity also may have increased the extent and severity the on-going mountain pine beetle outbreak because of the presence of more continuous areas of suitable habitat for the beetles.

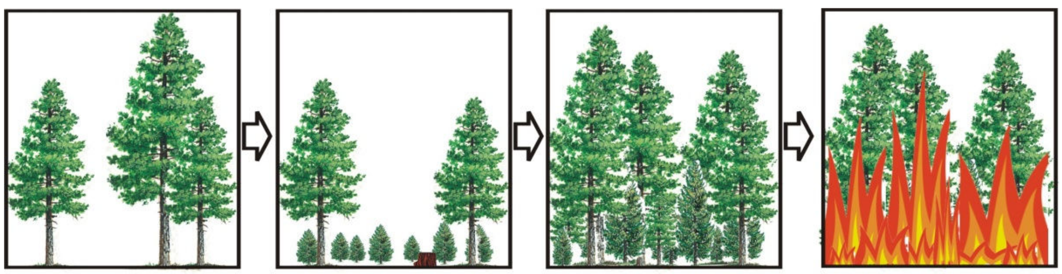


Figure 5. The *current* pattern in which increased stand densities, ladder fuels, and the loss of landscape mosaics have increased the likelihood of active crown fire when fires eventually (and inevitably) occur. Timber harvest also has led to a loss of larger and older trees in many stands.

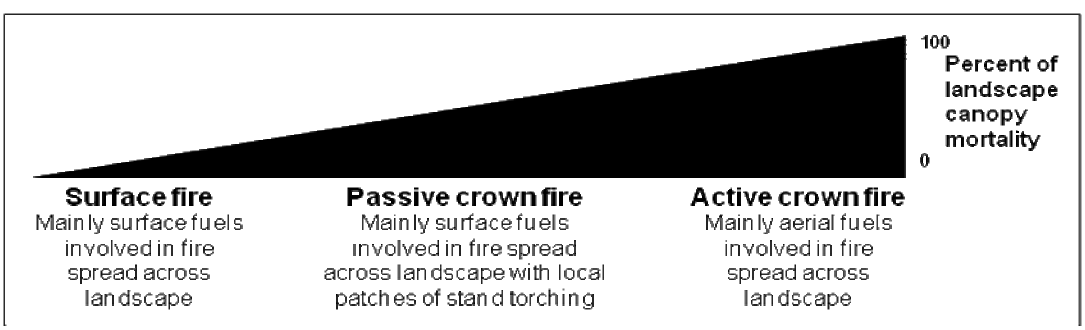


Figure 6. A continuum of possible fire behavior at *a landscape scale*. For active crown fire to occur, canopy continuity has to be great enough that once a fire has made the transition from surface to canopy fuels and weather conditions are right (hot, dry, windy), fire spread from stand to stand is predominately by canopy burning. Surface fuels may burn as well, but there is enough horizontal continuity in the crowns that they are not necessary for fire spread from place to place. In contrast, during passive crown fires, stands of denser trees "torch out" but the aerial fuels are discontinuous and fire spread across a landscape has to occur primarily through surface fuels.

3.1.4. Desired Conditions in Front Range Lower Montane Forests

The combination of timber harvest, fire suppression, and other land use impacts has resulted in on-going efforts to restore the historical forest structure of Front Range lower montane forests - including promoting the presence of larger and older trees - that will once again allow surface fires and passive crown fires to play their longer-term ecological role (Figure 7). Scientists agree that the most of the lower ponderosa pine dominated forests located in the Front Range ecological zone known as the lower montane are unnaturally dense and in need of fuels reduction treatment. Ecological restoration involves thinning mainly the younger and smaller trees from denser stands (especially less "fire-tolerant" species such as Douglas-fir, juniper, true fir, and spruce that have established since fire exclusion), retaining larger and older lower montanetrees (and those of other species) wherever they are encountered, restoring landscape diversity through creation of openings, meadows, and variable density stands, and restoring surface fires, either as prescribed fires ignited by managers or during future wildfires. Most importantly, these efforts are increasingly directed at ecological restoration across large landscapes, in which the historical diversity of forest and woodland structures, variable stand densities, and meadows and openings are recreated. These efforts are intended to maximize diversity of wildlife habitats, reduce threats from future disturbances such as active crown fires and extensive bark beetle outbreaks, and increase the capacity of Front Range lower montane forests to withstand impacts from future climate changes such as droughts and increased temperatures.

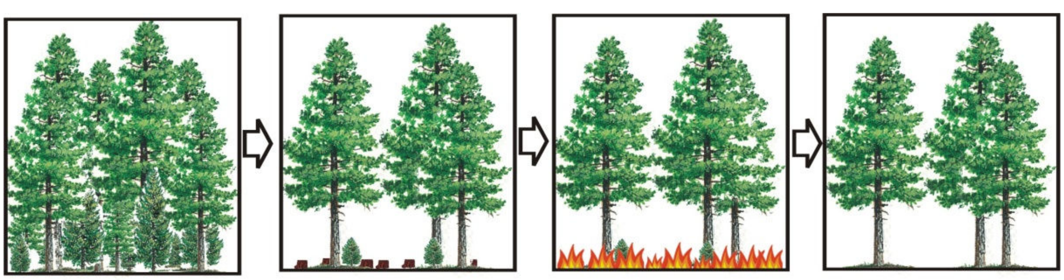


Figure 7. *Desired* conditions in Front Range lower montaneforests, with ecological restoration of stand structure and removal of ladder fuels through mechanical thinning. The main objective is for fires to be able to once again play their ecological role, maintaining not only the ecological integrity of the forests but protecting homes and other values at risk in the wildland urban interface area.

3.2. The Ecological Monitoring Program

This section of the monitoring plan outlines a comprehensive ecological monitoring program to assess success of CFLRP treatments for a minimum of 15 years after project implementation, and to guide future treatments through an adaptive management framework (Holling 1978; see additional comments below). Monitoring results will be used both to evaluate the rate and extent of achievement of individual project goals, and to incorporate data into analyses of cumulative effects at the landscape level. The monitoring protocols outlined in the following section are designed to address specific Desired Conditions. Desired Conditions are short descriptions of overall ecosystem goals that are to be achieved through the CFLRP project. Desired Conditions identified for Front Range montane ecosystems are based on concepts of ecosystem structural and functional sustainability, resilience, and adaptive capability, and were developed through the multi-stakeholder process described in the beginning sections of this document. Desired Conditions are expressed in broad, general terms, and have no specific date by which they are to be achieved. Rather, they are intended to form a focus for the restoration strategy and to provide a basis for developing treatment objectives and priorities that will be assessed during the monitoring program outlined in this chapter. Desired Conditions constitute a framework for management activities to be done under the CFLRP project.

Two essential and central concepts of a monitoring program are that ecosystems are constantly changing at multiple scales in both space and time, and there is often a great deal of uncertainty when we attempt to define specific rates or magnitudes of ecosystem changes that may take place (Holling 1978). Ecosystems are inherently dynamic and changes within them occur across spatial scales ranging from individual plants to landscapes and time scales ranging from days to centuries. Uncertainty arises because we usually do not know precisely how ecosystem components interact at these multiple scales to produce the rich variety of behavior that is present in natural systems. An example is future climate change, in which changes in temperature or precipitation patterns may lead to unexpected and unpredictable (although not necessarily "unnatural") ecosystem change.

Variability and uncertainty ecosystem dynamics mean that management actions must be flexible and adaptable to new data and new theories that further our understanding of how nature works. The basis for an adaptive management approach is that since we do not always know what will happen when we apply a treatment to an area, we must monitor ecosystem response and assess whether goals were, in fact, met by the treatment or if unforseen circumstances altered the response. Each management action is seen as an experiment to be performed, with outcomes that can be empirically assessed using various metrics or objective assessments. In this manner, future treatments are refined by past results. Data from the monitoring program outlined here will be used to objectively assess both structural and functional characteristics (short-term goals) and provide more refined directions for future management actions. Furthermore, new methods for monitoring and additional data describing Front Range montane forest ecological patterns and processes will likely be developed through the life of the CFLRP project, and therefore the monitoring process must be able to adapt to these new inputs.Data from the monitoring program outlined here will be used to objectively assess both structural and functional characteristics (short-term goals) and provide more refined directions for future management actions. Furthermore, new methods for monitoring and additional data describing Front Range montane forest ecological patterns and processes will likely be developed through the life of the CFLRP project, and therefore the monitoring process must be able to adapt to these new inputs.

The following section includes specific guidelines that will be used for ecological monitoring during implementation of the Colorado Front Range CFLRP project. These guidelines were developed as part of the collaborative process outlined in the opening sections of this document. However, please note that this is still a work in progress in some places. For example, a major question concerns how to assess success of CFLRP implementation at a landscape scale. This plan outlines a series of specific measurements that will be done in individual plots, largely based on existing NFS Common Stand Exam (CSE) protocols that are part of standard inventory procedures. CSE inventories are done before silvicultural and thinning treatments to define current stand characteristics and conditions and to provide baseline data for contracting purposes. However, during the collaborative process to get to this point, we identified several gaps in trying to translate individual plot data to the landscape scale. For example, our first Desired Condition is to "establish a complex mosaic of forest density, size, and age". The monitoring working group felt strongly that this Desired Condition should include some sort of spatial metric to define and assess that mosaic condition beyond simple averages and distributions of the identified monitoring variables as measured in the plots. However, we were not able at this time to come up with such a metric, nor how to measure it as part of the monitoring program. Some of these gaps may be overcome depending on funding available to implement the monitoring program. With more resources devoted to monitoring, a greater density of plots can be put into treatment areas which will increase understanding of landscape variability. Also future methodological advances may be used to decrease uncertainties in monitored variables. For example, remote sensing methods such as LIDAR could be coupled with the plot-level measurements to gain greatly increased understanding of landscape mosaics and variations in stand structures, and in modeling landscape-scale changes in fire behavior. Also a combined plot/transect approach to gain greater understanding of landscape metrics was proposed by a team member during development of this monitoring plan. However, it was decided that the method needs more testing before incorporation here, and we hope that will be done for future versions of the monitoring program.

Tables 1 and 2 below provide the basic monitoring guidelines as defined by the collaborative process outlined in Chapter 2. Figure 8 is the basic plot design to be used in the monitoring program. The plot design relies heavily on existing stand exam methods used by both the AR and PSICC National Forests for inventories before treatments are done. It is important to measure exactly the same variables to compare pre- and post-treatment data. We have modified some of the protocols for the monitoring program presented here, so variables may not be measured in exactly the same manner, but each can be scaled to a per acre basis such that pre- and post-treatment data can be compared.

A particular note is needed at this point about Table 2. Note that the monitoring guidelines presented in Table 2 do not include specific values for assessing success for each of the variables to be monitored. This is in contrast to lower montane forests of the Southwest or Black Hills, where there has been a great deal of scientific research on, for example, the number of trees per acre or the basal areas that were present in historical forests. As part of this monitoring plan, a Monitoring Metrics Sub-group was formed to delve into the subject of whether we could develop specific target metrics to include in Table 2 that would provide quantitative values of success for each of the variables to be monitored. The sub-group conducted first a comprehensive literature review of existing publications and unpublished research specifically looking for quantitative data that could be used to define target metrics. The group also conducted oral or written interviews with a group of scientists who are experts in Front Range montane forest and fire ecology. The list of literature reviewed, the experts interviewed, and a short summation of findings is presented in Appendix A. However, the bottom line result the Metrics sub-group found is that there is both too much variability in Front Range montane ecosystems and too little available data to develop a single value or even range of values that could serve as target metrics to assess success of the CFLRP restoration effort. The experts suggested that it is not appropriate or realistic to set target values of metrics that would be considered to represent restoration at all sites across the Front Range, and that specific and quantifiable Desired Conditions should be set on a site-by-site basis. Ideally site-by-site metrics are largely based on local fire and forest histories, that either could be done before specific treatments are undertaken at each site or, alternatively, treatments could be targeted to those areas where fire and forest histories have already been done (see further comments in Appendix A). However, this is not currently being done and more information is needed before this can be implemented (see Tier 2 variables). No consensus was reached and this suggestion was not adopted.

Table 1: Plot "meta-data" to be collected during ecological monitoring for the Colorado Front Range CLFRP. Each of these variables will be collected for each monitoring plot.

Variable	Comments
Latitude/longitude	Or UTM as appropriate; from GPS
Slope	In percent
Slope position	Bottom, Lower, Middle, Upper, Ridge
Slope shape	Concave, Straight, Convex
Aspect	In degrees (also make note of declination)
Elevation	In feet; from GPS or map
Date	
Personnel on plot	
Start time/End time	Time spent on plot: for economic monitoring
Reference photographs	Four photos taken on cardinal directions
Permanently marked?	Whether plot center is permanently marked and how
Plot description	Brief description of the plot

Table 2: Monitoring Protocols Table. Desired Conditions, restoration parameters, and monitoring details for the Colorado Front Range CLFRP. Note that several of the restoration parameters still need further details.

Restoration parameters	Desired trends	Variables to measure	Methods	At what point measured	Scale of analysis	Notes
Desired Condition: Establish a complex mosaic of forest density, size and age (at stand and treatment scales)						
Tree Density	• Decreased basal areas	• Basal area	• Count all trees ≥2.5" diameter at breast height (DBH) in a variable radius prism plot (10 or 20 Basal Area Factor) and scale up to per acre basis • Count all seedlings and saplings (<2.5" DBH) in fixed radius 1/200 ac (8.3' radius) plot centered on prism plot and scale up to a per acre basis	• Before treatment • After treatment • 5 to 10 years after treatment	• Treatment Unit	• Example data: 40-80 ft^2 per acre (1" DBH and above); however, expert review suggested this is site dependent
	• Decreased trees per acres	• Trees per acre	• Count all trees ≥2.5" diameter at breast height (DBH) in a variable radius prism plot (10 or 20 Basal Area Factor) and scale up to per acre basis • Count all seedlings and saplings (<2.5" DBH) in fixed radius 1/200 ac (8.3' radius) plot centered on prism plot and scale up to a per acre basis	• Before treatment • After treatment • 5 to 10 years after treatment	• Treatment Unit	• Example data: 40-100 trees per acre (1" DBH and above); however, expert review suggested this is site dependent
Tree Sizes	• Increased Quadratic Mean Diameters	• Diameters at breast height for larger trees and root collar for seedlings and saplings	• Measure diameters at breast height (DBH) using diameter tapes on all variable radius plot "tally" trees and scale up to per acre basis • Count number of seedlings and saplings (<2.5" DBH) in fixed radius 1/200 ac (8.3' radius) plot (seedlings = below BH; saplings = BH to <2.5" DBH) and scale up to per acre basis	• Before treatment • After treatment • 5 to 10 years after treatment	• Treatment Unit	• Quadratic Mean Diameter (QMD) – Integration of stems per acre and diameters – representative of average tree size
Tree Ages	• Increased ratios of old trees (>200 yrs) to transitional trees (150-200 yrs) to younger trees (<150 years).	• Tree ages	• Use visual references and morphology of all variable radius plot tally trees (RMRS-GTR-109 and 110) to define old/transitional/young trees and scale to per acre basis • Obtain dendrochronologically crossdated (or ring-counted) ages from increment cores as available	• Before treatment • After treatment • 5 to 10 years after treatment	• Treatment Unit	

Desired Condition						
Restoration parameters	**Desired trends**	**Variables to measure**	**Methods**	**At what point measured**	**Scale of analysis**	**Notes**
Within-stand spatial heterogeneity and structural stage diversity	• Increased tree clumps and spatial heterogeneity in stands • Increased number of openings (>.25 acre)	• Variation in structural stages at sub-stand level • Number of openings	• Exact method(s) to be determined • Test plot/transect method at Manitou Experimental Forest or with other spatial data sets • Test use of spatial stats derived from orthophotos	• Before treatment • After treatment	• Treatment Unit	• Needs further discussion. • A sub-group will determine specific details over the course of the next 6 months
Establish a more favorable species composition						
Tree Species	• Increased ratio of ponderosa pine to other conifers where appropriate	• Tree species	• Identify species of all variable radius plot "tally" trees and scale up to per acre basis • Count seedlings and saplings in fixed plot by species and scale up to per acre basis	• Before treatment • After treatment • 5 to 10 years after treatment	• Treatment Unit	
Establish a more characteristic fire regime						
Surface fuels	• Decreased litter and duff depths • Decreased or similar coarse woody debris	• Surface fuel conditions for development of surface fuel models	• Two Brown's transects (that measure log amounts and sizes, and litter and duff depths) running 50 ft from plot centers, alternating E/W, N/S in plots	• Before treatment • After treatment	• Treatment Unit	
Fire behavior	• Mixed-severity that trends toward surface fire • Reduced crown fire potential at 90% weather as modeled in fire behavior models	• Tree heights, canopy base heights (CBH), canopy bulk densities (CBD), surface fuel models	• Canopy base height (CBH), canopy cover measured using Common Stand Exam methods • CBH, canopy bulk density (CBD), surface fuel models, and fire behavior afterwards modeled with plot and Brown's transect data, aggregated across landscape	• Before treatment • After treatment	• Treatment Unit • Landscape	• Example data: decrease in crowning and torching indices in pre- and post-treatment model runs

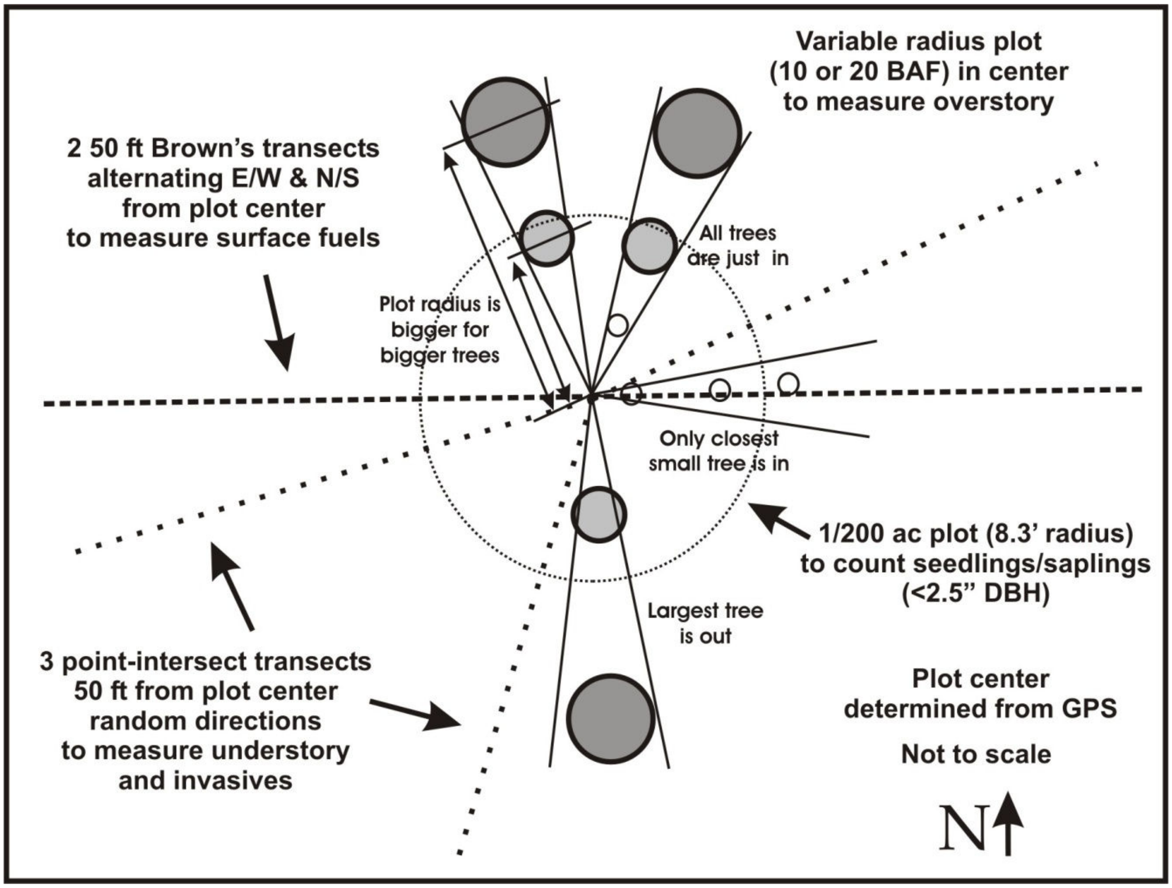
Increase coverage of understory plant communities (See Appendix A, page 37)						
Grass, forbs and shrubs.	• Increased cover by grass, forbs and shrubs • Decreased deep needle layers and bare ground.	• Ground cover by grass/forb/shrub functional groups • Presence and cover of key indicator species	• Average cover by functional groups (grass, forb, shrub, litter, rock, bare ground) measured on 3 50' point-intersect transects extending from plot centers • Average cover by individual or key indicator species as available (e.g., when botanist is available)	• Before treatment • After treatment • 5 years after treatment	• Treatment Unit	• See Appendix A for a list of possible Tier 2 indicator species for monitoring
Noxious or invasive plant species	• Similar (or decreased) occurrence and cover of noxious or invasive plant species	• Presence and cover of invasive species	• Average cover by individual or indicator species measured on 3 50' point-intersect transects extending from plot centers	• Before treatment • After treatment • 5 years after treatment	• Treatment Unit	• See Appendix A for a list of invasive species of concern
Occurrence of wildlife species that would be expected in a restored landscape (See Appendix B, page 39)						
Raptors (canopy nesters, accipiters)	• Increased use of restored areas • More nests, additional alternate nests • Increased number of plucking posts	• Goshawk (Cooper's and sharpshinned hawks also likely to respond to goshawk broadcast surveys)	• Identify active and inactive nests (GPS & photograph) • Search for evidence of raptor activity (pellets, whitewash,feathers, plucking posts). • Count, GPS, & photograph.	• Before treatment • After treatment	• Treatment Unit	
Carabid beetles (ground beetles)	• Increased species richness and Shannon diversity measurements	• Species diversity and abundance.	• Pitfall traps: plastic cups/coffee cans buried in the ground; one trap per plot • Photographs for later id.	• Before treatment • After treatment	• Treatment Unit	• Shannon index, is one of several diversity indices used to measure diversity in categorical data.
Snags	•	•	• Counted and diameter/height measured in variable radius plots	• Before treatment • After treatment	• Treatment Unit	Ken Morgan will give input

Tree squirrels (small mammals)	• Increased counts of squirrel sign	• Abert's squirrel	• Identify and GPS squirrel feed tree • Count at each plot and remove squirrel feeding sign (fungi digs, clippings, bones (twigs), cone cobs) • Indentify and count squirrel nests	• Before treatment • After treatment	• Treatment Unit	
Establish a complex mosaic of forest density, size and age (at landscape scale)						
Habitat Structure Stage at landscape scale ((6th or 7th level HUC) mosaic	• Increase larger, more open structure • Increased structural stages 4&5 • Slight increase of structural stage 1: grass, forbs • Decrease in closed, dense structure	• Change in ratio of structure stage	• Area of structure stage derived from existing veg layers (adjusted for change by treatments & other disturbances)	• Before treatment • 10 years after treatment	• Landscape	• A landscape is defined in this context as a 6th or 7th level watershed or a group of 6th and 7th level watersheds • Analysis should be of change in ratio of structural stages, differences and similarities between HUCs

Table 3: Tier 2 Ecological Monitoring Variables which could not be included as core, Tier 1 variables but which the Monitoring Working Group considers of great importance.

Monitoring Variable
4a. Tree ages (cross dated from cores)
4b. Tree ages (estimated from morphology)
6b. Tree status (dominant, co-dominant, suppressed)
11. Stem maps (measured for spatial statistics)
13b. Understory cover by indicator species
13c. Understory cover by individual species identification
14. Understory species richness and cover
15b. Understory exotic species presence by identifications
15c. Understory exotic species cover
16. Size of openings/meadows
17. Number of openings/meadows within landscape
21. Indicator wildlife species abundance and composition
22. Soil characteristics (e.g., nutrient status)
Local fire and forest histories to assist in creating site-specific metrics.

Figure 8. Plot design for the Colorado Front Range CFLRP



Chapter 4: Social and Economic Monitoring

CFRI investigated twenty-three websites and reviewed a total of fifteen U.S. based forest management (and/or stewardship) related documents that ecological, social and economic contain monitoring protocols. The full list is in Appendix D.

Based on the review of specifically the social and economic monitoring variables, CFRI presented to the group the list that was formulated by the Ecological Restoration Institute at Northern Arizona University in their Handbook 5: Monitoring Social and Economic Effects of Forest Restoration (see below). This list overlapped with all other social and economic monitoring documents CFRI reviewed, and was the most inclusive. After providing background information to the MWG, the group discussed the variables and went through a collaborative decision-making process to identify the variables that the group preferred be included in the social and economic monitoring part of this Plan. The list of variables identified by the MWG are displayed in Table 5, together with possible measurement methods.

After a review of existing methods (see Appendix D) used nationally to measure social and economic indicators, Jessica Clement provided suggestions for the MWG to consider. These were:

1. Doc: The collection and compilation of documentation (Doc) which means one or a number of individuals go through the process of obtaining information through telephone, email, web or documentation checking, compile documentation into report. Low subjectivity.
2. Assess: Conduct an assessment through document checking and interviews. Medium subjectivity.
3. Survey/Focus: Different methods to collect data regarding attitudes, beliefs, preferences through focus groups or a Q-study (extrapolate to an issue), or a random sample survey (extrapolate to a population). High subjectivity.

Table 4: Social and Economic Variables preferred by the Monitoring Working Group

FRR Monitoring Working Group Group Preferences regarding Social and Economic Variables (10 votes or more) April 27, 2011 List Adapted and Expanded based on Collaborative Forest Restoration Program Handbook 5: "Monitoring Social and Economic Effects of Forest Restoration".		
Enhance Community Sustainability	**Preference Vote**	**Possible Method**
Total number of workers employed by the project each month, season or year	16	Doc
Number and diversity of wood products and biomass utilization that can be processed locally	20	Doc
Number and size of contracts offered each year to do restoration work on public lands	14	Doc
Percent of all contracts awarded locally that go to local contractors	13	Doc
New – Local use of biomass	20	Doc
New – Indirect jobs gained (all industries)	20	Doc
Improve local restoration business and workforce skills		
Type of equipment used (such as chainsaws, harvesting equipment, skidding and loading equipment)	12	Doc
Improve or maintain local quality of life		
Availability and access to local utilization of materials from the forest.	16	Doc
Number of acres mitigated for fire hazard through the creation of defensible space, fuelbreaks or other fuels reduction projects.	22	Doc
Location of the project's fuels reduction acres in relation to areas considered to be at highest risk from wildfire.	21	Doc
Improve capacity for collaboration		
Level of commitment to communication and group learning (time, $ involved, are the same people showing up?).	16	Doc
Extent that stakeholders previously in conflict are now working together on this project.	10	Doc
Quality and timeliness of communication among all project owners.	10	Assess
Build support for forest restoration		
Extent that different perspectives are represented on project team and in project activities.	12	Assess
Extent of community, agency or environmental group participation in project activities.	17	Doc and Assess
Acceptance of frequent, low-intensity wildfire or prescribed fire.	23	Survey/Focus
Perceived benefits or issues of restoration activities.	20	Survey/Focus
Public attitudes toward the project and project collaborators.	21	Survey/Focus

On June 13, 2011, members of the Front Range Roundtable met to review what has been accomplished so far by the Monitoring Working Group in relation to social and economic monitoring indicators. Because the group included participants who had not been closely involved with the MWG's process so far, time was taken to provide information regarding the purpose of the CFLRP and CFLRA, the purpose of the monitoring plan, and what social and economic indicators would be most helpful to measure over the lifetime of the project. Participants included Carl Spaulding of the Colorado Timber Association, Tina Travis, Kathy Andrew and Commissioner Peggy Littleton of El Paso County and Matt Trummer with the Blue Knight Group as well as Sara Mayben with the USFS, Gali Beh (Beh Management Consultants) and Jonas Feinstein (Natural Resources Conservation Services).

Tony Cheng summarised the morning's discussion regarding realities faced by the private sector in relation to restoration projects in lower montane lower montaneand other related subjects. Based on this discussion, and previous MWG discussions (see Table 7), the group agreed that the following variables need to be measured in the future as part of Tier 1 protocols:

1. Total number of workers employed by the project by county and state, including wage scales and skill level
2. Number and diversity of wood products and biomass utilization that can be processed by county, state, region, and western multi-state region.
3. Average ($/ac) costs of treatment over time
4. Strike "local use of biomass" – don't need
5. Indirect jobs gained (all industries): use TREAT
6. Type of equipment used: mechanical or manual
7. Number of acres mitigated for fire hazard through the creation of… (all same)
8. Location of project fuels reduction acres… (all same)
9. Level of commitment to communication and group learning (e.g., time, $, …)
10. Legitimacy of the Front Range Roundtable collaborative (in terms of continuity, trustworthiness, delivering on expectations)
11. Extent that stakeholders previously in conflict are now working together
12. Fairness and transparency and timeliness of information sharing among all participants
13. Acceptance of frequent low intensity of widlfire, prescribed fire and/or other mechanical treatments

14. Perceived benefits or issues of restoration activities (pace and scale) and other mechanical treatments
15. Public attitudes toward the project and collaborators
16. Project operating costs over time: are they being reduced?
17. Fire costs: are restoration efforts reducing them?

The last two were added as a result of input received from the National Forest Foundation monitoring meeting that was held in Denver on June 7 and 8, 2011.

For next steps in establishing social and economic monitoring protocols, the group agreed that Tony Cheng and Julie Schaefers, Social Scientist with Region 2, will convene another meeting in the next three months to determine how these 17 variables will be measured. The group also discussed possible methods, as described in Table 7, that would allow for the periodical measurement of a number of variables at once, e.g. through a survey or documentation collation and reporting. There are opportunities and limitations which the group needs to evaluate together to arrive at a feasible set of protocols.

Chapter 5: Future Steps

As described in the first chapter, there are a number of uncertainties that currently exist and in the future will in all likelihood be reduced through the use of monitoring data collection efforts, collaborative learning and adaptive management. Keeping track of those uncertainties and documenting information that addresses them over time will be important.

As also mentioned, the core, or Tier 1, variables have been worked out by the MWG but with additional funding, the group hopes that a number of Tier 2 variables can be addresses as well. Below is the table that was used by the group to establish what were considered Tier 1 and Tier 2 variables.

Table 5: Tier 1 and Tier 2 variables, which may be addressed in the future. Green highlights Tier 1, Yellow highlights Tier 2.

Monitoring Variable	Tier 1	Tier 2
1. Tree density (stems/ac) (derived)	7	0
2. Tree basal areas (ft2/ac) (derived)	7	0
3a. Tree diameters (measured in inches)	8	0
3b. Tree size classes (counts of seedlings, poles, etc) – ocular estimate	3	2
4a. Tree ages (cross dated from cores)	1	7
4b. Tree ages (estimated from morphology)	4	4
5. Tree species	8	0
6a. Tree heights	4	3
6b. Tree status (dominant, co-dominant, suppressed)	2	5
7. Snags (density, height, diameter, conditions)	8	0
8. Canopy cover (derived)	4	2
9. Canopy base height (derived)	2	4
10. Canopy bulk density (crown width, crown ht, crown density) (derived)	1	5
11. Stem maps (measured for spatial statistics)	0	6
12. Seedling density	6	2
13a. Understory cover by classes (grass, forbs, shrub, bare soil, litter, rock)	5	3
13b. Understory cover by indicator species	3	3
13c. Understory cover by individual species identification	0	5
14. Understory species richness and cover	1	4
15a. Understory exotic species presence by indicator species	6	1

15b. Understory exotic species presence by identifications	2	4
15c. Understory exotic species cover	1	5
16. Size of openings/meadows	3	3
17. Number of openings/meadows within landscape	1	6
18. Vegetation structural stages/condition classes (derived)	2	4
19. Surface fuels (litter, duff)	5	3
20. Woody fuels	6	2
21. Indicator wildlife species abundance and composition	2	3
22. Soil characteristics (e.g., nutrient status)	0	6
23. Number and size of stumps and down logs (part of CSE)	3	4
24. Presence of insect and disease	X	
25. Other	1	

A third point is that the exact location of monitoring plots still needs to be determined, which will become clearer as the USFS has a chance to determine the locations of their sites and to discuss with the MWG where plots could be located.

Landscape-scale assessment of whether restoration objectives are being met is an important question to the group. One option that has frequently been discussed is that if there would be monitoring funding available LIDAR technology could be used to assess this component.

Funding will remain a critical determinant as to how much and what kind of monitoring takes place. MWG members are increasingly exploring additional funds to support these monitoring efforts. E.g. CFRI will be allocating a part of its budget to the Front Range CFLRP monitoring efforts. Jenny Briggs, USGS, Jonas Feinstein, USDA National Resource Conservation Service, and Paula Fornwalt, USDA Forest Service Rocky Mountain Research Station, have partnered with a number of other MWG participants and are recipients of Southern Rockies Landscape Conservation Cooperative (SRLCC) 2011 funding to conduct multi-species monitoring in the Southern Rockies to investigate impacts of forest restoration treatments on lower montaneecosystems in Colorado.

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Appendix A: Understory species to monitor in lower montane restoration treatment areas

Table 6 lists the exotic species that are of the greatest management concern, as compiled by Paula Fornwalt, PhD, with the Rocky Mountain Research Station and other colleagues. These have been recommended for monitoring under Tier 1 protocols.
Table 7 lists species that she and her colleagues recommend are also included in monitoring, if not under Tier 1 protocols, then under Tier 2 protocols. Species marked with "**" are those that are most important to monitor; it is likely that the monitoring team will only be able to monitor 5 – 10 species total

Table 6. Tier 1 Noxious and/or invasive understory species to monitor in lower montane lower montaneand hypothesized response to treatment.

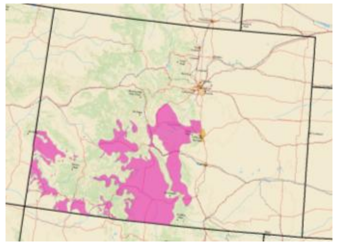
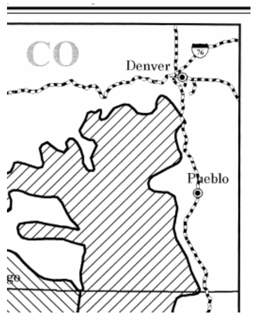
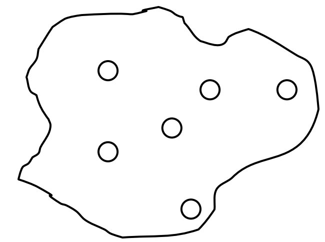
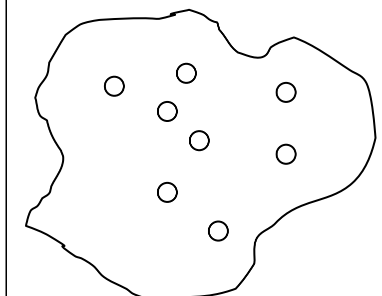
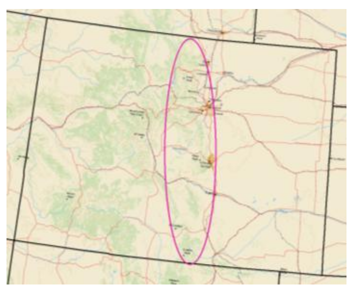
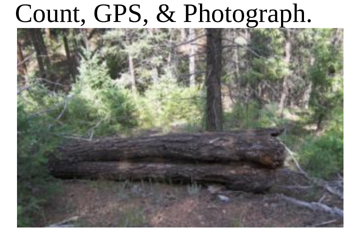
Species	Attributes	Expected response to treatment
Noxious and/or invasive species		
Smooth brome (*Bromus inermis*)	Perennial rhizomatous grass native to Europe	Increase in restored areas if not sprayed/pulled
Cheatgrass (*Bromus tectorum*)**	Annual grass native to Europe (Whitson et al. 2001); Colorado List C noxious weed	Increase in restored areas if not sprayed/pulled
Musk thistle (*Carduus nutans*)	Biennial forb native to Eurasia (Whitson et al. 2001); Colorado List B noxious weed	Increase in restored areas if not sprayed/pulled
Canadian thistle (*Cirsium arvense*)**	Perennial rhizomatous forb native to southeast Eurasia (Whitson et al. 2001); Colorado List B noxious weed	Increase in restored areas if not sprayed/pulled
Leafy spurge (*Euphorbia esula*)	Colorado List B noxious weed	Increase in restored areas if not sprayed/pulled
Dalmation toadflax (*Linaria dalmatica*)	Colorado List B noxious weed	Increase in restored areas if not sprayed/pulled
Butter-and-eggs (*Linaria vulgaris*)	Short-lived perennial rhizomatous forb native to Eurasia (Whitson et al. 2001); Colorado List B noxious weed	Increase in restored areas if not sprayed/pulled
Common mullein (*Verbascum thapsus*)**	Biennial forb native to Asia (Whitson et al. 2001); Colorado List C noxious weed	Increase in restored areas if not sprayed/pulled

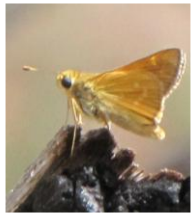
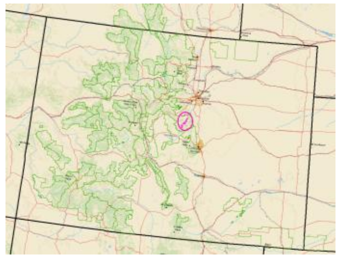
Table 7. Possible Tier 2 understory species to monitor in lower montane forests and hypothesized response to treatment.

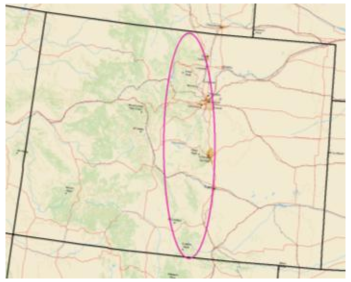
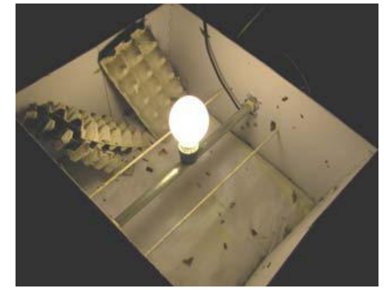
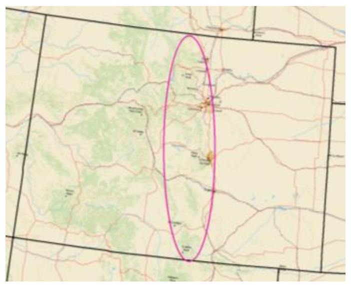
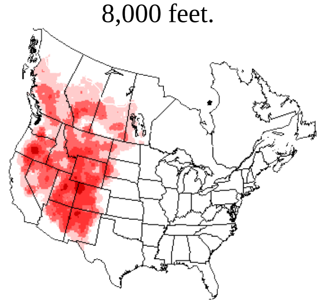
Species	Attributes	Hypothesized response to treatment
Native species		
Kinnikinnick (*Arctostaphylos uva-ursi*)		Decrease
Fringed sage (*Artemisia frigida*)**	Perennial forb	Increase
White sagebrush (*Artemisia ludoviciana*)	Perennial rhizomatous forb	Increase
Blue grama (*Bouteloua gracilis*)**	Perennial bunchgrass common in the plains and foothills of Colorado	Increase
Mountain mahogany (*Cercocarpus montanus*)**		Increase
Hairy golden aster (*Heterotheca villosa*)**		Increase
Scarlet gilia (*Ipomopsis aggregata*)**	Biennial forb	Increase
Common juniper (*Juniperus communis*)**		Decrease, particularly if fire is used in treatment activities
Dotted blazing star (*Liatris punctata*)	Perennial forb	Increase
Mountain muhly (*Muhlenbergia montana*)	Perennial bunchgrass	Increase
Little bluestem (*Schizacharium scoparium*)**	Perennial bunchgrass common in the plains and foothills of Colorado	Increase
Soapweed yucca (*Yucca glauca*)		Increase

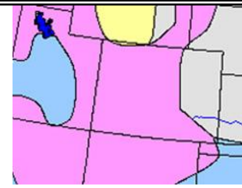
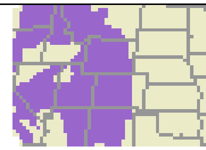
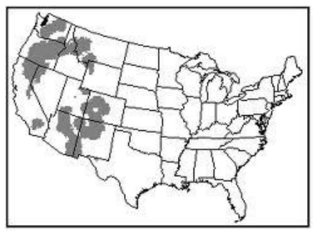
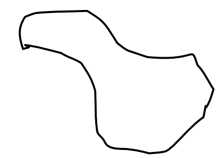
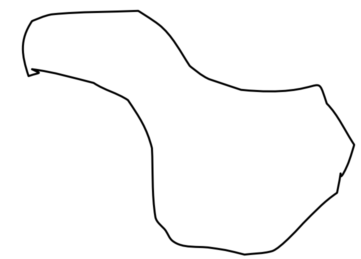
MAY 10, 2011. CFLRP - WILDLIFE MONITORING WORKING TABLE - DRAFT

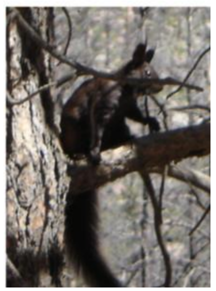
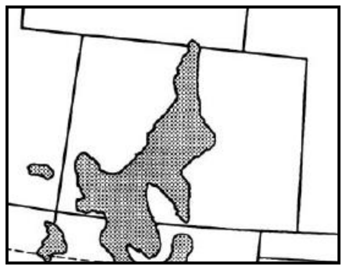
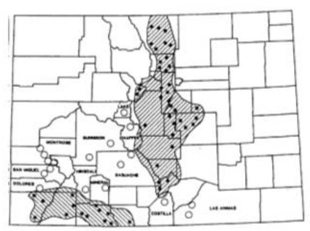
Density, Diversity, Population Persistence, or Population Trends

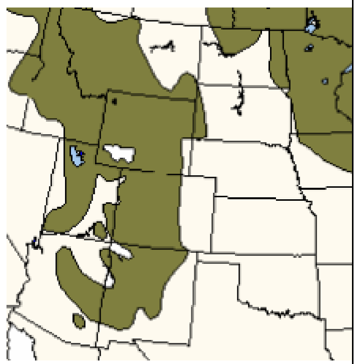
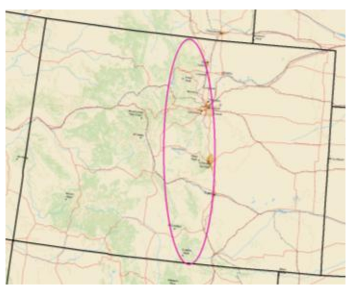
"GUILD"	"SUB-GUILD"	SPECIES	RANGE IN COLORADO	HABITATS	STUDY RESULTS, DISCUSSION, AND NOTES	SAMPLING METHODS	HYPOTHESIS / TREND
Federal Threatened Endangered Proposed Candidate Species **NEPA**	Small Mammal *Important prey species. Burrows used by other species.*	Gunnison's Prairie Dog (*Cynomys gunnisoni*) **ESA Candidate USFS R2 SS** 	 	Level to gently sloping grasslands and semi-desert and montane shrublands, at elevations from 6,000 to 12,000 feet. The northeastern range (central and south-central Colorado, and north-central New Mexico) consists primarily of higher elevation, cooler and more mesic plateaus, benches, and intermountain valleys. We call this portion ''montane'' for ease of reference, and it comprises approximately 40 percent of the total potential habitat within the current range. Gunnison's prairie dogs occupy grass-shrub areas in low valleys and mountain meadows within this habitat	- The USFWS has determined that populations of the Gunnison's prairie dog located in central and south-central Colorado and north-central New Mexico are warranted for protection under the Endangered Species Act. However, listing these populations at this time is precluded by pending actions for other species with higher listing priorities. The Service also determined that Gunnison's prairie dog populations in Arizona, Utah, and elsewhere in Colorado and New Mexico are not warranted for listing.	Presence or absence of prairie dog colonies. - Is the colony active or inactive? - Number of burrows (count the openings). - Use GPS to record waypoints of burrow openings, or walk one polygon around the entire colony. 	 - Restoration of historic conditions with more openings increases available habitats. - Increase in number of colonies or colony size. 
USFS R2 Sensitive Species Migratory Bird Treaty Act **NEPA**	Raptors. Canopy Nesters. Accipiters *Keystone species*	Northern Goshawk (*Accipiter gentilis*) **R2SS MBTA**  Cooper's Hawk Sharp-Shinned Hawk **MBTA** 	 Throughout Front Range	In the western U.S., characteristically nests in coniferous forests including those dominated by ponderosa pine (PINUS PONDEROSA; Bright-Smith and Mannan 1994, Reynolds et al. 1992), Forages in both heavily forested and relatively open habitats. In Ponderosa pine forest of Arizona, habitat on sites selected for foraging had higher canopy coverage, greater tree density, and greater density of large trees (greater than 40.5 centimeter DBH), but lower prey abundance than non-foraging	- Downed logs are important for perching and plucking posts. ○ Maintain or create downed logs. - Heterogeneous forest structure. - Dominant mammalian prey include five species of tree squirrels, four ground squirrels, and lagomorphs. Frequently killed birds include three galliformes, four corvids, six woodpeckers (piciformes) and the American robin (TURDUS MIGRATORIUS; Squires and Reynolds 1997). During the nesting season, the diet can vary with prey availability	Goshawk broadcast surveys and nest searches. (Cooper's hawk & Sharp-shinned hawk will likely also respond to goshawk broadcast surveys). - Identify **active and inactive nests**. GPS & Photograph.  - Search for **evidence of raptor activity** (pellets, whitewash, feathers, plucking posts). - Count, GPS, & Photograph. 	 - Increased use by accipiters. - More nests, additional alternate nests. - Increased number of plucking posts. Limited Resource. Difficult to find. **WHY?** Keystone predators.

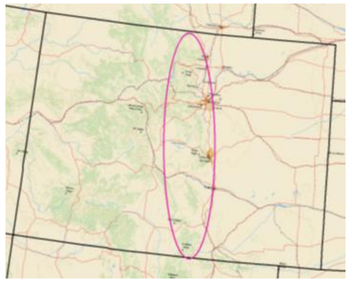
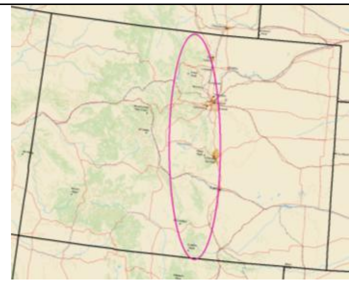
"GUILD"	"SUB-GUILD"	SPECIES	RANGE IN COLORADO	HABITATS	STUDY RESULTS, DISCUSSION, AND NOTES	SAMPLING METHODS	HYPOTHESIS TREND
Federal Threatened Endangered Proposed Candidate Species	Invertebrates Lepidoptera	Pawnee Montane Skipper (*Hesperia leonardus montana*) **ESA T**  *(Genter 2010)*	 Occurs within a 37.9-square-mile area of the Pikes Peak Granite Formation in the South Platte River system of central Colorado. The small, restricted range of the Pawnee montane skipper includes only four Front Range counties: Teller, Park, Jefferson, and Douglas Counties.	The Pawnee montane skipper inhabits dry, relatively open ponderosa pine woodlands with sparse understories at elevations between 6,000 to 7,500 feet.	- Trumbull monitoring study.	If project area is within skipper habitats, look for blue gramma grass and prairie gayfeather during the ground cover vegetation survey. - Record presence of blue gramma grass and prairie gayfeather. - Record percent ground cover of blue gramma grass and prairie gayfeather. 	- Increased presence of prairie gayfeather and blue gramma grass. - POST: Reduction in food plants. ESA CONSULTATION. - Increased percent ground cover of prairie gayfeather and blue gramma grass. - Waltz & Covington 2004, increase in butterfly abundance. Limited Resource. Limited Range & Distribution
Invertebrates	Carabid Beetles (ground beetles) Coleoptera:	Family Carabidae Genus: Pasimachus  Subfamily: Harpalinae Tribe: Harpalini Genus: Anisodactylus Species: sanctaecrucis 	 Throughout Front Range	Downed woody debris. Cheng 2006 -Pg. 169 – Carabids are abundant, exhibit high species diversity, and are functionally important (as predators) in ecosystems. Moreover, carabids are taxonomically stable and easy to collect with standardized methods, such as pitfall trapping. Pg 176: Each of the four forest conditions provided habitat for some species of beetles. No single forest condition can be labeled as optimum in providing habitat. If our management goal is to provide for the greatest diversity of carabids and tenebrionid populations, we must create a heterogeneous landscape of varying disturbance levels.	Pg 169 - Insects are an important component in terrestrial ecosystems with high diversity and abundance and high sensititivity to change in physical and chemical aspects of the environment over time and space, commonly used as indicators of ecosystem structured changes. Cheng 2006 - Pg 176: Both carabids and tenebrionids are suitable ecological indicators of ponderosa pine structural changes, most evidenced by the occurrence of indicator species in the wildfire stands. Silvicultural fuel reduction treatments did not cause a pronounced shift in their community assemblage, particularly for the carabids. **Fuel reduction treatments consistently increased species richness and Shannon diversity measurements for carabids, indicating that carabids may be more useful than tenebrionids as indicators for such treatments.** GTO-173: Higher richness and diversity of carabids more than seven years post-fire, 13 years post-treatment.	- Pitfall traps: plastic cups/coffee cans buried in the ground. - Species diversity and abundance. o Beetle counts. o Photographs for later id. o GPS of trap locations. - Cheng 2006 used 1trap/plot x 10 plots/stand x 16 stands. 	- Increased **species richness** and **Shannon diversity** measurements for carabids in fuels reduction treatments. The Shannon index, is one of several diversity indices used to measure diversity in categorical data. **WHY?** Indicator of heterogeneous landscape.

"GUILD"	"SUB-GUILD"	SPECIES	RANGE IN COLORADO	HABITATS	STUDY RESULTS, DISCUSSION, AND NOTES	SAMPLING METHODS	TREND HYPOTHESIS FEASIBILITY & WHY?
Invertebrates	Pollinator: Noctuid moths *Important prey species for flammulated owls and bats.* *Larvae important prey species for bears. High in fats.*	e.g. Miller Moths *Euxoa auxiliaris*  	 Throughout Front Range	Noctuids, which are large, cold-hardy nocturnal moths that appear more abundant in spring and summer than other arthropods (McCallum1994a), and there is evidence that these are more abundant in pondersa pine/Douglas fir forests than other western conifer forest types (Reynolds and Linkhart 1987)	- GTR 173 pg 24: Depending on timing of fuel reduction treatments, invertebrate herbivores and pollinators (moths and butterflies) that feed on and live in vegetation during some life stage can be immediately affected through direct mortality or loss of food or cover. ○ In the long-term, these invertebrates may benefit from changes in structural diversity caused by fuel reduction treatments that increase the amount of light reaching foliage and the forest floor.	- Light traps. 	 - Immediate Post: Perhaps decrease. - Increase over time with opening of forest structure. - **WHY?** Important prey species for nocturnal raptors and bats. Larvae high in fat and important for bears. 72 percent of moth's bodyweight is fat.  Nighttime Surveys
Bird **SNAGS DIVERSITY**	Cavity Nesters: Secondary Cavity Nesters	Western Bluebird (*Sialia Mexicana*)  Mountain Bluebird *(Sialia currucoides)* 	 Bluebirds commonly found on both sides of the Continental Divide in Ponderosa pine forests between 5,000 and 8,000 feet.  USGS Map, Patuxent Wildlife Research Center	Open areas, forest clearings, savannahs, or forest edges. Nest cavities, low perches, and insect prey in the lower understory and at ground level. Rely on cavities in snags – thinning decreases sang availability, in short-term. Mountain bluebirds normally occupy open woodland or edge habitat with exposed perches and fairly sparse ground cover. USFS FEIS: Hutto and others [33] listed 19 studies reporting increased mountain bluebird populations in partially cut or clearcut forests. In northern Arizona ponderosa pine stands, mountain bluebirds were present on clearcut sites but not in light, medium, and heavily cut stands or in uncut stands [60].	**Germaine 2002** Pg 363: **Recent declines associated with fire suppression activities that have caused open forest habitats to decrease.** Studied nesting success. Pg 365: Restoration treatments did not affect clutch size and had little effect on number of nestlings per nest. **Bluebirds nesting in treated forest had a higher probability of nest success and fledged more young per nest overall. This was due to differential rates of nest predation between forest types (snakes), and this difference diminished over time since treatment. Bluebird nests in treated forest were at greater risk of infestation from [a blood-sucking parasite].** Any management plan should consider the importance of snags for wildlife [39]. Hutto [32] emphasized the importance of snags for cavity nesters. It is generally recommended that all natural snags be left during timber harvest operations unless they pose immediate safety hazards [32,45,52].	Visual and auditory observations. - Point counts (morning surveys) - Monitor nesting. ○ Follow bird observations to active nests. ○ Track nest success. - GPS snags. ○ Verify presence of snags post treatment (as part of implementation monitoring?) 	 - Increased observations. - Increase in nest success. - Number of snags stays the same or increases. - **WHY?** Responds negatively to loss of open forest habitats.

"GUILD"	"SUB-GUILD"	SPECIES	RANGE IN COLORADO	HABITATS	STUDY RESULTS, DISCUSSION, AND NOTES	SAMPLING METHODS	TREND HYPOTHESIS FEASIBILITY & WHY?
Birds **SNAGS**	Cavity Nesters: Primary Cavity Nesters	Lewis's woodpecker *(Melanerpes lewis)* **R2SS**		Snags.	RMRS 2006 Decrease in canopy cover may favor the Lewis's Woodpecker.	Tree damage.	
Birds		Mountain Chickadee 	 Dry, mountainous forests of the West.				
 Birds **SNAGS** **ASPEN** **DIVERSITY**	Cavity Nester: Primary Cavity Nester *Maintain Aspen*	Williamson's Sapsucker (*Sphyrapicus thyroideus)* 		The species is relatively tolerant of disturbance, and maintained breeding densities in both logged and unlogged areas when aspens and large snags were spared (Franzreb and Ohmart 1978). However, contraction of mature aspen forest with snags and decaying trees suitable for nesting, and elimination of large snags generally due to fire or logging operations, decrease the extent of suitable habitat. **Fire suppression in high-elevation conifer forests has resulted in overall loss of aspen habitat. Sapsuckers require particularly soft nesting substrates**, which may be more common in older forests where snags have been standing longer (Dobbs et al. 1997). [NM Partners for Flight]	Maintain and restore (by controlled burning or mechanical thinning) ponderosa pine habitat with large trees, grassy understory, and an **open, park-like structure.** Where possible support controlled and natural fire in mixed conifer forest to increase aspen acreage. When carrying out logging operations, or when salvage-logging **burned forest, leave tall snags and some taller trees for nesting habitat.** Maintain a standing aspen component. Following the recommendations of Conway and Martin (1993), forest management plans should emphasize retention of groups of large snags and areas of high snag density, particularly in drainage bottoms. Management treatments of any habitat where Williamson's Sapsuckers are present should be accompanied by demographic studies and monitoring to determine species response. [NM Partners for Flight]	- Call and drumback surveys. - Identification of forage trees. o Count and GPS location  - GPS snags and cavity nests. o Verify presence of snags post treatment (as part of implementation monitoring?) - GPS Polygons of aspen stands 	 - Increased use of restored, open, park-like forest structure. o Increased number of forage trees. - Number of snags stays the same or increases. - Increased number and size of Aspen stands. **WHY?:** Indicator for diversity of tree species. 
Mammals	Small Mammals Prey Species	Deer mouse (*Peromyscus maniculatus*)	Throughout Front Range		Converse 2006. Pg 271: **Deer mice should increase with thinning or prescribed fire treatments in most areas.**	- Abundance → Mark recapture (Live trapping)	  Specialized Surveys

"GUILD"	"SUB-GUILD"	SPECIES	RANGE IN COLORADO	HABITATS	STUDY RESULTS, DISCUSSION, AND NOTES	SAMPLING METHODS	TREND HYPOTHESIS FEASIBILITY & WHY?
Mammals	Small Mammals: Tree Squirrel *Prey & Forest Growth*	Abert's Squirrel (*Sciurus aberti*) 	 	Ponderosa Pine	(FS Conservation Assessment 2003) Good squirrel habitat contains open, uneven-aged stands, with clusters of even-aged groups connected by canopy corridors to provide secure travel routes. Such forest structure will provide the foods required by squirrels, as well as the canopy cover necessary for fungi production, nesting, and escape. Squirrels reduce cone crops and perhaps growth in ponderosa pine. **However, they contribute to the well-being of the pine by dispersing spores of hypogeous fungi that facilitate water and nutrient uptake by the trees and thereby enhance seedling survival, forest regeneration, and growth**. High quality habitat for Abert's squirrels consists of an open forest with 150 to 250 trees per acre of various sizes, but mostly >30 cm dbh. Stands with trees clustered in small, even-aged groups best provide for the life requirements of squirrels (Patton 1984, Pederson et al. 1987). Bailey and Niedrach (1965) concluded that Abert's squirrels provided most of the food eaten by young northern goshawks, while Reynolds et al. (1992) reported that tassel-eared squirrels made up more than 10 percent of the biomass in their diet. J.G. Hall (1981), who studied Kaibab squirrels during summers from 1960 to 1974, observed a number of attacks on squirrels by predators, including hawks, a coyote, and a bobcat, but none were successful. During a 21-month study in Colorado, Farentinos (1972a) found skulls of Abert's squirrels in castings of great horned owls (Bubo virginianus), observed five unsuccessful attacks by goshawks on squirrels, and twice saw goshawks eating squirrels.	- Squirrel feed trees. ○ Identify and GPS - Squirrel feeding sign (count at each plot and remove) ○ Fungi Digs ○ Clippings ○ Bones (twigs) ○ Cone cobs - Squirrel nests.   Dodd et al. (1998) evaluated nest counts, counts of snow tracks, and counts of feeding sign as methods to obtain population indices on plots with known numbers of squirrels. The most reliable results were obtained with counts of combined feeding sign (fungi digs, cone cores, peeled twigs, and terminal bundles) on sampling plots in April.	- Increased counts of squirrel sign.

"GUILD"	"SUB-GUILD"	SPECIES	RANGE IN COLORADO	HABITATS	STUDY RESULTS, DISCUSSION, AND NOTES	SAMPLING METHODS	TREND HYPOTHESIS FEASIBILITY & WHY?
Mammals DIVERSITY	Small Mammals: Tree Squirrels *High canopy closure.*	Pine (red) Squirrel (*Tamiasciurus hudsonicus*) 		Pine squirrels depend heavily on tree seed and the storage of seed in middens; therefore, quality habitat occurs in forests providing shaded environments with mature trees that produce large seed crops as well as high canopy closure to maintain cool and moist microclimates for middens, and cover from predators	Management practices that eliminate or thin forests and disrupt the appropriate microclimates (Shaw 1936, Finley 1969), or practices that fragment 24 25 forests leading to negative edge effects observed for pine squirrels (Bayne and Hobson 2000), are likely to be detrimental in the short term. Prescriptions that restore conditions of cool, moist ground microclimates and promote cone crop productivity and regularity will likely favor the long-term persistence of pine squirrels.	- Count middens (seed caches) present in plot. Population monitoring: Middens and associated feeding sign are the most detectable means of monitoring **population trends and population persistence** in western forests where midden formation is the rule (Mattson and Reinhart 1996). Because middens are relatively conspicuous and unique structures created only by pine squirrels, surveys can be conducted by biologists with minimal training. Feeding sign associated with middens, including larders of the current year's crop of cones, fresh cone scales, and cone cores during fall and winter, enable occupancy status to be assessed enabling population persistence and trend to be assessed (Young 1995, Mattson and Reinhart 1996, Snow in press). Middens can be revisited each year to monitor population trends, or randomly placed transects or circular plots can be placed and searched to obtain density estimates (Young 1995, Mattson and Reinhart 1996, Snow in press). 	**WHY?** Management that maintains a diversity of successional stages in a temporal and spatial distribution that permits movement and use by pine squirrels is likely to enable long-term persistence within the native disturbance regime. Restored Heterogeneous Forest Structure.
Mammals	Large Mammals: Carnivores	Mountain Lion (*Felis concolor*) 	 Throughout Front Range			- Scat identification (if in plot)  - Motion capture cameras.  NPS	**WHY?** WUI Interface issues. - Collect scat for potential DNA analysis.

"GUILD"	"SUB-GUILD"	SPECIES	RANGE IN COLORADO	HABITATS	STUDY RESULTS, DISCUSSION, AND NOTES	SAMPLING METHODS	TREND HYPOTHESIS FEASIBILITY & WHY?
Mammals	Large Mammals: Omnivore	Black Bear (*Ursus americanus*)	 Throughout Front Range		RMRS Thinning increases amount of grasses and berries used by black bears for foraging, but may reduce the amount of hiding cover, den sites in hollow logs, and down wood used for foraging on ants and wasps.	- Scat - Destroyed logs - Hollow logs - Insect digs 	**WHY?** WUI Interface issues.
Mammals	Large Mammals Ungulates	Elk & Deer	 Throughout Front Range	Varied, open forests and meadows with productive grassy understory.	Kruse 1972Pg 3: After the fire, deer pellet groups increased in the burned areas. As with elk sightings of deer became more numerous before cattle were allowed to return. Observations indicate improved habitat for deer, especially where browse species increased.	Pellet counts (remove pellets after each count). 	**WHY?** Hunted species.

5-10-2010 Draft List:

MAMMALS →	Large Mammals →	Ungulates →	**Elk and Deer**		
		Carnivore →	**Mountain Lion**	***PLOT***	
		Omnivore →	**Black Bear**		
MAMMALS →	Small Mammals →	Tree Squirrels →	**Abert's Squirrel**	***PLOT***	
		Tree Squirrels →	**Red Squirrel**		
BIRDS →	Raptor / Canopy →	Accipiters →	**Northern Goshawk**	***PLOT OR SURVEYS***	
	Cavity Nesters →	Primary →	**Williamson's Sapsucker**		
	→	Secondary →	**Bluebirds**		
INVERTS →	Carabidae →	**Carabid Beetles**		***PITFALL TRAPS***	

Density, Diversity, Population Persistence, Occupancy, or Population Trends

Missing: Reptiles, Amphibians

Appendix C. Metrics Team Literature Reviewed, Expert Interviews, and Findings

As part of the process in developing this monitoring plan, a FRRT sub-group, the Metrics Team, was established to develop specific and quantifiable metrics that could be used as target values to define ecological restoration under the monitoring program. However, in the course of this review, it became apparent that almost all the experts agreed that specific metrics were not possible nor desirable because of the historical and environmental variation present in Front Range montane forests (see Chapter 3). The results of this effort informed the monitoring working team discussion and are included as an Appendix to emphasize the difficulty in establishing specific goals. However, the Monitoring working group did not reach concensus on the recommendations and they are not part of the CFLRP monitoring plan.

Table 8. Literature reviewed as part of the Metrics Team review to define monitoring metrics for ecological restoration in Front Range montane ecosystems (arranged in order of publication date)

Paula J. Fornwalt, Merrill R. Kaufmann, Laurie S. Huckaby, Thomas J. Stohlgren. 2009. Effects of past logging and grazing on understory plant communities in a montane Colorado forest. Published online: 4 October 2008, Springer Science+Business Media B.V. 2008. *Plant Ecol* (2009) 203:99–109. DOI 10.1007/s11258-008-9513-z (pdf 337 k)
Platt, R.V., T. Schoennagel. 2009. An object-oriented approach to assessing changes in tree cover in the Colorado Front Range 1938-1999. *Forest Ecology and Management*. 258: 1342–1349.
M.E. Hunter, W.D. Shepperd, L.B. Lentile, J.E. Lundquist, M.G. Andreu, J.L. Butler, and F.W. Smith. 2007. A Comprehensive Guide to Fuels Treatment Practices for Lower montanein the Black Hills, Colorado Front Range, and Southwest. USDA Forest Service RMRS-GTR-198. 2007
Kaufmann, Merrill R., Thomas T. Veblen, and William H. Romme. 2006. Historical fire regimes in lower montane forests of the Colorado Front Range, and recommendations for ecological restoration and fuels management. Front Range Fuels Treatment Partnership Roundtable, findings of the Ecology Workgroup. www.frftp.org/roundtable/pipo.pdf.
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Table 9. Experts interviewed for the monitoring plan.

Name	Role	Organization
Greg Aplet	Senior Forest Scientist	The Wilderness Society
Dan Binkley	Professor	Colorado State University
Peter Brown	Director	Rocky Mountain Tree-Ring Research
Paula Fornwalt	Research Ecologist	USFS Rocky Mountain Research Station
Laurie Huckaby	Ecologist	USFS Rocky Mountain Research Station
Chad Julian	Lead Forester	Boulder County Parks and Open Space
Merrill Kaufmann	Research Scientist Emeritus	USFS Rocky Mountain Research Station
Jose Negron	Research Entomologist	USFS Rocky Mountain Research Station
Claudia Regan	Regional Vegetation Ecologist	USFS Region 2
Richard Reynolds	Research Scientist	USFS Rocky Mountain Research Station
Monique Rocca	Associate Professor	Colorado State University
Tania Schoennagel	Research Scientist	Colorado University – Boulder
Rosemary Sherriff	Assistant Professor	University of Kentucky
Jim Thinnes	Regional Silviculturist	USFS Region 2
Tom Veblen	Professor	Colorado University - Boulder

Summary of the Expert Interview Findings

A. Planning where to do treatments

- Prioritize treatments near sites that have historical information already collected—leverage existing fire histories.
- Prioritize treatments on non-north facing slopes as these are likely to have changed the least (compared with 1938 aerial photos).
- Use aerial photos to see which forests have increased in density most since 1938.

B. Planning treatments at the site

- It is not appropriate or realistic to set target values of metrics that would be considered to represent restoration across the Front Range; Set specific and quantifiable desired future conditions site by site. Do some form of assessment of current conditions at each site selected for treatment. Do a quick and dirty fire history assessment before treatment.
    - Follow Bald Mountain example of assessing historic stand structure, interpreting literature to identify HRV for the area and using that information in planning the treatment.
    - Use IMPD fire history database for local fire histories to reconstruct fire regimes.
    - Use historical plot data - consolidate all GIS locations of known plots by scientists throughout the Front Range; use the plots to learn about historical fire regime and how the data should inform the treatment.

- Do not extrapolate from out-of-region data (e.g., Black Hills or Southwest).
- Do not extrapolate across the Front Range from data at one location (e.g. Boulder Co. or Cheesman Lake); need different metrics for North Front Range vs. South.
- Bark beetles are an example of disturbance that treated stands may experience. Treat for resilience: if we go into stands and try to implement perpetual thinning from below, we'll end up with a homogenous stand with large trees and a MPB outbreak would cause loss of all trees with no smaller trees left to regenerate the forest. Don't set up an "old folks' home".

C. Implementing treatments

- Leave a diversity of species and sizes of trees on the landscape; have groups of all ages in a particular area.
- Pay attention to clumps at a finer scale.
    - Don't want orchards or parks—even spacing between trees not desired.
    - Plan for dumpiness during implementation, don't just assume it will happen naturally over time from thinning; provide the dumpiness variability during the treatment.
    - Patches of acres or tens of acres, not hundreds of acres of even-aged stands of trees (need variability between patches).
    - Consider untreated stands as part of the landscape variability.

- Demonstration sites are helpful to show contractors examples of markings desired. If no treated demonstration area available, then the agency should do the marking, not the contractor. Photo series can also help.
- Need 2-5 trees with interlocking crowns to support squirrels and goshawks (data from the Southwest; might also apply to Front Range).

- Look to open existing meadows where forests have encroached; start with existing openings and expand. Avoid very large openings because they cannot look natural and would not be socially acceptable (openings should range between 1/2 ac up to 5 ac); openings should be on southerly and western aspects as much as possible.
- If MPB is present within 3-9 kilometers of a planned treatment site, take risk of MBP attack into account - project possible MPB mortality. Don't leave only larger trees; leave some smaller trees too in case of MBP attack on larger trees.
- Where there are older, larger trees, maintain them.
- Maintain some Douglas fir mainly on north-facing slopes, since they tended to historically exist there (i.e., if removing Douglas fir, remove it mainly from non-north facing slopes).

D. Monitoring

- Be aware that post-treatment, some wildlife will benefit but some will not; be specific about expected benefits expected for specific wildlife.

Appendix D: Review compiled by Colorado Forest Restoration Institute of Ecological, Social and Economic Monitoring Indicators used in Forest Projects nationally.

Our investigation of twenty-three websites uncovered a total of fifteen U.S. based forest management (and/or stewardship) related documents that contain monitoring protocol with indicators for capturing Ecological, Social and Economic impacts. These documents are formatted as either 1) how-to guides for setting up collaborative processes and identifying / establishing pertinent monitoring criteria, or 2) are specific criteria indicator examples that have been pulled for existing demonstration and pilot project management plans. I found eight of these documents as the most useful and they are listed at the end of this report, accompanied with synopsis and link. Below is a complete list of the websites which have useful information, starting with the source cited in the Collaborative Forest Landscape Restoration Act and used in the Front Range CFLRP monitoring working group:

Ecological Restoration Institute, Northern Arizona University

These publications are specifically mentioned in the CFLRP legislation and is on the CFLRP website: http://www.fs.fed.us/restoration/CFLR/index.shtml. ERI has the most extensive set of handbooks on multiparty monitoring.

Following is a brief list of ecological, economic, and economic, and social indicators from the ERI Multiparty Monitoring and Assessment of Collaborative Forest Restoration Projects - Short Guide for Grant Recipients
http://www.eri.nau.edu/files/Implementation/CFRPmonitoringShortGuide.pdf.

Ecological indicators

1) Live and dead tree density
2) Live and dead tree size
3) Overstory canopy cover
4) Understory cover
5) Surface fuels

Social and economic indicators

1) Jobs created
2) Skills gained
3) Value of wood products
4) Outreach and education
5) Community perceptions

Derr and Schumann – A series of 6 Handbooks:

- http://library.eri.nau.edu/gsdl/collect/erilibra/index/assoc/HASH014e/748544ce.dir/doc.pdf -
  Handbook 1 What is Multiparty Monitoring?
- http://library.eri.nau.edu/gsdl/collect/erilibra/index/assoc/HASH015b.dir/doc.pdf
  Handbook 2: Developing a Multiparty Monitoring Plan
- http://library.eri.nau.edu/gsdl/collect/erilibra/index/assoc/HASH01a0/ffe7bfd0.dir/doc.pdf
  Handbook 3: Budgeting for Monitoring
- http://library.eri.nau.edu/gsdl/collect/erilibra/index/assoc/HASH5773.dir/doc.pdf
  Handbook 4: Monitoring Ecological Effects
- http://library.eri.nau.edu/gsdl/collect/erilibra/index/assoc/HASH015d.dir/doc.pdf
  Handbook 5: Monitoring Social and Economic Effects of Forest Restoration
- http://library.eri.nau.edu/gsdl/collect/erilibra/index/assoc/HASH010e.dir/doc.pdf
  Handbook 6: Analyzing and Interpreting Monitoring Data

Other Monitoring Documents and Information

- **Forest Sustainability Indicator Tools for Communities (2003)** http://www.communitiescommittee.org/fsitool/index.html - (*Documents on this site were developed in a collaborative effort with the purpose of Linking Communities to the Montreal Process Criteria and Indicators project.* Site provides links to resources, workbooks and organizations)

- **National Forest Foundation** http://www.nationalforests.org/ – (Lemhi County Multi-party Monitoring Plan)www.nationalforests.org/file/download/703 **–** This multi-party monitoring plan establishes a framework of monitoring actives and protocols to be carried out on 16,000 acres in Salmon-Challis National Forestlands and adjacent private lands. Protocol and monitoring framework focuses on: fuel reduction; fire breaks; restorative vegetation; enhancing designated old growth units and riparian areas; and an aquatic restoration project design. The project also aims to track economic indicators associated with community-oriented fuel reduction, forest and watershed restoration related activities. General note: Economic indicators identified are weak in comparison to other monitoring indicators but are none the less included.

- **Roundtable on Sustainable Forests** www.sustainableforests.net – (Summary of Indicators and Refinements document)

- **Western Collaboration Assistance Network** http://www.nationalforests.org/conserve/programs/westcan – (Outcome Based Monitoring Plan with indicator suggestions)
- **USDA Forest Service** http://www.fs.usda.gov/wps/portal/fsinternet/!ut/p/c4/04_SB8K8xLLM9MSSzPy8xBz9CP0os3gjAwhwtDDw9_AI8zPyhQoY6BdkOyoCAGixyPg!/?ss=1103&navtype=BROWSEBYSUBJECT&cid=fsbdev3_022173&navid=240110000000000&pnavid=240000000000000&position=Not%20Yet%20Determined.Html&ttype=detail&pname=Region%203-%20Grants%20&%20Agreements – (Multiparty monitoring & assessment guidelines)
- **USFS Resource Information Group/Ecosystem Management Coordination page** http://www.fs.fed.us/emc/rig/lucid/index.shtml – (Provides link to LUCID Projects as well as additional Criteria & Indicator links)
- already have below**University of Oregon's Ecosystem Workforce Program** http://ewp.uoregon.edu — (Multiparty Monitoring for Sustainable Natural Resource Management Guidebook found under resources within the Community Based Monitoring and Assessment section)
- **Wisconsin Department of Natural Resources** http://dnr.wi.gov/forestry/assessment/framework.htm
- **Pinchot Partners** http://www.pinchotpartners.org/projects-forest.htm
- **Official Northwest Forest Plan** — http://www.reo.gov/ - interagency regional monitoring program has module links to: Implementation monitoring; species monitoring; social-economic monitoring; and tribal monitoring. Listing of Socioeconomic reports and publications found here: http://www.reo.gov/monitoring/reports/socioeconomic-reports-publications.shtml
- **Canadian Forest Service**: Link to sustainability indicators (broken down by topic areas), but hard to navigate http://canadaforests.nrcan.gc.ca/indicator
- **Fraser Basin, British Columbia:** ***'A Preliminary Framework for the Development of Sustainability Indicators for the Fraser Basin'*** - www.fraserbasin.bc.ca/programs/indicators.html
- **Montana Forest Restoration Committee** - http://www.montanarestoration.org/monitoring
- **Sourcebook on Criteria and Indicators of Forest Sustainability in the Northeastern Area** http://na.fs.fed.us/pubs/sustainability/sourcebook02/criteria_indicators.pdf - This sourcebook is by far the most informative and useful piece of information I've found. Section IV Evaluation of Existing Sustainability/Indicator Projects (pgs 9-23) gives a comparative analysis and dissemination of 60 sustainability/indicator efforts being implemented across the nation. Appendix E Proposed Metrics and Their Data Sources for the Base Set of Forest Sustainability Indicators for the Northeastern Area (pgs 55-60) spans seven criteria areas: Conservation of Biological Diversity; Maintenance of Productive Capacity of Forest Ecosystems; Maintenance of Forest Ecosystem Health and Vitality; Conservation and Maintenance of Soil and Water Resources; Maintenance of

Forest Contribution to Global Carbon Cycles: Maintenance and Enhancement of Long-term Multiple Socio-economic Benefits; and Legal, Institutional, and Economic Framework for Forest Conservation and Sustainable Management. Appendix G Database (pgs 63-64) provides a list of the 60 efforts analyzed broken down by the size and scope of project efforts (i.e. International, National, State, Unit etc.).

- **The Vermont Forest Resources Plan 1999-2008**
  http://www.vtfpr.org/forplan/index.htm - This online report presents a very broad and large-scale strategic vision for sustaining Vermont forests and has identified eight program (or action) areas for achieving long-term desired conditions: Forest Ecosystem Health; Land Ownership and Conservation; Forest Stewardship; Forest-Based Economy/Sustained Economic Prosperity; Recreation; Planning and Policy; Education and Outreach; and Research. The Program of Action Section presents a broad description of each of the desired conditions and lists corresponding objectives or actions to take in achieving these goals.
- **Final Cat Creek Monitoring Protocol** - www.nationalforests.org/file/download/704 – This Monitoring Protocol is designed to be an evaluative tool for local stakeholders to monitor and assess the socio-economic and ecological impacts of the Cat Creek Stewardship Project. While this document outlines indicators for tracking both ecological silviculture and socio-economic objectives associated with the project, it definitely carries more weight on ecological silviculture side which feels more developed and specific.
- **2007-2009 Oregon Forests Report: Introducing Oregon's Indicator of Sustainable Forest Management**
  http://www.oregon.gov/ODF/PUBS/docs/Oregon_Forests_Reports/OFR_2007.pdf – Similar to the Vermont Forest Resource Plan in its broad overarching strategic priorities. This document identifies 7 strategies that encompass ecological, economic and social monitoring indicators for ensuring sustainable forest management practices. A few newly mentioned indications include: Ecosystem Services and Carbon Storage Stock.
- **Monitoring For Forest Management Unit Scale Sustainability: The Local Unit Criteria and Indications Development (LUCID) Test** -
  http://www.fs.fed.us/emc/rig/documents/lucid/LUCID_Management_Edition.pdf - This report presents the results of the USDA Forest Service's project to develop a sustainability monitoring program for the local or forest management unit (FMU) of scale. This document is presented in an overview format with discussions on the purpose, priorities and process approaches taken as well as results and recommendations for future implementation. It also includes a thirteen page Appendix: Final Suite of LUCID Principles, Criteria, Indicators and Measures.
- **New – Wisconsin's Forest Sustainability Framework**
  http://dnr.wi.gov/forestry/assessment/pdf/WisForestFramework_Final.pdf - Outlines seven Criteria of Sustainability (Biological Diversity; Productive Capacity; Ecosystem

Health and Vitality; Soil and Water Resources; Contributions to Global Carbon Cycle; Benefits of Forests and Their Ecosystem Services; Legal and Institutional Framework for Conservation and Managements). This short, easy-to read document provides a Summary of Criteria that lists all associated indicators and metrics that appear in the Framework for each of the seven criteria.

- **Forest Sustainability Indicator Tool Kit (Appendix D: Case Studies)** http://www.communitiescommittee.org/fsitool/AppendixD.pdf (taken from the Forest Sustainability Indicator Tool Kit for Communities which can be found here: http://www.communitiescommittee.org/fsitool/index.html) – This appendix provides information on three pilot community case studies that used the Indicator Toolkit for initiating the Montreal Process Criteria and Indicators framework. The "lessons learned" by each of these pilot communities provides a new frame of reference on the perceptions and usability of this framework. Both the first and third pilot communities (Gogebic County, Michigan; and Baltimore County, Maryland) provide a matrix of indicators identified in their process.
- Adaptive Management and Social Learning in Collaborative and Community-Based Monitoring: a Study of Five Community-Based Forestry Organizations in the western USA http://www.ecologyandsociety.org/vol13/iss2/art4/ES-2008-2400.pdf
- Navigating the Motives and Mandates of Multiparty Monitoring http://www.forestguild.org/publications/research/2007/Navigating_Multiparty_Monitoring.pdf
- Programmatic Monitoring of the Role Local Communities Play in Developing Stewardship Contracts. Pinchot Institute for Conservation http://www.pinchot.org/uploads/download?fileId=560
- Measuring Community Forest-Sector Dependence: Does Method Matter? http://dx.doi.org/10.1080/08941920701329660
- Seeing the Forest and the Trees: Ecological Classification for Conservation http://www.natureserve.org/library/seeingforest.pdf
- Multiparty Monitoring and Assessment Guidelines for Community Based Forest Restoration in Southwestern Lower montane forests
    - ftp://ftp.nifc.gov/Fire_Planning/AZ_FIRE/Planning/Reference%20Documents/Sec%20VI/FS%20MM%20chapter-2.pdf Chapter 2: Multiparty Monitoring Process

Appendix E: Participants in the Front Range Collaborative Forest Landscape Restoration Monitoring Working Group

Participants in the Front Range Collaborative Forest Landscape Restoration Monitoring Working Group			
Last Name	**First Name**	**Also on the CFLRP Econ and Soc Team**	**Organization**
Andrew	Kathy	x	El Paso County
Aplet	Greg		The Wilderness Society
Babler	Mike		The Nature Conservancy
Battaglia	Mike		US Forest Service
Beh	Gali	X	Beh Management Consulting, Inc.
Briggs	Jenny		US Geological Survey
Brown	Peter	x	Rocky Mountain Tree-Ring Research
Bruno	Jonathan	x	Coalition for the Upper South Platte
Casamassa	Glenn		US Forest Service, ARP
Champ	Patty		Rocky Mountain Research Station
Clement	Jessica	x	Colorado State University
Dziomba	Richard		Blue Knight Group
Edwards	Rich	X	Colorado State Forest Service
Edwards	Richard (Dick)		US Forest Service
Ellwood	Leslie		US Fish and Wildlife Service
Feinstein	Jonas	x	Natural Resources Conservation Service
Ford	Susan		US Forest Service-Region 2
Fornwalt	Paula		US Forest Service
Gibbs	Hal	X	US Forest Service, ARP
Gunsalus	Chelsea		US Forest Service, ARP
Hackett	Jan		Colorado State Forest Service
Hansen	Craig	x	US Fish and Wildlife Service
Hardman	Amanda		Center of the American West
Ignatius	Jim		Teller County
Jahnke	Jeff		Colorado State Forest Service
Julian	Chad		Boulder County
Kaufmann	Merrill		US Forest Service
Kennedy	Don		Denver Water

Kent	Brian		Rocky Mountain Research Station
Krebs	Kathleen		Clear Creek County
Len	Dan		US Forest Service, ARP
Lewis	Paige	x	The Nature Conservancy
Limerick	Patricia		Center of the American West
Long	Larry		Colorado State Forest Service
Martin	Bryan	x	Colorado Mountain Club
Martin	Deborah		US Geological Survey
Martin	Mark		US Forest Service
Mayben	Sara	X	US Forest Service, PSICC
McHugh	Mike		City of Aurora
Morgan	Ken		Colorado Division of Wildlife
Motley	Pam		Uncompahgre Partnership
Ortega	Aaron		US Forest Service, PSICC
Pecotte	Maribeth		US Forest Service, ARP
Peterson	John		US Forest Service, PSICC
Regan	Claudia		US Forest Service-Region 2
Schaefers	Julie	x	US Forest Service
Schoennagel	Tania		University of Colorado at Boulder
Sharp	Tonya		Colorado Division of Wildlife
Smith	Rocky		Colorado Wild
Stremel	Nick		Boulder County
Trummer	Matt	x	RM Technology
Underhill	Jeff		US Forest Service, PSICC
Valladares	Janelle		US Forest Service, PSICC
Veblen	Tom		University of Colorado at Boulder
Walsh	Christine		US Forest Service
Woods	Scott		Colorado State Forest Service
Yates	Wade		Jefferson County
Zimlinghaus	Kevin		US Forest Service
Ny	Kawu		US Forest Service