Landscape Conservation Forecasting for Upper Monument Creek

Report to Upper Monument Creek Collaborative Landscape Restoration Initiative

July 30, 2013

By Greg Low

Applied Conservation

Table of Contents

Page

Executive Summary 4
- **Introduction** 4
- **Process and Methods** 4
- **Key Findings** 7

Introduction 8
- **Project Background and Objectives** 8
- **Project Area** 9

Process and Methods 11
- **Vegetation Data** 12
- **Ecological Models**
  - Review and Refinement 13
  - Natural Range of Variability 14
  - Accounting for Fire 15
- **Assessment of Ecological Condition – Metrics**
  - Ecological Departure 16
  - Open Forest Departure 17
  - Uncharacteristic Vegetation 18
- **Assessment of Future Ecological Condition – Alternative Management Strategies** 18
  - Management Strategies 19
  - Management Scenarios 19
  - Computer Simulations and Reporting Variables 21
- **Return-on-Investment Analysis** 22
- **LCF Benefits and Limitations** 22

Findings
- **Current Ecological Condition**
  - Ecological Systems 25
  - Ecological Departure 25
  - Open Forest Departure 29
  - Uncharacteristic Vegetation 29
- **Forecast of Future Ecological Condition Without Management**
  - Departure 29
  - Alternative Fire Futures 30
- **Management Scenarios Forecasts**
  - Mechanical Thinning Only 31
  - Prescribed Burning Only 31
  - Combined Thinning and Burning 32
  - Large Prescribed Burn Addition 32
  - Zero Open Canopy Departure 32

Feasible Treatment Scenario Forecasts
Treatment Allocation 33
Departure 34
Trajectory 35
Budget 35

Return-on-Investment 35

Acknowledgements 36

Appendices
A. Summary Descriptions of UMC Ecological Systems
B. Model Descriptions of UMC Focal Systems
C. VDDT Model Parameters
D. Management Treatments Summary
E. Model Run Worksheets - Ponderosa Pine/Douglas-fir Woodland
F. Model Run Worksheets - Dry-Mesic Mixed Conifer Forest & Woodland
G. Model Run Worksheets - Mesic Mixed Conifer Forest & Woodland

Executive Summary

Introduction

In 2012-2013, the Upper Monument Creek Collaborative Landscape Restoration Initiative engaged a diverse suite of collaborators to develop science-based restoration and management recommendations for the Upper Monument Creek (UMC) project area in Colorado's Pike National Forest. The group sought to provide community-based information for consideration in the U.S. Forest Service's development of a Proposed Action for a project area on the Pike's Peak Ranger District. The initiative also hoped to serve as a smaller-scale forum to address in depth some of the restoration, management and monitoring issues being considered by the Front Range Roundtable for forests across the Front Range.

The 67,000 acre UMC project area supports a diversity of ecosystems in Colorado's southern Front Range in the vicinity of Colorado Springs. The predominant ecosystems consist of three types of forest and woodland systems: ponderosa pine-Douglas fir woodland, dry-mesic mixed conifer forest, and mesic mixed conifer forest. Historically the area's forests were heavily logged. Fires have been suppressed over many decades, resulting in forest conditions that are vulnerable to unnaturally large and severe wildfires. Portions of the UMC landscape have experienced two large, high-severity fires over the past 20 years, including approximately 11,000 acres burned in the 2009 Waldo Canyon Fire. The area is bordered in several locations by developed lands in the Wildland-Urban Interface (WUI).

Process and Methods

The collaborative analyses and assessment done at the UMC project area included a process known as Landscape Conservation Forecasting ™ (LCF). LCF helps to develop a landscape-level "road map" for considering and adjusting management actions over time. Building upon methods developed under the national interagency LANDFIRE program, LCF is used to assess current ecological conditions, develop management strategies that achieve meaningful and measureable ecological benefits, and forecast future conditions under varied management scenarios, including the associated benefits and costs. The LCF models and methods provide a powerful tool for adaptive ecosystem management.

LCF was one element of a comprehensive assessment at UMC which also included recommendations on the design and spatial placement of treatments. The LCF process comprised six general steps:

1. Vegetation Data. Secured geodata on the major vegetation types, termed synonymously as biophysical settings or ecological systems, by interpreting National Forest vegetation data.
2. Ecological Models. Refined descriptive and predictive ecological models for the major ecological systems by updating models developed initially by the national, interagency LANDFIRE program.

3. Current Condition. Determined current condition of focal ecological systems using the Ecological Departure metric, a broad-scale measure of their "health," and incorporating a new metric to assess the degree of departure from the historic open canopy conditions.
4. Future Condition – Minimum Management. Used computerized ecological models to forecast anticipated future condition of focal ecological systems under minimum management (i.e., no action other than continued fire suppression).
5. Future Condition – Alternative Management Strategies and Scenarios. Used the computerized ecological models to forecast anticipated future condition of ecological systems under alternative management strategies, including a "Feasible Treatment" scenario. A 10-year time horizon was used for the core forecasts; the primary "Feasible Treatment management scenario was also extended for 20 and 50 year forecasts to show each ecological system's projected longer-term trajectory.
6. Return on Investment. Determined costs of alternative management treatments and used return-on-investment analysis to assess which strategies for which ecological systems yield the most advantageous results.

A working group reviewed and refined the LANDFIRE program's ecological models for the UMC's three major woodland and forest ecological systems -- Ponderosa Pine/Douglas-Fir Woodland, Dry-Mesic Montane Mixed Conifer Forest and Woodland, and Mesic Montane Mixed Conifer Forest and Woodland. Model descriptions, vegetation succession classes, and fire return intervals were all revised as needed to reflect local knowledge, research and conditions. The changes were incorporated into the reference condition models using the Vegetation Dynamics Development Tool (VDDT), and model runs were conducted to re-simulate the historical reference conditions (aka NRV, or natural range of variability).

The local Forest Service's extensive vegetation data were reviewed and cross-walked with the revised ecological models for the three major woodland and forest systems. Key data included vegetation type, tree size class, tree cover percentage, habitat structure type, and aspect. Data on soil burn severity and vegetation burn severity were used to assess conditions after the large Waldo Canyon fire. The amount of acres was calculated for each of the five succession classes for each system.

Eight major vegetation types in the UMC project area were initially included in the overall analysis. These systems and the acreage of each system (rounded) are as follows:

Ecological System	Acres
Ponderosa Pine/Douglas Fir Woodland	20,500
Dry-Mesic Montane Mixed Conifer Forest and Woodland	18,700
Mesic Montane Mixed Conifer Forest and Woodland	15,700
Montane Riparian Systems	3,000
Lodgepole Pine Forest	2,400
Gambel Oak-Mixed Montane Shrubland	2,100
Montane-Subalpine Grassland	1,900
Pinyon-Juniper Woodland	100

The three major forest and woodland systems comprise 85% of the UMC area, and were selected as focal systems to be considered using the LCF assessment of management options. Five other systems with small areal coverage within the project area were not included in the LCF methodology.

The *ecological departure* metric developed by the LANDFIRE program (aka Fire Regime Condition Class) was used to assess the UMC project area's ecological condition. Ecological departure is an integrated, landscape-level estimate of the condition of terrestrial and riparian ecological systems. Ecological departure incorporates species composition, vegetation structure, and disturbance regimes to estimate an ecological system's *departure* from its natural range of variability (NRV). NRV is the percentage of each vegetation succession class that would be expected in an ecological system across the landscape under a natural disturbance regime. Ecological departure (from NRV) is measured on a scale of 0 to 100, where higher numbers indicate greater departure. Because the ecological departure metric did not sufficiently reflect important changes in achieving open canopy condition over a 10 year planning time horizon, a separate metric and calculation of *open forest departure* was also developed and applied.

Over the course of three workshops and two webinars, members of the UMC Collaborative reviewed and refined map data, ecological models, potential vegetation management scenarios, and findings from varied simulations of future conditions. A separate working group met to refine the ecological models for the three major systems.

Alternative management strategies were explored to improve the condition of the three UMC forest and woodland systems. Three primary management strategies – mechanical treatment (including mechanical thinning and openings creation), manual hand thinning, and prescribed burning – were incorporated into the VDDT models. Based upon the professional judgment of Forest Service staff, each management strategy was assigned a "success rate" in terms of creating the desired open forest conditions -- 100% for mechanical treatments (50% in mesic forest), 60% for manual thinning, and 50% for prescribed burning after two entries. VDDT computer models were used to simulate conditions under alternative future management scenarios. Using the computer-based models, the likely future condition of the systems was assessed after 10 years under varied management scenarios. Scenarios tested included the following:

1. No management – no management actions except continuation of current fire suppression.
2. Mechanical treatments only – mechanical thinning of closed canopy vegetation, including varying levels of openings creation, to create more open canopy conditions.
3. Prescribed fire only – broadcast burning (after site preparation treatments) to create more open canopy conditions.
4. Combined mechanical treatment and prescribed fire, including the possibility of conducting one large prescribed burn.
5. "Zero canopy departure" – management treatments geared to restore open canopy conditions to the greatest possible degree, regardless of budget or feasibility constraints.
6. "Feasible treatment" – combined mechanical treatment with the addition of manual hand thinning – both at levels deemed feasible based upon the Forest Service's GIS analysis of potential and marginal

treatment areas (e.g., slope, accessibility and other variables), as well as a conservative Forest Service estimate of the amount of feasible, prescribed broadcast burning (following site preparation).

A return-on-investment (ROI) calculation was done for all scenarios, to compare ecological benefits against costs, both *within* and *across* the three ecological systems.

Key Findings

1. The Landscape's Current Condition

The approximately 67,000 acre UMC project area includes a diversity of Southern Rocky Mountain Front ecological systems, ranging from lower elevation grasslands, to oak shrublands, to mid elevation woodlands, to higher elevation woodlands and forests**.**

Three woodland and forest systems dominate the UMC landscape – comprising 85% of the project area. These three systems are ponderosa pine/Douglas-fir woodland (20,500 acres), dry-mesic mixed conifer forest and woodland (18,700 acres) and mesic mixed conifer forest and woodland (15,700 acres).

The three woodland and forest systems are all moderately departed from their natural historic condition. There is a substantial over-abundance of closed canopy conditions, creating an approximately 15,000 acres shortfall of the more open canopy forests that occurred historically. Approximately 63% of the forest is in closed canopy condition, about twice as much as occurred historically. Moreover, because of historical logging, the older succession classes are under-represented in the forests.

Severe fires have created an Uncharacteristic vegetation class. Where the Waldo fire showed a combination of high severity vegetation burn along with high severity soil burn, the vegetation is likely to have a long-term type conversion from the current forest vegetation. This conversion is estimated to have affected approximately 3% of the current forest vegetation.

2. Future Condition Without Management

No management essentially perpetuates the current condition. In the absence of management, and with continued fire suppression, the three focal systems will remain moderately departed from their historic condition, with very little predicted change from current conditions over the next 10 years. Their Open Forest Departure scores are virtually unchanged.

3. Management Strategies

All management strategies – thinning (both mechanical and manual) and prescribed burning – produce ecological benefits in all three forest systems. The benefits accrue independently but are maximized when the treatments are combined.

Benefits achieved depend largely upon levels of treatment application. For example, using the models unconstrained by budgets, policies or physical limitations, it was possible to achieve open canopy forests that approximate historic canopy conditions. Adding a large prescribed burn also proved beneficial in the model outcomes. However, real-world physical constraints limit the amount of acres that can actually be treated.

"Feasible Treatment" Scenario Results

The final "Feasible Treatment" scenario treats approximately 18,000 acres of the forest, based upon the number of acres deemed feasible for each major treatment type – mechanical thinning, manual thinning and prescribed fire. Over a 10 year period, this scenario manages approximately 6,000 acres with mechanical thinning, 6,000 acres with manual hand thinning, 3,000 acres of site preparation, and 3,000 acres with prescribed fire.

The Feasible Treatment scenario substantially increases open forest canopy conditions in all three focal systems over 10 years as compared to current condition and the minimum management scenario. However, there was a smaller improvement in the ecological departure metric over the 10 year time horizon, since the late succession classes are still under-represented.

Management Scenario	Ponderosa Pine-Douglas Fir Woodland		Dry-Mesic Montane Mixed Conifer Forest		Mesic Montane Mixed Conifer Forest	
	Ecological Departure	Open Forest Departure	Ecological Departure	Open Forest Departure	Ecological Departure	Open Forest Departure
Current Condition	40	43	52	43	42	57
No Management - 10 Yrs	39	44	49	43	36	56
Feasible Treatments-10 Yrs	37	**14**	48	**19**	31	**42**
Feasible Treatments-20 Yrs	32	**16**	46	**20**	28	**44**
Feasible Treatments-50 Yrs	23	**21**	36	**24**	22	**49**

Mesic mixed conifer forest canopy remains more closed than the ponderosa pine/Douglas-fir and dry-mesic mixed conifer, but shows the lowest overall ecological departure. A more conservative amount of management thinning occurs in this system due to greater uncertainties and other constraints, but the mesic forest has a higher initial percentage of the late succession classes.

The overall trajectory over 20 and 50 years is good for all three systems. Ecological departure scores improve for all three systems, as the forests mature. However, the forest canopy becomes slowly more closed in the absence of management thinning in future years.

The total 10 year budget for the management treatments totals slightly over $10 million, or approximately $1 million average cost per year.

4. Return on Investment

Return on investment analysis shows roughly equivalent results across all management scenarios and ecological systems. There is relatively little ROI difference between the Mechanical Thinning and Prescribed Burning scenarios – the former treatment costs more but the increased cost is compensated by a higher success rate in achieving open forest conditions. Manual thinning at a lower cost and 60% success rate produces the highest treatment ROI. On an area-weighted basis, the highest overall ecological benefits per dollar invested accrue in the ponderosa pine/Douglas-fir woodland (largely due to a higher level of manual thinning) and least in mesic mixed conifer.

Introduction

Project Background and Objectives

In 2012-2013 the Upper Monument Creek Collaborative Landscape Restoration Initiative engaged a diverse suite of collaborators to develop science-based restoration and management recommendations for the Upper Monument Creek (UMC) project area in Colorado's Pike National Forest. Collaborators included public agency staff, scientists, conservation organization staff, utility company representatives, local community leaders, and others. The group sought to provide community-based information for consideration in the U.S. Forest Service's development of a Proposed Action for the Pike's Peak Ranger District, specifically the Purpose and Need for action. The initiative also hoped to serve as a smaller-scale forum to address in depth some of the restoration, management and monitoring issues being considered by the Front Range Roundtable.

The overall restoration assessment and recommendations included four key elements:

(1) Landscape Conservation Forecasting -- to assess the current condition of the area's ecological systems, test alternative management strategies at varied scales of application, forecast the future condition under alternative management scenarios, and determine the cost required to achieve the desired outcomes. LCF helps to develop a landscape-level "road map" for considering and adjusting management actions over time.
(2) Wildfire Risk Assessment – to determine and map values at risk from wildfire.
(3) Spatial Mapping – to show the location of potential treatment areas based upon fire risk, vegetation types, ecosystem restoration opportunities and management constraints.
(4) Treatment Design Recommendations – to provide detailed assessment and recommendation of treatment guidelines for each focal ecological system.

This report includes a description of the process and findings of the first element -- Landscape Conservation Forecasting. Greg Low, along with Dr. Louis Provencher (Director of Science at The Nature Conservancy's Nevada Chapter), and Susan Abele (currently US Fish & Wildlife Service in Nevada), developed the LCF concept (trademarked by The Nature Conservancy in Nevada), building upon methods developed under the national interagency LANDFIRE program. Landscape Conservation Forecasting is used to assess current ecological conditions, develop conservation strategies that achieve meaningful and measureable ecological benefits, and forecast future conditions under alternative management scenarios, including benefits and costs. The models and methods provide a powerful tool for adaptive ecosystem management.

***Landscape Conservation Forecasting*:**

- uses satellite imagery and vegetation data to assess the health of existing vegetation communities, or ecological systems;

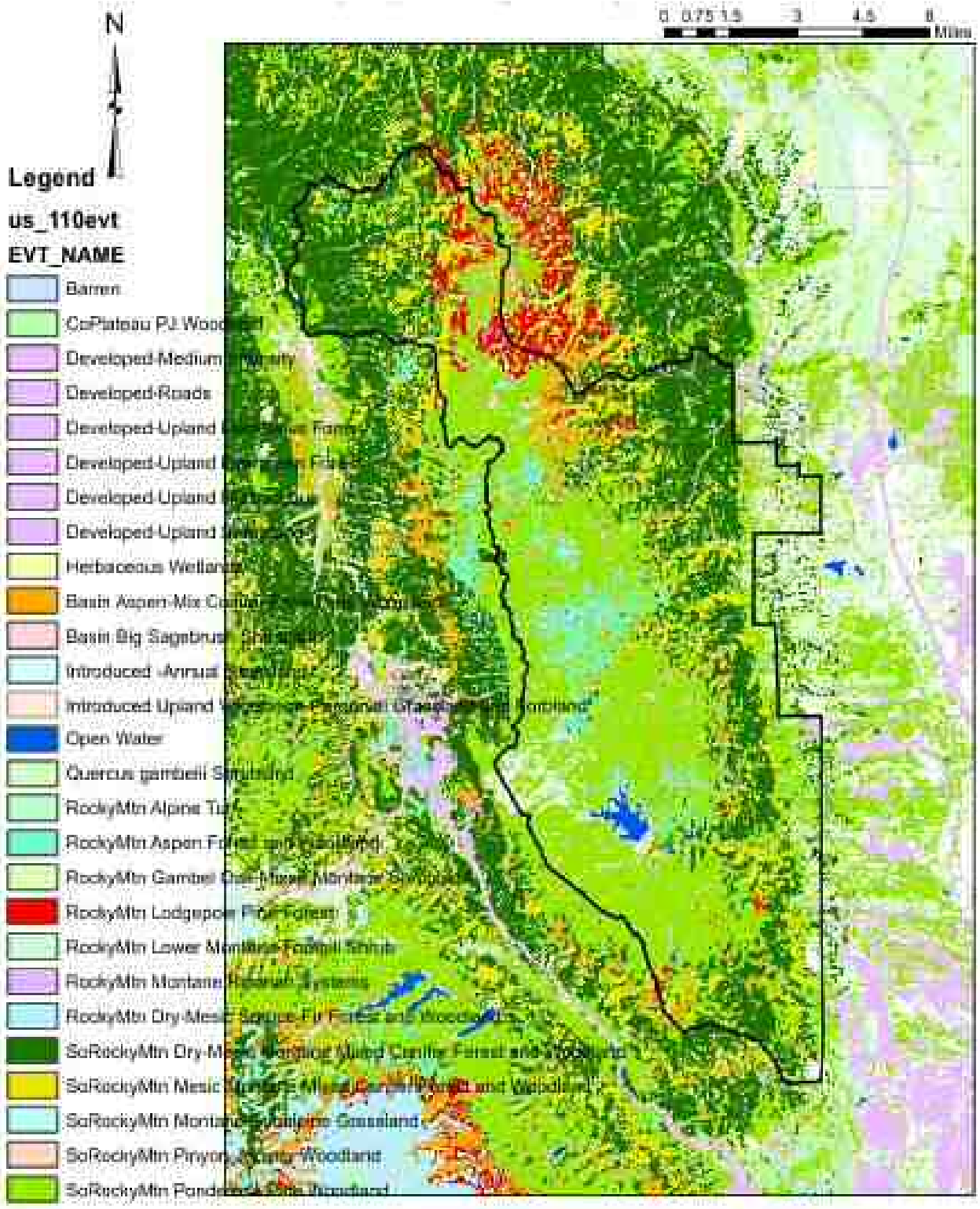
- employs predictive ecological models to demonstrate how those ecological systems will change over time;
- utilizes computer simulations to assess how alternative management actions can influence those changes; and
- measures success by calculating an ecosystem's departure from its natural range of variability (and other customized metrics), with and without various management actions.
- evaluates the cost and benefits of each strategy in order to help land managers prioritize on-the-ground actions to get the highest conservation return on investment.

Project Area

The approximately 67,000 Upper Monument Creek project area is located within the Pikes Peak Ranger District of the Pike National Forest, northwest of Colorado Springs. The area supports a diversity of ecosystems in Colorado's southern Front Range. The predominant ecosystems consist of three types of forest and woodland systems: ponderosa pine-Douglas fir woodland, dry-mesic mixed conifer forest, and mesic mixed conifer forest. Historically the area's forests were heavily logged. Fires have been suppressed over many decades, resulting in forest conditions that are vulnerable to unnaturally large and severe wildfires. Portions of the UMC landscape have experienced two large, high-severity fires over the past 20 years, including approximately 11,000 acres burned in the 2009 Waldo Canyon Fire. The area is bordered in several locations by developed lands in the Wildland-Urban Interface (WUI).

A map of the area's current vegetation (based upon national LANDFIRE vegetation mapping is shown below in Figure 1. The UMC project area is bounded by the dark line.

Figure 1. UMC Project Area Vegetation per LANDFIRE map

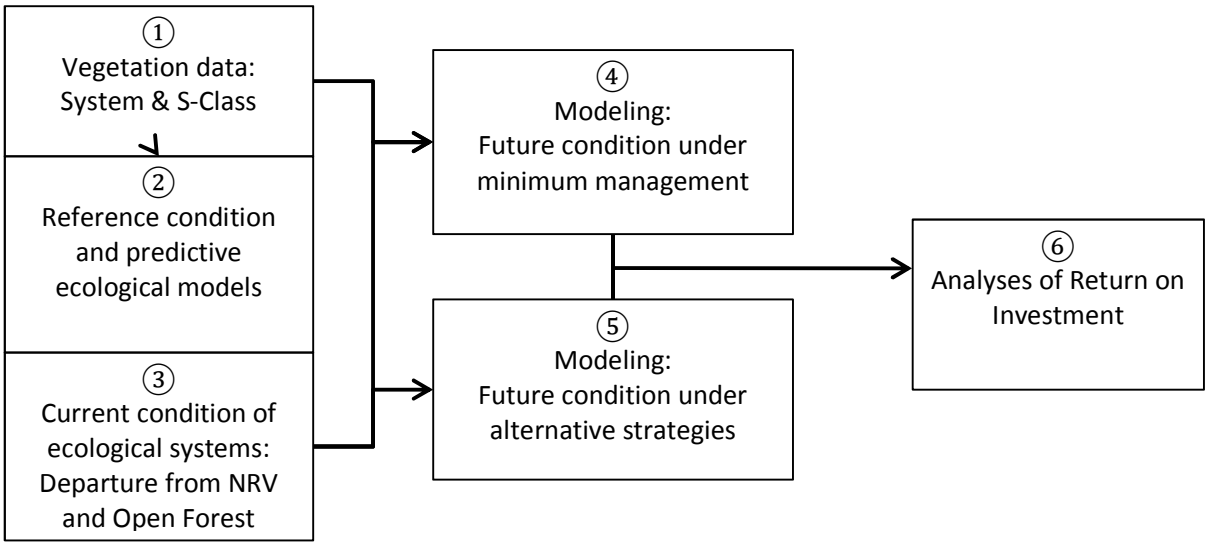


Process and Methods

The analyses and assessment done at the UMC project area included a process known as Landscape Conservation Forecasting™. The Landscape Conservation Forecasting (LCF) process comprised six general steps:

1. Vegetation Data. Secured geodata on the major vegetation types, termed synonymously as biophysical settings or ecological systems, by interpreting National Forest vegetation data.
2. Ecological Models. Refined descriptive and predictive ecological models for the major ecological systems by updating models developed initially by the national, interagency LANDFIRE program.
3. Current Condition. Determined current condition of focal ecological systems using the Ecological Departure metric, a broad-scale measure of their "health," and incorporated a new metric to assess the degree of departure from the historic open canopy conditions.
4. Future Condition – Minimum Management. Used computerized ecological models to forecast anticipated future condition of focal ecological systems under minimum management (i.e., no action other than continued fire suppression).
5. Future Condition – Alternative Management Strategies and Scenarios. Used the computerized ecological models to forecast anticipated future condition of focal ecological systems under alternative management strategies, including a "Feasible Treatment" scenario. A 10-year time horizon was used for the core forecasts; the primary Feasible Treatment management scenario was also extended for 20 and 50 year forecasts to show the projected longer-term trajectory.
6. Return on Investment. Determined costs of alternative management treatments and used Return-on-Investment analysis to assess which strategies for which ecological systems yield the most advantageous results.

A simple schematic diagram that displays the relationship of these components to each other is presented below:



The work on these steps was done over a one year period between July 2012 and July 2013. Detailed descriptions of methods used in each of the project's component six steps are presented in the subsections that follow.

Vegetation Data

The foundation of the geodata component of the project is the stratification of the landscape into biophysical settings or ecological systems.

Initially the project explored the use of biophysical setting (BpS) data available from the national LANDFIRE program. BpS reflects the type of dominant vegetation that is expected in the physical environment under natural ecological conditions and disturbance regimes. However, as the LANDFIRE data were reviewed and compared with locally available Forest Service Common Vegetation Unit (CVU) vegetation data, the latter were judged to be a much more accurate reflection of the vegetation patterns and characteristics across the landscape.

The local Forest Service's vegetation type data were cross-walked with the project area's eight types of major ecological systems (Table 1), using the ecological system descriptions initially developed by NatureServe under the LANDFIRE program. Descriptions and characteristics were modified for several systems for the local project area (see next section on Ecological Models). Key data included vegetation type, tree size class, tree cover percentage, habitat structure type, and aspect.

Table 1. Ecological Systems of the Upper Monument Creek project area.

Ecological System	Acres	% of Area
Ponderosa Pine/Douglas-Fir Woodland	20,470	32%
Dry-Mesic Montane Mixed Conifer Forest and Woodland	18,680	29%
Mesic Montane Mixed Conifer Forest and Woodland	15,660	24%
Montane Riparian Systems	2,970	5%
Lodgepole Pine Forest	2,360	4%
Gambel Oak-Mixed Montane Shrubland	2,140	3%
Montane-Subalpine Grassland	1,890	3%
Pinyon-Juniper Woodland	110	0%

Data were further sub-divided to determine the number of acres in each vegetation succession class (S-class) for each ecological system. Again, the LANDFIRE methodology provided the frame of reference, represented by some variation around A-B-C-D-E succession classes. The A-E vegetation classes typically represent natural succession, from early to mid to late succession, as well as open and closed canopy. The crosswalk is shown in Table 2.

Table 2. Crosswalk of Forest Service Vegetation Data to Ecological Systems & S-Classes.

Crosswalk of USFS Vegetation Data to S-Classes (before Waldo fire)			
Ecological System	**Ponderosa Pine/Douglas-Fir**	**Dry-Mesic Montane Mixed Conifer**	**Mesic Montane Mixed Conifer**
Corresponding FS Vegetation Types	Ponderosa Pine - Douglas-Fir	Aspen Dominated Stands - South Aspect	Aspen Dominated Stands - North Aspect
	Ponderosa Pine/Grass	Douglas-Fir - South	Douglas-Fir - North
		Mixed Conifer - warm &/or dry	Mixed Conifer - cool &/or moist
		Bristlecone/Limber Pines	Spruce-Fir
	Except, on N/NE/NW aspect, >8400'	Ponderosa Pine/Gambel Oak	And, on N/NE/NW aspect, >8400':
	(This was due to a consistent mapping error by		Ponderosa Pine - Douglas-Fir
	one mapper.)		Ponderosa Pine/Grass
A - Early	Tree Cover % >= 10% AND Habitat Structure Type = Shrub/Seedling, previously trees, OR		
	Habitat Structure Type = Grass/Forb, previously trees, OR		
	Tree Size Class = Established		
B - Mid Closed	Tree Size Class = Small OR Medium OR Large, AND		
	Tree Cover % >= 40%		
	Small was included based on the general age criteria for the type as modelled - all S sized stands in this analysis area are > 40 years old.		
C - Mid Open	Tree Size Class = Small OR Medium OR Large, AND		
	Tree Cover % = 10% - 39%		
	Small was included based on the general age criteria for the type as modelled - all S sized stands in this analysis area are > 40 years old.		
D - Late Open	Tree Size Class = Very Large, AND		
	Tree Cover % = 10% - 39%		
	Large was removed to make this class consistent across the MXCON types and our refined PPDF model.		
E - Late Closed	Tree Size Class = Very Large, AND		
	Tree Cover % >= 40%		
	Large was removed to make this class consistent with the MXCON types, which doesn't match our refined PPDF model.		

Additional data were used to assess conditions after the large Waldo Canyon fire, in particular the creation of new early succession Class A vegetation, as well as the creation of new uncharacteristic vegetation due to high soil burn severity and high vegetation burn severity.

Ecological Models

Review and Refinement

On a separate, concurrent track, a working group of the Collaborative reviewed and refined *state-and-transition ecological models* for the project area. A state-and-transition model is a discrete, "box-and-arrow" representation of the continuous variation in vegetation composition and structure of an ecological system. The models are used to represent vegetation classes and dynamics of each major ecological system.

The UMC models working group made revisions and refinements to the LANDFIRE reference condition model descriptions for UMC's three major woodland and forest ecological systems in order to better reflect the local conditions. The three revised models were Ponderosa Pine/Douglas-fir Woodland, Dry-Mesic Montane Mixed Conifer Forest & Woodland, and Mesic Montane Mixed Conifer Forest & Woodland. Revisions included descriptions of the vegetation and the succession classes, age, tree cover, tree size, and fire return intervals. Less extensive revisions were made to the model descriptions for lodgepole pine and montane riparian systems.

Natural Range of Variability

The vegetation classes of pre-European settlement vegetation were considered to be each ecological system's reference condition. The changes were incorporated into the reference condition models using the Vegetation Dynamics Development Tool (VDDT), a computer-based simulation tool developed for LANDFIRE by ESSA Technologies. VDDT model runs were conducted to re-simulate the historical reference conditions (aka, natural range of variability or NRV), using 10 simulations over a 1,000 year time horizon. The natural range of variability for each ecological system is listed below in Table 3.

Table 3. The natural range of variability for UMC's 3 focal woodland and forest systems.

Ecological System	Vegetation Class				
	A	B	C	D	E
Ponderosa Pine/Douglas-Fir Woodland	10	10	15	45	20
Dry-Mesic Montane Mixed Conifer Forest & Woodland	10	5	20	40	25
Mesic Montane Mixed Conifer Forest & Woodland	10	25	20	15	30

Standard LANDFIRE coding for the 5-box vegetation model: A = early-development; B = mid-development, closed; C = mid-development, open; D = late-development, open; E = late-development, closed. See Appendix A for vegetation class descriptions for each of the three systems.

The models for the three focal systems were also revised to include a new *uncharacteristic* (U) class. An Uncharacteristic class is one that would not be expected under a natural disturbance regime (i.e., outside of reference conditions), such as invasion by non-native plants. For UMC, the new U-class was the percentage of vegetation type conversion created by severe wildfires (based upon Waldo fire data) where both high soil burn severity and high vegetation burn severity occurred.

In addition to modeling reference conditions, the predictive models also provide for inclusion of management actions to allow managers to simulate future conditions under alternative management strategies and scenarios. Potential management treatments (described in detail in the following section of "Management Strategies") were incorporated into the VDDT models as transitions (e.g. from a mid-closed class to a mid-open class).

Summary descriptions of all UMC ecological systems and their vegetation classes are provided in Appendix A. Complete descriptions of the revised models for the three focal forest systems are found in Appendix B, and detailed model parameter values (e.g., probabilistic transitions, including potential management actions) for these systems are shown in Appendix C.

Accounting for Fire

The basic VDDT state-and-transition models incorporate stochastic disturbance rates that vary around a mean value for a particular disturbance associated with a given succession class

for each ecological system. For example, fire is a major disturbance factor for all three UMC focal ecological systems, including replacement fire, mixed severity fire and surface fire. These fire regimes have different rates (i.e., mean fire return interval) that are incorporated into the models. VDDT then varies the actual amount of each type of fire that occurs each year around the established rate.

Two factors were considered in accounting for fire activity in the UMC VDDT models: the amount and pattern of wildfire activity in the Pike National Forest over the past 20 years, and the virtual certainty of continued fire suppression as an overarching management activity. These two factors are closely related. The vast majority of wildfires in the area are immediately suppressed; however, a small number of fires escape suppression, and some of these may become large fires in size. The pattern of wildfires in the region over the past 20 years has been many years with no fires, and a few years with large fires. This extreme "either-or" fire variability is challenging to forecast in VDDT, especially over a short 10 year planning time horizon. LCF model runs typically include five replicates. With this pattern of UMC fire activity, in model test runs one of the replicates tended to show a large fire, whereas three replicates showed no or virtually no fire, and one replicate a small amount of fire.

On the other hand, it is relatively straightforward to model fire suppression in VDDT, using *transition multipliers*. A transition multiplier is a number that multiplies a base disturbance rate in the VDDT models: e.g., for a given year, a transition multiplier of 1.0 creates no change in a disturbance rate, whereas a multiplier of 0 is a complete suppression of the disturbance rate, and a multiplier of 0.5 halves the disturbance rate. For UMC a set of transition multipliers was developed and applied for all three types of fire: surface, mixed and replacement fire. A very low multiplier (.10) was applied to surface fire, as these fires tend to be effectively suppressed (i.e., 90% of potential acres burned by surface fire are suppressed; 10% of acres are burned). A higher multiplier (.50) was applied to replacement fire – while these fires are very few in number, suppression is not as effective in controlling the *number of acres* burned; a middle multiplier (.25) was used for mixed fire. Model runs were conducted to test and fine tune these three multipliers for UMC, comparing the amount of fire that occurred in the model runs to the actual amount of fire over the past 20 year time period.

A partial transition to the Uncharacteristic class was added to any replacement fire occurring in the model, based upon the percentage of conversion that was estimated from the Waldo Canyon fire with both severe vegetation burn and severe soil burn – 30% conversion in ponderosa pine and dry-mesic mixed conifer and 20% conversion in mesic mixed conifer.

Assessment of Ecological Condition - Metrics

Ecological Departure

The ecological departure methodology originally developed under the LANDFIRE program was used to assess the ecological condition of each of the three focal systems. Ecological departure is a broad-scale measure of ecosystem "health" – an integrated, landscape-level estimate of the ecological condition of terrestrial and riparian ecological systems. Ecological

departure incorporates species composition, vegetation structure, and disturbance regimes to estimate an ecological system's *departure* from its natural range of variability (NRV).

The fundamental inputs of ecological departure analysis are two-fold: (1) mapping the distribution of biophysical settings or ecological systems; and (2) mapping the current vegetation succession classes of each ecological system. For UMC, as described previously, local Forest Service current vegetation data layers were used in lieu of LANDFIRE data on biophysical settings. The level of departure, or dis-similarity, from NRV for each ecological system was calculated by comparing the current vegetation succession-class distribution with the expected "natural" distribution (see ponderosa pine example in Table 4).

Ecological departure (sometimes called FRC or Fire Regime Condition by federal agencies) is scored on a scale of 0% to 100% departure from NRV: Zero percent represents NRV while 100% represents total departure [i.e., the higher the number, the greater the departure]. Further, a coarser-scale metric known as Fire Regime Condition Class (FRCC) is used by federal agencies to group ecological departure scores into three classes: FRCC 1 represents ecological systems with low (<34%) departure, which is color coded green; FRCC 2 indicates ecological systems with moderate (34 to 66%) departure, which is color coded yellow; and FRCC 3 indicates ecological systems with high (>66) departure, which is color coded red. An example of ecological departure and corresponding ecological departure class is shown in Table 4.

Table 4. Calculation of Ecological Departure for UMC Ponderosa Pine/Douglas-fir.

Ponderosa Pine/Douglas Fir Woodland							
Class	**A-Early**	**B-Mid Closed**	**C-Mid Open**	**D-Late Open**	**E-Late Closed**	**U-Unchar**	**Total**
Acres in Class	1,783	8,569	4,263	1,982	3,239	636	20,472
NRV	10	10	15	45	20	0	100
Current % in Class	9	42	21	10	16	3	100
Min of NRV/Current	9	10	15	10	16	0	
Ecological Departure							**41**

$$\text{Ecological Departure} = 100\% - \sum_{i=1}^{n} \min\{Current_i, NRV_i\}$$

Ecological departure was not considered a relevant metric for the UMC's five smaller ecological systems (all less than 3,000 acres), as the small size and/or peripheral occurrence of these systems within the project area were not well suited for Landscape Forecasting.

Open Forest Departure

In addition to assessing future condition via *Ecological Departure*, a newly created metric of *Open Forest Departure* was created, designed to measure the departure from historical open canopy conditions. As defined above, ecological departure is an integrated measure of composition, structure, and disturbance regime, and is a key metric to assess current and long term condition. The importance of adding Open Forest Departure as a second indicator was discovered when model simulations showed that an ecological system's overall ecological departure score over 10 years changed very little with targeted management strategies, whereas

its area of open canopy significantly increased (an improvement toward NRV), but was not captured in the integrated ecological departure metric – the reason being that the forest still showed a shortfall of late succession classes.

Open Forest Departure was simply calculated as 100 minus the total of Classes A, C & D divided by the total of those three classes under NRV. For example, if the NRV total of the three classes was 70%, and predicted total in 10 years under minimum management was 40%, there would be a shortfall of open canopy forest. The Open Forest Departure score would be 43 (calculated as 100-(40/70). As with the Ecological Departure metric, a score of 0 would represent no departure from historic open conditions, whereas higher scores would indicate more closed forest conditions.

Uncharacteristic Vegetation

A third factor for assessing future condition was the percentage of the Uncharacteristic vegetation class. However, a noticeable increase in this metric depends upon the occurrence of a large severe fire, which *on average* did not occur in the 10 year model runs due to fire suppression. Therefore, while acknowledging its importance, this metric was not used as a key reporting indicator.

Assessment of Future Ecological Condition – Alternative Management Strategies

Predictive state-and-transition computer models are a key tool in assessing future condition because they can simulate management scenarios.

The three focal UMC ecological systems were selected for management treatment analyses based upon their size, departure from NRV and open forest conditions, and likelihood of continued future departure. As noted previously, the fundamental purpose of LCF is to identify specific, cost-effective vegetation management strategies to maintain, enhance or restore the desired more natural conditions. The assessment of current ecological condition and of future ecological condition under minimum management are merely precursors to this ultimate endpoint. The UMC Collaborative worked on two interrelated tasks toward achieving this fundamental purpose: (1) developed a set of specific management *strategies* (aka *treatments*) that the Forest Service can implement; and (2) analyzed the results of various alternative management *scenarios*, i.e., combinations of management strategies that have a similar theme.

No Management

Using the VDDT computer-based models, the likely future condition of each focal system was assessed after 10 years, assuming *no active management action to restore ecological condition*. No Management essentially represents a “no action” scenario -- other than the continuation of fire suppression. Potential future conversion into the Uncharacteristic class was also included in the model.

Management Strategies

The UMC Collaborative focused on developing large-scale management strategies to restore more natural forest conditions. As such, all strategies were fundamentally designed to: (1) restore more open forest canopy conditions, including early succession, and (2) establish a trajectory over time that would lead to low overall ecological departure, as the forests matured. Working with Forest Service staff and workshop participants, a set of potential management strategies was developed for all of the targeted ecological systems. Costs-per-acre and potential yearly application rates were determined for each management strategy, using the local experience of managers as well as GIS analysis.

Three primary management strategies – mechanical treatment (including mechanical thinning and creation of openings), manual hand thinning and prescribed burning – were reviewed by the Collaborative and were incorporated into the VDDT state-and-transition models. All of the strategies were used for ponderosa pine/Douglas-fir woodland and the dry-mesic mixed conifer forest; all but manual thinning were used in the mesic mixed conifer. Management treatments were expressed as "Area Limits" in VDDT, which was the maximum area that could be treated per year for individual actions.

The models also included a "failure rate" for many management strategies to reflect that some management actions only partially succeed at restoring a vegetation class. Based upon the professional judgment of Forest Service staff, each management strategy was assigned a "success rate" (i.e., the inverse of a failure rate) in terms of creating the desired open forest conditions -- 100% for mechanical treatment in ponderosa pine and dry-mesic mixed conifer and 50% in mesic mixed conifer; 60% for manual thinning; and 50% for prescribed burning after two entries.

A summary table of the management treatment strategies, their ecological effects, success rates and costs is provided in Appendix D.

Management Scenarios

Management scenarios basically represent common "themes" or approaches for grouping individual management strategies, so that the effectiveness of sets-of-strategies can be better compared within and across ecological systems. Six major 10-year scenarios were explored for the UMC project area, some of which included sub-sets of the scenarios.

1. No management – no management actions except continuation of current fire suppression.
2. Mechanical treatments only – mechanical thinning of closed canopy vegetation, including three different levels of openings creation, to create more open canopy conditions.
3. Prescribed fire only – broadcast burning (after manual hand treatments) to create more open canopy conditions.
4. Combined mechanical treatment and prescribed fire, including the possibility of conducting one large prescribed burn.

5. "Zero canopy departure" – a suite of management treatments geared to restore open canopy conditions to the greatest possible degree, regardless of budget or feasibility constraints.
6. "Feasible treatment" – combined mechanical treatment with the addition of manual hand thinning – both at levels deemed feasible based upon the Forest Service's GIS analysis of potential and marginal treatment areas (e.g., slope, accessibility and other variables), as well as a conservative Forest Service estimate of the amount of feasible, prescribed broadcast burning (following site preparation).

The specific parameters of the Feasible Treatment scenario are shown in Table 5 following:

Table 5. Feasible Treatment Scenario Parameters

Mechanical Thinning

Treatments are conducted over first 7 years

6,000 acres total treatment (860 acres/year) for the three focal systems, based upon GIS feasibility analysis (see Table 13)

- Primarily Closed classes (B & E) but some Open classes (C & D) acres are captured within treatment areas
- Allocated 2,300 acres Ponderosa Pine; 1,900 acres Dry Mixed Conifer; and 1,800 acres Mesic Mixed Conifer
- Includes some "marginal" acres with steeper slopes
- Converts Closed to Open classes (C & D)
  - 100% success rate in Ponderosa Pine and Dry Mixed Conifer
  - 50% success rate in Mesic Mixed Conifer; 50% remains Closed
- Mechanical Thinning partly done by Openings Creation (converts Closed to Class A), allocated as follows
  - 20% of mechanical treatment in Closed Ponderosa Pine & Dry Mixed Conifer
  - 10% in Closed Mesic Mixed Conifer
- No s-class change from treatments in Open Classes; cost factor only

Manual Thinning

Treatments are conducted over first 7 years

6,000 acres total treatment (860 acres/year) in two focal systems (see Table 13)

- Occurs within the "marginal" areas in GIS analysis that were not feasible for Mechanical Thinning
- Allocated 60% in Ponderosa Pine and 40% in Dry Mixed Conifer
- Focused on Closed classes (B & E); allocations per GIS analysis
- Converts Closed to Open classes at 60% success ratio; 40% remains Closed

On Site Treatment – Prep for Controlled Burning

Treatments are conducted over first 8 years – two years before controlled burns

3,000 acres total treatment (375 acres/year) in Closed classes of focal systems

Allocated at 33% Pine; 40% Dry; 27% Mesic, based on prescribed burning allocations.

No direct s-class changes; cost factor only

Broadcast Burning

Conducted over final 8 years sequentially following On Site Treatment

3,000 acres total treatment (375 acres/year) in Closed classes of three focal systems

Allocated at 33% Pine; 40% Dry; 27% Mesic; allocations within systems by s-class prorated

Assumes two entries, completed as conditions permit

Converts Closed to Open classes @ 50% success rate after two entries; 50% remains Closed

- *Note: the time frame for second entries will extend beyond the 10 year period but outcomes are reflected in the 10 year model runs*

Maintenance burning @ 250 total acres/year after Year 10 for the 20 & 50 year model runs, to help maintain open conditions

Computer Simulations and Reporting Variables

VDDT computer runs were used to test the scenarios and their sub-sets for each of the focal ecological systems over a 10-year time horizon. The Feasible Treatment management scenario was also extended for 20 and 50 year forecasts to show the projected longer-term trajectory as compared to minimum management. Because the VDDT software does not have an optimization mechanism, this required testing varied combinations of management strategies and levels of treatment for some scenarios.

The primary reporting variables for simulations were: (1) ecological departure score, (2) open forest departure score, (3) total acres treated, and (4) total cost. Results were tallied in a set of Excel-based UMC Model Run Worksheets.

Return on Investment (ROI) Analysis

The final step in the process was the calculation of benefits (magnitude of ecological improvement) as compared to costs of management strategies. Both intra- and inter-system return-on-investment (ROI) metrics were used to determine which of the scenarios produced the greatest ecological benefits per dollar invested *within* each ecological system, and *across* the three focal ecological systems, in relation to MINIMUM MANAGEMENT. The two ROI metrics calculated were:

(1) Ecological Intra-system ROI. The change of ecological departure and open forest departure classes between the MINIMUM MANAGEMENT scenario and an ALTERNATIVE MANAGEMENT scenario for a given ecological system in year 10, divided by total cost of the scenario over 10 years. Correction factors were used to bring all measures to a common order of magnitude.

(2) Ecological Inter-system ROI. The change of ecological departure and open forest departure classes between the MINIMUM MANAGEMENT scenario and an ALTERNATIVE MANAGEMENT scenario in year 10, multiplied by total area of the ecological system, divided by total cost of the scenario over 10 years. Correction factors were used to bring all measures to a common order of magnitude.

If the ROI values within or across systems differ substantially, they are sometimes a useful tool for land managers to decide where to allocate scarce management resources among many possible choices on lands that they administer. Of course, managers also select final strategies or treatment areas based upon a variety of additional factors, such as availability of financial resources, policy constraints, and other multiple-use or societal objectives.

LCF Benefits and Limitations

By developing a decision support tool to assess the benefits and costs of alternative management strategies, LCF provides many benefits to natural resource managers. Among the key benefits are the answers that LCF provides to the following questions:

What is the current condition of each ecosystem in the landscape
What systems are likely to get worse, and how much worse
Which management treatments, and how much, will improve altered ecosystems
What degree of improvement can be feasibly achieved
Where to place treatments on the landscape, by ecosystem and vegetation class
Which management treatments produce the biggest bang for the buck

The models used to help develop the answers to these questions are relatively simple, transparent and easily adaptable, thereby providing a solid framework for adaptive ecosystem management.

Some additional LCF benefits include:

Scorecards of current & future condition
Scientific documentation for National Environmental Policy Act (NEPA) documents
Help attract funding for implementation
Help build collaborative learning and consensus among resource managers and stakeholders

Landscape Conservation Forecasting has some inherent limitations in its applications. Some of the constraints were overcome by adaptations for the UMC project, such as revising LANDFIRE ecological models based upon local expertise, adding an uncharacteristic vegetation class, creating a supplemental metric for open forest departure, and substituting local Forest Service vegetation data for national LANDFIRE data. The following general constraints and challenges are inherent in the LCF methods and tools.

Landscape and Ecosystem Size. LCF is designed for large landscapes (e.g. 50,000 acres +). The larger the landscape and its ecological systems, the more effective is the use of the ecological departure metric. The departure scores of ecological systems become increasingly uncertain as landscape and system size decrease, especially for systems with longer return intervals of stand-replacing disturbances.

Aquatics. LCF does not address aquatic ecosystems. It does address riparian and wetland systems.

Maps and Data. The assessment of current condition is only as good as the vegetation data that supports it. Moreover, this data serves to establish the "initial conditions" for model runs to forecast future conditions. LANDFIRE provides a free, easy-to-use data set with coverage across the United States. However, LANDFIRE data is highly variable in its accuracy. High-resolution and well-interpreted geospatial data is best for understanding current conditions and conducting project-level treatment forecasts. Coarser data or expert knowledge may be acceptable for populating current conditions for large-scale assessments serving a broader purpose.

Models. "All models are wrong, but some are useful." A well-developed predictive model can provide a reasonable approximation of reality. LANDFIRE was designed to use peer-reviewed, consistent, and repeatable scientific methods in developing ecological models. VDDT state-and-transition models exist for reference conditions for most terrestrial and riparian systems of the United States. However, some of the models have not been sufficiently peer reviewed and other

models might be outdated or simplistic. Moreover, many models do not accurately reflect local conditions, including uncharacteristic vegetation classes, and therefore require local, expert-based modifications. Incorporating management actions into models requires expert-based judgments on their ecological effects and probability of success.

Metrics. While ecological departure is a powerful, unified metric of overall ecological "health" – incorporating vegetation structure, composition, and all relevant ecological processes – it does not fully account for all impairments to ecosystems, or all improvements in ecological health over shorter time horizons. Supplemental metrics (e.g. high-risk vegetation, species-based habitat departure) have therefore been developed to meet local needs.

NRV. Ecological departure typically is based upon the natural range of variability (NRV) for the reference conditions (pre-European settlement) of an ecosystem. However, NRV does not necessarily have to serve as the desired future condition (DFC) if local goals or conditions suggest an alternative standard. It is possible to model and measure towards DFC in addition to or instead of NRV. However, NRV does reflect many elements of what is typically desired for a given ecosystem, such as the amount of late succession vegetation, the amount of early succession habitat, and the degree of open canopy desired.

Climate Change. LCF can and has addressed climate change effect in VDDT models, but it is complex and challenging to do so comprehensively and with a high confidence level in the models. Some initial LCF climate change forecasting in the northern Sierra Nevada found that effects are not occurring at a significant level until 40 years out. Two important finding were that management actions taken to restore ecosystems closer to NRV helped to improve future condition in the face of climate change, and the sooner these restoration actions were taken, the better the long-term outcome. Also, without trying to create a direct linkage to climate change models, the VDDT models can be used to simulate predicted future changes in fire regimes and potential other disturbances to explore what ecosystems may look like, and then test alternative management strategies on how to adapt.

Precision. The 0-100 ecological departure scores and other related metrics may suggest a high level of precision to some readers (e.g. a departure score of 53), whereas the scores should be more appropriately viewed as approximations that reflect ranges. A small percentage difference in scores (e.g. 52 vs. 55) is not meaningful, given the inherent imprecision of the underlying models and/or data.

Non-Spatial. The more common non-spatial application of LCF using VDDT models does not address the pattern of vegetation and succession classes across the landscape. Addressing vegetation heterogeneity and fragmentation requires the addition of other spatial modeling tools (TELSA or ST-Sim) and metrics.

Stand-level Dynamics and Treatments. LCF is a landscape-scale planning tool. It does not address vegetation patch size, openings, or stand-level treatments if these occur at the scale of small projects and computer simulations are non-spatial. Qualitative management treatment guidelines cannot be simulated because quantitative rules are required by all simulation platforms.

Findings

Current Ecological Condition

Ecological Systems

The approximately 67,000 acres Upper Monument Creek project area supports a diversity of ecosystems, ranging from lower elevation grasslands to oak shrublands to mid elevation woodlands to higher elevation woodlands and forests. Eight major vegetation types in the UMC project area were identified from the Forest Service vegetation data. These systems and the acreage of each system (rounded) are as follows:

Ecological System	Acres
Ponderosa Pine/Douglas Fir Woodland	20,500
Dry-Mesic Montane Mixed Conifer Forest and Woodland	18,700
Mesic Montane Mixed Conifer Forest and Woodland	15,700
Montane Riparian Systems	3,000
Lodgepole Pine Forest	2,400
Gambel Oak-Mixed Montane Shrubland	2,100
Montane-Subalpine Grassland	1,900
Pinyon-Juniper Woodland	100

Three woodland and forest systems dominate the UMC landscape – comprising 85% of the project area. These three systems are ponderosa pine/Douglas-fir woodland (20,500 acres), dry-mesic mixed conifer forest and woodland (18,700 acres) and mesic mixed conifer forest and woodland (15,700 acres). These three systems are distributed across the UMC area, and often found commingled, with location and patch size based upon aspect, elevation, soils, and other factors. Five smaller systems comprise the remainder of the area's vegetation communities. The montane riparian systems (3,000 acres) are largely embedded with the various forest systems. Lodgepole pine forest (2,400 acres) is found predominantly in one area in the northern part of UMC. Gambel oak-mixed montane shrubland (2,100 acres), montane subalpine grassland (1,900 acres) and pinyon-juniper woodland (100 acres) are found in drier, lower-elevation site locations on the eastside.

Ecological Departure

The three woodland and forest systems are all moderately departed from their natural historic condition (Table 6).

Table 6. Ecological Departure of the UMC ecological systems. The measure of Ecological Departure is scored on a scale of 0% to 100% departure from NRV: 0% represents NRV while 100% represents total departure. Departure was not calculated for the five smaller systems.

Ecological System	% Departure	Acres (rounded to next 100)
Ponderosa Pine/Douglas Fir Woodland	41	20,500
Dry-Mesic Montane Mixed Conifer Forest and Woodland	52	18,700
Mesic Montane Mixed Conifer Forest and Woodland	42	15,700

There are two primary causes of the moderate departure scores at UMC: canopy condition and forest age. There is a substantial over-abundance of closed canopy conditions (vegetation classes B & E), creating an approximately 15,000 acres shortfall of the more open canopy (classes C & D) forests than occurred historically. Overall, approximately 63% of the forest is in closed canopy condition, about twice as much as occurred historically. Moreover, because of historical logging, the older succession classes (classes D & E) are under-represented in the forests. Table 7 displays the current acres and percentage in each vegetation class for each system, as well as the percentage expected under NRV.

Ecological departure was not considered a useful metric to assess the condition of the five smaller systems. The departure scores of ecological systems become increasingly uncertain as system size and landscape size decreases. The lodgepole pine occurrence at UMC, for example, is part of a larger occurrence that extends beyond the project boundary, which itself is a somewhat isolated representation of this system in the southern Front Range.

The acres in the vegetation classes (s-classes) for all ecological systems were determined both *before* and *after* the large Waldo Canyon fire. The Waldo fire affected approximately 11,000 acres of vegetation within the project area. The fire had three primary effects on the vegetation classes:

(1) created substantially more early succession vegetation (Class A) for most systems; altogether over 5,000 acres of new early succession vegetation was created;
(2) reduced the amount of closed canopy forest; and
(3) created a new uncharacteristic vegetation class.

The additional amount of early vegetation and reduced closed canopy forest actually served to improve the ecological departure scores for the three woodland and forest systems, even in light of the new uncharacteristic vegetation class. This result confirms that wildfires can indeed have some beneficial ecological effects on forest condition (although they can have devastating effects on lives, property and other community values). *However, the distribution of these ecological effects was highly concentrated spatially.* For example, rather than small patches of early succession forest well-distributed across the landscape, large patches were created, concentrated in the area of the fire. Table 8 displays the acres and percentages of each vegetation found before the Waldo fire.

Table 7. Vegetation Succession Classes and Ecological Departure – After Waldo Fire

Ponderosa Pine/Douglas Fir Woodland							
Class	**A-Early**	**B-Mid Closed**	**C-Mid Open**	**D-Late Open**	**E-Late Closed**	**U-Unchar**	**Total**
Acres in Class	1,783	8,569	4,263	1,982	3,239	636	20,472
NRV	10	10	15	45	20	0	100
Current % in Class	9	42	21	10	16	3	100
Ecological Departure							**41**
Dry-Mesic Montane Mixed Conifer Forest and Woodland							
Class	**A-Early**	**B-Mid Closed**	**C-Mid Open**	**D-Late Open**	**E-Late Closed**	**U-Unchar**	**Total**
Acres in Class	1,985	8,949	4,559	978	1,423	787	18,681
NRV	10	5	20	40	25	0	100
Current % in Class	11	48	24	5	8	4	100
Ecological Departure							**52**
Mesic Montane Mixed Conifer Forest and Woodland							
Class	**A-Early**	**B-Mid Closed**	**C-Mid Open**	**D-Late Open**	**E-Late Closed**	**U-Unchar**	**Total**
Acres in Class	1,707	9,995	1,024	270	2,275	385	15,656
NRV	10	25	20	15	30	0	100
Current % in Class	11	64	7	2	15	2	100
Ecological Departure							**42**
Montane Riparian Systems							
Class	**A-Early**	**B-Mid Closed**	**C-Late All**	**-**	**-**	**U-Unchar**	**Total**
Acres in Class	1,284	358	1,278	0	0	49	2,969
NRV	10	25	65	-	-	0	100
Current % in Class	43	12	43	0	0	2	100
Ecological Departure							**35**
Lodgepole Pine Forest							
Class	**A-Early**	**B-Mid Closed**	**C-Mid Open**	**D-Late Closed**	**E-Late All**	**U-Unchar**	**Total**
Acres in Class	47	779	552	352	631	0	2,361
NRV	20	20	20	30	10	0	100
Current % in Class	2	33	23	15	27	0	100
Ecological Departure							**33**
Gambel Oak-Mixed Montane Shrubland							
Class	**A-Early**	**B-Mid Closed**	**C-Late Closed**	**-**	**-**	**U-Unchar**	**Total**
Acres in Class	462	1,122	550	0	0	8	2,142
NRV	10	35	55	-	0	0	100
Current % in Class	22	52	26	0	0	0	100
Ecological Departure							**29**
Montane-Subalpine Grassland							
Class	**0**	**0**	**0**	**0**	**0**	**0**	**Total**
Acres in Class	107	1,770	0	0	0	12	1,888
NRV	*model not reviewed*						
Current % in Class	6	94	0	0	0	1	100
Ecological Departure							**-**
Pinyon-Juniper Woodland							
Class	**0**	**0**	**0**	**0**	**0**	**0**	**Total**
Acres in Class	66	0	39	0	0	0	105
NRV	*model not reviewed*						
Current % in Class	63	0	37	0	0	0	100
Ecological Departure							**-**

Table 8. Vegetation Succession Classes and Ecological Departure – Before Waldo Fire

Ponderosa Pine/Douglas Fir Woodland UMC						
Class	**A-Early**	**B-Mid Closed**	**C-Mid Open**	**D-Late Open**	**E-Late Closed**	**Total**
Acres in Class	303	10,072	4,464	2,054	3,579	20,472
NRV	10	10	15	45	20	100
Current % in Class	1	49	22	10	17	100
Ecological Departure						**46**
Dry-Mesic Montane Mixed Conifer Forest and Woodland UMC						
Class	**A-Early**	**B-Mid Closed**	**C-Mid Open**	**D-Late Open**	**E-Late Closed**	**Total**
Acres in Class	388	10,497	5,187	953	1,656	18,681
NRV	10	5	20	40	25	100
Current % in Class	2	56	28	5	9	100
Ecological Departure						**59**
Mesic Montane Mixed Conifer Forest and Woodland UMC						
Class	**A-Early**	**B-Mid Closed**	**C-Mid Open**	**D-Late Open**	**E-Late Closed**	**Total**
Acres in Class	39	12,315	583	265	2,454	15,656
NRV	10	25	20	15	30	100
Current % in Class	0	79	4	2	16	100
Ecological Departure						**54**
Montane Riparian Systems						
Class	**A-Early**	**B-Mid Closed**	**C-Late All**	**-**	**-**	**Total**
Acres in Class	1,173	467	1,329	0	0	2,969
NRV	10	25	65	-	-	100
Current % in Class	40	16	45	0	0	100
Ecological Departure						**30**
Lodgepole Pine Forest						
Class	**A-Early**	**B-Mid Closed**	**C-Mid Open**	**D-Late Closed**	**E-Late All**	**Total**
Acres in Class	47	779	552	352	631	2,361
NRV	20	20	20	30	10	100
Current % in Class	2	33	23	15	27	100
Ecological Departure						**33**
Gambel Oak-Mixed Montane Shrubland						
Class	**A-Early**	**B-Mid Closed**	**C-Late Closed**	**-**	**-**	**Total**
Acres in Class	142	1,349	651	0	0	2,142
NRV	10	35	55	-	0	100
Current % in Class	7	63	30	0	0	100
Ecological Departure						**28**
Montane-Subalpine Grassland						
Class	**0**	**0**	**0**	**0**	**0**	**Total**
Acres in Class	0	1,888	0	0	0	1,888
NRV	*model not reviewed*					
Current % in Class	0	100	0	0	0	100
Ecological Departure						**-**
Pinyon-Juniper Woodland						
Class	**0**	**0**	**0**	**0**	**0**	**Total**
Acres in Class	0	0	99	6	0	105
NRV	*model not reviewed*					
Current % in Class	0	0	94	6	0	100
Ecological Departure						**-**

Open Forest Departure

The Open Forest Departure metric isolates the degree of canopy closure as compared to the more open historical conditions. As with ecological departure, a lower score indicates less departure. The three forest systems all had substantial Open Forest Departure, most notably the mesic montane mixed conifer forest (Table 9).

Table 9. Ecological and Open Forest Departure Scores for 3 UMC Forest Systems (post Waldo).

Ponderosa Pine-Douglas Fir Woodland		Dry-Mesic Montane Mixed Conifer Forest		Mesic Montane Mixed Conifer Forest	
Ecological Departure	Open Forest Departure	Ecological Departure	Open Forest Departure	Ecological Departure	Open Forest Departure
40	43	52	43	42	57

Uncharacteristic Vegetation

The severity of the Waldo fire in some locations created a new, uncharacteristic vegetation class. In those locations where the Waldo fire showed a combination of high severity vegetation burn along with high severity soil burn, the vegetation was deemed likely to experience a long-term type conversion from the current forest vegetation. Scientists in the Collaborative were uncertain as to what particular vegetation types (e.g., grassland) are likely to succeed in these areas, with what ecological trajectory, and over what time horizon; however, a "permanent" vegetation type conversion is expected over decades. Based on Forest Service fire severity data, this conversion was estimated to have affected approximately 3% of the current UMC forest vegetation (3% for ponderosa pine/Douglas-fir; 4% for dry-mesic mixed conifer; and 2% for mesic mixed conifer).

Future Ecological Condition – Without Management

Using the VDDT computer-based models, the likely future condition of each forest system was simulated after 10 years, assuming *no active management action to restore ecological condition*. No Management essentially represents a "no action" scenario – other than the continuation of fire suppression.

Departure

No management was found essentially to perpetuate the current condition (Table 10). In the absence of management, and with continued fire suppression, the Ecological Departure of the three forest systems will all remain moderately departed from their historic condition, with little predicted change from current conditions over the next 10 years (although all systems benefit from an increase in the late seral classes). The future Open Forest Departure scores are essentially unchanged for all three systems in the absence of management.

Table 10. Departure Scores in 10 Years Without Management. Ecological Departure colors based on LANDFIRE/ FRCC standard: Green (<=33), Yellow (34-66), Red (>67); Open Forest Departure color gradient from Green (low departure) to Yellow/Orange (moderate) to Red (high)

Management Scenario	Ponderosa Pine-Douglas Fir Woodland		Dry-Mesic Montane Mixed Conifer Forest		Mesic Montane Mixed Conifer Forest	
	Ecological Departure	Open Forest Departure	Ecological Departure	Open Forest Departure	Ecological Departure	Open Forest Departure
Current Condition	40	43	52	43	42	57
No Management - 10 Yrs	39	44	49	43	36	56

Alternative Fire Futures

The extreme "either-or" fire variability of the UMC region (no fire or large fire) is challenging to forecast in VDDT, especially over a short 10 year planning time horizon. The core VDDT simulations for UMC all reflect an "average" amount of fire based upon recent fire data, which incorporates ongoing fire suppression. However, to see the effects of alternative fire futures, VDDT simulations were run to reflect two other wildfire scenarios: (1) no fire and (2) a large amount of fire (Table 11).

The "no fire" alternative produced results very similar Ecological Departure scores to the "average" score (i.e., continued fire suppression). However, a complete absence of fire (i.e., 100% effective fire suppression) showed some adverse effects in Open Forest Departure, particularly for the mesic mixed conifer forest, and to a lesser degree the dry-mesic mixed conifer. On a similar vein, a "high" fire future showed beneficial effects in Open Forest Departure for all three forest systems. On the negative side, the "high" fire simulation caused an adverse 2% increase in uncharacteristic vegetation.

Table 11. Departure Scores in 10 Years Without Management Under Alternative Fire Simulations

Management Scenario	Ponderosa Pine-Douglas Fir Woodland		Dry-Mesic Montane Mixed Conifer Forest		Mesic Montane Mixed Conifer Forest	
	Ecological Departure	Open Forest Departure	Ecological Departure	Open Forest Departure	Ecological Departure	Open Forest Departure
No Mgmt - Fire Supression	39	44	49	43	36	56
No Mgmt - No Fire	38	46	49	47	39	64
No Mgmt - High Fire	37	36	48	36	31	31

These simulated outcomes using VDDT are all non-spatial – while they do reflect varying levels of severity (surface, mixed and replacement), they do not reflect any configuration of the fire or patch sizes. However, they do help demonstrate the potential benefits of a carefully managed wildland fire use policy.

Management Scenario Forecasts

Using the VDDT computer-based models, the likely future condition of each forest system was simulated after 10 years applying varying levels and combinations of the key management strategies identified by the Collaborative for the forest ecosystems. The three primary strategies that were incorporated into the VDDT models (described more fully in Appendix D) were: (1) mechanical thinning; (2) manual thinning; and (3) prescribed burning.

Selected combinations and variations of strategies were characterized as *management scenarios*. The "No Management" scenario forecasts were described in the previous section. The active management scenarios that were simulated included: (1) mechanical treatment only, with varying levels of openings creation; (2) prescribed burning only; (3) combined mechanical treatment and prescribed burning, including the addition of a large controlled burn; (4) combined mechanical treatment and prescribed burning designed to achieve zero canopy departure; and (5) a feasible management treatments scenario that also included manual thinning. Details on acres treated and outcomes of all scenario simulations are provided in the Model Run Worksheets in Appendix E (ponderosa pine), F (dry-mesic mixed conifer) and G (mesic mixed conifer).

The results of all scenario simulations were informative (see summary in Table 12 and details in Appendix E, F and G). All management strategies – thinning and prescribed burning – produced ecological benefits in all three forest systems.

Mechanical Thinning. Mechanical thinning proved to be very efficient at achieving more open forest conditions in a short time horizon ("Mechanical Only" row in Table 12). For example, mechanically thinning a total of 600 acres per year of ponderosa pine/Douglas-fir over seven years reduced Open Forest Departure from current 43% to a very low 16%. Similar benefits accrued in dry-mesic mixed conifer, and somewhat lesser in mesic mixed conifer (which had fewer acres treated). Three different ratios of open canopy creation ("regen harvest" in the models) were tested – 5%, 20% and 40% – in other words, the percentage of the mechanical thinning that was devoted to creating Class A early successional openings. The overall results in improving Open Canopy Departure were essentially identical (Appendices E, F and G), with only a few percentage points difference; the amount of Class A created, however, varied, with higher amounts as would be expected from the higher ratios.

Prescribed Burning. Independently, prescribed burning also improved Open Forest Departure ("Prescribed Burn Only" row in Table 12), but to a lesser degree than mechanical thinning in the 10 year simulations. Two factors account for this outcome: Fewer acres of forest were treated in the simulations with prescribed fire, due to varied practical and policy constraints. For example, the ponderosa pine had 600 acres/year of thinning in the Mechanical Only scenario but only 150 acres/year of prescribed burning in the Prescribed

Burn Only scenario (Appendices E). In addition, prescribed fire had a lower success rate (50%) at achieving open classes.

Combined Thinning and Burning. The treatment benefits accrued independently from thinning and from burning, but were maximized when the thinning and burning treatments were combined (see "Mechanical + Rx Burning" row in Table 12). The benefits achieved from each type of treatment depend largely upon levels of treatment application.

Large Controlled Burn. Adding a large (6,750 acres) prescribed burn in the combined treatment simulation above proved very beneficial, substantially improving the Open Forest Departure outcomes (see "Mechanical + Large RxBurn" row). Ponderosa pine and dry-mesic forests forecasts went to almost zero Open Canopy Departure.

Zero Open Departure. In the "Zero Departure Open Forest" scenario -- using treatment acres in the models unconstrained by budgets, policies or physical limitations, it was possible to achieve open forests that approximated historic canopy conditions (see "10 Year Zero Departure Open" row). However, real-world physical, budget and policy constraints limit the amount of acres that can actually be treated. The "Feasible Treatments" scenario (described more fully in the following section) represents a level of treatments over the ten year period that was deemed realistic and affordable.

Table 12. Departure Scores in 10 Years Under All Scenarios. Ecological Departure colors based on LANDFIRE/ FRCC standard: Green (<=33), Yellow (34-66), Red (>67); Open Forest Departure color gradient from Green (low departure) to Yellow/Orange (moderate) to Red (high).

Management Scenario	Ponderosa Pine-Douglas Fir Woodland		Dry-Mesic Montane Mixed Conifer Forest		Mesic Montane Mixed Conifer Forest	
	Ecological Departure	Open Forest Departure	Ecological Departure	Open Forest Departure	Ecological Departure	Open Forest Departure
Current Condition	40	43	52	43	42	57
No Management - 10 Yrs	39	44	49	43	36	56
Mechanical Only (20% Regen)	36	16	47	19	31	44
Prescribed Burn Only	38	39	49	36	33	49
Mechanical + Rx Burning	37	11	47	10	29	38
Mechanical + Large Rx Burn	35	1	47	3	26	27
10 Year Zero Departure Open F	36	0	47	0	25	0
Feasible Treatments-10 Yrs	37	14	48	19	31	42

Feasible Treatment Scenario Forecasts

The "Feasible Treatment" scenario was the final scenario considered by the Collaborative. This scenario was informed by Forest Service GIS analysis and built upon the findings of previous model runs. This scenario treats approximately 18,000 acres of the forest, based upon the number of acres deemed feasible for each major treatment type – mechanical thinning, manual thinning and prescribed fire. Over a 10 year period, this scenario manages approximately 6,000 acres with mechanical thinning, 6,000 acres with manual hand thinning, 3,000 acres of site preparation, and 3,000 acres with prescribed fire.

Treatment Allocation

The thinning was allocated across the forest systems by type of thinning (mechanical vs. manual) based upon the results of the Forest Service GIS analysis (Table 13). Most thinning occurred in highly over-represented, mid-succession Class B forests, but some thinning was allocated to the late succession Class E. Some of the thinning (2,270 acres) was allocated for Open Classes C & D across the three forest systems, and therefore does not change the canopy condition. The greatest amount of thinning – 5,910 acres in all classes over the 10 years – was allocated to ponderosa pine. The mesic mixed conifer received the lowest amount of thinning – 1,785 acres. The dry-mesic mixed conifer received thinning of 4,340 acres. The 3,000 acres of site preparation is not reflected in the model runs, as this treatment does not cause a change in vegetation succession class.

Table 13. Allocation of Mechanical and Manual Thinning by System and S-Class

Mechanical Treatment Allocations

	By S-Class (Pro-Rated Using FS %s)				
Focal Systems	**B**	**C**	**D**	**E**	*Rounded Totals*
Dry-Mesic Mixed Conifer	920	300	80	630	*1,930*
Mesic Mixed Conifer	850	280	70	580	*1,780*
Ponderosa Pine/Douglas-Fir	1,110	370	90	750	*2,320*
Total Focal Systems	**2,880**	**950**	**240**	**1,960**	***6,030***

Manual Thinning Allocations

	By S-Class (Prorated Using %s for Marginal s-class)				
Focal Systems	**B**	**C**	**D**	**E**	*Rounded Totals*
Dry-Mesic Mixed Conifer	1,540	340	100	430	*2,410*
Mesic Mixed Conifer					
Ponderosa Pine/Douglas-Fir	2,300	500	140	650	*3,590*
Total Focal Systems	**3,840**	**840**	**240**	**1,080**	***6,000***

Prescribed burning treatment was somewhat evenly allocated across the three systems, based upon Forest Service estimates, with 1,000 acres in ponderosa pine, 1200 acres in dry-mesic mixed conifer, and 800 acres in mesic mixed conifer.

Departure

Open Forest Departure. The Feasible Treatment management scenario substantially increased Open Forest canopy conditions in all three forest systems over 10 years as compared to current condition and the no management scenario (Table 14). Open Forest Departure improved by a very substantial 30 points for ponderosa pine and 24 points for dry-mesic mixed conifer – both reaching the "low" departure range within 10 years. There was meaningful but lower improvement (14 points) in the mesic mixed conifer open canopy condition; a more conservative amount of management thinning occurred in this system due to greater uncertainties and other constraints.

Ecological Departure. There was a smaller improvement in the Ecological Departure metric than the Open Forest metric over the 10 year time horizon, since the late succession classes are still under-represented in this near future. Although the mesic mixed conifer forest canopy remained more closed than the ponderosa pine/Douglas-fir and dry-mesic mixed conifer, it showed the lowest overall ecological departure score, and it alone reached the LANDFIRE "green" zone of fire regime condition class. The mesic forest had a higher initial percentage of the late succession classes, thereby giving it a "jump start" on forest age structure.

All in all, the greatest ecological improvement occurred in the ponderosa pine/Douglas-fir system, but this result is not surprising, given that it received the greatest amount of thinning. The least improvement occurred in the mesic mixed conifer, also not surprising, as this system received the lowest amount of thinning.

Table 14. Departure Scores in 10, 20 and 50 Years Under Feasible Treatment Scenario. Ecological Departure colors based on LANDFIRE/ FRCC standard: Green (<=33), Yellow (34-66), Red (>67); Open Forest Departure color gradient from Green (low departure) to Yellow/Orange (moderate) to Red (high).

Management Scenario	Ponderosa Pine-Douglas Fir Woodland		Dry-Mesic Montane Mixed Conifer Forest		Mesic Montane Mixed Conifer Forest	
	Ecological Departure	Open Forest Departure	Ecological Departure	Open Forest Departure	Ecological Departure	Open Forest Departure
Current Condition	40	43	52	43	42	57
No Management - 10 Yrs	39	44	49	43	36	56
Feasible Treatments-10 Yrs	37	**14**	48	**19**	31	**42**
Feasible Treatments-20 Yrs	32	**16**	46	**20**	28	**44**
Feasible Treatments-50 Yrs	23	**21**	36	**24**	22	**49**

Trajectory

Model runs were also conducted over a 20 and 50 year time horizon to forecast the trajectory of the outcomes (see last two rows of Table 14). The overall trajectory over 20 and 50 years is very good for all three systems. Ecological Departure scores improve for all three systems as the forests mature. However, Open Forest Departure scores get slightly worse over time, as the forest canopy slowly becomes more closed in the absence of management treatments in future years. All three systems fared noticeably better in one or both metrics than they would have fared with no management over 20 and 50 years (Appendices E, F and G).

Budget

The 10 year budget for the management treatments totaled slightly over $10 million, or approximately $1 million average cost per year (Appendices E, F and G). Funding requirements are slightly higher in the initial seven years, as this was the time period devoted to the more expensive mechanical thinning treatment, whereas less expensive prescribed burning was conducted in the last eight year time period.

The "lion's share" of the 10 year budget was devoted to mechanical thinning -- a total of approximately $6 million. Approximately $2.25 million was devoted to prescribed burning treatments. The remainder was spent on site preparation and manual thinning.

Looking across the three focal ecological systems, costs over 10 years totaled as followed:

Ponderosa pine/Douglas-fir	$ 3.8 million
Dry-mesic mixed conifer	$ 3.6 million
Mesic mixed conifer	$ 3.0 million

Return on Investment

The final step in the LCF process was calculating the benefits (magnitude of ecological improvement) as compared to costs of management. Both intra- and inter-system return-on-investment (ROI) metrics were used to determine which of the scenarios produced the greatest ecological benefits per dollar invested *within* each ecological system, and *across* the three focal ecological systems. If ROI values differ substantially, they are sometimes a useful tool to assist land managers in allocating scarce management resources.

Return on investment analysis showed roughly equivalent results across all management scenarios and ecological systems, with some small variations (Appendices E, F and G).

> There was a relatively small ROI difference between the Mechanical Thinning Only and Prescribed Burning Only scenarios – the former treatment costs more but the increased cost is compensated by a higher success rate in achieving open forest conditions. For example, the ROI for ponderosa pine (Appendix E) was 0.8 for Mechanical vs. 0.6 for

Prescribed Burning. The spread was similar for the two other forest systems. This is a difference of 25% in ROI scores, but not a 100% or larger difference between scenarios that has been seen sometimes in other project areas.

> Note: the absolute size of the ROI numbers is not relevant within a given project area, only the relative difference between numbers.

The "Feasible Treatments" scenario (combined thinning and burning) generated similar results -- 0.9 for ponderosa pine, 0.7 for dry-mesic, and 0.6 for mesic.

Spending more money to achieve more results slightly reduced the ROI for ponderosa pine and dry-mesic forest, but actually benefited the mesic forest. The "Zero Departure" ROI scores were 0.6 for ponderosa pine, 0.6 for dry-mesic, and 1.1 for mesic.

As far the individual management treatments are concerned -- manual thinning -- at a lower cost and 60% success rate produced the highest treatment ROI (not calculated in model runs, but rather as a direct measure of ecological benefit x probability / cost.)

On an area-weighted, inter-system basis, the highest overall ecological benefits per dollar invested accrue in the ponderosa pine/Douglas-fir woodland (largely due to a higher level of manual thinning) and least in mesic mixed conifer (Table 15).

Table 15. Summary of 10 Year Benefits, Cost & ROI Across Systems – Feasible Treatment Scenario

Ecological System	Acres	Ecological Departure		Open Canopy Departure		10 Year Total Cost	ROI (area-weighted)
		No Mgmt	Feasible Treatment	No Mgmt	Feasible Treatment		
Ponderosa Pine-Douglas Fir Woodland	20,500	39	37	44	14	$3,754,800	0.9
Dry-Mesic Montane Mixed Conifer Forest	18,700	49	48	43	19	$3,618,000	0.7
Mesic Montane Mixed Conifer Forest	15,700	36	31	56	42	$2,985,100	0.5

Acknowledgements

Applied Conservation thanks all members of the UMC Collaborative who participated actively in the model reviews, data assessment, workshops, and webinars to review, discuss, question and revise all elements of the Landscape Conservation Forecasting process. Special thanks go to Paige Lewis and Sara Mayben for their strong support of the LCF approach. The work could not have been completed without good models and good data, so appreciation goes to Mike Babler and the team of scientists and managers who reviewed and refined the ecological models, and to Ed Biery for assembling and cross-walking the initial vegetation data to and Jan Koenig for helping to crunch the data. Last, but far from least, special thanks go to Jeff Underhill for his calm, streadfast and knowledgeable contributions at every stage of the process, including the models, data, management actions, and feasible treatment area assessment. This work represented a great team effort!

Appendices

A. Summary Descriptions of UMC Ecological Systems

B. Model Descriptions of UMC Focal Systems

C. VDDT Model Parameters

D. Management Treatments Summary

E. Model Run Worksheets - Ponderosa Pine/Douglas-fir Woodland

F. Model Run Worksheets - Dry-Mesic Mixed Conifer Forest & Woodland

G. Model Run Worksheets - Mesic Mixed Conifer Forest & Woodland

Appendix A

Summary Descriptions of UMC Ecological Systems

Revised February 26, 2013
Systems listed in order of descending size – with LANDFIRE model codes and full names

Forest & Woodland Systems

Ponderosa Pine Woodland
2810540M – Southern Rocky Mountain Ponderosa Pine Woodland

Dry-Mesic Montane Mixed Conifer Forest and Woodland
2810510M – Southern Rocky Mountain Dry-Mesic Montane Mixed Conifer Forest & Woodland

Mesic Montane Mixed Conifer Forest and Woodland
2810520M – Southern Rocky Mountain Mesic Montane Mixed Conifer Forest & Woodland

Lodgepole Pine Forest
2810500M –Rocky Mountain Lodgepole Pine Forest

Other Systems

Gambel Oak-Mixed Montane Shrubland
2711070 – Rocky Mountain Gambel Oak-Mixed Montane Shrubland

Montane Riparian Systems
2811590M – Rocky Mountain Montane Riparian Systems

Notes:

All model numbers with suffix "M" have been modified from the original LANDFIRE model descriptions to reflect local conditions.
Descriptions, age ranges and parameters for three major forest and woodland systems (Ponderosa Pine-Douglas Fir, Dry-Mesic Montane, and Mesic Montane) are revisions of LANDFIRE models by the UMC Models Working Group to reflect the local project area conditions. Cover percentages, tree size, height and DBH parameters are modified to reflect local Forest Service data.
The model for Montane Riparian has also been modified, where an additional age class was added.
Descriptions and parameters for other systems are from LANDFIRE.
NRV (natural range of variability) among the vegetation classes for each ecological system was calculated using Vegetation Dynamics Development Tool (VDDT) software simulations over 1000 years.

Ponderosa Pine Woodland

2810540M – Southern Rocky Mountain Ponderosa Pine Woodland

The lower montane zone dominated by ponderosa pine (historically < 30% canopy cover below 6600ft), more dense stands of Douglas-fir on north-facing slopes with occasional large Douglas -fir on other aspects. The upper montane zone the ponderosa pine cover type occurs both as relatively pure stands, and with significant components of Douglas-fir. There is typically a striking contrast in stand density and species composition on south- as opposed to north-facing slopes. Douglas-fir prominent on north facing slopes. Structural stages will greatly vary depending on past disturbance history. Limber pine occurs in higher elevations in groups and as scattered individuals. Understory can include gambel oak, mountain mahogany, Arizona fescue, Mountain muhly, kinnikinick, yucca. Fire includes Surface, Mixed & Replacement.

NRV %[1]	**Class Code**	**Veg Class**	**Description**[2]	**Cover %**	**Age**	***Height & DBH***
10	A	Early	Openings with up to 10% remnant overstory trees dominated by ponderosa pine and sometimes Douglas-fir. Some openings persist.	0- 70%	0 – 39 yrs	*0 – 5m <5"DBH*
10	B	Mid-Closed	Greater than 40% canopy closure, often in small patches with some persistent openings. Uneven age structure developing.	41- 70%	40 – 149 yrs	*5 – 15m 5 - 16" DBH*
15	C	Mid-Open	< 40% canopy cover. Mosaic composition with pockets of regeneration, shrubs, grass, openings. Uneven age structure usually present.	10 – 40%	40 – 149 yrs	*5 – 15m 5 - 16" DBH*
45	D	Late-Open	< 40% canopy cover. Mosaic composition with pockets of regeneration, shrubs, grass, openings. Uneven age structure usually present.	10 – 40%	150+ yrs	*15 – 25m 16 - 30" DBH*
20	E	Late-Closed	> 40% canopy cover. Mosaic composition with pockets of regeneration, shrubs, grass, openings. Old trees likely present. Uneven aged stand structure dominates.	41- 70%	150+ yrs	*15 – 25m 16 - 30" DBH*

All Ecological Systems			
-	U	Uncharacteristic	Long-term type conversion due to high severity fire effects (high severity soil burn + high severity vegetation burn)

Dry-Mesic Montane Mixed Conifer Forest and Woodland *2810510M – Southern Rocky Mountain Dry-Mesic Montane Mixed Conifer Forest & Woodland* The composition and structure of overstory varies based on the temperature and moisture relationships of the site. Ponderosa pine, Douglas-fir, Limber pine, and aspen make up the warm/dry mixed conifer. Gambel oak is often the dominant shrub in southern part lower elevations of map zone. Ponderosa pine regeneration typically occurs after fire. Limber pine regeneration happens continuously between fires. Douglas-fir regeneration can happen in between and after fires. Douglas-fir gains fire resistance more quickly than white fir and can be a canopy dominant with Ponderosa pine. Generally found between 6900 - 9500 ft; it can be found at higher elevations on south facing slopes than north facing slopes. Its distribution is variable on east and west aspects. Soils are usually well drained granitic) or limestone based. Fire includes Surface, Mixed & Replacement						
10	A	Early	Succession after a lethal fire will depend on what vegetation was on site before. In a general conifer dominated scenario, some ponderosa are likely to survive. Fire will be an opportunity for new ponderosa establishment. On site Gambel oak will resprout. Limber pine will also be generating. If aspen cover is 50% or greater prior to disturbance, the stand would regenerate back to aspen.	n/a	0 – 39 yrs	*<5" DBH*
5	B	Mid-Closed	If aspen is dominant the stand will achieve a mid-closed stage. Conifers such as Limber pine and Douglas-fir could be regenerating with it. Any surviving conifers such as ponderosa pine would be canopy dominants.	41 – 80%	40 – 149 yrs	*5 – 20m* *5 - 16" DBH*
20	C	Mid-Open	Ponderosa is the canopy dominant with an understory dominated by Douglas-fire. Limber pine is present and some of its regeneration is entering the canopy. If aspen were present, the stand would have undergone some self thinning that would have opened up the canopy. The conifers in the stand create a more flammable litter bed with their needles so that patchy surface fire could carry. Any fire would further open the stand by thinning aspen and fir.	11 – 40%	40 – 149 yrs	*5 – 20m* *5 - 16" DBH*
40	D	Late-Open	Ponderosa pine is the canopy dominant. Douglas-fir can also be a canopy dominant. Recurrent fire maintains white fir as an understory tree, but a rare white fir will join the other two species in the canopy. If aspen is present, its numbers are few. Low levels of suckering may keep it in the stand. Open aspen stands are not common in this class in warm/dry mixed conifer.	11 – 40%	150+ yrs	*20 – 30m* *16 - 30" DBH*
25	E	Late-Closed	Conifer stand with minor Aspen component. Mature to over-mature with heavy understory of conifers. Mainly Ponderosa, Douglas-fir, Limber pine and Aspen.	41 – 80%	150+ yrs	*20 – 30m* *16 - 30" DBH*

Mesic Montane Mixed Conifer Forest and Woodland *2810520M – Southern Rocky Mountain Mesic Montane Mixed Conifer Forest & Woodland* The mixed conifer is driven by elevation and aspect. The cool moist mixed conifer will have much less ponderosa pine than the warm/dry. However, ponderosa pine is found in small groups or isolated places usually in open areas, edges of meadows, ridges. Douglas-Fir and Spruce are often canopy dominants with aspen present in most stands. The other major tree species found in the cool/moist are limber pine, englemann spruce, blue spruce, and aspen. Near riparian areas, wetlands and drainages blue spruce, englemann spruce and white fir can be quite common. PICO is uncommon but may be found. The system is found on northerly aspects, generally on steep slopes, from 7500' to 9500'. Soils are generally Pike Peak granite. Fire includes Surface, Mixed & Replacement						
10	A	Early	Post-lethal fire vegetation will depend on what was on site before it burned. Aspen may or may not be present, depending on what was present prior to the fire or other replacement disturbance. The site will start as grass/forb/ shrub; aspen may also be present. Fire will maintain or prolong this stage. Conifers may be present. Any surviving conifers will be seed source. This class may look like a pure aspen stand from above.	0 - 100%	0 - 39 yrs	*0 – 5m <5" DBH*
25	B	Mid-Closed	If present, aspen will be over 10' tall and very dense. Seedling-medium sized conifers can be found mixed with aspen, if present. Understory may include mountain snowberry, common juniper, wild rose, and many species of grasses and forbs.	41- 80%	40 - 149 yrs	*5 – 20m 5 - 16" DBH*
20	C	Mid-Open	If present, aspen will be over 10ft' tall and patchy. Seedling-medium sized conifers may be found mixed with aspen. Understory may include mountain snowberry, common juniper, wild rose, and many species of grasses and forbs. Canopy cover low.	11 – 40%	40 - 149 yrs	*5 – 20m 5 - 16" DBH*
15	D	Late-Open	Aspen will be rare and mid-level. Understory is a diverse mix of grasses, forbs and shrubs.	11 – 40%	150 - 189 yrs	*20 – 30m 16 - 30" DBH*
30	E	Late-Closed	Dense conifer stand. Blue spruce and Englemann spruce can come in. Aspen present in small amounts. Lots of dead & downed material. Understory possibly depauperate.	41- 100%	150+ yrs	*20 – 30m 16 - 30" DBH*

Lodgepole Pine Forest *2810500M – Rocky Mountain Lodgepole Pine Forest* Upper montane to subalpine. Lodgepole pine is generally persistent, although sometimes aspen may be seral to it. Sometimes with sparse shrub, grass or barren understories. Elevations vary from above 9000 feet. Disturbances: Fire (Mixed & Replacement); Insects/Disease; Wind/Weather; Competition/Maintenance.						
20	A	Early	Grasses, forbs, low shrubs and lodgepole seedlings-saplings; aspen maybe present. Even-aged, canopy closure will tend to exceed 30-40% after seedlings are established at moderate to high densities and well distibuted and majority of the trees are small sapling size, > 1.0" dbh.	0 – 80%	0 – 39 yrs	*0 – 10m <5" DBH*
20	B	Mid-Closed	Moderate to dense pole-sized trees, sometimes very dense (dog-hair); aspen usually not present. Even-aged.	61 – 100%	40 - 159 yrs	*10 – 20m 5 – 9" DBH*
20	C	Mid-Open	Variety of size classes, some mature trees, often somewhat patchy. If aspen present, lodgepole usually dominates. Even-aged, older stands with larger trees in the overstory. These stands are trending towards S-Class E.	21 – 60%	40 - 159 yrs	*10 – 20m 5 – 9" DBH*
30	D	Late-Closed	Many mature lodgepole pine with closed canopy. Trees' age may vary, but consistent in size & heights. Even-aged, canopy starting to open up, creating uneven-aged conditions. For these stands this transition is occurring later than the older stands in S-Class C.	61 – 100%	160+ yrs	*>20m 9 – 24" DBH*
10	E	Late-All	Many mature lodgepole pine, somewhat patchy, variety of size classes, open canopies overall but patches of denser trees. Dead and down woody materials, young trees infilling openings. Uneven-aged.	31 – 60%	160+ yrs	*>20m 9 – 24" DBH*

Gambel Oak-Mixed Montane Shrubland *2711070 – Rocky Mountain Gambel Oak-Mixed Montane Shrubland* Gambel oak occurs as the dominant species ranging from dense thickets to clumps associated with serviceberry or sagebrush. Generally has a well-developed understory. Occurs between 6600-9570ft on all aspects; at higher elevations it is more predominant on southern exposures. Disturbances: Fire (Replacement)						
10	A	Early	Dense resprouting with high number of stems/acre. Abundant grass & forb cover.	0 – 20%	0 - 4 yrs	*>3.1m*
35	B	Mid-Closed	3 to 6' feet tall, up to 3 inches DBH. Slight decrease in understory species due to shading. Grass and forbs declining.	21 – 50%	5 - 30 yrs	*.6 – 3.0m*
55	C	Late-Closed	Greater than 6' tall and greater than 3" DBH. Small stands with open canopy & scattered throughout a grass-land or shrub type, as well as nearly continuous canopy cover with occasional openings.	51- 100%	31+ yrs	*1.1 to >3.1m*

Montane Riparian Systems *2811590M – Rocky Mountain Montane Riparian Systems (Revised & Class C added)* Encompasses a broad array of riparian species; highly variable and generally consist of one or more of the following: 1) aspen; 2) conifers; 3) willows/birch/alder; 4) sedges and other herbaceous vegetation; and 5) cottonwoods. This system exists as relatively small linear stringers in the landscape. Disturbances: Fire (Surface, Replacement); Wind/Weather; Beaver; 50 Year Flooding						
10	A	Early	Vegetation will depend on what was on site before replacement fire. Shrub or grass dominated. Composition varies within reach.	0 – 70%	0 – 24 yrs	*0- 5m <5" DBH*
25	B	Mid-Closed	Transitional class. Conifers will become dominant as class develops. Hardwood dominated early with conifer establishment in understory over time.	41- 100%	25 -100 yrs	*5 to 25m 5-9" DBH*
65	C	Late-All	Mature conifer dominated. Hardwoods dying out and present as scattered individuals or groups. Heavy layer of forbs, grasses, low shrubs and down woody materials.	41- 100%	100+ yrs	*10 to 25m 21-33" DBH*

Appendix B

Model Descriptions for UMC Focal Systems

1. **Ponderosa Pine/Douglas-fir Woodland**
2. **Dry-Mesic Montane Mixed Conifer Forest & Woodland**
3. **Mesic Montane Mixed Conifer Forest & Woodland**

LANDFIRE Biophysical Setting Model

Biophysical Setting: 2810540M Southern Rockies Ponderosa Pine/Douglas-Fir Woodland UMC

☐ *This BPS is lumped with:*
☐ *This BPS is split into multiple models:*

General Information

Contributors (also see the Comments field) **Date** 12/27/2012

Modeler 1 Ed Biery	ehbiery@fs.fed.us	**Reviewer**
Modeler 2 Jeff Underhill	junderhill@fs.fed.us	**Reviewer**
Modeler 3 Mike Babler	mbabler@tnc.org	**Reviewer**
		FRCC

Vegetation Type

Forested

Dominant Species*

PIPO
PSME

General Model Sources

☑ Literature
☑ Local Data
☑ Expert Estimate

Map Zones

28	0
0	0
0	0
0	0
0	0

Model Zones

☐ Alaska	☐ N-Cent.Rockies
☐ California	☐ Pacific Northwest
☐ Great Basin	☐ South Central
☐ Great Lakes	☐ Southeast
☐ Northeast	☐ S. Appalachians
☐ Northern Plains	☑ Southwest

Geographic Range

This model is specific to Upper Monument Creek. Original model was for map zone 28, In MZ 28 the dominant forest type along the eastern slope of the continental divide. The montane zone borders the Plains grasslands to the east, and in the foothills of the eastern slope includes shrublands and meadows.

Biophysical Site Description

South of I-70 the southern Front Range southwards to Pikes Peak, ponderosa pine-Douglas-fir forest exists on all site conditions (I.e., aspect) . Pure ponderosa pine exists in isolated patches.

Vegetation Description

The lower montane zone dominated by ponderosa pine (historically < 30% canopy cover below 2000m(6600ft)), more dense stands of Douglas-fir on north-facing slopes with occasional large Douglas fir on other aspects. The upper montane zone the ponderosa pine cover type occurs both as relatively pure stands, and with significant components of Douglas fir. There is typically a striking contrast in stand density and species composition on south- as opposed to north-facing slopes. Douglas-fir prominent on north-facing slopes. Structural stages will greatly vary depending on past disturbance history. Limber pine occurs in higher elevations in groups and as scattered individuals. Understory can include gambel oak, mountain mahogany, Arizona fescue, Mountain muhly, kinnikinick, yucca.

Disturbance Description

Primarily low-severity fire regime with generally small (acres to 10s of acres) patches of mixed-severity fire, although this varies with elevation. At lowest forest border with oak/grasslands, fire frequency varied from 10 to 20 years (mean 15) with mixed-severity every 300 years. As elevation increases or on north-facing aspects, fire frequency increased to 15 to 45 years (mean 30) with mixed severity fires every 150 years. Overall means for the southern Front Range on order of 20 years for surface fire (range 10 to 45) and 200

*Dominant Species are from the NRCS PLANTS database. To check a species code, please visit http://plants.usda.gov.
**Fire Regime Groups are: I: 0-35 year frequency, surface severity; II: 0-35 year frequency, replacement severity; III: 35-100+ year frequency, mixed severity; IV: 35-100+ year frequency, replacement severity; V: 200+ year frequency, replacement severity.

years (range 150 to 300) for mixed (mainly Brown et al. 1999, Kaufmann et al. 2000, Veblen et al. 2000, Ehle and Baker 2003, Sherriff 2004). These fires range from low severity to high severity fires, and the forest structure was shaped by the pattern of fire at a landscape scale. Drought and other weather events (e.g., blowdown); insects such as mountain pine beetle, Douglas-fir beetle, and western spruce budworm (Negron 1998, 2004; Swetnam and Lynch 1993); and pathogens such as dwarf mistletoe (Hawksworth) also play important roles in this type.

Replacement fire rotation uncertain but probably largely rare, and this affects the amount of forest in each class. Cheesman Lake -fire rotation (all fires 75 years) and stand-replacement (460 years) estimation.

Adjacency or Identification Concerns

Native Uncharacteristic Conditions

Scale Description

Sources of Scale Data ☑ Literature ☑ Local Data ☑ Expert Estimate

Southern range -- patch sizes from less than 1 ha to a landscape scale of 35km2 plus.

Issues/Problems

11/19/12. Sclass was determinded by diameter, not heights used in standard LANDFIRE process. Replacement fire rotation uncertain, and this affects the amount of forest in each class. If this model seems incorect, review 2711172-Ponderosa Pine Savanna-North.

Comments

11/19/12 version based on comments rom modelling team for Upper Monument Creek project. Authors are …… Reivsion for UMC based on 2810540 by Kaufmann, Sherriff, Baker dated 10/28/2004. We lumped with 2711172 for UMC. MB 9/28/2012. 2810540 Kaufmann et.al. Based on the Rapid Assessment model R3PPDF, by Merrill Kaufmann (mkaufmann@fs.fed.us), Rosemary Sherriff (sherriff@colorado.edu), Bill Baker (bakerwl@wyo.edu), Jose Negron, and Brian Kent. Was also reviewed in workshop by Vic Ecklund (vecklund@csu.org) 7/25/2005.

Vegetation Classes

Class A 10 %

Early1 All Structures

Description

Openings with up to 10% remnant overstory trees dominated by ponderosa pine and sometimes Douglas-fir. Some openings persist.

Indicator Species* and Canopy Position

CEMO2	Low-Mid
PIPO	All
PSME	All
BOGR2	Lower

Upper Layer Lifeform

- ☐ Herbaceous
- ☐ Shrub
- ☑ Tree

Structure Data (for upper layer lifeform)

	Min	*Max*
Cover	0 %	70 %
Height	Tree 0m	Tree 5m
Tree Size Class	Seedling Sapling <5" DBH	

☑ Upper layer lifeform differs from dominant lifeform. Height and cover of dominant lifeform are:

Remnant overstory trees could be PIPO and PSME. Dominant mapped vegetation is seedling and grass and shrub.

Fuel Model 2

*Dominant Species are from the NRCS PLANTS database. To check a species code, please visit http://plants.usda.gov.
**Fire Regime Groups are: I: 0-35 year frequency, surface severity; II: 0-35 year frequency, replacement severity; III: 35-100+ year frequency, mixed severity; IV: 35-100+ year frequency, replacement severity; V: 200+ year frequency, replacement severity.

Class B 10 %

Mid1 Closed

Description

Greater than 40% canopy closure, often in small patches with some persistent openings. Uneven age structure developing.

Indicator Species* and Canopy Position

PIPO	Upper
PSME	Upper
ARUV	Lower
JUCO6	Lower

Upper Layer Lifeform

- ☐ Herbaceous
- ☐ Shrub
- ☑ Tree

Fuel Model 8

Structure Data (for upper layer lifeform)

	Min	Max
Cover	41 %	70 %
Height	Tree 5.1m	Tree 15m
Tree Size Class	Medium 5-9"DBH	

☐ Upper layer lifeform differs from dominant lifeform. Height and cover of dominant lifeform are:

Class C 15 %

Mid1 Open

Description

< 40% canopy cover. Mosaic composition with pockets of regeneration, shrubs, grass, openings. Uneven age structure developing.

Indicator Species* and Canopy Position

PIPO	Upper
PSME	Upper
CEMO2	Low-Mid
GRASS	Lower

Upper Layer Lifeform

- ☐ Herbaceous
- ☐ Shrub
- ☑ Tree

Fuel Model 2

Structure Data (for upper layer lifeform)

	Min	Max
Cover	10 %	40 %
Height	Tree 5.1m	Tree 15m
Tree Size Class	Medium 5-9"DBH	

☐ Upper layer lifeform differs from dominant lifeform. Height and cover of dominant lifeform are:

Class D 45 %

Late1 Open

Description

< 40% canopy cover. Mosaic composition with pockets of regeneration, shrubs, grass, openings. Old trees likely present. Uneven aged stand structure dominates.

Indicator Species* and Canopy Position

PIPO	Upper
PSME	Upper
CEMO2	Lower
GRASS	Lower

Upper Layer Lifeform

- ☐ Herbaceous
- ☐ Shrub
- ☑ Tree

Fuel Model 8

Structure Data (for upper layer lifeform)

	Min	Max
Cover	10 %	40 %
Height	Tree 15.1m	Tree 25m
Tree Size Class	Large 9-21"DBH	

☐ Upper layer lifeform differs from dominant lifeform. Height and cover of dominant lifeform are:

---

*Dominant Species are from the NRCS PLANTS database. To check a species code, please visit http://plants.usda.gov.
**Fire Regime Groups are: I: 0-35 year frequency, surface severity; II: 0-35 year frequency, replacement severity; III: 35-100+ year frequency, mixed severity; IV: 35-100+ year frequency, replacement severity; V: 200+ year frequency, replacement severity.

Class E **20 %**

Late1 Closed

Description

> 40% canopy cover. Mosaic composition with pockets of regeneration, shrubs, grass, openings. Old trees likely present. Uneven aged stand structure dominates.

Indicator Species* and Canopy Position

PIPO	Upper
PSME	Upper
	Lower

Structure Data (for upper layer lifeform)

	Min	Max
Cover	41 %	70 %
Height	Tree 15.1m	Tree 25m
Tree Size Class	Large 9-21"DBH	

Upper Layer Lifeform

- ☐ Herbaceous
- ☐ Shrub
- ☑ Tree

☐ Upper layer lifeform differs from dominant lifeform. Height and cover of dominant lifeform are:

Fuel Model 8

Disturbances

Fire Regime Group:** **3**

Historical Fire Size (acres)

Avg 0
Min 0
Max 0

Sources of Fire Regime Data

- ☑ Literature
- ☑ Local Data
- ☐ Expert Estimate

Fire Intervals

	Avg FI	Min FI	Max FI	Probability	Percent of All Fires
Replacement	550			0.00182	4
Mixed	160			0.00625	13
Surface	25			0.04	83
All Fires	21			0.04807	

Fire Intervals (FI):

Fire interval is expressed in years for each fire severity class and for all types of fire combined (All Fires). Average FI is central tendency modeled. Minimum and maximum show the relative range of fire intervals, if known. Probability is the inverse of fire interval in years and is used in reference condition modeling. Percent of all fires is the percent of all fires in that severity class.

Additional Disturbances Modeled

- ☑ Insects/Disease
- ☐ Wind/Weather/Stress
- ☐ Native Grazing
- ☑ Competition
- ☐ Other (optional 1)
- ☐ Other (optional 2)

References

Alington, C. 1998. Fire History and Landscape Pattern in the Sangre de Cristo Mountains, Colorado. Dissertation. Colorado State University, Fort Collins, Colorado.

Allen, C.D., technical editor. 1996. Fire Effects in Sothwestern Forests. Proceedings of the second La Mesa fire symposium. USDA Forest Service General Technical Report RM-GTR-286, Fort Collins Co.

Allen, C.D. 1989. Changes in the landscape of the Jemez Mountains, New Mexico. Ph.D. dissertation, University of California, Berkeley.

Allen, C.D., R. Touchan, and T.W. Swetnam. 1995. Landscape-scale fire history studies support fire management action at Bandelier. Park Science:Summer, pp. 18-19.

Cooper, C. F. 1960. Changes in vegetation, structure, and growth of Southwestern pine forests since white settlement. Ecological Monographs 30(2):129-164.

Allen, R. B., R. K. Peet, and W. L. Baker. 1991. Gradient analysis of latitudinal variation in Southern Rocky Mountain forests. Journal of Biogeography 18:123-139.

*Dominant Species are from the NRCS PLANTS database. To check a species code, please visit http://plants.usda.gov.
**Fire Regime Groups are: I: 0-35 year frequency, surface severity; II: 0-35 year frequency, replacement severity; III: 35-100+ year frequency, mixed severity; IV: 35-100+ year frequency, replacement severity; V: 200+ year frequency, replacement severity.

Bradley, Anne F., Nonan Noste, and William C. Fischer. 1992. Fire and Ecology of Forests and Woodlands in Utah. USDA Forest Service, GTR INT-287.

Brown, P.M, M.W. Kaye, L.S. Huckaby, and C.H. Baisan. 2001. Fire history along environmental gradients in the Sacramento Mountains, New Mexico: Influences of local patterns and regional processes. Ecoscience 8(1):115-126.
Brown, P.M., M.R. Kaufmann, and W.D. Shepperd. 1999. Landscape Ecology 14:513-532.

Brown, P. M. 2004. Final Report: Bar NI Fire History. Rocky Mountain Tree-Ring Research, Fort Collins, CO.

Brown, P. M., and W. D. Shepperd. 2001. Fire history and fire climatology along a 5 degree gradient in latitude in Colorado and Wyoming, USA. Palaeobotanist 50:133-140.

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

Ehle, D. S., and W. L. Baker. 2003. Disturbance and stand dynamics in ponderosa pine forests in Rocky Mountain National Park, USA. Ecological Monographs 73:543-566.

Fule, P., Covington, and M. M. Moore. 1997. Determining reference conditions for ecosystem management of southwestern ponderosa pine forests. Ecological Applications 7:895-908.

Huckaby, L. S., and M. R. Kaufmann. 2000. Bar NI Ranch Fire History Study. Unpublished report. USDA Forest Service, Rocky Mountain Research Station.

Huckaby, L. S., M. R. Kaufmann, J. M. Stoker, and P. J. Fornwalt. 2001. Landscape patterns of montane forest age structure relative to fire history at Cheesman Lake in the Colorado Front Range. Pages 19-27 in R. K. Vance, C. B. Edminster, W. Covington, and J. A. Blake, editors. Pondersoa Pine Ecosystems Restoration and Conservation: Steps Toward Stewardship, Conference Proceedings, Flagstaff, AZ, April 25-27, 2000. USDA Forest Service, Rocky Mountain Research Station, Ogden, UT.

Kaufmann, M. R., P. J. Fornwalt, L. S. Huckaby, and J. M. Stoker. 2001. Cheesman Lake--A historical ponderosa pine landscape guiding restoration in the South Platte watershed of the Colorado Front Range. Pages 9-18 In: R. K. Vance, C. B. Edminster, W. W. Covington and J. A. Blake, editors. Ponderosa pine ecosystems restoration and conservation: Steps
toward stewardship, conference proceedings [Flagstaff, AZ--April 25-27, 2000]. USDA Forest Service Proceedings RMRS-P-22, Rocky Mountain Research Station, Fort Collins, Colorado.

Kaufmann, M. R., L. S. Huckaby, C. M. Regan, and J. Popp. 1998. Forest Reference Conditions for Ecosystem Management in the Sacramento Mountains, New Mexico. Genereral Technical Report RMRS-GTR 19, USDA / Forest Service, Fort Collins.
Kaufmann, M. R., C. M. Regan, and P. M. Brown. 2000b. Heterogeneity in ponderosa pine/Douglas-fir forests: age and size structure in unlogged and logged landscapes of central Colorado. Can. J. For. Res. 30:698-711.

Marr, John W. 1961 Ecossytems of the Esat Slope of the Front Range in Colorado. University of Colorado Studies, Series in Biology, No. 8; 1-134.

*Dominant Species are from the NRCS PLANTS database. To check a species code, please visit http://plants.usda.gov.
**Fire Regime Groups are: I: 0-35 year frequency, surface severity; II: 0-35 year frequency, replacement severity; III: 35-100+ year frequency, mixed severity; IV: 35-100+ year frequency, replacement severity; V: 200+ year frequency, replacement severity.

Mast, J. N., T. T. Veblen, and Y. B. Linhart. 1998. Disturbance and climatic influences on age structure of ponderosa pine at the pine/grassland ecotone, Colorado Front Range. Journal of Biogeography 25:743-755.

NatureServe. 2004. International Ecological Classification Standard: Terrestrial Ecological Classifications, NatureServe Central Databases. Arlington, VA. U.S.A. Data current as of November 4, 2004.

Peet, R. K. 1981. Forest vegetation of the Colorado Front Range: Composition and dynamics. Vegetation 45:3-75.

Peet, R. K. 1978. Latitudinal variation in southern Rocky Mountain forests. Journal of Biogeography 5:275-289.

Pohl, K. 2004. History of the Upper Purgatoire Basin. Report prepared for the Culebra Range Community Coalition and The Fire Learning Network.

Romme, William, M. Lisa Floyd, David Hanna, and Jeff Redders. 1999. DRAFT Ch. 4 Mixed Conifer Forests in Landscape Condition Analysis for the South Central Highlands Section, Southwestern Colorado and Northwestern New Mexico.

Sherriff, R. L. 2004. The historic range of variability of ponderosa pine in the northern Colorado Front Range: Past fire types and fire effects. Ph.D. Dissertation. University of Colorado, Boulder.

Swetnam, T. W., and A. M. Lynch, 1993. Multi-century, regional-scale patterns of western spruce budworm history. Ecological Monographs 63(4):399-424).

Touchan, R., T. W. Swetnam, and H. D. Grissino-Mayer. 1995. Effects of livestock grazing on pre-settlement fire regimes in New Mexico. Pages 268-272 in Brown, J. K., R. W. Mutch, C. W. Spoon, and R .H. Wakimoto, Technical Coordinators. Proceedings: Symposium on fire in wilderness and park management. Missoula, Montana, March 30-April 1, 1993. USDA Forest Service Intermountain Research Station General Technical Report INT-320.

Veblen, T. T., and D. C. Lorenz. 1986. Anthropogenic disturbance and recovery patterns in montane forests, Colorado Front Range. Physical Geography 7:1-24.

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

White, M.A., J.L. Vankat. 1993. Middle and high elevation coniferous forest communities of the North rim region of Grand Canyon National Park, Arizona, USA.

Wu, R. 1999. Fire History and Forest Structure in the Mixed Conifer Forests of Southwest Colorado. Master Thesis. Colorado State University.

*Dominant Species are from the NRCS PLANTS database. To check a species code, please visit http://plants.usda.gov.
**Fire Regime Groups are: I: 0-35 year frequency, surface severity; II: 0-35 year frequency, replacement severity; III: 35-100+ year frequency, mixed severity; IV: 35-100+ year frequency, replacement severity; V: 200+ year frequency, replacement severity.

LANDFIRE Biophysical Setting Model

Biophysical Setting: 2810510M Rocky Mountain Dry-Mesic Montane Mixed Conifer Forest and Woodland UMC

☐ *This BPS is lumped with:*
☐ *This BPS is split into multiple models:*

General Information

Contributors (also see the Comments field) **Date** 12/27/2012

Modeler 1 Ed Biery	ehbiery@fs.fed.us	**Reviewer**	
Modeler 2 Mike Babler	mbabler@tnc.org	**Reviewer**	
Modeler 3 Jeff Underhill	junderhill@fs.fed.us	**Reviewer**	
		FRCC	

Vegetation Type

Forested

Dominant Species*

PIPO ABCO
PSME
PIFL2
POTR5

General Model Sources

☑ Literature
☑ Local Data
☑ Expert Estimate

Map Zones

28	0
0	0
0	0
0	0
0	0

Model Zones

☐ Alaska	☐ N-Cent.Rockies
☐ California	☐ Pacific Northwest
☐ Great Basin	☐ South Central
☐ Great Lakes	☐ Southeast
☐ Northeast	☐ S. Appalachians
☐ Northern Plains	☑ Southwest

Geographic Range

South Colorado Front Range, specific to Upper Monument Creek project on the Pike National Forest. Occupies slopes other than north facing in this area.

Biophysical Site Description

This BpS is found generally found between 2100 to 2880 m (6900-9500ft). It can be found at higher elevations on south facing slopes than north facing slopes. Its distribution is variable on east and west aspects. Soils are usually well drained granitic (Pikes Peak Granite) or limestone based.

Vegetation Description

The composition and structure of overstory varies based on the temperature and moisture relationships of the site. Ponderosa pine, Douglas-fir, white fir, and aspen make up the warm/dry mixed conifer. Gambel oak is often the dominant shrub in southern part lower eleveations of map zone. In higher elevation areas of mapzone Cercocarpus montanus and Ribes cereum are common. Limber pine and Rocky Mountain juniper can be present. Ponderosa pine regeneration typically occurs after fire. Limber pine regeneration happens continuously between fires. Douglas-fir regeneration can happen in between and after fires. Douglas-fir gains fire resistance more quickly than white fir and can be a canopy dominant with Ponderosa pine. Other specieis that may occur include PICO, PIEN, PIPU.

Disturbance Description

This BpS has a fire regime very similar to ponderosa pine. Frequent low intensity surface fire is the dominant mode of disturbance. Fire intervals range from 2 - 71 years with a mean of 15. Lethal fires can occur on a limited scale but is not the norm unless aspen is involved. These will be characterized as mixed fires because they most likely occur as a part of a more widespread surface fire. Bark beetle may impact this BpS in isolated areas at small scales.

*Dominant Species are from the NRCS PLANTS database. To check a species code, please visit http://plants.usda.gov.
**Fire Regime Groups are: I: 0-35 year frequency, surface severity; II: 0-35 year frequency, replacement severity; III: 35-100+ year frequency, mixed severity; IV: 35-100+ year frequency, replacement severity; V: 200+ year frequency, replacement severity.

Adjacency or Identification Concerns

Native Uncharacteristic Conditions

Scale Description

Sources of Scale Data ☐ Literature ☐ Local Data ☐ Expert Estimate

Matrix, 2,000 to 10,000 ha.

Issues/Problems

Comments

12/19/2012. Revised further for Upper Monument Creek. Authors Ed Biery USFS, Jeff Underhill USFS, Diane Strohm USAFA, Jonas Feinstein NRCS, Peter Brown CFRI, Mike Babler TNC.Latest revisions for Upper Monument Creek are based on Oct 2007 2810500.(Mbabler 9 25 12). Based on R3MCONwd, by R. Wu (rwu@fs.fed.us) 10/20/2004. For 1051, Mike Babler(mbabler@tnc.org) made minor edits 4/26/2005.

Peer review of R3MCONwd resulted in an overall reduction by half or more of replacement and mixed severity fire frequencies (originally 100 and 40 years, respectively) and a slight lengthening of surface fire frequency (originally 20 years). The original model had an MFI of 12 years. These changes in fire frequencies had minimal (<5%) effect on the resulting percent in each class A-E. Review also identified a complex mosaic of species, stand composition and terrain. Based on this information and ongoing unpublished research, mixed fire was reduced from 160 to 10 years. Results were minor, changing All fire from 20 to 19, and no changes in class distributions.

Vegetation Classes

Class A 10 %

Early1 All Structures

Description

Succession after a lethal fire will depend on what vegetation was on site before. In a general conifer dominated scenario, some ponderosa are likely to survive. Fire will be an opportunity for new ponderosa establishment. On site Gambel oak will resprout. Limber pine will also be regenerating. If aspen cover is 50% or greater prior to disturbance, the stand would regenerate back to aspen.

Indicator Species* and Canopy Position

PIPO	All
PSME	All
QUGA	All
POTR5	All

Upper Layer Lifeform

- ☐ Herbaceous
- ☐ Shrub
- ☑ Tree

Fuel Model 5

Structure Data (for upper layer lifeform)

	Min	Max
Cover	0 %	80 %
Height	Tree 0m	Tree 5m
Tree Size Class	Sapling <5"DBH	

☐ Upper layer lifeform differs from dominant lifeform. Height and cover of dominant lifeform are:

*Dominant Species are from the NRCS PLANTS database. To check a species code, please visit http://plants.usda.gov.
**Fire Regime Groups are: I: 0-35 year frequency, surface severity; II: 0-35 year frequency, replacement severity; III: 35-100+ year frequency, mixed severity; IV: 35-100+ year frequency, replacement severity; V: 200+ year frequency, replacement severity.

Class B 5 %

Mid1 Closed

Description

If aspen is dominant the stand will achieve a mid-closed stage. Conifers such as Limber pine and Douglas-fir could be regenerating with it. Any surviving conifers such as ponderosa pine would be canopy dominants. If aspen canopy cover is 50% or greater.

Indicator Species* and Canopy Position

POTR5	Upper
PIFL2	Mid-Upper
PIPO	Mid-Upper
PSME	Mid-Upper

Upper Layer Lifeform

- ☐ Herbaceous
- ☐ Shrub
- ☑ Tree

Fuel Model 5

Structure Data (for upper layer lifeform)

	Min	Max
Cover	41 %	80 %
Height	Tree 5.1m	Tree 20m
Tree Size Class	Medium Large 5-16" DBH	

☐ Upper layer lifeform differs from dominant lifeform. Height and cover of dominant lifeform are:

Class C 20 %

Mid1 Open

Description

Ponderosa is the canopy dominant with an understory dominated by Douglas-fire. Limber pine is present and some of its regeneration is entering the canopy. If aspen were present, the stand would have undergone a some self thinning that would have opened up the canopy. The conifers in the stand create a more flammable litter bed with their needles so that patchy surface fire could carry. Any fire would further open the stand by thinning aspen and fir.

Indicator Species* and Canopy Position

PIPO	Mid-Upper
PIFL2	Mid-Upper
PSME	Mid-Upper
POTR5	Upper

Upper Layer Lifeform

- ☐ Herbaceous
- ☐ Shrub
- ☑ Tree

Fuel Model 8

Structure Data (for upper layer lifeform)

	Min	Max
Cover	11 %	40 %
Height	Tree 5.1m	Tree 20m
Tree Size Class	Medium Large 5-16" DBH	

☐ Upper layer lifeform differs from dominant lifeform. Height and cover of dominant lifeform are:

Class D 40 %

Late1 Open

Description

Ponderosa pine is the canopy dominant. Douglas-fir can also be a canopy dominant. Recurrent fire maintains white fir as an understory tree, but a rare white fir will join the other two species in the canopy. If aspen is present, its numbers are few. Low levels of suckering may keep it in the stand. Open aspen stands are not common

Indicator Species* and Canopy Position

PIPO	Mid-Upper
PSME	Mid-Upper
PIFL2	Mid-Upper
POTR	Upper

Upper Layer Lifeform

- ☐ Herbaceous
- ☐ Shrub
- ☑ Tree

Fuel Model 8

Structure Data (for upper layer lifeform)

	Min	Max
Cover	11 %	40 %
Height	Tree 20.1m	Tree 30m
Tree Size Class	Large Very Large16.1-30"DBH	

☐ Upper layer lifeform differs from dominant lifeform. Height and cover of dominant lifeform are:

*Dominant Species are from the NRCS PLANTS database. To check a species code, please visit http://plants.usda.gov.
**Fire Regime Groups are: I: 0-35 year frequency, surface severity; II: 0-35 year frequency, replacement severity; III: 35-100+ year frequency, mixed severity; IV: 35-100+ year frequency, replacement severity; V: 200+ year frequency, replacement severity.

in the warm/dry mixed conifer.

Class E **25 %**

Late1 Closed

Description

Conifer stand with minor Aspen component. Stand is mature to over mature with a heavy understory of conifers. Mainly Ponderosa, Douglas-fir, Limber pine, and Aspen.

Indicator Species* and Canopy Position

PIPO	Upper
PIFL2	Upper
PSME	Upper
POTR5	Mid-Upper

Upper Layer Lifeform

- ☐ Herbaceous
- ☐ Shrub
- ☑ Tree

Fuel Model 10

Structure Data (for upper layer lifeform)

	Min	*Max*
Cover	41 %	80 %
Height	Tree 20.1m	Tree 30m
Tree Size Class	Large Very Large 16.1-30"DBH	

☐ Upper layer lifeform differs from dominant lifeform. Height and cover of dominant lifeform are:

Disturbances

Fire Regime Group:** **1**

Historical Fire Size (acres)

Avg 0
Min 0
Max 0

Sources of Fire Regime Data

- ☐ Literature
- ☑ Local Data
- ☑ Expert Estimate

Fire Intervals

	Avg FI	*Min FI*	*Max FI*	*Probability*	*Percent of All Fires*
Replacement	333			0.00300	4
Mixed	45	80	200	0.02222	32
Surface	23	2	70	0.04348	63
All Fires	15			0.06870	

Fire Intervals (FI):

Fire interval is expressed in years for each fire severity class and for all types of fire combined (All Fires). Average FI is central tendency modeled. Minimum and maximum show the relative range of fire intervals, if known. Probability is the inverse of fire interval in years and is used in reference condition modeling. Percent of all fires is the percent of all fires in that severity class.

Additional Disturbances Modeled

- ☐ Insects/Disease
- ☐ Wind/Weather/Stress
- ☐ Native Grazing
- ☐ Competition
- ☐ Other (optional 1)
- ☐ Other (optional 2)

References

Bradley, Anne F., Nonan Noste, and William C. Fischer. 1992. Fire and Ecology of Forests and Woodlands in Utah. USDA Forest Service, GTR INT-287.

M.A. White, J.L. Vankat. 1993. Middle and high elevation coniferous forest communities of the North rim region of Grand Canyon National Park, Arizona, USA.

NatureServe. 2005. NatureServe Explorer: An online encyclopedia of life [web application]. Version 4.4. NatureServe, Arlington, Virginia. Available http://www.natureserve.org/explorer. (Accessed: April 29, 2005).

Romme, William, M. Lisa Floyd, David Hanna, and Jeff Redders. 1999. DRAFT Ch. 4 Mixed Conifer Forests in Landscape Condition Analysis for the South Central Highlands Section, Southwestern Colorado and Northwester New Mexico.

Wu, R. 1999. Fire History and Forest Structure in the Mixed Conifer Forests of Southwest Colorado.

*Dominant Species are from the NRCS PLANTS database. To check a species code, please visit http://plants.usda.gov.
**Fire Regime Groups are: I: 0-35 year frequency, surface severity; II: 0-35 year frequency, replacement severity; III: 35-100+ year frequency, mixed severity; IV: 35-100+ year frequency, replacement severity; V: 200+ year frequency, replacement severity.

Master Thesis. Colorado State University.

*Dominant Species are from the NRCS PLANTS database. To check a species code, please visit http://plants.usda.gov.
**Fire Regime Groups are: I: 0-35 year frequency, surface severity; II: 0-35 year frequency, replacement severity; III: 35-100+ year frequency, mixed severity; IV: 35-100+ year frequency, replacement severity; V: 200+ year frequency, replacement severity.

LANDFIRE Biophysical Setting Model

Biophysical Setting: 2810520M Rocky Mountain Mesic Mixed Conifer Forest and Woodland UMC

☐ *This BPS is lumped with:*
☐ *This BPS is split into multiple models:*

General Information

Contributors (also see the Comments field) **Date** 12/27/2012

Modeler 1 Ed Biery	ehbiery@fs.fed.us	**Reviewer**
Modeler 2 Jeff Underhill	junderhill@fs.fed.us	**Reviewer**
Modeler 3 Mike Babler	mbabler@tnc.org	**Reviewer**
		FRCC

Vegetation Type

Forested

Dominant Species*

PSME	PIFL2
POTR5	PIPO
PIPU	PICO
PIEN	ABCO

General Model Sources

☑ Literature
☑ Local Data
☑ Expert Estimate

Map Zones

28	0
0	0
0	0
0	0
0	0

Model Zones

☐ Alaska	☐ N-Cent.Rockies
☐ California	☐ Pacific Northwest
☐ Great Basin	☐ South Central
☐ Great Lakes	☐ Southeast
☐ Northeast	☐ S. Appalachians
☐ Northern Plains	☑ Southwest

Geographic Range

South Colorado Front Range, specific to Upper Monument Creek project on the Pike National Forest. Occupies north facing slopes in this area.

Biophysical Site Description

This Bps distribution is strongly driven by moisture gradients such as aspect and elevation. It is found on Northerly aspects, generally on steep slopes. found from 7500' to 9500'. Soils are generally Pike Peak granite. The same moisture gradients will influence the cool/moist mixed conifer's distribution elsewhere and it can be found much lower and much higher elevations than those described here.

Vegetation Description

The mixed conifer is driven by elevation and aspect. The cool moist mixed conifer will have much less ponderosa pine than the warm/dry. However, ponderosa pine is found in small groups or isolated places usually in open areas, edges of meadows, ridges. Douglas-Fir and Ponderosa pine are often canopy dominants with aspen present in most stands. The other major tree species found in the cool/moist are limber pine, englemann spruce, blue spruce, and aspen. Near riparian areas, wetlands and drainages blue spruce,englemann spruce and white fir can be quite common. PICO is uncommon but may be found.

Major understory species at the lower elevational range include Arcotstaphylos uva-ursi, Mertensia spp, Carex geyeri, Physocarpus monogynus, etc.

Disturbance Description

Fire is the primary disturbance although insects can also play a major role. Fire frequencies are very variable and the cool/moist supports a mixed fire regime. Mixed severity fires occurred every 6 - 60 years. Lethal fires are usually at longer intervals, 100+ years.

*Dominant Species are from the NRCS PLANTS database. To check a species code, please visit http://plants.usda.gov.
**Fire Regime Groups are: I: 0-35 year frequency, surface severity; II: 0-35 year frequency, replacement severity; III: 35-100+ year frequency, mixed severity; IV: 35-100+ year frequency, replacement severity; V: 200+ year frequency, replacement severity.

Insect and disease can act as a thinning agent to larger scale mortality agent, but was not modeled.

Adjacency or Identification Concerns

Native Uncharacteristic Conditions

Scale Description

Sources of Scale Data ☑ Literature ☑ Local Data ☑ Expert Estimate

Large patch, 50-2,000 ha.

Issues/Problems

Could not model the aspen and mixed conifer succession in one model because of box limitations.

Comments

12/19/2012. Revised further for Upper Monument Creek. Authors Ed Biery USFS, Jeff Underhill USFS, Diane Strohm USAFA, Jonas Feinstein NRCS, Peter Brown CFRI, Mike Babler TNC. Latest version 10/29/2012 based on 2810250, Oct 2007. Based on the Rapid Assessment model R3MCONcm by R Wu (rwu@fs.fed.us) 10/26/2004, reviewed by Bill Baker (bakerwl@wyo.edu).

Review of R3MCONcm, states fire interval should be doubled or longer, that replacement interval is likely longer than 200 years. One reviewer had several concerns about the area that this BpS describes, species distributions, and class percentages.

Vegetation Classes

Class A 10 %

Early1 All Structures

Description

Post-lethal fire vegetation will depend on what was on site before it burned. Aspen may or may not be present, depending on what was present prior to the fire or other replacement disturbance. The site will start as grass/forb/shrub; aspen may also be present. Fire will maintain or prolong this stage. Conifers may be present. Any surviving conifers will be seed source. This class may look like a pure aspen stand from above.

Indicator Species* and Canopy Position

POTR5 All
PSME All
PIFL2 All
SYOR2 All

Upper Layer Lifeform

☐ Herbaceous
☐ Shrub
☑ Tree

Fuel Model 8

Structure Data (for upper layer lifeform)

	Min	*Max*
Cover	0 %	100 %
Height	Tree 0m	Tree 5m
Tree Size Class	Seedling Sapling <5"DBH	

☐ Upper layer lifeform differs from dominant lifeform. Height and cover of dominant lifeform are:

*Dominant Species are from the NRCS PLANTS database. To check a species code, please visit http://plants.usda.gov.
**Fire Regime Groups are: I: 0-35 year frequency, surface severity; II: 0-35 year frequency, replacement severity; III: 35-100+ year frequency, mixed severity; IV: 35-100+ year frequency, replacement severity; V: 200+ year frequency, replacement severity.

Class B 25 %

Mid1 Closed

Description

If present, aspen will be over 10' tall and very dense. Seedling-medium sized conifers can be found mixed with aspen, if present. Understory may include mountain snowberry, common juniper, wild rose, and many species of grasses and forbs.

Indicator Species* and Canopy Position

POTR5	Upper
PSME	Mid-Upper
PIFL2	Mid-Upper
JUCO6	Lower

Upper Layer Lifeform

- ☐ Herbaceous
- ☐ Shrub
- ☑ Tree

Fuel Model 8

Structure Data (for upper layer lifeform)

	Min	*Max*
Cover	41 %	80 %
Height	Tree 5.1m	Tree 20m
Tree Size Class	Medium Large 5-16" DBH	

☐ Upper layer lifeform differs from dominant lifeform. Height and cover of dominant lifeform are:

Class C 20 %

Mid1 Open

Description

If present, aspen will be over 10' tall and patchy. Seedling-medium sized conifers can be found mixed with aspen, if present. Understory may include mountain snowberry, common juniper, wild rose, and many species of grasses and forbs. Canopy cover is low.

Indicator Species* and Canopy Position

PSME	Upper
PIEN	Upper
POTR5	Upper
2GRA	Upper

Upper Layer Lifeform

- ☐ Herbaceous
- ☐ Shrub
- ☑ Tree

Fuel Model 8

Structure Data (for upper layer lifeform)

	Min	*Max*
Cover	11 %	40 %
Height	Tree 5.1m	Tree 20m
Tree Size Class	Medium Large 5-16" DBH	

☐ Upper layer lifeform differs from dominant lifeform. Height and cover of dominant lifeform are:

Class D 15 %

Late1 Open

Description

Aspen will be rare and mid-level. Understory is a diverse mix of grasses, forbs and shrubs.

Indicator Species* and Canopy Position

PSME	Upper
PIEN	Upper
PIPU	Upper
POTR	Upper

Upper Layer Lifeform

- ☐ Herbaceous
- ☐ Shrub
- ☑ Tree

Fuel Model 8

Structure Data (for upper layer lifeform)

	Min	*Max*
Cover	11 %	40 %
Height	Tree 20.1m	Tree 30m
Tree Size Class	large 16.1-30"DBH	

☐ Upper layer lifeform differs from dominant lifeform. Height and cover of dominant lifeform are:

*Dominant Species are from the NRCS PLANTS database. To check a species code, please visit http://plants.usda.gov.
**Fire Regime Groups are: I: 0-35 year frequency, surface severity; II: 0-35 year frequency, replacement severity; III: 35-100+ year frequency, mixed severity; IV: 35-100+ year frequency, replacement severity; V: 200+ year frequency, replacement severity.

Class E **30 %**

Late1 Closed

Description

Dense conifer stand. Blue spruce and Englemann spruce can come in. Aspen present in small amounts. Lots of dead and downed material. Understory possibly depauperate.

Indicator Species* and Canopy Position

PSME	Upper
PIEN	Upper
PIPU	Upper
POTR5	Middle

Upper Layer Lifeform

- ☐ Herbaceous
- ☐ Shrub
- ☑ Tree

Fuel Model 10

Structure Data (for upper layer lifeform)

	Min	*Max*
Cover	41 %	100 %
Height	Tree 20.1m	Tree 30m
Tree Size Class	Large 16.1-30"DBH	

☐ Upper layer lifeform differs from dominant lifeform. Height and cover of dominant lifeform are:

Disturbances

Fire Regime Group:** **3**

Historical Fire Size (acres)

Avg 0
Min 0
Max 0

Sources of Fire Regime Data

- ☑ Literature
- ☑ Local Data
- ☑ Expert Estimate

Fire Intervals	*Avg FI*	*Min FI*	*Max FI*	*Probability*	*Percent of All Fires*
Replacement	300	80	200	0.00333	25
Mixed	135	35	250	0.00741	56
Surface	400	10	200	0.0025	19
All Fires	76			0.01324	

Fire Intervals (FI):

Fire interval is expressed in years for each fire severity class and for all types of fire combined (All Fires). Average FI is central tendency modeled. Minimum and maximum show the relative range of fire intervals, if known. Probability is the inverse of fire interval in years and is used in reference condition modeling. Percent of all fires is the percent of all fires in that severity class.

Additional Disturbances Modeled

- ☐ Insects/Disease
- ☐ Wind/Weather/Stress
- ☐ Native Grazing
- ☐ Competition
- ☐ Other (optional 1)
- ☐ Other (optional 2)

References

Alington, C. 1998. Fire History and Landscape Pattern in the Sangre de Cristo Mountains, Colorado. Dissertation. Colorado State University, Fort Collins, Colorado.

Allen, C.D., technical editor. 1996. Fire Effects in Sothwestern Forests. Proceedings of the second La Mesa fire symposium. USDA Forest Service General Technical Report RM-GTR-286, Fort Collins Co.

Allen, C.D. 1989. Changes in the landscape of the Jemez Mountains, New Mexico. Ph.D. dissertation, University of California, Berkeley.

Allen, C.D., R. Touchan, and T.W. Swetnam. 1995. Landscape-scale fire history studies support fire management action at Bandelier. Park Science:Summer, pp. 18-19.

Cooper, C. F. 1960. Changes in vegetation, structure, and growth of Southwestern pine forests since white settlement. Ecological Monographs 30(2):129-164.

Allen, R. B., R. K. Peet, and W. L. Baker. 1991. Gradient analysis of latitudinal variation in Southern Rocky Mountain forests. Journal of Biogeography 18:123-139.

*Dominant Species are from the NRCS PLANTS database. To check a species code, please visit http://plants.usda.gov.
**Fire Regime Groups are: I: 0-35 year frequency, surface severity; II: 0-35 year frequency, replacement severity; III: 35-100+ year frequency, mixed severity; IV: 35-100+ year frequency, replacement severity; V: 200+ year frequency, replacement severity.

Brown, P.M, M.W. Kaye, L.S. Huckaby, and C.H. Baisan. 2001. Fire history along environmental gradients in the Sacramento Mountains, New Mexico: Influences of local patterns and regional processes. Ecoscience 8(1):115-126.
Brown, P.M., M.R. Kaufmann, and W.D. Shepperd. 1999. Landscape Ecology 14:513-532.

Brown, P. M. 2004. Final Report: Bar NI Fire History. Rocky Mountain Tree-Ring Research, Fort Collins, CO.

Brown, P. M., and W. D. Shepperd. 2001. Fire history and fire climatology along a 5 degree gradient in latitude in Colorado and Wyoming, USA. Palaeobotanist 50:133-140.

Fule, P., Covington, and M. M. Moore. 1997. Determining reference conditions for ecosystem management of southwestern ponderosa pine forests. Ecological Applications 7:895-908.

Huckaby, L. S., and M. R. Kaufmann. 2000. Bar NI Ranch Fire History Study. Unpublished report. USDA Forest Service, Rocky Mountain Research Station.

Huckaby, L. S., M. R. Kaufmann, J. M. Stoker, and P. J. Fornwalt. 2001. Landscape patterns of montane forest age structure relative to fire history at Cheesman Lake in the Colorado Front Range. Pages 19-27 in R. K. Vance, C. B. Edminster, W. Covington, and J. A. Blake, editors. Pondersoa Pine Ecosystems Restoration and Conservation: Steps Toward Stewardship, Conference Proceedings, Flagstaff, AZ, April 25-27, 2000. USDA Forest Service, Rocky Mountain Research Station, Ogden, UT.

Kaufmann, M. R., L. S. Huckaby, C. M. Regan, and J. Popp. 1998. Forest Reference Conditions for Ecosystem Management in the Sacramento Mountains, New Mexico. Genereral Technical Report RMRS-GTR 19, USDA / Forest Service, Fort Collins.
Kaufmann, M. R., C. M. Regan, and P. M. Brown. 2000b. Heterogeneity in ponderosa pine/Douglas-fir forests: age and size structure in unlogged and logged landscapes of central Colorado. Can. J. For. Res. 30:698-711.

NatureServe. 2004. International Ecological Classification Standard: Terrestrial Ecological Classifications, NatureServe Central Databases. Arlington, VA. U.S.A. Data current as of November 4, 2004.

Peet, R. K. 1978. Latitudinal variation in southern Rocky Mountain forests. Journal of Biogeography 5:275-289.
Bradley, Anne F., Nonan Noste, and William C. Fischer. 1992. Fire and Ecology of Forests and Woodlands in Utah. USDA Forest Service, GTR INT-287.

Pohl, K. 2004. History of the Upper Purgatoire Basin. Report prepared for the Culebra Range Community Coalition and The Fire Learning Network.

Romme, William, M. Lisa Floyd, David Hanna, and Jeff Redders. 1999. DRAFT Ch. 4 Mixed Conifer Forests in Landscape Condition Analysis for the South Central Highlands Section, Southwestern Colorado and Northwestern New Mexico.

Touchan, R., T. W. Swetnam, and H. D. Grissino-Mayer. 1995. Effects of livestock grazing on pre-settlement fire regimes in New Mexico. Pages 268-272 in Brown, J. K., R. W. Mutch, C. W. Spoon, and R .H. Wakimoto, Technical Coordinators. Proceedings: Symposium on fire in wilderness and park management. Missoula, Montana, March 30-April 1, 1993. USDA Forest Service Intermountain Research Station General

*Dominant Species are from the NRCS PLANTS database. To check a species code, please visit http://plants.usda.gov.
**Fire Regime Groups are: I: 0-35 year frequency, surface severity; II: 0-35 year frequency, replacement severity; III: 35-100+ year frequency, mixed severity; IV: 35-100+ year frequency, replacement severity; V: 200+ year frequency, replacement severity.

Technical Report INT-320.

White, M.A., J.L. Vankat. 1993. Middle and high elevation coniferous forest communities of the North rim region of Grand Canyon National Park, Arizona, USA.

Wu, R. 1999. Fire History and Forest Structure in the Mixed Conifer Forests of Southwest Colorado. Master Thesis. Colorado State University.

*Dominant Species are from the NRCS PLANTS database. To check a species code, please visit http://plants.usda.gov.
**Fire Regime Groups are: I: 0-35 year frequency, surface severity; II: 0-35 year frequency, replacement severity; III: 35-100+ year frequency, mixed severity; IV: 35-100+ year frequency, replacement severity; V: 200+ year frequency, replacement severity.

Appendix C
VDDT Model Parameters for UMC Focal Systems

Ecological System	Probabilistic Transition Type	From State Class	From Cover	To State Class	To Cover	Min Age	Max Age	TSD Min	Prob-ability	Pro-portion	Rela-tive Age	Keep Rel Age
Ponderosa Pine/Doug-fir	AltSuccession	Early1	ALL	Mid1	CLS	0	39	0	0.01	1	0	FALSE
Ponderosa Pine/Doug-fir	MixedFire	Early1	ALL	Early1	ALL	0	39	0	0.0063	1	0	FALSE
Ponderosa Pine/Doug-fir	SurfaceFire	Early1	ALL	Early1	ALL	0	39	0	0.04	1	0	FALSE
Ponderosa Pine/Doug-fir	ReplacementFire	Mid1	CLS	Early1	ALL	40	149	0	0.002	0.7	0	FALSE
Ponderosa Pine/Doug-fir	MixedFire	Mid1	CLS	Mid1	OPN	40	149	0	0.0063	1	0	FALSE
Ponderosa Pine/Doug-fir	SurfaceFire	Mid1	CLS	Mid1	CLS	40	149	0	0.04	1	0	FALSE
Ponderosa Pine/Doug-fir	Mech-Thin-B	Mid1	CLS	Mid1	OPN	40	149	0	0.01	1	0	TRUE
Ponderosa Pine/Doug-fir	RxBurn-Closed	Mid1	CLS	Mid1	OPN	40	149	0	0.01	0.5	0	FALSE
Ponderosa Pine/Doug-fir	ReplacementFire	Mid1	CLS	Unchar	ALL	40	149	0	0.002	0.3	0	FALSE
Ponderosa Pine/Doug-fir	Regen-B	Mid1	CLS	Early1	ALL	40	149	0	0.01	1	0	FALSE
Ponderosa Pine/Doug-fir	RxBurn-Closed	Mid1	CLS	Mid1	CLS	40	149	0	0.01	0.5	0	FALSE
Ponderosa Pine/Doug-fir	Manual-Thin-B	Mid1	CLS	Mid1	OPN	40	149	0	0.01	0.6	0	TRUE
Ponderosa Pine/Doug-fir	Manual-Thin-B	Mid1	CLS	Mid1	CLS	40	149	0	0.01	0.4	0	TRUE
Ponderosa Pine/Doug-fir	ReplacementFire	Mid1	OPN	Early1	ALL	40	149	0	0.002	0.7	0	FALSE
Ponderosa Pine/Doug-fir	SurfaceFire	Mid1	OPN	Mid1	OPN	40	149	0	0.04	1	0	FALSE
Ponderosa Pine/Doug-fir	MixedFire	Mid1	OPN	Mid1	OPN	40	149	0	0.0031	1	0	FALSE
Ponderosa Pine/Doug-fir	MixedFire	Mid1	OPN	Early1	ALL	40	149	0	0.0031	1	0	FALSE
Ponderosa Pine/Doug-fir	AltSuccession	Mid1	OPN	Mid1	CLS	40	149	60	1	1	0	FALSE
Ponderosa Pine/Doug-fir	RxBurn-Open	Mid1	OPN	Early1	ALL	40	149	0	0.01	0.5	0	FALSE
Ponderosa Pine/Doug-fir	RxBurn-Open	Mid1	OPN	Mid1	OPN	40	149	0	0.01	0.5	0	FALSE
Ponderosa Pine/Doug-fir	ReplacementFire	Mid1	OPN	Unchar	ALL	40	149	0	0.002	0.3	0	FALSE
Ponderosa Pine/Doug-fir	SurfaceFire	Late1	OPN	Late1	OPN	150	999	0	0.04	1	0	FALSE
Ponderosa Pine/Doug-fir	ReplacementFire	Late1	OPN	Early1	ALL	150	999	0	0.002	0.7	0	FALSE
Ponderosa Pine/Doug-fir	AltSuccession	Late1	OPN	Late1	CLS	150	999	0	0.003	1	0	FALSE
Ponderosa Pine/Doug-fir	MixedFire	Late1	OPN	Late1	OPN	150	999	0	0.0063	1	0	FALSE
Ponderosa Pine/Doug-fir	RxBurn-Open	Late1	OPN	Late1	OPN	150	999	0	0.01	1	0	FALSE
Ponderosa Pine/Doug-fir	ReplacementFire	Late1	OPN	Unchar	ALL	150	999	0	0.002	0.3	0	FALSE
Ponderosa Pine/Doug-fir	Regen-E	Late1	CLS	Early1	ALL	150	999	0	0.01	1	0	FALSE
Ponderosa Pine/Doug-fir	ReplacementFire	Late1	CLS	Early1	ALL	150	999	0	0.002	0.7	0	FALSE
Ponderosa Pine/Doug-fir	MixedFire	Late1	CLS	Late1	OPN	150	999	0	0.0063	1	0	FALSE
Ponderosa Pine/Doug-fir	SurfaceFire	Late1	CLS	Late1	CLS	150	999	0	0.04	1	0	FALSE
Ponderosa Pine/Doug-fir	Mech-Thin-E	Late1	CLS	Late1	OPN	150	999	0	0.01	1	0	TRUE
Ponderosa Pine/Doug-fir	RxBurn-Closed	Late1	CLS	Late1	OPN	90	999	0	0.01	0.5	0	FALSE
Ponderosa Pine/Doug-fir	ReplacementFire	Late1	CLS	Unchar	ALL	150	999	0	0.002	0.3	0	FALSE
Ponderosa Pine/Doug-fir	RxBurn-Closed	Late1	CLS	Late1	CLS	90	999	0	0.01	0.5	0	FALSE
Ponderosa Pine/Doug-fir	Manual-Thin-E	Late1	CLS	Late1	OPN	150	999	0	0.01	0.6	0	TRUE
Ponderosa Pine/Doug-fir	Manual-Thin-E	Late1	CLS	Late1	CLS	150	999	0	0.01	0.4	0	TRUE

Ecological System	Probabilistic Transition Type	From State Class	From Cover	To State Class	To Cover	Min Age	Max Age	TSD Min	Prob-ability	Pro-portion	Rela-tive Age	Keep Rel Age
Dry-Mesic Mixed Conifer	SurfaceFire	Early1	ALL	Early1	ALL	0	39	0	0.01	1	0	FALSE
Dry-Mesic Mixed Conifer	AltSuccession	Early1	ALL	Mid1	OPN	0	39	0	0.01	1	0	FALSE
Dry-Mesic Mixed Conifer	MixedFire	Early1	ALL	Mid1	OPN	0	39	0	0.02	1	0	FALSE
Dry-Mesic Mixed Conifer	MixedFire	Mid1	CLS	Mid1	OPN	40	149	0	0.022	1	0	FALSE
Dry-Mesic Mixed Conifer	ReplacementFire	Mid1	CLS	Early1	ALL	40	149	0	0.005	0.7	0	FALSE
Dry-Mesic Mixed Conifer	Mech-Thin-B	Mid1	CLS	Mid1	OPN	40	149	0	0.01	1	0	TRUE
Dry-Mesic Mixed Conifer	RxFire-Closed	Mid1	CLS	Mid1	OPN	40	149	0	0.01	0.5	0	FALSE
Dry-Mesic Mixed Conifer	Regen-B	Mid1	CLS	Early1	ALL	40	149	0	0.01	1	0	FALSE
Dry-Mesic Mixed Conifer	ReplacementFire	Mid1	CLS	Unchar	ALL	40	149	0	0.005	0.3	0	FALSE
Dry-Mesic Mixed Conifer	RxFire-Closed	Mid1	CLS	Mid1	CLS	40	149	0	0.01	0.5	0	FALSE
Dry-Mesic Mixed Conifer	Manual-Thin-B	Mid1	CLS	Mid1	OPN	40	149	0	0.01	0.6	0	FALSE
Dry-Mesic Mixed Conifer	Manual-Thin-B	Mid1	CLS	Mid1	CLS	40	149	0	0.01	0.4	0	FALSE
Dry-Mesic Mixed Conifer	SurfaceFire	Mid1	OPN	Mid1	OPN	40	149	0	0.067	1	0	FALSE
Dry-Mesic Mixed Conifer	ReplacementFire	Mid1	OPN	Early1	ALL	40	149	0	0.0025	0.7	0	FALSE
Dry-Mesic Mixed Conifer	AltSuccession	Mid1	OPN	Late1	CLS	40	149	60	1	1	0	FALSE
Dry-Mesic Mixed Conifer	MixedFire	Mid1	OPN	Mid1	OPN	40	149	0	0.0166	1	0	FALSE
Dry-Mesic Mixed Conifer	AltSuccession	Mid1	OPN	Mid1	CLS	40	149	60	1	1	0	FALSE
Dry-Mesic Mixed Conifer	RxFire-Open	Mid1	OPN	Mid1	OPN	40	149	0	0.01	1	0	FALSE
Dry-Mesic Mixed Conifer	ReplacementFire	Mid1	OPN	Unchar	ALL	40	149	0	0.0025	0.3	0	FALSE
Dry-Mesic Mixed Conifer	SurfaceFire	Late1	OPN	Late1	OPN	150	999	0	0.067	1	0	FALSE
Dry-Mesic Mixed Conifer	AltSuccession	Late1	OPN	Late1	CLS	150	999	0	0.02	1	0	FALSE
Dry-Mesic Mixed Conifer	ReplacementFire	Late1	OPN	Early1	ALL	150	999	0	0.0024	0.7	0	FALSE
Dry-Mesic Mixed Conifer	MixedFire	Late1	OPN	Late1	OPN	150	999	0	0.016	1	0	FALSE
Dry-Mesic Mixed Conifer	RxFire-Open	Late1	OPN	Late1	OPN	150	199	0	0.01	1	0	FALSE
Dry-Mesic Mixed Conifer	ReplacementFire	Late1	OPN	Unchar	ALL	150	999	0	0.0024	0.3	0	FALSE
Dry-Mesic Mixed Conifer	ReplacementFire	Late1	CLS	Early1	ALL	150	999	0	0.005	0.7	0	FALSE
Dry-Mesic Mixed Conifer	MixedFire	Late1	CLS	Late1	OPN	150	999	0	0.033	1	0	FALSE
Dry-Mesic Mixed Conifer	Mech-Thin-E	Late1	CLS	Late1	OPN	150	999	0	0.01	1	0	TRUE
Dry-Mesic Mixed Conifer	RxFire-Closed	Late1	CLS	Late1	OPN	150	199	0	0.01	0.5	0	FALSE
Dry-Mesic Mixed Conifer	Regen-E	Late1	CLS	Early1	ALL	150	199	0	0.01	1	0	FALSE
Dry-Mesic Mixed Conifer	ReplacementFire	Late1	CLS	Unchar	ALL	150	999	0	0.005	0.3	0	FALSE
Dry-Mesic Mixed Conifer	RxFire-Closed	Late1	CLS	Late1	CLS	150	199	0	0.01	0.5	0	FALSE
Dry-Mesic Mixed Conifer	Manual-Thin-E	Late1	CLS	Late1	OPN	150	999	0	0.01	0.6	0	FALSE
Dry-Mesic Mixed Conifer	Manual-Thin-E	Late1	CLS	Late1	CLS	150	999	0	0.01	0.4	0	FALSE

Ecological System	Probabilistic Transition Type	From State Class	From Cover	To State Class	To Cover	Min Age	Max Age	TSD Min	Prob-ability	Pro-portion	Rela-tive Age	Keep Rel Age
Mesic Mixed Conifer	ReplacementFire	Early1	ALL	Early1	ALL	0	39	0	0.0033	0.8	-39	FALSE
Mesic Mixed Conifer	AltSuccession	Early1	ALL	Mid1	OPN	0	39	0	0.005	1	0	FALSE
Mesic Mixed Conifer	ReplacementFire	Early1	ALL	Unchar	ALL	0	39	0	0.0033	0.2	0	FALSE
Mesic Mixed Conifer	MixedFire	Mid1	CLS	Mid1	OPN	40	149	0	0.01	1	0	FALSE
Mesic Mixed Conifer	ReplacementFire	Mid1	CLS	Early1	ALL	40	149	0	0.0033	0.8	0	FALSE
Mesic Mixed Conifer	RxBurn-Closed	Mid1	CLS	Mid1	OPN	40	149	0	1	0.5	0	FALSE
Mesic Mixed Conifer	Mech-Thin-B	Mid1	CLS	Mid1	OPN	40	149	0	0.01	0.5	0	TRUE
Mesic Mixed Conifer	RegenHarvest	Mid1	CLS	Early1	ALL	40	149	0	0.01	1	0	FALSE
Mesic Mixed Conifer	ReplacementFire	Mid1	CLS	Unchar	ALL	40	149	0	0.0033	0.2	0	FALSE
Mesic Mixed Conifer	RxBurn-Closed	Mid1	CLS	Mid1	CLS	40	149	0	1	0.5	0	FALSE
Mesic Mixed Conifer	Mech-Thin-B	Mid1	CLS	Mid1	CLS	40	149	0	0.01	0.5	0	TRUE
Mesic Mixed Conifer	ReplacementFire	Mid1	OPN	Early1	ALL	40	149	0	0.0033	0.8	0	FALSE
Mesic Mixed Conifer	AltSuccession	Mid1	OPN	Mid1	CLS	40	149	80	1	1	0	FALSE
Mesic Mixed Conifer	MixedFire	Mid1	OPN	Mid1	OPN	40	149	0	0.013	1	0	FALSE
Mesic Mixed Conifer	ReplacementFire	Mid1	OPN	Unchar	ALL	40	149	0	0.0033	0.2	0	FALSE
Mesic Mixed Conifer	RxBurn-Open	Mid1	OPN	Mid1	OPN	40	149	0	0.01	1	0	FALSE
Mesic Mixed Conifer	SurfaceFire	Late1	OPN	Late1	OPN	150	189	0	0.013	1	-189	FALSE
Mesic Mixed Conifer	ReplacementFire	Late1	OPN	Early1	ALL	150	189	0	0.0033	0.8	0	FALSE
Mesic Mixed Conifer	ReplacementFire	Late1	OPN	Unchar	ALL	150	189	0	0.0033	0.2	0	FALSE
Mesic Mixed Conifer	RxBurn-Open	Late1	OPN	Late1	OPN	150	189	0	0.01	1	0	FALSE
Mesic Mixed Conifer	ReplacementFire	Late1	CLS	Early1	ALL	150	999	0	0.0033	0.8	0	FALSE
Mesic Mixed Conifer	MixedFire	Late1	CLS	Late1	OPN	150	999	0	0.01	1	0	FALSE
Mesic Mixed Conifer	RxBurn-Closed	Late1	CLS	Late1	OPN	150	999	0	1	0.5	0	FALSE
Mesic Mixed Conifer	Mech-Thin-E	Late1	CLS	Late1	OPN	150	999	0	0.01	0.5	0	TRUE
Mesic Mixed Conifer	RegenHarvest	Late1	CLS	Early1	ALL	150	999	0	0.01	1	0	FALSE
Mesic Mixed Conifer	ReplacementFire	Late1	CLS	Unchar	ALL	150	999	0	0.0033	0.2	0	FALSE
Mesic Mixed Conifer	RxBurn-Closed	Late1	CLS	Late1	CLS	150	999	0	1	0.5	0	FALSE
Mesic Mixed Conifer	Mech-Thin-E	Late1	CLS	Late1	CLS	150	999	0	0.01	0.5	0	TRUE

Appendix D
Management Treatments Summary for UMC Focal Systems

Ecological System	Management Action in Model	Management Action Description	From Class	To Class	Cost/ Acre	Success Rate	Comment
Ponderosa pine/Douglas-fir woodland	RxFire	Prescribed broadcast burning following manual hand prep; two entries	B & E	C & D	750	50%	Success rate is after 2 entries; manual hand prep cost of $175/ac not included
Ponderosa pine/Douglas-fir woodland	Mechanical Thinning	Ground based logging (thinning from below or above) with machine pile burning on landings post treatment	B & E	C & D	925		Post treatment burning cost of $75/ac included
Ponderosa pine/Douglas-fir woodland	Regen Harvest	Ground based logging, either selection or clearcutting leaving seed trees, integrated with the mechanical thinning treatments	B & E	A	1075		Post treatment burning cost of $75/ac included
Ponderosa pine/Douglas-fir woodland	Manual Thinning	Thinning of pole sized and smaller material with chainsaws, hand piling of slash.	B & E	C & D	175	60%	
Ponderosa pine/Douglas-fir woodland	RxFire-Maintenance	Prescribed burning to maintain open conditions	C & D	no change	350		
Dry-mesic montane mixed conifer forest & woodland	RxFire	Prescribed broadcast burning following manual hand prep; two entries	B & E	C & D	750	50%	Success rate is after 2 entries; manual hand prep cost of $175/ac not included
Dry-mesic montane mixed conifer forest & woodland	Mechanical Thinning	Ground based logging (thinning from below or above) with machine pile burning on landings post treatment	B & E	C & D	950		Weighted average cost of mostly south ($850) and north ($1000) aspects, plus post treatment burning cost of $75/ac.
Dry-mesic montane mixed conifer forest & woodland	Regen Harvest	Ground based logging, either selection or clearcutting leaving seed trees, integrated with the mechanical thinning treatments	B & E	A	1100		Weighted average cost of mostly south ($1000) and north ($1150) aspects, plus post treatment cost of $75/ac
Dry-mesic montane mixed conifer forest & woodland	Manual Thinning	Thinning of pole sized and smaller material with chainsaws, hand piling of slash.	B & E	C & D	230	60%	Weighted average cost of mostly south ($175) and north ($550) aspects
Dry-mesic montane mixed conifer forest & woodland	RxFire-Maintenance	Prescribed burning to maintain open conditions	C & D	no change	350		
Mesic montane mixed conifer forest & woodland	RxFire	Prescribed broadcast burning following manual hand prep; two entries	B & E	C & D	750	50%	Success rate is after 2 entries; manual hand prep cost of $175/ac not included
Mesic montane mixed conifer forest & woodland	Mechanical Thinning	Ground based logging (thinning from below or above) with machine pile burning on landings post treatment	B & E	C & D	1075	50%	Includes post treatment burning cost of $75/ac.
Mesic montane mixed conifer forest & woodland	Regen Harvest	Ground based logging, either selection or clearcutting leaving seed trees, integrated with the mechanical thinning treatments	B & E	A	1225		Includes post treatment cost of $75/ac.
Mesic montane mixed conifer forest & woodland	RxFire-Maintenance	Prescribed burning to maintain open conditions	C & D	no change	350		

Appendix E

Model Run Worksheets - Ponderosa Pine/Douglas-fir Woodland

Strategy Worksheet — *Ponderosa Pine-Douglas Fir Woodland* — *20,500 acres*

Vegetation Class	NRV	Current Condtion	No Management - 10 Yrs	Mechanical Only - 5% Regen	Mechanical Only - 20% Regen	Mechanical Only - 40% Regen	Prescribed Burn Only	Mechanical + Rx Burning	Mechanical + Large Rx Burn
A - Early	10%	9%	6%	8%	11%	15%	7%	11%	11%
B - Mid Closed	10%	42%	38%	25%	26%	24%	36%	23%	19%
C - Mid Open	15%	21%	22%	34%	31%	29%	24%	34%	38%
D - Late Open	45%	10%	11%	18%	17%	15%	12%	17%	20%
E - Late Closed	20%	16%	19%	12%	12%	13%	18%	11%	10%
U - Uncharacteristic		3%	3%	3%	3%	3%	3%	3%	3%
Ecological Departure		**40**	**39**	**37**	**36**	**37**	**38**	**37**	**35**
Open Forest Departure		**43**	**44**	**14**	**16**	**16**	**39**	**11**	**1**
Total Cost			$ -	$ 4,100,300	$ 4,194,800	$ 4,320,800	$ 1,083,800	$ 5,094,800	$ 6,782,300
ROI (vs. Min. Mgmt)				**0.8**	**0.8**	**0.7**	**0.6**	**0.7**	**0.7**

Number of Acres/Year, Costs & Number of Years for Each Management Treatment

Scenarios (enter name below)	**Notes**	Mechanical Thinning	Regen Harvest	Hand Thin	RxBurn (2 entries)		RxBurn (large)	
No Management - 10 Yrs	with fire suppression via Transition Multipliers							
Mechanical Only - 5% Rege	1200 ac/yr Mech (50% PPine); 500 ac/yr Man (30%	**570**	**30**	**150**				
Mechanical Only - 20% Reg	1200 ac/yr Mech (50% PPine); 500 ac/yr Man (30%	**480**	**120**	**150**				
Mechanical Only - 40% Reg	1200 ac/yr Mech (50% PPine); 500 ac/yr Man (30%	**360**	**240**	**150**				
Prescribed Burn Only	Two entries following hand treated acres			**150**	**150**			
Mechanical + Rx Burning	Mech@20% Regen + RXBurn hand treated	**480**	**120**	**150**	**150**			
Mechanical + Large Rx Bur	add 6,750 acre burn in year 8 (2250 PP, 2500 Dry, 2000	**480**	**120**	**150**	**150**		**2250**	
Cost of Strategy (per acre)		$ 925	$ 1,075	$ 175	$ 750		$ 750	
Number of Years		7	7	7	8		1	

Acres Treated								
No Management - 10 Yrs								
Mechanical Only - 5% Rege		**3,990**	**210**	**1,050**	**-**	**-**	**-**	**-**
Mechanical Only - 20% Reg		**3,360**	**840**	**1,050**	**-**	**-**	**-**	**-**
Mechanical Only - 40% Reg		**2,520**	**1,680**	**1,050**	**-**	**-**	**-**	**-**
Prescribed Burn Only		**-**	**-**	**1,050**	**1,200**	**-**	**-**	**-**
Mechanical + Rx Burning		**3,360**	**840**	**1,050**	**1,200**	**-**	**-**	**-**
Mechanical + Large Rx Bur		**3,360**	**840**	**1,050**	**1,200**	**-**	**2,250**	**-**

Strategy Worksheet ***Ponderosa Pine - Fire Alts, 10 Yr Zero, Mech+Burn*** *20,500 acres* 100000

Enter percentages from "Final Conditions" as a whole number

Vegetation Class	NRV	Current Condtion	No Mgmt - Fire Supression	No Mgmt - No Fire	No Mgmt - High Fire	10 Year Zero	Mech + Rx Burning - 10 Yrs	Mech + Rx Burning - 20 Yrs	Mech + Rx Burning - 50 Yrs
A - Early	10%	9%	6%	6%	11%	11%	11%	11%	8%
B - Mid Closed	10%	42%	38%	39%	33%	17%	23%	21%	17%
C - Mid Open	15%	21%	22%	21%	23%	40%	34%	31%	25%
D - Late Open	45%	10%	11%	11%	11%	20%	17%	20%	24%
E - Late Closed	20%	16%	19%	20%	17%	9%	11%	14%	21%
U - Uncharacteristic	0%	3%	3%	3%	5%	3%	3%	4%	5%

Ecological Departure	**40**	**39**	**38**	**37**	**36**	**37**	**31**	**23**
Open Forest Departure	**43**	**44**	**46**	**36**	**0**	**11**	**11**	**19**
Total Cost	$ -	$ -	$ -	$ -	$ 7,753,000	$ 5,094,800	$ 5,444,800	$ 6,494,800
ROI (vs. Min. Mgmt)		**-**	**-**	**0.6**	**0.7**	**0.8**	**0.6**	

Scenarios (enter name below)	**Notes**	Number of Acres/Year, Costs & Number of Years for Each Management Treatment						
		Mechanical Thinning	Regen Harvest	Hand Thin	RxBurn	RxBurn (maintenance)	RxBurn (maintenance)	
No Mgmt - Fire Supression	with fire suppression via Transition Multipliers							
No Mgmt - No Fire	no fire							
No Mgmt - High Fire	4300 ac Pond burned;30% replacement; 45% mixed;							
10 Year Zero	Add thinning & burning to get zero open forest departure	**500**	**120**	**500**	**500**			
Mech + Rx Burning - 10 Yrs		**480**	**120**	**150**	**150**			
Mech + Rx Burning - 20 Yrs	Added maintenance burning after year 10	**480**	**120**	**150**	**150**	**100**		
Mech + Rx Burning - 50 Yrs	Added maintenance burning after year 10	**480**	**120**	**150**	**150**		**100**	
Cost of Strategy (per acre)		$ 925	$ 1,075	$ 175	$ 750	$ 350	$ 350	
Number of Years		7	7	7	8	10	40	

Acres Treated								
No Mgmt - Fire Supression								
No Mgmt - No Fire		-	-	-	-	-	-	-
No Mgmt - High Fire		-	-	-	-	-	-	-
10 Year Zero		**3,500**	**840**	**3,500**	**4,000**	-	-	-
Mech + Rx Burning - 10 Yrs		**3,360**	**840**	**1,050**	**1,200**	-	-	-
Mech + Rx Burning - 20 Yrs		**3,360**	**840**	**1,050**	**1,200**	**1,000**	-	-
Mech + Rx Burning - 50 Yrs		**3,360**	**840**	**1,050**	**1,200**	-	**4,000**	-

Strategy Worksheet | ***Ponderosa Pine - Feasible Treatments & Trajectory*** | *20,500 acres*

Enter percentages from "Final Conditions" as a whole number

Vegetation Class	NRV	Current Condtion	No Mgmt - 10 Yrs	Feasible Treatments-10 Yrs	No Mgmt - 20 Yrs	Feasible Treatments-20 Yrs	No Mgmt - 50 Yrs	Feasible Treatments-50 Yrs	-
A - Early	10%	9%	6%	9%	5%	9%	3%	7%	
B - Mid Closed	10%	42%	38%	25%	33%	23%	23%	18%	
C - Mid Open	15%	21%	22%	34%	22%	31%	20%	23%	
D - Late Open	45%	10%	11%	17%	12%	19%	18%	25%	
E - Late Closed	20%	16%	19%	12%	23%	15%	32%	22%	
U - Uncharacteristic		3%	3%	3%	4%	3%	5%	4%	
Ecological Departure		**40**	**39**	**37**	**38**	**32**	**34**	**23**	**-**
Open Forest Departure		**43**	**44**	**14**	**44**	**16**	**41**	**21**	**-**
Total Cost			$ -	$ 3,754,800	$ -	$ 4,104,800	$ -	$ 5,154,800	$ -
ROI (vs. Min. Mgmt)				**0.9**	**-**	**0.9**	**-**	**0.8**	**-**

Number of Acres/Year, Costs & Number of Years for Each Management Treatment

Scenarios (enter name below)	**Notes**	Mechanical Thinning	Openings Creation	Manual Thinning	On Site RxBurn Prep	RxBurn (2 entries)	Rx Burn (Maintenance)	Rx Burn (Maintenance)
No Mgmt - 10 Yrs	with fire suppression via Transition Multipliers							
Feasible Treatments-10 Yrs	MechTreat 2320 total acres: 1110 B & 750 E w mech-thin 80% & regen 20%; ManualThin 3590 tot ac: 2300 B & 650 E	**265**	**65**	**510**	**125**	**125**		
No Mgmt - 20 Yrs								
Feasible Treatments-20 Yrs	trajectory with some maintenance burning	**265**	**65**	**510**	**125**	**125**	**100**	
No Mgmt - 50 Yrs								
Feasible Treatments-50 Yrs	trajectory with some maintenance burning	**265**	**65**	**510**	**125**	**125**		**100**
Cost of Strategy (per acre)		$ 925	$ 1,075	$ 175	$ 175	$ 750	$ 350	$ 350
Number of Years		7	7	7	8	8	10	40

Acres Treated								
No Mgmt - 10 Yrs								
Feasible Treatments-10 Yrs		**1,855**	**455**	**3,570**	**1,000**	**1,000**	**-**	**-**
No Mgmt - 20 Yrs		**-**	**-**	**-**	**-**	**-**	**-**	**-**
Feasible Treatments-20 Yrs		**1,855**	**455**	**3,570**	**1,000**	**1,000**	**1,000**	**-**

Cost - 10 Year Total	**$ 1,715,875**	**$ 489,125**	**$ 624,750**	**$ 175,000**	**$ 750,000**	**$ -**	**$ -**

Appendix F

Model Run Worksheets - Dry-Mesic Mixed Conifer Forest & Woodland

Strategy Worksheet — *Dry-Mesic Montane Mixed Conifer Forest*

18,700 acres

Vegetation Class	NRV	Current Condtion	No Mgmt - 10 Yrs	Mechanical Only - 5% Regen	Mechanical Only - 20% Regen	Mechanical Only - 40% Regen	Prescribed Burn Only	Mechanical + RxBurning	Mechanical + Large Rx Burn
A - Early	10%	11%	7%	9%	11%	14%	8%	12%	12%
B - Mid Closed	5%	48%	43%	30%	29%	29%	39%	25%	19%
C - Mid Open	20%	24%	26%	38%	37%	35%	30%	41%	46%
D - Late Open	40%	5%	7%	10%	9%	9%	7%	10%	10%
E - Late Closed	25%	8%	12%	9%	9%	9%	11%	8%	8%
U - Uncharacteristic		4%	5%	5%	5%	5%	5%	5%	5%
Ecological Departure		**52**	**49**	**47**	**47**	**47**	**49**	**47**	**47**
Open Forest Departure		**43**	**43**	**19**	**19**	**17**	**36**	**10**	**3**
Total Cost - 20 Years			$ -	$ 3,507,000	$ 3,619,000	$ 3,724,000	$ 1,522,000	$ 4,819,000	$ 6,694,000
ROI (vs. Min. Mgmt)				**0.7**	**0.7**	**0.7**	**0.5**	**0.7**	**0.6**

Number of Acres/Year, Costs & Number of Years for Each Management Treatment

Scenarios (enter name below)	**Notes**	Mechanical Thinning	Regen Harvest	Hand Thin	RxBurn (2 entries)		RxBurn (large)	
No Mgmt - 10 Yrs	with fire suppression via Transition Multipliers							
Mechanical Only - 5% Regen	1200 ac/yr Mech (40% Dry); 500 ac/yr Man (40% Dry)	**450**	**25**	**200**				
Mechanical Only - 20% Rege	1200 ac/yr Mech (40% Dry); 500 ac/yr Man (40% Dry)	**380**	**100**	**200**				
Mechanical Only - 40% Rege	1200 ac/yr Mech (40% Dry); 500 ac/yr Man (40% Dry)	**280**	**200**	**200**				
Prescribed Burn Only	Two entries following hand treated acres			**200**	**200**			
Mechanical + RxBurning	Mech@20% Regen + RXBurn hand treated	**380**	**100**	**200**	**200**			
Mechanical + Large Rx Burn	add 6,750 acre burn in year 8 (2250 PP, 2500 Dry, 2000 Wet)	**380**	**100**	**200**	**200**		**2500**	
Cost of Strategy (per acre)		$ 950	$ 1,100	$ 230	$ 750		$ 750	
Number of Years		7	7	7	8		1	

Acres Treated								
No Mgmt - 10 Yrs								
Mechanical Only - 5% Regen		**3,150**	**175**	**1,400**	**-**	**-**	**-**	**-**
Mechanical Only - 20% Rege		**2,660**	**700**	**1,400**	**-**	**-**	**-**	**-**
Mechanical Only - 40% Rege		**1,960**	**1,400**	**1,400**	**-**	**-**	**-**	**-**
Prescribed Burn Only		**-**	**-**	**1,400**	**1,600**	**-**	**-**	**-**
Mechanical + RxBurning		**2,660**	**700**	**1,400**	**1,600**	**-**	**-**	**-**
Mechanical + Large Rx Burn		**2,660**	**700**	**1,400**	**1,600**	**-**	**2,500**	**-**

Strategy Worksheet — *Dry-Mesic - Fire Alts, 10 Yr Zero, Mech+Burn*

18,700 acres

100000

Enter percentages from "Final Conditions" as a whole number

Vegetation Class	NRV	Current Condtion	No Mgmt - Fire Supression	No Mgmt - NoFire	No Mgmt - High Fire	10 Year Zero	Mech + Rx Burning - 10 Yrs	Mech + Rx Burning - 20 Yrs	Mech + Rx Burning - 50 Yrs
A - Early	10%	11%	7%	7%	11%	12%	12%	9%	3%
B - Mid Closed	5%	48%	43%	46%	39%	16%	25%	22%	19%
C - Mid Open	20%	24%	26%	24%	27%	49%	41%	40%	35%
D - Late Open	40%	5%	7%	6%	7%	11%	10%	12%	17%
E - Late Closed	25%	8%	12%	13%	10%	7%	8%	11%	20%
U - Uncharacteristic		4%	5%	4%	6%	5%	5%	5%	6%
Ecological Departure		**52**	**49**	**49**	**48**	**47**	**47**	**43**	**35**
Open Forest Departure		**43**	**43**	**47**	**36**	**0**	**10**	**13**	**21**
Total Cost - 20 Years			$ -	$ -	$ -	$ 7,748,500	$ 4,819,000	$ 5,169,000	$ 6,219,000
ROI (vs. Min. Mgmt)				**-**	**-**	**0.6**	**0.7**	**0.7**	**0.6**

Number of Acres/Year, Costs & Number of Years for Each Management Treatment

Scenarios (enter name below)	**Notes**	Mechanical Thinning	Regen Harvest	Hand Thin	RxBurn	RxBurn (maintenance)		
No Mgmt - Fire Supression	with fire suppression via Transition Multipliers							
No Mgmt - NoFire	no fire							
No Mgmt - High Fire	4500 acres Dry burned;30% replacement; 45% mixed;							
10 Year Zero	Add thinning & burning to get zero open forest departure	**420**	**100**	**550**	**550**			
Mech + Rx Burning - 10 Yrs		**380**	**100**	**200**	**200**			
Mech + Rx Burning - 20 Yrs		**380**	**100**	**200**	**200**	**100**		
Mech + Rx Burning - 50 Yrs		**380**	**100**	**200**	**200**		**100**	
Cost of Strategy (per acre)		$ 950	$ 1,100	$ 230	$ 750	$ 350	$ 350	
Number of Years		7	7	7	8	10	40	

Acres Treated								
No Mgmt - Fire Supression		**-**	**-**	**-**	**-**	**-**	**-**	**-**
No Mgmt - NoFire		**-**	**-**	**-**	**-**	**-**	**-**	**-**
No Mgmt - High Fire		**-**	**-**	**-**	**-**	**-**	**-**	**-**
10 Year Zero		**2,940**	**700**	**3,850**	**4,400**	**-**	**-**	**-**
Mech + Rx Burning - 10 Yrs		**2,660**	**700**	**1,400**	**1,600**	**-**	**-**	**-**
Mech + Rx Burning - 20 Yrs		**2,660**	**700**	**1,400**	**1,600**	**1,000**	**-**	**-**
Mech + Rx Burning - 50 Yrs		**2,660**	**700**	**1,400**	**1,600**	**-**	**4,000**	**-**

Strategy Worksheet ***Dry-Mesic Forest - Feasible Treatments & Trajectory*** *18,700 acres*

Enter percentages from "Final Conditions" as a whole number

Vegetation Class	NRV	Current Condtion	No Mgmt - 10 Yrs	Feasible Treatments-10 Yrs	No Mgmt - 20 Yrs	Feasible Treatments-20 Yrs	No Mgmt - 50 Yrs	Feasible Treatments-50 Yrs	-
A - Early	10%	11%	7%	10%	6%	7%	4%	3%	
B - Mid Closed	5%	48%	43%	31%	38%	28%	24%	20%	
C - Mid Open	20%	24%	26%	37%	27%	38%	25%	35%	
D - Late Open	40%	5%	7%	10%	9%	11%	13%	15%	
E - Late Closed	25%	8%	12%	7%	16%	11%	26%	21%	
U - Uncharacteristic		4%	5%	5%	5%	5%	7%	7%	
Ecological Departure		**52**	**49**	**48**	**44**	**46**	**33**	**36**	**-**
Open Forest Departure		**43**	**43**	**19**	**40**	**20**	**40**	**24**	**-**
Total Cost - 20 Years			$ -	$ 3,618,000	$ -	$ 3,968,000	$ -	$ 5,018,000	$ -
ROI (vs. Min. Mgmt)				**0.7**	**-**	**0.7**	**-**	**0.6**	**-**

Number of Acres/Year, Costs & Number of Years for Each Management Treatment

Scenarios (enter name below)	**Notes**	Mechanical Thinning	Openings Creation	Manual Thinning	On Site RxBurn Prep	RxBurn (2 entries)	Maintenance Burn	Maintenance Burn
No Mgmt - 10 Yrs	with fire suppression via Transition Multipliers							
Feasible Treatments-10 Yrs	MechTreat 1930 total acres: 920 B & 630 E w mech-thin 80% & regen 20%; ManualThin 2410 tot acres: 1540 B & 430 E	**220**	**55**	**345**	**150**	**150**		
No Mgmt - 20 Yrs								
Feasible Treatments-20 Yrs	trajectory with some maintenance burning	**220**	**55**	**345**	**150**	**150**	**100**	
No Mgmt - 50 Yrs								
Feasible Treatments-50 Yrs	trajectory with some maintenance burning	**220**	**55**	**345**	**150**	**150**		**100**
Cost of Strategy (per acre)		$ 950	$ 1,100	$ 230	$ 230	$ 750	$ 350	$ 350
Number of Years		7	7	7	8	8	10	40

Acres Treated								
No Mgmt - 10 Yrs								
Feasible Treatments-10 Yrs		**1,540**	**385**	**2,415**	**1,200**	**1,200**	**-**	**-**
No Mgmt - 20 Yrs		**-**	**-**	**-**	**-**	**-**	**-**	**-**
Feasible Treatments-20 Yrs		**1,540**	**385**	**2,415**	**1,200**	**1,200**	**1,000**	**-**

Cost - 10 Year Total	**$ 1,463,000**	**$ 423,500**	**$ 555,450**	**$ 276,000**	**$ 900,000**	**$ -**	**$ -**

Appendix G

Model Run Worksheets - Mesic Mixed Conifer Forest & Woodland

Strategy Worksheet | ***Mesic Montane Mixed Conifer Forest*** | *15,700 acres*

Enter percentages from "Final Conditions" as a whole number

Vegetation Class	NRV	Current Condtion	No Mgmt - 10 Yrs	Mechanical Only - 5% Regen	Mechanical Only - 20% Regen	Mechanical Only - 40% Regen	Prescribed Burn Only	Mechanical + RxBurning	Mechanical + Large Rx Burn
A - Early	10%	11%	9%	9%	10%	11%	9%	10%	9%
B - Mid Closed	25%	64%	59%	55%	54%	55%	55%	52%	48%
C - Mid Open	20%	7%	8%	11%	12%	10%	12%	14%	19%
D - Late Open	15%	2%	3%	3%	3%	3%	2%	4%	5%
E - Late Closed	30%	15%	19%	19%	19%	19%	19%	18%	16%
U - Uncharacteristic		2%	3%	3%	3%	3%	3%	3%	3%
Ecological Departure		**42**	**36**	**33**	**31**	**33**	**33**	**29**	**26**
Open Forest Departure		**57**	**56**	**49**	**44**	**47**	**49**	**38**	**27**
Total Cost - 20 Years			$ -	$ 1,485,800	$ 1,501,500	$ 1,522,500	$ 1,477,500	$ 2,401,500	$ 3,901,500
ROI (vs. Min. Mgmt)				**0.7**	**1.1**	**0.8**	**0.7**	**1.0**	**1.0**

Number of Acres/Year, Costs & Number of Years for Each Management Treatment

Scenarios (enter name below)	Notes	Mechanical Thinning	Regen Harvest	Hand Thin	RxBurn (2 entries)		RxBurn (large)	
No Mgmt - 10 Yrs	with fire suppression via Transition Multipliers							
Mechanical Only - 5% Regen	1200 ac/yr Mech (10% Mesic); 500 ac/yr Man (30%	**115**	**5**	**150**				
Mechanical Only - 20% Regen	1200 ac/yr Mech (10% Mesic); 500 ac/yr Man (30%	**100**	**20**	**150**				
Mechanical Only - 40% Regen	1200 ac/yr Mech (10% Mesic); 500 ac/yr Man (30%	**80**	**40**	**150**				
Prescribed Burn Only	Two entries following hand treated acres			**150**	**150**			
Mechanical + RxBurning	Mech@20% Regen + RXBurn hand treated	**100**	**20**	**150**	**150**			
Mechanical + Large Rx Burn	add 6,750 acre burn in year 8 (2250 PP, 2500 Dry, 2000	**100**	**20**	**150**	**150**		**2000**	
Cost of Strategy (per acre)		$ 1,075	$ 1,225	$ 550	$ 750		$ 750	
Number of Years		7	7	7	8		1	

Acres Treated								
No Mgmt - 10 Yrs								
Mechanical Only - 5% Regen		**805**	**35**	**1,050**	**-**	**-**	**-**	**-**
Mechanical Only - 20% Regen		**700**	**140**	**1,050**	**-**	**-**	**-**	**-**
Mechanical Only - 40% Regen		**560**	**280**	**1,050**	**-**	**-**	**-**	**-**
Prescribed Burn Only		**-**	**-**	**1,050**	**1,200**	**-**	**-**	**-**
Mechanical + RxBurning		**700**	**140**	**1,050**	**1,200**	**-**	**-**	**-**
Mechanical + Large Rx Burn		**700**	**140**	**1,050**	**1,200**	**-**	**2,000**	**-**

Strategy Worksheet | ***Mesic Forest - Fire Alts, 10 Yr Zero, Mech+Burn*** | *15,700 acres*

Enter percentages from "Final Conditions" as a whole number

Vegetation Class	NRV	Current Condtion	No Mgmt - Fire Supression	No Mgmt - No Fire	No Mgmt - High Fire	10 Year Zero	Mech + Rx Burning - 10 Yrs	Mech + Rx Burning - 20 Yrs	Mech + Rx Burning - 50 Yrs
A - Early	10%	11%	9%	8%	13%	13%	10%	8%	4%
B - Mid Closed	25%	64%	59%	61%	49%	35%	52%	47%	38%
C - Mid Open	20%	7%	8%	6%	14%	29%	14%	15%	14%
D - Late Open	15%	2%	3%	2%	4%	6%	4%	4%	5%
E - Late Closed	30%	15%	19%	20%	16%	14%	18%	23%	35%
U - Uncharacteristic	0%	2%	3%	3%	4%	3%	3%	3%	4%

Ecological Departure	42	36	39	31	25	29	25	22
Open Forest Departure	57	56	64	31	0	38	40	49
Total Cost - 20 Years	$ -	$ -	$ -	$ 6,320,000	$ 1,960,500	$ 2,135,500	$ 2,660,500	
ROI (vs. Min. Mgmt)		-	-	1.1	1.3	1.2	0.8	

Number of Acres/Year, Costs & Number of Years for Each Management Treatment

Scenarios (enter name below)	**Notes**	Mechanical Thinning	Regen Harvest	Hand Thin	RxBurn	RxBurn (maintenance)	RxBurn (maintenance)	
No Mgmt - Fire Supression	with fire suppression via Transition Multipliers							
No Mgmt - No Fire	no fire							
No Mgmt - High Fire	~2400 ac Mesic burned;30% replacement;69% mixed;1%							
10 Year Zero	Add thinning & burning to get zero open forest departure	**400**	**80**	**400**	**400**			
Mech + Rx Burning - 10 Yrs	Mech@20% Regen + RXBurn hand treated	**100**	**20**	**150**	**150**			
Mech + Rx Burning - 20 Yrs		**100**	**20**	**150**	**150**	**50**		
Mech + Rx Burning - 50 Yrs		**100**	**20**	**150**	**150**		**50**	
Cost of Strategy (per acre)		$ 950	$ 1,100	$ 230	$ 750	$ 350	$ 350	
Number of Years		7	7	7	8	10	40	

Acres Treated								
No Mgmt - Fire Supression		-	-	-	-	-	-	-
No Mgmt - No Fire		-	-	-	-	-	-	-
No Mgmt - High Fire		-	-	-	-	-	-	-
10 Year Zero		**2,800**	**560**	**2,800**	**3,200**	-	-	-
Mech + Rx Burning - 10 Yrs		**700**	**140**	**1,050**	**1,200**	-	-	-
Mech + Rx Burning - 20 Yrs		**700**	**140**	**1,050**	**1,200**	**500**	-	-
Mech + Rx Burning - 50 Yrs		**700**	**140**	**1,050**	**1,200**	-	**2,000**	-

Strategy Worksheet | ***Mesic Forest - Feasible Treatments & Trajectory*** | *15,700 acres*

Enter percentages from "Final Conditions" as a whole number

Vegetation Class	NRV	Current Condtion	No Mgmt - 10 Yrs	Feasible Treatments-10 Yrs	No Mgmt - 20 Yrs	Feasible Treatments-20 Yrs	No Mgmt - 50 Yrs	Feasible Treatments-50 Yrs	-
A - Early	10%	11%	9%	10%	7%	8%	5%	4%	
B - Mid Closed	25%	64%	59%	53%	53%	49%	40%	38%	
C - Mid Open	20%	7%	8%	12%	9%	13%	10%	13%	
D - Late Open	15%	2%	3%	4%	3%	4%	5%	6%	
E - Late Closed	30%	15%	19%	18%	25%	22%	37%	35%	
U - Uncharacteristic		2%	3%	3%	3%	3%	4%	4%	
Ecological Departure		**42**	**36**	**31**	**31**	**28**	**25**	**22**	**-**
Open Forest Departure		**57**	**56**	**42**	**58**	**44**	**56**	**49**	**-**
Total Cost - 20 Years			$ -	$ 2,985,100	$ -	$ 3,160,100	$ -	$ 3,685,100	$ -
ROI (vs. Min. Mgmt)				**0.6**	**-**	**0.6**	**-**	**0.6**	**-**

Number of Acres/Year, Costs & Number of Years for Each Management Treatment

Scenarios (enter name below)	**Notes**	Mechanical Thinning	Openings Creation	Manual Thinning	On Site RxBurn Prep	RxBurn (2 entries)	Rx Burn (Maintenance)	Rx Burn (Maintenance)
No Mgmt - 10 Yrs	with fire suppression via Transition Multipliers							
Feasible Treatments-10 Yrs	MechTreat 1780 total acres: 850 B & 580 E w mech-thin @ 90% & regen 10%	**230**	**25**	**0**	**100**	**100**		
No Mgmt - 20 Yrs								
Feasible Treatments-20 Yrs	trajectory with some maintenance burning	**230**	**25**	**0**	**100**	**100**	**50**	
No Mgmt - 50 Yrs								
Feasible Treatments-50 Yrs	trajectory with some maintenance burning	**230**	**25**	**0**	**100**	**100**		**50**
Cost of Strategy (per acre)		$ 1,075	$ 1,225		$ 550	$ 750	$ 350	$ 350
Number of Years		7	7		8	8	10	40

Acres Treated								
No Mgmt - 10 Yrs								
Feasible Treatments-10 Yrs		**1,610**	**175**	**-**	**800**	**800**	**-**	**-**
No Mgmt - 20 Yrs		**-**	**-**	**-**	**-**	**-**	**-**	**-**
Feasible Treatments-20 Yrs		**1,610**	**175**	**-**	**800**	**800**	**500**	**-**

Cost - 10 Year Total	**$ 1,730,750**	**$ 214,375**	**$ -**	**$ 440,000**	**$ 600,000**	**$ -**	**$ -**