Forest Management and Monitoring Guidelines for Peaks to People Water Fund Projects

Working Final 1.0

Introduction and Purpose

The Cache la Poudre and Big Thompson watersheds of the northern Colorado Front Range supply water and other valuable ecosystem services to over 300,000 people in Fort Collins, Loveland, Greeley, and surrounding municipalities (Talberth et al. 2013). High forest densities and heavy fuel loads put these watersheds at risk of high-severity wildfire, with potential for negative impacts to water resources through soil erosion, sedimentation, and debris flow. The High Park Fire of 2012 illustrated the vulnerability of northern Front Range watersheds to fire, burning nearly 90,000 acres and negatively impacting local water supplies through soil erosion and sedimentation.

The Peaks to People Water Fund is working to improve watershed health and protect water resources on the northern Front Range through well-designed forest management targeting areas of highest wildfire risk and impact to water resources. Management activities (i.e., treatments) under Peaks to People are focused on changing forest structure and fuel loads in ways that reduce the potential for active crown fire and high-severity fire effects over broad scales. Where possible, additional ecological and social values will be incorporated, such as protection of infrastructure within the wildland urban interface and habitat enhancement for wildlife.

Projects funded by the Peaks to People Water Fund will follow a process of planning, implementation, and project evaluation as outlined in the Peaks to People Operations Plan (Section 2 Participation in the Water Fund). The planning phase of project development involves identifying management goals and objectives, followed by the development of treatment prescriptions that specify how work is to be conducted on the ground. The project evaluation phase then incorporates monitoring criteria that can be used to assess project performance and whether management goals and objectives were met. This document provides a broad set of forest management goals, treatment guidelines, and monitoring criteria to guide the development of projects under the Peaks to People Water Fund. This document is intended to serve as a starting point for the design and monitoring of initial projects, but should be considered a "living" document to be updated and modified as the water fund continues to develop.

General Forest Management Goals

A wide range of forest types occur within the Cache la Poudre and Big Thompson watersheds, ranging from ponderosa pine and dry mixed-conifer forests (ponderosa pine/Douglas-fir forests) at lower elevations (up to ~8,500 feet), to wet mixed-conifer and lodgepole pine forests at intermediate elevations (up to ~10,500 feet), and grading into spruce-fir forests at higher elevations (above ~10,000 feet) (Peet 1981; Veblen and Donnegan 2005). Across forest types, treatments aim to create forest conditions that are resilient to disturbances such as wildfire and that provide important ecosystem services, especially as they relate to water supply and security. Forest management under the Peaks to People Water Fund will be conducted with the following primary goals:

- Wildfire – create and maintain forest structural conditions that reduce the potential for active crown fire and high-severity fire effects over broad scales;
- Water resource and infrastructure protection – protect rivers, streams, reservoirs, and infrastructure (e.g., intakes) from adverse impacts associated with post-fire soil erosion and sedimentation.

Where possible, forest management should incorporate additional social and ecological values to achieve multiple resource benefits. Secondary forest management goals include:

- Community protection and fire response – promote fire adapted communities and provide tactical opportunities for safe and effective fire response within the wildland urban interface;
- Forest health and resilience – create and maintain forest conditions that are resilient to insect and disease outbreaks, as well as climate change impacts;
- Wildlife – enhance wildlife habitat elements at necessary scales to benefit multiple species and guilds, such as ungulates, Abert's squirrel, Merriam's turkey, and cavity nesting birds;
- Recreation – maintain forest conditions that provide opportunities for a wide variety of recreational activities such as hiking, mountain biking, rafting, camping, and horseback riding.

Considerations by Forest Types

Ponderosa pine and mixed-conifer

While the general management goals above are applicable across forest types, the way in which these goals will be achieved on the ground varies based on forest type. In ponderosa pine and dry mixed-conifer forest types, planners and practitioners are encouraged to follow a restoration-based approach to forest management based on guidance in Dickinson and SHSFRR (2014), Tinkham et al. (2017), and Addington et al. (2018). The following treatment specifications apply in these forest types:

Stand Density and Spatial Distribution – Reduce overall stand density by removing trees across size classes, with emphasis on small trees (< 6" diameter at breast height [dbh]). Residual density should not be uniform but rather should vary with terrain and soil moisture. Enhance spatial heterogeneity by establishing openings and retaining groups of trees and scattered individual trees. Dry areas (ridges and south-facing slopes) within treatment units should be open with low tree densities while wet areas (lower slopes and north-facing slopes) may contain higher tree densities. Post-treatment canopy cover, averaged over the entire treatment unit, should be in the 10 to 40 percent range. At finer scales within the unit (e.g., plot scale), canopy cover may range from 0 to 60+ percent cover to achieve spatial heterogeneity goals.

Openings – Enhance existing openings by removing conifer encroachment. Establish new openings wherever possible, especially in areas where no historical remnants or features (e.g., stumps, downed logs, old trees) are present, as lack of these features may indicative historical openings where conifer encroachment has occurred. Openings should be irregularly spaced and should be variable in size, ranging in size from 0.1 to 5+ acres.

Species Composition – Preferentially retain ponderosa pine over other conifer species such as Douglas-fir and lodgepole pine. Retain healthy aspen and limber pine. Rocky Mountain juniper may be retained on dry sites if locally rare and not serving as a ladder fuel to the ponderosa pine canopy.

Size and Age Class Distributions – Focus tree removals on overrepresented size and age classes, especially overabundant post-settlement trees. Avoid removing old ponderosa pine trees (> 200 years), regardless of size. Use morphological characteristics such as flattened crown form, large branches, thick bark plates, and deep fissures as distinguishing features to identify old trees (see Huckaby et al. 2003 for more information about identifying old trees). Avoid removing old Douglas-fir on fire-protected sites, regardless of size. Remove small-diameter trees and ladder fuels near old trees in order to decrease competition and reduce the potential for crown fire. Maintain a mix of tree size and age classes overall to promote an uneven-aged stand structure and ensure long-term sustainability of the stand.

Disease and Insects – Remove trees infected with mistletoe and those that are infested with mountain pine beetle. Remove beetle-killed trees except for larger diameter trees that would make good wildlife trees and are not hazard trees.

Snags – Retain an average (over the entire treatment unit) of 2-3 snags per acre to provide wildlife value.

Coarse Woody Debris – Retain modest amounts of coarse woody debris (> 3" diameter) on the forest floor for wildlife.

Understory Vegetation – Identify areas that have well-developed yet suppressed understory vegetation and attempt to daylight those areas to stimulate an understory response. Minimize disturbance of understory vegetation throughout the treatment unit.

Surface Fuels/Residual Biomass – Treatments should avoid leaving heavy residual fuel loads on the forest floor. Where possible, whole-tree removal should be considered as a treatment option to minimize residual biomass. Broadcast prescribed burning should also be used where possible following mechanical treatments to reduce surface fuels. Other techniques for dealing with residual biomass include lop-and-scatter, mastication, and pile burning. Mastication and lop-and-scatter should be avoided if the mechanical treatment is to be followed by broadcast prescribed fire, to avoid creating heavy surface fuel loads that can present challenges for prescribed fire operations. If pile burning is used, residual biomass should be prepared for burning using guidelines in the Colorado Pile Construction Guide (http://co.grand.co.us/DocumentCenter/View/5641).

Lodgepole pine and spruce-fir

In higher-elevation forest types such as lodgepole pine, the restoration basis for management may not be as prevalent, but management may still be justified to protect water resources and other values at risk. Management in higher-elevation forests should be aimed at reducing fuel loads and canopy continuity, increasing structural and age-class diversity, and enhancing resilience to fire and pine/spruce beetles. Because higher-elevation forests are adapted to longer fire return intervals and stand-replacing events such as crown fire, a management approach that mimics this disturbance dynamic is appropriate. Resources useful for guiding management specific to lodgepole pine forests include Kaufmann et al. (2008) and Dennis et al. (2009). General treatment specifications include:

- Create openings to increase landscape forest structural and age-class diversity. Large patch cuts are appropriate in higher-elevation forests, up to 100+ acres in size. Uncut reserves up to approximately 10 acres in size within patches can be incorporated as well.
- Patch cuts should be irregularly spaced and shaped to create landscape heterogeneity and a diversity of patch age structures.
- Increase aspen cover by daylighting existing aspen stands.
- Treatment specifications for surface fuels/residual biomass described above apply to higher-elevation forests as well.

Monitoring Guidelines

Monitoring is a necessary part of the forest management process for Peaks to People Water Fund projects to determine if management goals and objectives have been achieved, and if not, how future work should be modified. Primary monitoring questions to frame project evaluation include:

- How effective has forest management been in reducing fuels and restoring forest structure and composition?
- How effective has forest management been in reducing the potential for high-severity fire effects, post-fire soil erosion, and negative impacts to water resources through sedimentation?

For initial projects supported by Peaks to People, monitoring may include both an on-the-ground, plot-based approach and a model-based approach using the Watershed Investment Tool (Table 1). For the plot-based approach, fuels and forest structure can be measured using monitoring protocols developed by the Colorado Forest Restoration Institute at Colorado State University (see Wolk and Hoffman 2016), or similar field measurement protocols. Metrics for project evaluation may include basal area, trees per acre, canopy cover, canopy height, canopy base height, overstory species composition, shrub cover, understory vegetation cover, and surface fuel loads, as described in Wolk and Hoffman (2016).

The Peaks to People Watershed Investment Tool can then be used for the model-based approach to project evaluation. The Watershed Investment Tool links fire behavior and soil erosion models to predict impacts from post-fire sedimentation to important water supply infrastructure such as reservoirs and diversions (Gannon 2017). The tool calculates a benefit-cost ratio associated with forest management that can be used to prioritize and optimize project opportunities based on specified budget levels. To use the Watershed Investment Tool for evaluating project performance, the following data are necessary: canopy cover, canopy height, canopy base height, canopy bulk density, and fire behavior fuel model assignment based on Scott and Burgan (2005). These data can be gathered from the plot-based monitoring approach described above and used to adjust model inputs to represent post-treatment conditions. Model output can then be used to report changes in predicted fire behavior (e.g., area in active crown fire), soil erosion, and a benefit-cost ratio for treatments related to water resource protection and costs avoided due to forest management. Additional considerations for monitoring include:

- Control sites – Control sites should be incorporated to the extent possible to determine if changes in fuels and forest structure reported for projects are due to treatments versus other factors such as climate. A before-after-control-impact (BACI) monitoring design should be implemented where possible (Stewart-Oaten et al. 1986). Control sites that are in proximity and representative of conditions within the treatment areas are ideal if available, but if not, other controls may be used. The Colorado Forest Restoration Institute has numerous monitoring projects within the Cache la Poudre and Big Thompson watersheds and the extent to which existing controls already established for other projects can be used for Peaks to People projects as well should be further evaluated.
- Spatial scale of assessment – While project-scale monitoring will occur for individual projects as they are implemented, it is also important to assess cumulative impacts of water fund activities at a larger, watershed scale. As details of the monitoring program continue to be worked out, we encourage Peaks to People to consider instituting a regular cycle of watershed-scale evaluation, likely every 3-5 years depending on rates of treatment implementation.
- Additional benefits – Peaks to People is currently working with the Colorado Forest Restoration Institute to incorporate additional benefits of forest management (e.g., wildlife habitat enhancement and recreation) into the Watershed Investment Tool. Peaks to People may wish to develop monitoring protocols for these additional benefits with future projects so that they are accounted for during project evaluation.

- Prioritizing monitoring – Not all projects have to be monitored. If an agency or organization is implementing multiple projects in similar forest types, Peaks to People may choose to monitor a subset of projects using plot-based monitoring approaches. All projects can be evaluated using the Watershed Investment Tool (even if plot data are not available) by applying adjustment factors in the model that best represent conditions on the ground.
- Adaptive management – Adaptive management should be used based on results of monitoring to determine any modifications that should occur in future projects. Aplet et al. (2014) provide a useful outline and description of the adaptive management process being applied to forest management projects through the Collaborative Forest Landscape Restoration Program on the Front Range. This adaptive management approach (or something similar) should be adopted by the Peaks to People Water Fund as well.
- Adaptive monitoring – Key to adaptive management is adaptive monitoring as well, whereby the monitoring program is evaluated on a regular basis and adjustments made to ensure the program is continuing to meet the needs of the water fund in evaluating project performance. We encourage use of this document as a starting point for monitoring, with the idea that adjustments will be made as additional projects are developed by Peaks to People.

Definitions

Canopy base height – Canopy base height refers to the height of the lowest component of the tree canopy. Measurement of canopy base height can be coupled with field measures of canopy height.

Canopy bulk density – Canopy bulk density is the mass of the canopy divided by the canopy volume, typically expressed in kg/m^3. CBD is challenging to measure in the field and is thus often estimated from species-specific allometric equations.

Canopy cover – Canopy cover refers to the amount of ground area covered by tree canopy, expressed as a percentage. For example, 50% canopy cover means that 50% of the ground area is covered by tree canopy. Canopy cover can be measured in the field using a densitometer or via remote sensing.

Canopy height – Canopy height is the height of the highest component of the tree canopy, expressed in meters (m). Canopy height can be measured in the field using a clinometer or laser range finder.

Coarse woody debris – Dead woody material on the forest floor such as downed logs and limbs.

Diameter at breast height – The diameter of a tree stem measured at breast height (4.5 ft or 1.37 m above the ground). The height of the ground is usually measured from the uphill side of the tree base.

Fire behavior fuel model – Fire behavior fuel models describe fuel bed conditions such as fuel loading and fuel bed depths that affect fire behavior.

Opening – A non-forested area containing graminoid, forb, and shrub species within a larger forested patch, stand or landscape.

Stand – A contiguous group of trees sufficiently uniform in age-class distribution, composition, and structure, and growing on a site of sufficiently uniform quality, to be a distinguishable unit (Helms 1998). Defined here as 1 to 100+ acres in size.

Treatment unit – Management unit within which a management treatment may occur, similar to a stand in size (1-100+ acres) but defined more by operational boundaries (natural topographic breaks, roads, property boundaries) than by vegetation; may contain multiple forest types or stands.

Tree group – An isolated, generally dense, subset of trees that have interlocking or directly adjacent crowns (Larson and Churchill 2012; Helms 1998), or have the potential to have interlocking or directly adjacent crowns at maturity.

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Table 1. Questions, metrics, and methods associated with Peaks to People Water Fund projects.

Monitoring/Modeling Question	Metrics	Methods	Use of the Data for Project Evaluation
How effective has forest management been in reducing fuels and restoring forest structure and composition?	Surface fuel loads (tons/acre); tree canopy cover (%); tree species composition, basal area (ft^2/acre) and trees per acre; shrub and herbaceous vegetation cover (%) and load (tons/acre).	The CFRI forest structure and fuels sampling protocol (or similar protocol) will be used to collect data on the ground before and after treatments.	Data will be used to report changes in fuels and forest structure due to treatments, and will provide inputs to fire behavior models.
How effective has forest management been in reducing the potential for high-severity fire effects and post-fire soil erosion?	Modeled fire behavior metrics such as area in active crown fire; modeled soil erosion and sedimentation (tons/acre).	Field data will be used to inform inputs to the Watershed Investment Tool. Specific inputs include canopy cover, canopy height, canopy base height, canopy bulk density, and fire behavior fuel model assignment.	Model output will be used to report changes in predicted fire behavior, soil erosion, and a benefit-cost ratio for treatments.